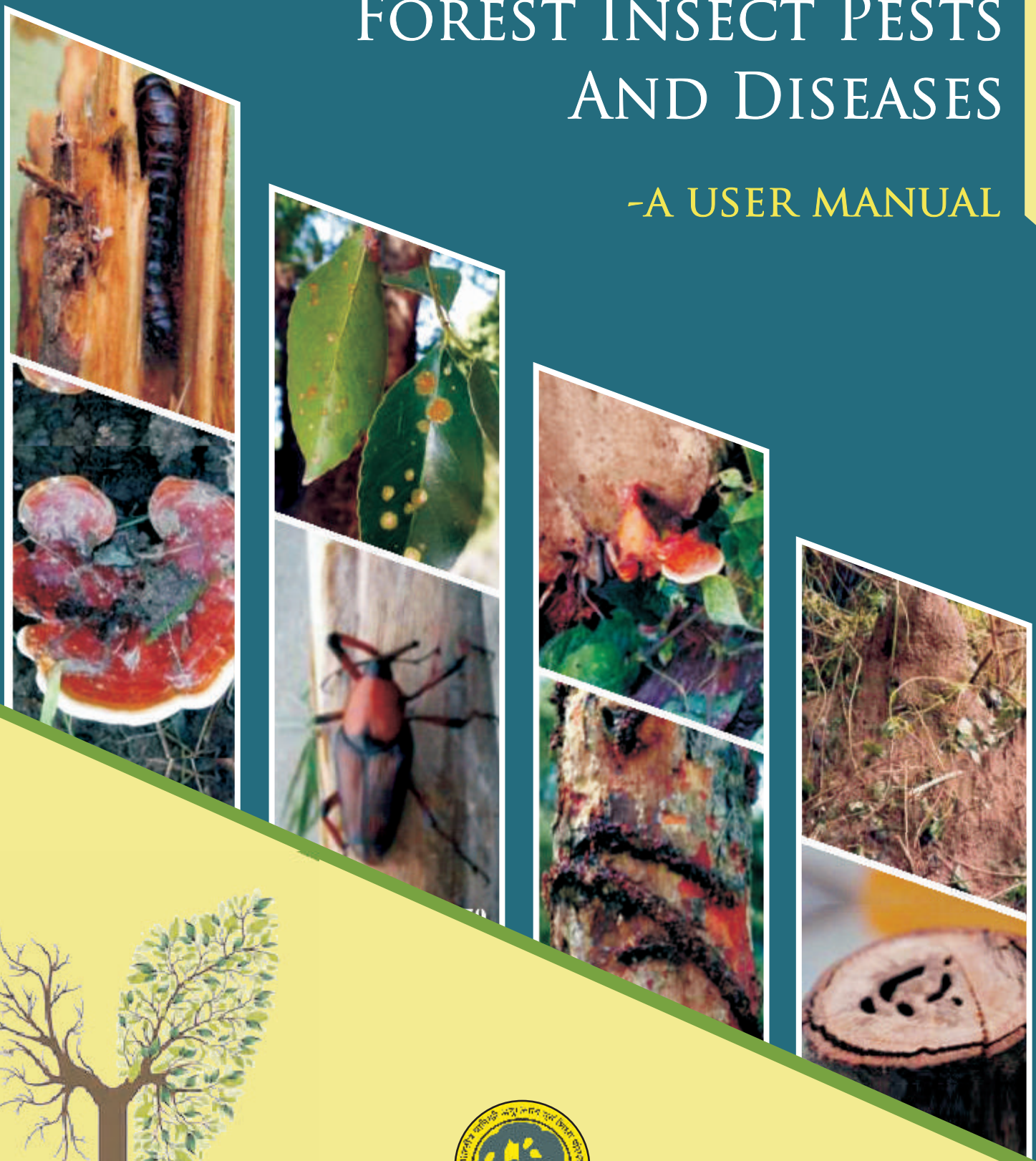
Forest Insect Pests And Diseases

-A USER MANUAL



INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION, DEHRADUN
(An Autonomous body of Ministry of Environment, Forest and Climate Change, Government of India)

FOREST INSECT PESTS AND DISEASES

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INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
P.O. New Forest, Dehradun - 248 006

www.icfre.gov.in

Published by

Indian Council of Forestry Research and Education
P.O. New Forest, Dehradun 248 006

Citation

ICFRE, 2020. A User Manual on Forest Insect Pests and Diseases
Indian Council of Forestry Research and Education, Dehradun, India.

Processed and Realization
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Foreword

Dr. Suresh Gairola, IFS
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Forestry Research and Educatrion

ICFRE with its Headquarters at Dehradun is an apex body in the national forestry research system that promotes and undertakes need based forestry research and extension. The Council that came into being in 1986 has a pan India presence with its 9 Regional Research Institutes and 5 Centers in different bio-geographical regions of the country. Since then research in different fields of forestry has been a major focus of ICFRE.

There is an earnest need to present its research findings to the stakeholders in a simple and lucid manner, to improve the visibility and relevance of ICFRE. Therefore it was decided that the information available on the technologies, processes, protocols and practices developed by ICFRE be published in the form of operational manuals/user manuals. It is also desirable that the manual should be a comprehensive national level document depicting extent of knowledge in applicable form.

Accordingly, 18 scientists of ICFRE were nominated as National Subject Matter Coordinators (NSMCs) to carry out the task on the specified subject. These NSMCs were assigned the task to select and nominate nodal officers from other Institutes of ICFRE as well as other organizations if necessary, collect and collate the information on the subject from various sources in coordination with the nodal officers of ICFRE institutes.

This manual has been compiled in order to enable the forest managers, tree growers and plantation based undertakings to look for and tentatively identity the causes of common pathological and entomological problems based on the sign and symptoms displayed in various species in nurseries, plantation and agroforestry trees. An informed decision regarding causal agent of the problem will help them in

talking up appropriate remedial measures timely. This will minimize the losses, ensure successful plantation programme and enhance productivity. The manual is written in easy to use format and would be of help in addressing common health issues quickly. In case of complex health issues, however, taking expert's advise becomes mandatory.

I congratulate the efforts made by the authors and I am sure that this publication will prove effective to all the people working towards the conservation and sustainable management of native biodiversity in the country.

Dr. Suresh Gairola

Preface

The diseases and insect-pest problems lead to heavy productivity losses in forest nurseries and plantations. The epiphytotic conditions may result in completely wiping-out the entire nursery seedlings stock and adversely effect the plantation health and vigour leading to large scale tree mortality. The mortality discourage the forestors, farmers and the nursery managers because the whole plantation programme is jeopardized. The economic losses and hampered raw material supply adversely affect the wood-based industries. Several plant health management strategies are adopted to control disease and insect pest problems. Use of pesticides is most effective, however, it is impractical when it comes to plantations and also poses threat to environment. It can however, be judiciously used in forest nurseries and agroforestry systems. In plantations, ecofriendly methods are only feasible, such as cultural practices, biological control and use of resistant germplasm.

Nursery and plantation managers are often encountered with health problems of nursery stock and trees. It is practically not possible for the foresters and farmers to approach the expert every time for identifying the problems and devising control strategy due to their engagements, logistics and preoccupations. This manual has been designed in a user-friendly fashion and could be put to use in field conditions. The photographs would help in tentatively identifying the cause of the problem and thereby application of management practices accordingly. Suitable control measures as suggested for a problem should be applied initially to combat the problem. However, in case of little response, the manager would be required to approach the pathologist or entomologist depending upon the signs and symptoms.

The book has been divided into mainly two sections. The first deals with the pathological problems causing different diseases. The diseases are caused by microorganisms such as bacteria, viruses, phytoplasma, fungi, etc. However, the most common causal organism is fungus. The second section deals with the insect-pest problem and could even predispose the plant to pathogenic infections.

This manual has been written in a simple form and is easy to use. Compilation of this manual has possible because of the different manuscripts submitted by the scientists and researchers working

in pathology and entomology disciplines of all the ICFRE institutes to their respective Nodal Officers designated for this purpose. These experts, whether pathologists or entomologists have contributed with their vast experience and suggested pragmatic approach to the management of these problems. The work of earlier workers have also been included.

I would like to utilise this opportunity to thank the Director General, ICFRE for giving me the opportunity to be part in the compilation of this user friendly manual. I am thankful to the Director, FRI for providing the necessary infrastructure, logistics and support during the preparation of this manual. I wish to thank all the Nodal Officers from all the ICFRE institutes who have painstakingly requested the scientists and researches of their respective divisions to contribute the information presented in this manual. I would like to thank Dr Sudhir Singh and Dr Shailesh Pandey who have compiled the the Entomology and Pathology section of this manual respectively. Thanks are also due to Mr Jalaj Saxena, Research Scholar for his assistance during the preparation of this manuscript.

Hope this manual will be of use to different stakeholders and assist in solving many of their date-to-day plant health related issues.

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Contents

1

DISEASES

1 INTRODUCTION

The huge diversity and life styles of plant pathogens and insect pests severely impacting crop/tree performance poses a serious global threat. The severity and spread of plant pathogens and insect pests seriously impact forest productivity and competes with commercial forest values. Tree diseases are equally important as diseases in agriculture crops. Indeed, 40 % of the world's land surface is covered by forests and other wooded lands (FAO 2010). Crowther et al. (2015) have recently estimated that the global number of forest trees is approximately 3.04 trillion, exceeding previous estimates by far and stressing the magnitude of this massive biomass. Not only do trees produce food in abundance, planted at the right places they also help protect soil from erosion, and boost crop growth by slowing wind speeds and improving crop water efficiency. Another area of concern is the serious decline in pollinator numbers throughout the agricultural landscape, partially as a result of the loss of nearby tree habitats. The health of forests and woody cropping systems is therefore of particular relevance. However, a range of biotic factors continuously compromise the fitness, development and production of trees and woody plants. Many soil-borne fungi provoke severe losses in economically-relevant tree crops in nurseries, plantations and natural forests. Among them, different fungal genera (e.g. *Fusarium, Armillaria, Heterobasidion, Rosellinia, Verticillium,* etc.) and oomycetes (e.g. *Phytophthora, Pythium,* etc.) are particularly harmful and may cause extreme losses. Similarly a variety of insect pests including defoliators, shoot borers, sap suckers, root damagers, gall formers etc., cause tremendous damage in the nursery, plantations and standing trees. The challenge for forest resource managers is therefore two-fold.

First is to assess the risks posed by potential and actual outbreaks and spread. Second is to apply risk-based decision-making to manage forest ecosystems in a way that minimizes the negative impacts of outbreaks. Reliable scientific information and advancing technology is a pre-requisite for reliable decisions regarding minimizing the disease outbreaks. In this manual, based on research data published in various journals and reports, the major disease and insect pest problems of economically important tree species are compiled. We recommend growers must first carefully examine different symptoms including damping off, wilt, root rot, leaf spots, branch dieback, cankers etc., to identify the cause of the disease. Try to find signs of the causal agents such as fungus fruiting bodies, mycelia webs, spore masses, eggs, larvae etc. In some cases it is difficult to distinguish the exact symptoms as mixed symptoms resulting from several different agents is so alike. In case if you cannot make the positive identification, consulting a forest pathologist and entomologist is recommended.

This manual has been presented in a simple format and language suitable for common stakeholders. Too much technical details have been avoided as it becomes overwhelming for the user. The manual is indicative and cannot replace a specialized expert opinion on case to case basis. However, broadly it gives fair amount of information regarding common problems in nurseries, plantations, agroforestry and ways to manage them. The first section of the manual deals with the pathological problems while the second with entomological aspects of forest nurseries, plantations and agroforestry. Different problems have been explained in lucid manner followed by remedial measures.

2 NURSERY DISEASES

The role of Forest nurseries are of immense importance as they provide the desired planting stock, and keep our Nation's forest lands productive. Factors influencing the quantity and quality of nursery seedlings ultimately influence our future timber supply. Fungal diseases are the major factors that negatively affect the quality and quantity of nursery grown seedlings. The pathogenic fungi, which are active during sowing time and outplanting, may kill seedlings directly, or stunt or malform them so they must be rejected. Common nursery diseases include problems related to germination of seeds, sprouting of cuttings, rotting or wilting of germinated plantlets and many foliar diseases. Main diseases are pre-emergence damping off, post-emergence damping off, wilt, collar rot, root rot, leaf spots, leaf blight, leaf curling, powdery mildew, rust etc. The pathogens may be carried through seeds and gets established in the nurseries. The soil borne propagules of the pathogen also attacks the young seedlings in the nurseries. Nursery diseases further pose a threat as the infected seedlings have lower field survival. Importantly, infected seedlings are the biggest threats to our forests as they serve as a source of inoculums when planted in uninvaded forest areas.

2.1. DAMPING OFF

Damping-off is one of the biggest problems in forest nurseries. Many fungi reported to cause damping-off in newly sown nursery-beds. Damping-off disease caused by *Fusarium* sp. has been reported to cause severe losses in *Albizia lebbek, Dalbergia sissoo* and *Leucaena leucocephala* (Harsh 1993). *Rhizoctonia solani* is responsible for damping off in *Aquilaria malaccensis. Fusarium oxysporum* has been reported to cause damping off in eucalyptus (Sharma 1984). It is of two types:-

1) Pre-emergence Damping off
2) Post-emergence Damping off

Causal Organism

Phytophthora, Pythium, Fusarium, Rhizoctoni, etc (Riffle and Smith, 1997). Other fungi responsible for occasional damping off are *Cylindrocladium* spp, *Botrytis cinerea* and *Sphaeropsis sapinea* (Fisher, 1941), *Macrophomina phaseolina* (Boyce, 1961), *Alternaria alternata, Cladosporium cladosporoides, Penicillium expansum* (Huang and Kuhlman, 1991) and *Phoma* spp. (Russell, 1990).

Symptoms

- In pre-emergence damping-off, before the emergence of seedlings from the soil—fungal attack on the developing radicle kill the seedlings, which may go undetected or sometimes explained as poor seed.
- Post-emergence damping-off is often characterized as a water-soaked or necrotic area on the succulent stem
- In conifers this tissue collapses, and the seedling becomes flaccid and topples over (Fig 1-3).

- In contrast, hardwood seedlings usually remain upright, gradually wilt, and break off (Filer et al., 1975)
- In early stage, seedlings show stunted growth with typical discoloration on the collar region.
- Small lesions on roots near to soil level.
- In severe infection, the entire root was found to be rotted and mortality of the seedlings occurs.

Management

- Selection of seeds which is free from seed borne diseases, control of watering, good drainage in container is very important for controlling and avoiding damping off.
- Fungicidal seed treatment with Topsin-M (Thiophanate methyl) and Bavistin (0.1%) provides an adequate control at a low cost (Harsh 1993).
- Shade over the nursery beds need to be regulated to allow more sunlight over the beds.
- Fungicides like Bavistin (0.01%), Dithane M 45 (0.01%) should be applied as soil drench at an interval of four hours, in place of normal watering.
- After treatment, watering should be regulated to prevent build up of excess soil moisture (Mohanan 2014).

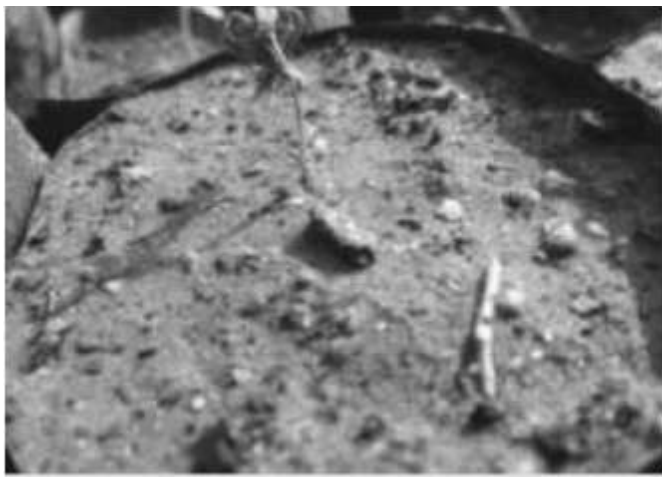


Fig 1. Post emergence Damping off

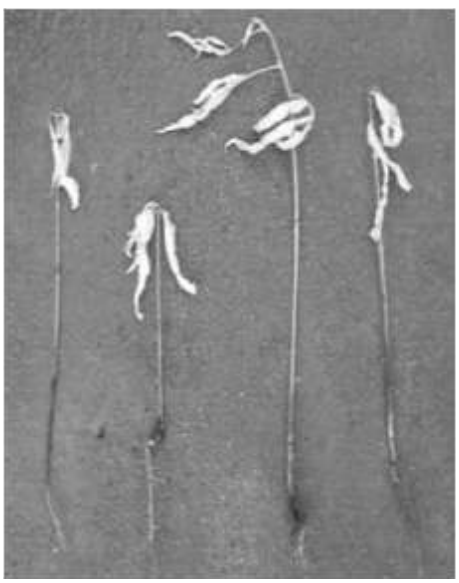


Fig 2. Damping off disease of *A. malaccensis*

Fig 3. Damping off of Sandalwood

2.2. FOLIAR DISEASES

Foliar diseases are generally characterized by leaf spots, leaf blight, leaf curling, powdery mildew, rusts etc. General symptom is circular or irregular patches of yellow, purple, brown and ash color or burn like symptom or curling and crinkling of leaves and defoliation. An established plant can tolerate almost complete defoliation if it happens late in the season or irregular in the year. Small or newly planted trees that become defoliated are more at risk of suffering damage until they become established.

2.2.1. LEAF SPOT

Causal Organism: *Alternaria* spp., *Cercospora* spp., *Phytophthora* spp., *Xanthomonas* spp., etc.

Symptom

- Brown to dark brown spots on leaves which were oval to angular in shape having a bull's eye
- Lower leaves affected first; then, the disease progresses to upper leaves. Gradually, these spots coalesce into dark brown areas of irregular shape, often surrounded by a chlorotic zone (Fig. 4).
- The halo, surrounding the spots, is created by the diffusion of fungal metabolites, may be toxin.
- Sometimes, concentric ring inside the spots gives target like appearance.
- The plants showed symptoms of yellow to dark brown margins, defoliation and weakening of the saplings
- In northwest India, symptoms of leaf spot disease caused by *Curvularia eragrostidis* (Bagwari *et al.* 2015) on *P. deltoides* appears in late July and remained on nursery seedlings until late September (Fig.4)

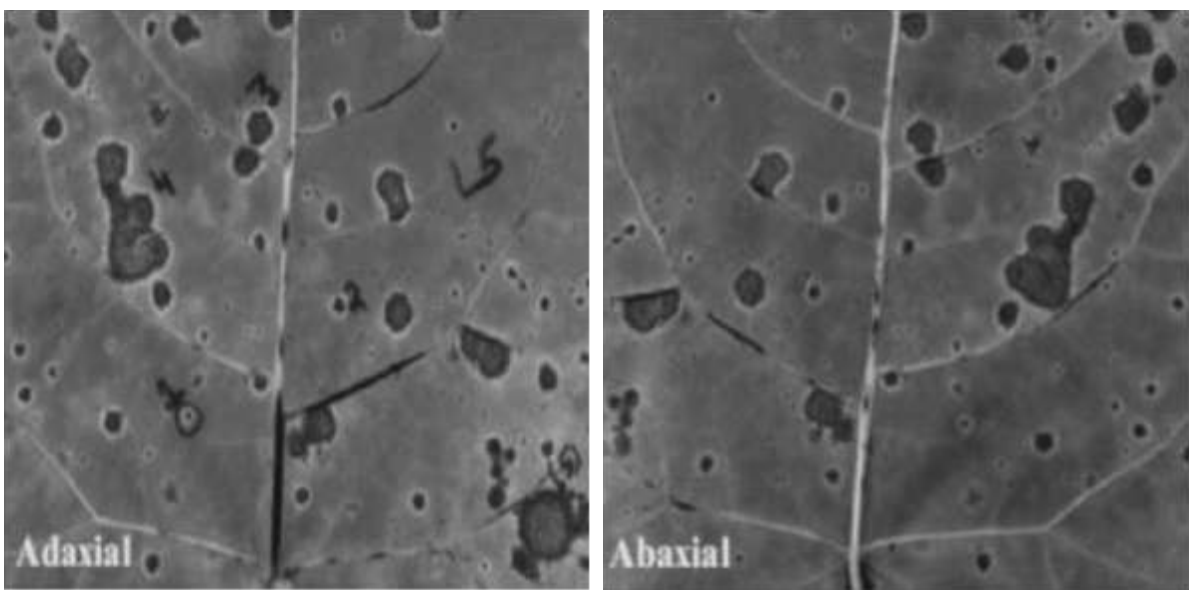


Fig 4. Leaf spot of P. deltoides

Fig 4. Leaf spot disease of *A. malaccensis*

- Corynespora cassiicola has been reported to cause leaf spot disease on A. malaccensis (Fig. 5)

Management

- Bavistin (0.2%) followed by Dithane M-45 and Captan are effective against leaf spot disease.
- Application of Blitox fungicide (0.2%) at fortnightly intervals is effective against leaf spot.
- Spraying of Mancozeb @ 2.5 g/l or Carbendazim @ 1g/l of water at 10-12 days interval is found effective.

2.2.2. BLIGHT

Causal organism

Cylindrocladium quinqueseptatum, Coniella fragariae, Alternaria alternata,Cercospora spp.

Symptom

- Leaf and seedling blight caused by Cylindrocladium quinqueseptatum is a serious disease of Eucalyptus nurseries (Fig.6), especially in north India including Punjab, Haryana and Uttarakhand (Mohanty et al, 2012). Extensive to complete premature defoliation accompanied by die-back of tender shoots during peak period of monsoon (July-August) in nurseries (Mohanan *et al.* 2005).

Fig 6. Eucalyptus leaf blight

- *Coniella fragariae* causes severe leaf blight and, thereby defoliation in *E. camaldulensis, E. grandis* and *E. tereticornis* plantations (Mohanan 2015).
- *Alternaria alternata* causes circular lesions in *Azadirachta indica,* which spread to the whole leaf and became necrotic and cause foliage blight (Fig.7)
- *Rhizoctonia solani* has been reported to cause web blight in Shisham, *Bauhinia variegate, Cassia fistula* and *Populus deltoides* (Mehrotra 1998). In Eucalyptus, the disease generally appeared within two weeks of seedling emergence Leaves of the infected seedlings developed watersoaked lesions and wilted. Later, they became necrotic and dried up. The stem showed characteristic pale grayish-black necrotic lesions. The pathogen often produced off white to light brown irregular sclerotia on the affected stem and leaves of older seedlings (Mohanan, 2014).
- *Spiropes* sp., is repoted to cause needle blight in *Casuarina equisetifolia* (Fig.8)

Fig 7. Leaf blight of *A. indica*

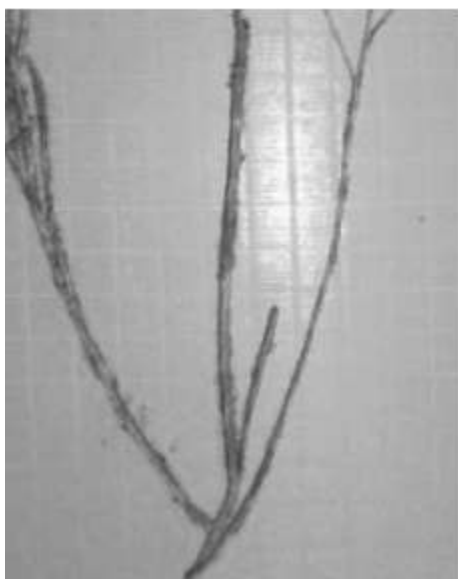


Fig 8. Needle blight of Casuarina

Management

- Application of Dithane M 45 (0.2%) is effective for controlling Coniella Leaf Blight(Mohanan et al. 2005).
- Application of 0.2 % carbendazim and benomyl and captafol is effective against Cylindrocladium leaf blight. The most appropriate disease management strategy is the introduction of disease resistance eucalypt provenances/species rather than chemical management. (Mohanan 2014).
- Application of Blitox fungicide (0.2%) at fortnightly intervals is effective against leaf spot and blight of *A. indica*
- Bavistin or Benlate (0.02 %) can be applied as soil drench for controlling Rhizoctonia blight (Mohanan 2014).
- Application of carbamate fungicides

- (@1%) in summer and prevention of water logging in the nursery is effective against Casuarina needle blight

Note: In Mysore, Karnataka some important nursery diseases have been identified in the recent past and fungicidal treatment has been suggested. *Myrothecium roridum* was found to be associated with leaf spot and blight disease of *Dendrocalamus strictus.* Leaf spot of *D. strictus* was found to be caused by *Cercospora apii. Fusarium solani* have been reported as causal agents of leaf blight of *Terminalia catappa,* respectively. Leaf spot and blight of *Azadirachta indica* is caused by *Alternaria alternata,* a destructive plant pathogen.

2.2.3. RUST

Dalbergia sissoo

Causal Organism

Maravalia achroa

Symptoms

- The disease appears in February-March on leaves and juvenile twigs and continues attacking the foliage and young twigs up to July-August.
- The affected parts are killed resulting in die-back and subsequent death of affected seedlings.
- The infected leaves are often deformed and the infected plants show perceptible retardation in growth and look stunted and weak.

Management

Application of 0.08% Bayleton at fortnightly intervals.

2.3. ROOT DISEASES

Root disease is one of the most common diseases of conifer seedlings. Fusarium oxysporum attacks and kills the roots of a seedling, causing chlorosis, stunting, and wilting of the top and eventually death. As with many root diseases, the effects are chiefly seedling mortality in the nursery bed, increased number of cull (stunted) seedlings, and increased losses after outplanting because of impaired root systems.

2.3.1. WILT

Many soil inhabiting fungi are reported to cause wilt disease. These fungi enter in their host through young roots and restrict themselves in vascular tract and multiply there, which results in the blockage of vascular system f the plants. Fusarium is the major pathogen causing wilt in the nursery as well as in plantation. It has been reported on *Dalbergia sisso, Eucalyptus, Cassia siamea, A. tortilis, P. juliflora, A. indica* (Srivastava and Verma, 2008), *Melia dubia* and *Santalum album* (sandalwood) etc.

Causal Organism

Furasium spp., *Verticillium* spp. (Escudero and Blanco, 2011) and *Rhizoctonia bataticola* (Singh, 2000).

Symptoms

- Withering, drying and dying of the seedling (Fig. 9-10).

Fig 9. Collapse of *M. dubia* seedlings

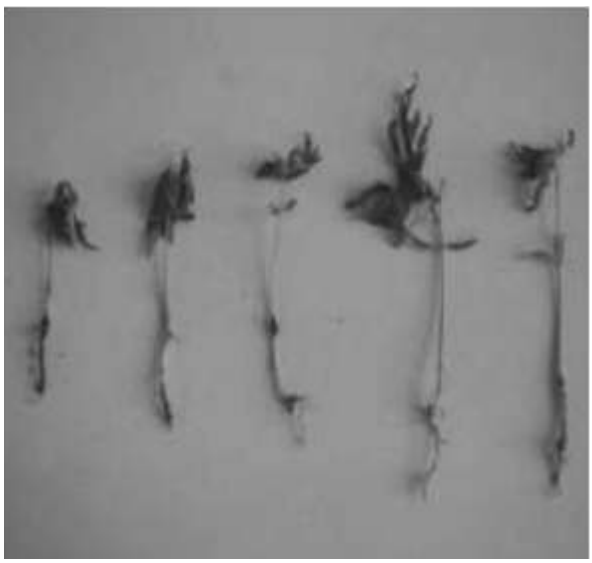


Fig 10. Wilt symptoms

Management

- Soil drenching with 0.2% Dithane M-45, Captan and Bavistin.
- Avoid excess watering to plants.
- Drench the potting medium with copper fungicide and nematicide (Blitox/Bordeaux mixture and Quinalphos or Phorate).

2.3.2. ROOT ROT

Causal Organism

Phytophthora cinnamomi, Macrophomina phaseolina, F. oxysporum, R. solani, Rosellinia necatrix

Symptoms

- Initially leaves become yellowish and then turn brown.
- Disease is visible in form of wilting and drying of seedlings.

- Stunted vegetation and increasingly extensive yellowing of large sectors of the crown; leaves eventually wither and fall off.
- The terminal stage of the disease is marked by the death of the main branches dependent on the infected roots, and the entire plant is often killed.

Management

- Drenching of soil around affected plants with 0.2 % Bavistin and Dithane-M-45 (Soni et al. 1984).
- The affected plants should be uprooted and destroyed.
- The infected area of the nursery should not be replanted for one season.

2.3.3. COLLAR ROT

The disease mainly occurs in hot and humid conditions. The disease has been recorded on *A. nilotica, T. undulata, P. juliflora* and *A. lebbek* from arid regions of Rajasthan (Srivastava and Verma, 2008).

Causal Organisms

Rhizoctonia solani, Phytophthora spp., *Lasidiploidia thoebromae* etc.

Symptoms

- Collar rots occur at the soil line where the plant emerges. The tissue may turn brown to black in the localized area around the soil line.
- The discoloration may migrate upward and downward around the outside of the tissue from the point of infection.
- Eventually, when the pathogen has almost completely encircled the stem, the plant will begin to show wilting and dieback symptoms

Management

- Nursery soil should be well drained
- Application of *Trichoderma harzianum* to soil

2.3.4. DIEBACK

Causal Organism

Colletotrichum gloeosporioides, Fusarium spp., *Rhizoctonia solani, Phytophthora cinnamomi* and *Botryosphaeria* spp. (Benic, 2014).

Symptoms

Drying of branches start from the tip and proceed to base hence called as dieback.

Common Management Practices of Nursery Diseases

- Potting media should be properly fumigated with 4% formaldehyde before use in the nursery.
- Excess soil moisture should be avoided since the fungus like *pythium* and *phytophthora* thrives on free moisture available to them.

- Cleanliness and hygiene are very important inside the mist chambers, poly tunnels and shade house. Infected tissues should not be taken inside these structures. The nursery and its surroundings should be kept neat and clean.
- Application of biofertilizers e.g. Arbuscular Mycorrhizae (AM fungi), Ectomycorrhizal fungi, *Rhizobium, Azospirillum, Phosphobacterium* etc. and biocontrol agents (*Trichoderma viride, T. harzianum, Pseudomonas fluorescence* etc) reduce/inhibit the growth of soil borne fungi. Bioagents are applied making suspension in sterilized water at the rate of 10 g of formulation per litre (108 cfu/ml) while VAM is applied at the rate of 50gm of inoculums per seedling/saplings.
- Chemical seed coating with thiram captan, metalaxyl (1gm fungicide per 500 gm of seeds) or with Bavistin 50WP or Topsin-M WP (2g/Kg)(Rathore, 2008) for seed borne pathogens and soil drenching with 0.2% of above fungicide (Singh, 2000) or 0.2% Bavistin for soil borne pathogens will be benificial (Song et. al, 2004).
- For foliar disease, spray inoculation is done on the leaf surface using many chemicals depending upon the pathogens associated with it. Carbendazim spraying (0.1%) for *Cercospora* leaf spot (Rathore, 2008) or Dithane M-45 (0.3%) or Rovarol for *Alternaria* spp. appears to be beneficial (Janardhanan, 2002).
- Powdery mildew disease can be effectively managed by alternate sprays of triadimefon at 0.1% followed by wettable sulphur at 0.3% at an interval of 12-15 days.
- Rust disease is managed by spraying mancozeb at 0.2% or zineb at 0.2% or wettable sulphur at 0.2%.
- For the control of root diseases application Ridomil was effective against the disease causing pathogens.

3 AGROFORESTRY AND PLANTATION DISEASES

AGROFORESTRY DISEASES

3.1. FOLIAR DISEASES

3.1.1. LEAF SPOT

Leaf Spot of Eucalyptus (*E. grandis* and *E. tereticornis*)

Causal Organism

Phaeoseptoria eucalypti (Mohanan 2014)

Symptoms

- First symptoms appear as purple to brownish purple amphigenous spots which were characteristically angular and marked by veins.
- The leaf spots gradually progresses upwards and late in the season, appears on younger leaves. Due to heavy infection by this time, the mature leaves show premature defoliation.
- The spots turn necrotic and minute black fruiting bodies develops on the abaxial leaf surface.
- Pycnidia produce long grayish-back tendrils which appear as brownish black wooly mass on both the leaf surfaces. Due to rain or dew, the conidia got dispersed from the tendrils and form a black layer over the leaf surface.

Management

Two applications of Bavistin (0.03%) at weekly intervals are effective in controlling the leaf infection.

3.1.2. LEAF BLIGHT

Leaf Blight of Poplar (*P. deltoids*) (Singh *et al.* 2012)

Causal Organism

Bipolaris maydis (Khan, 1999)

Symptoms

- The disease usually appears after onset of monsoon in late July. Pink to brown, pin head size spots develop on leaves (Stage-1).
- Gradually, the spots enlarge into dark brown, irregular spots, often surrounded by a chlorotic margin (Stage-2).

- In rainy or humid weather, the irregular spots coalesce to cover the leaf blade that gave blighted appearance to the entire foliage (Stage-3).
- Sometimes, the chlorotic spots were marginalized through midrib and veins giving a defined pattern of disease spread (Stage-4).
- Severely infected leaves crumble in dry weather and ultimately fall off prematurely (Stage-5).
- Necrotic lesions, sometimes developing into sunken, black spot also appear on green pedicles and shoots (Stage-6) (Fig. 11).
- Premature defoliation of the seedlings took place in short span of 3-4 days. In case of nursery, the susceptible plants collectively provided burning appearance and in case of single plant, it stood conspicuously out of its green neighbours.

Management

The disease can be effectively managed through foliar application of Dithane -M-45 and Bayleton.

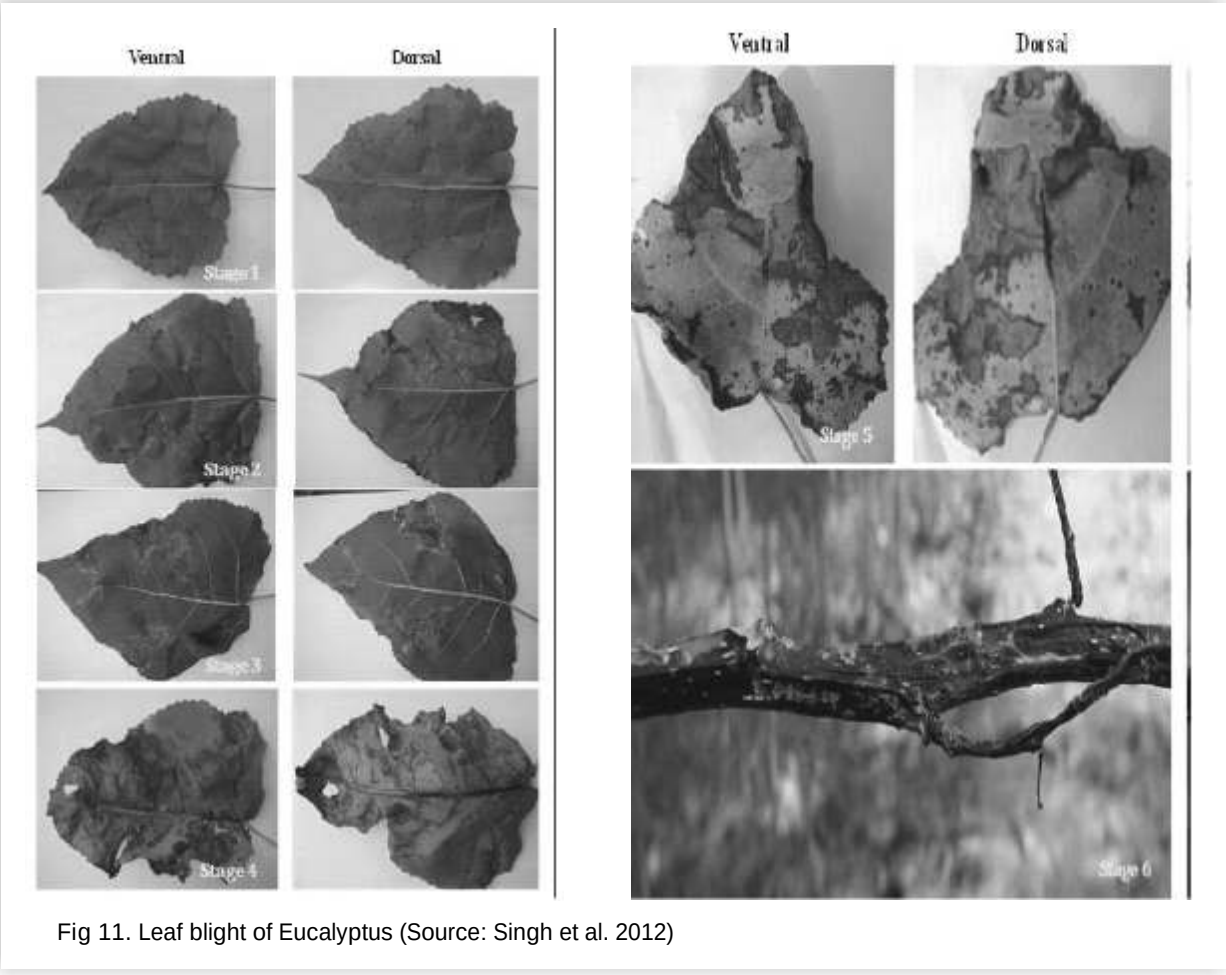


Fig 11. Leaf blight of Eucalyptus (Source: Singh et al. 2012)

Leaf and Shoot Blight of *Populus ciliata* and *P. nigra* - Kamraj and Baramulla Forest Divisions (Jammu and Kashmir State).

Causal Organism

Pollaccia elegans (Khan and Mishra 1986)

Symptoms

- At first small circular to irregular light brown to brown spots appear on young juvenile leaves.
- Later bigger spots forms as these spots enlarge and coalesce, sometimes with dark margin, and olive green to greyish green fungal mass covers the necrotic spots.
- As the disease progresses, the leaves become black, brittle and crumpled, and the shoots curved into characteristic crooks.
- Ultimately, heavy defoliation and death of young shoots occurs. Patches of fungal mass may also appear on the petioles and young shoots.

Management

The disease can be effectively managed through proper sanitation, weeding and foliar application of Bayleton - 0.1% at fortnightly intervals.

3.1.3. PINK DISEASE

Pink Disease of Eucalyptus (*E. tereticornis, E. grandis* and *E. citriodora*)

Causal Organism

Corticium salmonicolor (Seth *et al.* 1978)

Symptoms

- Stems and branch infection takes place through lenticels. The bark becomes slightly depressed in the infected region of the stem.
- In 2–3 year old plants the cambium may die all around the stem resulting in girdling of the stem and death of plant part above the girdled portion.
- In *E. tereticornis,* several epicormic branches appear below the girdled region. One such branch eventually takes the role of the leading shoot which again becomes infected in the next growing season followed by girdling and death of the new leader, formation of epicormic branches below the region of infection, and the process continues.
- The infected plants, therefore, show negative increment in height growth and may be killed eventually.
- In *E. grandis*, a few epicormic branches may develop following girdling but they do not usually develop into shoots. Affected plants are killed outright.
- If plants escape infection for the first 3 to 4 years, they show good height growth. However, such plants may later become infected on the main stem.

- Normally such infection is localized and trees are not girdled. Healing may occur resulting in longitudinal cracks on the bark due to pressure of callus growth. The cracked bark is flaked off exposing the wood from beneath and resulting in the formation of cankers.

Management

Calixin, Bordeaux and Macuprax mixed with Triton are effective in preventing *C. Salmonicolor* infection (Seth *et al.* 1978).

Note: *Corticium salmonicolor,* a polyphagous species found in the tropics as the agent of so- called "pink disease" on eucalyptus, rubber tree, tea shrubs and other cultivated plants; in India, its incidence has recently been increasing in *P. deltoides, P.* × *euramericana* and *P. yunnanens* is plantations exposed to high temperatures and humidity. It attacks on the trunk and branches and often kills the main shoot (http://www.fao.org/docrep/004/AC492E/AC492E03.htm) and can be cured by application of 0.2% Dithane-M-45 + 0.1% Bavistin spray (Singh and Singh, 1986).

3.1.4. LEAF RUST

Leaf Rust of Poplar

Causal Organism

Melampsora ciliate (Singh *et al.* 1983; Khan 1988 & 99; Rehill *et al.* 1988, Khan, 1994; Sharma *et al.* 2005)

Symptoms

- The first symptoms appears as minute roundish chlorotic spots with indistinct edges, randomly spread over the leaf abaxial side, which gradually become more evident and circumscribed while others continue to appear.
- After 2-3 days, the more developed spots give rise to small yellow to orange pustules that over the course of a few hours grow into irregular shapes after lacerating the leaf cuticle.
- These powdery formations are composed of masses of urediniospores, which are able to reinfect distant plants since they are readily dispersed by light breezes and, probably, also by the bodies of some insects.
- Very young and very old leaves are less susceptible than those of middle age, therefore uredinia are usually first noted at a certain distance from the apical leaflets, and then spread to the leaves close to them.
- As the growing season proceeds, repeated infections on the same plants result in thick uredinia over most leaves, which are thus sprinkled with a fine yellowish-orange powder that is the typical symptom of the disease.

Management

The disease can be effectively managed through-

- Copper oxychloride (0.2%)/ fortnight; Bavistin (0.1%) or combinations of calixin (0.075%) + Dithane-M-45 (0.15%) /three sprays/20 days intervals.
- 0.1% Bavistin; Nurseries/ six sprays/ fort night/ Bavistin 0.1% spray at fortnightly interval

- Cyproconazole(0.03%) or Triadimefon (0.05%) at two weeks intervals.

3.1.5. POWDERY MILDEW

Powdery Mildew of Poplar

Causal Organism

Uncinula salicis. (Singh and Singh, 1986)

Symptoms

- The symptoms of the disease appear as patches of white-gray powder, sometimes with scattered black fruit bodies of the fungus on leaf surfaces.

Management

0.2% Dithane-M-45 or any copper oxychloride fortnightly spray.

3.2. STEM DISEASES

3.2.1. STEM CANKER

Stem Canker of Eucalyptus

Causal Organism

Chrysoporthe cubensis

- The disease is characterized by the development of slightly sunken, elongate areas measuring about 15-20 cm on the trunk either at the base or above ground, just after the south-west monsoon.
- The tissue beneath the depressed bark (inner bark) was brown and apparently dead.
- As canker developed during the dry period (December-April), the bark showed vertical splitting, which increased in length and width with age. Generally, at this time gummosis was observed in a few of the cankers (Mohanan 2014).

Management

Brush on application of 1 % fungicidal paste of copper fungicide on bark and cut surface of the stumps or application of tridemorph (0.2%) can control the infection on stem (Mohanan 2014).

3.2.2. DIE BACK OF TWIGS AND BRACHES

Branch drying of *Aquilaria malaccensis*

The primary cause of the disease is nematode i.e., *Pratylancus* sp.

The fungus *Fusarium solani* makes entry through the injury in the roots caused by nematodes and resulting in rotting of roots and ultimately death of the trees.

Symptoms

- Symptoms appear as rotting of the collar region and of roots.

Fig 12. Wilt and dieback symptoms on Aquilaria malaccensis

Management

- Application of Furadon 3G at the base of the tree.
- Application of biocontrol agent *Trichoderma*

3.3. ROOT DISEASES

3.3.1. ROOT ROT

Root Rot of Poplar

Causal Organism

Ganoderma lucidum. (Harsh, 2012)

Symptoms

- The affected trees exhibit drying of branch tips when the root system is decayed by the fungus.
- Young trees of 2-3 years die fast from top downwards. The older trees may uproot during storms and heavy rains due to rotting of anchoring roots. T.

- The fruiting bodies (Fig. 13) develop during the rainy season at the base of the trees which are with a dark brown shiny stipe and reddish brown laccate cap.

Management

To break the continuity of *Ganoderma* infections in plantations mixed planting with deciduous species like semul (*Bombax ceiba*) and kanju (*Pongamia pinnata)* is recommended. Before raising poplar plantations, roots and stumps of previous crop should be removed from the plantation site. Spread of the disease in lines can be checked by increasing spacing in between plants in lines, isolating the disease patches by digging 0.7m deep and 0.3m wide trenches from the healthy plants (Singh and Singh 1986).

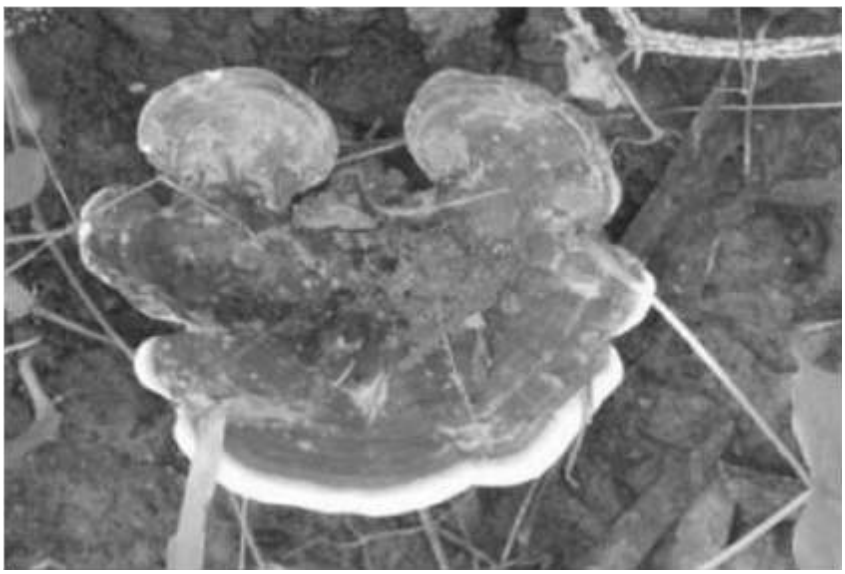


Fig 13. Fruiting Body of *G. lucidum*

3.3.2. DECLINE AND DIEBACK

Premature decline and dieback in Melia dubia

*Melia dubia, i*n parts of South India express premature decline and dieback which is a serious problem caused due to multiple factors. Some of the prime factors causing early decline of trees is drought along with improper silvi-cultural practices. Condition of soil matters a lot, in case of a hard sub- soil trees may not be very healthy therefore ascends problem of pest and diseases.

Causal Organism

Armillaria fumosa, Botryosphaeria spp. *Fusarium oxysporum, Neofusicoccum grevilleae, Leptographium* and *Septoriam usiva.*

Management

Proper site selection for plantation and use of resistant host germplasm

3.4. FOLIAR DISEASES

There are many foliar diseases of conifers as well as broad- leaved trees caused by pathogenic fungi. These diseases can extend its affect to the fruits, flowers, twigs and branches etc.

3.4.1.LEAF SPOT

Leaf Spot of Shisham (*Dalbergia sissoo*) - Jaipur and Udaipur districts of Rajasthan

Causal Organism

Curvularia affinis (Sharma et al 2011)

Symptoms

- The symptoms of the diseases appear as irregular spots those starts from the leaf margin to inwards.
- The colour of leaf spots was light reddish with dark margins and a light yellow halo surrounding the lesion.
- Light reddish spots appear on leaves which increase in size with time.

Management

The disease can be effectively managed through proper sanitation, weeding and foliar application of Bayleton - 0.1% at fortnightly interval

3.4.2.LEAF BLIGHT

Leaf Blight of Shisham (*Dalbergia sissoo*)

Causal Organism

Rhizoctonia solani

Symptoms

- The disease first appears on leaves close to the ground as water soaked grayish brown blotches which increase in size with time.
- The leaflets eventually turn brown and the infected adjoining leaflets often join together by the fungal hyphae. Leaflets or entire leaf detached prematurely but they remain clinging to the stem for a considerable period as they are joined together by the fungal hyphae.
- There is a cluster of hyphae at the base of the petiole or petiole.

Management

The disease can be effectively managed through proper sanitation, weeding and foliar application of Bayleton - 0.1% at fortnightly intervals.

Web Blight of D. sissoo

Causal Organism

Rhizoctonia solani (Mehrotra 1998).

Symptoms

- Grayish brown water soaked spots first appears on the leaf surface, which increase in size and cover the entire leaf blade.
- The distinctive feature of the disease is the presence of hyaline to brown mycelia threads running over healthy portion of the leaf blade adjacent to the invaded leaves.
- On the stem, branches, petioles and leaflets, initially the fungus produces white microsclerotia which later turns brown.
- The adjoining blightened leaves got webbed by the over-running fungal hyphae, hence the name webs blight

Management

The disease can be effectively managed through proper sanitation i.e. removal of infected seedlings and removal of weeds. Foliar application of 0.08% Bayleton at fortnightly intervals is effective (Mehrotra 1998).

Note: Besides Shisham, *Rhizoctonia solani* has been reported to cause web blight in *Bauhinia variegate, Cassia fistula* and *Populus deltoides* (Mehrotra 1998).

Needle bight of *Pinus roxburghii*

Important disease of pines nursery and during early stages of plantations.

Causal Organism

Cercoseptoria pini-densiflorae

Symptoms

- During onset of monsoons, disease first appear on lower needles and slowly spreads upwards.
- Pale green lesions appears on needles which turns grayish brown and cover entire needle with appearance of number of minute, dark fruit bodies.
- The infected needles become dry and curl around the stem. Heavy attack may cause mortality.

Management

Spray with 1% Dithane M-45 or Dithane Z-78 or 0.8% Calixin at tri-weekly intervats from the onset of monsoon.

3.4.3.LEAF RUST

Leaf Rust of Sandalwood

Causal Organism

Cephaleuros virescens Kunze

Symptoms

- Leaf rust orange to brown pustules on leaves (Fig. 14).
- Rust is commonly seen as coloured powder, composed of tiny aeciospores which land on vegetation producing pustules, or uredia, that form on the lower surfaces.
- During later spring or early summer, yellow orange or brown, hair like or ligulate structures called telia row on the leaves.

Management

Spraying of Sulphur dust or wettable sulphur

Note: Two distinctive rust fungi, *Ravenelia acaciae-arabicae* Mundk. & Thirum. and *R. evansii* Syd. & P. Syd., were found on *A. nilotica* sub sp. indica in both Tamil Nadu and Gujarat (*Shivas et al.,*2013)

Fig 14. Sandalwood red rust

Leaf and petiole rust of *D. sissoo*

Causal Organism

Maravalia achroa (Harsh 2006)

Symptoms

- Deformity and premature defoliation of younger leaves and juvenile twigs in early spring (February–March), leading to growth retardation of the plants.
- The affected parts are killed resulting in dieback and subsequent death of affected plants.
- The initial symptoms appear as yellowish-orange pustules appearing on the lower surface of the leaves and on petioles and juvenile twigs.

Management

Bavistin 0.01% found to be effective in control of disease.

3.4.4.SOOTY OR BLACK MOLD

Sooty mould fungi grow on plant exudates and honey dew secreted by insects such as aphids, whiteflies etc. Severely infected leaves shows premature defoliation in various tree species (Srivastava and Verma, 2008).

Causal Organism

Cladosporium, Aureobasidium, Antennariella, Limacinula, Scorias and *Capnodium* (en.wikipedia.org/wiki/Sooty_mold, 2014).

Management of Diseases in Plantation

- Field sanitation i.e. removal and burning of infected plant debris.
- Application of Rogor 30EC (0.05%) + Blitox (0.2%) for sooty moulds.
- Soil drenching with Dithane M-45 or Bavistin @ 0.2% for soil borne fungal pathogens which causes wiltings and rottings.
- Application of suspension of bioagents like Trichoderma viride, Trichoderma harzianum, Pseudomonas flourescence etc. @8-10g of formulations/l water.

Sooty or Black Mold of Sandalwood

Causal Organism

Mainly by Meliola species and sometimes other species like *Alternaria, Aspergillus, Cladosporium, Penicillium*

Symptoms

- The fungi can invade leaf surface causing discolouration, black point, or smudge.
- Sooty mold is a black, powdery coating adhering to the leaves caused by superficial accumulation of mycelia and sporulating fungal tissue.
- In severe cases, the trees turn completely black due to the presence of mould over the entire surface of twigs and leaves.

Fig 15. Sooty mould (Source:www.yates.com.au)

Management

- Applications of formulations of Neem oil, which is an organic broad spectrum pesticide, fungicide and miticide
- Pruning of affected branches and their prompt destruction prevents the spread of the disease
- Spraying of 2 per cent starch is found effective
- Spray of Nottasul + Metacin + Gumacasea (02.%+ 0.1% + 0.3%)
- Insecticidal soap, Dish soap, or detergent dissolved in water and sprayed on plants.

3.4.5.POWDERY MILDEW

Powdery Mildew of Salix (Willow)

Causal Organism

Erysiphe spp.

Symptoms

- Whitish-gray,
- powdery growth appears on leaves
- Premature defoliation

Management

- Scrape and remove fallen leaves

The susceptible cultivars can be sprayed with fare evident.

Fig 16. Powdery mildew

Powdery Mildew of Sandalwood

Causal Organism

Pseudoidium spp.

Symptoms

- White powdery coating on the leaves (Fig 16)
- Mycelium of fungus forms mats and appears as white, grayish white or tan coloured patches on leaves
- Fruiting bodies appear as small black or brown specks on the mycelial mats
- Mycelium of infected leaves often appears chlorotic due to decreased photosynthetic activity

Management

- Sprays of fungicides at 15 days interval recommended for effective control of the disease.
- Wettable sulphur 0.2 per cent (2 g Calixin/ lit. water)
- Tridemorph 0.1 per cent (1 ml Sulfex/ lit. water)

- Dinocap 0.1 per cent (1 ml / g Karathane/ lit. water)

3.4.6.SPIKE DISEASE

Causal Organism

Phytoplasma

Symptoms

- Shrinking and reduction in size of leaves, both length and breadth accompanied by stiffening and shortening of internodes resulting in crowning of leaves (Fig.17)
- Stunted height with reduced growth, malformation of laminae (reminiscent of mango malformation or phyllody occurring in inflorescence of plants either due to phytoplasma infestation or as a result of zinc deficiency)
- In advance stage the new leaves become smaller and show a tendency to stand stiffly which gives a spike inflorescence appearance to the entire shoot.
- Spiked plants show chlorosis of the leaves due to lower iron content.
- Plants give witches broom like appearance.
- The diseased plants do not bear any flowers/fruits or develop only abortive flowers.
- The death of taproot, inadequate production of lateral root, haustoria damage or blocking of conducting strands which impairs translocation, assimilation and transport of photosynthesis

Fig 17. Sandal spike symptoms

Management

No effective control of spike disease as so far been evolved. Attempts were made in the past to remove or kill the spiked sandalwood trees generally but arsenical poisons and also by removing diseased plants and destroying them. Plantations have to be managed and monitored by regular weeding and also preventing any growth of collateral hosts that may be a source of sandal spike infestation. As spike disease can infect sandalwood during any stage of its growth, practices to protect the plantation from sandal spike disease should be given priority. None of the measures is completely effective, but the burning of the undergrowth in affected plantations (eliminating possible carrier plants and vectors) is recommended as a cheap method of control. A clear understanding would ensure survival of the planted materials and assure anticipated yield to the growers and the stakeholders.

3.5. STEM DISEASES

3.5.1. STEM CANKER

Stem canker is one of the important diseases of the tree and posses threat to the quality timber production. Many insects and fungi are reported to cause stem canker in different host trees. A wide range of trees and shrubs suffer from canker diseases. A 'canker' is in fact a symptom of an injury often associated with an open wound that has become invaded by pathogenic microorganisms. Canker diseases kill the branches or structurally weaken a plant until the infected area breaks free. In the arid region of India, insect pests and disease studies revealed that the tree deformity pertaining to hollowness might initiate the formation of cankers in the main trunks of the trees. It was further stated that the infection occurs in the form of splitting of bark on the bole, which spreads in upward and downward direction (Ahmed, S.I (2007).

Causal Organism

Fusarium solani, F. oxysporum and *F. decemcellulare* (Lombar *et al.,* 2008) and *Acremonium strictum* and *F. roseum* (Hassan and Hassan, 2008).

Symptoms

- Cankers are generally oval to elongate, but can vary considerably in size and shape.
- Typically, they appear as localized, sunken or raised (Fig 18), slightly discolored, brown-to- reddish lesions on the bark of trunks and branches, or as injured areas on smaller twigs.
- The bark between the diseased and the healthy tissue often splits, and sometimes ooze a watery sap.
- Sometimes, the inner bark turns black and gives off a foul odor.

Fig 18. Stem Canker

- The newest leaves on affected branches are usually the first to show decline symptoms. Leaves may appear smaller than normal, pale green to yellow or brown, often curled and sparse.
- As the fungal pathogen invades bark and sapwood, the water-conducting tissues (vascular system) become blocked or dies, causing wilting and dieback to occur.
- Fungal cankers may contain fruiting bodies that appear as pinhead-sized, black or colored (red-orange on Nectria canker) raised bumps embedded in the bark.

Management of Cankers

- Pruning of the disease twigs or branches at several inches behind the infection is recommended.
- Importantly, avoiding unnecessary bark wounds restricts the entry of many pathogens that may enter through injuries.
- Between cuts, the pruning tools should be sterilized with alcohol.
- Pruning should be avoided when the bark is wet.

Note: Vajna (1986) described branch canker caused by *Botryodiplodia* spp. on *Quercus prinu*s in the USA. *Botryodiplodia theobromae* (Botryosphaeriaceae) isolates is also associated with die- back and bark canker of pear trees in Punjab, India (Shah *et.al.,* 2010), stem canker of *Jatropha curcas* in Malaysia (Sulaiman *et al.,* 2012) and of Almond in California (Chen and Morgan, 2013).

Stem Canker of Sandalwood

Causal Organism

Fusarium oxysporum

Symptoms

- Appearance of small areas of dead tissue, which grow slowly, often over years (Fig.19)

Fig 19. Sandalwood canker

Control Measures

- Avoid water logging
- Brush on application of 1 % fungicidal paste of copper fungicide on bark and cut surface of the stumps or application of tridemorph (0.2%) can control the infection on stem (Mohanan 2014).

Pitch Canker of Pines

Causal Organism

Fusarium sp.

Symptoms

- Infected tissues have excessive resin flow associated with sunken, discoloured lesions that girdle twigs, small branches, and trunks
- Diseased bark appears dark-red and the wood below is also discoloured
- Shoot and branch dieback are mostly occur from late autumn to early spring.
- Wounds by insect, weather and mechanical injuries are important infection courts.

Management

- Pruning and removal infected parts on the appearance of symptoms.
- Cuts should be made several inches below the infected part.
- Avoid unnecessary wounding to trees.

3.5.2. HEART ROT

Heart Rot causes progressive decay and, therefore, the volume of decay increases in the tree and in the stand with age. Furthermore, diseased trees constitute a source of infection to the healthy tree. Early detection of decayed trees in the forest is, therefore, necessary do that the maximum timber may be salvaged from them and forest may be protected from excessive decay loss.

Causal Organism

Fomes caryophylli, Fomes fastuosus, Fomes pini, Fomes senex, Fomes badius, Ganoderma applanatum, Hymenochaete rubiginosa, Trametes incerta, Polyporus gilvus and *Polyporus glomeratus* etc.

Symptoms

- Presence of fungal fruiting body of heart rot fungi on the tree is a sure indication of decay.
- Cylindrical core of soft punky tissue of the wood decayed by the fungus i.e. Punk knots.
- Swollen knots are formed as living wood tries to grow over the infected knots.
- Swelling of the boles in the region of decay.
- Opening and scars may indicate former infection courts.

Management

- Avoid any injury to the trees specially fire injury as these serve as infection courts.
- Timely thinning and improvement felling to remove diseased, forked, malformed and injured trees.

Spongy rot of Acacia Nilotica

Causal Organism

Fomes badius

Management

Removal of infected trees and sporophores, and improved soil aeration provide some protection.

Heart Rot of Pinus wallichiana

The incidence is higher in high rainfall areas (100 cm and above) in outer Himalayas but gradually diminishes with decrease in rainfall in the inner ranges of Himalayas.

Causal Organism

Fomes pini

Management

The practice of lopping of the branches should be prohibited or controlled to minimize the injuries through which infection takes place.

3.5.3. BLISTER BARK

Blister Bark of Casuarina equisetifolia

Causal Organism

Trichosporium vesiculosum

Symptoms

Foliage yellowing, rapid wilting, desiccation. Disease can be recognized by firm raised blistering of bark (Fig. 20), varying in size and shape, join together lengthwise along trunk or branches on some dead trees. Black, sooty spore masses formed beneath the bark often exposed on bark rupturing, peeling or flaking. Dry atmosphere prevents sporulation.

Fig 20. Blister bark diseased plantation

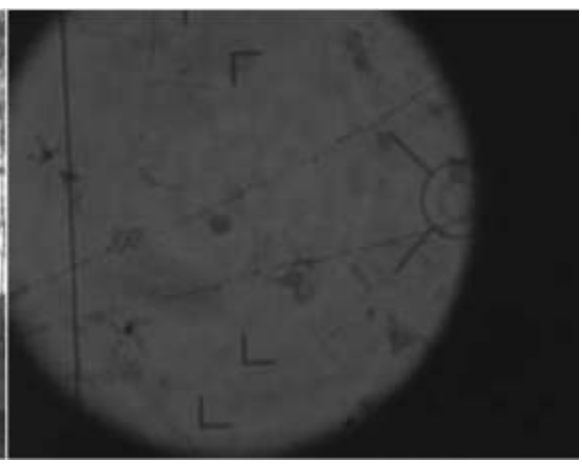


Fig 21. *Trichosporium vesiculosum*

Management

lopping and pruning should be discouraged; Trenching; Removal of dead and diseased trees at the earliest; Maintaining soil pH of 6.5 to 6.8; spraying copper fungicide; Disease favored by excessive watering and congestion - Early thinning checks it to some extent; Interval of two years between felling and replanting; planting of other trees such as *Anacardium occidentale, Azadirachta indica, Pithecellobium dulce, Pongamia glabra, Sapindus laurifolius* and *Syzygium cumini,* along with *Casuarina*.

3.5.4. STEM BLISTER RUST

A. Pine (*Pinus roxburghii*)

Chir pine is susceptible to infection upto an age of about 10-15 years and develop resistance with age. The infected brances are killed and the entire tree may die in case of heavy attack.

Causal Organism

Cronartium himalayense. It is heteroecious and macrocyclic rust with pycnial and aecial stages (Fig. 22) on chir; uredial and telial stages on *Swertia* spp.

Symptoms

- Resin exudation followed by bark cracking and canker formation on branches and stem.
- Pycnia appear on bark as minute blisters of the size of pinhead followed by orange yellow aecia (around –March) in the form of larger blisters.
- Orange yellow or rusty yellow uredia developed on leaves and stems of *Swertia* spp. followed by light brown, filiform telial columns giving a felty appearance. The basidiospores produced on telia infect chor pine, thus completing the life cycle of rust.

Management

- Eradication of alternate host, *Swertia* spp. upto a distance of 300 metres from the edge of chir forest, thus breaking the life cycle of the rust. Such eradication should be continued for about three years.
- Infected pine trees may be removed to reduce the inoculum in the form of aeciospores.

3.5.5. DIE BACK OF TWIGS AND BRACHES

Die Back of Parkia

Causal Organism

Fusarium oxysporum.

Symptoms

- Symptoms appear as yellowing of leaves and die back of twigs (Fig 22-23).
- Dark necrotic lesions are noticed all over the main stems and branches. Subsequently, tree exhibit symptoms of blister bark.
- It is also noticed that affected trees develop vertical cracks and splits in the main stem.

Fig 22. Yellowing of leaves

Fig 23. Die back of twigs

Management

Painting of a mixture of Malathion 50% EC: lime powder (1:10) at the base of the affected trees was found to check further spread of the mortality.

3.6. ROOT DISEASES

The root system of the plant suffers from a number of diseases but it remains unnoticed until disease symptoms do not manifest on the above ground parts. These diseases may be parasitic i.e. originated from bacteria, fungi and nematodes etc. or may be of physiogenic origin.

3.6.1. ROOT ROT

It is generally caused by pathogens like Ganoderma lucidum, causing white root rot in conifers as well as broadleaved trees and Macrophomina phaseolina causing Charcoal root rot (Srivastava and Mishra, 1998). Both the disease has been reported from tree species such as A. nilotica, A. leucophloea, A. indica, Dalbergia sissoo (Shisham) (Bakshi, 1976), Prosopis cineraria (Khejri), Prosopis juliflora (Vilayati babool), Khair, Ailanthus, Semul, Oak, Toon, Cassia and Albizia etc.

Symptoms

- Affected tree may exhibit yellowing, wilting, or undersized leaves and dead branches.
- The tree vigor decline as decay advances in sapwood.
- Fruiting bodies appears on the lower trunk and exposed roots.

- Decay can lead to death of trees depending upon time of infection, tree vigor and environmental stresses.

Management

- Avoid damage to tree trunks and roots.
- Remove brackets when they seen on tree trunk and roots. If the plant becomes diseased, remove as much of it as possible, including the stump and roots.
- Practice mixed plantations.

Root Rot of *Dalbergia sissoo*

Causal Organism

Ganoderma lucidum.

Symptoms

Typical symptoms of root rot disease are crown die-back, reduced growth and tree death (Harsh2011).

Management

- Proper selection of site with light textured soil, adequate soil moisture and good drainage, is important for raising healthy plantations.

Fig 24. Ganoderma lucidum

- Planting should be done in blocks, preferably in mixed cropping.
- Monoculture of sissoo should be avoided to prevent the root rot from G. lucidum as a result of root contact.
- Shisham prefers to grow on the well-drained porous and sandy soils, instead of waterlogged and clayey soils; which favours disease development.
- Sanitation practices such as uprooting and removal of infected trees should be followed.

Root Rot of Sal

Causal organism

Polyporus shoreae sporophores

Symptoms

- Most of the trees show top-drying, dieback symptoms (Fig 30).
- The live but infected tree have Polyporus shoreae sporophores at the distal end of its root
- The sporophores are found to be growing on the superficial root (Fig 31).
- The cross-section of the decayed root revealed white pocket rot in the sapwood. The decay is commonly referred to as partridge rot (Fig 32).

- Sporophores were sessile or sub-stipitate, dimidiate, sometimes funnel- shaped, brittle, dry, light weight, single or imbricate; upper surface was brown to black, hymenial surface was brown to dark brown
- In some trees show epicormic branching.
- In the decayed root tissues, white to light yellow mycelia felts of the fungus are observed
- In the infected but live tree the sporophore are recorded at the distal end of the root, whereas, in dead trees the sporophores are observed in the collar region.
- Diseased trees are mostly in groups (Fig 30).
- Apparently more soil moisture and vegetation growth are observed under the trees in the affected area.

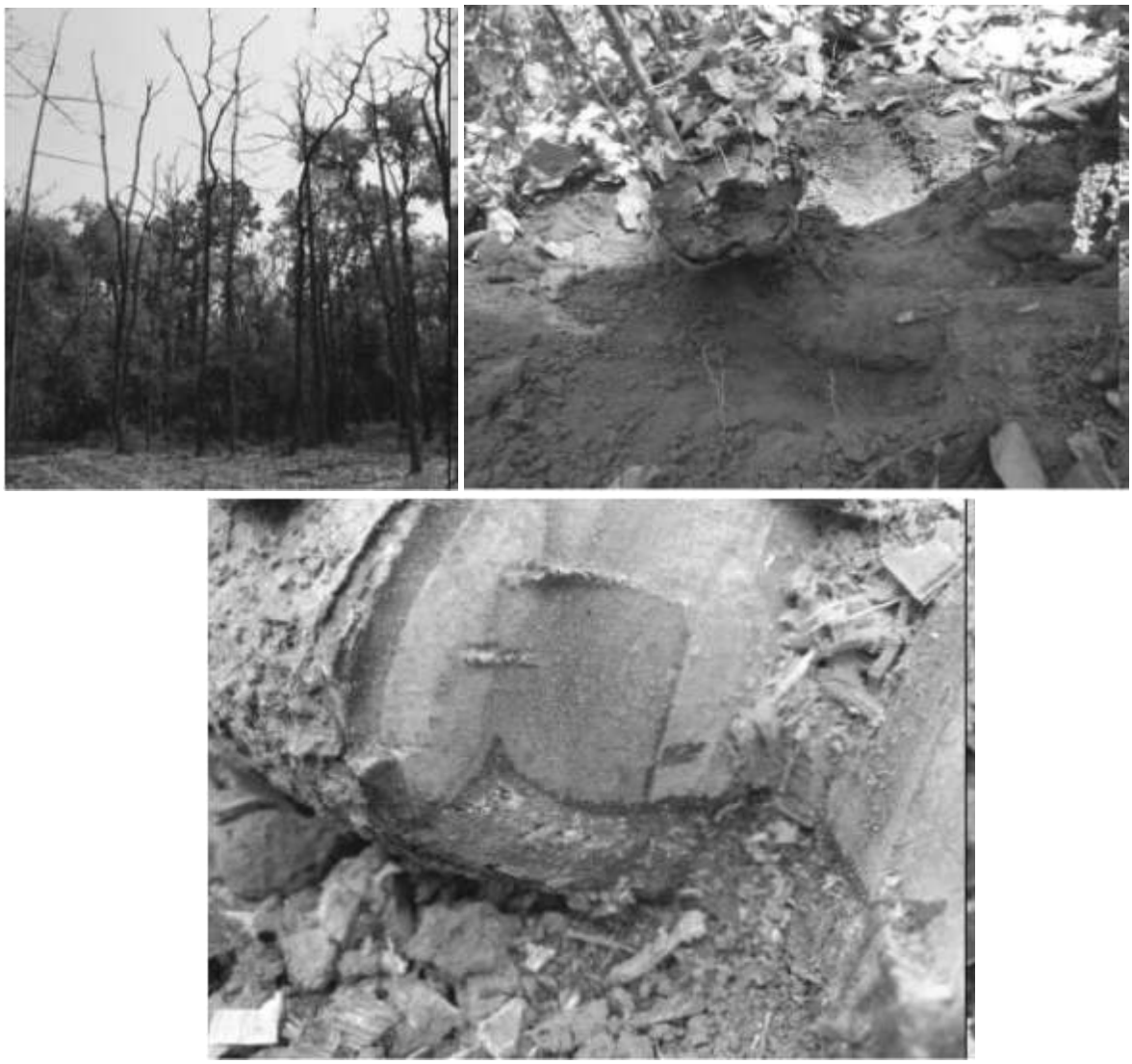


Fig 30-32. Forest nursery beds adjacent to diseased and dead Sal trees; Polyporus shoreae sporophore growing on Sal tree roots causing root rot; White pocket rot (partridge rot) in the decayed root sapwood of Sal tree

Management

- Earlier studies suggest that P. shoreae root rot in sal is economically significant in areas of high rainfall, from 2000 mm and above. In drier locations, killing of trees is slow. However, periodic monitoring and estimation of disease progression is necessary.
- In wet sal forests, control burning, a necessary silvicultural measure in such forests is an effective method of reducing soil moisture and thereby minimizing infection by the fungus. Burning also helps in checking weed growth which conserves and increase soil moisture favourable for disease development (Bakshi and Boyce 1959). Burning results in increase in Trichoderma in the soil.
- Though the pathogen is capable of infecting healthy and uninjured roots, any damage to root system may facilitate its easy entry in roots thus forming infection court. Thus human activities / interferences in and around Sal forest must be discouraged.

Root Rot of Deodar (Cedrus deodara)

In the natural forests, the pathogen exists in endemic form and the disease spreads in localized patches through root contacts or rhizomorphs. The disease is dangerous in pure stands.

Armillaria mellea Root Rot

Causal organism

Armillaria mellea

Symptoms

- Yellowish brown fruit bodies develop at the base of the attacked trees.
- Thick fungal mat between the bark and wood, brown to brownish-black, flattened rhizomorphs below the bark and fluorescent character of the decayed wood in the dark.
- Brown foliage, stunted growth, pitch oozing from base of tree and dieback.
- The fungus attacks both heartwood and sapwood and cause white fibrous rot.

Management

- Remove soil and bark from base of infested tree and allow drying to kill the mycelium.
- Cultural practices like isolation trenches may be used to further spread of infection.
- Remove infested trees and neighboring trees.
- Do not plant in infested sites.
- Mixed plantation should be practiced.

Annosum Root and Butt Rot of Deodar

Causal organism

Heterobasidion annosum

Symptoms

- Pereneial fruiting bodies of pathogen develop on affected plants at ground level.
- Thin fungal mat in patches between the bark and the wood, on the bark of the roots looking like splashing of lime wash and cause white rot of wood with small pockets.

Management

- By rasing mechanised plantations where stumps and residual roots are removed to eliminate the inoculaum from infected roots.
- To prevent stump colonisation, freshly cut stumps are treated with the cheicals like Creosote and Ures (20%); Sodium nitrate (10%); herbicides-Reglone and Gramoxone, conataing diquat and para-quat respectively (5.5%).

Phytophthora Root Rot of Deodar

Causal organism

Phytophthora cinnamomi. It was first time reported in Himalayan region by Singh and Lakhanpal (2000).

Symptoms

- Pale yellowing of leaves followed by defoliation
- The affected tree look appeared as destroyed by fire.
- Reduced vigor, discolored inner bark, debarking and finally death of tree.

Management

- Make sure soil is well drained
- Digging isolation tranches to check further spread of disease.
- Practice mixed plantations.
- Ridomil (metalaxyl) soil drench around root zone
- AgriFos, Fosphite, Phostrol: foliar or drench

3.6.2. WILT

Different species are associated with this disease but most common species are Fusarium oxysporum (Chavan and Dake, 2001; Russell, 1975) and Verticillium (Levin et. al., 2003; Tjamos at.al., 1991). Fusarium oxysporum has been recorded from different host species viz. D. sisso, Eucalyptus spp., Cassia siamea, A. totilis, P. juliflora and A. indica causing loss of about 20-25% in various tree species (Srivastava and Verma, 2008).

Wilt of D. sissoo

This disease is common when shisham trees are planted in stiff and clayey soil with poor drainage.

Causal organism

Fusarium solani

Symptoms

- Drying trees exhibit pale-yellow foliage, followed by defoliation, dieback, stag head and finally death of affected trees.
- The symptoms of wilt in shisham are systemic and are characterized by drooping leaves and branches due to loss of turgor.
- The leaflets gradually turn, yellow, and eventually drop off. The entire tree becomes 'thin' and light coloured, and stands out sharply in contrast to adjoining densely clothed green healthy trees (Fig 25-26).
- The nodules and slender branches on roots which characterize healthy shisham are absent on the roots of wilted trees.
- On splitting the diseased roots, the bark and the outer sapwood exhibit a well-defined, pinkish-brown, (sorghum brown, army brown, light seal brown,) stain, and though the stain is restricted in this region, it may rarely penetrate into the inner sapwood.
- The heartwood is free from the stain. The stain also progresses along the outer sapwood from the roots to the stem and, in the late stage of wilt; it may extend up to stem to about ten feet from the ground (Bakshi 1954).

Fig 25 & 26. Wilt of Shisham

Management

Raising plantations with proper selection of site having loose soil texture and good drainage avoid Fusarium wilt.

Wilt of Pine (Pinus roxburghii)

Causal organism

Fusarium sp.

Symptoms

- The needles in growing shoots become flaccid, droop down and finally dry up.
- The drying advances downwards, resulting in death of seedlings.

Management

The disease can be controlled by avoiding too dry or too wet condition of the soil. Drenching of soil with 0.1% Emisan-6 is effective to arrest further spread of disease.

Bacterial wilt of Casuarina hybrid clones (CH5) Tinidivanam, Tamilnadu

Causal organism

Ralstonia solanacearum

Symptoms

- The needles in growing shoots become flaccid, droop down and finally dry up (Fig. 27)
- The drying advances downwards, resulting in death of seedlings.

Management

Application of Micromonospora maritam, a biological control, in the root zone of infected plants @20ml/ tree (Fig. 28)

Fig 27. Wilt disease in *Casuarina* hybrid

Fig 28. Application of *Micromonospora solanacearum* at the root zone of infected clones

3.6.1. DECLINE AND DIEBACK

Dieback of Carrilia brachiata- Karnataka, India

Observation of symptoms on the infected trees and experimental analysis of the samples under laboratory conditions revealed the incidence of Neofusicoccum sp., a first report on Carallia brachiata. This particular Neofusicoccum sp. belongs to Botryospaeriaceae family, and is considered to be an important fungal pathogen associated with tree decline in forest and plantation worldwide.

Causal organism

Neofusicoccum sp.

Symptoms

- The field data were based on observations done from external symptoms of the dead tree, which actually revealed the severity of the tree decline (Fig. 29). The dead trees truly disposed symptoms of die back/tree decline.
- The morphological observation from the dead trees consists of reddish brown to black discoloration and lesions on the trunk region.
- The symptoms or the effect of diseases caused by this fungal species under naturally growing trees is very difficult to judge, however the damage have been found significant, where ever it was observed
- The countenance of disease for species of Botryosphaeriaceae is virtually completely linked with certain system of stress or non-optimal growth situations of trees

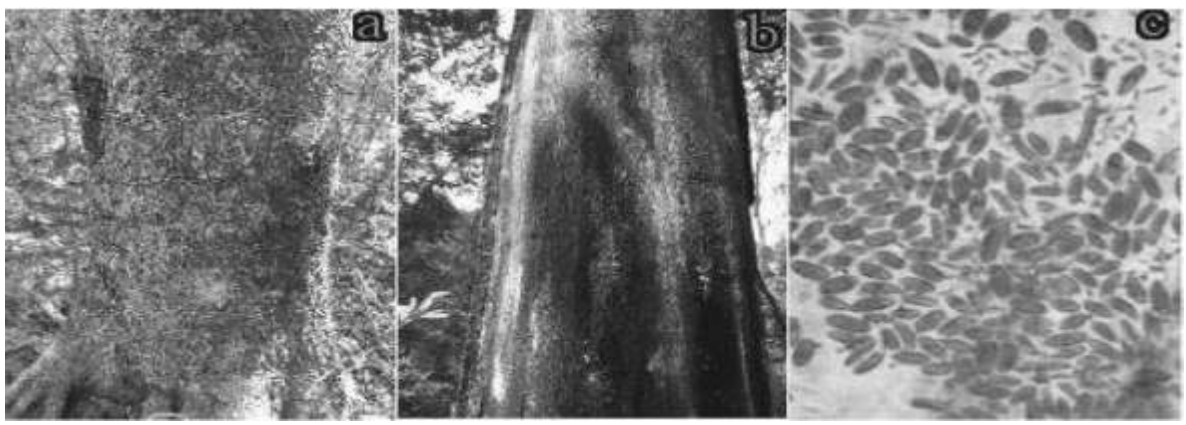


Fig 29. Symptoms on *Carallia brachiata* (a & b) and *Conidia* (c

Management

The disease can be controlled by avoiding too dry or too wet condition of the soil. Drenching of soil with 0.1% Emisan-6 is effective to arrest further spread of disease.

2

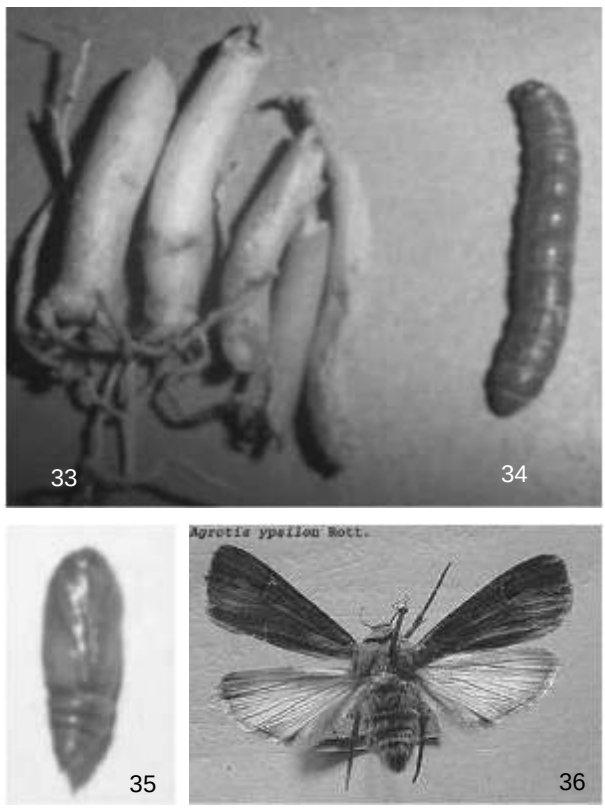
INECTS

4 INSECTS PESTS OF NURSERIES AND THEIR MANAGEMENT

4.1 INSECTS PESTS OF NURSERIES

4.1.1. CUTWORMS (Figs 33-36)

Cutworms are the larvae of certain genera of Noctuid moths (Agrotis and others). There are many species of cut-worms in India. They live on or just below the surface of the soil and damage seedlings and small plants, cutting them off near the ground level or defoliating leafy parts. The two major species found in India are *A. ipsilon* (the greasy cutworm) and A. segetum (the turnip cutworm) feed on large number of plants thus are truly polyphagous. *Agrotis ipsilon* is the most injurious in nurseries of conifers and particularly to sowings of Cedrus deodara.



Figures 33- 36. *Agrotis ipsilon*: 33, seedlings cut by the larvae of cut worm; 34, larva; 35, pupa and 36 moth of *A. ipsilon*

The types of damages done by cutworms are: a) cutting of young plants close to the soil surface (deodar, pine and other seedlings) and b) gnawing on roots or other subterranean/ parts of the plants which may result in complete destruction of the crop. Usually, there is only one complete generation per year in temperate Himalayas. Parts of this population over- winter as last-instar larvae in the soil (from August to April-May), but a portion develops into a second generation in August-September. The development of this second generation is incomplete and depends very much on prevailing weather conditions. Larvae of the second generation may over-winter as smaller stages from Sept. - October to May-June. Most pupae are found in the soil during April-May, and adults start emerging in the second half of May. The emergence period lasts from the end of May to middle of July, the later part of emergence is found in the second half of June.

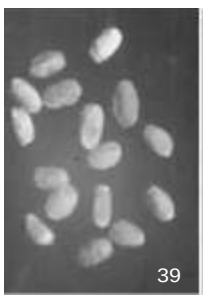
Eggs are laid in the last half of June and beginning of July. The female places egg singly on leaves (fresh or dry) or on the ground. One female may lay more than 2000 eggs. It is characteristic that a female lays a small number of eggs within a restricted area and then fly to another area. Larvae in field therefore occur in clusters.

Young larvae live on leaves and new shoots of the inner parts of plants, whereas older larvae (from 3rd instar onwards) go into the soil where they feed on roots. Sometimes, however, they may move to the surface at night where they cut plants near the root collar and may draw the fresh leaves down into the soil. Weather conditions influence populations of cutworms to a great degree. Thus "cutworm years" always seem to be correlated with dry summers, whereas these insects do not constitute a pest in years with much rain. This fact reflects the apparent high mortality of young larvae during periods of high relative humidity and rain. In the plains of India cutworms have several generations per year. During summer, however, the insects aestivate due to high temperatures. The dry climate in the spring months explains why cutworms are a constant pest on crops in the arid areas.

The best protection against cut-worms when raising plants in nurseries is to mix soil insecticides such as folithion, 10% dust @ 500 gm, or thimet 10 gm @ 200 gm in the soil, at the time of preparation of nursery beds.

4.1.2. CHAFERS (Coleoptera) (Figs 37-41)

Chafer is a serious problem in forestry. The adults of these are defoliators while the grubs are subterranean in habit and most of the year live near the roots of the seedlings and plants, feeding voraciously upon them. These insects are injurious to seedlings in nurseries. Clinteria klugi, Holotrichia serrata grubs are injurious to seedlings of teak. Anamola polita damages seedlings of Casia fistula, Holotrichia consanguinea damages seedlings of Tectona grandis, Shorea robusta and Melolontha furcicauda damages seedlings of conifers.



Figures 37 - 41.
White grub problem in nursery:
37, damaged nursery bed; 38, bed without damage;
39, eggs; 40, grub and beetle of white grub.

Chafer beetles feed on trees at dusk and do not fly by day. Eggs laid in the soil, the females often burrowing several centimeters deep for the purpose. The larva is a large (up to 5 cm) white grub of an eruciform type in the form of a „C?. The larval stage is passed in the soil near the roots of the plants on which it feeds. In very cold and in hot dry weather the grubs descend to the deeper layers of the soil, in wet and cool weather they come within a few centimeter of the surface, but do not leave it to travel above ground. Cockchafer grubs are frequently most injurious in nursery beds, especially in the richer soils. Seedlings are killed by the destruction of the rootlets or removal of bark of the tap root. In the sub-tropical plains the life cycle is normally annual with a larval period of 8 to 10 months; in the mountains above 2000 meters the life cycle lasts for 2 years.

As a control measure, the nursery beds have to be prepared before May-June, i.e., the swarming time of chafers. Sowings of autumn or winter should be done at a time when the beetles are not on the wing so that they may not lay eggs into the beds. The surface of the beds should be covered with sand in advance of swarming time of beetles.

It is inadvisable to weed during the flight period as disturbance of the surface soil invites oviposition. Folithion, 10% dust @ 500 gm, or Thimet 10 gm @ 200 gm or Furadon 3 gm @ 300 gm per 102 m. When mixed mechanically into the soil at the time of seed bed preparation gives effective control. White grubs in teak nursery, can be controlled by applying 200 gm thimet 10 G per bed (10 mx1m) if applied in split dosages, half at the time of sowing and rest after one month of germination.

4.1.3. CRICKETS (ORTHOPTERA)

The crickets Brachytrypes portentosus feed on young seedlings and low shoots, cutting them off at night and dragging the pieces into the tunnel for feeding.

The greatest damage is done in March, April and September. It is injurious in nurseries of *Casuarina* spp. *Dalbergia* spp., *Eucalyptus* spp. and *Tectona grandis*. The attack of crickets is comparatively more in nurseries with sandy soil.

4.1.4. GRASSHOPPERS (ORTHOPTERA) (FIG.42)

Grass hoppers (*Aularches miliaris*) also defoliate the nursery plants. The leaf stock and edges of leaves are nibbled or ragged so that more foliage falls to the ground than eaten. The tree species, which are commonly attacked, include *Tectona grandis*, *Artocarpus* spp., *Erythrina* Spp. for controlling hoppers, foliage spray of 0.5% folithion/malathion will give effective control.

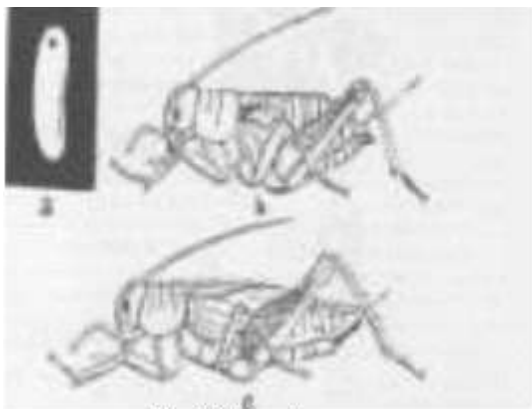


Fig 42. Grasshoppers.

4.1.5. TERMITES (ISOPTERA) (FIGS 43-52)

Common termites, Microcerotermes minor, Odontotermes feae, O. microdentatus, O. parvidens etc. are problem in many nurseries. They may be

controlled by incorporating thiodon or dursban in potting soil or nursery soil at the rate of 300 gm of 1% dust per cubic meter of the soil. Plants in boxes or pots can be raised slightly off the ground and Folithion dusted underneath periodically. As a remedial measure chlorpyriphos or endosulfan 0.1%-0.2% may be used. In one bed (10x1m) 50 litres of emulsion in water should be applied to kill termites.

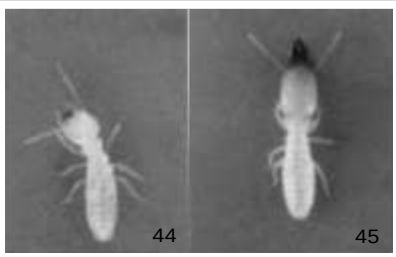
4.1.6. DEFOLIATORS (COLEOPTERA, LEPIDOPTERA)

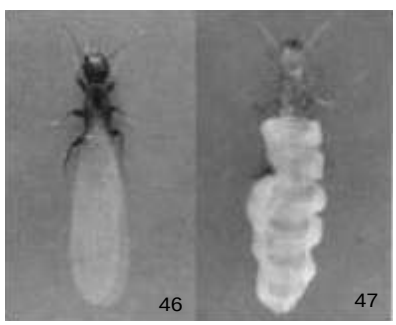
Lepidopterous and coleopterous defoliators of nursery plants are generally the same which attack mature trees and cause considerable damage to nursery plants. Foliage spray of 0.001-0.002% cypermethrin or 0.1 – 0.2% fenitrothion will give effective foliage protection to the nursery plants from defoliators. Application of insecticides may be done at monthly interval.

4.1.7. NEMATODES

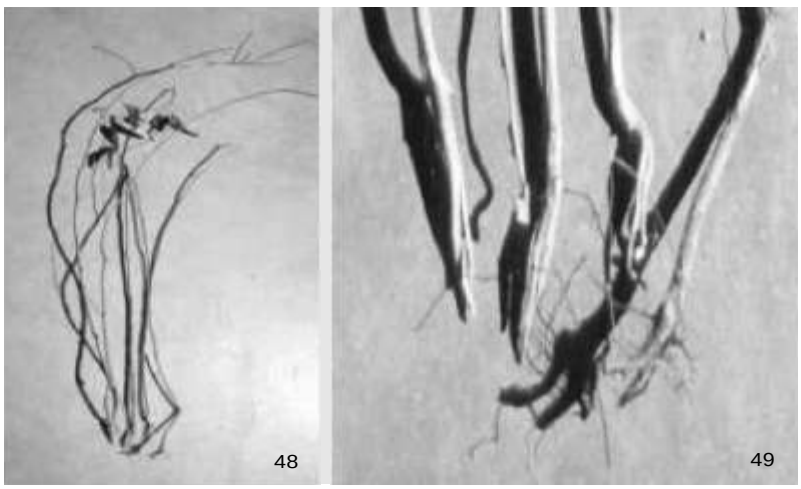
Several hundred species of nematodes are known to attack plants in nurseries. They are root knot nematodes, cyst nematodes, stunt nematodes, spiral nemotodes and digger nemotodes. There are two methods of nematode control-cultural practices including cultivation of namatode resistant varieties and soil treatment with nematicides. Soil fumigants are always most effective in order to remove nematodes. In the process of chemical treatment vapour of chemical spreads out and kills nematodes, most of which are normally distributed down to a depth of 30-40 cm. Nematicides such as chloropicrin, D.D. mixture 1,2-Dichloropropane with 1,3-Dichloropropene (Dichloropropylene, dichloropropane), D.B.C.P. (dibromochloropropane), vapam, nemagon, aldicarb, thimet carbafuron can be used for sterilizing the soil before sowing and planting. D.D. mixture is normally injected 20 cm deep in soil at 30 gm interval. 2 to 3 ml chemical per injection is applied.

4.2 TERMITES AND THEIR MANAGEMENT





Figures 43 - 47. Termites: 43, mound; 44, worker; 45, soldier; 46, reproductive alate and 47, queen.



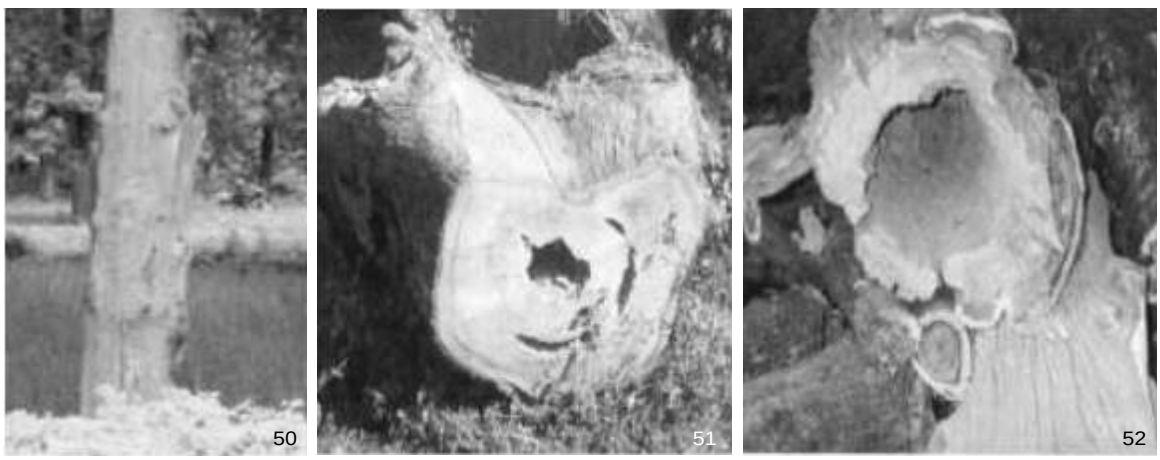
Figures 48 - 49. Damage to young eucalyptus plants by termites: 48, dead plants with roots girdled and eaten and 49, close up of the root showing damage.

It is a known fact that many afforestation programmes, at times, suffer total failures due to insect problems. Termites in particular have posed a major problem to forest nurseries and plantations. The subterranean termites move to and fro from the underground colonies through their galleries and damage the nursery plants and bark of the standing tress. The damage to living tissues is, by and large, limited only to the outer portion of the tree. Though very rare but whenever and wherever they have assumed pest status, they have caused havoc and have incurred serious losses. Termite damage is not very alarming in the older trees.

4.2.1. Termite damage in forest nurseries

In the well managed nurseries, the problem of termite damage is negligible, but at times, it becomes a serious problem, resulting in mortality of nursery plants. The critical period during which most termite damage occurs is 4 - 6 months after planting. The damage becomes prominent during scarcity of water. In nurseries usually, termite attack is noticed only when the seedlings are weak due to some earlier infestation or infection or scarcity of water. The mortality of the plants occur as a combined action of more than one factor, and the termites only hasten the death of the plant.

4.2.2. Termite damage in Forest trees



Figures 50 - 52. Damage to trees by termites: 50, mud galleries on the outer surface of tree; 51 and 52, heart wood hollowed by termite

In the growing trees, the termites attack only the outer dead bark and are mostly restricted to the dead portions. The worker termites eat away thin layers of the bark surface. The attack usually under earthen galleries which covers the bark and under which workers and soldiers travel to and fro from the ground connection leading to sometimes to tree branches or inside the trunk through wood scars of branches and freedom heart wood. Such type of damage causes hollowness in the large trees. However, by and large, damage is limited to a part of the tree. As a rule, it is only in weak trees that the subterranean termites extend their operations to sapwood.

Nature of damage:

(a) Most termite damage young plantations immediately after planting up to one year, is by and large, a primary causal factor. Here, the tap root is ring barked after feeding on secondary hosts, which is completely eaten up followed by wilting and drooping of tender leaves, and ultimate death of the seedlings or young plants. The attacked plant can be easily pulled out from the ground or falls down automatically in due damage. This is a most common cause of mortality during the first year of planting.

(b) When the seedlings or young plants become debilitated due to drought, fungal pathogens or other unfavorable factors, especially during summer months, the seedlings or the transplants are vulnerable to termite attack. This is considered as a secondary cause responsible for the mortality. In such cases, the young plants exhibit evidence of damage partially by other factors and partially by root injury caused by termites.

4.2.3. Management of termites:

Control of termites in the forest nurseries

Treatment of nursery beds: For protection of nursery beds, it must be treated before the seeds are

sown. Mix folition 10% dust in soil. Spray 0.2% water suspension of Chlorpyriphos at the rate of five litres per sq. meter area.

The insecticide is sprayed in the nursery beds few days before sowing. For preparation of the insecticidal solution, add 1 liter of chlorpyriphos 20EC in 125 litres of water and mix it thoroughly with a stick. Drench the nursery bed of 12m x 1.2m size (40? x 4?) with 125 litres of the chloripyriphos solution using the sprinkler or common fountain bucket.

Control of termites after the attack has been noticed (Post planting treatment): Pre-planting treatment is always recommended as it is more effective and economical. In the areas where the termite infestations are severe, post planting treatment do not field good results and by the time termite attack is noticed it is too late to save the affected seedlings. However, after inspection of the planting area, dead plants are removed and replaced with healthy seedlings. Make a few holes about 10-15 cm deep around each seedling and pour half liter of 0.3% of chlorpyriphos or 0.2% of Endosulfan.

Control of termites attacking standing trees (bark feeding termites):

In the plantations or roadside avenue trees, standing trees in the agro-forestry plantations, it is a common sight to see the muddy plasters or the eastern galleries all over the lower portion of the stem. Pre planting treatment (treatment of planting pit)

Control in older trees

In areas of high termite activity, where the damage is very extensive and is likely to affect the growth, chemical treatment may be carried out as follows:

Soil treatment: One to two liter of insecticidal conclusion of 0.2% Chlorpyriphos may be applied by digging a trench encircling the base of the tree.

Bark treatment: To prevent the termite attack on the bark or the outer portion of the tree trunk, brush painting with 0.2% Chlorpyriphos or endosulfan or may be done after scrapping off the earthen plaster or galleries after treatment at the base of the tree.

Control of termite mounds: Mounds are permanent abodes of these species where they multiply and become a continuous source of termite attack to the plantations. Complete destruction of a mound colony is quickly and economically achieved by making a few holes in the mound and pouring solution of the insecticide by means of a bucket and a large mouthed funnel. It takes about a week for the complete killing of the entire mound colony. Another most effective method is by poisoning the mounds with Aluminum Phosphoric tablets. Two to four tablets should be placed in 1 meter mound and close all the openings with wet mud. The termites will die due to fumigant action (Mound poisoning).

The average annual productivity of wood per ha. in India has been worked out at 0.7 cubic meter which is much less than the world average of 2.1 cubic meter. The average potential productivity of Indian forests has been estimated at 6 cubic meters per ha. per annum. Concerted efforts are made to raise large-scale plantations to bridge this gap between the potential and realized productivity.

5 INSECT PESTS OF AGROFORESTRY AND PLANTATION SPECIES

5.1. AGAR/XANCHI (*Aquilaria malaccensis*)

5.1.1. Defoliator - *Heortia vitessoides* (Figs 53-56)

Figures 53 – 56. *Aquilaria malaccensis* defoliation by *Heortia vitessoides*: 53, healthy plantation; 54, defoliated plant; 55, young larvae and 56, mature larvae of *H. vitessoides*

Heortia vitessoides, A leaf-eating caterpillar is the most destructive pest for agar plantation. It causes menace to the plantations twice in a year being first in May- June and second in August- September, by complete defoliation of agar trees. The intensity of attack during the months of March- April (drier season) is more as compared to the months of July- August (rainy season). Agar trees grown in open condition are more prone to this pest as compared to the trees under shade.

Management: Hand collection and destruction of caterpillars while in clusters. Severe infected site should be treated with an extra dose of nitrogenous fertilizer to boost up the growth of the infected trees.

Bio-pesticides such as neem extract can be sprayed in 7- 14 days interval. Besides, the natural enemies such as birds, frogs etc. should be encouraged to control this pest.

5.2. ANJAN (*Hardwicke binate*)

5.2.1. Defoliator- *Enarmonia palamedes*

Infestation period of insect is June-September. Larvae feed on leaves.

Management: Spraying Carbaryl 0.01% i.e. 2 ml wettable powder in 1 Lt. water is effective to kill this pest.

5.3. AONLA (*Emblica officinalis*)

5.3.1 Shoot gall insect- *Betousa stylophora*

Infestation period of insect is June-October. Twigs/shoots swell and form galls.

Management: Foliar spraying of 0.04% monocrotophos i.e. 1.1 ml /Lt. water in June-August at 15 days interval.

5.3.2. Semilooper- *Ophiusa (Achaea) janata*

Infestation period of insect is July-October. Larvae feed on leaves of seedlings.

Management: Foliar spraying of carbaryl 0.2% i.e. 4 gm powder/Lt of water or phosphamidon 0.05% i.e. 0.6 ml /Lt. of water kills the larvae.

5.3.3. Bark eating caterpillar- *Indarbela quadrinotata* (Figs 57-58)

Infestation period of insect is May-July. Larva bores a short tunnel down wards into the wood. This tunnel is used as a shelter tunnel during the day hours. At night the larva comes out through this shelter tunnel to feed upon the outer surface of the bark. A silken roofed path from shelter tunnel to the place of feeding is constructed by each larva.

Management: Removal of excreta web and insert into holes linen swabs of cotton wools socked in 0.03% Dichlorvos and seal the holes with mud. Combination of Cleistanthus collinus + cow urine + vermiwash 10% was found to be most effective. Varieties – Anand-1, Hatizola, Kanchan, Francis, Chakaiya, NA-7 found to be least preferred by this pest.

Figures 57 – 58. Damage by bark eating caterpillar: 57, Larva hidden inside a crevice in the dead wood at the point of pruned branch and 58, feeding tunnels made up of silken threads and it own frass by the larvae

5.3.4. Defoliator- *Selepa celtis*

Infestation period of insect is July-October. Larvae feed on leaves from tip of a branch. Management: Spraying of monocrotophos 0.04% i.e. 1.1 ml /Lt. water is effective.

5.3.5 Defoliator- *Spilosoma (Diacrisia) oblique*

Infestation period of insect is July-October. Larvae feed on leaves of seedlings.

Management: Foliar spraying of carbaryl 0.2% i.e. 4 gm power/Lt. of water or phosphamidon

0.05% i.e. 0.6 ml /Lt. of water or monocrotophos 0.05% i.e. 1.4 ml insecticide/Lt. water kills the larvae.

5.4. BABUL (Acacia nilotica)

5.4.1. Defoliator- Heliothis armigera

Infestation period of insect is July-October. Larvae feed on leaves.

Management: Spraying of carbaryl 0.1% i.e. 2 gm wettable power/Lt. of water is effective.

5.4.2. Caster semilooper- Ophiusa (Achaea) janata

Infestation period of insect is July-October. Larvae feed on leaves of seedlings.

Management: Foliar spraying of phosphamidon 0.05% i.e. 0.6 ml/Lt. of water kills the larvae.

5.4.3. Defoliator- *Rhesala* spp.

Infestation period of insect is July-October. Larvae feed on leaves by binding them with silk. Management: Foliar spraying of malathion 0.05% i.e. 1 ml/Lt. of water kills the larvae.

5.4.4. Cutworm- *Agrotis ipsilon*

Infestation period of insect is July-September. Larvae cut young seedlings.

Management: Flooding the nursery beds for at least 2-3 hrs. Dusting wood-ash on nursery beds should be done whenever the symptoms are seen. Soil mixing 5% malathion @ 60 kg/ha should be done.

5.5. BAMBOOS

Bamboo in India is damaged by more than 150 insects. Out of this more than 100 species of insects feed on green standing bamboo, majority of these insects are the sap suckers. But only one sapsucker, Oregma bambusae causes outbreaks. Other groups of insects are of defoliators Algedonia (Pyrausta) coclesalis causes frequent outbreaks while among culm borer Estigmena chinensis is a major pest. The felled bamboo or bamboo in use is severely damaged by the *ghoon borers Dinoderus brives, D. ocellaris* and *D. minutus*, particularly in bamboo depots. The cumulative attack of all these insects causes heavy losses in the quantity and quality of bamboo grown in India.

5.5.1. Seed insects of bamboo

Ochrophara montana (Hemiptera; Pentatomidae) is a major pest of bamboo seed. During gregarious flowering of bamboo of all the species, the nymphs and adults of this insect suck the sap of developing seed resulting in infertile seed production. The adult buds and nymphs are brought to the ground by smoke. On ground these may either be killed by the spray of 0.002% cypermethrin or destroyed mechanically. Sitotroga cerealella (Lepidoptera; Gelechidae) is one of the serious pest of stored grains and also cause 100% loss of stored bamboo seed.

Management: The insect can be controlled by closed space fumigation of attacked seed using 6 ml. Carbon disulphide per 100 kg. seed kept for 48 hrs.

5.5.2. Insects of bamboo nursery

Young seedlings of bamboo are killed by the larvae of *Agrotis ipsilon* (Lepidotera; Noctuidae)

while old seedlings which have developed rhizomes are damaged by chafer groubs, Holotrichia serrata. The attack of termite *Odontotermes* spp. and *Microtermes* sp. is very common in bamboo nurseries

Management: The cut worms and chafer grubs can be controlled in the nurseries by the application of

thimet at the rate of 200g. per bed. Termites can be controlled by the application of endosulfan of chlorpyriphos 0.2% in water. Fifty liters of emulsion per bed should be applied.

5.5.3. Green culm borers

There are many culm bores which damage young or old culms. Important among them are Cyrtotrachelus dux, C. longimanus, Myocalandra exarata (Coleoptera; Curculionidae) Argyroploce paragramma (Lepidoptera : Encosmidae), Chelyophora ceratatina (Diptera; Trypetidae) and Estigmina chinensis (Coleoptera; Chrysomelidae). Among above mentioned insects, Cyrtotrachelus spp. And Estigmina chinensis causes maximum damage.

Management: Congestion of clump should be avoided by way of removing culms at regular intervals by horse shoe shape thinning method. This will reduce the incidence of these borers. Internodal injection of 0.02% Dimethonate will kill the existing attack of these bores. The injection should be applied at the middle of the basal internode. 20-25 ml emulsion may be injected per culm. The application of insecticide should be done during monsoon when the larval activity of these borers is maximum.

5.5.4. Defoliators

There are many defoliators damaging leaves of different species of bamboo. Among the

lepidopteran defoliator important are Algedonia (Pyrauta) coclesalis, Algidinia (Pyrausta) bambusivora and Massepha absolutalis (Pyralidae). Among the orthopteran defoliators, Hieroglyphus banian, Poecilocerus pictus and Schistocerca gregaria are damaging the foliage of bamboo. Algedonia coclesalis is a major defoliator (leaf roller) of bamboos particularly those with broader leaves together with Algidonia bambucivora Pionea flavofimbriata and Massepha absolutalis are also leaf roller of minor importance. Out breaks of Algedonia coclesalis are very common in bamboo plantation/forests and even nurseries. Dendrocalamus strictus is most susceptible for the attack of *A. coclusalis* all over India.

a. Greater bamboo leaf roller- Algedonia (Pyrausta) coclesalis (Lepidoptera: Pyralidae) (Figs. 59-61)

Distribution: Leaf roller distributed throughout India and southeast Asia

Hosts: *Arundinaria* sp., *Bambusa vulgaris, Bambusa nutuns, Cephalostachyum pergracile. Dendrocalamus strictus, D. giganteus, D. latiflorus, Phyllostachys pubescens, P. viridis* and *Schistostachyumper gracile.*

Outbreaks of this defoliator occur regularly in the bamboo forest/plantations all over India. In nurseries the outbreak may kill the plants. Eggs are laid on the leaf buds of bamboo. Larva on hatching starts rolling the leaves. The young larvae feed on the upper leaf tissue and skeletonize numerous small irregular areas in the leaf blades or make small punctures on the leaves. The larvae web the leaf into a roll and feed inside it and move from such leaf roll to another made from newer tender leaves until the larval feed period is over. Older caterpillars roll several adjoining leaves and feed on the inner whorl of the leaves and the space inside is filled with frass mixed with silk. It has three to four generations per year and larval stage included seven to eight instars. Normally the attack of this insect is kept under check by tachinid and ichneumonid parasitoids and carabid and mantid predators.

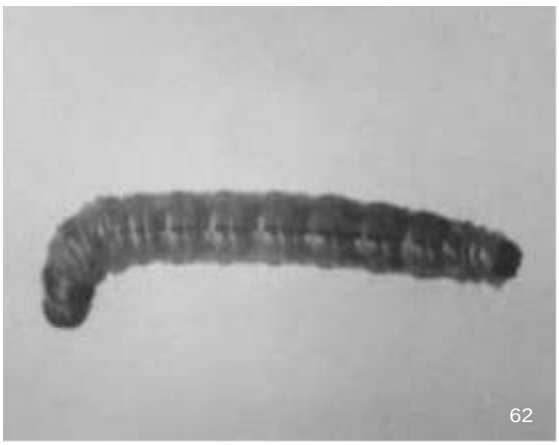
Figures 59–61. Greater bamboo leaf roller- *Algedonia (Pyrausta) coclesalis*: 59, bamboo leaf rolls; 60, larva and 61, moth

b Lesser bamboo leaf roller - *Algedonia (Pyrausta) bambucivora* (Lepidoptera: Pyralidae) (Figs 62-63)

It is a leaf roller of bamboo. The species is injuries in bamboo forest of Northwest Himalaya specially in Punjab during July-Oct. Eggs are deposited in masses of 6 to 40. Larva feeds between the rolled up leaves. Pupates in a cocoon made inside a roll. Attacked bamboo species are *Bambusa nutans, B. vulgaris, Cephalostachyum pergracile, Dendrocalamus strictus, D. giganteus,* and *Schistostachyumper gracile.*

Other defoliator- *Hieroglyphus banian, Massepha absolutalis, Poecilocerus pictus, Schistocerca gregaria.*

Management: Spraying 0.01% dimethoate or monocrotophos.



Figures 62–63. Lesser bamboo leaf roller - Algedonia (Pyrausta) bambucivora: 62, larva and 63, moth

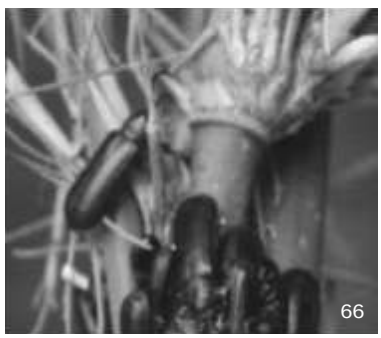
5.5.5. Shoot and Culm Borers of Bamboos

a. Hispine bamboo beetle, *Estigmena chinensis* (Coleoptera: Chrysomelidae) (Figs 64-66)

Distribution: India, Bangladesh, Myanmar and Sri Lanka.

Hosts: *B. bambos, B. burmanica, B. mutants, D. strictus, Gigantochloascor techinii* and *Schizostachyumper gracile.*

Damage and Biology: It is a major shoot and culm borer of bamboos and attacks during the initial stage of culm growth. Its attack makes the bamboo weak, deformed and unfit for any use. Hispine bamboo beetle lay eggs in batches and are concealed with chewed fragments of bamboo leaves etc. eggs are laid at



Figures 64–66. Hispine bamboo beetle: 64, bamboo showing damage; 65, larva feeding inside the node and 66, beetles feeding on leaves

intermodal area beneath culm sheath. The newly hatched larva feed by scratching tissue of the culm and leaf sheath and later excavates a small tunnel in the culm wall. bore into the wall of the internode. The larva, which is enlarged into an irregular chamber in course of time. Pupation takes place inside the tunnel. Life-cycle is annual and the beetle emerges during the next rainfall. The tunneling of the larvae degrades the culm which is sometimes bent at the point of damage. Sometimes, all the culms in a clump are attacked.

Management: Diamethoate or Monocrotophos 0.04% through internodal injection method.

b. Bamboo Weevil, *Cyrtotrachelus dux* (Coleoptera: Curculionidae) (Figs 67-70)

Figures 67–70. Bamboo Weevil, *Cyrtotrachelus dux*: 67 & 68 bamboo showing damage; 69, larva feeding inside the culm and 70, beetle

Distribution: Northern India, Bangladesh, Sri Lanka and Myanmar.

Biology and damage: Weevil bores and damage young sprouting culms of Dendrocalamus. hamiltoni, *D. stictus* and other bamboos. *C. dux* has an annual life cycle. The adults are active at the time of onset of monsoon. After mating the beetles bite small pit on young culms which are about one meter tall and feed by making holes in the tender culm shoots. It lays 3 to 4 white elliptical eggs at various places on a culm. The young grubs, which hatch after a week's time, bore the internodal wall and make irregular long galleries through the nodes and internodes to the apex of a shoot. The culm becomes very weak due to galleries and readily breaks. Larval period lasts about four weeks, after which it escapes from it pupate in soil. The pupal period lasts for nearly three weeks. Adult emerges out during monsoon.

Management: Soil around the clumps should be dug to expose the pupae formed in the soil or Spray 0.04% dimethoate on sprouting culms. Attacked culms should be treated by internodal injection of 0.2% monocrotophos.

c. *Phloeobius crassicollis* (Coleoptera: Anthribidae)

Hosts: *Bambusa bambos, Bambusa nutans, Bambusa polymorpha, Bambusa tulda, Bambusa vulgaris, Bambusa woman, Dendrocalamus calostachyus, Dendrocalamus giganteus, Dendrocalamus strictus* and *Gigantochloa atroviolacea*

It has been recorded damaging felled as well as green standing bamboos in natural stand. Longevity of male and female was 18.50 ± 0.38 and 22.60 ± 0.57 days respectively. The life cycle is annual. The beetles of *P. crassicollis* feed on the outer surface of the bamboo culms preferably at the nodes or culm sheaths. It deposits eggs near the nodes.

Management: Chlorpyriphos or Endosulphan 0.04 and 0.05% through internodal injection.

Other culm borers- *Cyrtotrachelus longimanus, Chelyophora ceratatina, Argyroploce paragramma, Myocalandra exarata*

Infestation period of insect is July-October. Leading young shoots up to 1 m height have an exit hole through which excreta comes out.

Management: Spraying 0.04% monocrotophos i.e. 1.4 ml /Lt. water on young culms during July-August at 15 days interval should be done. Internodal injection of 0.02% Dimethonate. Injection should be applied at the middle of the basal internode. 20-25 ml emulsion may be injected per culm. The application of insecticide should be done during monsoon when the larval activity of these borers is maximum. Congestion of clump should be avoided by way of removing culms at regular intervals by horse shoe shape thinning method. This will reduce the incidence of these borers.

5.5.6. Sap sucker- *Oregma bambusae*

Though sapsucker is the largest group of insect that damages bamboo but only Oregma bambusae (Homoptera; Aphidae) causes outbreaks. It is a polyphogous species feeding on more than 12 species.

Management: The sap suckers of bamboo can be controlled by spraying 0.01% dimethoate or monocrotophos.

5.5.7. Ghoon Borer- *Chlorophopus annularis, Dinoderus brives, Dinoderus minutes, Dinoderus ocellaris, Lyctus africanus*

Management: Bamboo products attacked by these bamboos are if placed in a kiln with 50-60 C temperature for 48 hrs. will kill the existing attack. As a prophylactic measure cypermethrin 0.5% in diesel should thoroughly be sprayed on the bamboo stacks. Before spray a sticker, triton @ 2ml per liter of emulsion may be added to avoid wash of the treatment. For preservation of bamboo it should be treated with 5% aqueous solution of CCA. Treatment with 3% boric acid and borax (1:1) or 3% boric acid + zinc chloride gave protection against dry bamboo borers.

5.5.8. White grubs- *Holotrichia serrata* (see Nursery pests)

Infestation period of insect is June-September. Wilting of the transplanted culms.

Management: Sandy soil should be avoided for raising seedlings. Semi decomposed FYM should not be used. Soil working should be avoided during monsoon i.e. June –July. Soil mixing of Phorate 10 G @ 200 gm/ bed (size 10 x 1 m) should be used.

5.5.9. Termite- *Microtermes* spp., *Odontotermes* spp. (See Termites Ch. 3B)

Infestation period of insect is throughout the year. Dying of saplings.

Management: Soil drenching by water emulsion of endosulfan or chlorpyriphos 0.5% (2.5ml/Lt. water.).

5.6. BEL (*Aegle marmelos*)

5.6.1. Defoliator- *Cryptocephalus* sp. (Fig. 71)

Infestation period of insect is July-September. Larvae feed in groups on leaves and defoliate the seedling. Defoliation of tender growing leaves result in drying of growing shoot tip.

Management: Leaves with aggregation of larva can be hand plucked and destroyed. Adult beetle can be collected with a sweep net and destroyed. 2% Neem oil emulsion or 5% tobacco extract can be sprayed to manage the initial stages of infestation. 0.05% monochrotophos spray can be used during severe infestation.

5.6.2. Defoliator- Citrus butterfly *Papilio demoleus* (Fig. 72)

Infestation period of insect is throughout the year. Defoliation. The larvae indiscriminately feed on leaves of Aegle and completely defoliate the whole bed in a day or two. Slow to stunted growth, loss of apical growing shoot tip resulting in development of branching and partial drying of plant.

Management: 5% tobacco extract or 2% Neem or Pungam oil spray can be given every 10 days. The presence of both the early and late stages of caterpillars on the seedlings is very conspicuous.

Therefore, hand picking and destruction of larvae to be done during monitoring till the seedlings are lifted. Alternate hosts like *Limonia acidicima*, Citrus and Curry leaf plant in the vicinity should be monitored and pruned if they sustain the pest population. If the incidence of larva in seedlings is found, as soon as the seedling put forth new tender leaves a spray of plant extract of Pongam-Neem oil extract or 5% Neem Seed Kernel Extract can be given which can be repeated after a week.. If still the problem persists, 0.06% of dimethoate or 0.05% of monocrotophos spray can be given.

5.7. CASURINA, JANGLISARU (*Casuarina equisetifolia*)

5.7.1. Sap feeding- *Ferrisia virgata* (Fig. 73)

Infestation period of insect is February-May. Partial or complete wilting and dieback of infested seedlings.

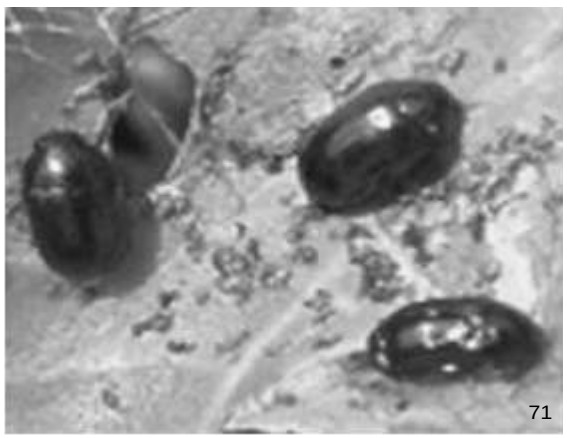


Figure 71. Bamboo Weevil, *Cryptocephalus* sp

Figure 72. Defoliator- Citrus butterfly *Papilio demoleus*

Figure 73. Sap feeding- *Ferrisia virgata*

Management: During low level infestations the scales can be scrapped off manually with a pair of sticks. Spray of 0.06% dimethoate or 0.05% methyl demeton can control the pest.

5.7.2. Sap feeding- *Icerya purchasei* (Fig. 74)

Infestation period of insect is throughout the year. Feed on the plant sap. Partial or complete wilting and dieback of infested seedlings.

Management: During low level infestations the scales can be scrapped off manually with a pair of sticks. Spray of 0.06% dimethoate or 0.05% methyl demeton can control the pest.

Figure 74. Sap feeding- *Icerya purchasei*

5.8. CHIRONJI (*Buchanania lanzan*)

5.8.1. Defoliator- *Lamida carbonifera*

Infestation period of insect is July-September. Leaves webbed with loose silk in the shelter of which grey colored larvae feed, skeletonizing & eating irregular patches.

Management: Foliar spray of monocrotophos 0.05% was found to be most effective after 3 and 7 days of treatment.

5.8.2. Stem borer- *Plocaederus obesus*

Infestation period of insect is July-October. Grub makes burrows beneath bark/tunnel in to trunks/main stem, moving upward, feeding on internal tissues. Tree shedding leaves & drying up.

Management: 10 ml solution of dichlorvos (nuvan) 0.5% showed cent per cent tree saved after 30 days of treatment.

5.9. DEODAR, PINES, FIR AND SPRUCE

5.9.1. *Pitygenus scitus* (Coleoptera : Scolytidae) (Figs 75-77)

Distribution: North-west Himalayas and Khasi Hills in India.

Host Plants: *Cedrus deodara, Picea smithiana, Pinus gerardiana, Pinus khasi, Pinus roxgurghii* and *Pinus wallichiana.*

The beetle bored into the green bark of the living branch / stem of young or old trees. The entrance

Figures75-77. Bark beetle, Pitygenus scitus; 75, Die back in deodar;76, galleries under the bark and 77, beetle


76


77

hole is marked by the thick ring of white and hardens resins. The larva of the beetle makes the galleries in the cambium stratum between the bark and the sapwood and the gallery-pattern is polygamous, a pairing chamber about 3- 4 mm wide, from which up to 5 rarely 6 mother galleries radiate to all sides in simple or bi-sinuate arcs of which the maximum length is about 15 mm. Once the grub destroys the cambium the needles start drooping and wilting. The color of needles changes from green to brownish and falls prematurely. The needles start drying from top of trees towards downside. If the attack of the beetle is severe the tree dries within 6-7 months. Period of Activity: Adult activity initiates from February and lasts still September.

Management: Dead trees should be removed and timber utilized because such trees if kept standing might serve as an epicenter of the infestation and many trees otherwise with time might lose their value due to insect borer holes in the wood. Salvage of the affected trees due to extraction should not be left in the area. It may be collected and burnt / disposed off. The infestation of stem borer can be controlled by applying Lindane @1.0% on infested stem.

5.9.2. *Ectropis deodarae* (Lepidoptera : Geometridae) (Figs 78-79)

Host Plants: Deodar; *Cedrus deodara*,

Distribution: North-west Himalayas. The moth is light gray to brownish in color, speckled and lined with black. Male is winged and capable to fly, but the female has the vestigial wings with a heavy abdomen and is able to crawl only. Adults of this univoltine defoliator start emerging in spring season (mid February) from the hibernated pupae of previous year. Population density of larvae was peaked during May and June which resulted in serious defoliation in the forest during middle of June. Almost all the larvae were transformed into pre- pupae or pupae by the end of June or early July.These pupae remained in the humus

as such for rest of the year and moths started emerging out in the spring season of the following year. During the epidemic, the infested trees had a network of silken threads on the stem, branches and under growth. As a result of insect infestation, deodar forests appeared yellowish with brownish burnt look from a distance. Because of damaged apical shoots and growing buds in seedlings stage, affected plants appeared a bushy and stunted growth. First and second instar larvae damaged only newly sprouted needles. The infested portion of the needles became yellow and changed to dark brown afterward. The growing bunch of needles showed the die back type of symptoms. The third instar larva damaged by gnawing the needles near the middle. Due to gnawing of the needle, even basal part of the needles ultimately dries and gives burnt look to the affected forest. Fourth and fifth instar larva fed variously on needles from top to base, cut bunch of needles at their base making them to fall down and consuming the whole bunch of needles. Period of activity: Adults emerge during March and lasts till June.

Figures 78-79. Deodar defoliator- *Ectropis deodarae*: 78, Defoliated deodar tree and 79, larva

Management: Application of sticky bands mixed with neem oil at breast height on the tree trunk to trap the female during April is essential. Sticky band can be prepared by heating the powdered resin (6-12 parts) and castor oil (5 parts) for 10-12 minutes and adding 3 parts of neem oil. Neem oil acted as repellent against female.

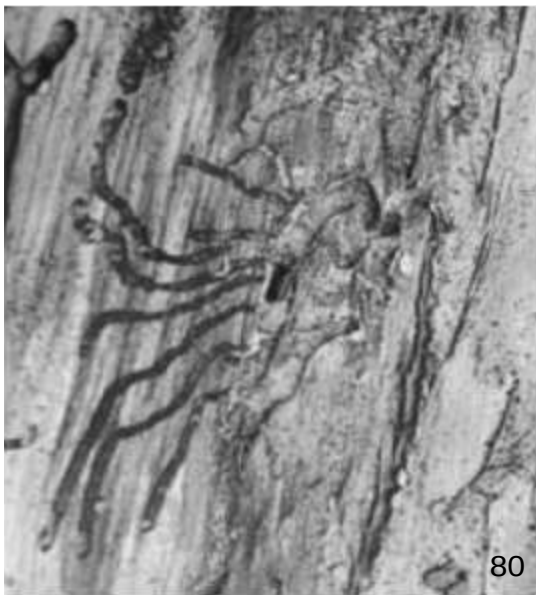
Raking of humus under the tree canopy to expose the pupae of the pest in June- July for their predation to the birds like Covus machrorhynchus and Gallus gallus.

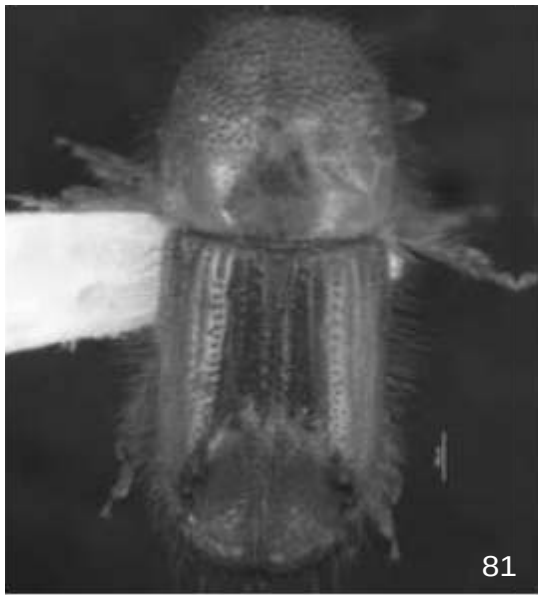
Augmentation of predator, Calosoma beesoni would help in controlling the pest in field and Wild Rose, Rosa macrophylla has been found as one of the preferred habitat of predator.

5.9.3. *Ips longifolia* (Coleoptera: Scolytidae) (Figs 80-81)

Host Plants: Cedrus deodara, Picea smithiana, Pinus gerardiana, Pinus roxburghii and Pinus wallichiana.

Distribution: This insect is classified as one of the dangerous pest of the tree. The species is polygamous and the gallery- pattern consist of an entrance tunnel running straight or obliquely through the bark to the cambium layer, one or more mother- galleries running for 5.0 or 7.5 cm vertically and joined by a small





Figures 80-81. Ips longifolia: 80, galleries and 81, beetle

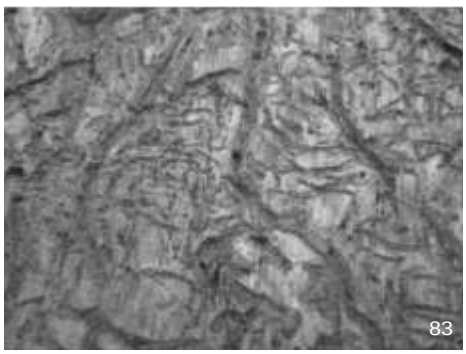
pairing chamber. Three mother-galleries in a Y shape is the commonest pattern. The larvae chiefly groove the inner bark, which is tightly packed with wood excreta. The larvae eat out galleries which are very winding and once the grub destroys the cambium the needles start drooping and wilting. The color of needles changes from green to brownish and falls prematurely. On maturing, the beetles bore straight through the bark to the outside of tree and fly away. The length of the life-cycle varies very considerably according to the climate and elevation of the forest. In the warmest localities e.g. at 750 m, the insect completes 4 generations per annum. At the highest elevation, there is only one generation a year. It is in the Pinus roxburghii forests that the insect is capable of most rapid multiplication.

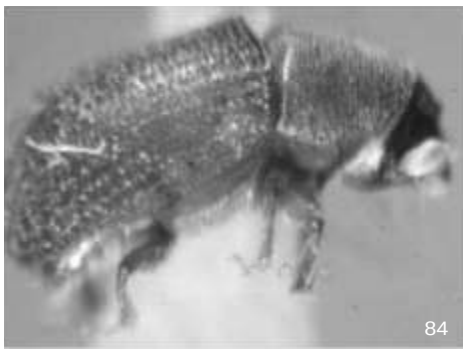
Management: The field applicability of aggregating pheromone, Ipsdienol ((s)-2-methyl-6 mehtyleneocta-2, 7-dien-4-0l) was studied with pheromones trap (Fero-TTM) and evaluated 4 level of dozes in field. A pheromone dose of 4 mg / dispenser (rubber) in Fero-TTM set up at 1.5 m height from the ground level was found to be effective to attract significantly greater number of beetles. Use of 4-5 traps per hectare for trapping the beetles was optimum for containing pest population under epidemic situation.

5.9.4. *Polygraphus longifolia* (Coleoptera: Scolytidae) (Figs 82-84)

Distribution: Northwest Himalayas and Shiwalik hills.

It is classed as one of the most formidable scolytid pest of chir pine, since it infests trees of all ages from the small seedling and sapling to the oldest tree. The male beetle bores through the thick bark of the tree, making a circular entrance hole which is usually very distinctly seen on the outside. This entrance tunnel leads to an enlarged circular pairing chamber, which is eaten out in the bark itself or in the bast. The gallery-system is polygamous and consists of small pairing chamber, 2-4 fairly straight mother-galleries running longitudinally for 5-9 cm mainly in the bark stratum and each having a few aeration holes. The egg-niches, larval galleries and pupal cells are almost entirely in the bast-stratum, consequently the sap wood surface





Figures 82-84. *Polygraphus longifolia*: 82, saw dust ejected by the beetles; 83, galleries and 84, beetle

from which the bark has been stripped shows only the tracks of mother galleries. The insect passes through three to four generations a year. The first eggs of the year laid in the trees during April, the first generation of beetles issuing towards the beginning of June. The eggs produced by these beetles produce a second generation sometime in August, which is followed by a third about the middle of October. The red and white wood is ejected by the beetle when tunneling down into the tree to prepare the pairing chamber, which either projects in a tiny cylinder from the surface of the bark or forms a little powdery mass just below it.

Management: Billets of size (80-120 cm in length and 90-110 cm gbh) of freshly felled chir- pine trees can be used for entrapping beetles on their emergence. As soon as they are full of mature larvae or of pupae, they should be barked and the bark exposed to the sun or burnt, as may be most advisable. If a tree trap is not seriously infested by the generation of beetles issuing soon after it was placed, it may be left to catch the next generation. The tree trap should be placed in the forest during April-May in the partially sunny places, not in the dense shade, as in that event the beetles will not resort to them to oviposit. For trapping, the tree which has a fair flow of sap and good moisture content (30-50 %) in the bast should be selected. Dead tree for this purpose will be useless, as the bast layer would rapidly dry and the beetles will not bore them for oviposition. They will only lay eggs in fresh sapy cambium with good moisture content Stem of infested trees can be treated with biopesticide i.e. Grownim @ 3.0 % in the month of April and August. Two treatments are sufficient to keep the population of Polygraphus longifolia under check.

5.9.5. *Dioryctria abietella* (Lepidoptera : Pyralidae)

Host Plants: *Abies pindrow, Cedrus deodara, Pinus gerardiana* and *Pinus wallichiana.*

Distribution: Western Himalayas between 1,800 - 2,700 m

The larva of this moth is primarily injurious to the cones and seed of different conifers but it also attacks the shoots of many conifers. Larva bores the cone through the scales and gradually feeds on the tender tissue of the cone for 19-28 days. The infested cones develop brown stains at the site of feeding and resin mixed brown frass remain on the cone. Ultimately the seeds become infertile. It infests the cones and seeds of different conifers. The infested cones do not develop, remain closed and small. Thus, it interferes with seed germination, adversely affecting the natural regeneration of conifers in general and causing direct economic loss in case of chilgoza pine, the only edible pine in the tribal area of inner Himalayas. The cone moth has the forewing grey mottled with black and 25-35 mm wing expanse. Egg is creamish white and become reddish brown in maturity, oval in shape The larva is about 23 mm in length when mature and reddish to greenish in appearance with black head with 5 larval instars and pupa about 10 mm, reddish brown in color. Adults appear from May-August and female lay eggs up to 60 eggs on cones and hatch within 4-7 days. The emergence of moths starts in spring and the eggs are laid on young cones. After hatching, the young larva bores tunnels through the scales and seeds destroying the later and causing the subsequent growth of the cones to be checked or distorted. Pupation occurs in papery silk cocoons in the cone or in soil from fallen cones and moths emerge from July onwards through the monsoon season and again next years in spring from hibernated pupae. Peak infestation during the month of July - September.

Management: Investigations on natural enemy complex of this pest reveled that three larval parasitoids belonging to Ichneumonidae family of order Hymenoptera e.g. Syzeuctus zanthorius (Cameron) causes up to 33 per cent parasitization of pest in pre-papal stage, Signophorus sp. and Scambus sp. being of minor occurrence (2-3%) only.

The infested cone may be fumigated with EDCT and burning the infested cones. Application of Azinphosmethyle @ 0.18% or Permethrin (0.025%) water emulsion during May-August.

5.10. JAMUN (Syzygium cumini)

5.10.1. *Euproctis fraterna, Metanastria hyrtaca, Trabala vishnou*

Infestation period of insects is July-September. Leaves eat voraciously from margins.

Management: Foliar spraying of fenitrothion 0.05% i.e. 1 ml insecticide/Lt. water is effective against these defoliators.

Figure 85. Pouch galls by *Aceria pongmiae*

5.11. KARANJ (*Pongamia pinnata*)

5.11.1. Pouch galls- *Aceria pongmiae* (Fig. 85)

Infestation period of insects is throughout the year. Eriophid mite feeding causes galls on leaves. Severe

infestation can totally disfigure the leaves resulting in stunted growth of seedlings.

Management: Hand picking of leaves during initial stages can reduce the spread of gall development to some extent. 0.06% of dimethoate or 0.076% of dicholrvos spray can be given coinciding with the new flush formation in seedlings with a repeat spray after 15 days of first application.

5.11.2. Leaf miner- *Acrocercops* spp. (Fig. 86) Infestation period of insects is June-August.

Leaf mining by the larva causes white blotches.

Premature shedding of the leaves, slow or stunted growth, loss of leaves, partial or complete drying of seedlings.

Management: Once the white patches start appearing on leaves of the seedlings, such leaves could be hand collected and destroyed by burning with debris or dried leaves. 0.06% of Dimethoate or 0.05% of Monocrotophos can be given as a prophylactic spray soon after the rain. If new leaves show the patches or blotch, spraying can be repeated after 15 days of first treatment.

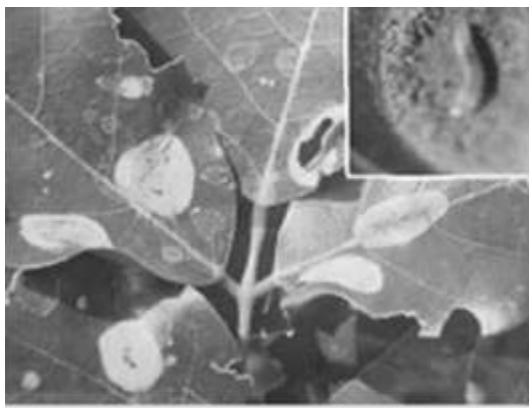


Figure 86. Leaf miner, *Acrocercops* sp.

5.11.3. Leaf folder- *Gracellaria* sp. (Fig. 87)

Infestation period of insects is April-August. Remaining inside the folded young leaf, the larvae skeletonize the leaf and ultimately the growing tender leaves dries up. Slow or stunted growth, loss of leaves, partial or complete drying of seedlings.

Management: The folded tender leaves at the apical growing tip indicate the incidence of this insect pest. After confirming the presence of the larval stages inside the leaf fold such folded leaves could be hand collected and destroyed. If the incidence of larva in seedlings is found, a spray of plant extract of Pongam or Neem oil extract or 5% Neem Seed Kernel Extract can be given. 0.076% of Dichlorvos or 0.05% of Monocrotophos can be given if the problem persists.

Figure 87. Leaf folder- *Gracellaria* sp.

5.11.4. Defoliator- *Hasora alexicalexis*

Infestation period of insects is July-September. Defoliate leaves by rolling them. Management: Foliar

spraying of 0.05% monocrotophos (i.e. 1.4 ml /Lt. water.

5.11.5. Leaf miner- *Lithocolletis virgulata*

Infestation period of insects is July-September. Blotches or blisters on leaves.

Management: Foliar spraying of 0.05% monocrotophos (i.e. 1.4 ml /Lt. water or 0.05% of phosphamidon i.e. 0.6 ml /lt. waster is suggested for its control.

5.11.6. Skipper butterfly- *Parnara mathias* (Fig. 88)

Infestation period of insects is September-October. Defoliation. Larva folds the leaves fastening the edges together with the help of silken threads produced by it and feeds from the edges. Generally a single larva is found in one fold. Newly emerged larvae feed on the tender leaves. Older larvae depend on mature leaves also. Feeding by the larvae and adults as well as the egg laying behavior of the adults cause drying of the growing apical stem region resulting in development of branching, partial or complete drying of seedlings.

Figure 88. Caterpillar of skipper butterfly- *Parnara mathias*

Management: Regular monitoring from the month of August, particularly soon after rains. 2% Pongamia oil emulsion can be sprayed once in 20 days. One round of 0.05% monocrotophos can be sprayed soon after the rain. Arrange 2-3 beds of other species in between the beds of Pongamia pinnata. Infested shoot tips can be easily located and hand picking should be done every 10 days. Pupal cases attached to dry apical leaves can also be collected and crushed. Broconid parasites parasitize the larvae. Adults of parasites emerge from the pupae of *P. alexis*. If parasitized pupae or sluggish larval stages are observed in the seedlings pesticide sprays should be delayed to enable the parasite population to survive and parasitize other larvae. . If the average number of insects per 50 seedlings increases to more than 12, pesticide spray can be initiated. 0,05% monocrotophos spray or 0.076% dicholrvos. Suitable microbial formulations of Beauveria bassiana can be applied to bring down the population.

5.12. KHMER (*Gmelina arborea*)

5.12.1. *Alcides gmelinae* (Fig. 89)

Infestation period of insects is August –September. Adult weevils gnaw out tender stem tissues and leaf petioles .Growing stem or leaf petioles breaks off and dries.

Figure 89. *Alcides gmelinae*

Management: Adults can be collected and destroyed using net. Application of 0.05% monochrotophos, or 0.076% dichlorvos. Application of 0.05% monochrotophos, or 0.076% dichlorvos.

Figure 90. *Craspedonta leayana*

5.12.2. Defoliator- *Craspedonta leayana* (=*Calopepla leayana*) (Fig. 90)

Infestation period of insects is April-January. Defoliation of trees by the larva and adults. Loss of leaves and apical shoot tip of seedlings leading to partial or complete drying.

Management: Mass of larvae aggregating under the leaves can be collected and burnt. 0.076% dichlorvos or 0.05% monocrotophos spray can be applied directing towards the under-side of the leaves. Foliar spraying of 0.05% chlorpyriphos i.e. 2.5 ml/Lt. water or 0.04% monocrotophos i.e. 1.1 ml /Lt. water or malathion 0.05% i.e. 1 ml /Lt. water.

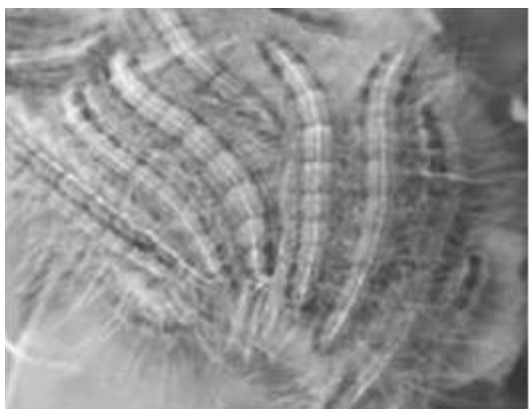


Figure 91. Defoliator- *Eupterote gemminata* larvae

5.12.3. Defoliator- *Eupterote gemminata* (Fig. 91)

Infestation period of insects is May-July Defoliation of trees by the larva. Loss of leaves and apical shoot tip leading to partial or complete drying.

Management: Mass of larvae aggregating under the leaves or bark can be collected and burnt. 0.076% dichlorvos or 0.05% monocrotophos spray can be applied directing towards the under- side of the leaves.

5.12.4. *Phyllocnistis amydropa* (Lepidoptera : Gracillariidae)

This small size insect was found to be infested on G. arborea leaf. *P. amydropa* was observed infesting to the plant from the month of June to October. Its larval stage was injurious and a newly emerged larva stars feeding on the leaves by making gallery. The greenish yellow larvae mine into the leaf and feed internally in the mine between the two layers and make irregular gallery. The pupation was observed near the edge of the leaf inside the galleries within the silken web and adult come out after maturity. Infested leaf could be identified by silver reflection of the galleries over the leaf. Adult was small about 8 mm long and 12 mm wing span; brown in color.

Management: Application of 2 % Neem oil emulsion pointed towards the under-side of the leaves can reduce the population level. 2.5 ml of dicofol per liter of water can be applied during severe infestation. Spraying of foliage with 0.05 to 0.075 % water emulsion of Dimethoate (Rogor) 2-3ml/liter or methyl demeton 20 EC 2 ml/liter or monocrotophos 36 EC 1.5 ml/liter or phosphamidon 40 SL 2ml/liter. control the pest.

5.12.5. Lace bug- Tingis beesoni (Fig. 92)

Infestation period of insects is throughout the year. Both adults and nymphs congregate on the lower surface of the foliage or at the leaf axils and feed on the sap. Drying and shedding of leaves and death of growing shoot tip resulting in development of epicromic branching. Complete defoliation, shoot turning black from tip to downwards due to sooty mould.

Management: Spraying of foliage with 0.05 to 0.075 % water emulsion of Dimethoate (Rogor) 2-3ml/liter or methyl demeton 20 EC 2 ml/liter or monocrotophos 36 EC 1.5 ml/liter or Bavistin 0.2 % (4gm./ lt.) or phosphamidon 40 SL 2ml/liter. control the pest.

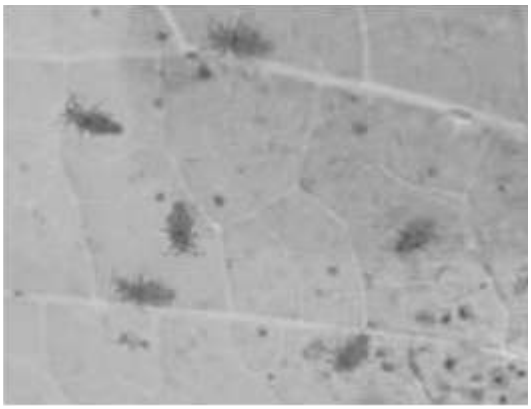


Figure 92. Lace bug- *Tingis beesoni*

5.12.6. Defoliator- *Yaminia gmelini* (Fig. 93)

Infestation period of insects is throughout the year. Adult beetles feed on the leaf margin and defoliate the trees and saplings. During severe defoliation all the leaves perforated and notched margins resulting in wilting of plants in patches. Slow growth, loss of leaves resulting in wilting of plants.

Management: Adults can be collected using sweep nets and killed. 2% Neem oil emulsion when adults are first observed in seedlings can limit the damage on leaves. 0.05% monocrotophos or 0.07% dichlorvos spray during severe defoliation.

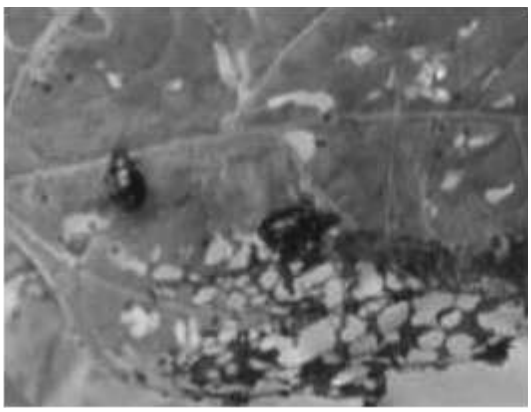


Figure 93. Defoliator- *Yaminia gmelini*

5.13. KHEJRI (*Prosopis cineraria*)

5.13.1. Root borer- *Acanthophorus serraticornis* (Fig.94)

Infestation period of insects is highest in summers.

Figure 94. Root borer- *Acanthophorus serraticornis*

5.14. MAHARUKH (*Ailanthus excelsa*)

5.14.1. *Atteva fabriciella* (Fig. 95)

Infestation period of insects is May-December. The larvae web around the tender leaves and feed from within. They also bore into the soft tissue of the terminal growing shoot tips. Partial or complete damage to

the terminal buds resulting in slow growth of seedling and development of branching.

Management: Light traps can be installed to monitor adult insects. Infested shoot tips can be easily located and larvae can be hand-picked and destroyed. Pupal cases attached to dry apical leaves can be collected and crushed. 0.05% monocrotophos spray or 0.076% dicholrvos or formothion 0.05% (1.6 ml/Lt. water) or malathion 0.05% (1 ml insecticide/Lt. water). Suitable microbial formulations of *Beauveria bassiana* can be applied to bring down the population.

Figure 95. *Atteva fabriciella* larva

5.14.2. Defoliator- *Eligma narcissus* (Fig. 96) Infestation period of insects is October-December. Larvae are a voracious feeder and feed on the leaves and defoliate the nursery bed. Complete defoliation of seedlings result in slow or retarded seedling growth.

Figure 96. *Eligma narcissus* larva

Management: Light traps can be installed to monitor adult insects. *Ailanthus malabaricus* and *Ailanthus triphysa* trees in the vicinity should be monitored since they act as alternate hosts and sustain nucleus populations and treatments like pesticide application or lopping of branches can done to reduce pest population. Hand picking and destruction of larva by immersing in a mixture water and kerosene at low level incidence of the pest. Pupal cases attached to the seedling stems can be detached and crushed. : 5% tobacco extract and 2% pungam oil can be sprayed alternatively in a gap of 15 -20 days. Suitable microbial formulations of Beauveria bassiana can be applied to bring down the population.0.05% monocrotophos spray or 0.076% dicholrvos.

5.15. MAULSARI (*Mimusops elengi*)

5.15.1. Thrips- *Arrhenothrips ramakrishnae*

Infestation period of insects is throughout the year. Gall formation in terminal young leaves. The gall formation results in twisting and curling of young leaves and the affected leaves ultimately fall. The damaged leaves are also characterized by numerous, irregular, yellowish mottled areas with total absence of chlorophyll leading to leaf drying shedding. Stunted growth of seedlings.

Management: Regular monitoring throughout the raising period. Apply 5% NSKE every 10-15 days interval. Bed arrangement alternatively with other species can be tried to reduce the spread of the pest. Characteristically folded terminal leaves can be easily located. Such leaves can be plucked every 10

days and destroyed. Suitable microbial formulations of Verticillium lecanii can be applied to bring down the population. 0.06% dimethoate or 0.01% imidacloprid or 0.076% dicholrvos can be sprayed.

5.15.2. *Nephopteryx eugraphella* (Fig. 97)

Infestation period of insects is January-December

Management: Regular monitoring throughout the raising period. Apply 2% Pungam oil every 10-15 days interval. Folded terminal leaves can be easily located and plucked every 10 days and destroyed. Suitable microbial formulations of Beauveria bassiana can be applied to bring down the population. 0.05% monochrotophos or 0.076% dichlorvos can be sprayed.

Figure 97. *Nephopteryx eugraphella* larva

5.16. Melia (*Melia dubia*)

5.16.1. Sap feeding- *Dasynus* sp. (Fig. 98)

Infestation period of insects is throughout the year. Nymphs and adults aggregate at the growing shoot tip and feed on the sap. Sap feeding by adults and nymphs result in necrosis and drying of leading shoot tip. Gummosis is also observed during certain occasions.

Management: Adults and nymphs can be collected by insect net and killed by burning with debris or dried leaves. 0.06% of Dimethoate or 0.05% of Monocrotophos can be given as a prophylactic spray. 0.02 % Cypermethrin can be used if many bugs are noticed in the plants. If new shoot tips show the patches or blotch, spraying can be repeated after 15 days of first treatment.

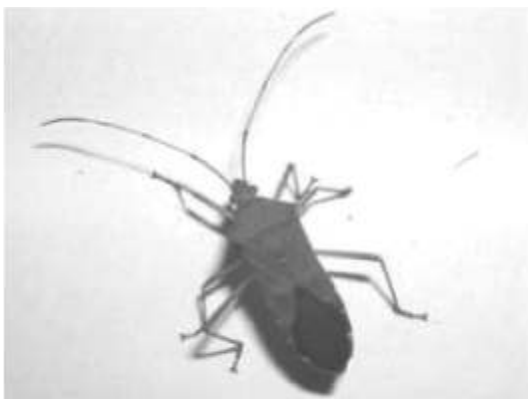


Figure 98. *Dasynus* sp.

5.16.2. Thrips- *Dolichothrips indicus* (Fig. 99)

Infestation period of insects is throughout the year. Both adults and nymphs feed on the sap and scrap off tissue of young leaves leading to twisting, curling and chlorosis of young terminal leaves. The damaged leaves are also characterized by numerous, irregular, yellowish mottled areas with total absence of chlorophyll.

Management: As a prophylactic measure regular

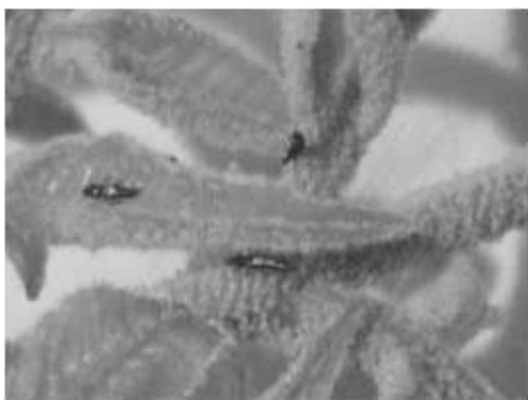


Figure 99. *Dolichothrips indicus*

monitoring throughout the raising period is required. Application of 5% NSKE every 10-15 days interval is effective. In plantations, planting different species alternatively with Melia can be tried to reduce the spread of the pest. Suitable microbial formulations of Verticillium lecanii can be applied to bring down the population. 0.06% dimethoate or 0.01% imidacloprid or 0.076% Dichlorvos can be sprayed.

5.16.3. *Parlatoria* sp. (Fig. 100)

Infestation period of insects is February to April. This scale attacks the young plants all above ground parts of the trees particularly the bark of the stem and leaves. Severity of this pest leads to drying up of the plants.

Figure 100. *Parlatoria* sp.

Management: Light traps can be installed to monitor adult insects. Infested shoot tips can be easily located and larvae can be hand-picked and destroyed. Pupal cases attached to dry apical leaves can be collected and crushed. 0.05% monocrotophos spray or 0.076% dicholrvos Suitable microbial formulations of *Beauveria bassiana* can be applied to bring down the population.

5.17. Neelgiri (*Eucalyptus* spp.)

5.17.1. Cutworms- *Agrotis ipsilon* (See nursery pests)

Infestation period of insects is June-October. Young seedlings are cut by larvae and sometimes remain thrives in beds.

Management: Flooding the nursery beds for at least 2 hrs kills the larvae. Dusting wood-ash on nursery beds should be done whenever the symptoms are seen. Soil mixing of 4% endocel dust 60 Kg/ha or application of 0.1% water emulsion of chlorpyriphos i.e. 5 ml /Lt. Nearly 50 Lt. water emulsion is required for a 10x1 m nursery bed.

5.17.2. Borer- *Celosterna scabrator* (Fig. 101) Infestation period of insects is September-march.

Grub forms tunnel in main shoots and roots.

Management: Grub should be removed from the attacked roots by cutting them from side nearly at 40 cm deep in soil. A small quantity of petrol or kerosene or 0.1% dichlorvos (nuvan) should be poured through the exposed hole and later it should be sealed with moils soil.

Figure 101. *Celosterna scabrator*

5.17.3. Gall Wasp- *Leptocybe invasa* (Fig. 102-109)

Infestation period of insects is throughout the year. Insect forms galls on leaf midrib, petioles & stem of seedlings/saplings/coppice shoots, resulting in stunting of growth.

Figures 102-109. Eucalyptus Gall Wasp- Leptocybe invasa: 102, Young heavily infested eucalyptus plant on left; 103, 104, infested nursery plants abandoned; 105, gall wasp inspecting site for oviposition; 106, freshly infested branch; 107, green galls; 108 & 109, Megastigmus sp.-A parasitoid of galls.

Management: Mix different clones for plantations. Use resistant clones. Continuous monitoring, pruning and destruction of affected shoots in nursery seedlings and saplings in plantations may contain the problem. Use light trap hanging over water trough containing few drops of kerosene for killing adults during emergence & check further egg laying. Phorate 5 gm (2 teaspoon) per polybag. Phorate 10 gm /pit. Spray Imidacloprid or monocrotophos 0.03% + 1-2 drop liquid soap monthly interval.

5.17.4 *Termites- Odontotermes* spp.

Infestation period of insects is throughout year, serious in July- August., April-May. Wilting and ultimately death of seedlings.

Management: Soil mixing 5% chlorpyriphos dust @ 40 to 60 kg/ha during June-July should be done. Soil drenching by water emulsion of chlorpyriphos 0.05% i.e. 2.5 ml /Lt. of water.

5.18. NEEM (*Azadirachta indica*)

5.18.1. Shoot borer- *Lasperasia auruntiana* (Fig. 110)

Infestation period of insects is may to June and November to December. Larva bores the shoots, defoliating terminal leaves of seedlings. The apical growing shoot develops forked branching. Slow or stunted growth, partial or complete drying of seedlings.

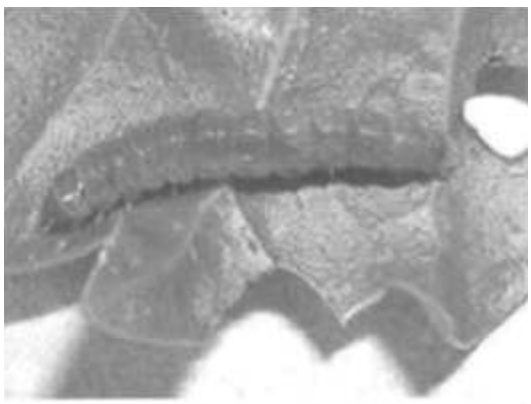


Figure 110. *Lasperasia auruntiana*

Management: Larvae fold the apical leaves and remain inside. Hand collection and destruction of such folded leaves could reduce the damage to some extent. 0.06% dimethoate spray or 0.076% dicholrvos spray can control if occurring at very high levels.

5.18.2. *Ascotis selenaria* and *Cleora cornata*

Both these species are voracious feeder on neem and defoliate the trees in UP, Punjab and Haryana. Infestation starts in early April and continue till late September. In epidemics several generations of the defoliators are noticed and tree is cent per cent defoliated. In winter it hibernates in pupal form.

Management: Light traps can be installed to monitor adult insects. Infested shoot can be easily located and larvae can be hand-picked and destroyed. Soil around the trees should be dug up to expose the pupae to the natural enemies like birds and ants. 0.05% monocrotophos spray or 0.076% dicholrvos Suitable microbial formulations of *Beauveria bassiana* can be applied to bring down the population.

5.18.3. White grubs- *Holotrichia* sp.

Infestation period of insects is June-September. Wilting of foliage due to eating of roots and rootlets.

Management: Sandy soil should be avoided for raising seedlings. Semi decomposed FYM should not be

used. Soil working should be avoided during monsoon i.e. June –July. Soil mixing of Phorate 10 G @ 200 gm/ bed (size 10 x 1 m) should be used.

5.18.4. Shoot borer- *Laspeyresia koenigana*

Infestation period of insects is November-January. Young larvae bore from apical end of shoot to downward, plant exhibits forked appearance.

Management: Foliar spraying or monocrotophos 0.04% i.e. 1 ml /Lt. water is effective against this borer.

5.18.5. Scale insect- *Megapulvinaria maxima* (Fig.111)

Infestation period of insects is January to March and June to August. Partial or complete drying of seedlings.

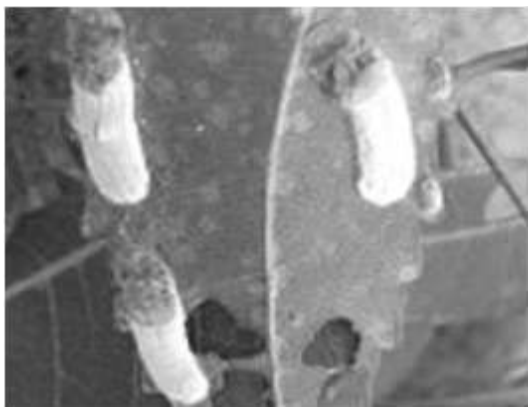
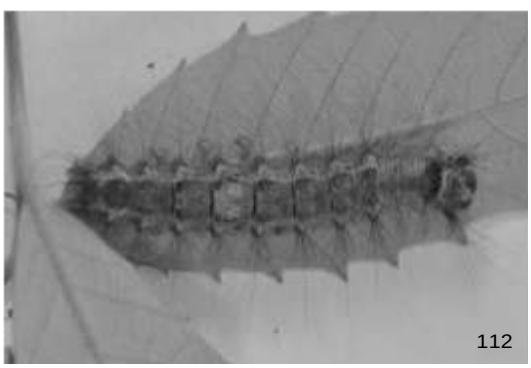


Figure 111. *Megapulvinaria maxima*

Management: 5% tobacco extract or 2% Pungam or Neem oil emulsion can be sprayed every 15-20 days. Care may be taken to avoid washing away of the extract applied while watering. Infestation of this scale insect originates from nearby standing trees in the vicinity. Branches of such trees with infestation should be lopped and destroyed by burning. Severely infested seedlings should be segregated and destroyed. During low level of infestation leaves with white patches (egg masses) can be plucked and destroyed. If the pest is located at the egg laying stage (as white elongated patches on leaves) spray of 2% neem oil emulsion or Pongam oil can be given to avoid the emerging nymphal stages from moving and settling on leaves. During severe infestation 0.06% dimethoate or 0.05% methyl dematon can be sprayed.

5.18.6. Neem scale- *Pulvinaria maxima*

Infestation period of insects is throughout the year. Thick coating of white patches having nymphs and adults feeding sap from tender shoots and leaves.



112

Management: Spraying of monocrotophos 0.03% i.e. 8 ml /10 Lt. of water is effective.

5.19. OAK (*Quercus* spp)

5.19.1. Indian Gypsy Moth, *Lymantria obfuscate* (Noctuidea: Eribidae: Lymantriinae) (Figs 112-115)

Host Plants: Oak (*Quercus* spp.), willows (*Salix*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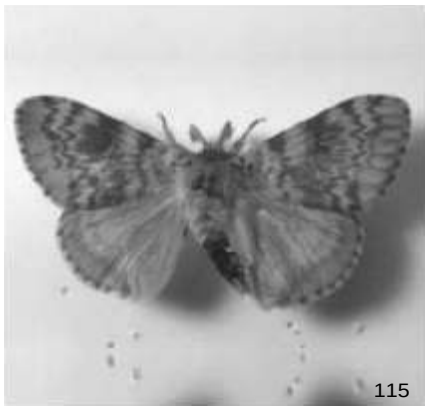
114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Figures 112-115. Indian Gypsy Moth, Lymantria obfuscate: 112, caterpillar; 113, pupa; 114 male moth and 115, female moth

spp.), poplar (*Populus* spp.), walnut (*Jugulans* spp.), apple (*Malus* spp.), apricot (*Prunus* spp.), cherry (*Prunus cerasus*) and almond (*Prunus amygdalis*). It was reported as the major pest of ban oak

A female lays up to 300-400 eggs in batches in June-July under the bark of trees and covers them with a felted layer of yellow brown hairs and scales. The eggs remain unhatched up to next spring for about 8-9 months. The caterpillars nocturnal and fed gregariously, from the periphery towards the mid rib of the leaves. Young caterpillars spread to new locations by spinning silken thread. Later instars of gypsy moth move down the trees at dawn and climb back at the dusk. Larval period varied from 66-100 days. The pupation takes place under the protection of the silk webs from May to mid July and pupal period varied from 9-21 days. There is one generation per year. Males are active flyers. Female moths are apterous types, therefore, unable to fly.

Management: Moths is subjected to natural control buy a number of parasites and predators which attack all stages from egg to pupa. Diseases particularly a polyhedral virus disease are a major regulating influence in gypsy moth populations. Foliar spray of 0.1 per cent carbaryl or fenitrothion is effective in controlling the pest. Attack can also be suppressed by sex pheromone trapping of males.

5.19.2. Pink Gypsy Moth, *Lymantria mathura* (Noctuidea: Eribidae: Lymantriinae: Lymantriini) (Figs 116-120)


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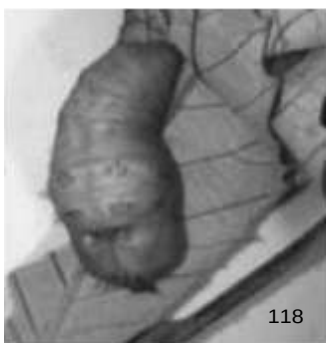
117


118

Figures 116-120. Pink Gypsy Moth, Lymantria mathura: 116, caterpillar; 117, cocoon; 118, pupa; 119, female moth and 120,male moth

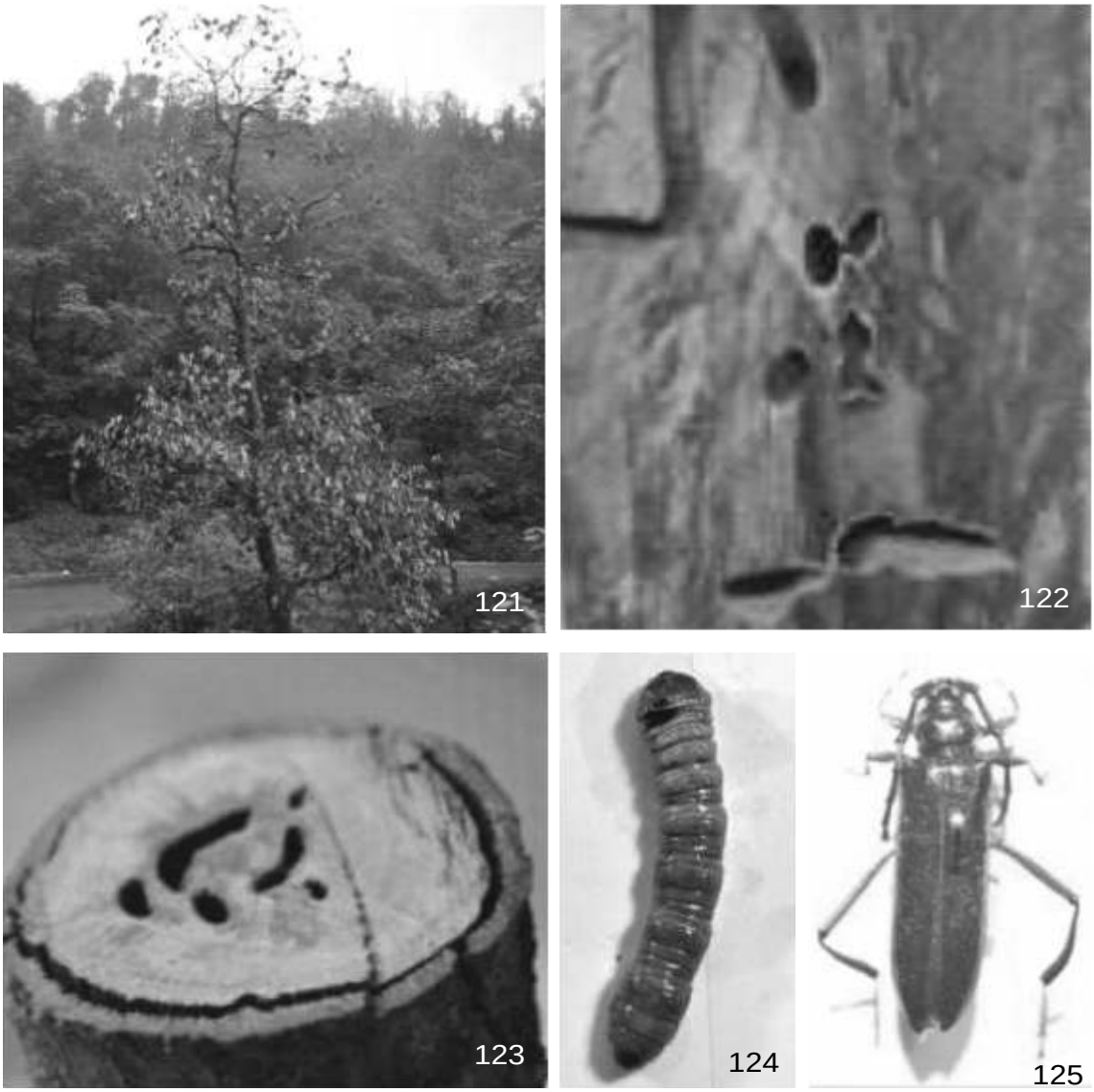
Major Host Plants: *Shorea robusta* in Assam & North India. Other food plants are *Quercus leucotrichophora, Q. serrata, Eugenia jambolana, Terminalia arjuna, T. myriocarpa, Abies, Castanea, Castanea mollissima, Larix, Liquidambar formosana, Litchi chinensis, Mangifera indica, Neolamarckia cadamba , Pinus, Pseudotsuga menziesii, Quercus leucotrichophora, Quercus mongolica, Quercus serrata, Shorea robusta, Syzygium cumini, Terminalia arjuna, Terminalia myriocarpa* (Plantwise.org)

Distribution: North West Himalaya, Sikkim

L. mathura is one of the most important defoliators of deciduous trees (especially Quercus). Its outbreaks usually occur over large areas and often result in complete defoliation of forests. Pest damage does not usually kill trees but lead to significant loss of vigor. Furthermore, outbreaks of *L. mathura* are also very often followed by outbreaks of wood borers (Scolytidae, Cerambycidae and others). These pests are able to kill trees which are heavily stressed by *L. mathura. L. mathura* attack thus leaves forests susceptible to pest outbreaks and predisposes them to forest fires. Outbreaks of *L. mathura* usually occur once in 4 years. Eggs with almost completely developed larvae overwinter under bark scales. Neonate caterpillars usually appear in the first half of May and continue to hatch for around 20 days. For the first 4–5 days, they neither spread nor feed. The feeding period covers May, June and July. Caterpillars feed first on buds, then on leaves, preferring to stay on leaves and not on branches. The most active feeding is observed in the evening. During outbreaks, the pest population level may reach more than 1000 caterpillars per tree. Larval development lasts 50–60 days. Pupation of *L. mathura* occurs on leaves and branches in crumbly cocoons or almost without cocoons in July, Pupal development lasts 12–18 days. Flights occur at the end of July and in August. Males and females are strong fliers, active at night and attracted to lights.

Management: Forecasting of population development is possible by trapping *L. mathura* adults in light traps and analyzing weather conditions. New pheromones are now being developed for monitoring and control purposes. Control measures can also be applied in adjoining infested areas, especially during outbreaks, to limit spread. To prevent introduction, plants for planting and cut branches of host plants from the infested areas should be free from soil. Alternatively, such commodities should originate in a pest-free

area, or be produced in protected houses, or fumigated or imported during winter. Wood should be debarked or heat-treated or originate in a pest-free area, or be imported during winter, and isolated bark should be treated against contaminating insects. For chemical control foliar spray of 0.1 % carbaryl or Fenitrothion is effective in controlling the pest.



Figures:121-125, Oak Stem Borer, Aphrodisium hardwickianum; 121, Dead Oak tree; 122&123, galleries in the heart wood;124, larva and 125, beetle

5.19.3. Oak Stem Borer, *Aphrodisium hardwickianum* (Coleoptera: Cerambycidae) (Figs 121-125)

Host: Ban oak, *Quercus leucotrichophora* (Fabaceae).

Distribution: Western Himalaya to Central Himalaya up to Sikkim.

Visible symptoms of attack are drying of leaves on branches and accumulation of dust heap on the ground. Recent attack is visible by ejected frass and crescent shaped exit-holes on the stem; failed attack on branches is indicated by the formation of cankers. The attack of several years eventually kills the tree, and considerably reduces the weight and value of the wood for fuel. Attack of several generations kills the trees by destroying the stems and even when the host survives its timber is rendered useless for anything but firewood . Bores through both sapwood and heartwood. Life cycle is believed to be annual with emergence taking place during pre- monsoon (June) and monsoon. Eggs are laid in crown and side branches and the upper portions of the stems of living trees. The larva on hatching bores along the branch towards the stem into which it enters and continues the tunnel downwards. The simple tunnel excavated in the early stages becomes more complicated as it reaches branches of greater girth. In the stem the tunneling is extensive and the accumulated attack of several years removes great portion of the wood as the dust is all ejected. The larvae pupate in the stem and the beetles begin to emerge with the onset of rains from crescent shaped emergence holes.

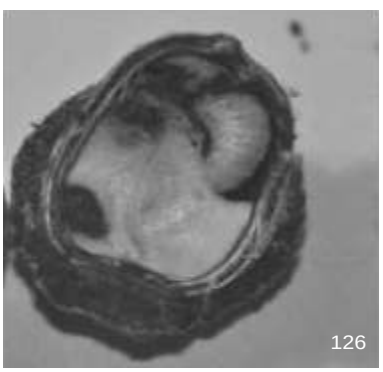
Management: Prohibition of lopping of oak trees in badly borer infested oak stands help in further spread of the borer infestation besides burning of oak slash, removal of dead infested trees and logs from infested sites and oak stands. Infested trees should be marked and monitored for spread of infestation. Prohibition of lopping in severely affected areas besides being compensated by planting of alternate fodder species in fringe villages around oak forest. Chemical treatment should be given using systemic insecticides i.e. monocrotophos (36EC) or Dimethoate (30 EC) @ 0.02-0.04%) as tree injections or application of a fumigant i.e. saturated solution of 'para-di-chlorobenzene' in kerosene oil @ 5-10ml/lowest ejection hole on the trunk and then plugging the holes with clay or stones, during post monsoon season. The reduction in borer infestation and beetle mortality in treated trees in relation to control trees can be assessed during next summer when emergence takes place. At this time beetles will be found dead in larval galleries that can be checked by removing the plugs.

5.19.4. Acorn Weevil, *Calandra glandium* (Coleoptera: Curculionidae) (Figs. 126-128)

Host plants: *Quercus leucotrichophora, Quercus floribunda, Quercus glauca, Quercus lanuginose*.

Distribution: North-West Himalaya.

The damaged acron is rendered useless and is unable to germinate which results in loss in regeneration.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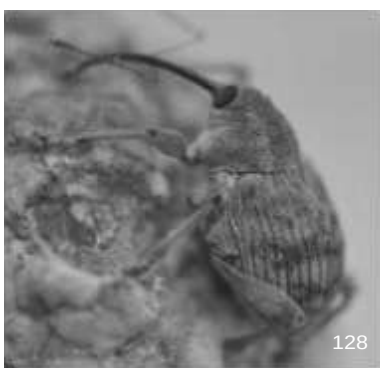
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Figures 126-128. Acorn Weevil, *Calandra glandium*: 126, larvae feeding on the endosperm; 127, mature larva escape from the acorn and 128, beetle

There are at least two generations a year one of which overwinters in fallen acorns. The egg is laid on the young acorn above the cupule ; the early mines of the young larva run throughout the acorn but later work is concentrated at the basal portion often leaving the tip entirely untouched. The larvae are short, and cylindrical in shape, and move by means of ridges on the underside of the body. It reaches a length of 4 to 8mm. Throughout its life the larva is a fat obconical grub but becomes cylindrical just before pupating. A small, white, short, stunted, legless grub, almost as broad in the centre as long, with a small pale-brown head. Throughout its life the larva is a fat conical grub but becomes cylindrical just before pupating. A larva feed inside, reducing the kernel to a powdery mass, no external opening being visible in the outer skin of the fruit. The acorns fall to the ground during the attack about the time the larvae become full- fed. Many individual (up to 10) reaches maturity in one acorn. This weevil first begins to emerge from the acorns about the middle of June and continues to do until the end of the month. When ready to emerge a hole is bored through the shell to the outside. Emergence occurs by means of a circular hole, before which the acorn shows no signs externally of being attacked. Before emergence the acorn shows no signs externally of being attacked.

Management: Chemical control can be done by spraying of water emulsion (contact insecticides) with Fenitrothion 0.25% or Monocrotophos 0.02% or Carbaryl 0.1% or Dimacaron/ Rogor 0.04% or mixing of systematic insecticides in soil with Carbofuron (Furadon 10G) or Thimet (Phorate 10G)@ 10gm/m^2. For stored acorns disinfect the store (godown), seed storage bags and containers with water emulsion at the rate of 3 litres per 1000m^2 of 0.3% pyrethrin or fumigate the seeds @ 3ml per 100Kg (24 hours) using Carbon tetrachloride or Methyl bromide @ 16-24g/m3 20°C.

5.20. PINES

5.20.1. Cryptorhynchus rufescens (Coleoptera: Curculionidae) (Figs129-131)

Distribution: Northwestern Himalayas.

Hosts: *Pinus khasya* and *Pinus roxburghii.*

Needles of the badly infested trees are pale yellow to brownish in appearance and fall prematurely. The

Figures 129-131. *Cryptorhynchus rufescens*: 129, dying tree; 130, mature larva and 131, beetle.

attacked trees have faded look. Bark of the tree is coated with a mass of resin exuding from the holes made by mature weevils on exits. Large round holes are easily visible on the thick bark of trees. Presence of rough loose pupal cocoons on the inner bark of trees. The larval galleries are grooved in the cambium and sap wood and always filled with loosely packed ejected dust wood and wood excreta. Galleries are irregular in fashion, proceeding around the circumferences of the trees.

The female lay egg into deep crevices in the bark of trees, or pierces down to the cambium layer and places them there. The young larvae on hatching out remain in the thinnest portion of the cambium layer, at first eating out small galleries in an irregular fashion. As it increases in size, the grub bores deeper gallery in the thick bark, cambium and the sapwood. The galleries are irregular and winding, proceeding around the circumference of the tree and also up and down the tree trunk. The galleries are packed with red dust and about 15-25 cm long. When the grub has reached full growth, and just before pupation, Pupating chamber is about 10-15 mm long, oval in shape and lined with coarse interlaced wood-fibers and having the appearance of a small kind of cradle. In this cocoon the larva changes into the papal stage. When the beetle is fully mature, it bites out a circular straight exit hole through the thick bark of tree and thus escapes from it. These holes have a considerable diameter, and are easily visible even in the thick bark which trees put on. This weevil is elongate-ovate, having head and rostrum black and measures about 6.6-8.5 mm in length. There are 3 generations a year. The beetles of overwintering generation emerge from April onwards. Eggs laid in April give rise to beetles at the end of June. A second generation is completed between July and September and 3rd overwinters in any stage, larva, pupa and beetle.

Management: Badly infested trees in the forest only add to build up of population of this pest and therefore need to be cut out and burnt at the earliest. Best time for such removal would be winters when the insects and their stages of development are in hibernating stage in the tree. Bark beetles are attracted toward freshly felled trees. Billets (80 – 120 cm in length X 90 – 110 cm gbh) of freshly felled chir pine trees can be used for entrapping beetles on their emergence. Optimum time for placing these tree traps in the forest is in the month of May – June (Period of pest emergence). These billets should be removed after the peak emergence is over, the billet debarked and the bark burnt. Chir Pine forest need to be protected against fire as these affected trees lose their vigor and become easy targets for ovi position by this insect. It is therefore suggested that after each fire incidence, the forest should be kept under strict vigil and in case the trees start showing symptoms of insect attack, treatment as suggested above be initiated.

5.21. POPLAR (*Populus* spp.)


132

133

5.21.1. Shoot and root borer- *Apriona cinerea* (Figs132-135)

Infestation period of insects is March-October. Excretes the wooded pellets through the hole and can be easily recognized near the tree base. Infestation of this insect pest takes place in younger to three year old P. deltoides plantations. After hatching grub penetrate in to the soft stem and feed internally and make the downward gallery. Grub,


134


135

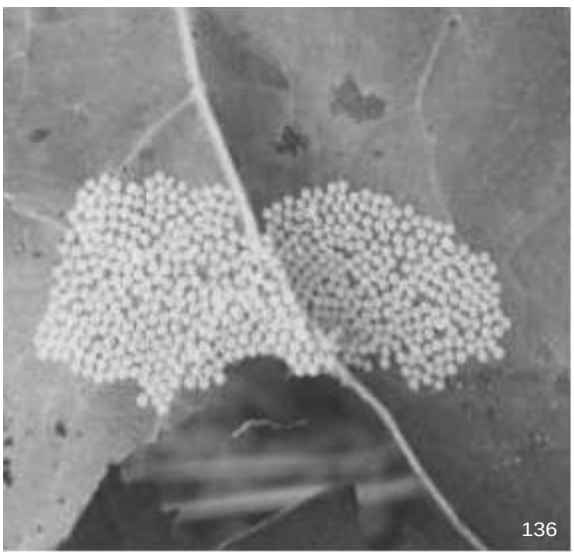
Figures 132-135. Shoot and root borer- *Apriona cinerea*: 132, early sign of borer, wet saw dust and sap oozing from stem; 133, larva feeding inside the stem; 134, larval gallery and 135, beetles.

feed the wood along the pith and move up to the root and again upward. A single larva can make two-three parallel galleries in a single tree.

Management: Regular field monitoring. Avoid planting of other alternate/collateral host plants like mulberry, apple in the vicinity of poplar plantations or visa-a-vis. Prune the branches regularly to prevent the entry of grub in the main stem. Insert the iron wire into the hole and kill the insect and plug the hole with mud. Inject dichlorvos 76 EC or of chlorpyriphos 20 EC -2 ml saturated in kerosene oil or other fumigant insecticide in the lowest hole and seal the hole with mud. Cut the heavily infested branches or tree and kill the internal insect stages. Grow resistant clones: G-48.

5.21.2. Poplar leaf defoliator- *Clostera cupreata* (Figs136-138)

Infestation period of insects is March-October. Feed gregarious on the lower surface of the leaf.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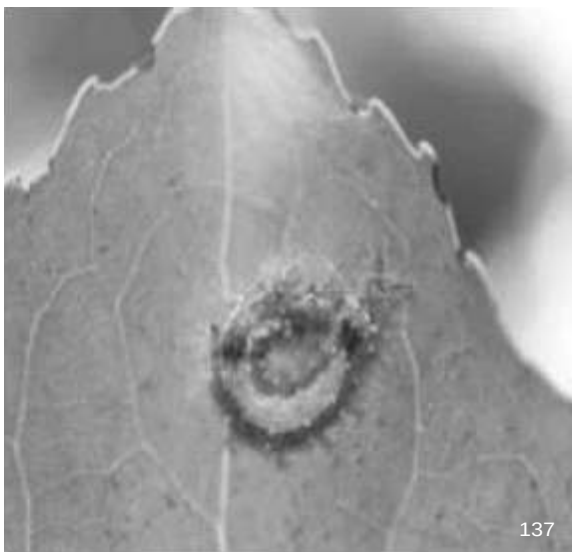
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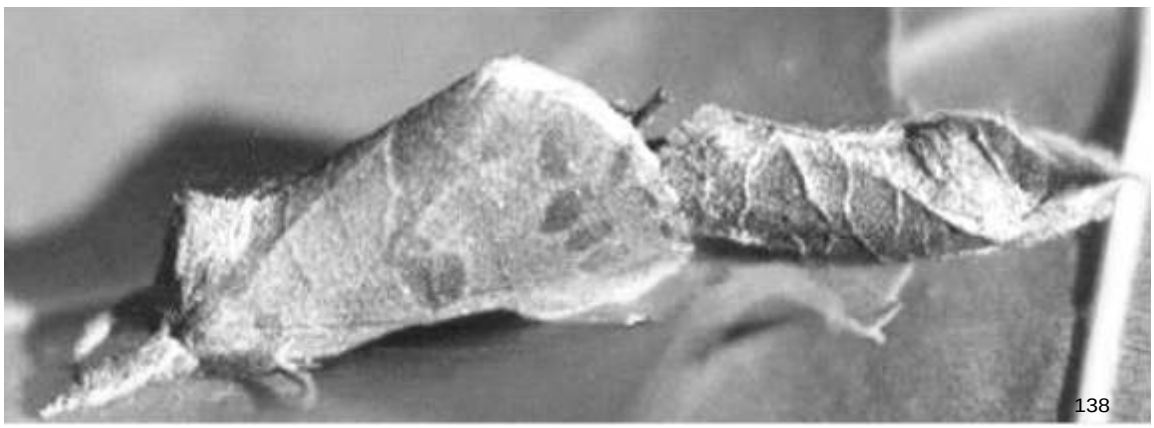


Figures 136-138. Poplar leaf defoliator- *Clostera cupreata*: 136, batch of eggs; 137, larvaand 138, mating moths

5.21.3. Poplar leaf defoliator- *Clostera fulgurita*

Infestation period of insects is March-October. Feed gregarious on the lower surface of the leaf. Only larval stage is injurious to the plant. Young larvae feed gregariously and later 4th-5thinstars stages larvae feed individually on the foliage. Populus deltoides is the most preferred species and the infestation of this insect is appeared to be almost every year in all poplar growing states.

Management: Conserve and promote larval predator *Canthecoana furcellata*. Grow resistant clones viz. WSL-4, WSL-12,WSL-18, WSL-64, D-67, D-82, D-172, D-273, S7C4,82-42-5. Collect and destroy the egg masses of the insect. Plough the field 2-3 times in December to expose the over-wintering pupae in soil and debris. Application of egg parasitoids viz. *Trichogramma chilonis, Trichogramma poliae, Trichogramma acheae* or *Trichogramma exiguum* @ 1-1.5 lakh eggs per ha. Application of bacterial bio-pesticide i.e. *Bacillus thuringiensis* (Bio-lip, Bio-bit, Dipel or Bio-tox) @1-2 kg per ha. along with water. Application of neem seed extract @ 0.1 % . 8. The insecticides such as carbaryl @ 0.04%; quinalphos @ 0.05 % or profenophos @ 0.02 % water based solution may be applied in the affected fields in the evening to control the population of this defoliators.

5.21.4. Bark eating caterpillar- *Indarbela quadrinotata* (Figs139-144)

Figures 139-144. Bark eating caterpillar- *Indarbela quadrinotata*: 139 & 140, feeding galleries on stem; 141 & 142, larval gallery;,143 mature larva; 144 moth

Infestation period of insects is July-October. Presence of ribbon like silken webs running on the bark of the trunk and branches. Repeated infestation of this insect pest results complete death of young trees. Both larva and adults are nocturnal in behavior. After hatching caterpillar feed on the bark and move towards the branches, make the hole at the base of the branches and penetrate inside. Sometimes larva penetrates through the young branches and move towards the main trunk. Larva feeds internally for 9-11 months on the bark at night and makes covering with pieces of bark, fecal pellets and glued with saliva (silken). The larva makes L-shaped tunnels in the trunk usually at the joints of the branches.

Management: Collect and burn the loose bark, damaged bark and affected branches. Avoid dense plantation preferably use 8-10 fit or more distance to reduces the infestation. Regular cleaning and ploughing of field should be done. Irrigation of the plantation must be ensured in summer months. Plantation should be avoided near or mixes to/with fruit orchard (especially Litchi, Guava) or visa-vis. Attract and kill the adult moths using light trap @ 1no/ ha in the month of July and August. Insert an iron wire into the holes made by insect and kill the caterpillars mechanically. Clean the affected portion of the trunk and insert a cotton swab soaked in petrol or kerosene into the hole and plug the hole with mud. Inject dichlorvos@ 5 ml in the bore in the month of September and October and plug the hole with mud. Carbofuran 3G granules may be placed @ 5 gm per hole and plugged with mud. Spray of monocrotophos@ 0.05%; or quinalphos @ 0.05%; or chlorpyriphos @ 0.04 % or carbaryl 50WP @0.04%water solution using power or foot sprayer.

5.21.5. Poplar butterfly (leopard butterfly)- *Phalanta phalantha* (Figs145-147)

Infestation period of insects is July-September. Only larval stage of this insect pest is injurious to the plant, larva feeds on young leaves and shoots of poplar and cause damage to the plant. Heavy infestation of this pest, defoliate the plant, results adverse effect the photosynthesis process of the plant.

Management: Keep the field clean and remove the alternate hosts from nearby the field. Pick and kill the larvae in nursery stages. Application of bacterial bio-pesticide i.e. *Bacillus thuringiensis* (Bio-lip, Bio-bit, Dipel or Bio-tox) @1-2 kg per ha. along with water. Spray of malathion insecticide @0.05% solution with water.

Figures 145-147. Poplar butterfly (leopard butterfly)- *Phalanta phalantha*: 145, caterpillar feeding on poplar leaf; 146 caterpillar and a chrysalis and 147 butterfly

5.22. SAL (*Shorea robusta*)

Sal Heart-wood borer, *Hoplocerambyx spinicornis*. (Coleoptera: Cerambycidae) (Figs148-151)

Distribution: In India Sal is distributed in two main regions viz. Northern and Central regions bisected by Gangetic plains occupying an area of about 11.6 million hectares (105,790 sq. km area in Northern and Central region) approximately, 14.2% of the total forest in the country.

Sal trees when attacked by the borer shows symptoms which are categorized as follows:

Category 1. Leafless crown (c), epicormics (e) dead, resin spots (r) on stem and plant with heap of wood dust (w) more than 7 cm.

Category 2. Crown and epicormics brown, resin spots on stem and heap of wood dust more than 7 cm.

Category 3. Crown brown, epicormics green, resin spots on stem and heap of wood dust more than7 cm.

Category 4. Crown and epicormics green, resin spots on the stem and plant with scattered heap of wood dust, less than 7 cm, at the base of tree.

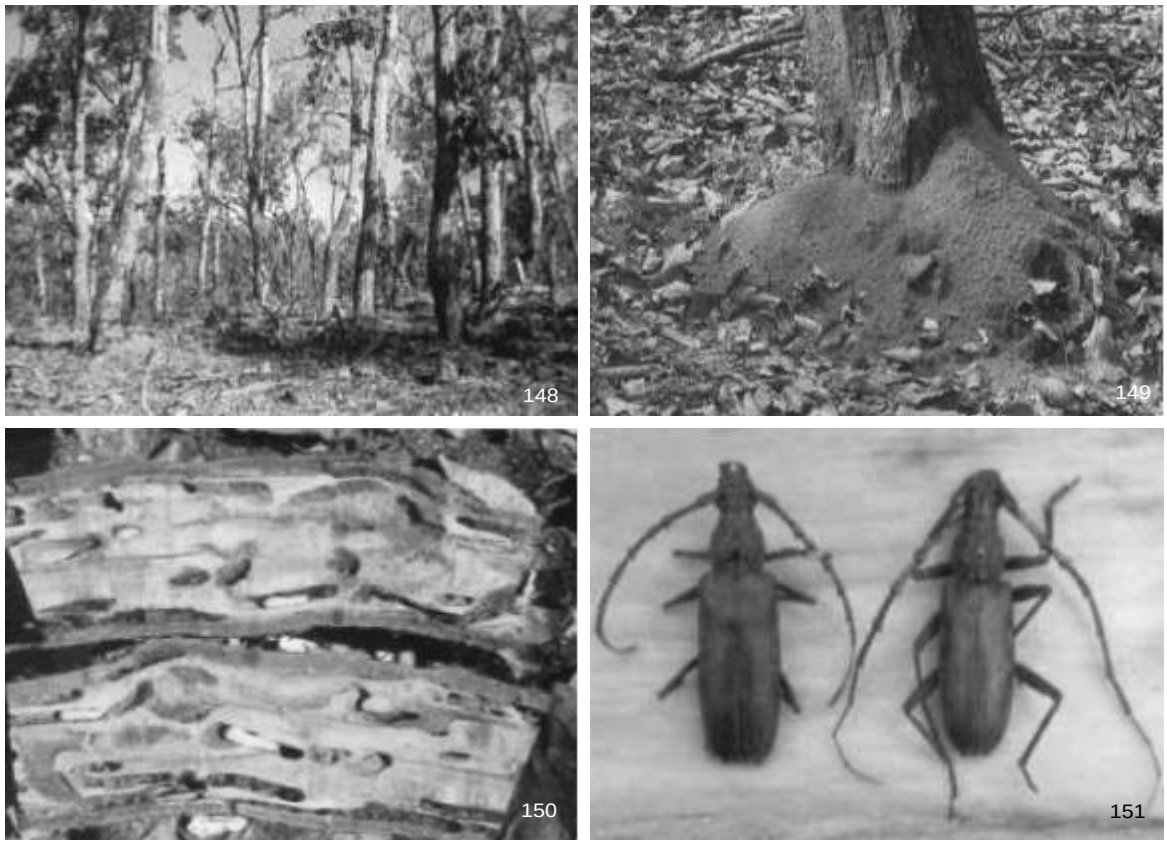
Category 5. Half crown dead and rest of half crown and epicormics green, resin spots on stem and heap of wood dust less than 7 cm at the tree base.

Category 6. Stumps attacked by the borer with heap of wood dust at the base of stump.

Category 7. Crown and epicormics green, resin abundant and wood dust scattered or scanty. Healthy Sal Tree.

Female Beetle is about 6 cm long, uniformly dark brown. The elytra are shiny black to reddish- brown. The antennae of males are longer than the body while in females it is equal or shorter than the body. The beetle feed on the oozing sap of the Sal tree and lays about 200 eggs in the crevices of bark. Larvae when reaches the bast, the tree exudes resin which flow out and can be seen on the stem. Freshly oozed resin is pinkish

brown in color which becomes light yellow after sometime. The larva feed on the bast by making irregular tunnels. Later it enters the sapwood and riddles it with zigzag tunnels. In the process of feeding and tunneling a large heap of wood dust is deposited at the base of attacked tree. The mature larva then enters the heart wood. Affected Sal trees are invariably killed outright due to girdling caused by criss-cross larval tunnels.



Figures 148-151. Sal Heart-wood borer, *Hoplocerambyx spinicorni*: 148, infested sal forest; 149, heap of saw dust at the base of sal tree; 150, galleries by larvae and 151, beetles, left female and right male

Management: Management of Sal heart-wood borer in attacked forest is done mainly through following measures:

i) Monitoring of attacked trees: After the end of monsoon season the infested trees should be enumerated and marked as per the described damage categories. Category 1 and 2 of infested tree should be removed from the forest before the onset of next monsoon and should be stored at least 3-4 km away from the edge of the sal forest.

ii) Trap tree operation (Fig. 152): Trap tree operation is based on the fact that adult beetles are strongly attracted to the smell of exuding sap from the freshly injured tree. It has been reported that the adults fly to newly felled trees from as far as 800 m away within five minutes and can smell the sap from a distance of 2 km.

b) Selection of unsound trees for making traps

- Unsound trees like top broken, crooked and category 7 trees, as described above, are selected for making the traps.

c) Preparation of logs

- Depending upon the intensity and incidence of attack one or two such trees per hectare are felled and commercial logs are prepared.
- Bark at both the cut ends is beaten up to 30 cm with the help of back of an axe or hammer to provide sap and shelters for the beetles. The beaten ends are covered with the twigs and leaves of undergrowth to avoid quick drying.

Figure 152. Trap tree operation of Sal Heart-wood borer, *Hoplocerambyx spinicornis*: Preparation of a log for trapping beetles

d) Collection and killing of beetles

- The beetles which are attracted to the sap should be handpicked regularly at dawn and dusk and killed by immersing them in water to which kerosene it added to form a top layer.
- On the 10th day, the dried bark should be removed and further 30 cm bark should be beaten for fresh exudation of sap.
- When trap work is over logs should be immediately removed, shifted to the depot and converted into planks.

SOME IMPORTANT POINTS

- Trap tree operations should first be concentrated on heavily affected coupes of forests.
- Record of daily catches must be maintained and the laborers engaged should be suitably paid for the catches as incentive.
- All the collected beetles should be burnt and buried in the presence of responsible forest officer.
- After felling and removal of category 1 and 2 sal trees, the timber should be kept in depots, which are situated at least 3 km away from the edge of the nearest sal forest.
- Forest hygiene should be maintained strictly after felling in coupes.
- Lops, tops, bark etc should be removed or burnt through controlled burning.
- It is mandatory that after felling stump dressing should be done.
- After intensive trap tree operation, when the incidence comes down to below 1% of growing stock in the following years, indicator traps (1 or 2 per compartment) should be laid each year to know the population of beetles during monsoon.
- If the beetle catch in the indicator trap increases then extensive trap tree operation should be conducted in the following monsoon till the incidence is brought down to below 1% of growing stock.

5.23. SANDAL/CHANDAN (*Santalum album*)

5.23.1. Scale insects

75 species of Hemipteran sucking pests including 23 species of scales and mealy bugs (coccids) are recorded as sap sucking insects on sandalwood. Among these 10 species of coccids are considered injurious to the sandalwood seedlings and trees causing drying of branches with visible die-back symptoms. Use of sandalwood twigs for grafting purposes, when affected by coccids lead to the failure of the grafted plants. As the coccids produce honeydew, badly infested plants get completely covered by sooty molds, which affect photosynthesis in the leaves and loss of vigor in the sandalwood seedlings.

Figure 153. *Aonidiella orientalis*

a. *Aonidiella orientalis* (Diaspididae: Hemiptera) (Fig. 153).

It is a flat circular scale ranging in color from almost white to light yellow. Male scale is slightly oval and exuvae is near one end. Female scale is roundish and exuvae is in center. Early instar looks like small yellowish dot on leaves and it is stationary. It is found infesting throughout the year and attacks mainly the young leaves.

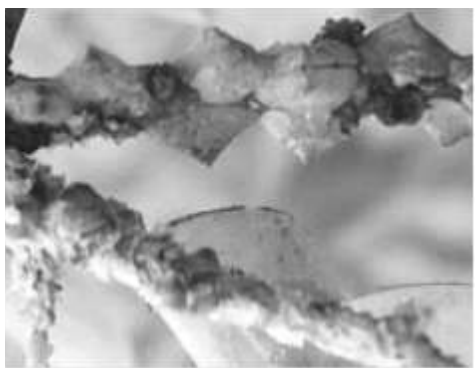


Figure 154. *Cardiococcus bivalvata*

b. *Cardiococcus bivalvata*. (Coccidae:Hemiptera) (Fig. 154).

It is often observed to cause dieback of branches and in severe cases, death of saplings and young sandalwood trees. Sexual dimorphism noticed. Females covered with 2 glossy shells like plates, no distinct segmentation and body parts except for small antennae and hair like sucking siphon/tube. It measures 5 mm long and 3 mm broad. Male puparium is covered by brittle waxy lamina, median dorsal area occupied by an elongated plate with a central cone surrounded by a heart shaped plate. Measures 1.8 long 1.1 mm broad. This coccid is found throughout the year, causing die-back and drying of branches and trees during summer months. It completes 9-10 generations in a year.

Figure 155. *Ceroplastes actiniformis*

a. *Ceroplastes actiniformis* (Coccidae: Hemiptera). (Fig. 155).

b. This insect has thick waxy spherical test; marginal area is divided into eight portions, which encloses

central cone shaped area. Color is pale white found infesting throughout the year. Two peaks are found, one in March to May and the other in December to February.

c. *Ceroplastes ceriferus* has been observed either singly or in groups on sandalwood trees causing leaf drop, reduction in plant vigor, leading to dieback of plants.

d. *Megapulvinaria maxima* (Coccidae: Hemiptera) (Fig. 156).

Figure 156. *Megapulvinaria maxima*

Matured females are oval to round in shape and reddish brown in color. On the anterior ventral side there are pair of antennae and three pairs of legs. Freshly hatched nymphs are reddish in color with prominent eyes, a pair of antennae, a pair of anal processes and 3 pairs of legs. Male scales are white and generally found conspicuously on the leaves. They are elongated rather broad and comparatively smaller than females. Its incidence was found in October-December and Jan-March months. Its attack causes drying of the terminal shoots followed by dropping of leaves and fruits.

Figure 157. *Nipaecoccus viridis*

e. *Nipaecoccus viridis* (Pseudococcidae: Hemiptera) (Fig. 157)

Freshly emerged first instar nymphs are reddish brown having well developed legs and antennae. They are mobile in nature. White mealy matter on their body covers late instar nymphs. It occurs throughout the year with two peaks, one in February to March and the other in August to September. It attacks the foliage, tender growing shoots, flowers and fruits. There are 10 to 12 generations in a year.

Figure 158. *Saissetia coffeae*

f. *Parasaissetia nigra* and *Saissetia coffeae* (Coccidae: Hemiptera). (Fig. 158)

They are commonly known as black bugs. They attack almost all parts of the plant and immature fruits, which fall off and do not germinate. The honey dew secreted by these scales cause sooty mould formation. *S. coffeae* are elliptical in outline, convex, brown and shining. Early instars of the P. nigra scales are flat orange yellow in color and noticed on both the sides of the leaves and on tender branches. Matured females are round and black in color in

Figure 159. *Paratachardina* sp.

the case of former and brown in the case of latter bug. These coccids are found infesting throughout the year and attacks main branches, tender shoot, leaves and fruits. It could be a serious pest of sandalwood.

g. *Paratachardina silvestri* and *P. lobata lobata* (Kerridae: Hemiptera). (Fig. 159)

The lac insects cause die back and mortality of the plants in sandalwood plantations. Females of *P. silvestri* have four lobes with pointed tip. Female of *P. lobata* has length and width equal (about 1.5-2 mm) and with two pairs of prominent lobes. The testa is extremely hard and brittle, glossy and dark reddish brown in color, often dull and black in color due to coating of sooty mould. The first instars (crawlers) are elongate oval deep red. They are found infesting throughout the year attacking main branches, tender branches, leaves and young fruits.

Infestation period of insects is throughout the year.

Species of coccids are considered injurious to the sandalwood seedlings and trees causing drying of branches with visible die-back symptoms. Coccids produce honeydew, badly infested plants get completely covered by sooty molds, which affect photosynthesis in the leaves and loss of vigor in the sandalwood seedlings. Causing leaf drop, reduction in plant vigor, leading to dieback of plants. Male scales are white and generally found conspicuously on the leaves. attack almost all parts of the plant and immature fruits, which fall off and do not germinate. The honey dew secreted by these scales cause sooty mould formation.

Management: Sprays are to be timed to coincide with the crawler stage and preference to be given to less persistent chemicals. Spraying of Monocrotophos (0.02 – 0.05%), 0.2 – 0.3% Chlorpyriphos, Quinalphos, Metasystox or Imidacloprid or neem oil at 0.5% at the initial stages can control the pests. Initial stages of lac insects can be controlled by spraying 0.1% Dimethoate or 0.04% Cypermethrin. Control of later stages can be achieved by spraying the affected trees thoroughly with 0.5% Quinalphos along with 0.05% sticker. Soil drenching primarily with neonicotinoid insecticides (e.g. imidacloprid and thiamethoxam) is highly effective. Soil application of plant seed cakes and/or carbofuran granules @0.75 to 1gm a.i/plant. Preference to be given to systemic insecticides and same chemical should not be used repeatedly.

5.23.2. Defoliators- Weevils

a. *Dereodus vigilans* (Curculionidae: Coleoptera) (Fig. 160).

Color black with dense brown and grey scaling, the under parts whitish; the prothorax grey, with a broad brown lateral stripe, edged internally by a whitish line; the elytra grey, or sandy grey, more or less mottled with brown. Length 12-13.5; breadth 4.5 – 5.5 mm.

Figure 160. *Dereodus vigilans*

b. *Indomias cretaceous* (Curculionidae: Coleoptera) (Fig.161).

It is a polyphagous weevil defoliating several trees of forestry importance including sandalwood seedlings in

nurseries. Weevils are black with uniform yellowish chalky white scaling, 6-6.5mm long, 2-3.5 mm broad. The weevil feeds on the leaves mostly at night, from the edges towards the midrib. Sometimes the distal half of the leaves is cut off because of circular holes in a line made by the adult weevils. The weevils may be noticed on the under surface of leaves, or inside leaf curls or in between webbed leaves during day.

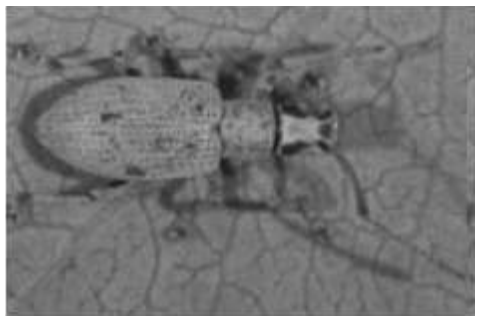


Figure 161. *Indomias cretaceous*

c. *Myllocerus* spp. (Curculionidae: Coleoptera) (Fig. 162). There are many species of weevils which are small, scaly, short snouted beetles defoliate the plants. The adults, which are active from April to July feed on the leaves of various dicotyledonous trees like *Azadirachta indica, Santalum album, Tectona grandis* and *Toona ciliata*.


Figure 162. *Myllocerus* sp.

Infestation period of insects is April-July. Damage the foliage of seedlings, saplings and trees. feeds on the leaves mostly at night, from the edges towards the midrib. Sometimes the distal half of the leaves is cut off because of circular holes in a line made by the adult weevils.

Management: Spraying of 0.02–0.05% of Monocrotophos, Quinalphos, Chlorpyriphos or neem formulations as per the recommended dosage. Preference to be given to contact insecticides.

5.23.3. Defoliator- Bag worm

a. *Eumeta cramerii* (Psychidae: Lepidoptera) (Fig. 163).


Figure 163. *Eumeta cramerii*

Young larva prepares a protective case formed of small pieces of the stem of sandalwood placed side-by-side so as to form a cylindrical bag, which is open at both ends. Caterpillar is seen outside the case when it is feeding or walking. The case inside is lined with a shining layer of white silk. New cases are either formed after subsequent instars or enlarged by adding pieces of twigs or branch lets. Head is large and prominent. Front legs black and yellow, long and stout. The mature larva (2.5 to 3.5 cm) smooth bodied, brown in color or purplish. In sandalwood nursery, the seedlings are badly cut down at the ground level. The feeding by young larva results in total defoliation. Females are wingless, stays in the bag.

b. *Acanthopsyche moorei* (Psychidae: Lepidoptera) The bagworm, carries its bag upright angles to the stem or leaf of the seedling but in the later instars the bag is heavy and carried in a pendant position. The

black caterpillar was seen defoliating the sandalwood seedlings presenting a burnt appearance on the leaves. Males moth grey brown with a wing expanse of 16-20mm. Female, wingless, stays in the bag.

c. *Pteroma plagiophleps* (Psychidae: Lepidoptera) Attack of this bagworm, leads to the total defoliation and drying up of sandalwood seedlings. The defoliation by these bagworms also imparts a burnt appearance on the leaves. Seedlings are badly cut down at the ground level. Black caterpillar was seen defoliating the sandalwood seedlings presenting a burnt appearance on the leaves. Attack of this bagworm, leads to the total defoliation and drying up of sandalwood seedlings.

Management: Spraying of 0.02–0.05% of Monocrotophos, Quinalphos, Chlorpyriphos or neem formulations as per the recommended dosage. Preference to be given to contact insecticides.

5.23.4. Defoliator-Grass hoppers

a. *Holochlora albida* (Orthoptera: Tettigoniidae) (Fig. 164).

Figure 164. *Pteroma plagiophleps*

The adults are 2.25- 4.0 cm long. Nymphs and adults are green in color and the wing venation resembles as a leaf. The antennae are very long and fine. They are well concealed among the young seedlings and their presence can only be noticed when they are in motion. These hoppers usually gnaw on tender shoots of sandalwood seedlings and saplings.

b. *Chrotogonus* spp. (Pyrgormorphidae: Orthoptera) (Fig. 165)

Figure 165. *Chrotogonus* sp.

Nymphs and adults of the grasshoppers are short-winged, slender and resemble the stem of sandalwood seedlings. They feed voraciously on the foliage causing damage to the sandalwood seedlings. Gnaw on tender shoots of sandalwood seedlings and saplings. Feed voraciously on the foliage causing damage to the sandalwood seedlings.

c. *Teratodes monticollis* (Acrididae: Orthoptera) (Fig. 166)

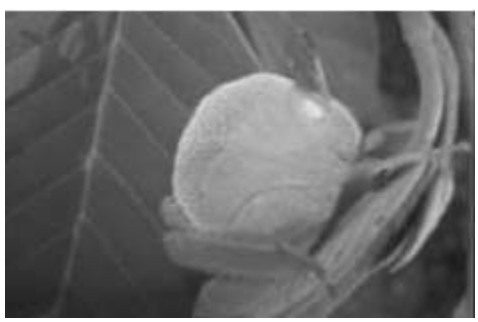


Figure 166. *Teratodes monticollis*

Nymphs and adults of the grasshopper are dull green in color, brighter under the wings. The pronotum is produced into a sharp hood over the body, giving it a striking appearance. Its green color and appearance camouflages well with the sandalwood seedlings. They have been observed as a serious defoliator of sandalwood seedlings.

Management: Spraying of 0.02–0.05% of Monocrotophos, Quinalphos, Chlorpyriphos or neem formulations as per the recommended dosage. Preference to be given to contact insecticides.

5.23.5 Bark eating caterpillar- *Indarbela quadrinotata* (Fig. 167).


Figure 167. *Indarbela quadrinotata*

(Lepidoptera: Indarbelidae). Survey of the sandalwood plantations revealed the presence of the bark caterpillar in many trees, both young and old. Attack was mostly in the junction of the branches, the tunnels extending to the sapwood. Young saplings show the symptoms of dieback and develop epicormic shoots. The number of infestations indicated by the silken galleries on bark varies from 1-20. Full-grown larvae are 4-5 cm long. Pupation takes place in the shelter tunnels. The life cycle is annual and the moths emerge during May-July. Life cycle is annual and the moths emerge during May-July. Attack was mostly in the junction of the branches, the tunnels extending to the sapwood, Young saplings show the symptoms of dieback and develop epicormic shoots. The number of infestations indicated by the silken galleries on bark varies from 1-20.

Management: Application of Monocrotophos 0.1% or Fenvalerate 0.08% or Quinalphos 0.1% to drench the bore hole; sleeve the surrounding bark. Application of Entomopathogenic fungi Metarhizium anisopliae or *Beauveria bassiana* at the time of emergence of adults.

5.23.6. Red stem borer, moth- *Zeuzera coffeae* (Lepidoptera: Cossidae) (Fig. 168).


Figure 168. *Zeuzera coffeae*

The red borer is a polyphagous pest, which bores into the soft sapwood of saplings and young trees. Young saplings are sometimes killed by the attack.

The larvae enter through the axial of leaf or stem and branch. The tunnels made by young larvae are cylindrical, and those by older larvae are wide with irregular cavities. The life cycle takes about 4-5 months with a larval period of about 3-4 months. The larvae do not attack heartwood.

Life cycle takes about 4-5 months with a larval period of about 3-4 months. The larvae do not attack heartwood. Bores into the soft sapwood of saplings and young trees.

Management: Lopping and burning of infested shoots/ branches. Insertion of thick wire through the bore hole or injecting insecticides like 0.1-0.25% Monocrotophos or dimethoate, quinophos or 0.2% Paradichlorobenzene in kerosene oil and plaster them with wax or mud. Introducing any fumigant and plugging the borer hole also kills the borer. Spraying of fenthion or fenitrothion or phosalone or monocrotophos or etofenprox or cartap hydrochloride or chlorphyrifos, or phenthoate or spinosad at 0.5kg a.i./ha or flubendiamide @ 25g a.i./ha or indoxacarb @0.30kg a.i./ha. Soil application of carbofuran @ 2kg

a.i./ha, or phorate 1kg a.i./ha. Application of Sealer cum healer.

5.23.7. Heartwood borer- *Aristobia octofasciculata* (Coleoptera: Cerambycidae) (Fig. 169).

This is a monophagous borer prevalent in all the sandalwood areas. Saplings and younger trees showed drying of branches and sometimes mortality due to the attack of this pest. Many living trees contain several bore holes leading into long cavities in the heartwood and in older trees, the heartwood is found to be hollow in varying degrees. Saplings and younger trees showed drying of branches and sometimes mortality due to the attack of this pest. Many living trees contain several bore holes leading into long cavities in the heartwood and in older trees, the heartwood is found to be hollow in varying degrees.

Figure 169. *Aristobia octofasciculata*

Management: Lopping and burning of infested shoots/ branches. Insertion of thick wire through the bore hole or injecting insecticides like 0.1-0.25% Monocrotophos or dimethoate, quinophos or 0.2% Paradichlorobenzene in kerosene oil and plaster them with wax or mud. Introducing any fumigant and plugging the borer hole also kills the borer. Spraying of fenthion or fenitrothion or phosalone or monocrotophos or etofenprox or cartap hydrochloride or chlorphyrifos, or phenthoate or spinosad at 0.5kg a.i./ha or flubendiamide @ 25g a.i./ha or indoxacarb @0.30kg a.i./ha. Soil application of carbofuran @ 2kg a.i./ha, or phorate 1kg a.i./ha. Application of Sealer cum healer.

5.23.8. Termites- *Odontotermes* spp. (Fig. 170).

Arboreal termites, *Odontotermes* spp. are often observed in sandalwood plantations. The attack leads to loss of bark, poor health and infestation of stem- boring insects. The infestation is highest (upto 50%) in winter months. It was observed that use of insecticides give adequate protection only up to four months, with decreasing protection thereafter. Infestation is highest (upto 50%) in winter months. The attack leads to loss of bark, poor health and infestation of stem-boring insects.

Figure 170. *Odontotermes* sp.

Management: Drenching of soil with 1.5% Chlorpyriphos, Cypermethrin, Bifenthrin.

5.23.9. Defoliators

a. Nettle grub- *Parasa lepida* (Limacodidae: Lepidoptera) (Fig. 171).

The larvae feed voraciously on the leaf blade including the midrib. Larva blue or green striped „Nettle grub? as is normally known; when fully grown it is 2.25-2.5 cm long and is bright apple green to yellowish –green with a dorsal stripe and lateral stripes of olive, edged with dark blue. The cocoon hemispherical or broadly

flattened, oval with silk webbing incorporating the irritating spines from the body of the caterpillar and is attached to a branch or bark. Forewing of moth with a reddish-brown base and broad pea green or emerald green area crossing the middle of the wing; thorax green and the abdomen brown. Larvae feed voraciously on the leaf blade including the midrib.


Figure 171. *Parasa lepida*

b. *Euproctis fraterna* (Lymantriidae: Lepidoptera) (Fig. 172).

It is a polyphagous species of lymnatrid found feeding in forestry, silvi-horticultural and agro- forestry models. Adult moth is yellow with pale transverse lines and black spots on the forewings. The larvae are reddish brown hairy caterpillar, their head is red in color surrounded by white hairs and abdomen has tufts of hairs all over the body and a long pre anal tuft. Extensive defoliation by the larvae is an indication of its attack, which gives the field a brown, scorched appearance.


Figure 172. *Euproctis fraterna*

5.24. SEMUL (*Bombax ceiba*)

Semul shoot borer- *Tonica niviferana*

Infestation period of insects is May-October. Young larvae bore the shoots from leaf axil under the shelter of silken web.

Management: Collection and destruction of pupae on bark and leaves in March-May and in July-August from seedlings should be done. Soil mixing of sevidol 4G granules or phorate 10 G @ 6 gm/plant is highly effective.

5.25. SIRIS (*Albizia lebbeck*)

5.25.1. Sap feeder

a. *Acizzia indica* and

b. *Psylla hyaline* (Fig. 173)

Infestation period of insects is March-December. The attacked seedlings remain stunted with a bunchy top appearance. The infested leaflets curl and wrinkle with tiny depressions. The honeydew secreted by the nymphs gives way to the development of sooty mold. The seedlings will ultimately dry up.


Figure 173. *Psylla hyaline*

Management: Regular monitoring from the month of March till seedlings are lifted. While arranging beds of Albizia, alternatively arrange 2-3 beds of other species in between the beds of Albizia. Spraying of 5% tobacco extract or 2% Pungam or Neem oil emulsion once in 20 days, followed by one round of dimethoate during June and September soon after the rain. Management of weeds around the nursery can limit the incidence of Psyllids on Albizzia. Segregation of affected seedlings from the main lot will reduce the spread of insect population. Application of 5% Tobacco extract. Spraying of 0.06% of dimethoate or 0.05% of methyl dematon can control the Psyllids.

5.25.2. Sap feeding- Aphids (Fig. 174).

Infestation period of insects is March-October. The attacked seedlings remain stunted with a bunchy top appearance.

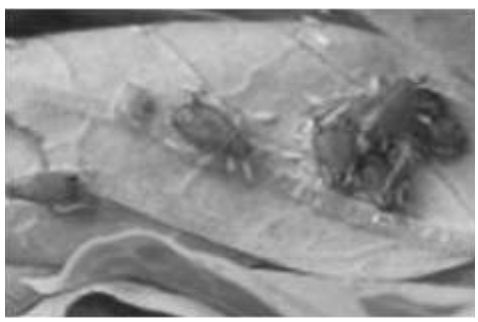


Figure 174. *Aphids*

Management: Regular monitoring from the month of March till seedlings are lifted. While arranging beds of Albizia, alternatively arrange 2-3 beds of other species in between the beds of Albizia. Spraying of 5% tobacco extract or 2% Pungam or Neem oil emulsion once in 20 days, followed by one round of dimethoate during June and September soon after the rain. Management of weeds around the nursery can limit the incidence of Psyllids on Albizzia. Segregation of affected seedlings from the main lot will reduce the spread of insect population. Application of 5% Tobacco extract. Spraying of 0.06% of dimethoate or 0.05% of methyl dematon can control the Psyllids. If sufficient numbers of predatory Coccinellid beetle *Menochilus sexmaculatus* are available during early infestation time, chemical spray can be delayed for 10 days for the establishment natural enemies and control by biological means. If the percentage of damaged seedlings increases, pesticide spray can be initiated.

5.25.3. Defoliator- *Eurema hecabe* (Fig. 175).

Infestation period of insects is September-December. Defoliation by larvae. Slow growth of seedlings, partial or complete drying of seedling.

Figure 175. *Eurema hecabe* larvae

Management: Larvae can be handpicked and destroyed. Beds of Albizzia, Samana saman and Cassia species should not be maintained side by side to avoid build up of the pest. 0.05% monocrotophos or 0.075% dichlorvos spray can be given.

5.25.4. Leaf defoliator- *Rhesala imparata*

Infestation period of insects is May-September. Leaf webbing larva. Usually the larva attacks the tender leaflets emerging after rain. The larvae fold the leaf lets by means of silken web and feed on the leaves from within. They pupate in between the leaf folds. Loss of apical growing shoot tip resulting in development of branching and partial drying of plant.

Management: 5% tobacco extract or 2% Neem or Pungam oil spray can be given every 10 days. The presence of both the early and late stages of caterpillars on the seedlings is very conspicuous. Therefore, hand picking and destruction of larvae to be done during monitoring till the seedlings are lifted. Alternate hosts like *Limonia acidicima* (Wood apple), Citrus and Curry leaf plant in the vicinity should be monitored and pruned if they sustain the pest population. Hand picking and destroying of larvae. If the incidence of larva in seedlings is found, as soon as the seedling put forth new tender leaves a spray of plant extract of Pongam-Neem oil extract or 5% Neem Seed Kernel Extract can be given which can be repeated after a week. If still the problem persists, 0.06% of dimethoate or 0.05% of monocrotophos spray can be given.

5.26. SAFED, SIRIS (*Albizia procera*)

5.26.1. Aphid- *Aphis gossypii*

Infestation period of insects is throughout the year. Nymphs and adults suck sap from shoots and leaves.

Management: Foliar spraying of phosphamidon (dimecron 85 EC) 0.05% i.e. 5.8 ml /10 Lt. water or dimethoate (rogor 30 EC) 17 ml /10 Lt. water should be used.

5.26.2. *Catopsilia crocale*

Infestation period of insects is June-October. Larvae voraciously feed on leaves.

Management: Foliar spraying of malathion 0.05% i.e. 1 ml /Lt. of water.

5.27. SISSOO/SHISHAM (*Dalbergia sissoo / D. latifolia*)

5.27.1. Shisham leaf miner- *Dichomeris eridantis* (Fig. 176-177).

Dichomeris eridantis is an important defoliator of *D. sissoo* particularly in irrigated plantations and in the absence of the principal defoliator *Plecoptera reflexa*, may be of local importance and destroy half the canopy in the month of June to August.


176


177

Figures 176-177. Shisham leaf miner- *Dichomeris eridantis*: 176, blotched leaves and 177, moths

Biology: Moths light fuscous, with narrow oblong forewings, ashy or ochreous grey; slightly speckled with black. Eggs are dull white elliptical in shape. Moths appear in early March from hibernating pupae and start egg lying after two or three days on the underside of leaves. Hatching occurs after two or three days during May to September and 5 days in March and October. The caterpillar feeds on the leaves of shisham within shelters made by rolling a single leaf or more commonly by fastening together two leaves with silk. The inner leaf surface is abraded or small holes are eaten up in the edges of leaf blade, mainly at night. A shelter is often abandoned and a new one is constructed. The caterpillar often uses a silk thread to move about the foliage. Both young and old leaves are defoliated

Management: This defoliator can also be controlled by spraying 0.1% water emulsion of fenitrothion. *Anthia sexgutaltea* is a polyphagous predators attacking caterpillars, pupae and moths of Plecoptera reflexa and *Dichomeris eridantis*. *Chrysoperla carnea* (Neuroptera : Chrysopidae) is an egg and larval predator of *D.eridantis*. Other insect predators of importance are *Hierodula ventralis, Canthecona furcellata* etc. Infestation period of insects is July-October. Feed on young leaves. Leaf rolling, holes in the edges of leaf blade.

Management: Spraying carbaryl 0.1% i.e. 2 gm wettable powder in 1 Lt. water. Spraying 0.1% water emulsion of fenitrothion. *Anthia sexgutaltea, Canthecona furcellata, Hierodula ventralis, Chrysoperla carnea* are some predators for the control.

5.27.2. Shisham defoliator- *Plecoptera reflexa* (Fig. 178-181).

Figures 178-181. Shisham defoliator- *Plecoptera reflexa*: 178, defoliated tree; 179 & 180 larvae and 181, moths

It is a serious defoliator of Dalbergia sissoo throughout India. Moths are grayish brown with irregular bands. Also recorded as a defoliator of Dalbergia latifolia and Pterocarpus marsupium.

Biology: The moths are nocturnal in habit. Eggs are laid during night on young leaves. The female moth lays about 400 eggs. After 4-5 days eggs hatch out. Young larvae feed on tender leaves. When touched they fall down on ground with silken thread. Larval period varies from 10-20 days depending upon temperature. The larvae undergo five moults. Pupation takes place on ground among leaves or loose soil. Pupal covering is made up of silk and debris. The pupal period varies from 5-7 days in hot season and 8-11 days in winter. Hibernation takes place in pupal stage and last for 80-100 days. It completes 10-13 generation in a year. The life cycle is completed in 17-30 days.

Heavy defoliation starts from April onwards. Last brood go into hibernation in October-November. Repeated defoliation during the growing season badly affects the growth increment of the plant. This may cause dying of twigs and leading shoots and epicormic branching. Repeated defoliation may cause death of young plantations.

Management

Attack by the defoliator can be minimized by cultural practices. Emergence of moth can be desynchronized with the appearance of new flush on the plants by giving early irrigation, so that the leaves become matured by the time the larvae appear. As the larvae of this moth form loops hence they are also termed as loopers. The looper was found to be parasitized by *Disophrys sissoo* and *Microgaster plecopterae* etc. Besides *parasitoids, Hierodula ventralis, Deiphobe* spp. (Orthoptera: Mantidae) and *Anthia sexguttata* (Coleoptera: Chrysomelidae) *Canthecona furcellata* (Hemiptera: Pentatomidae) and *Chrysoperla carnea* (Neuroptera: Chrysopidae) are important predators which are helpful in checking the epidemic of these defoliators. 0.1% water emulsion of fenitrothion was found effective to control the population Plecoptera reflexa.

Infestation period of insects is July-October. Green colored looper larvae feed on young fleshy leaves. Dying of twigs and leading shoots and epicormic branching.

Management: Spraying carbaryl 0.1% i.e. 2 gm wettable powder in 1 Lt. water. Emergence of moth can be desynchronized with the appearance of new flush on the plants by giving early irrigation, so that the leaves become matured by the time the larvae appear. 0.1% water emulsion of fenitrothion was found effective.

5.28. TEAK (*Tectona grandis*)

5.28.1. Canker grub of Teak- *Dihammus cervinus* (Fig. 182).

Adult beetles girdle the teak stem near the base, this injury results in hypertrophy of the tissue. Continued hypertrophy results in formation of a round bulbous callus. Cankers are found usually near the base but sometimes 3-4 feet above the ground.

Management: Insertion of thick wire through the bore hole or injecting insecticides like 0.1-0.25% Monocrotophos or dimethoate, quinophos or 0.2%. Paradichlorobenzene

Figure 182. *Dihammus cervinus*

in kerosene oil and plaster them with wax or mud. Introducing any fumigant and plugging the borer hole also kills the borer.

5.28.2. Leaf skeletonizer- *Eutectona machaeralis* (Fig. 183).

Figure 183. *Eutectona machaeralis*

Infestation period of insects is July-October. Larvae feed on green tissue of leaf and skeletonize it. Leaf skeltonizing retards the seedling growth and during severe damage seedlings dries.

Management: Regular monitoring throughout the raising period particularly soon after the monsoon rains. Install light traps to monitor and trap adult moths. Leaves folded at the margins can be located and insect larva can be plucked every 10 days and destroyed. Spray of Neem oil or Pungam oil emulsion can be done 15-20 days interval to deter the caterpillars. Foliar spraying of 0.01% alphamethrin or 0.02% cypermethrin (2 ml /5 Lt. water) or 0.005% deltamethrin (9 ml /5 Lt. water) is recommended for control. Introduction of egg parasitoid, Trichogramma raoi @ 1.25 lakhs/ ha between June to October in 5 installment should be done.

5.28.3. White grubs- *Holotrichia* spp.

Infestation period of insects is June-September. Wilting of the seedlings; Grubs feed roots.

Management: Sandy soil should be avoided for raising seedlings. Semi decomposed FYM should not be used. Soil working should be avoided during monsoon i.e. June –July. Soil mixing of Phorate 10 G @ 200 gm/ bed (size 10 x 1 m) should be used.

5.28.4. Teak defoliator- *Hyblaea puera* (Fig. 184).

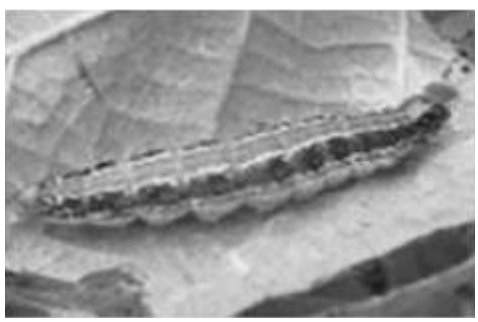


Figure 184. *Hyblaea puera* larva

Infestation period of insects is June-October. Larvae defoliate seedlings, young and old trees. Early larval stages feed by scraping on the leaf surface. Late stages feed on the whole leaves. They also cut flaps of leaf edge, ties up with silk, remain inside and feed from within. Defoliation leads to complete drying of seedlings.

Management: Regular monitoring throughout the raising period particularly soon after the monsoon rains. Install light traps to monitor and trap adult moths of *Hyblaea puera*. Leaves folded at the margins can be located and *Hyblaea puera* larva can be plucked every 10 days and destroyed. Spray of Neem oil or Pungam oil emulsion can be done 15-20 days interval to deter the caterpillars. 0.05% monocrotophos or 0.076% dicholrvos can be sprayed. *Bacillus thuringiensis* at 1.5% concentration is effective.

5.28.5. Sap sucker- *Tetranychus urticae* (Fig. 185).

Infestation period of insects is June-September. Presence of chlorotic spots which coalesce into pale

patches. There will be extensive webbing underneath the leaves. Leaves start drying from the edges and slowly wither away.

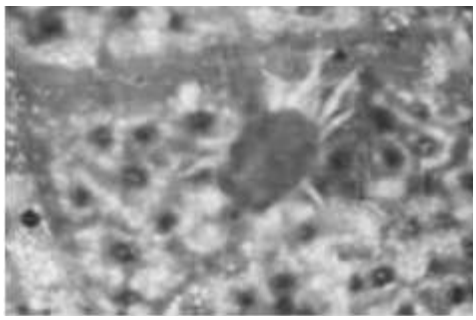


Figure 185. *Tetranychus urticae*

Management: Application of 2 % Neem oil emulsion pointed towards the under-side of the leaves can reduce the population level. 2.5 ml of dicofol per liter of water can be applied during severe infestation.

5.28.6. *Tingis beesoni*

Infestation period of insects is march-November. The leaf lamina becomes spotty with brownish patches near the base. Leaf ultimately withers and leading to complete defoliation of the plant. Stunty growth with side shoot growth and plant become bunchy.

Management: Application of 2 % Neem oil emulsion pointed towards the under-side of the leaves can reduce the population level. 2.5 ml of dicofol per liter of water can be applied during severe infestation. Spraying of foliage with 0.05 to 0.075 % water emulsion of Dimethoate (Rogor) 2-3ml/liter or methyl demeton 20 EC 2 ml/liter or monocrotophos 36 EC 1.5 ml/liter or phosphamidon 40 SL 2ml/liter. control the pest.

5.29. TENDU (*Diospyros melanoxylon*)

5.29.1. Tendu leaf defoliator- *Hypocala rostrata*

Infestation period of insects is April-October. Larvae feed on the leaves of tendu.

Management: Spraying of fenvalerate 20 EC i.e. 0.5 ml /lit. of water.

5.29.2. Psyllid- *Trioza obsolete*

Infestation period of insects is April-June. Nymphs/adults suck the sap from the leaves and makes the galls.

Management: Spraying of synthetic pyrethroides like cypermethrin or fenvalerate 0.03% twice in March-April at 15 days interval or Monocrotophos 0.03% proved to be next. Pruning should be done in the first week of March for reducing.

5.30. TOON, MAHOGANY (*Swietenia* spp.)

5.30.1. Meliaceae/Toon or Mahogany fruit and Shoot-Borer, *Hypsipyla robusta* (Lepidoptera: Pyralidae) (Fig. 186-188)

Major Host Plants: *Cedrela toona, Chickasha tabularis, S. macrophylla, S. mahagoni*

186

188

187

Figures 186-188. Toon or Mahogany fruit and Shoot-Borer, *Hypsipyla robusta*: 186, tip of young plant bored; 187, tunnel by the larva and 188, moth

Distribution: Sub-tropical and tropical forests of Indo-Malayan region, Australia, Africa, West Indies and South America.

Fruit or seed pest is capable of destroying the greater part of the seed crop of *cedrela tona* and *Carapa molucccensis* in India. As a shoot borer of young trees of Cederela and Swietenia, it attacks seedling of various growth when they are as young as three months and less than on foot high; in plantations a 100 % infestation may be raised in the second year; later on the liability of the sapling or pole depends not so much on each age as on the density of stocking and on each rate of growth and less frequent production of soft green shoot; older trees in which height growth has ceased are less liable to serious attack because the production and elongation of the terminal shoot is seasonally restricted and the borer cannot breed continuously in older stand. The combined work of the shoot generations on young cedar and mahogany trees may completely nullify the season growth; not only are the leaders of the current year killed of the laterals which have made progress on the woody stems of the previous years. The growth of the sapling appears to be completely checked but in the course of time, occasional shoots escape the borer and become lignified so that some upward progress made. Frequent bifurcation produces a dense bush plant.

Infestation period of insects is April-June in trees and most of the year in young plants. The life cycle and sequence of generation vary with the food plant and the climate of the region. It can be found on the species throughout the year feeding on different parts of the tree with following generations:

1. Flower generation: The eggs of the first generation are laid on the flowering shoots, early in March. Each female lays about 400-600 eggs the larva feed on the all parts of the inflorescence binding together individual adjacent flowers into bunches with loose silken net work. A panicle in which a colony of larva has fed remains a ragged mass of shriveled floral fragments long after the dispersal of the larvae. The life cycle lasts for 24- 29 days. Egg 4-5 days, larval stages 4 + 2 + 2 + 4, pupa 8 –12 days; the earliest moths appear in the last week of March. This generation lasts for 8 to 9 weeks.

2. Fruit generation: This is the second generation, which starts after the falling of all the flowers and setting of fruit pods. The second-generation larvae feed on the young and soft fruits. Older larvae feed on the mature fruits and feed inside them and hollowing them. Feeding habit is the same as in flower generation four to seven fruits are bound together with the silken network. The larva inside the seed seals the exit hole with the excrement and silken threads. The life cycle lasts for 28-29 days. The moths appear in the last half of April.

The pupation of the first and second generation takes place in the crevices of the tree trunk. The larvae descend the branches with the silken threads and search for the suitable place in the bark for pupation. In the heavy infested trees, the pupation takes place in mass. There may be two to three layered, the concentration of pupae may run into 1000 per square foot.

3. The shoot generations: The third, fourth and fifth generations are passed on the shoots. Larvae feed on the soft tissue of the new branches. Eggs are laid on the new unopened leaves, larva on hatching descends to the stouter part of the growing shoots and feeds by removing the epidermis by irregular patches, at the same time testing the shoot for a suitable spot to enter. If too vigorous tissue is selected as the site of entry the attack fails and a flow of sap or gum drowns or entraps the larval; constant tapping of the sap weakens the shoot and the larva eventually gain an entry. Once established with in the shoot it excavates a central tunnel in the pith and increases it gradually until it may be two feet long. The larva usually remains in one shoot throughout each life but, in the later instars, may abandon a stunted shoot and attack second one at the axil of smaller twig. A gummy mass of frass bound with silk marks the entrance hole. The shoot above the entrance hole dies or shrivels, eventually falling over or breaking off. Below the site of entry, the shoot with each ends and lateral shoots dies and dries up as far downwards as the tunnel extends. Pupation of these generations take place inside e the shoot tunnel. Third and fourth generations last for 65- 80 days. The fifth generation over winters as fourth and fifth instar and lasts for 150-170 days.

Management: Application of thimet 10G @ 5-10 grams per polypot in soil or spray 0.01%-0.02% dimethoate or monocrotophos.

5.31. TREE BEAN (*Parkia timoriana*)

5.31.1. Bark eating caterpillar- *Indarbela quadrinotata* Galleries/tunnels made up of frass woven with silken threads.

5.31.2. Stem borer grub- *Coptops aedifecator* (Fig. 189).

Tunnels on the cambium region of the trees. The pests make the holes in the stem/branches of the tree like the shot of a gun on any surface.

Figure 189. *Coptops aedifecator*

Management: Painting of a mixture of Malathion

50% EC: lime powder (1:10) at the base of the affected trees is found to check further spread of the mortality.

5.32. WILLOW (*SALIX* SPP.) *Yponomeuta rorellus* (Lepidoptera: Yponomeutidae) (Fig. 190-193).

Bionomics: Moth forewing elongated, uniformly silver grey sprinkled with grayish, very small black dots present on whole surface. Hind wing dark fuscous-grayish, posteriorly clothed with hairy scales. Eggs were

Figures 190-193. *Yponomeuta rorellus*: 190, larva feeding on leaf; 191, silken webs made by the larvae; 192, pupae on the tree trunk and 193, moth.

light to dark grey, flat and laid in masses on the bark of tree and young twigs and shoots. The eggs hatched during the spring season in the month of May. After hatching larvae remain under the protection of the egg masses for some time. They then spin a communal web over the developing foliage and feed within or in the neighborhood of the web, extending it as the leaves are consumed. There were 5 larval instars during the larval period. Larval period lasted about 41-45 days. Entire willow tree s may be defoliated in cases of severe infestation. Fifth instar full-grown larvae usually pupate within their web. It completed only one generation in a year in cool arid zone of Ladakh.

Host Plants: *Salix* spp. *Salix alba*, *S.caprea, S. fragalis, S. matsudana, S. viminalis, S.tetrespecturm, S.wallichiana,* and *S.dephnoides.*

Nature of damage: Ermine moth formed web on willow trees and caused severe defoliation, thus eating away available biomass and reducing the photosynthetic efficiency of the tree. They gave a complete burnt look to the willow plantation when viewed aerially. The larvae start feeding from first week of May on leaf

buds, which was slow initially till second week of May. The first instars larvae emerged and active during first week of May. The feeding of first instars larvae was slow and caused no remarkable damage. The larvae were yellow with black prominent head. The stage lasted for 7-9 days. The second instar larvae color changed to creamish-white and completed the stage in 13-16 days. The color of third instar larvae changed into light green to gray. They had four black larger hairy spots. The feeding rates of larvae were increased and they feed on tented twigs. They completed this stage in 7-9 days. The fourth instars larvae were dull green or dull gray and fifth abdominal segments turned light pink in color. This stage feed in webs and lasted for 6-8 days. The color of fifth instar larvae was changed into olive green or complete grey with dark spot on abdominal segments. The period of this stage in ranged from 5-7 days. There was 90-100% defoliation on Broqchang type willow (Salix fragilis L), while Mulchang type willow had very less infestation.

Management: Defoliator can be controlled by spraying of Malathion @ 100ml in 100 liter of water in the month of May - June. It can also be controlled by spraying of Nimbecidine @ 400 ml in 100 liter of water. Resistant planting stock like *Salix fragilis* L (Broqchang Type) reported to be highly susceptible to this defoliator. The other species of willow-*Salix alba*, *S. caprea* (Mulchang type) are reported to be more resistant to pest infestation.

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