

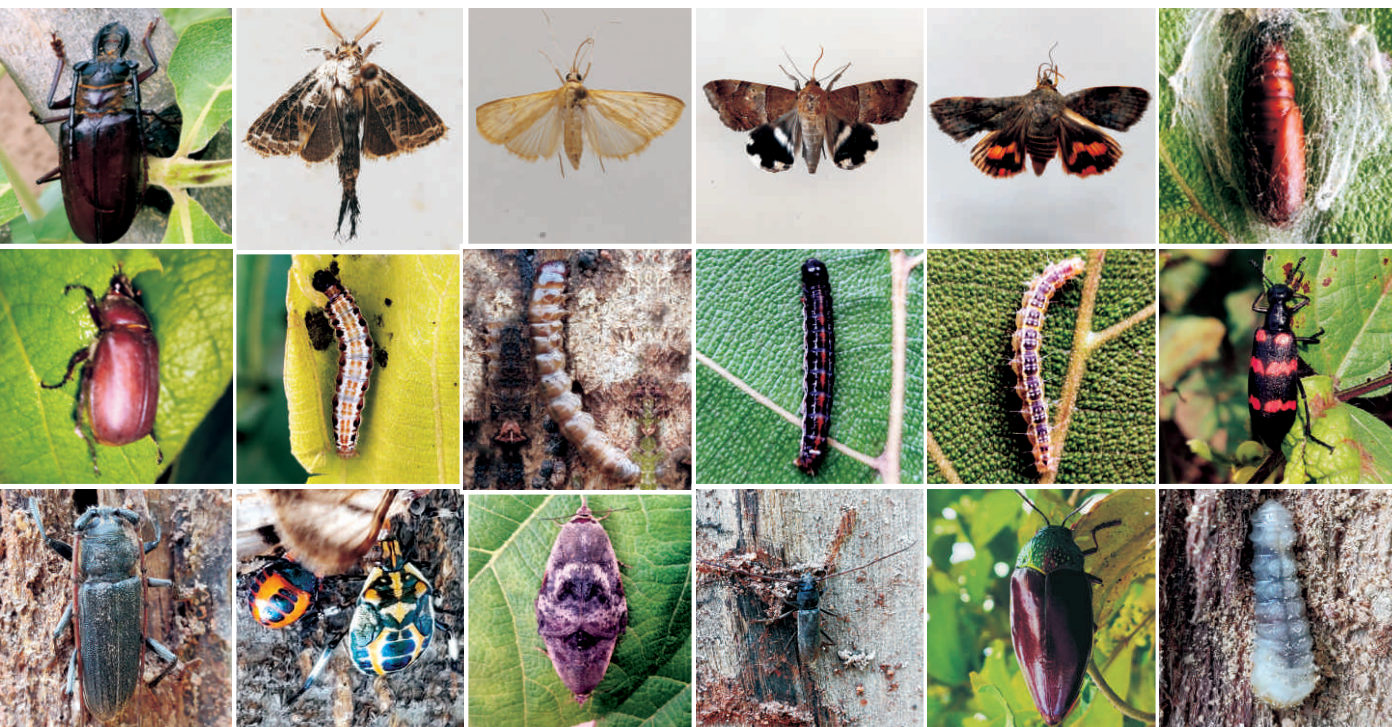


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Insect Pests in Agroforestry

A Ready Reckoner

YN Venkatesh, M Ashajyothi, R Vishnu, AK Handa and A Arunachalam



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Near Pahuj Dam, Gwalior Road, Jhansi 284003, Uttar Pradesh, India

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The document has been prepared fully in academic spirit for educational and ready reckoning purposes so that apt measures are taken to control diseases in agroforestry trees and bamboo. The information in the document is based on primary observations and secondary information from published sources.

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Foreword



Agroforestry as a farming practice is age old but the science of agroforestry is taking new turns to reveal the best of nature with thorough scientific understanding. Unlike conventional agricultural landscapes based on monoculture systems, agroforestry provides both the environmental benefit as well as food and nutrition security. To promote the large-scale practice of the same, requires quality planting material.

However, insect pests and diseases are common problems in nurseries and established plantations which reduces the chance of further survival and economic value of perennial component of agroforestry in the main field. The knowledge on seasonal variation in occurrence of insect pests on important agroforestry tree species and their management is still scarce. New scientific reports on insect pests from various parts of the country also stress up on the changing climate in terms of rain fall pattern, temperature fluctuations, relative humidity variation on insect dynamics and diversity. The information on these factors and their correlation with the existing weather will help us to predict the pattern shift of biotic agents and their damage estimation.

Keeping this background, a ready reckoner on "Insect Pests in Agroforestry" comprising seven major agroforestry species including Teak, Sandal, Eucalyptus, Malabar neem, Poplar, Bamboo and Indian rosewood which are prominent in the Indian agroforestry systems, has been prepared to supplement the needs of agroforestry practitioners those who involved in nurseries and plantation management. This document provides highly useful basic information of tree systematics, distribution, major insect pest variation and their management methods.

(Sunil Chandra Dubey)



Preface

The ready reckoner on 'Insect pests in Agroforestry' is a result of a discussion at ICAR-Central Agroforestry Research Institute on status of current insect pest scenario on important agroforestry tree species and available management strategies. As per our knowledge there has been no such document dedicated in this regard for agroforestry practitioners, extension workers, students etc. Therefore, we attempted to fulfil the information gap by including seven important agroforestry tree species (teak, sandal, eucalyptus, malabar neem, poplar, bamboo and Indian rosewood). This publication provides basic tree biosystematics, distribution data in the world as well as in India, most commonly occurring insect pests, their nature and symptoms of damage and integrated management practices to be followed for each major Insect pests. This publication is an outcome of secondary information sourced from various scientific reports and data.

We do understand that the usefulness of this ready reckoner will be ultimately decided by the stakeholders. However, the feedback on this effort will help updating the information from a scientific perspective. The information on new insect pests outbreak reports, major insect pests of economic importance and their management practices will be extended to other forestry/agroforestry tree species in further editions.

**YN Venkatesh
M Ashajyothi
R Vishnu
AK Handa
A Arunachalam**



Acknowledgement

Authors are thankful for the financial support provided by the ICAR-Central Agroforestry Research Institute to bring this document. This publication has been prepared to have it as first-hand information on insect pest management in agroforestry nurseries and plantations. We acknowledge the works of scientific fraternity who has been publishing in this reference area and dedicated their time to generate valuable information through various books, journals and scientific reports of insect pests on important agroforestry tree species. Authors are thankful to Director, ICAR-CAFRI for guidance, support, design and conceiving the idea of bringing this publication for the benefit of agroforestry practitioners to promote agroforestry at national level.



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1

Teak (*Tectona grandis* L.)

Teak is one of the most promising tree species considered as “royal tree” suitable for agroforestry. It is economically valuable because of its wood characteristics like colour, figure, grain, high dimensional stability and most importantly its high durability. The superior qualitative properties of teak incited itself as one of the potential commercial tree species globally. Besides, teak has the potential to tolerate termite attack and wood-decaying fungi which are the characteristic features owing to its demand worldwide used as furniture, shipbuilding and decorative components. Besides, teak provides several beneficial eco-system services such as carbon sequestration, stand structural diversity to maintain environmental biodiversity, beautification across the roadside/ as ornamental outside forest areas, shade provision, windbreak, soil micro fauna diversity and microbial density subsequently maintain soil fertility, water conservation through runoff control.

1.1 Plant systematics

Kingdom : Plantae
 Clade : Tracheophytes
 Order : Lamiales
 Family : Lamiaceae
 Genus : *Tectona*
 Species : *T. grandis*



Teak seedling



Teak trees



Foliage

1.2 Distribution

Teak considered as one of the world's premier hardwood species. Its natural distribution area encompassing parts of India, Myanmar, Thailand and Laos. The teak

plantation also naturalized in Java, Indonesia, where it was probably introduced about 400 to 600 years ago. Teak has been introduced in different parts of the world outside its natural occurrence in South-east Asia, Pacific, East and West Africa, Australia, the Caribbean islands, South America and Central American regions.

1.3 Insect pests

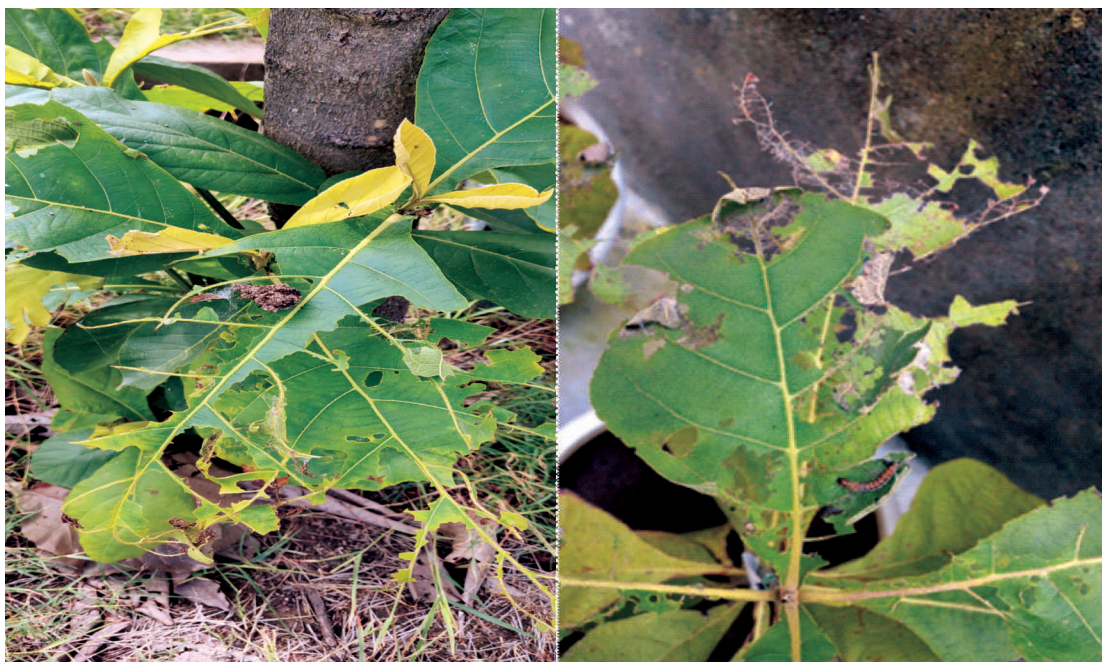
Teak saplings are prone to many insect pests, mainly two species of defoliators i.e., Teak defoliator (*Hyblaea puera*) and teak skeletonizer (*Eutectona machaeralis*) damage extensively in all stages of growth. Other commonly occurring major pests are Teak sapling borer (*Sahyadrassus malabaricus*), Trunk borer (*Alceterogystia cadambae*), Bark eating caterpillar (*Indarbela* spp.) and White grubs (*Holotrichia rustica*, *Holotrichia mucida*, *Schizonychia ruficollis*).

1.4 Major Insect pests in Teak

1.4.1 Teak Defoliator -*Hyblaea puera* (Lepidoptera: Hyblaeidae)

Nature and symptoms of damage

- The neonate larva feeds on foliage to leave a shallow depression on the surface of the tender leaf and protects itself with strands of silk
- The first and second instars feed mainly on the leaf surface, third instar larva cuts out a leaf flap, folds it over with silk and feeds within
- The larvae consume the entire leaf leaving only the major veins of the tender leaf



Foliar damage symptoms of *Hyblaea puera*



Larva

Pupa

Adult moth

Management:

- Deep summer ploughing
- Collection and destruction of egg masses and larvae
- Spraying entomopathogenic fungus *Metarhizium anisopliae* @ 2-5 g/litre
- Spraying Spinosad 45% SC @ 0.4 ml/L (or) Navaluran 10 EC @ 1 ml/L (or) Profenophos 50 EC @ 0.9 ml/L (or) Indoxacarb 14.5 SC @ 0.5 ml/L (or) Chloropyrifos 20 EC @ 1 ml/L

1.4.2 Teak skeletonizer - *Eutectona machaeralis* (Lepidoptera: Pyralidae)

Nature and symptoms of damage

- Early instar larvae feed initially on the superficial epidermal cells of the leaf lamina under a protection of open silken web
- Later instar larva skeletonizes the leaf completely



Foliar damage symptoms of teak skeletonizer, *Eutectona machaeralis*



Larva

Pupa

Adult moth

Management:

- Deep summer ploughing
- Collection and destruction of egg masses and larva
- EPN (Entomoparasitic Nematode), *Heterorhabditis indica* @ dose of 30 ijs (infective juveniles) larvae/ acre
- Spraying of *Bacillus thuringiensis* (B.t) @ 1.5%
- Spraying of Flubendiamide 480 SC @ 0.3 ml/l (or) Spinosad 45% SC @ 0.4ml/l (or) Emamectin benzoate 0.5 SG @ 0.2 g/l / Novaluran 10 EC @ 0.75 ml/l / Profenophos 50 EC @ 1ml/l / Indoxacarb 14.5SC and Chlorantraniliprole 18.5SC @ 0.2 ml/l

1.4.3 Teak sapling borer *Sahyadrassus malabaricus* (Lepidoptera, Hepialidae)

Nature and symptoms of damage

- The larva excavates a long cylindrical tunnel equal to the diameter of the larva, longitudinally along the pith
- Bark is browsed in a ring around the entire girth of the sapling
- The tunnel can be an entry point for many wood-decaying fungal species
- The larva bores into the stem of saplings and lives in a tunnel along the pith
- The mouth of the tunnel is covered by a thick mat of wood particles spun together with silk, underneath which the larva feeds on the callus tissue

Management:

- Killing the larva physically by inserting a twig or sharp wire into the borer hole
- Plugging the borer hole with tar
- Injecting insecticide into the borer hole by syringe
- Application of kerosene or petrol at 5 ml/hole and plugging it with mud

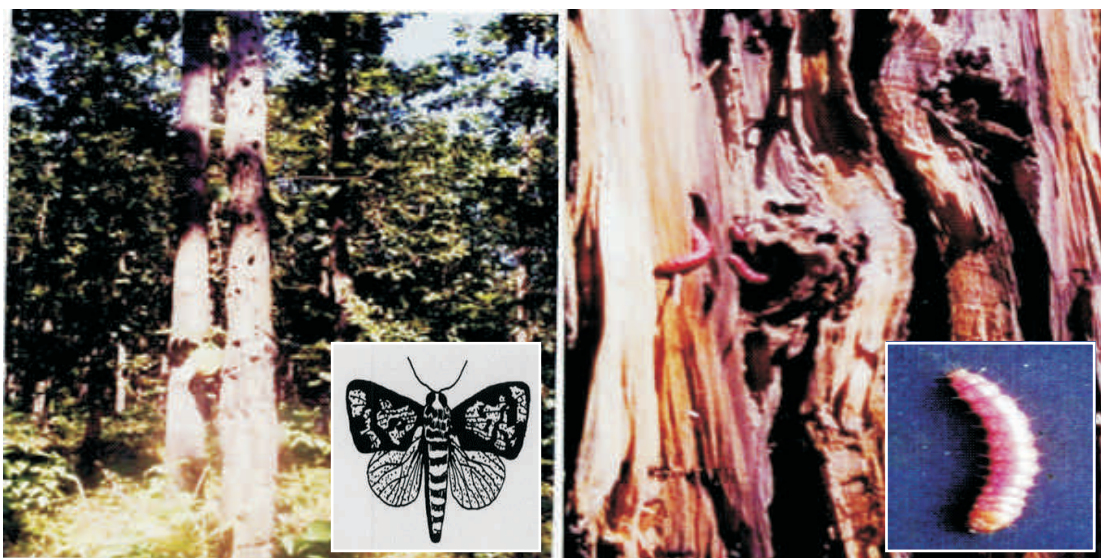


(Pc: K. Nair, 1982 and R.R. Rishi et al., 2018)

1.4.4 Trunk borer - *Alcterogystia cadambae* (Lepidoptera: Cossidae)

Nature and symptoms of damage:

- Larva feed on the bark including outer sap wood that results in girdling of shoots
- Infected trunk shows holes and initially larva feed on sap wood and later feed on heart wood
- Greater number of holes results in drying of trees
- Presence of excreta on trunk is another indication of the damage



(Pc: Santhosh , 2002)

Management:

- Remove all affected teak trees or extraction of all trees with low infestation during routine silvicultural thinning will prevent outbreak of pest
- Suppressing the existing population by treating affected plants with fumigants

- Destruction of larva in the soil at the time of pupation by summer ploughing

1.4.5 Bark eating caterpillar - *Indarbela* spp (Lepidoptera: Cossidae)

Nature and symptoms of damage:

- The sleeve-like structure made up of frass and excreta extending from the borer holes are seen on the trunk of affected trees
- Extensive bark injury as well as tunnelling into the wood affect the vigour of the trees
- The affected trees may also get exposed to infestation by various pathogenic organisms which result in the die-back and rotting of the trees



Healthy teak trunks



Damaged teak trunks

Management:

- Removal and destruction of dead and severely affected branches of the trees
- Swab coal tar + kerosene @ 1:2 (or) Carbaryl 1 50 WP @ 20 g/litre of water on the basal portion of the trunk up to 3 feet height
- Scraping the loose bark and subsequent padding with Imidacloprid 18.5 SL @ 0.5 ml/L prevent oviposition by adult beetles
- Hook out the caterpillar from the bore hole and application of carbofuran 3G @ 5 g per hole and plug with mud

1.4.6 White grubs: *Holotrichia rustica* (Coleoptera: Melolonthidae)

Holotrichia mucida

Schizonycha ruficollis

Nature and symptoms of damage:

- The newly hatched grubs inside the soil grow by feeding on the roots and rootlets, thereby leading to external symptoms of wilting and plant mortality
- Adult beetles will be active in the field after dusk only for 18-19 days and feed on teak during night, before sunrise, enters teak bed and lay eggs



White grub damaged field



Larvae



Adult

Management:

- Deep summer ploughing
- Set-up bonfire or light traps immediately on receipt of first shower in monsoon
- Collect the adult beetles from their hosts and destroy them
- Root treatment with chlorpyrifos 20EC or quinolphos 25EC @ 12ml/kg
- Soil application of carbofuran 3G @ 12.5 kg/ha at the time of planting
- Apply *Metarhizium anisopliae* @ 5-10 kg/ha mixed with 500 kg of FYM and vermicompost
- Soil drenching with chlorpyrifos 20EC @ 10 ml/l in affected plants and surrounding plants

2

Indian sandalwood tree (*Santalum album* L.)

Indian Sandalwood is one of the most economically valuable tree species in the world because of its scented timber and oil. Sandalwood tree is mainly exploited for its heartwood which yields the renowned East Indian Sandalwood oil, rated very high for its sweet, persistent, spicy, warm, tenacious aroma and fixative property. Sandalwood and its oil have been used in religious rituals and Ayurvedic medicine for millennia. It is deeply associated with the social rituals of Indians and has held a special place in all the major religions of India. The current interests in sandalwood oil are growing in the aromatherapy, cosmetics and food industries due to its sedative action and fragrance. Wood also used for making fine furniture and for carving.

2.1 Plant systematics

Kingdom : Plantae

Clade : Tracheophytes

Order : Santalales

Family : Santalaceae

Genus : *Santalum*

Species : *S. album*



Seedling



Sandalwood tree



Foliage

2.2 Distribution

Indian sandalwood is an evergreen tree commonly found in dry deciduous forests of India. It is indigenous to peninsular India and can adapt well in various agro-climatic conditions. It is distributed 30°N to 40°S from Hawaiian Archipelago in the north to New Zealand in the south and from Indonesia in the east to Juan Fernandez Islands (Chile) in the west. In India, its natural distribution is confined to southern parts of India especially in Karnataka, Tamil Nadu and Kerala. However, it is introduced to Northern, Central, Northwestern and Northeastern India because of its huge market price and economic yield.

2.3 Common Insect pests

To fetch maximum returns sandalwood plantations, require many years and the initial care taken right from seedling stage to main field only will ensure the sustainable healthy sandalwood production without pest and disease damage which otherwise severely effect the market value. Young saplings are bored by larvae of Coffee borer (*Zeuzera coffeae*), Striped Mealy Bug (*Ferrisia virgate*) and Sandal spike (*Phytoplasma*) transmitted by leaf hopper (*Jassus indicus*) is another menace in sandal cultivation.

2.4 Major Insect pest in sandalwood tree

2.4.1 Coffee borer-*Zeuzera coffeae* (Lepidoptera: Cossidae)



Healthy leaves



Damaged tree

Nature and symptoms of damage

- Moths tunnel the heartwood of living trees causes a J-shaped tunnel
- The large holes usually cause smaller trees to become more susceptible to wind damage
- Degrades timber value

Management:

- Injecting any one of the insecticide into the tunnel and block the hole with mud after treatment (Flubendiamide 480 SC @ 0.75 ml/litre or Spinosad 45% SC @ 0.4ml/litre or Emamectin benzoate 0.5 SG @ 0.2 g/litre or Novaluran 10 EC @ 0.75 ml/litre or Profenophos 50 EC @ 1ml/litre or Indoxacarb 14.5 SC or Chlorantraniliprole 18.5SC @0.2 ml/litre)

2.4.2 Striped Mealy Bug *Ferrisia virgate* (Hemiptera: Pseudococcidae)

- Nymphs and adults suck the sap from branches and leaves leads to honeydew secretion which results wilting of seedlings



Management:

Infected branches and leaves

(Pc: R. Shanbhag et al., 2017)

- Spray Dichlorvos 1ml/litre(or) chlorpyrifos 1.5ml/litre (or) buprofezin 25SC @1.0-1.5 litre
- Make sure the coccinellid predator beetle, *Scymnus coccivora* presence in plantation area by judicious application of chemicals

2.1.3 Leaf hopper -*Jassus indicus* (Hemiptera: Cicadellidae)

Nature and symptoms of damage

- Distorted leaves and branches
- Chlorosis, stunting and bushy appearance of the plants with no flowers and fruits
- Death of the plants after 1 or 2 years at young age
- Most importantly it serves as a vector for Sandal spike disease (*Phytoplasma*)



Healthy sandal plant



Deformed sandal plant

(Pc: Arun et al. 2012)

Management:

- Use healthy seedlings developed from tissue culture
- Removal of phytoplasma infected plants
- Inject tetracycline to the affected tree trunk
- Spray chlorpyrifos 20EC @1 ml/litre on affected plants

3

Eucalyptus (*Eucalyptus grandis*)

Eucalyptus commonly known as rose gum, is an attractive, straight-trunked tree with multiple utilities. It is mainly used for veneer and plywood because of its light, fairly hard, straight grained and medium textured wood. Since it is available in excellent widths and lengths in lumber, *E. grandis* is being considered as a possible alternative for a variety of hardwoods, including mahogany. Common uses of structural timber of this species include cabinetry, furniture, doors and windows, millwork, interior flooring, moldings, decking, exterior siding and trim, and outdoor furniture. *Eucalyptus grandis* is an important source of pulp to produce printing, writing, specialty and tissue papers. This is widely planted as ornamental shade tree along roadsides and as windbreaks in agroforestry systems. The leaves yield 0.3 - 4.7% essential oil which is used in aroma industry. Traditional healer use eucalyptus oil to treat many illnesses such as infections, colds, flu, sore throats, bronchitis, pneumonia, aching, stiffness, neuralgia, and as an antibiotic and anti-fungal agent.

3.1 Plant systematics

Kingdom : Plantae
 Clade : Angiosperms
 Order : Myrtales
 Family : Myrtaceae
 Genus : *Eucalyptus*
 Species : *E. grandis*

3.2 Distribution

Eucalyptus is native to Australia cultivated throughout the world and distributed widely in the tropical and temperate regions including America, Europe, Africa, the Mediterranean Basin, the Middle East, China and the Indian subcontinent. In India it was first introduced in the state of Karnataka by Mysore Emperor (Tipu Sultan) first and now widely cultivated in Andhra Pradesh, Bihar, Goa, Daman and Diu, Gujarat, Haryana, Kerala, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal.

3.3 Insect pests

Eucalyptus is attacked by various insect pests which cause severe losses at nursery level and also in main field. Some of the economically important pests are Eucalyptus gall wasp (*Leptocybe invasa*) and Erythrina gall wasp (*Quadrastichus erythrinae*) which are invasive species besides Termites (*Microtermes* spp. and *Odontotermes* spp.) and Bark eating caterpillar (*Indarbela* spp.).



Seedling



Nikgiri trees



Foliage

3.4 Major Insect pests in *Eucalyptus*

3.4.1 *Eucalyptus* gall wasp - *Leptocybe invasa* (Hymenoptera: Eulophidae)

Nature and symptoms of damage

- Damage to young foliage by inducing a typical bump shaped galls on petiole and leaves
- Leaf deformity due to which plant growth is retarded
- Severe damage can be observed in nurseries



(Pc: R. Hassan 2012)

Management:

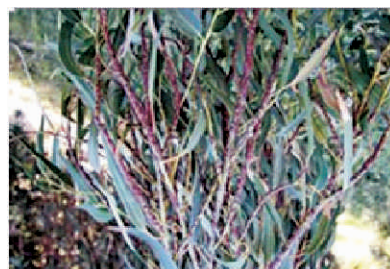
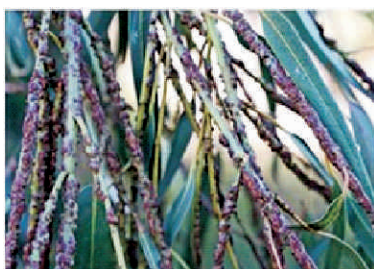
- Continuous monitoring and pruning infected shoots of seedlings in nursery and sapling stage

- Fogging with synthetic pyrethroids in nursery
- Spray systemic insecticides like Dimethoate (or) Imidacloprid @0.3 to 0.5 ml/litre

3.4.2 *Erythrina gall wasp - Quadrastichus erythrinae* (Hymenoptera: Eulophidae)

Nature and symptoms of damage

- Causes galls on stem, petiole and leaf lamina
- Enlargement and malformation of branches
- Stunting and finally drying up of the entire plant



(Pc: La Salle J et al., 2009)

Management:

- Continuous monitoring and pruning infected shoots of seedlings and saplings
- Fogging with synthetic pyrethroids in nursery
- Spray systemic insecticides like Dimethoate (or) Imidacloprid @0.3 to 0.5 ml/litre

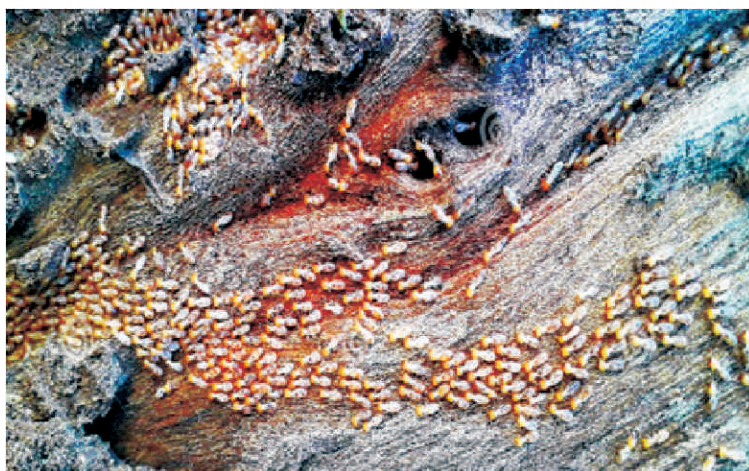
3.4.3 *Termites - Microtermes spp. & Odontotermes spp.* (Isoptera: Termitidae)

Nature and symptoms of damage

- Attack on the trunk results in wilting of the tree
- Termite mounds seen at the base of the trunk



Healthy tree trunk



Termite attacked trees

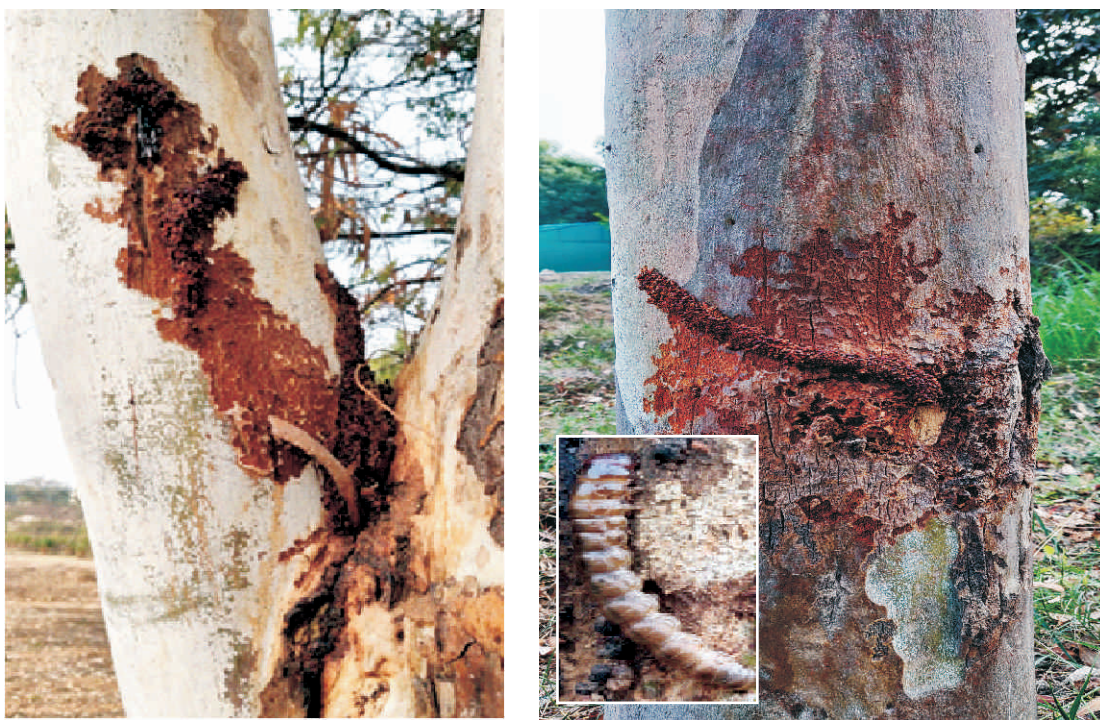
Management

- Locating termite mounds in and around the field
- Destroying the termite mounds along with the queen
- Drenching/application of chloropyriphos 20 EC @ 2-3 litre per acre mixed in 500-1000 litre of water on the termite mound's with solution
- Irrigating the crop regularly to reduce the incidence

3.4.4 Bark eating caterpillar - *Indarbela* spp. (Lepidoptera:Cossidae)

Nature and symptoms of damage:

- Young trees more susceptible to the attack
- Caterpillars bore into the trunk and junction of branches
- Presence of gallery made out of silk and frass can be clearly spotted at damage site
- Caterpillars remain hidden in the wood tunnel during day time and come out at night to feed on the bark
- Loss of timber quality and weakens the tree make it prone for secondary infections



Damaged tree trunk

Management

- Removal and destruction of dead and severely affected branches of the trees
- Swab coal tar + kerosene @ 1:2 or Carbaryl 50 WP @ 20 g/litre of water on the basal portion of the trunk up to 3 feet height
- Scraping the loose bark and subsequent padding with monocrotophos 36 WSC @ 10 ml in 2.5 cm / tree soaked in absorbent cotton prevent oviposition by adult beetles
- Hooking the caterpillar out from the bore hole and placement of carbofuran 3G @ 5 g per hole and plugging them with mud

4

Malabar neem (*Melia dubia*)

Malabar neem is a fast-growing short rotation agroforestry tree species. Its wood is mainly used for making plywood. It has been identified as an alternate species for high quality pulpwood. The wood is also used for packing cases, match box sticks, photo frames, pencils, mini furniture, musical instruments, ceiling planks, agricultural implements etc. *Melia dubia* is a promising tree for agroforestry because of its short rotation of 8 to 12 years. In addition to this, its leaf is used for several medicinal purposes and used as fodder during off season.

4.1 Plant systematics

Kingdom : Plantae
 Clade : Tracheophytes
 Order : Sapindales
 Family : Meliaceae
 Genus : *Melia*
 Species : *M. dubia*



4.2 Distribution

It is an indigenous species of south-east Asia and Australia belonging to family Meliaceae. In India, it is naturally found at an altitude of 600-1800 msl especially in the Sikkim Himalayas, northern Bengal, Assam, Khasi hills and hilly regions of Odisha, Deccan Plateau and the Western Ghats. Due to its wider adaptability, it is planted successfully in most parts of India



Neem seedling



Malabar neem plantation

4.3 Major Insect pests in malabar neem

4.3.1 Red spider mite - *Tetranychus urticae* (Trombidiformes: Tetranychidae)

Nature and symptoms of damage

- Nymphs and adults suck sap from underside of leaves results in presence of chlorotic spots
- Later spots will coalesce into pale patches
- Extensive webbing can be observed underneath the leaves
- Leaves start drying from the edges and slowly wither away



Adult mites on leaf



Lower side of leaf



Upper side of leaf

Management:

- Spraying of spiromesifen 22.9% SC @ 1ml/litre or Propargite @ 2ml/litre
- Spraying of dicofol 2 ml (or) wettable sulphur 2g/litre at nursery level

4.3.2 Scales and Mealy bugs (*Hemiptera: Pseudococcidae*)

Nature and symptoms of damage

- Group of scale and mealy bugs attached to the leaves and stem for sap feeding results in partial or complete wilting and dieback of infested seedlings

Management:

- Spraying of malathion 50 EC or phosalone 35 EC or methyl demeton 25 EC @ 1 ml/litre will reduce the damage



Infected Melia plants with mealy bugs

- Spray dichlorvos 76 WSC @ 1 ml/litre with fish oil rosin soap @ 25 g/litre
- Conserve predator Coccinellid beetle (*Cryptolaemus montrouzieri*) in plantation

4.3.3 Thrips - *Scirtothrips dorsalis* (Thysanoptera: Thripidae)

Nature and symptoms of damage

- Nymphs and adults suck the sap
- Scrap off the tissue of young leaves
- Curling and chlorosis of young terminal leaves



Management:

- Use of yellow sticky traps @ 15 traps/ha
- Spraying imidacloprid @ 0.5 ml/litre or Fipronil 5% SC @ 0.5 ml/litre

4.3.4 Termites - *Odontotermes obesus* & *Microtermes obesi* (Isoptera: Termitidae)

Nature and symptoms of damage

- Base of trunks plastered with runways made up of soil and fibers
- Scrapping of outer bark and trunk tissue by damage
- Wilting and drying of seedlings and trees



Management:

- Locating termite mounds in and around the field and destroying the termite mounds along with the queen
- Drench / pour the termite mound's with solution of chloropyriphos 20 EC @ 3ml/L
- Irrigate the crop regularly to reduce the incidence
- Drench the soil with chloropyriphos 20 EC @ 2-3 litre per acre mixed in 500-1000 litre of water

5

Poplar (*Populus deltoides*)

Populus deltoides is a fast-growing short rotation tree species. It is very popular around the world because of its properties like short-rotation, rapid growth, easy vegetative propagation, high potential for trait manipulation through breeding, hemisphere-wide distribution and economically valuable wood and fibre. Populus species are also used in remediation of contaminated sites, effluent disposal and restoration or establishment of riparian buffers. Its wood is used for variety of purposes and raw material for many wood-based industries like match wood and plywood industries. It is also used for fuelwood, packing cases for fruits and other food stuffs, agricultural implements, sports goods and is an excellent source of fibre for various grades of paper (fine paper, packing paper and newsprint). It can be incorporated in different agroforestry systems and have an average productivity of 0–25 m³/ha/yr, which is five times higher than traditional forest plantations with native species.

5.1 Plant systematics

Kingdom : Plantae
 Clade : Rosids
 Order : Malphigiales
 Family : Salicaceae
 Genus : *Populus*
 Species : *P. deltoides*



Seedlings



Foliage



Poplar trees

5.2 Distribution

Populus deltoides is native of North America, commonly known as poplar in India. It was first introduced in North India above 28°N latitude in 1950s. It is planted in plains of North-West India, i.e., Western Uttar Pradesh, Punjab and Haryana and to some extent in the outer plains/valleys of Uttarakhand and Himachal Pradesh. It is widely planted in the Tarai belt extending up to Bihar and West Bengal. Several promising clones of have been developed and planted extensively in farm/agroforestry systems throughout Punjab, Haryana, Tarai region of UP and some parts of Bihar, West Bengal and Assam state.

5.3 Common Insect pests

Intensive cultivation of poplar hybrids in the modern times made to succumb the poplar to various insect pests. In India 133 insect pest species have been reported on poplar so far at various locations. Out of them some are economically importance like Leaf defoliators(*Clostera fulgurita* and *Clostera cupreata*) Leaf Webber (*Asphadistis cryphomycha*) Poplar Stem Borer (*Apriona cinerea*)and Poplar Bark Eating Caterpillar (*Indarbela quadrinotata*).

5.4 Major Insect pest problems in Poplar

5.4.1 Leaf Defoliators - *Clostera fulgurita* and *Clostera cupreata* (Lepidoptera: Notodontidae)

Nature and symptoms of damage

- Young gregarious larvae feed on the green matter of leaves
- Older larvae feed on the entire leaf leaving only the mid veins
- Complete defoliation of the tress



Healthy plantation



Damaged plantation



Gregarious larvae

Management:

- Collecting gregarious larvae and destroying them at nursery and sapling stages
- Collection and destroying of yellow creamy egg masses laid on the leaves by burning or crushing them

- Growing resistant poplar clones (L 47/88; L 48/89) to reduce attack of defoliator in nursery and subsequently in plantations
- Ploughing the field 2-3 times in December to bury pupae in soil debris

5.4.2 Leaf Webber - *Asphadistis cryphomycha* (Lepidoptera: Crambidae)

Nature and symptoms of damage

- Young larvae web 2 or 3 leaves with silken threads and eat the epidermis resulting in drying of leaves
- The webbed leaf folds give scorched appearance when seen from below



Healthy poplar tree



Damaged leaf

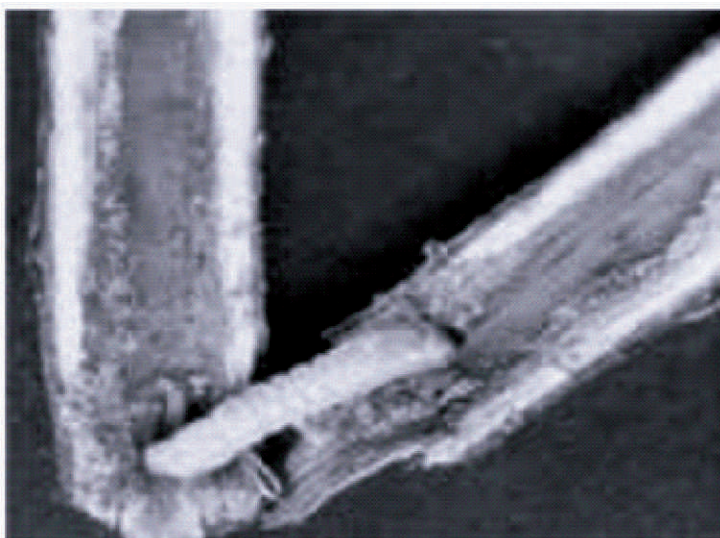
Management:

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- Ploughing the field 2-3 times in December to bury pupae in soil debris

5.4.3 Poplar Stem Borer - *Apriona cinerea* (Coleoptera: Cerambycidae)

Nature and symptoms of damage

- In nursery, the grubs bore and make galleries towards the roots
- In older trees the grubs make 8-10 circuitous holes for throwing out excreta and chewed wooden fibre at an interval of 10-12 cm in the branches of main stem and reach to the trunk
- The branches, stem and main trunk become hollow from inside
- Ultimately the trees become weak and break in strong winds



Larva feeding inside



Adult beetle

Management:

- Pruning of infested branches before the entry of grub in the main stem in August - September
- Identifying all ejection holes of live infestation in each tree and plugging them with wet clay
- Injecting 2 ml of chlorpyrifos 20% EC along with kerosene oil in the bottom hole
- Removing other collateral hosts like mulberry, apple in the vicinity of poplar plantations

5.4.4 Poplar Bark Eating Caterpillar - *Indarbela quadrinotata* (Lepidoptera: Cossidae)

Nature and symptoms of damage

- The sleeve-like structure made of frass and excreta extending from the borer holes are seen on the trunk of affected trees
- Extensive bark injury as well as tunnelling into the wood
- The affected trees may also get exposed to infestation by various pathogenic organisms which result in the die-back and rotting of the trees
- Overall, this pest affects the vigour of the trees



Larval attack on the Poplar bark

Management:

- Removal and destruction of dead and severely affected branches of the trees
- Swab coal tar + kerosene @ 1:2 (or) Carbaryl 50 WP @ 20 g/litre of water on the basal portion of the trunk up to 3 feet height
- Scraping the loose bark and subsequent padding with monocrotophos 36 WSC @ 10 ml in 2.5 cm / tree soaked in absorbent cotton prevent ovi position by adult beetles
- Hooking the caterpillar out from the bore hole and application of carbofuran 3G @ 5 g per hole and plugging them with mud

6

Bamboo (*Dendrocalamus* spp.)

Dendrocalamus strictus (Roxb.) commonly known as “Solid or Lathi bamboo” is one of the most important and commonly found bamboo species, native to India and deciduous in nature. It grows up to 18.5 m in height and 12.7 cm in diameter. This species of bamboo finds its use in both domestic as well as agricultural purposes apart from being extensively used in paper industries. In rural areas, it is used for making shaft, walking sticks, axe handle, baskets, bridges, coffins, beds, toys, and weapons and therefore, it is rightly called as 'poor man's timber'. The young shoots are also used for eating purpose in different parts of North-east India because of its high nutritive values. It is assumed that the antioxidant capacity of the bamboo leaves provides the medicinal benefits and help to get rid of certain diseases. The leaf decoction alone is used as abortifacient. Leaf powder has cut and wound healing property. Because of fast growing nature, *Dendrocalamus strictus* can fix the atmospheric carbon in above and below ground biomass more rapidly than other slow growing species. It is also used to rehabilitate degraded lands and control soil erosion.

**6.1 Plant systematics**

Kingdom : Plantae
 Class : Liliopsida
 Order : Poales
 Family : Poaceae
 Genus : *Dendrocalamus*
 Species : *D. strictus*

6.2 Distribution

D. strictus is widespread and native in India, Nepal, Bangladesh, Burma (Myanmar) and Thailand. In India, it is widely distributed in dry deciduous forests of Central India and grows rapidly in all climatic conditions. It occurs throughout the country except the northern parts of West Bengal, Assam and other very moist areas. It is



Bamboo saplings

common in most hilly parts of Peninsular India, except very moist places. It occurs in alluvial plains and ravines, and on hill slopes to an altitude of about 1100 m.

6.3 Common Insect pests

Leaf roller(*Pyrausta coclesalis*); aphids (*Myzus obtusirostris*); Armoured bamboo Scale (*Kuwanaspispseudoleucaspis*); Bamboo borer (*Estigmena chinensis*) and Termites (*Microtermes* spp. & *Odontotermes* spp.) are serious pests of bamboo forests in India. These pests attack young shoots and clumps causing reduction in the economic value.

6.4 Major Insect pest problems in bamboo

6.4.1 Leaf roller - *Pyrausta coclesalis* (Lepidoptera: Pyralidae)

Nature and symptoms of damage:

- The larvae tie the leaves together as leaf cases
- Larvae feed on the upper tissues of the leaves inside the leaf case



Healthy bamboo leaves



Leaf case with excreta

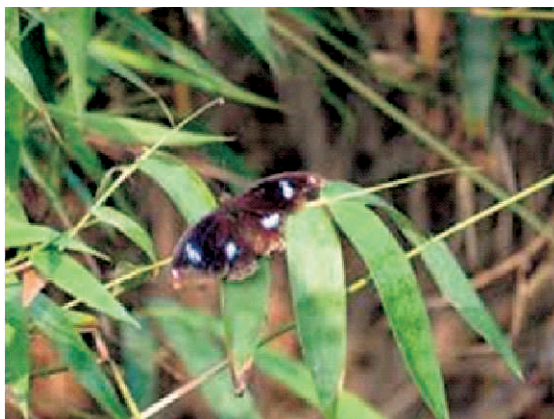
Management:

- Spray spinosad 45 SC @ 0.12 ml/l Flubendiamide 39.35 SC @ 0.75 ml/litre Lambda-cyhalothrin 5 EC @ 0.5 ml/l/ Navaluran 10 EC @ 1 ml/l / Profenophos 50 EC @ 0.9 ml/litre

6.4.2 Bamboo defoliator - *Discophora sondaica* (Lepidoptera: Pyraustidae)

Symptoms

- The larva feeds on the tender and matured leaves and cause defoliation



Management:

- Spraying of any one the following insecticide like Lambda cyhalothrin 5EC @ 0.5 ml/litre or Fenvalrate 10 EC @ 0.5 ml/Emamectinbenzoate 5 SG @ 0.4 g/l
- Spraying of Flubendiamide 480 SC @ 0.75 ml/l / Indoxacarb 14.5 SC and Chlorantraniliprole 18.5 SC @ 0.2 ml/l in severely affected nurseries is advisable

6.4.3 Aphids - *Myzus obtusirostris* (Hemiptera :Aphididae)

Nature and symptoms of damage

- Nymphs and adults suck the sap from the leaves and tender shoots
- Leaves often yellow, curl or drop and new growth may be distorted
- Aphids produces sooty mold colonies and interfere with photosynthesis



Management:

- Spraying of azadirachtin 1EC @ 2 ml/l

- In heavy infection sites, spraying of Imidocloprid 17.8SL @ 0.3 ml/l / Thiamethxam 25WG @ 0.3g/l / Flonicamid 50 WG @ 0.3g/l is advisable

6.4.4 Armoured Bamboo Scale - *Kurwanaspis pseudoleucaspis* (Hemiptera: Pseudococcidae)

Nature and symptoms of damage

- The wingless female adults and nymphs feed by inserting minute suckers into plant tissues
- Scales suck the sap and cause a general reduction in growing, vigor and the death of bamboo plants

Management:

- Spray azadirachtin 1EC @ 2 ml/l
- In heavy infection sites spray Imidocloprid 17.8SL @ 0.3 ml/l / Thiamethxam 25WG @ 0.3g/l / Flonicamid 50 WG @ 0.3g/l



(Pc: Chris Stapleton)

6.4.5 Bamboo borer - *Estigmene chinensis* (Coleoptera: Chrysomelidae)

Nature and symptoms of damage

- Grubs and adults damage the tender culm shoots during the rainy season
- The grubs completely devour the soft tissues of the young shoots, leaving only the culm sheaths



Larva inside

(Pc: Singh, K.P and Singh, I. 2018)

Management:

- Removal and destruction of dead and severely affected trees
- Spraying or injecting any fumigant like Malathion or Profenophos 50 EC @ 1ml/litre

6.4.6 Termites -*Microtermes* spp. & *Odontotermes* spp. (Isoptera: Termitidae)



Nature and symptoms of damage

- Attack on the roots of germinating seedlings and rhizomes of bamboos results in wilting of plant



Management:

- Locating termite mounds in and around the field and destroying it along with the queen
- Drenching and application of Chloropyriphos 20 EC @ 2-3 litre per acre mixed in 500-1000 litre of water on the termite mound's
- Irrigate the crop regularly to reduce the incidence

7

Indian rosewood (*Dalbergia sissoo*)

Dalbergia sissoo (shisham/rosewood) is the most valuable and highly priced cultivated timber tree in India after teak. It is a fast-growing multipurpose tree species. Sissoo is highly suitable for cabinetry and furniture because of its colour, strength, elasticity, grain, figure, and durability. Additionally, it is used for fuelwood, decorative veneer, marine and aircraft grade plywood, ornamental turnery, carving, engraving, tool handles and sporting goods, agricultural, and musical instruments, floorings, etc. It is planted along roadsides, and as a shade tree for tea plantations. The young branches and foliage are used as fodder for livestock. Due to its vigorous reproduction through suckers, it is useful for stabilizing eroding sites. Being a nitrogen fixing tree it improves the fertility of the soil. It is used as a windbreak and shelter belt and as a shade tree in intercropping of orchards, mango, tea, and coffee plantations.

7.1 Plant systematics

Kingdom : Plantae

Class : Rosids

Order : Fabales

Family : Fabaceae

Genus : *Dalbergia*

Species : *D. sissoo*



7.2 Distribution

In India, shisham is found almost all states, and widely distributed along river beds in sub-Himalayan tract from Indus to Assam and Himalayan valleys, up to 900 m and occasionally ascending to 1500 m. Outside India the species is found in Nepal, Bhutan, Bangladesh, Myanmar (Burma), Malaysia, Pakistan and Afghanistan. It is also found under cultivation in tropical to sub-tropical Africa and Asia.

7.3 Common Insect pests

About 130 insect species have been recorded on *D. sissoo*. The important ones include defoliators, sap sucking insects and stem borers belongs to the order-Coleoptera, Lepidoptera, Hemiptera and Isoptera. Among all few insect species are known to have attained the economic status and so recognised as potential pests of nurseries and plantations.

7.4 Major Insect pest problems in Shisham

7.4.1 Shisham Defoliator - *Plecoptera reflexa* (Lepidoptera: Noctuidae)

Nature and symptoms of damage

- Larvae feed on leaves and tree remains leafless and epicormic branches are produced
- Repeated defoliation affects the plant dieback
- Severe defoliation leads to poor quality plantations



Management:

Defoliator damage in shisham leaves

- Spray any one the following insecticide Lambda-cyhalothrin 5 EC @ 0.5 ml/l Fenvalerate 10 EC @ 0.5 ml/litre, Emamectinbenzoate 5 SG @ 0.4 g/l Spray Flubendiamide 480 SC @ 0.75 ml/l/ Indoxacarb 14.5 SC and Chlorantraniliprole 18.5 SC @ 0.2 ml/l in shisham nurseries

7.4.2 Wood borer - *Sinoxylon anale* (Coleoptera: Bostrichidae)

Nature and symptoms of damage

- Damage is typically caused by the boring of adults and grubs in the stems, branches, twigs of dead, damaged or stressed trees
- Due to severe bore holes secondary infection will occur
- Drying and death of trees



Infested tree, bore holes and larvae of the *S. anale*

(Pc: Kumar, V. et al., 2017)

Management:

- Removal and destruction of dead and severely affected trees
- Application of lime solution to bark of the tree base
- Injecting phorate or carbofuron granules into bore holes and plug them with mud

7.4.3 Termites - *Microtermes* spp. and *Odontotermes* spp. (Isoptera: Termitidae)

Nature and symptoms of damage

- Base of trunks plastered with runways made of soil and fibers
- Scrapping of outer trunk or bark
- Wilting of seedlings and trees
- Finally fall down

Management:

- Locate termite mounds in and around the field, and destroying it along with the queen
- Drenching the termite mound with solution of chloropyriphos 20 EC @ 3ml/l
- Irrigating the crop regularly to reduce the incidence
- Drenching the soil with chloropyriphos 20 EC @ 2-3 litre per acre mixed in 500-1000 litre of water



7.4.4 Bark Eating Caterpillar - *Indarbela* spp. (Lepidoptera: Cossidae)

Nature and symptoms of damage

- The sleeve-like structure made of frass and excreta extending from the borer holes are seen on the trunk of affected trees
- Extensive bark injury as well as tunnelling into the wood affect the vigour of the trees

- The affected trees may also get exposed to infestation by various pathogenic organisms which result in the die-back and rotting of the trees

Management:

- Removal and destruction of dead and severely affected trees
- Swab coal tar + kerosene @ 1:2 or Carbaryl 50 WP @ 20 g/litre of water on the basal portion of the trunk up to 3 feet height
- Scraping the loose bark and subsequent padding with monocrotophos 36 WSC @ 10 ml in 2.5 cm/tree soaked in absorbent cotton prevent oviposition by adult beetles
- Hooking the caterpillar out from the bore hole and application of carbofuran 3G @ 5 g per hole and plug with mud





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