PRACTICAL MANUAL

FOREST PROTECTION

Course No. FNR-118; Credit Hrs. 3(2+1)

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COLLEGE OF HORTICULTURE AND FORESTRY
RANI LAKSHMI BAI CENTRAL AGRICULTURAL UNIVERSITY
JHANSI - 284003

Syllabus: Visit to forest areas with fire damages, Studying fire registers as records, studying encroachments and problems caused due to disturbance-visit to illegally felled areas- Visit to fire station, Study and acquaint with machinery used for fire control, identification of weeds, parasites and epiphytes. Observation of symptoms in laboratory and in forests - examination of scrapings - host-parasite relationships - causal organisms of above forest diseases. Examination of cultures of important pathogens. Visit to nurseries and plantations. Insect pests of forest seeds; forest nurseries; standing trees; freshly felled trees and finished products. Survey and identification of invertebrate fauna from forest areas. Methods of isolating soil invertebrate macro and micro fauna. Insecticides and their formulations, plant protection appliances.

Name of Students .....

Roll No. .....

Batch .....

Session .....

Semester .....

Course Name : .....

Course No. : ..... Credit .....

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Date: Course Teacher

INDEX

Experiment No. 1

Objective: To study different types of forest fires and observe tree damages caused by fire.

Aim:……

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Exercise: Each student has to observe and then record in the form of a report for damages caused by the fire, which includes foliage, stem/bark, roots, soil, regeneration/seeds and fauna. The students can also write their observations in terms of any benefits of fire observed in the field.

A. Categories of Forest Fires

Surface fire: ……

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Groundfire: ……..

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Crownfire: ……

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Damages Caused by Forest Fire (foliage, stem and roots):

Effects on The Foliage: ……..…

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Effects on The Stem: ……..

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Effects on The Roots: ……..

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Experiment No. 2

Objective: To analyze the use of burning out and backfiring in tackling forest fires.

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Important to Note Down

Conducting these operations and activities requires great care and timing. Because of the complexity, it generally requires more planning and coordination. All the conditions must be right and all safety precautions must be in place.

Exercise: Each student has to analyze and observe that how forestry department personnel are carrying out and implementing the burning out and backfiring activities in tackling fires in the forests. All the procedures followed in the field should be recorded and everyone must develop in the form of report for practical assessments.

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Experiment No. 3

Objective: Field visit to understand the importance of fire lines and fire gaps as a preventive measure for controlling forest fires.

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Exercise: Students while visiting the forest fire prone areas have to observe the constructions, objectives, designs etc. of fire lines or fire gaps. Each student has to prepare the field report after analyzing fire line from the field; the report has to be submitted to the course instructor/coordinator for the practical assessment.

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Experiment No. 4

Objective: To acquaint with different types of firefighting equipment.

Aim:

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Exercise: Students have to familiarize with the equipment's and PPE's and subject to the availability in the laboratory or students will be shown videos of firefighting equipment's (activity 1). Each student after the completion of activity 1 will write or prepare the report regarding the description and use of firefighting equipment's for effective suppression on forest fires.

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Experiment No.5

Objective: To study the different types of plant disease symptoms produced due to infection by pathogen

1. Blights:……

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2. Chlorosis:……

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3. Mosaic:……

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4. Vein-clearing:……..

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5. Vein-banding:…….....

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6. Leaf curl:……..……

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7. Phyllody:……

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8. Canker:……

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9. Anthracnose:……

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10.Damping-off:……

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11. Mottle:……..……...

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12. Yellows:……

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Experiment No.6

Objective: To prepare Potato Dextrose Agar medium

Materials required: ……

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Procedure……

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Experiment No. 7

Objective: To isolate plant pathogens from disease Plant Tissues

Materials required: ……

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Procedure:……

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Experiment No. 8

Objective: To observe the symptoms of the diseases of neem (*Azadirachta indica*)

Exercise: Visit a nearby neem plantation site and note the important diseases of neem, its symptoms and identify the causal organisms

Name of the disease	Symptoms	Causal organism
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
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Experiment No. 9

Objective: To observe the symptoms of the diseases of *Albizia* spp.

Exercise 1: Visit a nearby *Albizia* spp tree and note important diseases of the symptoms and identify the causal organisms

Name of the disease	Symptoms	Causal organism
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……

Experiment No. 10

Objective: To observe the symptoms of the diseases of *Pongamia pinnata*

Exercise: Visit a nearby tree of *Pongamia pinnata* and note the symptoms of diseases and causal organism

Name of the disease	Symptoms	Causal organism
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
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Experiment No. 11

Objective: To observe the symptoms of the diseases of teak (*Tectona grandis*)

Exercise: Visit the nearby teak (*Tectona grandis*) plantation site and note the important diseases, their symptoms and causal organisms

Name of the disease	Symptoms	Causal organism
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
…… …… …… …… ……	…… …… …… …… …… …… ……	…… …… ……
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Experiment No. 12

Objective: To observe the diseases of sissoo (*Dalbergia sissoo*)

Exercise: Note the important diseases of sissoo (*Dalbergia sissoo*), their symptoms and causal organisms

Name of the disease	Symptoms	Causal organism
……………… ……………… ……………… ……………… ………………	…………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	…………………… …………………… ……………………
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Experiment No. 13

Objective: To study the insect pest of nurseries plant and white grub

Exercise 1: Enlist the insect pest of nurseries plant

Common Name	Scientific name	Order	Family
…….. …….	…….. ……..	…….. ……..	…… ……
…….. …….	…….. ……..	…….. ……..	…… ……
…….. …….	…….. ……..	…….. ……..	…… ……
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White Grub:

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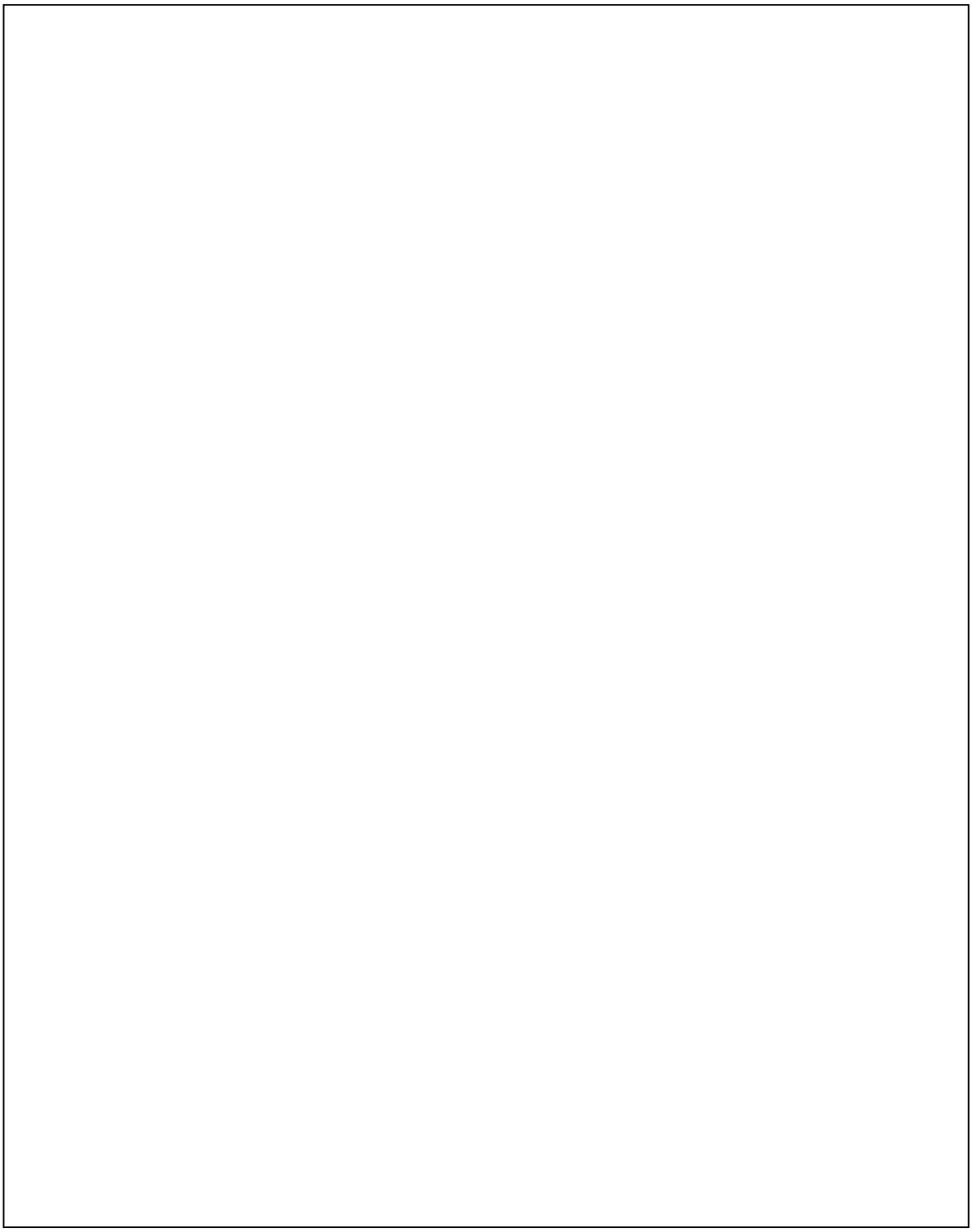
Draw the diagram of life cycle of white grub



Experiment No. 14

Objective: To study major insect pests of natural forest and Sal heartwood borer

Exercise: Enlist the major Insect Pests of Natural Forest

Sal heart wood borer:

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Draw the diagram of life cycle of Sal heart wood borer

Experiment No. 15

Objective: To study major pest of forest trees

Five-spined bark beetle:.....

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Christmas beetles (*Anoplognathus chloropyrus, A. porosus, A. boisduvali, A.* spp.) : ……

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Cigarette beetles (*Lasioderma serricorne*): …….

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Common furniture beetle *(Anobium punctatum*): ……

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Giant wood moth (*Endoxyla cinereus*): …….

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Gumleaf skeletoniser (*Uraba lugens*):.....

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Leaf beetles (Chrysomelid leaf beetles): ……

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Lerps and psyllids (*Glycaspis species, Cardiaspina species, Creiis lituratus, Eucalyptolyma maideni*): …….

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Lesser auger beetle (*Heterobostrychus aequalis*):

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Experiment No. 16

Objective: To study the major insect pests of forest seed, fruit and conifers

Exercise 1: Enlist the major insect pests of forest seed, fruit and conifers

Common Name	**Scientific name**	**Order**	**Family**
…… ……	…… ……	…… ……	…… ……..……
…… ……	…… ……	…… ……	…… ……
…… ……	…… ……	…… ……	…… ……
…… ……	…… ……	…… ……	…… ……
…… ……	…… ……	…… ……	…… ……
…… ……	…… ……	…… ……	…… ……
…… ……	…… ……	…… ……	…… ……

Experiment No. 17

Objective: Survey and identification of invertebrate fauna from forest areas

Requirement of survey and identification of invertebrate fauna from forest area

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Methods for surveying and identification of invertebrate's fauna

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Suitable time for survey and sampling of invertebrate fauna

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Draw the diagram of equipment which are used during collection and identification

Experiment No. 18

Objective: To study about the Plant Protection Appliances

Exercise1: Observed the different Plant Protection Appliances and Comment

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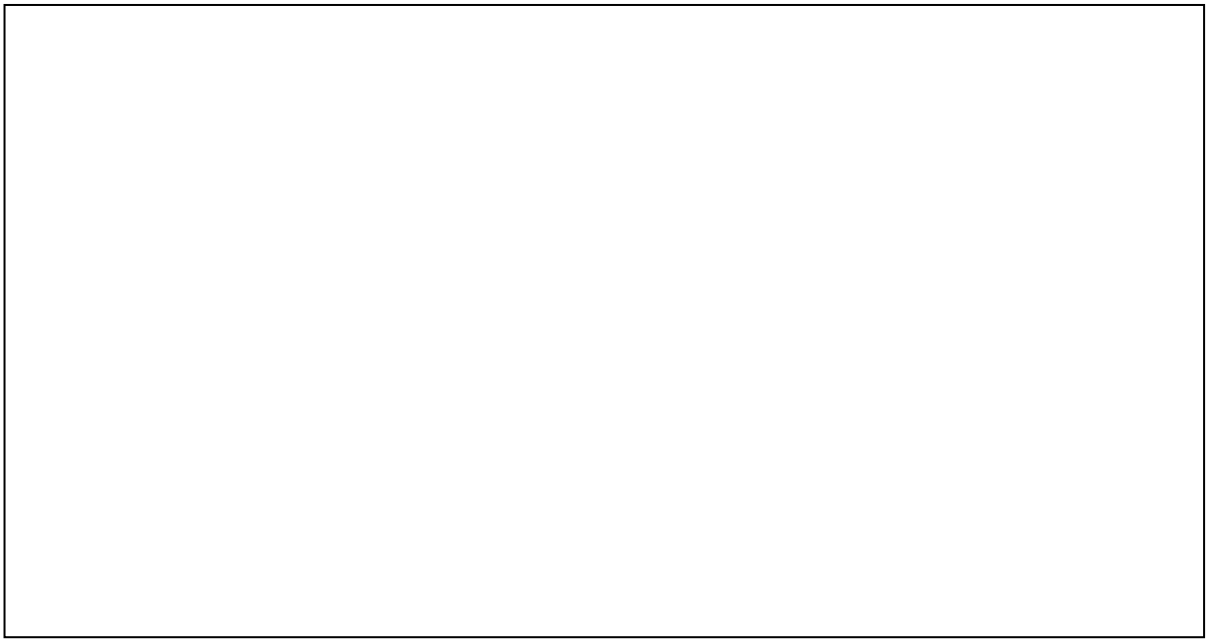
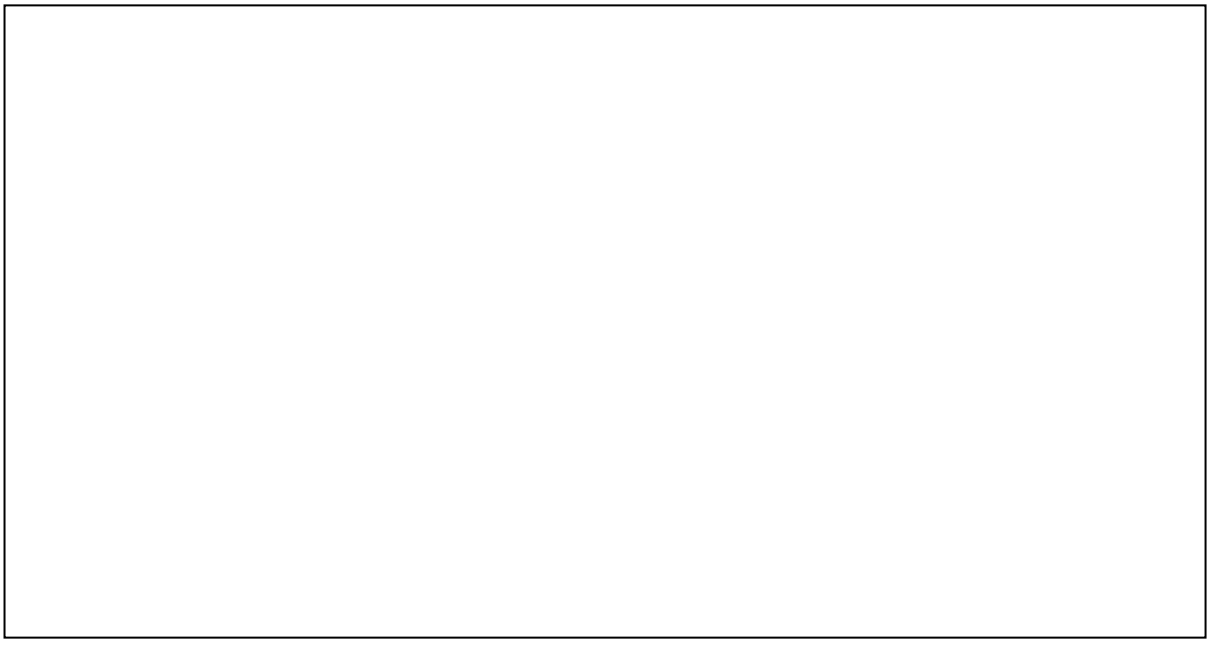
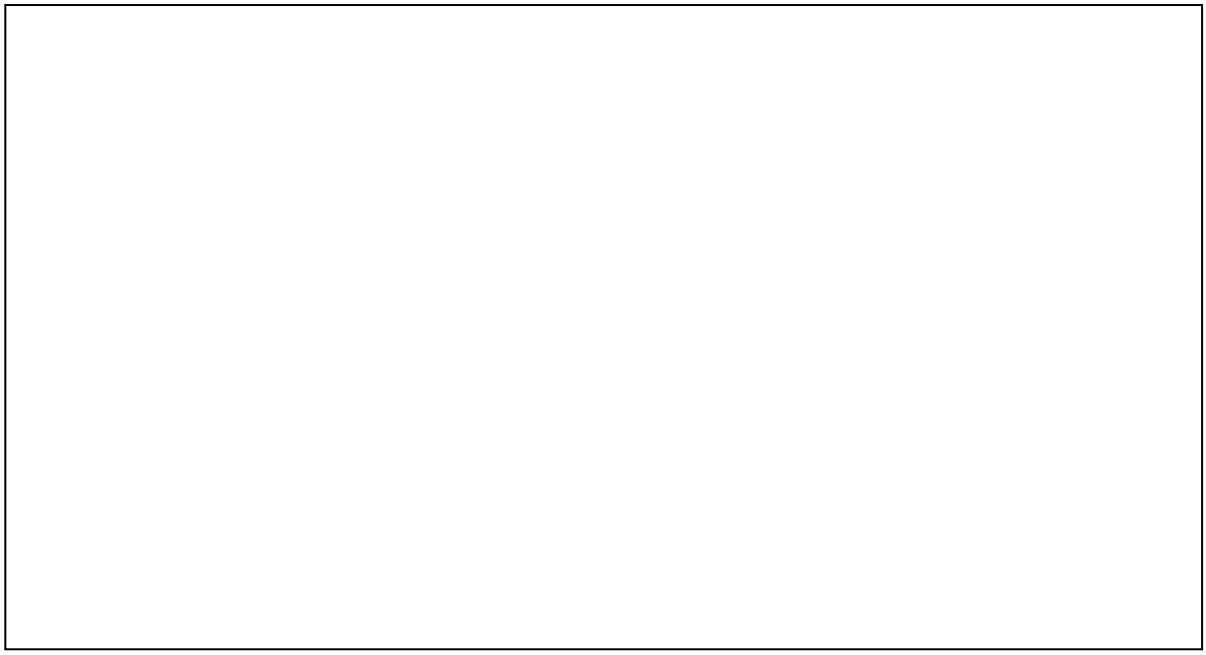
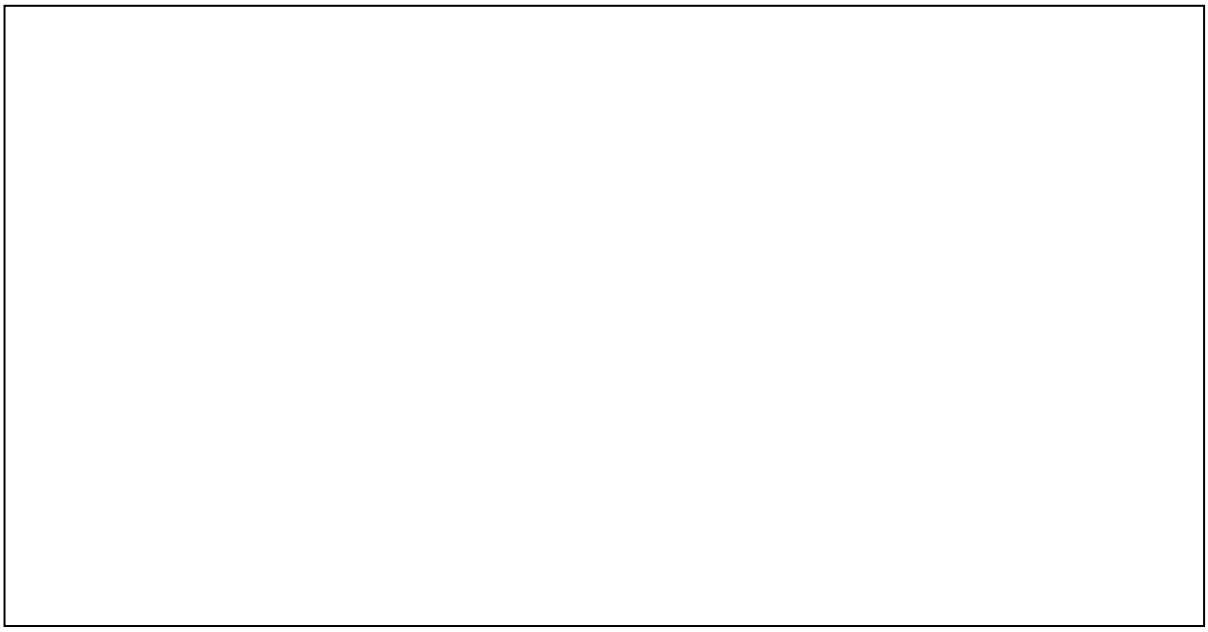
Observe the different types of nozzle and Draw the diagram of different types of nozzle





Draw the well labeled diagram of Cynogas pump and Seed dressing drum





Note the features of rotary duster

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Experiment No. 19

Objective: To study the different types of Insecticides formulation and its classes

Exercise: Note the different types of Insecticide formulation

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Synergist and Adjuvant

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Precautionary measures:……

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APPENDICES

TYPES OF FOREST FIRES

A. Categories of Forest Fires:

Surface fire: This type of fire spreads through the litter lying along the floor of forest. It includes the loose debris containing senescent leaves, twigs, dead branches, dry grasses and low growing vegetation. The fire may be smoldering (i.e., the process of combustion which occurs only at the surface of the fuels and without flames) or engulfed by low spreading flames. The intensity and the rate of spread of fire is very much affected by wind and fuel moisture content.

Ground fire

It is a low intensity fires in which organic matter (e.g., peat, duff, root mats lying beneath the level of surface litter of forest floor is consumed. Usually in dense forests a thick mantle of organic matter is formed on top of the mineral soil. By consuming such materials this fire is smoldering in nature and spreads very slowly and entirely underground. Ground fires are extremely difficult to extinguish and may continue for weeks, months or more. They kill the roots of the overlying vegetation.

Crown fire

The fire which passes through the crowns of trees and shrubs burn is termed as crown fire. Often sustained by the underlying surface fire these fires are always flaming in nature. Crown fires burn the foliage of trees and shrubs, thereby causing severe damage to the tree crop. In coniferous forests the crown fires can be very dangerous due to oozing out resin from logs which burn furiously

B. Damages Caused by Forest Fire (foliage, stem and roots):

Effects on The Foliage: The destruction of leaves or needles by a fire reduces temporarily the photosynthetic activity. The deterioration of the buds stops any growth of the branch. The resistance of these vital parts to heat is variable according to the species: in some cases, a layer of protective cells covers the needles (e.g., waxes) or the buds (e.g., scales). The development stage of the plant also conditions its resistance to thermal stress. Visually, fire effects on the foliage result in crown scorch (browning). Browning is followed by the loss of leaves and needles.

Effects on The Stem: The bark protects sub-cortical tissues (phloem and xylem) responsible for the diameter growth and the sap circulation. These are more or less modified according to the heating of the stem at the time of the fire passage. The slightly damaged tissues are regenerated by the sapwood, with appearance of a healing mark. On the other hand, the destruction of the phloem prevents the storage of photosynthesis assimilates in the roots and the tree survival time is then one to two years (use of reserves accumulated before fire). If even the xylem is destroyed, any communication between the foliage and the root system is interrupted, and the tree dies within few weeks. The fire resistance varies according to species, in particular in function of bark thickness.

Effects on The Roots: The deterioration of the root collar (buttress) reduces the vigour of the tree, often resulting in death. The heating of the ground at the time of the fire passage can also be responsible for the tree weakening, affecting the root tips located in the upper soil layer. Ground fires kill roots and trees.

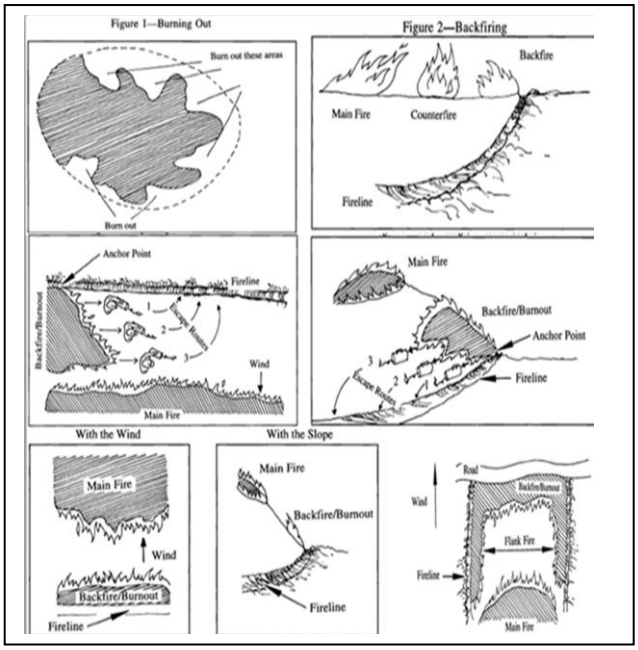
Forest fire causes imbalances in nature and endangers biodiversity by reducing faunal and floral wealth.

USE OF BURNING OUT AND BACKFIRING IN TACKLING FOREST FIRES

Burning out is used with direct and parallel attack. In direct attack a fireline is built close to the edge of a fire. Burning out is setting fire inside the fireline to consume fuel between the fireline and the edge of the fire. Parallel attack is generally defined as a method of suppression in which fireline is constructed approximately parallel to, and just far enough from, the fire edge to enable workers and equipment to safely operate. Parallel attack can shorten the fireline by cutting across unburned areas. The intervening strip of unburned fuel is normally burned out as the fireline proceeds, but may be allowed to bum out

unassisted where this occurs without undue delay or threat to the line.

Backfiring is an indirect method of attack and it is the act of setting fire along the inner edge of a fireline to consume the fuel in the path of a fire, change the direction or force of the fire's convection column, and also slow or change the fire's rate of spread. Counterfires are sometimes used in conjunction with backfiring. Counter fires are set between the main fire and the backfire to hasten the spread of the backfire when large areas of unburned fuel are involved.



The primary objectives of burning out and backfiring are:

Burning out

- Removing of unburned fuels adjacent to the line.
- Intentionally setting fire to fuels inside the control line to strengthen the line.
- Burning out is almost always done as a part of line construction.

The control line is considered incomplete unless there is no fuel between the fire and the line.

Backfiring

- To eliminate fuel in advance of the fire, thus widening the fireline.
- To change the direction of the fire.
- To slow the fire's progress, allowing more time for suppression actions.

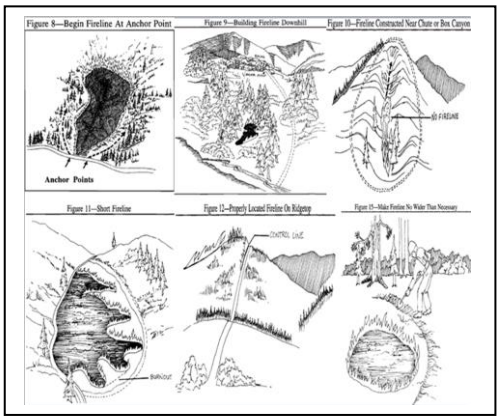
FIRE LINES AND FIRE GAPS

Fire prevention activity is the beginning and most critical stage of the forest fire controlling process. Prevention activities have included primarily the creation and maintenance of fire lines and fire gaps. A fire line (Fire gaps) is a line through a forest which has been cleared of all vegetation. The width depends on the type of forest being protected. Once the blaze has burnt out all combustibles in the affected compartment, it fizzles out and the neighboring compartments are saved. This is the most common methods of prevention employed by forest departments in India which is creation of fire lines and fire gaps.

The fire line or fire gaps are constructed by clearing vegetation strip or flammable material has been removed by scraping or digging down to the mineral soil. When a fire line or fire gaps are built above a fire burning on a slope, generally the steeper the slope, the wider the line must be because the fire usually burns faster and more intensely than on a gentler slope. The gentler the slope the narrower the line can be. When a fire line is built below a fire burning on a slope, the width of the line does not depend so much on the slope, but trenching becomes important. Generally, the steeper the slope, the deeper the trench must be, to prevent rolling burning material from crossing the fire line.

To acquaint with different types of firefighting equipment

Firefighting is a difficult, tiring and dangerous operation. Thus, it is necessary to take care of safety like PPE's or individual protective equipment's of the firefighting staff. Currently, there is an inadequate equipment's currently used and lack of basic safety gear, clothing and need for more trainings, especially for firewatchers, firefighters and community volunteers. However, India has emerged as a leading example of how satellite technologies can be utilized for the detection and monitoring of forest fires. Firefighting strategies generally define two principal objectives; control the fire at an initial stage and to contain the spread/extent of fires which could not be suppressed at initial stage. The following is the list of firefighting equipment's



currently in use:

1. ***Hand tools*:** Rake, Rake hoe, Fire Beater or Swatter, Pulaski Tool, Knapsack Spray or Backpack Sprayer and Firebug Torch
2. ***Portable powered tools*:** Leaf Blower and Chain Saw
3. ***Small Motorized*:** Off-road bikes or trail bikes and Quad bikes
4. ***Personal protective equipment's (PPE's)*:** Additional firefighting equipment's (below table)

Axe	Spade	Beaters
Leaf blower	Bucket	Rake
Lightweight fire extinguishers	First aid kit	Helmet
Fire resistant uniform	Gloves	Dust mask
Other dousing equipment's	Boots	Drones
Other equipment and clothing	Torch/Flashlight	Fire engine
Water tanker (truck or Tractor	Portable sprayers	
Communication devices or GPS	Transport Vehicles	
Light equipment's that are easy to carry	Protective eyewear	
Simple firefighting tools in sufficient quantity	Food and drinking water	
Additional manpower more useful than equipment	Other manual hand tools	

Different types of plant disease symptoms produced due to infection by pathogen

Symptoms produced by the pathogens

1. **Blights:** A disease characterized by general and rapid killing of leaves, flowers and stems.
2. **Chlorosis:** When repression of colour is partial i.e., normally green tissues are yellow or when yellow colour is uniform and unbroken in leaves infected by plant pathogen.
3. **Mosaic:** Patches of normal green tissues alternate with yellow areas resulting in mottling, spotting, flecking, striping or blotching against the normal background tending to have a clearly defined boundary delineated by the veins.
4. **Vein-clearing:** is a kind of sub-type of mosaic where tissues close to veins turn yellow and remaining lamina surface remains green.
5. **Vein-banding:** is a kind of sub-type of mosaic where tissues close to veins remain green and rest of the lamina surface turns yellow.
6. **Leaf curl:** is curling of the leaves as a result of over growth on one side of the organ.
7. **Phyllody:** it is a metaplastic symptom where all the floral parts develop into leaf-like structures.
8. **Canker:** A necrotic, often sunken, lesion on a stem, branch, or twig of a plant.
9. **Anthracnose:** A disease that appear as black sunken leaf, stem or fruit lesions, caused by fungi that produced their asexual spores in an acervulus.
10. **Damping off:** Destruction of the seedlings near the soil line, resulting in seedlings falling over on the ground
11. **Mottle:** A symptom in which small but numerous areas of discolouration, commonly chlorotic, irregularly shaped and without sharply defined boundaries, standout against a background of a different tint.
12. **Yellows:** Because of the reduction in chlorophyll synthesis the presence of carotene and xanthophylls becomes evident even in young leaves leading to yellowing.

Different types of disease symptoms		
		
1. Blights	2. Chlorosis	3. Mosaic

4. Vein-clearing

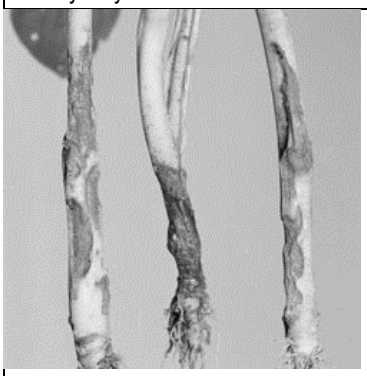
5. Vein-banding

6. Leaf curl

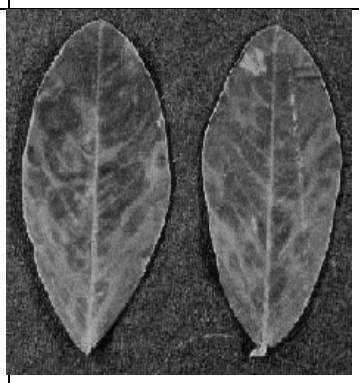
7. Phyllody

8. Canker

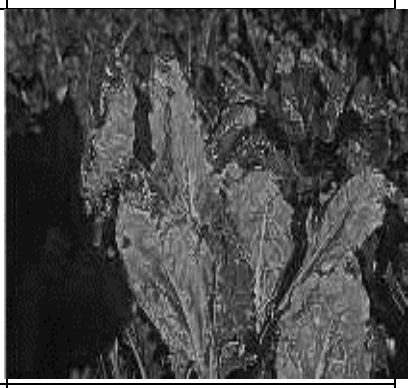
9. Leaf s



10. Damping off



11. Mottle



12. Yellows

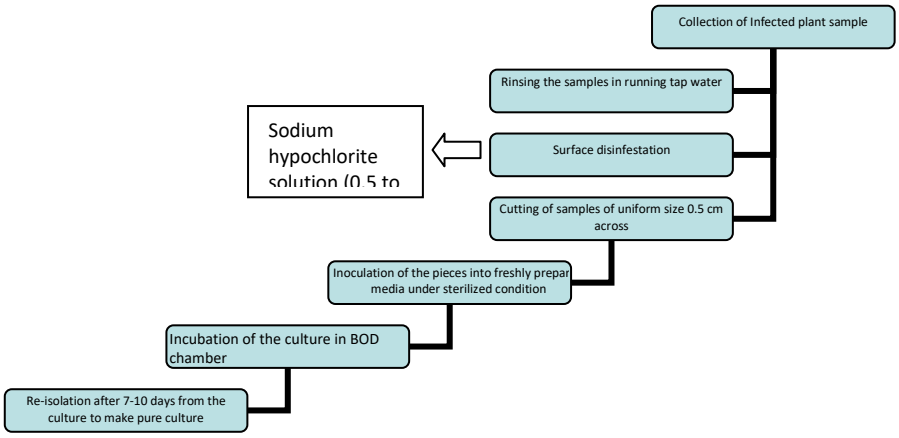
POTATO DEXTROSE AGAR MEDIUM

Materials required: (Peeled potato slices - 200g; Dextrose - 20g; Agar- agar- 20g; Distilled water-1000 ml)
Method:

(1) Potato slices are cooked in 500 ml of water.
(2) Then filtered with the help of muslin cloth.
(3) Agar-agar is melted in 500 ml of water.
(4) Potato juice is added to the melted agar.
(5) Volume is made 1000 ml by adding required water.
(6) Again lit is filtered through muslin cloth.
(7) Dextrose is added in this mixture and shaken well.
(8) Medium is sterilized in an autoclave at 1.1kg/cm^2 pressure for 20 minutes at temperature of 121.6°C. Thus the medium is ready for use.

ISOLATION OF PLANT PATHOGENS

Tissues sampled during the active stage of an infection are likely to have within them only the pathogen responsible for the infection; the surfaces of such tissues, however, are usually contaminated with saprophytic organisms. The steps of isolation of the pathogen have been given in the flowchart below:



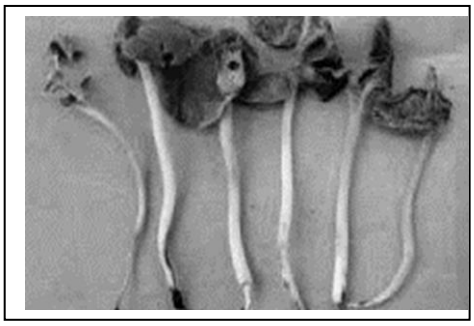
Flowchart showing steps of isolation of pathogen from plant tissues

SYMPTOMS OF THE DISEASES OF NEEM (*Azadirachta indica*)

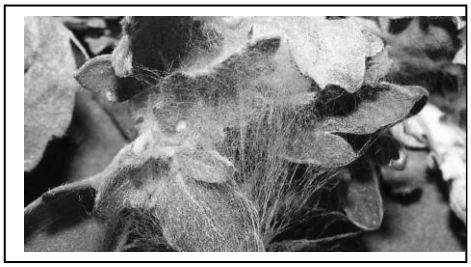
(a) Damping off:

Causal Organism: *Pythium, Phytophthora, Fusarium* and *Rhizoctonia*, of which the last two fungi are quiet prevalent in forest nurseries in India.

Symptoms: Damping-off is the most prevalent and highly destructive disease in the nursery. The seedlings become weak and the plants become soft ad rotted in the collar region or in the roots as indicated in the figure. The region become brownish in colour and the whole plants toppled down as it becomes weaken in affected area.



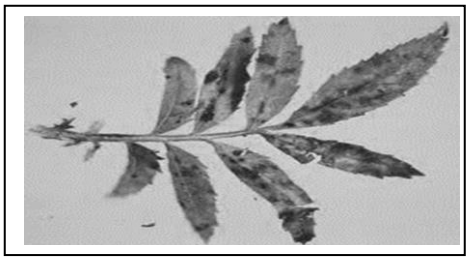
b) Leaf Web Blight: Causal organism: *Rhizoctonia solani.* **Symptoms:** Development of greyish brown blotches which increase in size with the advancing fungal hyphae and ultimately engulf the entire leaf blade. The infected adjoining leaves get joined together by the fungal hyphae as if caught in a spider's web, hence the name web blight. The leaflets or the entire pinnae become detached prematurely. The disease spreads through contact of the overlapping foliage



(c) *Alternaria* Leaf spot and blight:

Causal organism: *Alternaria alternata*.

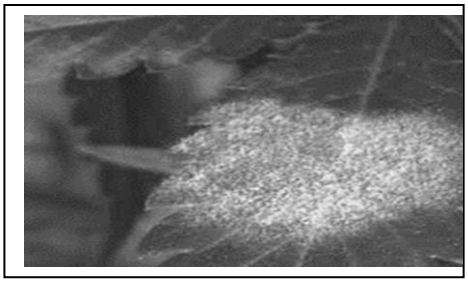
Symptoms: It is a destructive pathogen. It appears late in the growing season in the last week of October or early November. It attacks the leaves when the leaves become old and contain less soluble sugars and produced blighted light appearance.



d) Powdery mildew:

Causal Organism: *Oidium azadirachtae.*

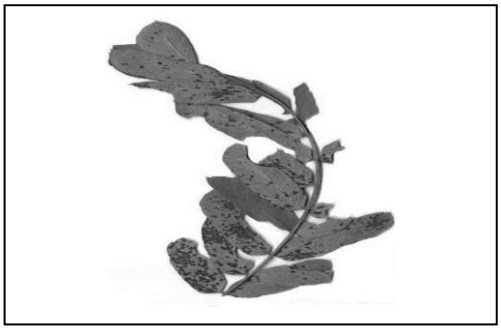
Symptoms: White patches seen on the surface of the leaves. These patches coalesced and covered the whole leaf lamina giving greyish white appearance. Severely infected leaves and leaflets defoliated prematurely.



SYMPTOMS OF THE DISEASES OF *Albizia* spp.

(a) Leaf spot and blight:

Causal Organisms: *Cercospora albizziae, Colletotrichum* sp., *Alternaria alternata, Camptomeris albizzia, Pleiochaeta setosa* and *Epicoccum* sp.



Symptoms: The disease manifests on older leaves of seedlings as a small water soaked yellowish spot which later develops into a circular light brown lesion with a distinct yellowish margin. The spot hole develops in the advanced stages of infection causing premature defoliation. The disease is aggravated under high humid conditions. The tender shoots of seedlings are also infested and damaged.

(b) Leaf Rust:

Causal organism: *Ravenalia clemensiae.*

Symptoms: The pathogen attacks leaflets of the seedlings. Profuse development of pustules takes place on the leaf surface adversely affecting the metabolic activity of the plants resulting even in death.

SYMPTOMS OF DISEASES OF *Pongamia pinnata*

a) Leaf spot and blight:

Causal organisms and Symptoms: Leaf spot and blight diseases caused by *Fusicladium pongamiae* on Pongamia pinnata. The pathogen causes severe leaf deformities. *Microstroma pongamiae* causes white to cream-coloured spots giving a yellowish appearance to the leaves. *Cercospora pongamiae* and *Sphaceloma pongamiae* cause anthracnose spots on leaves, tender shoots and pods resulting in severe damage and early defoliating in young seedlings and trees.

(b) Leaf Rust:

Causal Organism: *Ravenelia hobsoni* infects the leaves and produces numerous chest-nut brown teliospore heads on the lower surface of the leaves. Another rust fungus, *R. stictica* is also known to attack the leaves.

(c) Powdery mildew:

Causal organism: *Oidium* spp.

Symptoms: The pathogen formed irregular white patches, consisting of mycelium and asexual conidia on the surface of the leaves. These patches coalesced and covered the whole leaf lamina giving grayish white appearance. Severely infected leaves and leaflets defoliated prematurely.

SYMPTOMS OF THE DISEASES OF TEAK (*Tectona grandis*)

(a) Leaf blight:

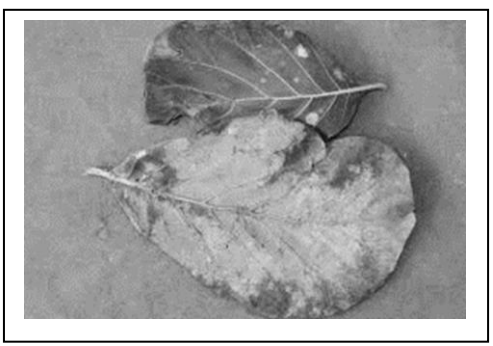
Causal organism: *Rhizoctonia solani.*

Symptoms: The infected plants show water soaked grayish brown patches that enlarge rapidly and cover a large part or the entire lamina. The blighted leaves often show holes in the infected portion as a result of shedding of infected tissues during heavy rains. The infected leaves dry up and are eventually shed. The disease spreads laterally in the nursery through overlapping foliage of the adjoining seedlings often resulting in group blighting of seedlings. In each case of severe infection, defoliation is high.

(b) Leaf rust:

Causal Organism: *Olivea tectonae.*

Symptoms: The infected leaves are almost plastered with yellowish brown fruit bodies of the fungus. The upper leaf surface presents a grey appearance due to the formation of fleeks, which correspond to the position of sori on the lower surface. Infected leaves fall off prematurely resulting in retardation of plant growth. The disease is common in nursery and young plantations.



(c) Powdery mildew:

Causal Organism: Members of the family Erysiphaceae have been recorded to cause mildews in teak. *Phyllactinia corylea* is recorded to attack teak laves (Bagchee, 1952). *Phyllactinia guttata* is also recorded to attack teak from other countries. *Uncinula tectonae,* widely occurs in nurseries and forests in central and southern India.

Symptoms: The fungus forms white powdery coating on the undersurface of teak leaves and later develops dark coloured cleistothesia over the white fungus weft (Spaulding, 1961). *Uncinula tectonae* is restricted to the upper leaf surface and the infected leaves are coated with a dull white mycelium and conidia borne on conidiophores. Conidia are air-borne which are produced abundantly and cause fresh infection. The metabolic changes in plants take place which lead to drying of infected leaves.

SYMPTOMS OF THE DISEASES OF SHISHAM (*Dalbergia sissoo*)

Leafspot: Different fungi viz., *Cercospora sissoo, Colletogloeum sissoo, Phyllachora dalbergiae, Phyllachora spissa, Phyllosticta sissoo, Mycosphaerella dalbergiae, Myrothesicum roridum* and *Alternaria alternata* causing leaf spots on this tree species and recorded from the region this tree species grows.

Cercospora sissoo attacks the leaves mostly on the lower surface, producing yellowish to grayish-green discoloration. Pustules are mostly intra-epidermal. Stomata are brown with simple or forked conidiophores (Sydow and Mitter, 1933). *Colletogloeum sissoo* causes imperceptible leaf spots and is recorded from Varanasi, Uttar Pradesh (Pavgi and Singh, 1971).

Phyllachora dalbergiae attacks the upper leaf surface and produces shining black cushion-like stromata which may occur scattered or in clusters (Saccardo, 1883).

Phyllachora sissa attacks the leaves and forms densely aggregated dot-like dark stromata on irregular brownish infection spots and recorded from Wynaad, Kerala and Meghalaya (Bakshi, 1976); Khandala, Maharashtra (Anantha narayanan, 1964).

Phyllosticta sissoo causes infection on leaves. The spots are round to irregular, greyish-brown which sometimes cover the entire leaf surface. Dark brown pycnidia are produced on lower leaf surface in densely aggregated groups (Saccardo, 1931).

Myrothecium roridum causes leaf spots in seedlings of sissoo from Bareilly and Dehra Dun (Uttar Pradesh) and Ambala (Haryana). Infection spots appear in June or early July. They are grey or light brown with dark brown margin on the concentric sones, coalescing to form larger leaf spots. The necrotic tissues usually fall off resulting in formation of shot holes (Tivari *et al.,* 1991).

Alternaria alternata appears in July continues throughout humid months and declines after September in Dehra Dun. The disease incidence is reported be as high as 100 per cent and almost 80-100 per cent leaflets are infected. Infection spots are dark brown, vary in size and shape and coalesce to form larger spots. The fungus sporualtes on the lower surface of the leaves. The heavily infected leaves are shed prematurely (Mehrotra, 1992a).

Insect pest of nurseries plant and study of white grub

Insect pests of Nursery

S. No.	Common Name	Scientific Name	Family	Order	Host range
1	White grub	*Holotrichia species*	Scabaraedae,	Coleoptera	Neem, Ber,. Khejri Prosopis cineraria, grapevine, guava, sonjana,· Mango, Babul, Jamun, phalsa,
2	Cutworm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	*Acacia nilotica, Dalbergia sissoo,*
3	Termite	*Odontotermis obesus*	Termitidae	Isoiptera	All tree plants
3	Locust	*Sheistocerca species*	Acrididae	Orthoptera	All tree plants
5.	Leaf hopper	*Empoasca fabae*	Cicadellidae	Homoptera	*Acacia nilotica, Dalbergia sissoo and other Nursery plant*
6.	Mealy bug	Pseudococcus species	Pseudococcidae	Hemiptera	All nursery plant

Common Name -White grub

Scientific Name- *Holotrichia serrata* F, *Holotrichia consanguinea* Bl. Hol, *Leucopholis coneophora* Family Scabaraedae,

Host Plant- Host Plant Adults of various species of genus *Holotrichia* (white grub) are noctural feeders on the foliage of plants such as Neem, Ber, Khejri Prosopis cineraria, grapevine, guava, sonjana, Mango, Babul, Jamun, phalsa, Anar, Punic a granatum, Karonda, fig, *Ficus carica*, pipal, gular, and other lac host tree.

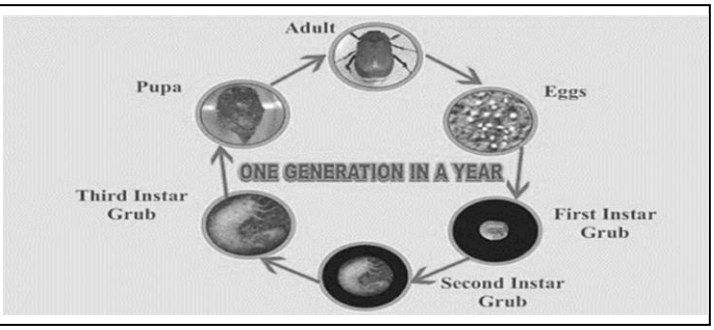
Nature and extent of damage: The rainy season provides favourable conditions for, grub attack. In case of severe infestation the entire plant stand is destroyed and sometimes the field needs resowing. White grubs (Melolonthid larvae) feed underground on the roots of host plants, while the adult beetles are observed feeding on the foliage of certain other choice plants in the vicinity during the night. The damage done by grubs to Khard crops is sometimes more than Imagination, The losses inflicted to the various crops by this pest range between 40 and 80 per cent in endemic pockets.

Identification: White grubs are white to cream-colored, C-shaped with brown sclerotized head and shiny transparent tail section. Fully grown larvae are about 1.5 in (38 mm) long if straightened out. All white grubs have three larval development stages (instars). True white grubs are distinguishable from other white grubs by two conspicuous parallel rows of stiff hairs on the tail end that are zipper-like in appearance. Annual white grubs possess the scattered hairs on the same location but lack the parallel rows of stiff hairs. The white grubs of Papilla beetles possess two rows of spines in inverted "V" pattern on the underside of the abdominal segment.

Adult May or June beetles are brownish, heavy bodied beetles that are about 1 in (25 mm) long. The beetles are attracted to lights after dark and the sound of their impact and buzzing on the screens of open windows on summer evenings is memorable. In contrast, the adults of the annual white grubs (beetles from genus cyclocephala) are much smaller, typically 7/16 -1/2 in. (11-13 mm). Some species are brown while others have a dull greenish metallic head and thorax similar to Japanese beetle. The adult Japanese beetle has metallic green or greenish head and thorax, shiny copper brown wing covers and diagnostic tufts of white hair near the end tip of the abdomen.

Life Cycle

Egg Stage**:** Adult beetles dig shallow holes in the soil where they lay their eggs. Depending on the particular white grub species, the egg laying period occurs between June and August. Several factors including soil moisture and temperature determine how quickly the eggs will hatch. Under regular conditions the eggs hatch in about 2 weeks.



Larvae Stage: After the eggs hatch, tiny 1st instar larvae begin feeding on grass roots close to the surface. feeding continues for several months into late fall. As the larvae mature into 2nd and 3rd instar, they grow in size and feed more aggressively. Turf damage can start to become visible if infestation levels are high. Animal digging from skunks and raccoons is also common during an infestation as the grubs are a great food source. The white grub overwinters as a 3rd instar larvae and moves deep into the soil as the ground freezes. When early spring arrives, the larvae move back towards the surface and continue to feed on the roots. This feeding lasts for a short time as the larvae stop feeding and turn into pupae.

Pupae Stage- The pupae life stage takes place after the larvae feeding has finished. The larvae transform into a pupae in the soil where they remain for several weeks. During this transformation process the pupae becomes an adult beetle, the last stage of its life cycle.

Adult Stage- After the completion of the pupae stage, Adult beetles emerge. The adult beetles dig their way out of the soil and move up to the surface. This takes place beginning in early summer lasting for about a month. After the beetle has crawled out of the soil it spends 2-3 weeks mating before laying eggs. The eggs (up to 60 eggs) are buried in the soil during the summer (June – Early August). The Adult beetle is the final stage in the life cycle of the white grub.

INSECT PESTS OF NATURAL FOREST

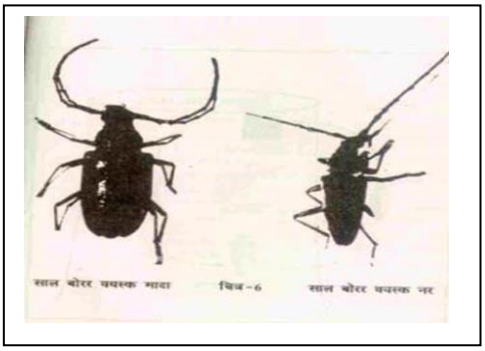
1. Insect pests of Natural Forest

S. No.	Common Name	Scientific Name	Family	Order	Host range
1	Bark borer	*Cyrtrrhynchus rufescens*	Curculionidae	Coleoptera	Chir, Deodar
2	four-eyed fir bark beetle	*Polyphagus major*	Curculionidae	Coleoptera	Deodar
3	Deodar defoliator	*Ectotrapis deodarae*	Geomeridae	Lepidoptera	Deodar
4.	Coneworms	*Deoryctri aabietella*	Pyralidae	Lepidoptera	Deodar
5.	Root borer	*Dorysthenes hugelli*	Cerambycidae	Coleoptera	Oak

6.	Longhorn beetle	*Aphrodisium hardwickianum*	Cerambycidae	Coleoptera	Oak, Chir
7.	Sal heartwood borer	*Hoploceramb spinicornix*	Cerambycidae	Coleoptera	Sal
8.	Spruce budworm	*Eucosma hypsidryas*	Tortricidae	Lepidoptera	Spruce

Common Name - Sal heartwood borer

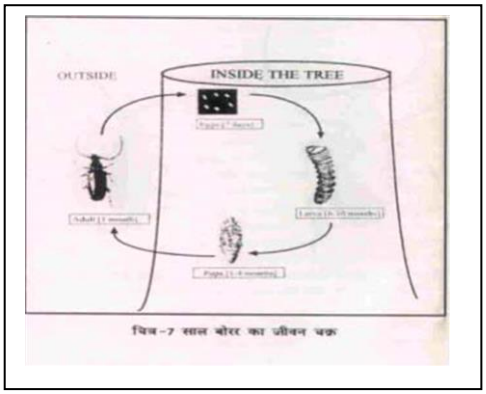
Scientific Name -*Hoploceramb spinicornix*



Distribution- This insect distributed throughout india but maijor attack was observed in Himachal Pradesh, Jharkhand, Uttarakhannd, Madhya Pradesh, Chhatisgarh, West Bengal

Nature of Damage-Its attacks felled trees, wind falls, damaged trees or infected by fungus. This is considered to be the most injurious forest insect in India. The grub remains active for six to seven-month June to November, gnaving in to the whitish sapwood and the red –brown heartwood. The grub form galleries, eating their way in and out, and up and down the stem of the tree.

Life Cycle of Sal heartwood borer



Sal heartwood borer (*Hoplocerambyx spinicornis* Newn.) is a beetle of the order- Coleoptera, family-Cerambycydae. The yearlong life cycle has four stages viz. Egg (3-7 days in June -July), Larva (July to April), Pupa (April to May) and Adult (June -July). Tshe beetles of sal borer emerge from infested trees each year as soon as the monsoon starts in the month of June, lasts till the end of July. The beetles are 3-7 cm. long, blackish to reddish brown in color. Pairing takes place immediately after emergence. Female begins to lay eggs 7 to 9 days after fertilization. Eggs are laid in cracks as deep as possible on fallen trees, on the trunk and branches of standing trees. During its life period, a beetle lays 100 to 300 eggs. The eggs hatch within 3 to 7 days of the laying and 80 to 90% of them hatch into larvae. After hatching from the eggs, the larvae enter the bark and then sapwood and finally bore into the heartwood. The progress of boring by the larvae can be judged from the heaps of wood dust, which accumulates at the base of trees. Before pupation, the larva bores a tunnel running horizontally from the sapwood and makes a pupal chamber where it pupates. The pupa turns into immature beetle in May, waiting to emerge when the monsoon sets in June.

MAJOR INSECT PEST OF FOREST TREES

Five-spined bark beetle: Native to the Americas, the five-spined bark beetle (*Ips grandicollis*) is now an established pest in Queensland's pine growing regions. Populations are usually managed through good forest cultivation practices and natural predators. They are also under biological control by 2 introduced parasitoid wasps.

Christmas beetles (*Anoplognathus chloropyrus, A. porosus, A. boisduvali, A.* spp.) are significant pests of young eucalypt plantations and can cause severe leaf loss in trees before canopy closure. Adult beetles emerge from the soil during the summer and feed on eucalypt foliage. They are hungry feeders and large swarms can defoliate trees rapidly. Larvae feed on grass roots and adults emerge from the soil in summer to feed on eucalypt leaves. Beetles feed in swarms, causing extensive damage to young plantations, especially if close to pastures.

Cigarette beetles (*Lasioderma serricorne*) are a pest found in stored food products, buildings and wooden ornamental materials. In Queensland, 4 species of anobiid beetles (Family: Anobiidae) occur in and around buildings. Queensland pine beetles and common furniture beetles, native to Europe, are economically significant, while pine bark anobiids and cigarette beetles are not very important. Only about 200, of about 1,100 species worldwide, are found in Australia. Improved building practices for timber constructions have reduced the risk of attack and reports of damage.

Common furniture beetle *(Anobium punctatum)* Native to Europe, common furniture beetles are an introduced pest of non-native pines and some hardwood timbers. They are found mainly in imported furniture and occasionally pine timber buildings in Queensland. In Queensland, four species of anobiid beetles (Family: Anobiidae) may be found in or around buildings; Queensland pine beetles and common furniture beetles, native to Europe, are economically significant, while pine bark

anobiids and cigarette beetles are not very important. Only about 200, of about 1100 species worldwide, are found in Australia. Improved building practices for timber constructions have reduced the risk of attack and reports of damage.

Giant wood moth (*Endoxyla cinereus*) Giant wood moths affect plantation productivity by weakening trees and increasing risk of breaking in strong winds. They attack trees more than 3 years old, and the damage can reduce the quality of harvested logs. Tunnels made by the larvae weaken smaller stems, which can snap in strong winds. Yellow-tailed black cockatoos tear into stems when feeding on wood moth larvae, further damaging and weakening the tree.

Gumleaf skeletoniser (*Uraba lugens*) is a common pest of eucalypt trees. Periodic outbreaks completely defoliate trees, causing widespread damage. Initially, foliage on affected trees has a typical bronze appearance, as if the tree has been scorched by fire. Outbreaks often occur during the winter, with most damage in late winter to early spring.

Leaf beetles (Chrysomelid leaf beetles) include eucalyptus tortoise beetles (*Paropsis*), northern eucalyptus leaf beetles (*Paropsisterna*) and their relatives. Larvae feeding on foliage can defoliate trees and repeated defoliation can negatively impact tree growth. In south-eastern Queensland and northern New South Wales, up to 4 generations a year cause at least 3 peaks in defoliation.

Lerps and psyllids (*Glycaspis species, Cardiaspina species, Creiis lituratus, Eucalyptolyma maideni*) Lerps are protective covers made by nymphs (larval stage that resembles adults) of jumping plant lice or psyllids (Family: Psyllidae). Nymphs excrete honeydew on the leaf surface and the sugars and amino acids in the honeydew crystallise in the air to form lerps. Leaves can look black and sooty when moulds grow on the honeydew. Lerp size and shape varies between species of psyllid. Adult and nymph psyllids are both sap suckers. Heavy infestations of nymphs can cause significant leaf-drop, defoliating trees.

Lesser auger beetle (*Heterobostrychus aequalis*), and damage consistent with its activity, has been found in mango and calliandra timber at 2 private residences in Cairns. The lesser auger beetle is mainly a pest of timber, affecting wood and wooden items. Damage occurs entirely below the surface of the wood, and isn't usually seen until the wood disintegrates. However, alerts for early detection are the tiny exit holes left by the adults when they emerge from wood and leave behind a sawdust-like material. The lesser auger beetle usually infests unsealed floors, window sills and furniture. Bamboo items are especially at risk.

INSECT PESTS OF FOREST SEED, FRUIT AND CONIFERS

Insect pests of Natural Forest

S. No.	Common Name	Scientific Name	Family	Order
1.	Oak acorn weevils	*Sitophilus glandium* (Marshall)	Curculionidae	Coleoptera
2.	Pine shoot borer	*Dioryctria abietella*	Pyralidae	Lepidoptera
3.	Pyralid moth	*Trachylepida fructicassiella*	Pyralidae	Lepidoptera
4.	Eucosmid moth	*Argyroploce illepida*	Eucosmidae	Lepidoptera
5.	Ailanthus webworm	*Atteva fabriciella* Swedrus	Yponomeutidae	Lepidoptera
6.	*Albizia* seed borers	*Bruchus bilineatopygus* Pic *B. spraspmaculatus* Pic *Caryedon gonagra* Fab.	Coleoptera	Bruchidae
7.	Sal seed borer	*Sitophilus rugicollis* Casey	Curculionidae	Coleoptera
8.	Weevil	*Mecobaris terminalae* Marshall	Curculionidae	Coleoptera
9.	Pyralid moths	*Dichocrosis punctiferalis* Guenee *Pagyda savalis* Walk	Lepidoptera	Pyralidae
Inflorescence of Feeder, Seed and Fruit borer				
10	Teak seed borer	*Eutectona machaeralis* Walk.	Lepidoptera	Pyralidae
11	Meliaceae fruit and shoot borer	*Hypsipyla robusta* Moore	Lepidoptera	Hypsipylidae

INVERTEBRATE FAUNA FROM FOREST AREAS

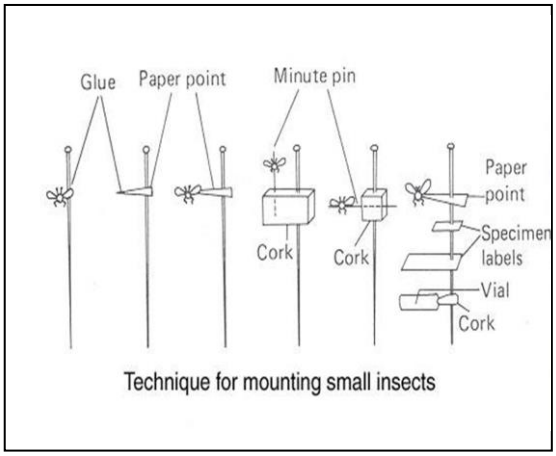
Collection Areas: Extensive field surveys for various insect pests of forest areas were carried out in various district of Bundelkhand regions from 2020. The present surveys were based on random sampling method, covering different ecological habitats, with special emphasis on forest area in bundelkhand region.

Collection Equipments: The minimum equipments required for the collection of relevant insect materials comprised of collection kit containing a pair of scissors, forceps, soft camel brush, collection tubes, polythene bags, paper bags, specimen

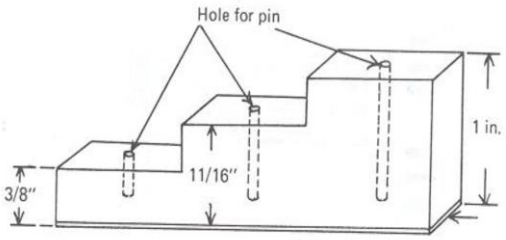
jars, and specimen tubes containing 75-90% alcohol as preservative, muslin cloth, rubber bands, hand lens, absorbent paper, field diary, permanent black pen and camera, etc.

Methods: Preparation of Ethyl acetate killing jar

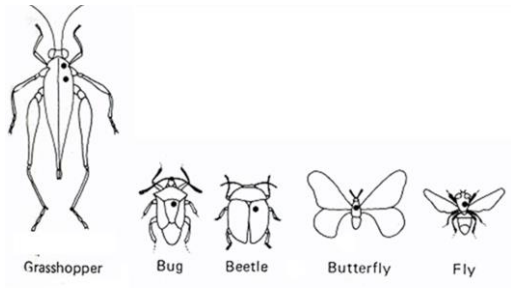
1. Keep 1.5 to 2.0 cm layer of dry sand or saw dust on the bottom of a jar.
2. Pour over this, 1.0 to 1.5 cm thick layer of wet plaster of paris and set it to dry.
3. Saturate it with ethyl acetate.
4. Label the jar "POISON'"
5. Place a filter paper on top of the dry plaster layer and use it for killing insects.
6. Keep the cork or lid tight so that gas does not leak.
7. Recharge after 2-3 days.



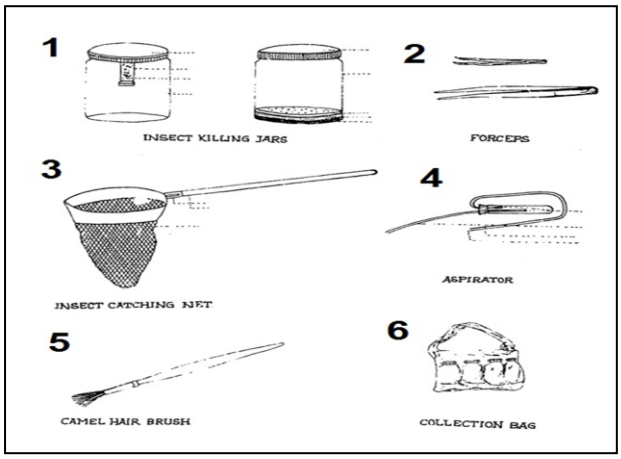
Technique for mounting small insects



Pinning step block used to regulate the height of specimens and labels on an insect pin



Position of pin hole for proper mounting of common insect orders



PLANT PROTECTION APPLIANCES

1.**Atomiser**: This is smallest and simplest sprayer. There is thin, plastic or glass container with a capacity of less than half litre. It is fitted with a small nozzle and a pump to be operated by hand. With each inward stroke of the pump the fluid is discharged through the nozzle in fine droplets. The spraying is not continuous and t is used in laboratories, glasshouses and houses.

2.**Hand sprayer**: This is a small single action sprayer. Capacity of the tank is about one litre. After filling the three fourth of tank give 8-10 strokes of the pump piston to build up the pressure. Press the lever and the nozzle gives you a continuous fine mist spray. Good for kitchen gardens and laboratories or glass house work.

3. Knapsack sprayer :This consist of non-pressurized tank with a hand pump (piston-type) fitted by its side. The capacity of the tank varies between 6 -16 or even 20 liters. The pump sucks the solution from tank which is then discharged through the lance and nozzles attached to the delivery pipe. It is carried on the back and held in position by means of two straps. Hold lances in spray about half a hectare in one day. In case of young crop or seedlings the single nozzle can be replaced by a double nozzle or even by a cluster of 3 to 4 nozzles and then a person can spray on hectare in a day. This sprayer is good for spraying water dispersible or wettable powder formulations of various pesticides.

4.**Hand Compression Sprayer**: This is an improved knapsack sprayer. There is a vertical hand-pump fitted in the tank. The cylindrical tank is usually of brass with variable a capacity up to 20 litres. It is filled three-fourth with spraying solution and in top one-third portion air is compressed. Then it is quite easy and con hectare in one day. The only drawback is that this sprayer is suitable for using wettable or water dispersable powder as there is no agitating mechanism provided in this sprayer

Fig. (c) Pinning step block used to regulate the basis of specimen and label on an insect

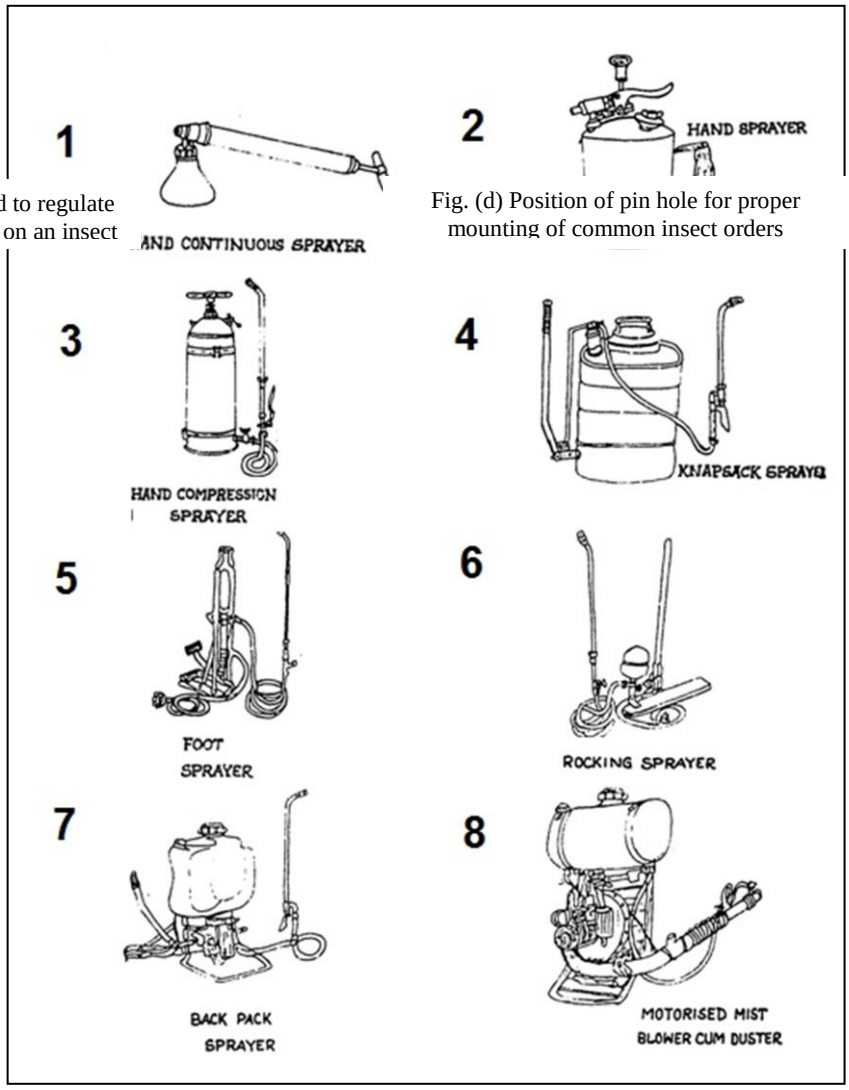


Fig. (d) Position of pin hole for proper mounting of common insect orders

5.**Foot sprayer**: There is no tank in this sprayer The pump is fitted on an iron stand and a pedal is attached to the plunger rod. There is a suction pipe with strainer fitted at the lower end which is dropped into the bucket containing the spray material. At the other end of the pump is a long delivery pipe fitted with a lance and a nozzle. Keep a foot on the pedal and press it down then release it to come up again, with each upward movement of the pedal, the spray solution is sucked up into the pump chamber and with the downward motion of the pedal the

solution is discharged. At least 2 persons are required one to pedal and other to hold lance and spray. Two more persons may be kept to fetch the water and prepare spray solution. They can easily spray about 2 hectares in one day.

6. **Rocker sprayer**

The principle is same as in pedal sprayer. In this instead of pedal there is along handle to be moved to and fro with hand. The pump along with brass chamber is fitted on a wooden board. The pump along with brass chamber sucks the solution through suction hose and releases it through the delivery pipe as in case of pedal sprayer. Usefulness and manpower requirement is also same. It is only matter of choice, whether one wishes to pump with hand or foot. This is cheaper than pedal sparyer, but pedal sprayer is more popular.

7**. Mist Blower**: This is a power-operated gaseous-energy knapsack sprayer which can be used for dusting as well as spraying. The hopper or tank is made of high-density polyethylene and has a capacity of 8-12 litres. Another small tank of one to two litres capacity is provided for fuel. The engine is generally 1.25 to 2.5 H.P. and is mounted on a frame with rubber packings to prevent the communication of vibrations of the engine to the person carrying it. There is a wide bore hose connected with the blower outlet; this is fitted with a cut off cork. A drain-out pipe for the dust or a nozzle (with delivery tube) for spraying can be fitted to this hose connecting it with the hopper and the blower used for dusting or spraying. This is a low volume sprayer. Spray liquid is blown out by an air current generate din the machine. Due to high pressure droplets size is ranging from 50 to 150 microns which easily stick to the plant surface and there is no run-off losses of chemical. Moreover, the water requirement is also less than half than required for conventional sprayings. A person can treat about 3 hectares in one day.

Dusters

8. **Dusting Gun:** A very simple type of plunger pump. The body is -cylindrical, 45 to 60 cm long and 7-9 cm in diameter, made of some light metal or tin. the out-stroke of the pump sucks-in the air which passes into the duster chamber and the in-stroke causes the dust to blow out through the discharge outlet. Good for kitchen-gardens, nurseries and house-hold pests.

9. **Rotary duster-** A consists basically of a blower complete with a gear box and a hopper. It is operated by rotating the crank. The cranking motion is transmitted through the gear box to the blower. A drive is taken for the dust agitator located in the hopper. The rotary duster may be hand carried type or shoulder mounted or belly carried type. The feed is controlled by a feed control lever, which operates a slide to control the aperture at the bottom of the hopper

10. **Soil-Injector:** A hand pump also known as soil injecting gun. It has a long, pointed, metallic, hollow tube on one side. This rod has several openings. It is pushed into the soil to a depth of 12-15 cm and then the soil fumigant contained in the body of the pump is pumped into the soil. It is generally used for soil fumigation with volatile liquids like carbon disulphide, EDB, etc. against nematode.

11.**Cynogas Foot Pump**: Another plunger type pump for dusting the rat burrows. It has cylindrical brass body 40 to 50 cm long and 8 to 12 cm in diameter fitted with air pump on one side, glass or plastic container (dust chamber) on other side and a discharge tube (rubber hose) fitted with a valve. Working principle is same as that of dusting gun. When pumped into rat-burrows, calcium cyanide comes in contact with soil moisture and liberates HCN gas which kills rats inside.

12.**Flame Thrower**: A knapsack type sprayer where the lance is fitted with a burner. The tank is filled with kerosene oil and compressed air. The burner is heated and oil allowed to flow through it, resulting in flames which are shot out. Used for killing locusts

13.**Seed-Dressing Drum**: A metallic drum of varying capacity (maximum 50 kg) is horizontally mounted (tilted slightly) on a stand. There are 3-4 iron-blades (baffles) fixed at the right angles to the inner surface of the drum which help in thorough mixing of the pesticide with seeds. The drum is rotated manually by means of a handle fitted at one end. Seed materials to be treated are put inside the drum along with appropriate quantity of chemicals with which the seed is to be treated. The drum is then rotated 30 -40 rotation (about 2 minutes) are enough to get the seed material uniformly coated with the chemical.

INSECTICIDES FORMULATION

Insecticide formulation-Insecticide formulation is a combination ion of active and inert ingredients that forms an end-use insecticide product. Pesticides are formulated to make them safer or easier to use. This is because many insecticide active ingredients, in “pure” (technical grade) form, are not suitable for application. In their concentrated form, some are extremely toxic, many do not mix well with water, some are unstable, and some are difficult (or unsafe) to handle, transport, or store.

Classes of Insecticides Formulation

1.Liquid Formulation

Emulsifiable Concentrates (EC): An emulsifiable concentrate formulation usually contains an oil-soluble liquid active ingredient, one or more petroleum-based solvents, and a mixing agent. The mixing agent allows the formulation to be mixed with water to form an emulsion. Most ECs contain between 2 and 6 pounds of active ingredient per gallon. ECs are among the most versatile formulations

Solutions (S): Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based diluents. When mixed, they form a solution that does not settle out or separate. Formulations of these pesticides usually contain the active ingredient, solvent (carrier or diluents), and one or more other ingredients. Solutions are suitable for any type of sprayer, indoors or outdoors.

Ready-to-Use (RTU) Low-Concentrate Solutions: Ready-to-use formulations require no further dilution before application. They consist of a small amount of active ingredient (often 1% or less per unit volume). Some ready-to-use products contain petroleum-based solvents; others are water-based. RTU products are produced for pest management professionals (who treat structural and institutional pests) and for non-occupational users

Ultra-Low Volume: Ultra-low-volume concentrates have almost 100% active ingredient. They are designed to be used "as is" or diluted with only small quantities of specified solvents. These special-purpose formulations are most suitable for outdoor applications, such as in agricultural, forestry, ornamental, and mosquito control programs. ULV products are applied as very fine droplets at very low rates per unit area (or volume).

Flowables (F or AF): Some active ingredients are in-soluble solids: substances that will not dissolve in either water or oil. These may be formulated as flowables. (Most manufacturers use the letter "F" by the trade name to designate that the formulation formulation is a flowable. However, some use the letter "L," meaning that an insoluble material is presented in "liquid" form.) Most flowables are prepared by first impregnating them onto a dry carrier, such as clay. Then, the active ingredient plus carrier (or the active ingredient alone) are ground into a fine powder. Next, the fine powder is suspended in a very small amount of liquid (and perhaps other inert ingredients). The resulting product is a thick liquid suspension.

2.Solid formulation

Dusts (D): Most dust formulations are ready-to-use and contain a low percentage of active ingredient (usually 10% or less by weight). A few dust formulations, however, are concentrates and contain a much higher percentage of active ingredient. These concentrates must be mixed with dry inert carriers before application

Granules (G): Granular formulations are similar to dust formulations; however, granular particles are larger and heavier. Like dusts, they are not water-soluble. They are ready-to-use–not intended to be mixed with water and applied as a liquid suspension. The coarse particles that serve as carriers for granular formulations are adsorptive substances like clay or absorptive plant material such as ground corncobs or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1% to 15%.

Pellets (P or PS): Most pellet formulations are very similar to granular formulations in their uses, advantages, and disadvantages. However, in pellet formulations, all the particles are more or less the same weight and shape. They are produced by combining the active ingredient with inert materials to form a "slurry" —a thick liquid mixture. This mixture is then extruded under pressure. As a result, pellets are round in cross section and cut to a specific length. Because pellet particles are more uniform, you can apply them with precision

Wettable Powders (WP or W): Wettable powders are dry, finely ground solid materials. Most include wetting and/or dispersing agents. Usually, they must be mixed with water and applied as a spray. A few products, however, may be applied dry or as a liquid suspension. Wettable powders contain 5% to 95% active ingredient—usually 50% or more. Wettable powder particles do not dissolve in water. When mixed with water, they form a suspension. They will settle out quickly without constant agitation to keep them suspended.

Water-Dispersible Granules (WDG) or Dry Flowables (DF): Water-dispersible granular formulations are wettable powder formulations compressed into dust-free, granule-sized particles. Most come with a product-specific measuring device, with dry ounce (or pound) increment marks based on product density (weight per unit volume). Because of this and the fact that they readily flow or pour out of their containers, they are easier to measure and cleaner to handle than WPs. Like wettable powders, water-dispersible granules are mixed with water and applied as a spray suspension. Once in water, the granules break apart into fine powder. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of wettable powders.

Soluble Powders (SP or WSP): Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily in water and form a true solution. After a thorough mixing, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15% to 95%; it usually is more than 50%.

Baits (B): A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Many baits are solid (blocks, granules, or pellets), but some are liquids,

pastes, or gels. The amount of active ingredient in most bait formulations is quite low, usually less than 5%

3.Gaseous Formulation

Fumigants: Fumigants are insecticides that deliver the active ingredient to the target site in the form of a gas. Some active ingredients are liquids when packaged under high pressure but become gases when released. Fumigants are used for agricultural pest control; fumigants are effective in soil, greenhouses, and commodity storage areas (such as grain bins).

Aerosols (A): Aerosol formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredients. There are two types of aerosol formulations

Formulations for Smoke or Fog Generators: Formulations for smoke or fog generators are not packaged and sold under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol). Using a rapidly whirling disk or heated surface, the machines produce and distribute very fine droplets. These formulations are used mainly for insect control in structures such as greenhouses, barns, and warehouses and for outdoor mosquito and biting fly control.