Ethiopian Forestry Development
Forest Disaster Protection




Training Manual on Forest Insect pests and disease management in Ethiopia (Draft)

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Table of content

List of Figure

List of table

Acronyms

EFD ……….. Ethiopian Forestry Development

CRGE ………Climate Resilient Green Economy

REDD+ …Reduce Emission from deforestation and degradation, enhancement of forest carbon stocks.

NDC ……… Nationally determined contributions

1 Introduction

1.1 Background

The Government of Ethiopia initiated the Pathway to Prosperity Ten Years Perspective Development Plan (2021- 2030) in parallel with Climate Resilient Green Economy (CRGE) Strategy which has triple core objectives; namely: reducing greenhouse gas emissions from Agricultural, Industry and services, reducing vulnerability to climate change, and ensuring economic growth that should lead the country to a middle income nations by the end of 2025.

In view of this, the Ethiopian Forest Development has been playing a pivotal role for the successful achievements of this strategy. Specifically, on reducing greenhouse gas emissions from deforestation and forest degradation, sustainable forest management, forest conservation and enhancing forest carbon stocks through (REDD+) fast tracking mechanisms. To ensure this, protecting the resource base from pests, disease and fire is vital.

Consequently, participating and capacitating of different stakeholders at various levels in forest protection is believed to be important for the effective implementation of CRGE strategy left for forestry sector. Ethiopian forestry Development (EFD) has developed its NDC, LT, and Led using the forest sector transformation strategy.

In general, Forests are not always routinely monitored in developing countries like Ethiopia, and working guidelines and forest protection measures are not always incorporated into forest management. Besides, many stakeholders working with forests do not pay systematic attention to forest protection. Therefore preparing introductory manual on forest pest and disease is required.

1.2 Objective of the manual

The main objective of this manual is

- To create awareness,
- To capacitating regional stakeholders with respect to the prevention and controlling mechanism of pest and diseases
- To highlight the principles of forest protection that enable experts to identify major pest and disease,

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1.3 Scope of the manual

This Training Manual on Forest insect pests and disease management in Ethiopia is prepared mainly to support the regional states to use as a reference while providing trainings to the lower level structures. The scope of the manual focuses on sharing knowledge and experiences to regions on control of insects and diseases to prevent them from becoming pests that cause widespread and serious damage, through a combination of techniques including biological control, habitat manipulation, modification of cultural practices, and use of disease resistant varieties.

1.4 Definition of important terms and concepts

A pest is any animal or plant harmful to humans or human concerns. The term is particularly used for creatures that damage crops, livestock, and forestry or cause a nuisance to people, especially in their homes. ***Forest pest*** means any insect or disease which is harmful, injurious or destructive to forests or timber. Pests and diseases are divided into sections based on the type of damage caused.

Primary stress agents which first and principally affect the health of the tree and that cause a sustained disruption of the normal physiological processes or structural functioning of a tree and are capable of attacking and injuring or killing otherwise healthy trees.

The secondary, stress agents which has a less important influence and usually affect trees already weakened by a predisposing factor.

Forest protection is the scientific branch of forestry concerned with the study and control of biotic (living) and abiotic (non-living) stress agents that affect the health and/or integrity of tree seedlings, mature trees forest communities, and wood products maintaining a healthy balance in forests is the goal of most modern forest managers. Besides, understanding the roles and impacts of biotic and abiotic stress factors are important in forest management, hence identification of these stress agents is the first step.

Forest protection does also require an understanding and utilization of the principles and practices of not only forest pathology and forest entomology, but also forest ecology, forest management, silviculture, tree physiology, tree anatomy, soil science, physics, chemistry, and general biology. Forest protection is a critical component of silviculture which is the science of forest establishment, growth, and composition.

The ultimate goal of forest protection is to minimize tree mortality and growth loss due to forest stress agents, and thereby protect and preserve healthy forest communities. The principle of pest control is to use a control method only when necessary to prevent unacceptable levels of damage.

1.5 Diagnosis of tree health problems

You can avoid most tree problems by planting the right tree in the right place and by providing proper care and protection from injury. While these measures can minimize stresses that lead to problems, it is not possible to avoid every threat to a tree's health. The first step in solving a tree health problem is to correctly identify the problem and its cause. This manual will guide you through a systematic process for learning about the plant and its needs and weaknesses, observing signs and symptoms, and gathering information about factors affecting the tree's health. These factors include:

- biological factors (insects, disease, wildlife)
- environmental factors (weather, soil, air pollution)
- cultural factors (pruning, watering, fertilization

Some problems are so common and widespread that diagnosis is fairly simple. For example, wilting during a drought may just indicate a need for water, which is easily remedied. However, most tree problems exhibit a set of characteristic symptoms, not just one. Failure to evaluate the full range of symptoms can lead to misdiagnosis or to treatment of the symptoms rather than the causes of the disorder.

2 Strategies and Principles of Pest and Disease management

2.1 Strategies of pest and disease management

The most effective strategy for controlling pests is to combine methods in an approach known as Integrated Pest Management (IPM). In IPM, information about pests and available pest control methods is used to manage pest damage by the most economical means while minimizing risks to you, your pets, and your environment. The strategies for plant disease management is reducing the level of infestation involves cultural practices, such as sanitation, removing diseased plants or plant parts, rotating crops, eliminating weeds or other plants that may be alternate hosts for the disease, and discouraging or preventing insect vectors.

2.1.1 Tactics of pest and disease management

Pest control tactics may include: host resistance, biological control, cultural control, mechanical control, sanitation, and chemical (pesticide) control.

2.1.1.1 Avoidance

Prevents disease by selecting a time of the year or a site where there is no inoculum or where the environment is not favorable for infection. Exclusion—prevents the introduction of inoculum. Eradication—eliminates, destroy, or inactivate the inoculum.

2.1.1.2 Exclusion

Exclusion of plant diseases consists of practices designed to keep pathogens (things that cause disease), vectors (things that spread disease) and infected plants out of disease-free areas. The goal of this method of management is to prevent the disease from entering the area where the plants are growing.

2.1.1.3 Eradication

This principle aims at eliminating a pathogen after it is introduced into an area but before it has become well established or widely spread. It can be applied to individual plants, seed lots, fields or regions but generally is not effective over large geographic areas.

2.1.1.4 Protection

It involves some cultural practice that modifies the environment, such as tillage, drainage, irrigation, or altering soil ph. It may also involve changing date or depth of seeding, plant spacing, pruning and thinning, or other practices that allow plants to escape infection or reduce severity of disease.

2.1.1.5 Resistance

Plant disease resistance protects plants from pathogens in two ways: by pre-formed structures and chemicals, and by infection-induced responses of the immune system.

2.1.1.6 Therapy

This method of plant disease management is achieved by incorporating a chemical control agent into the physiological processes of the plant to reverse the progress of disease development after infection has occurred.

2.2 Principles of forest insect pests and diseases

The Principles of Forest Management stated that forests, with their complex ecology, are essential to sustainable development of the economy and the maintenance of all forms of life. Forests provide wood, food, and medicine and contain a biological diversity as yet not fully uncovered. A key part of pest management is to use a pesticide only when it is needed to prevent an unacceptable amount of damage. Use of a pesticide may not be justified if the cost of control or potential harm to the environment is greater than the estimated damage or loss. Disease prevention and control involves the three interrelated processes of bio exclusion, surveillance, and bio containment. Disease prevention, diagnosis, and control strategies have changed to prevent physiological, nutritional, and agent-induced pathologies from affecting performance

Four common methods are used to control pests and diseases; biological, cultural, chemical and integrated control. Biological control is the use of useful and beneficial living organisms, such as predators or parasites, to control pests. Predator insects feed on the pests and can control their numbers.

The principles of IPM include:

- Identify pests, their hosts and beneficial organisms before taking action.
- Establish monitoring guidelines for each pest species.
- Establish an action threshold for the pest.

The principle of forest insect pest and diseases encompasses three major controlling mechanisms;

Legal control--- At present two categories of regulatory measures is in operation for control of pests, diseases and weeds. They are: i) Legislative measures through Plant Quarantine, and ii) Legislative measures through State Agricultural Pests and Diseases Act.

Cultural Control--- Cultural methods of pest management include use of resistant varieties, tillage, mulching, hand weeding and hoeing, pruning, trapping and hand picking of insects and weeds, and the use of physical barriers such as row covers and sticky bands.

Direct control--- temporary or emergency treatments directed against newly introduced pathogens before they become firmly established or against existing diseases that have reached, or threaten to reach, epidemic proportions under particularly favorable circumstances. Common examples of direct pest control include removing or destroying nests, blocking holes, windows or doorways, temperature control methods to kill pests, or setting traps to catch pests and then remove them from the area.

3 Forest insect pest management

3.1 Overview of external anatomy and physiology of insects

The three main insect body parts are head, thorax, and abdomen. The head contains the antennae, eyes, and mouthparts. The thorax is the middle body part to which the legs and wings are attached. The abdomen contains digestive and reproductive organs internally and often reproductive structures externally.

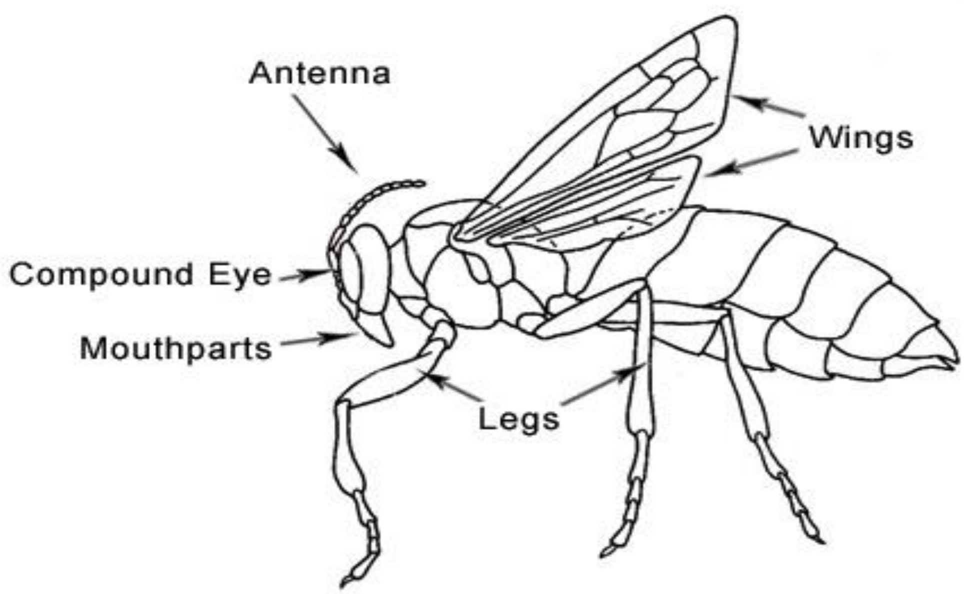

Figure 1 Parts of insect body

The study of insect physiology is usually divided into a systems approach. These systems are the same required by all animals. The major systems are: digestive, excretory, circulatory, immune, muscular, nervous, and reproductive.

Population dynamics--- is the portion of ecology that deals with the variation in time and space of population size and density for one or more species. Population dynamics refers to how populations of a species change over time. The study of a species' population dynamics usually seeks to answer questions such as: What explains average abundance of a population? What causes fluctuations in abundance? After all, population change is determined eventually by only four factors: birth, death, immigration, and emigration.

3.2 Overview of insect classification---

The classification of insects can be complex but it is very important to group and identify insects so that they can be studied reliably. Insects, like all animals, are classified using a hierarchical system of classification. Here is an example using the marmalade hoverfly, Episyrphus balteatus:

Kingdom: Animalia (all animals)

i) Phylum: Arthropoda (all arthropods)
ii) Class: Insecta (only the insects)
iii) Order: Diptera (only the true flies)
iv) Family: Syrphidae (only the hoverflies)
v) 3.1.1. 6 Genus: Episyrphus (only a sub-set of the hoverflies)
vi) Species: balteatus

Insects (from Latin insectum) are pancrustacean hexapod invertebrates of the class Insecta. They are the largest group within the arthropod phylum. Insects have a chitinous exoskeleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs, compound eyes and one pair of antennae.

Insect, (class Insecta or Hexapoda), is any member of the largest class of the phylum Arthropoda, which is itself the largest of the animal phyla. Insects have segmented bodies, jointed legs, and external skeletons (exoskeletons).

- ❖ Scientific name: Insecta
- ❖ Higher classification: Hexapoda
- ❖ Rank: Class
- ❖ Eaten by: Mantis, Snake, Coyote, Chinese wolf spider
- ❖ Order: Animal

Insect “blood” is called hemolymph, and, while it is analogous to blood and plays a similar role as blood, it is different in a few key respects. Unlike vertebrates such as mammals and reptiles, insects have an open circulatory system that lacks veins and arteries.

Even though insects and other arthropods, such as lobsters, do not look alike, all arthropods share the following characteristics:

- A segmented body
- Paired segmented appendages (legs)
- Bilateral symmetry (the right and left half look the same)
- An external skeleton that is molted as the animal grows.

Some kinds of insects are best kept dry. Ethanol (grain or ethyl alcohol) mixed with water (70% to 80% alcohol) is usually the best general killing and preserving agent. For some kinds of insects and mites, other preservatives or higher or lower concentrations of alcohol may be better.

3.2.1 Orders that encompass forest insect pests

The insect specimen drawer exemplifies the diversity of forms displayed by species in the four largest insect orders: Coleoptera (beetles & weevils), Hymenoptera (wasps, bees & ants), Lepidoptera (moths & butterflies), and Diptera (true flies).

3.2.2 Categories of forest insect pests

Forest insect pests are generally grouped by the type of damage they cause to their hosts. These insects fall into one of five categories: defoliators, bark beetles, wood borers, sap sucking insects, and meristem feeders. Meristems are small populations of rapidly proliferating cells that produce all the adult organs of a flowering plant. Two meristem populations are established in the embryo, the SAM (which gives rise to the aerial parts of the plant) and the RAM (which gives rise to the root system). Plant meristems are centers of mitotic cell division, and are composed of a group of undifferentiated self-renewing stem cells from which most plant structures arise. Meristem tic cells are also responsible for keeping the plant growing.

3.3 Biology, host range and distribution, economic significance, and management of forest insect pests in Ethiopia.

Only a few species of sucking insects kill forest trees directly by inject toxic saliva during feeding causing necrosis of plant tissue and shoot dieback. In addition to their direct feeding damage, some sucking insects are vectors of plant diseases. Many of these insects are individually quite small and are frequently transported on nursery stock. A few of the major forest pest species that make up this complex group are:

3.3.1 Cypress aphid (Cinara cupressivora)

The cypress aphid Cinara cupressi, is a brownish soft-bodied aphid. It sucks sap from twigs of conifers, and can cause damage to the tree, ranging from discoloring of the affected twig to the death of the tree. They may be pink, brown, black, whitish or greenish. The rate of development and reproduction of aphids is very rapid, producing many generations each year. Aphids suck plant juices from the tender, succulent parts of plants and that heavy feeding causes stunting of terminal buds, and needles become distorted or stunted. Often the first sign of attack is the presence of many aphids on the branches. They excrete sweet, sticky honeydew which may attract many ants. A fungus, sooty mold frequently develops on the honeydew and the branch or entire tree may appear black. Sap sucking on terminal growth of young and old trees retards new growth and causes desiccation of stems and progressive dieback on heavily infested trees. Aphids can be controlled by an application of labeled insecticides when necessary. Spray with soap, chili peppers, ash or a combination of the three can also be used for controlling this insect.

Figure 2 Cinara cupressi, mainly orange

brown to yellowish brown, with blackish markings diverging back from the thorax.

Figure 3 the pupa of a predatory syrphid surrounded by surviving Cinara cupressi

3.3.2 Blue gum chalcid (Leptocybe invasa)

Blue gum chalcid (Leptocybe invasa) is a major pest of young eucalypt trees and seedlings. It is native to Australia, currently spreading through Africa, Asia and the Pacific, Europe, Latin America and the Near East. Leptocybe damage: older galls with exit holes on eucalypt branches and leaf petioles. Developing larvae form bump-shaped galls on leaf midribs, petioles and stems of new growth of young eucalypt trees, coppice and nursery seedlings. Severely attacked trees show leaf fall, gnarled appearance, loss of growth and vigor, stunted growth, lodging, dieback and eventually tree death. Movement of nursery stock; international air traffic; flight and wind dispersal are major paths. The recently introduced chalcid pest known as the Blue Gum Chalcid (BGC) (L. invasa) is currently one of the major insect pests of Eucalyptus tree species in Ethiopia.

Figure 4 Blue gum chalcid (Leptocybe invasa) on grand Eucalyptus

3.3.3 Red Gum Lerp Psyllid (Glycaspis brimblecombei)

Red gum lerp psyllid is an insect that is native to Australia. In June 1998, this insect invaded California and was first found in Los Angeles County. This pest feeds exclusively on species of Eucalyptus and in California it exhibits high preference for river red gum (Eucalyptus camaldulensis), flooded gum (E. rudis), and forest red gum (E. tereticornis).

Red gum lerp psyllid has demonstrated remarkable invasion potential. After its initial discovery in California, red gum lerp psyllid was found in Baja California, Mexico in 2000, Florida and Hawaii in 2001, Mauritius 2001, South America in 2002, and Portugal and Spain in 2007. This pest is a major threat to susceptible Eucalyptus species that are grown in urban landscapes, as wind shelters, or as commercial forests.

Psyllid Biology: Psyllid nymphs and adults feed on sugar rich phloem. Honeydew is a sticky waste product excreted by nymphs and adult psyllids after digesting phloem. As nymphs feed they can use honeydew excretions to form a protective white cap called a "lerp," the conspicuous white cone seen on eucalyptus leaves. Nymphs feed and grow to adulthood under this crystalline cap. Upon completing development, winged adults leave the protection of the lerp and fly to new plants to mate, feed and lay eggs. This aphid like insect (family Aphalaridae, formerly in Psyllidae) sucks phloem sap and excretes large amounts of sticky honeydew.

Figure 5 Red Gum Lerp Psyllid (Glycaspis brimblecombei)

Damage: High density red gum lerp psyllid populations secrete copious amounts of honeydew and excessive feeding pressure causes premature leaf drop. Heavily infested leaves are readily noticeable because of the large numbers of white lerps encrusting the leaf surfaces. Falling leaves foul surfaces beneath infested trees such as vehicles parked under trees, and swimming pools, the bottoms of shoes are soiled when sticky leaves are walked on, and leaf drop results in the rapid accumulation of flammable material beneath trees and on the rooftops of houses and other buildings. Extensive and repeated defoliation weaken trees, and contributes to the premature death of some highly susceptible species, in particular E. camaldulensis.

Figure 6 Red Gum Lerp Psyllid (Glycaspis brimblecombei)

Biological Control of Red Gum Lerp Psyllid:

A biological control program against red gum lerp psyllid has used the parasitoid Psyllaephagus bliteus. This natural enemy is native to Australia and was widely released in California from 2000 through 2002 to control the red gum lerp psyllid, after quarantine studies indicated that it posed no significant risk to other species.

3.3.4 Seed borers

Borers are a group of insect pests that spend part of their adult or larval life stage feeding inside roots and branches, or tunneling beneath the bark or into the heartwood of many trees and shrubs. Many species of boring insects are capable of causing internal damage to a wide range of plants.

The seed borer attacks immature fruits and it is difficult to distinguish between infested and uninfected fruits prior to the emergence of larvae. Fruits with tiny exit holes are the only indication of seed borer infestation. During the tunneling process, the larva drags out the excreta from the seed to the pulp. The only long-term treatment for borer is a residual surface application of a product including insecticide or preservative. The treatment must last longer than the lifecycle of borer. This type of treatment can only be used on bare timber, so you may need to strip the timber of paint or vanish before treatment.

3.3.5 Termites

Termites are a group of detritophagous social insects which consume a wide variety of decaying plant material, generally in the form of wood, leaf, litter and soil humus. Termites are one of the most damaging pests in the tropics and can cause considerable problems in agriculture, forestry and housing. Some have nests underground, others in wood, for example hollow trees, and some build mounds. Before control methods can be adopted a basic identification of the pest species or family is needed. This can be done by observing pest behavior and the damage pattern on the tree or crop.

Fungus-growing termites prefer to eat dead plant material. Their attacks are thought to be related to soils with low organic matter content. This is because such soils do not contain enough food for termites to live and they resort to feeding on living plant material. Adding organic material to the soil solve this problem. Evidences of Termites include;

- Discolored or drooping drywall.
- Peeling paint that resembles water damage.
- Wood that sounds hollow when tapped.
- Small, pinpoint holes in drywall.
- Buckling wooden or laminate floor boards.

Figure 7 Termite on dead wood

Figure 8 Tunnel making termite

3.4 Basic tools for insect collection and preliminary identification

Nets used to collect insects and arthropods fall into three general categories; aerial nets, sweep nets, and aquatic nets (see Nets, right). Each is specifically designed to interface with the environment in which the sampling will take place. Making an insect collection is one of the best ways to learn about insects, as you'll observe them up-close.

The complete Insect Collecting Kit, which contains all items necessary to make an insect collection from the insects you catch. These kits are ;

Insect net

Killing jar

Ethyl acetate

Observation jar

Insect field guide

Forceps

Pinning block

Spreading board

Insect pins

Displaycase

Figure 9 Insect Net and its utilization

3.5 Observing and Identifying Insects

When searching for insects outside, look on flowers, in gardens, on decaying leaves, and through the air, if looking for insects in a field, use the sweep method: Carefully swing your net through the top edge of the grass and see what you catch in the end of your net. Identifying and Labeling Insects: Since insects can be beautiful or strange or scary-looking, it's fun to make a collection just for display. But if you're making a collection for school or researching which insects' lives in your area, you'll want to take the extra step to identify the specimens you collect. Take notes of where you found each insect (such as what plant it was on) while you're out collecting, and then use an identification guide when you get home to find the scientific and common names. Write or print out a small tag (card stock or other thin cardboard works well) with the name, and attach it to the pin that you use to hold down your insect. You may also want to list the date and place where you found the insect.

There are about a million insect species of all different colors, shapes, and sizes! However, despite the many differences, all insects share a few basic characteristics: **Exoskeleton** rather than bones inside their bodies, insects have a hard protective covering on the **outside.**

A. Antennae

Insects usually have one pair of antennae on their head used for touching and smelling.

B. Three body divisions

Insect bodies are divided into the head (with its eyes, mouth, and antennae), the thorax (where its legs and wings are), and the abdomen.

C. Six legs

All insects have six legs attached to their thorax.

3.6 Field data collection sheet for forest insect pests

Sampling is based on the extraction of invertebrates from a portion of the soil and litter using manual, physical or chemical means. Manual methods are also effective in extracting invertebrates from earth in cavities and the material produced by breaking up old tree wood.

The growing recognition that insect populations may be in decline has given rise to a renewed call for insect population monitoring by scientists, and a desire from the broader public to participate in insect surveys. However, due to the immense diversity of insects and a vast assortment of data collection methods, there is a general **lack of standardization** in insect monitoring methods, such that a sudden and unplanned expansion of data collection may fail to meet its ecological potential or conservation needs without a coordinated focus on standards and best practices.

4 Forest and tree diseases

4.1 Concept of disease in plants

Trees, like any other living thing, are susceptible to diseases. Some of the diseases encountered in trees are merely unsightly whereas others can reduce productivity or kill the tree.

A plant disease is defined as “anything that prevents a plant from performing to its maximum potential.” This definition is broad and includes abiotic and biotic plant diseases.

When the defenses against disease are compromised, the disease can gain a foothold in the tree resulting in infection and sometimes in tree death.

Plant disease is also defined as the state of local or systemic abnormal physiological functioning of a plant, resulting from the continuous, prolonged 'irritation' caused by phytopathogenic organisms (infectious or biotic disease agents).

a. Abiotic or non-infectious diseases:

These diseases are caused by conditions external to the plant, not living agents. They cannot spread from plant to plant, but are very common and should be considered when assessing the health of any plant. Examples of abiotic diseases include nutritional deficiencies, soil compaction, salt injury, ice, and sun scorch

Figure 10 Frost injuries on soybean seedlings

b. Biotic or infectious diseases:

These diseases are caused by living organisms. They are called plant pathogens when they infect plants. For the purposes of discussing plant pathology, only plant disease pathogens will be discussed. Pathogens can spread from plant to plant and may infect all types of plant tissue including leaves, shoots, stems, crowns, roots, tubers, fruit, seeds and vascular tissues

Figure 11 Soybean plants dying from Sclerotinia infection

4.2 Disease Triangle

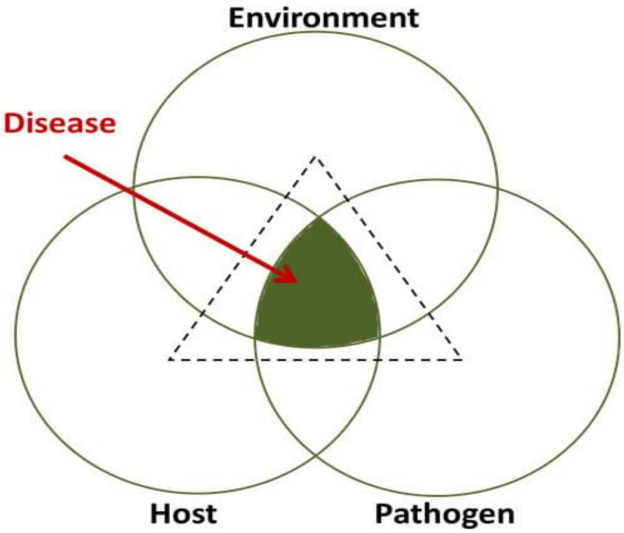

Figure 12 Venn - diagram of disease triangle.

Three components are absolutely necessary in order for a disease to occur in any plant system. The three components are:

- susceptible host plant
- virulent pathogen
- favorable environment

When these three components are present at the same time, a disease (shaded region) will occur if a susceptible host plant is in intimate association with a virulent plant pathogen under favorable environmental conditions. This concept is represented by the shaded portion of the diagram above. When there is a high degree of overlap (as the shaded area becomes larger), there will be a moderate to high amount of disease.

It is important to remember that within each of the three components –host, pathogen, and environment –there are numerous variables that may affect both the incidence and severity of the disease. These variables include genetic diversity, biology and lifecycle of the host plant and pathogen, and environmental conditions.

In order for a disease to develop, a pathogen must be present and successfully invade plant host tissues and cells. The chain of events involved in disease development includes inoculation, penetration, infection, incubation, reproduction, and survival

4.3 Causative agents of tree diseases

Living organisms inciting forest diseases are called pathogens, and the affected tree is called the host. Most pathogens of western trees are fungi, but several species of dwarf mistletoes, which are flowering plants, also cause serious diseases in trees.

Infectious plant diseases are mainly caused by pathogenic organisms such as fungi, bacteria, viruses, protozoa, as well as insects and parasitic plants.

4.4 Fungal biology, morphology and classification

Morphology: Fungi exist in two fundamental forms, filamentous or hyphal form (MOLD) and singe celled or budding form (YEAST). But for the classification of fungi, they are studied as mold, yeast, yeast like fungi and dimorphic fungi. Yeast is Unicellular while Mold is multicellular and filamentous. Fungi can be divided into two basic morphological forms, yeasts and hyphae. Yeasts are unicellular fungi which reproduce asexually by blast conidia formation (budding) or fission. Hyphae are multi-cellular fungi which reproduce asexually and/or sexually.

Fungi are eukaryotic microorganisms. Fungi can occur as yeasts, molds, or as a combination of both forms. Some fungi are capable of causing superficial, cutaneous, subcutaneous, systemic or allergic diseases. Yeasts are microscopic fungi consisting of solitary cells that reproduce by budding.

Fungi are usually classified in four divisions: the Chytridiomycota (chytrids), Zygomycota (bread molds), Ascomycota (yeasts and sac fungi), and the Basidiomycota (club fungi). Placement into a division is based on the way in which the fungus reproduces sexually.

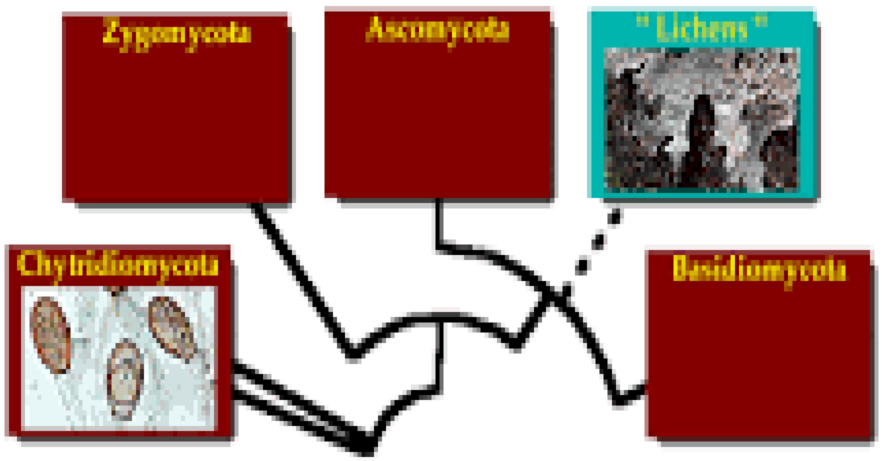

Figure 12 Systematics of the Fungi

4.5 Biology, host range and distribution, economic significance and management of major forest tree diseases in Ethiopia

Diseases attacking a forest reduce their value to a very different degree; they may even destroy the forest as a whole. They may have a significant impact on forest productivity and hence also on forest management in general. Diseases brought about by one or several of the agents (fungi, bacteria, viruses, nematodes, etc.)can cause mortality of valuable timber, destruction of wood, reduction of growth increment and wood quality, deficiency on stocking, and delayed regeneration (M Hulluka, 2015). Two factors in forest management are of most significant influence on disease situation, the establishment of man-made monoculture, comparable with those of agricultural crops, and the worldwide distribution of fast growing exotics. Indeed, there is no principal difference of forest trees to fruit or ornamental trees. But fruit trees mostly command a higher value as compared to forest trees so that specialized and intensive protective measures can be used to combat their diseases. On the other hand, mode of cultivation, utilization, management of forest trees is very different and the forest areas are very extensive, the crop has rotations of many years, so that many epidemiological relations and the possibilities of prevention and control are very different.

Forestry has a big impact on Ethiopia's economy. It is a source of income and employment to many farmers and contributes valuable resources to local industries and communities. When compared to forest fires, which are sudden and spectacular, diseases and insects work slowly and insidiously, but the loss is much higher in many regions. Root, foliage, and stem diseases cause heavy losses by reducing increment for stands not yet reached merchantable size, by causing the lengthening of the rotation, and by actual killing of trees and by causing under-stocking. In general, all of which contribute to reduction in the future capital of timber (Boyce, 1961). Forest tree diseases are also important factors that did not command much attention, but are highly involved in the gradual loss of growing stocks. The effect of these diseases is often not as striking as the other factors destroying the forest, but it is nevertheless of great importance.

4.5.1 Foliar diseases

Diseases of tree foliage can be broken roughly into three groups: hardwood foliage diseases, needle casts, and needle blights. Hardwood foliage diseases are diverse.

Foliar disease is a disease that impacts the leaves of a tree, shrub, or other plants. And it is usually a response to an irritating agent. The majority of the time, this is a fungal or fungal-type organism. Foliar diseases can be caused by fungi, bacteria, or even viruses. These diseases can spread quickly and easily from plant to plant, which is why it's important to take measures to prevent them. There are many different types of foliar diseases, but some of the most common include: Powdery mildew. The typical foliar disease life cycle begins in early spring as spores from dead, fallen leaves or dead twigs become air-borne infecting young, susceptible foliage. Later in spring and early summer, fruiting structures form on infected leaves and additional infections occur.


Figure 13 Foliar diseases

4.5.2 Stem diseases

Stem infection leads to wilting and yellowing of the foliage. Tubers are typically infected by way of stolon. The fungus quickly grows over the tuber surface and invades, resulting in a moist cheesy decay. Portions of infected plant parts and nearby soil often are covered with the white, radiating mycelium.

4.5.3 Stem rot

Stem rot is a disease caused by a fungus infection in the stem. Fungus that causes stem rot is in the Rhizoctonia, Fusarium or Pythium genera. Stem rot can readily infect crops that are in their vegetative or flowering stages. The disease can survive up to five years in the soil.

4.5.4 Canker Disease

Many stem canker and dieback pathogens are more successful when attacking stressed trees; climate change will result in more water/drought-stressed trees and, therefore, there will be a greater incidence of these canker pathogens. Cankers (diseases leading to dead sections on branches or main trunks of trees) are usually caused by the infection of bark tissues by plant pathogens. Although numerous canker pathogens are capable of attacking vigorous trees, many canker-causing fungi are favored by heat and drought stress.

a. ***Atropellis canker causes distinct blue-black staining***

All conifers are susceptible if they have been attacked by bark beetles. The apparent staining is actually the color of the fungal hyphae. The staining pattern marks the location of the fungi. Stem cankers usually have abundant resin flow on the outer bark. The outer margin of the canker appears as a discolored area surrounding the dead bark. The fungus causes branch and stem cankers that eventually lead to top kill or death of most infected trees. Generally, the larger the tree is at the time it becomes infected, the longer it survives after infection.

b. Damage

Atropellis piniphila changes the composition and usefulness of the wood, and also reduces tree growth. The quality of lumber from infected trees is reduced by blue-black stain, an abnormally high proportion of non woody cells, and resin-soaking. The high pitch content of infected wood interferes with penetration by wood preservatives. The value of affected wood for pulp is greatly reduced by the stain, which increases bleaching costs; in addition cankered wood is difficult to debark, if infected trees are malformed, wood fibers and the high pitch content of infected wood can cause chips to be rejected.

Figure 14 Atropellis canker

4.5.5 Stem Rusts of Pine

Rusts can adapt to a wide range of environmental conditions, their limits are unknown and the incidence of rusts will be determined chiefly by host distribution and are likely to remain the cause of damaging and lethal diseases. Typically, rusts exhibit wave year increases of intensity and expansion in distribution when the weather is especially favorable for sporulation, dispersal, and infection. Spore development, dispersal, and germination of rust fungi are directly affected by the abiotic environment.

4.5.6 Root diseases

Mortality of young trees is most likely caused by one of the three of the most common root diseases, Armillaria, annosus and laminated root rots. Stumps often serve as a source of inoculum for these pathogens, leading to higher mortality rates near stumps than elsewhere in a stand. Rhizoctonia is also a common cause of root disease and stem canker. Rhizoctonia solani causes damping-off, root rot, crown rot, web blight, and stem canker in numerous greenhouse grown crops. Unlike Pythium and Phytophthora, dry soil is more favorable for disease development.

Root rot is a disease that attacks the roots of trees growing in wet or damp soil. This decaying disease can cut the life short of just about any type of tree or plant and has symptoms similar to other diseases and pest problems, like poor growth, wilted leaves, early leaf drop, branch dieback, and eventual death. Root rot is caused by numerous fungi, especially Armillaria mellea, Clitocybe tabescens, and Fusarium, and many oomycetes, including Pythium, Phytophthora, and Aphanomyces. Plants lose vigour, become stunted and yellow, and may wilt or die back and drop some leaves.

Damage

Root disease spreads from roots of diseased trees to those of healthy ones. The result is usually several to hundreds of trees dying or dead in groups called root disease patches. Trees of all sizes, ages, and species are killed by root disease.

4.5.7 Seed borne diseases

Seed-borne diseases refer to plant diseases disseminated or transmitted by seed. Diseases of plants are caused primarily by three types of pathogens: bacteria, fungi and viruses. In some cases the seed transmission is insignificant as compared to the population density of the pathogen that exists in soil or on weed species. In other instances, the disease spreads primarily through seed.

A conventional method of detecting pathogen inoculum located on the seed surface (oospores of downy mildew fungi, teliospores of smuts and bunts, etc.) is detected. Seeds infected with bunt disease or tundu (yellow ear rot disease) disease is detected by using the NaOH soak method (Agarwal and Verma, 1983; Agarwal and Srivastava, 1985).

Seed-borne can be prevented by treating with fungicide solutions. A fungicide is a specific type of pesticide that controls fungal disease by specifically inhibiting or killing the fungus causing the disease. They inhibit the reproductive cycle of the fungal spores and thus protect the seeds from getting destroyed.

5 Basic equipment and hand tools for tree disease diagnosis

5.1 The right tools are also required to accurately assess and diagnose your trees. The basic tools include:

Tools	Dissecting Kit	Measurement Tools	Reference Material
Duck-billed Spade (Drain Spade) Garden Spade Hand Trowel Hatchet Machete Draw Knife (Bark Knife) Handsaw Pruning Shears Loppers Pole Saw / Pruner Pocket Knife Tool Disinfectant Rope Binoculars	Forceps (Various sizes) Small Scissors Pointed Probes Razor Blades / Scalpels Hand Lens Magnifying Glass Small Brush	D-Tape Ruler Clinometer Increment Borer Increment Core Case Compass	Pest Control Manual Insect Identification Guide Disease Identification Guide Weed Identification Guide Tree Identification Guide NC Agricultural Chemicals Manual Pamphlets/Brochures Business Cards

Table 1 Tools that help for tree disease diagnosis

5.2 Personal Protection Equipment

First Aid Kit

Leather Gloves

Protective Eyewear

Hard Hat

Latex Gloves

Hand Sanitizer

Poison Ivy Soap & Treatment

Sting Relief Pads

Rubber Boots

Bottled Water

An **Arborist** must have the expertise and the knowledge to:

- Safely climb a tree
- Know which rigging to use

- ❖ Know which type of saw should be employed when cutting limbs and branches
- ❖ And make sure that the cut limbs and branches fall in the target location

6 Field data collection sheet for tree diseases

The goal of collecting plant disease data is to assess if a particular practice affects disease development and consequently impacts yield. Since there can be many diseases affecting a crop in the test field, a target disease needs to be identified, and an assessment unit (leaf, stem, whole plant) decided upon. Depending upon the distribution of the disease in the field, different sampling patterns and designs can be used to most accurately quantify disease incidence and/or severity in the field. Place samples in appropriate bags: tubers in paper bags and leaf tissue in plastic bags with a moist paper towel and air. Keep samples cool and moist, protected from crushing, freezing and heat. Label the sample with the pertinent information required.

References:

1. Agarwal and Verma, 1983; Agarwal and Srivastava, 1985; Detection of seed borne pathogens in wheat: recent trends.
2. Anne Branthomme , , 2009, , Manual for integrated field data collection, Working Paper NFMA 37/E FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, FORESTRY DEPARTMENT
3. Diseases of exotic plantation forestry trees in Ethiopia by Alemu Gezahgne M. Phil. (University College of North Wales, Bangor) - March 2003
4. Encyclopedia of Microbiology (Third Edition), 2009
5. Eyob Tadesse and Beyene Seboko . 2013. Training Manual on Forest / Wildland Fire Prevention and Control for sustainable Forest Management. Wondo Genet, Ethiopia(Unpublished
6. FAO .2011. Eucalyptus in East Africa, Socio-economic and environmental issues, by Gessesse Dessie,
7. Hagle, S.K., Gibson, K.E., and Tunnock, S. 2003. Field guide to diseases and insect pests of northern and central Rocky Mountain conifers. [Accessed date 10 / 13/ 2015]
8. John Shaw Boyce. 1961; Pathogenic fungi; Forest Pathology · McGraw-Hill Book Company, Incorporated, 1938- 600 pages...
9. Mark S. Hoddle Department of Entomology, University of California Riverside Photos courtesy of Jack Kelly Clark, University of California Statewide IPM Program; **Center for Invasive Species Research, University of California Riverside**
10. MEFCC. 2015. Introductory Manual for Forest Protection.
11. Mengistu Hulluka, 2015 Forest Tree Diseases in Ethiopia; BASELINE SURVEY OF FOREST TREE DISEASESIN ETHIOPIA
12. Nair, K. S. S. 2007. Forest Insect Pests Ecology, Impact, and Management. www.cambridge.org/9780521873321 [Accessed date, 11/09/2015].
13. Richert-Pöggeler K.R., Minarovits J., Plant virus-host interaction: Molecular aroachesand viral evolution / Eds Gaur
14. Teklu Erkossa. Planted Forests and Trees Working Paper 46/E, Forest Management Team, Forest Management Division. FAO, Rome (unpublished).