A Training Manual for Training of Trainers on Recognition and Management of Major Field Crops (Maize, Sorghum and Common Bean) with emphasis on Integrated Diseases Management

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By

Getachaew Ayana (PhD)

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Getachew Ayana (PhD); Email: Getachew_ayana@yahoo.com
Ethiopian Institute of Agricultural Research, Melkassa Agricultural Research Center, P.O. Box 436, Tel. 251-022) 2250210, Fax: (251-022) 225 0213

INTRODUCTION

Plant diseases are of paramount importance to humans because they damage plants and plant products on which humans depends for food, clothing, furniture, the environment and in many cases the housing. The kinds and amounts of losses caused by plant diseases vary with the plant or plant products, the pathogen, the locality, the environment, the control measures practiced and combination of these factors. Disease is one of the major biotic constraints to reduce crop yield and also deteriorate the quality of product that ultimately reduce the market price. The reason behind the low productivity of most of the crops in Ethiopia is due to the attack of many plant diseases at different stages of the crop. Maize, sorghum and common bean are major important field crops in Ethiopia.

Maize (*Zea mays* L.) is an important staple crop in Ethiopia, ranking first among cereals in total grain production and second in area coverage. The national average yield of the crop which has now reached 3.4 t/ha which is the highest of all the sub-Saharan African countries except South Africa. In Ethiopia, maize growing agro-ecologies are broadly classified into four major categories: mid-altitude sub-humid (1000-1800 meter above sea level (m.a.s.l.) transitional highland to highland sub-humid (1800-2400 m.a.s.l. lowland moisture stress areas (300-1000 m.a.s.l. and lowland sub-humid less than 1000 m.a.s.l. A number of diseases are reported on maize in Ethiopia. The major and most important diseases identified/recognized are Turcicum leaf blight (TLB) caused by *Exserohilum turcicum* (Pass.), common leaf rust (CLR) caused by *Puccinia sorghi* Schw , gray leaf spot (GLS) caused by *Cercospora zeae-maydis,* and maize streak virus (MSV). Apart from foliar diseases maize suffers from different ear/kernel, stalk and storage diseases caused by various fungi. Ear and kernel rots (*Fusarium* and *Gibberella* spp.) and storage diseases (*Fusarium* spp., *Penicullim* spp. and *Aspergillus s*pp.) are some of important diseases caused by fungi. Recently maize lethal necrosis disease has been emerged as a recent threat to maize production.

Sorghum (*Sorghum bicolor*) is also a staple crop for millions of subsistence small-scale farmers in Ethiopia. In Ethiopia, sorghum is produced in diverse agro-ecologies that vary in total rainfall, elevation and temperature and with differing production constrains. Diseases caused by different pathogens are major constraints of sorghum production and poses severe challenges. Severity of disease infection depends on environmental conditions, presence of causal organisms, and levels of the host plant resistance. Generally, potential yield losses from diseases can be minimized by adopting integrated disease management approaches such as: using seeds treated with fungicide to prevent seed rots and seedling blights, using tolerant/resistant grain sorghum products, rotating to a different crop, removing infested crop residue and managing growing conditions throughout the growing season. The intermediate and low altitude areas in the Western parts of Ethiopia provide sufficient moisture and other climatic conditions for optimal sorghum production but productivity is severely challenged by pathogens.

Common bean (*Phaseolus vulgaris* L.) is one of the most important lowland pulses. Common bean is important in crop and livestock production systems where it serves as food for human and feed for livestock mainly in the dry land areas of the country. The crop is also important to replenish soil fertility by fixing nitrogen that helps to reduce the requirements for inorganic commercial fertilizers. The production and supply of common bean also is serving to earn income from both in local and in international markets, thus enhancing smallholders' income. Despite their importance, the average yield of common bean in Ethiopia is lower than the productive potential of the crop. This low production is largely due to the negative effects of many biotic and abiotic factors that limit the genetic potential of the crop. Diseases, mainly foliar and soil-borne ones are among the biotic factors affecting the production and productivity of these crops in Ethiopia. Almost all-important diseases on common bean have global and regional importance depending on the environmental conditions that support their distribution and epidemic development. Generally, the most important diseases of common bean known in Ethiopia so far include anthracnose (*Colletotrichum lindemuthianum*), rust (*Uromyces appendiculatus*), common bacterial blight (*Xanthomonas axonopodispvphaseoli* (synX. *campestris pvphaseoli*), web blight (*Rhizoctonia solani (=Thanatephorus cucumeris*), angular leaf spot (*Phaeoisariopsis griseola*), leaf blight (*Phomaexiguavar diversispora*), halo blight (*Pseudomonas sysringaepv.phaeolicola*) and floury leaf spot (*Mycovelosiella phaseoli*).

Therefore, this note provides summary the general principles of diseases management approaches and concepts and important diseases of field crops mainly Maize, Sorghum and common bean diseases and their management.

2. Concept and Definition of Integrated Diseases Management (IDM)

Integrated Disease Management (IDM) as applied to field crops means using all the tactics available to the grower (cultural, biological, host-plant resistance, field scouting, and chemical) that provide acceptable yield and quality at the least cost and are compatible with the tenets of environmental stewardship. The concept and definition of integrated disease management in most cases associated with integrated pest management (IPM). IDM varies both in terms of application and the understanding of the ecological interrelationships within a farming system. The understanding of the ecological interrelationships within a farming system (crop plants, pest organisms and factors influencing their development); of the economic factors within in a production system (infestation, loss ratio market potentials and product prices); of socio-cultural decision making behavior of farmers (traditional preferences, risk behaviors, etc); the involvement of the farmers in the analysis of their crop protection problems and elaboration of solutions; and the successful creation of legislative and agricultural frame work conducive for a sustainable IPM strategy (plant quarantine, legislation and /pesticides registration price policy are the major factors that affect application of IPM. Different authors and institution define IPM differently. The most common IPM definitions include:

1. An “applied pest control, which combines and integrates biological and chemical control.

2. A pest management system that in context of associated environment and population dynamic of pest species which utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels of below those causing economic injury.

3. IPM as a combination of techniques which is giving precedence to biological, biotechnological plant breeding, cultivation and methods, restricts application of chemical pesticides to the necessary minimum.

4. IPM as the farmer’s best mix of control tactics in comparison with yields profits and safety alternatives.

5. As strategies aimed at minimizing pest damage through the careful integration of available pest control techniques, giving priority to non-chemical control such as host plant resistance, biological and cultural control, only using chemicals when alternatives are clearly unlikely to afford sufficient protection.

In recent years also the concept of Integrated pest management is a categorized in to integrated crop management (ICM) where it is defined as ICM embraces of plant production most appropriate to the respective location and environment, in which consideration of economic and environmental requirements, all suitable procedures of agronomy, plant nutrition and plant protection are employed as harmoniously as possible with each other utilizing biological technical progress as well as natural regulatory of noxious organisms in order to guarantee long term assured yields and economic success. Similarly, some other institution also defines ICM as it embraces all activities in the production of system and is composed of several management activities focusing on particular constraints, such as Integrate pest management, integrate nutrient management, integrate water management etc. ICM is concerned with managing a production system to optimize the use of natural resources, reduce environmental risk, and maximize output. The goals of particular management systems are dependent up on natural, socio economic and technological resources and their inter relationships.

Hence knowledge on recognition and management of important diseases of field crops is useful to mitigate damaged and yield losses on the crops.

3. Component of Integrated Disease Management (IDM)

3.1. Prevention

Restrict entry of pathogens into fields through planting materials, irrigation water, workers, and tools.

3.2. Monitoring

Engage in regular field scouting to identify disease symptoms and plant disease vectors. Monitoring can be direct (looking for the pathogen or disease) or indirect (recording environmental conditions that affect disease development). Financial considerations weigh heavily in the choice of monitoring practices. Direct disease monitoring can be based on symptoms or signs of the pathogen. Pathogen identification is generally difficult because they are usually microscopic and can be detected typically after the disease process has begun. Most monitoring is actually for disease symptoms, with the control strategy aimed at reducing further spread. Even when visible symptoms are evident, disease levels may be so low as to make detection very difficult. To optimize the chances of detection, one should concentrate on those areas where disease is most likely to occur; for example, low areas or areas of lush growth. If this is not possible, an array of sampling designs may be used, such as a diagonal across the field, a random walk, a stratified design where each subsection of the field is sampled, or a stratified random design where a random sample is taken in each subsection of the field. The appropriate sampling design depends on the level of disease expected, the distribution of the disease, and sampling schemes already in place for other pests.

Disease distribution within a field is dependent, in large part, on the source of inoculum for the pathogen. If the disease is seed-borne, in many cases the first diseased plants are more uniformly distributed in the field. If the disease is soil-borne, it may often be found in clusters in the field. If insects transmit the disease, the distribution may be more random, or a field edge effect may be apparent. Thus, it is important to understand the pathogen's biology when developing an appropriate sampling strategy for it. Indirect disease monitoring most often involves stand-alone computer systems with probes or whole units in the field. Data commonly gathered include temperature, relative humidity, and leaf wetness and can be used to update real-time indices of disease likelihood at a given time.

3.3. Accurate disease diagnosis

Proper disease identification is critical for making appropriate disease management decisions, and it saves time, money, and the environment. Effective use of fungicides and other pesticides depends on accurate identification of the problem. The accuracy of any diagnosis depends upon the information supplied, the specimen material selected, and the condition of the specimen when it arrives at a clinic. Digital images of the fresh specimen with symptoms and field-view images of the problem might be useful in some cases. In order to apply disease management practices, there should be knowledge of which pathogens are present or are likely to appear in a particular field or season. Descriptive and pictorial manuals are helpful for identification of diseases commonly found in the field. It is important to know the common diseases of a given crop specific to the area. Hence, monitoring is a critical component of an effective IPM program. Monitoring can be direct (looking for the pathogen or disease) or indirect (recording environmental conditions that affect disease development). Financial considerations weigh heavily in the choice of monitoring practices.

3.4. Development of acceptable disease thresholds

Understand the effect of a disease and yield loss. For example, 10% disease incidence because of a specific pathogen may not cause a significant yield loss in a vegetable crop, in which case chemical control may be an unnecessary expense.

3.5. Optimal selection of management tools

Identify an integrated management plan depending upon the disease, crop, and field history. The field history of disease outbreaks is highly relevant in assessing the risk involved in the production. Cultural, host-plant resistance, biological, and chemical control options should be based on the conditions in that specific location. For disease management, it is important to understand the potential of a pathogen to infect a crop and spread within the crop in a specific region. These parameters interact to produce a rapid increase in pathogen populations, which manifests as exponential disease development in many production systems. The rate of disease increase over time is dependent upon the interactions of the pathogen, host plant, and the environment. For disease management purposes, the biggest concern for growers is the interaction of the pathogen and host and the ideal environmental conditions, which plays a critical role in determining the nature of plant disease epidemics. This set of interactions is known as the disease triangle (Figure 1), which determines the fate of a disease on a crop.

Figure 1 Disease triangle indicating interaction of the pathogen, host, and the environment leading to a plant disease

3.6. Site Selection and Preparation

Soil-borne diseases remain a major limiting factor for the production of vegetables in general. It is important to start with clean soil and proper sites for crops. Plowing and disking reduces pathogen carryover in old crop refuse. The longer the fallow period, the more pathogen populations are reduced. It is also essential to follow the latest recommendations for soil fumigation, cultural practices, and biological control options to eliminate or reduce initial inoculum of soilborne pathogens. It is important to avoid soil compaction because this interferes with root growth, encourages soil moisture retention, and promotes root diseases. Preparation of raised beds generally allows for better drainage. Prior to planting, soil should be tested for nutrient levels and nematode populations (and other pathogens if tests are available). Knowing the history of soilborne disease outbreaks is important for predicting possible future problems. Planting times can be altered to avoid or reduce development of certain diseases.

3.7. Host Resistance

Host-plant resistance is the inherited ability of a plant species to ward -off or resist attack by diseases or be able to tolerate damage caused by various diseases. Resistant varieties are one the most important components of disease management and can easily be combined with other control methods. In the field, however, crop resistance to diseases and insect pests can eventually break down. Therefore, plant resistance breeding program continuously select new varieties to replace older ones. Plant resistance to pests is expressed in three ways: tolerance, non-preference and antibiosis. The host plant shows tolerance when it survives heavy infection without significant yield loss. Non-preference is shown when diseases/insects do not feed on the resistant variety, lay eggs on it, or use it for shelter. The host plant shows antibiosis when pathogens/insects do not grow, survive, or reproduce well on it. Hence it is very important to choose cultivars/variety with multiple pathogen and nematode resistance whenever possible.

3.8. Irrigation Management

High soil moisture enhances the development of soilborne pathogens, including *Phytophthora* spp *Pythium spp*. Excess water damages roots by depriving them of oxygen and creating conditions that favor infection by certain soil-borne pathogens. Irrigation management based on plant needs helps create an environment unfavorable for pathogen survival and disease development. Avoiding low areas and using tensiometers or other devices for irrigation scheduling can help in disease management.

3.9. Soil and Fertilizer Management

Plant nutrition and soil pH can also impact some diseases. Fertilizers with a higher proportion of nitrate nitrogen (NO_3) than ammoniacal nitrogen (NH_4) help to reduce the incidence of wilt diseases. Increasing soil pH by liming is a good management strategy to reduce Fusarium wilt incidence as well as Botrytis gray mold severity. Optimal calcium nutrition and higher soil pH may reduce the incidence of bacterial wilt in the field. Adequate calcium is necessary to minimize blossom end rot and to provide for overall healthy growth. Avoiding excessive nitrogen leads to less dense canopies, thus improving air movement in the canopy.

3.10. Cultural Practices

Cultural practices serve an important role in plant disease prevention and management. Cultural control practices, however, are aimed at reducing the primary inoculum (sanitation) or reducing the rate of disease increase by modifying the crop environment. The benefits of cultural control begin with the establishment of a growing environment that favors the crop over the pathogen. Reducing plant stress through environmental modification promotes good plant health and aids in reducing damage from some plant diseases. Excessive handling of plants, such as in thinning, pruning, and tying, may be involved in spreading pathogens, particularly bacteria. It is advisable to handle plants in the field when plants are driest. Because some pathogens can only enter the host through wounds, situations that promote plant injury should be avoided. During the pruning process and harvest, workers should periodically clean their hands and tools with a disinfectant, such as isopropyl alcohol. If

applicable, plants can be staked and tied for improved air movement in the foliar canopy. A more open canopy results in less wetness, discouraging growth of most pathogens.
Soil aeration and drying can be enhanced by incorporating composted organic amendments in the soil. The pathogen inoculum can be reduced by removing plant material (infected and healthy) after harvest. Between-row cover crops reduce plant injury from blowing sand.

In order to reduce dispersal of soil-borne pathogens between fields, stakes and farm equipment should be decontaminated before moving from one field to the next. Reduction of pathogen survival from one season to another may be achieved by crop rotation and destroying volunteer plants. Removal of cull piles and prompt crop destruction should be done as general practice. Avoid soil movement from one site to another to reduce the risk of moving pathogens. Minimizing wounds during harvest and packing reduces postharvest disease problems. Depending on crops and other factors, soil sanitation can be achieved to some degree by solarization. A good example of cultural practice is also the use of drip irrigation rather than overhead irrigation to reduce free water on foliage.

3.11. Crop rotation

Crop rotation is a very important practice, especially for soil borne disease control. For many soil-borne diseases, at least a 3-year rotation using a non-host crop greatly reduces pathogen populations. This practice is beneficial for Maize gray leaf spot, root rot and many soil borne diseases of field crops. Land previously cropped to alternate and reservoir hosts should be avoided whenever possible. Field crops fields should be located as far away as possible from inoculum and insect vector sources. Weed control is important for the management of viral diseases. Weeds may be alternate hosts for many important field crops viruses. Eliminating weeds might reduce primary inoculum. Non-host cover crops also help to reduce weed populations and primary inoculum of soil-borne pathogens.

3.12. Biological Control

The use of bio-control agents in managing field crops is not common in field crops. However, the most common biocontrol agents include the fungi ***Trichoderma harzianum*** and ***Gliocladium virens***, an actinomycete ***Streptomyces griseoviridis***, and a bacterium ***Bacillus subtilis***. Bacteriophages (phages) have been found to be an effective bio-control agent for managing bacterial spot on tomato. Phages are viruses that exclusively infect bacteria. One of the limitations of using biocontrol agents is their inability to survive in certain field conditions. However, bio-control agents have the ability to improve disease management when integrated with other management options described in this document.

3.13. Chemical Control

Fungicides and bactericides are an important component of many disease management programs. It is important to remember that chemical use should be integrated with all other appropriate tactics mentioned in this chapter. Information regarding a fungicide's physical mode of action helps producers improve fungicide application timing. Physical modes of action of fungicides can be classified into four categories: protective, after infection, presymptom, and antisporulant (postsymptom). Protectant fungicides include the bulk of the foliar spray materials available to producers. In order to be effective, protectant fungicides, such as copper compounds and mancozeb, need to be on the leaf (or plant) surface prior to pathogen arrival. Systemic (therapeutic) fungicides, based on their level of systemic nature (true systemic) are active inside of the leaf (can penetrate at different rates through the cuticle). Systemic fungicides may stop an infection after it starts and prevent further disease development. Fungicides must be used based on recommended fungicide resistance management strategies. A new strategy to chemically manage plant diseases without direct interference with the pathogen is by triggering the plant's defense reaction. Acibenzolar-S-methyl (Actigard®), a chemical in this category, was registered for the control of different diseases.

Chemicals must be used at recommended rates and application frequencies. Besides selection of the most efficacious material, equipment must be properly calibrated and attention must be paid to the appropriate application technique. As always, the key to effective disease management is correct diagnosis of the problem. Follow the latest fungicide recommendations provided at specific location. Always read the pesticide labels and follow the instructions carefully.

Many fungicides have been developed, and several chemical industries have invested several millions of dollars in developing fungicides. More than 100 active fungicide ingredients have been registered, and several hundred fungicide formulations are available in the market. In contrast, very few bactericides are available to control bacterial diseases. Although a few bactericides are available, their uses in management of bacterial diseases are limited. Their efficacy in the field varies widely. Most of the bacterial pathogens are systemic, but most of the bactericides are surface protectant. Bacteria also develop resistance to antibiotics very quickly. Persistence of antibiotics in plants is very low, requiring that antibiotics be applied once every four to five days. This is impractical and will be uneconomical. The current bactericides cannot reach sites where bacteria overwinter, such as blighted wood, cankers, and lesions in the case of woody plants. Only partial control of bacterial diseases is achievable with the available bactericides.

Among the various methods of disease management, chemical methods appear to be the most important. Many farmers believe that control of crop diseases is possible only by using fungicides, as they reduce diseases dramatically. Fungicides are the most important components in the management of fungal diseases. More than 100 fungicides have been developed, and several hundreds of fungicide formulations are available. They have been formulated as dustable powders, wettable powders, emulsifiable concentrates, flowables, liquids, granules, and gases. Special formulations have also been developed specifically for seed treatment and soil application. Formulations consist of several adjuvants in addition to the active ingredients. Formulations of mixtures of fungicides are also available. The mode of action of different classes of fungicides varies widely, and each class of fungicides controls different groups of diseases. Specificity of fungicides appears to be restricted to the fungal genera level, not the species level.

Various types of application equipment are available to apply fungicides to crops. Fungi develop resistance to certain fungicides, and several techniques have also been developed to manage fungicide resistance in pathogens. Several commercial companies are involved in the development of fungicides. Numerous compounds are screened to select compounds with fungicidal action. The selected compounds are tested against a wide range of pathogens in the laboratory, particularly against economically important pathogens affecting crops of high commercial value and causing heavy losses in those crops cultivated in vast areas. When thousands of chemicals are screened, a large number of chemicals with some fungitoxicity can be identified. These compounds undergo stringent secondary tests which identify the concentration at which the compound loses its efficacy, compared to a suitable standard fungicide. The compound should be active at a low concentration (normally at 10 to 25 ppm) to merit elevation to the next stage. Further tests include laboratory and greenhouse studies to assess the efficacy of the selected compounds against test diseases in the appropriate hosts. Normally, these tests will be initially conducted with a single target pathogen (most important pathogen), and then the selected compound will be tested against other taxonomically related pathogens. Many more tests are required to develop a compound as a commercial fungicide. The selected compounds should have a broad disease-control spectrum and an extended control period. Their mobility after application in the plant should be assessed. The curative properties of the compounds should also be explored. The absence of curative activity is a disadvantage unless systemicity or the potential to redistribute in the crop is demonstrated. Immobile protectant activity alone may limit the use of the candidate chemical. The product should be compatible with other products, and the formulations should be easy to use. The selected chemical should be safe to the crops (without phytotoxicity). Several fungi are known to develop resistance to fungicides. Anti-resistance activity of the selected chemicals should be tested. The selected chemical should be cost effective, the dosage required to control diseases should be low, and it should require fewer treatments per season. The candidate chemical should be safe to users and consumers of the treated product and be environmentally acceptable.

4. Maize Diseases and their Management

4.1. Turcicum Leaf Blight (TLB)

The disease is caused by (*Exserohilum turcicum)*, an early symptom is the easily recognized, slightly oval, water-soaked, small spots produced on the leaves. These grow into elongated, spindle-shaped necrotic lesions. They may appear first on lower leaves and increase in number as the plant develops, and can lead to complete burning of the foliage. Turcicum leaf blight (or northern leaf blight) occurs worldwide and particularly in areas where high humidity and moderate temperature prevail during the growing season. When infection occurs prior to and at silking and conditions are optimum, it may cause significant economic damage. Development of the disease later in the season might not cause heavy yield losses. The disease can occur in all growing regions. It is favored by warm weather when leaves are wet from dew or rainfall for extended periods. Under conducive weather conditions, it can cause significant yield losses in susceptible hybrids or variety. Turcicum leaf blight is one of the widely distributed and economically very important diseases of maize production in Ethiopia. The infection appears during both off and main seasons, but it is more serious during the main season in constantly wet and humid areas. High disease incidence and severity of TLB were recorded at Hawassa, Aleta Wondo, Enemor, Siraro, Sigmo Satama, Bedele, Gimbi and Bafano with incidence ranging from 95-100% for all woredas (localities) and severity ranging from 2.5-5.0 using 1-5 scoring scale). High yielding maize varieties (e.g. Beletech and BH541) have been banned out of production due to the heavy infestation of TLB.

Symptom: Long, spindle-shaped, greyish-green, water-soaked spots (up to 150 mm long and usually less than 20 mm wide) develop on leaves and later turn light purplish-brown or grey. After flowering, the disease can develop rapidly, resulting in blighting of infected leaves.

Disease cycle: The fungus survives on volunteers and maize residues, and its spores are spread long distances by wind.

Figure 2 Turcicum leaf blight symptom on leaf and plants under field condition

Control

1. 1. Host resistance: Plant resistance maize varieties. Maize varieties released recently have higher levels of resistance. Example: BH547, AMH853, AMH852Q, Melkassa 1-Q etc

2. Cultural: Rotating maize with non-host crops can reduce disease pressure for at least one year. Never plant maize after a diseased maize crop. Bury infected debris soon after harvest to enhance break-down of the residue so that the fungus dies in a short period of time.

3. Application of farmyard manure (FYM), nitrogen, and phosphorus were also reported to reduce the intensity and frequency of turcicum leaf blight.

4. Chemical: Fungicide application can effectively control Turcicum leaf blight when applied at the right time. Fungicide should be applied when lesions first become visible on the lower leaves. In seasons not favorable to Turcicum leaf blight (cool and dry seasons), fungicide application may not be cost effective particularly for grain production. The feasibility and economy of foliage spraying have not yet been worked out; promising fungicides have been reported in controlling turcicum leaf blight and common rust in maize. A combined application of mancozeb and propoconazol at the rate of 2.0 kg a.i

ha-1 two to three times reported to control turcicum leaf blight and common rust diseases.

4.2. Common Leaf Rust

Common leaf rust is also an important disease in Ethiopia is caused by fungal pathogen Puccinia *sorghi*. The disease is widely distributed throughout major maize growing regions of the country. However, the importance varies from area to area. The disease is more severe in the southern mid-altitude areas of Ethiopia than in the western mid-altitude sub-humid areas. The highest incidence was recorded at Hawassa, Shebedino, Arsi-Negelle and Ejaji woreda each with 100% incidence. As a result, it is difficult to produce rust susceptible varieties like BHQP542 around Hawassa where common leaf rust severity is high.

Symptom: The disease is recognized by the abundant oval-elongate, red-brown pustules up to 2 mm long, which erupt through both leaf surfaces in scattered groups. This distinguishes common rust from polysora rust, which has little development of rust pustules on the lower leaf surface. The pustules contain numerous powdery spores that can be spread long distances by wind. Disease cycle: Common rust survives between seasons only on living maize plants.

Figure 3 Symptom of common leaf rust on maize leaves

Management of Common rust

1. Timely planting, intercropping maize with legume and crop rotation reduces the level of infestation.
2. Using varieties relatively resistant/tolerant to the disease. Example. BH-670, BH-660, Kuleni and others recently released varieties such as BH547, AMH853, AMH852Q, Melkassa 1-Q etc
3. Chemicals control: Two fungicides, namely triadimefon and mancozeb, Triadimefon, sprayed twice at higher rates (250 and 300 g ha-1) and mancozeb sprayed five times at the rate of 400 and 600 g ha-1 effectively reduced incidence and severity of the disease.
4. Combination of mancozeb and propoconazole at the rate of 2 kg active ingredient per ha of maize (2-3 times of application at ten days interval).

4.3. Gray Leaf Spot

The disease is caused by *Cercospora zeae-maydis*, *C. sorghi varmaydis.* This disease, also known as *Cercospor*a leaf spot, may occur in subtropical and temperate, humid areas. Lesions begin as small, regular, elongated brown-gray necrotic spots growing parallel to the veins. Occasionally, lesions may reach 3.0 x 0.3 cm. Minimum tillage practices have been associated with an increased incidence of GLS. Development is favored by extended periods of leaf wetness and cloudy conditions, and can result in severe leaf senescence following flowering and in poor grain fill.

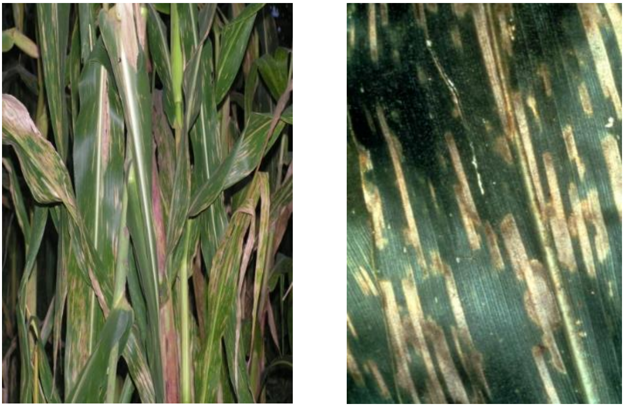

Figure 4. Symptom of Gray leaf spot

Management of Grey Leaf Spot

1. Avoid infected plant debris, recommended spacing between and within rows, deep ploughing to bury crop debris, crop rotation and early sowing (at the onset of rainy season) are recommended.
2. Resistant/tolerant varieties: Use varieties with relatively better resistant/tolerant to the disease. Example: BH-670, BH-660, Kuleni, and others.
3. Chemical control: Spraying of benomyl at the rate of 0.5 kg/ha is recommended. A combined application of mancozeb and propoconazol at the rate of 2.0 kg a.i ha-1 two to three times reported to control the disease
4. Proper irrigation. Because moisture on leaf surfaces is important throughout the disease cycle, efforts should be made to avoid practices that extend dew periods. Therefore, irrigation should not be scheduled during late afternoon or early evening, especially after outbreaks have already occurred.
5. Regular and timely scouting is important to help reduce maize disease outbreaks. Fields containing foliar diseases should also be scouted for stalk health, since the reduction in photosynthesis can cause later problems in maize plants, such as stalk lodging. Identification of foliar diseases can help determine the need for changes in management practices such as

tillage, crop rotation, and the selection of more resistant corn products to help reduce incidence of disease next season.

4.4. Maize Smut

Maize smut is a disease caused by the pathogenic plant fungus *Ustilago maydis*. Smut can cause significant economic damage in dry, hot maize growing areas, as well as in mid hill zones and under temperate conditions. The infection is systemic: the fungus penetrates the seedlings and grows inside the plant without showing symptoms, until the tasseling and silking stages. The most conspicuous symptoms are (a) abnormal development of the tassels, which become malformed and overgrown; (b) black masses of spores that develop inside individual male florets; and (c) masses of black spores in place of the normal ear, leaving the vascular bundles exposed and shredded. The smutted ear develops no grains. Common smut of maize easily identified by tumor-like galls that form on actively growing host tissues and contain masses of dark, sooty teliospores. Throughout most of the world, common smut is considered to be a troublesome disease of maize. In Mexico, galls on ears of maize are considered an edible delicacy known as cuitlacoche (Syn. Huitlacoche).

Figure 5. Symptom of Maize common Smut

Control

1. **Host Resistance:** Maize varieties that are resistant to common smut are widely available and offer the most cost-effective and practical means of disease management.
2. **Fungicide:** Efforts to control common smut through the application foliar fungicides and seed treatments have not been highly successful.
3. **Cultural control**: ·Avoiding mechanical damage to plants will reduce plant injury, which is the primary means of infection by the fungi. Controlling insect damage (e.g. controlling maize borers) will also limit plant injury. Removing galls before they rupture will limit the spread of teliospores but is not practical in large-scale maize cultivation.
4. A well-balanced fertilizer regime will reduce disease severity. High levels of nitrogen fertilization increase disease severity, although application of phosphorous reduces disease incidence. Various cultural control practices have been demonstrated. The on-set of certain diseases in maize with respect to planting date varied within and across locations.

4.5. Ear Rot /Kernel rot

Ear Rot /Kernel rot is caused by different fungal species such as *Diplodia zea*, Fusarium *monoliformae* and *Gibberela zea*. Ear rots are commonly found in hot, humid maize-growing areas. Maize ears show characteristic development of irregular bleached areas on husks. These areas enlarge until the husks become completely dried, although the plant is still green. If husks are removed, ears appear chaffy and bleached, with a white, cottony growth between the kernels. Late in the season, many small, black pycnidia form on kernels and cob tissues. These pycnidia serve as sources of inoculum for the following season's crop. Microscopic observation of the spores is the only way to identify which pathogen is present. Severely infected ears are very light. Infection more frequently occurs through the shank and moves from the cob to the kernels. Stem borer injury in the ear often increases incidence of this disease. Stenocarpella maydis produces the mycotoxin diplodiatoxin and S. macrospora produces diplodiol both harmful to birds.

Figure 6 Symptom of Ear Rot /Kernel rots

Management of ear rot

1. Use a resistant cultivar if available. Irrigate if possible to reduce plant stress.
2. Chemical control seed dressing with fungicide Luxan TMTD at 200-500 g/qt of seed is recommended.
3. Plow under old crop residue each dry season to reduce disease levels.

4.6. Maize Streak Virus

The disease was reported first from East Africa, and has now extended to many other African countries. The virus is transmitted by *Cicadulina* spp. *Leahopper*s. *Cicadulina mbila* (Naude) is the most prevalent vector, and will transmit the virus for most of its life after feeding on an infected plant. Early disease symptoms begin within a week after infection and consist of very small, round, scattered spots in the youngest leaves. The number of spots increases with plant growth; they enlarge parallel to the leaf veins. Soon spot become more profuse at leaf bases and are particularly conspicuous in;.the youngest leaves. Fully elongated leaves develop chlorosis with broken yellow streak along the veins, contrasting with the dark green color of normal foliage. Severe infection causes stunting, and plants can die prematurely will not develop cobs. Many cereals crops and wild grasses serve as reservoirs of the virus and vectors.

*Figure 7.*Symptom of Maize Streak Virus

Control

1. Cultural method early sowing, inspection and rouging infected plants especially at early stage are recommended. Various cultural control practices have been demonstrated. The on-set of certain diseases in maize with respect to planting date varied within and across locations. Planting maize after May 4 at Loko, resulted in a severe infection of maize streak virus
2. Resistant varieties: Use varieties like Abo-Bako and Gambella comp-1
3. Chemical control: Controlling the vector (*Cicadulina mbila)* that transmits the disease using insecticide is recommended.

4.7. Maize lethal necrosis disease (MLND)

Maize lethal necrosis disease is a recent disease threatening maize production in Ethiopia. In July 2014, the cases of maize infection by Maize Lethal Necrotic Disease was reported from eastern rift valley regions of Ethiopia and confirmed by ELISA test. Maize Lethal Necrosis (MLN), caused by co-infection of SCMV and MCMV, is one of the most threatening diseases of maize in countries where the disease has been reported. Currently, MLN infestation has spread to enormous areas of the country. Thus, the co-infection of SCMV and MCMV in maize plantings of Ethiopia represents a serious threat to the seed producers, local maize industry and also to small scale farmers at large Both MCMV and SCMV are transmitted through mechanical means and are known to be seed transmitted. Currently, there is inadequate information on methods of control of MLN disease in Ethiopia.

Figure 8 Symptom of Maize lethal Necrosis Disease

Recommended practices

Cultural Methods: Uprooting infected plants as soon as the disease appear in the field, growing maize only one season in a year, Rotate maize with other crops. Use disease free seeds produced under free areas and apply systemic insecticide to control vectors.

5. Sorghum Diseases and Their control measures

A number of sorghum diseases are recorded in Ethiopia which are caused due to fungal, bacterial and virus pathogen. The list of sorghum diseases recorded in Ethiopia is indicated as in table 1.

Table1. Status of Sorghum Diseases recorded in Ethiopia

Disease	*Causative agent*	Status
Fungal diseases		
Anthracnose	*Colletotrichum graminicolas*	Major
Rust	*Puccinia purpurea.*	Major
Downy mildew	*Sclerospora sorghi & Pernosclerospora sorghi*	Major
Diverse leaf spot and blight	*Diverse fungal spp*	moderate
Root and Stalk disease		
Seedling disease	*Pythium spp.*	Moderate
Charcoal rot	*Macrophomina phaseoli*	moderate
Grain and panicle diseases		
Covered kernel smut	*Sphacelotheca sorghi Clint*	major
Loose kernel smut	*Sphacelotheca . cruenta*	Major
Head smut	*Sphacelotheca . reiliane (Kuehn) Clint.*	minor
Long smut	*Tolyposporium chrenbergii (Kuehn) Pat.*	minor
Honey dew/Ergot	*Sphacelia sorghi Macrae*	moderate
Grain mold	*Alternaria, Asppergillus spp, Curvularia spp. Cunninghamella elegans, Fusarium spp, Mycosphaerella spp., Mucor spp. Penicillium spp.. Phoma spp, Rhizopus spp, Stemphylium spp. Trichoderma spp.*	Major
Bacterial diseases		
Bacterial leaf strip	*Pseudomonas andropogoni*	minor

Bacterial leaf streak	*Xanthomonas holcicola*	Major
Viral diseases		
Maize dwarf mosaic virus	*Maize dwarf mosaic virus*	minor
Sugar cane mosaic		minor

5.1. Seedling blight

Seedling blights are often referred to as "damping off diseases." Seedling diseases may be caused by soil-borne pathogens, soil and weather climatic factors, seedling vigor, or any combination of these factors. Every seed lot produced should be checked for warm and cold germination and for the presence of disease. This ensures producers the highest quality seed available. Even with high quality seed, soil-borne fungi can attack seeds and seedlings under certain climatic conditions. Cold, wet soils can severely impact sorghum emergence by weakening the seed, thus allowing pathogens to infect seed and seedlings. There are several fungal diseases associated with seedling blights. The primary seedling disease pathogens are: Pythium, Fusarium, Aspergillus, and Rhizoctonia. These pathogens may occur independently or in combinations to cause seedling disease problems.

Seedlings blight Symptoms

The disease is characterized by specific disease symptoms: Seedling root rot may result in sparse or irregular stands. Roots are rotted, with a brown to black appearance, and may also be missing.

Management: The disease is favored by wet to saturated soils, along with cool soil temperatures that are unfavorable for plant growth.

Figure 9. Symptom of Sorghum seedling blight

Control of seedling blight

1. Using high quality seed,
2. Planting only when soils are above 25^0C
3. Use of appropriate seed treatments will minimize seedling disease

5.2. Downy Mildew

Crazy Top (Downy Mildew) is a disease caused by the fungus *Sclerophthora macrospora*. The disease can often be most noticeable in low spots of fields where water stands, as high soil moisture levels and flooding are favorable conditions for the disease to develop.

Symptom and Sign

Infected plants have thick, stiff, twisted, pale green leaves with bumpy surfaces. The leaves often turn downward and the plants produce many shoots or suckers, giving the plant a bunchy appearance. Infected plants produce a proliferation of leafy tissue instead of producing heads. Both systemic and localized infection occurs. Soil-borne spores cause systemic infection of the young seedlings. These systemically infected plants will not produce heads. Infected leaves often will be more narrow than usual, erect and shredded. Plants may be stunted and chlorotic, and have an no seed set. Young, systemically infected plants have light green to yellowish stripes lengthwise in the leaves often with a grayish-white downy fungal growth consisting of numerous tiny spores on the lower surface of the leaf opposite the pale striped areas. These sporangia can cause further localized infection.

Figure 10 Symptom of down mildew on sorghum plant

Predisposing factor to down mildew

1. Cool - wet - humid weather
2. Intermittent rains, the rapid growth of fungal pathogen is favored by rainy and humid environment.

Management strategy of down mildew

1. Fields should be adequately drained.
2. Use resistant hybrids/Tolerant sorghum products should be used; although there are differences in susceptibility among grain sorghum products, these differences are not substantial.
3. Seed treatment with metalaxyl.
4. Long-term rotation to soybeans –wheat.
5. Avoid maize-sorghum rotation where the disease occurs.

5.3. Anthracnose

Anthracnose, a disease caused by the fungus *Colletotrichum graminicola*, can damage leaves, panicles, and stems. The disease is prevalent whenever sorghum is grown in a warm and humid environment and is commonly observed in farmer's fields at Keffa, Wellega, Illubabor and Gonder in the northern part of Ethiopia and in Hararghe. Generally, occurs in all sorghum-growing regions under hot and humid conditions with frequent rains. around Bako and East Wellega. Infected stems cut lengthwise may show brick-red sections surrounding areas of the infected pith tissues, which may appear healthy and white in color (Figure 11). Anthracnose development is weather dependent and has been mostly restricted to the more humid regions. Severe infection can greatly reduce the yield potential. Most of the local land races including improved varieties are susceptible to this disease

Figure 11. Anthracnose infection under field condition and damage on leaf

Management

1. Sorghum products that are rated as "susceptible" should be avoided in fields with a history of anthracnose. Use resistant sorghum varieties/
2. Rotating to a crop that is unrelated to grain sorghum is highly recommended. Cotton should be planted for at least two years before

planting grain sorghum; however, this practice will not eliminate the problem but can reduce disease severity.

3. Cultural method: Good residue management should be adopted,

5.4. Sorghum Smut

Covered kernel smut caused by *Sphacelothea sorghi* clint and loose smut caused by *Sphacelothea cruenta* are important Sorghum smut diseases of sorghum in Ethiopia because farmers plant a contaminated seed from the previous harvests. Covered kernel smut is caused by the fungus *Sporisorium sorghi* (Syn. *Sphacelotheca sorghi*) and occurs in most regions where sorghum is grown. Teliospores of S. sorghi are seedborne and germinate within the seed. Seedling plants are infected, but symptoms generally are not apparent until booting or heading. The pathogen grows within the plant to the meristem and invades floral tissues. Maturing fungal fruiting structures called sori rupture and release teliospores that infect seeds on other plants. Only seedborne spores cause infection.

Disease symptoms

Head replaced by brown, powdery mass of fungal spores covered by gray to brown membrane; entire head may be affected or fungus may be localized at the top, bottom or sides of the head; plants are usually or normal height. Disease is apparent only after heading. Individual ovules are replaced by smut fruiting bodies that vary in size from less than the size of glumes to greater than 0.4 inches in length. Most sori are conical or oval and resemble an elongated sorghum seed, but vary in color from white to gray or brown. Infected plants are generally the same height and size as healthy plants.

*Figure 12.*Sorghum covered (left) and loose smut (right) symptom

Management Approaches of Sorghum smut

1. **1.** Host resistance, Plant only high-quality seed free of the covered kernel smut pathogen. Varieties vary in their susceptibility to covered kernel smut, and less susceptible varieties should be grown if available. Growing resistant varieties can also help to control both sorghum covered and loose smuts and some sources of sorghum resistance to covered smut were also reported worldwide. Similarly, a good degree of resistance to covered smut has also been reported from local sorghum collection in Ethiopia. "Tetron" local cultivar showing high resistance to covered smut following artificial inoculation under filed conditions. Other studies also indicated the superiority of the local sorghum cultivars resistant to sorghum covered and loose smuts with good agronomic performance. IS158X (ETS 3235) and Red Degalit were highly resistant to loose smut, while ETS 1176 and ALOBS Nur Acc# 2002B showed less susceptible (<2%). 9302, Birmash and Aba-melko reported to show reasonable resistance to covered smut disease than the local varieties at Bako.
2. Chemical Control

Economical and complete protection from covered kernel smut can be achieved with proper seed treatment. Different seed treatments were compared on local sorghum cultivars Degalit planted on May 19 and Jigurti planted on July 3 at Sirinka. Results indicated that thiram/lindane (Fernasa-D) and Apron plus (Thiamethoxan+Mefenoxam+Difenocunazole) reduced both covered and loose smuts incidence in early-planted sorghum, but trace incidence was observed, Yield increase was also obtained in treated plots with Apron plus in both smut experiments in early planted sorghum but had no difference in late-planted sorghum in covered and loose smut treatments, On-farm demonstration also confirmed the potential effect of both synthetic fungicides and alternative sorghum seed treatments. Both fungicides consistently showed high effect in reducing covered smut incidence in early and late-planted sorghum. Yield increase was observed with Apron Plus treatment in early planted, whereas thiram gave better yield than the control in late-planted sorghum.

3. Cultural and Traditional practice

Following traditional sowing date, different seed treatments were compared in controlling covered smut on different sorghum varieties. As it was exemplified in the untreated plots, sowings of Masungi in early May resulted in reduced smut incidence (10%) as compared to sowing of Seredo in late June (38%). Early planting avoids risk of covered smut infection during seedling growth stage while late planting increases the risk of infection. However, early planting is unlikely to have a major impact on the incidence of sorghum-covered smut, as there is uncertainty of rainfall in most sorghum growing regions during late May or early April.

Traditional control of covered and loose smuts involves the use of cow and goat urine stored at different days and diluted with water have been evaluated and found reduced covered kernel smut incidence by up to 81% in 1999 and 26 to 70% in 2000 and increased grain yield, respectively, by up to 95% in 1999 and up to 38% in 2000. Irrespective of storage durations, goat urine treatments significantly reduced smut incidence by 50 and 85% in 1999 and 55 to 82% in 2000, respectively. Sorghum grain yield increased, respectively, to 20 and 140% in 1999 and 28 and 67% in 2000 compared to the control. Additionally, it was also concluded that soaking one kilograms of sorghum seed for 20 minutes in either cow or goat urine diluted with water in a 1:1 (v/v) mixture appeared most effective than 1:2 and 1:3 (v/v) in reducing covered smut.

5.5. Sorghum Ergot

The disease Ergot or Sugary disease caused by pathogen *Claviceps purpurea*. The disease is a serious problem in some areas of sorghum production. In North Shew the disease reported to cause serious problem. In North showa locally described as“Aynewuha" The severity of problem related with onset of rain fall where it usually affects crop sown late in July. Infected plants fail to produce seeds, resulting in tremendous yield loss; especially in the lowland areas.

Symptom

Cream to pink sticky "honeydew“droplets ooze out of infected florets on panicles bearing millions of conidia. These spores are carried by insects or splashed by rain to infect other kernels. The "honeydew" droplets dry and harden, and dark brown to black sclerotia ("ergots") develop in place of seeds on the panicle. Sclerotia left behind in the field serve as sources of infection for the next season. The fungus produces mycotoxins as alkaloids which are highly poisonous to humans and animals, and are used for pharmaceutical applications. Pre disposing factor for ergot diseases include relative humidity greater than 80%, and temperatures between 20 to 30°C.

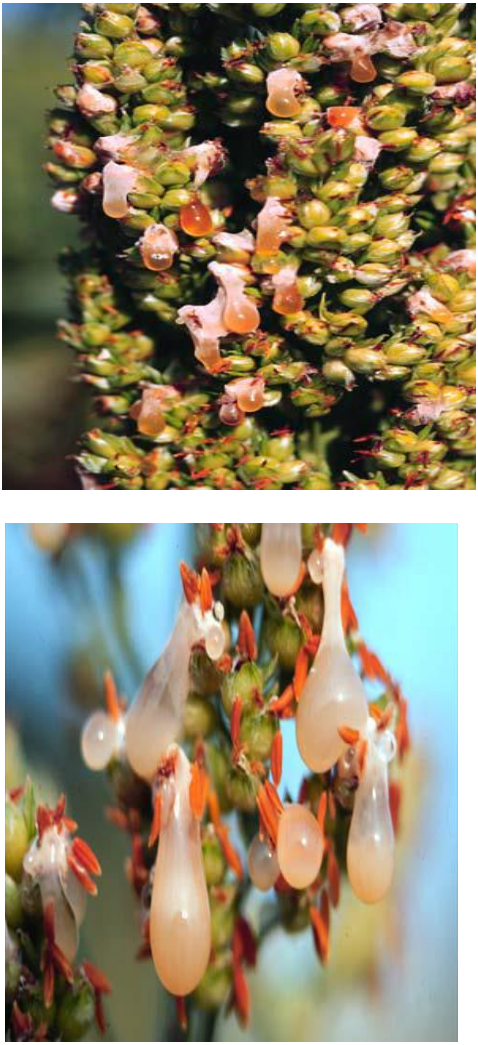

*Figure 13.*Ergot disease symptom on sorghum head

Management strategy of ergot

1. Use of resistant cultivars
2. use of certified seed,
3. cultural practices, phytosanitary measures (to reduce inoculum levels),
4. crop rotation and
5. fungicide treatments of seed and planted fields

5.6. Grain mold

Currently, over 20 causing agents of grain mold have been isolated from either matured sorghum grain under field condition or in stored grain sorghum. Grain mold complex is more serious particularly where sorghum is growing in warm and wet weather conditions and increases in severity if harvesting is delayed after grain maturity. Apparently, the disease is more pronounced in improved early maturing than late maturing sorghum varieties as the late maturing varieties mature at the end of the rainy season and escape grain mold infection. Almost the majority improved sorghum varieties released in Ethiopia in the past, are susceptible to grain mold in the wet and humid environments. The mycoflora associated with the grain sorghum in pits identified include *Phoma sorghina*, *Colletotrichum* and *Fusarium moniliforme*, with mean of 57, 29 and 4%, respectively. However, the frequency of isolated pathogens varied with geographic locations. For example, *Colletotrichum* spp. was isolated only from grains collected from Bako and Jimma, while *Phoma sorghina* was isolated from sorghum grains from all locations. Other fungi were found specific and varied with locations collected. Relatively few pathogens were isolated from sorghum samples collected from dry land areas such Adama and Miesso, while more population of fungi were isolated in sorghum samples collected from Bako and Pawe.

Figure 14. Grain mold symptom on sorghum panicles

Management of Grain mold

Sources of resistance: Major research efforts to manage grain molds still rely on host plant resistance. Hence, diverse sorghum genotypes collected from various sources have been evaluated. Thirty-eight advanced elite materials collected from the Ethiopian National Sorghum Improvement Program and 40 germplasm accessions collected from ICRISAT were planted and visually assessed after harvest at Pawe, Bako and Jimma. After subsequent evaluations eight genotypes, which showed a moderate to high degree of grain mold resistance, were identified.

6. Major Common Bean diseases and their management

6.1. Roots and Stem rots

There are many root diseases of beans and several occur throughout many bean growing areas of the world. Continues bean production, improper crop rotations, and increased soil compaction are some of the factors that contribute to the prevalence and severity of root diseases. Root rots have caused considerable damage to beans in many countries and locations. However, yield losses can be considerable and often vary among fields of the same area, as well as in the same field from season to season. This variability is affected by prevailing environmental and soil conditions at planting time and, mid season stresses, and type and number of root pathogens present and active during disease initiation and development. Root diseases also indirectly affect beans by reducing their efficiency in using soil nutrients. They make roots susceptible to an increased range of stress such as temperature variation, drought, and many biological stresses.

Causes of root rots

Bean root disease can be incited by species of several plant pathogenic fungi. The major ones are species of Fusarium, Rhizoctonia, Pythium, Thieviopsis, Sclerotium, Aphanomyces, Phymatotrichum, and Macrophomina. These pathogens may infect beans, causing a characteristic disease, or may, if occurring together, infect in any possible combination, resulting in disease complex. The shape and color of lesions on stem and root tissues are specific and characteristic for each attacking pathogen. The major root pathogens that predominate and becoming a limiting production factor differ from one bean-growing region to another.

Root and stem rot Symptoms

Above ground symptoms in a field with severe incidence of root diseases include poor seedling establishment, uneven growth, chlorosis and premature defoliation of severely infected plants. Poor seedlings establishment and reduced plant density are results of seed rot and damping off. Root-rot infection of older plants usually results in reduced vigor; discoloration and slow rotting of stem and root tissues. To properly examine bean roots, plants must be dug up carefully and the soil removed without disturbing the fibrous root system.

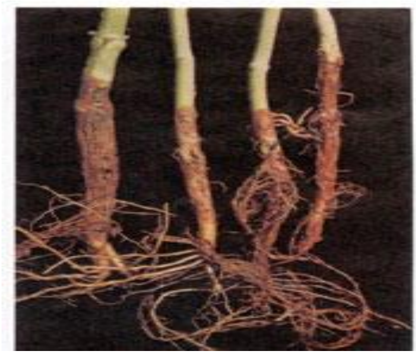

Figure 15common bean root rot symptom

Management of root rots

To manage root rots the **use of resistant bean cultivars** is the most effective. In absence of adaptive and resistant bean cultivars, combinations of compatible and effective measures are required. A susceptible bean cultivar can be managed with economical management of chemical seed or soil treatment, cultural (crop rotation, organic mulch, adjusting planting time, fertilizer or herbicide use, land preparation), biological (addition or enhancement of beneficial soil borne organisms), or combination of these measures. When putting into practice root rot control measures, one must remember that the pathogen is not seedborne, but is strictly a soil organism. Because it is carried with the bean straw, this should never be fed to animals, for the manure will carry the organisms. The bean refuse should always be hauled where beans probably will not be grown for 6 or more years. It is not known how long the root rot fungus can live in the soil; but where a 6-year or longer rotation is practiced, the disease is held in check sufficiently to grow a profitable crop. Where the usual 3-year rotation is practiced, root rot increases until finally bean growing in those fields becomes impossible. In addition to correct disposal of the bean straw and long rotations, a few general recommendations can be made. Any diseased bean refuse left on the field should be turned under deeply by fall plowing. Beans should be planted only on well-drained, well-fertilized soil that is likely to give an excellent growth of vines. Close cultivation should be avoided. If the base of the plant rots off and new side shoots form above the lesion, the plant may live if the newly formed roots are not cut off by the cultivator. The more plant food and moisture available in the soil, the faster these side roots will form, and the more chance there is for recovery and production of an acceptable, although reduced, crop. Plant breeders are working to develop a variety resistant to root rot.

6.2. Common bacterial blight (CBB)

Common bacterial blight caused by *Xanthomonas campestris.Pv. Phaseoli* is ranked among the most important diseases on bean in Ethiopia. It is most prevalent in the low altitude areas and at various degrees, wherever beans are grown. While this disease occurs, its prevalence varies within the same country and within season. The actual yield loss caused by this pathogen is estimated at 21%. The incidence and severity have been reported to be very high in many parts of the country. Estimated yield losses in United States, Canada and Colombia ranges between 13% and 60%. Though no immune variety is found, efforts are currently being made to produce varieties resistant or tolerant to these diseases.

Symptoms of CBB

Initial infection appears as water-soaked lesions on the underside surface leaves. The lesions enlarge and coalesce to produce irregular areas of necrosis. The blighted areas are typically bordered by a narrow zone of yellow tissue. On lower leaf surfaces, frequently there is a distinct black exudate associated with the lesions. Stems and pods often infected, and pod infection can lead to seed discoloration as well as to subsequent seed transmission.

Figure 16. Bean leaves showing common bacterial blight symptoms caused by *Xanthomonas campestris pv. phaseoli* in the field.

CBB Control: Seed treatment with copper fungicides, cultural control methods such as crop rotation, deep plowing, dry weeding and use of disease-free seeds, Use of resistant varieties (Awash-1, Nasser, Awash Melka).

6.3. Halo blight

Halo blight is caused by bacterium *Pseudomonas syringae pv. Phaseolicola* and is a wide spread and important disease favored by cool conditions.

Figure 17. H**alo blight chlorosis on bean leaves, caused by Pseudomonas syringae pv. phaseolicola.**

Symptoms of Halo blight

Initial symptoms of halo blight appear three to five days after infection as small, water-soaked spots on the leaves. A halo of greenish yellow tissue then develops around the lesions. Under epidemic conditions, stem and pods also become infected, the later leading to seed infection. On the pods, the lesions are surrounded with a greasy appearance and distinct halos. Seed contamination can cause stem girdling and joint rot at the nodes of seedlings.

Control of Halo blight

1. Use of pathogen free seeds that has been inspected during production and tested for freedom from *Pseudomonas syringae.pv. Phaseolicola*.
2. Seed treatment with antibiotic to eliminate surface inoculums.
3. Elimination of weeds and volunteer beans that serve as potential reservoirs of *Pseudomonas syringae Pv. Phaseolicola*.

4. Bactericidal sprays containing fixed copper to reduce epiphytic population and control secondary disease spread.
5. Use of tolerant or resistant cultivars/varieties

6.4. Anthracnose

Anthracnose is caused by a fungus *Colletotrichum lindemuthianum*. It is the most important disease of beans worldwide. Yield losses can reach 100%, especially when infected seed is used and prolonged conditions favorable to disease development (high humidity, free moisture, and temperature between 14 and 24 ^{0}C) occur during the crop cycle.

Symptoms of Anthracnose

The pathogen occurs in numerous pathogenic races. Symptoms commonly can occur on cotyledons, leaves, petioles, branches and stems and pods. Leaf symptoms appear initially on lower leaf surface as dark-red to black lesions along the veins. On large veins, these lesions may develop into slightly into slightly sunken canker, within which condia bearing acervuli are produced. Such lesions coalesce, causing necrosis of leaf margins. Pod lesions are typically sunken and containing masses of salmon-pink condia, which are disseminated by rain splash and wind as wells as by physical contact between plants and transmission from infected seed to –plant.

Figure 18.Anthracnose symptoms on the foliage (reddish-brown lesions and pods (sunken tan lesions with dark borders

Control of Anthracnose:

(1). Use of healthy seed and crop rotation of two to three years and field sanitation (bean straw) are effective measures to control anthracnose in the field and

(2). Chemical control: Treatment of seeds with Benomyl (2.5g/kg of seed) and spray with Benomyl (0.4kg/ha) and Mancozeb (00.2% concentration) alternatively in 5 to 7 days interval from just before flowering to harvest. The spray will only pay in high value seed crops. Other Fungicides labeled to control anthracnose include Bravo, Echo, Amistar, Quadris, Quadris Opti, Headline, and Thiophanate methyl products (Topsin).

(3). Avoid cultivating plants when wet; this helps prevent spread of pathogens, especially bacterial pathogens and anthracnose.

6.5. Bean rust

Bean rust is caused by a fungal species, *Uromyces appendiculatus*. In Ethiopia, severe outbreaks reported from the south and southwestern parts and the mid altitude and cooler regions. Up to 85% yield loss reported for the popular and widely grown, but susceptible cultivar, Mexican 142 compared with 30% for the partially resistance Cultivar, 6-R-395. (Yield loss depended on the resistance level of cultivars, location, and season).

Symptoms of bean rust

Infection and subsequent development of pathogen are favored by temperatures between 18 and 25^{0}C and high humidity. Symptoms of infection initially appear on the upper and lower leaf surfaces as chlorotic or white spots within which reddish brown postules (uredia) usually develop. Each uredium produces thousands of browns of brown –colored urediospores, and secondary pustules often develop a round the primary uredium. Sever infection later causes premature defoliation of the plant. Pustules are not confined to the leaves but may occur also on petioles, or on pods. Rust is not transmitted in seeds.

Figure 19. Common bena *rust symptom on leaves*

Control of Bean rust

(1) Growing resistant varieties (e.g. Awash Melka and Roba-1) is a good control method: Many resistant varieties are available in common market classes such as pinto and navy, however, few to none of the varieties in special market classes such as small red and pink are resistant.

(2) Sanitation, crop rotation, and varietal mixtures are found to be very helpful control measures

(3) Spraying mancozeb or systemic fungicides at different crop growth stage can be used as control measures: *A fungicide may be needed to control common bean rust on susceptible varieties. All fungicides registered for*

rust control on dry bean should be applied prior to onset of disease for maximum efficacy. Many of the same products labeled for control of anthracnose are labeled for rust control as well, with the exception of thiophanate methyl products.

6.6. Angular leaf spot

Angular leaf spot is caused by *Phaeoisariopsis griseola,* a pathogen with several physiological races that favored by fluctuating periods of humidity and temperature between 18 and 25^{0}C.

Symptoms of Angular leaf spots

Lesions initially appear as gray spots on lower leaf surface, and then extend to upper surface of leaves. The lesions turn brown and become covered with small column of hyphae, called synnemata (or incorrectly corema), carrying gray to black colored condia. On the primary leaves, the lesions are round and synnemata occur on both leaf surfaces. On the trifoliate leaves, the lesions are usually angular, being delimited by leaf veins, and synnemata are seldom observed on upper leaf surfaces. Lesions may cover large areas of the leaf. Leaf chlorosis due to toxin production by the fungus often leads to premature defoliation.

*Figure 20.*Symptoms of Angular leaf spots on leaf and pod

Control of Angular leaf spot

1. Use of pathogen free seed that has been treated with an effective fungicide
2. Crop rotation, with break of 2 years between bean crops to permit decomposition of infected residues.
3. Under plowing, destruction and burning of residues
4. Spray of fungicides (foliar sprays) when disease first detected and environmental conditions are favorable for disease spread
5. Use of resistant cultivars