A Training Manual for Training of Trainers Recognition and Management of Major Diseases of Irrigable Vegetables Crops with emphasis on Integrated Diseases Management

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Recognition and Management of Major Diseases of Irrigable Vegetables Crops with emphasis on Integrated Diseases Management

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Introduction

Vegetable crops are important high value commodities grown in many parts of Ethiopia. These crops are important food supplements and also serve as regular sources of income for the rural poor farmers. Different types of vegetables are grown around the Central Rift Valley and to some extent in urban and pre-urban areas. The major vegetables cultivated throughout the year by small and large-scale commercial farms include tomato, onion, pepper, cabbage and snap beans. Other vegetables like shallot, garlic, carrot, eggplant, lettuce, Ethiopian kale, Swiss chard are also grown in small and large scales especially in urban and pre-urban areas. However, the productivity of these vegetable crops is very low due to several biotic and abiotic factors among which diseases are the major ones. The major vegetable crops diseases are caused by fungi, bacteria, nematodes and viruses; although some of these pathogens have been identified correctly, the majority have either not been identified or named only based on the symptoms they cause. Relatively more research information is available on diseases caused by fungi than that of bacteria, viruses and nematodes. Production of Vegetable crops however, is threatened by a complex of production constraints. There are a number of diseases recorded from various vegetables crops across different agro-ecologies of the country associated with a variety of vegetable crops cultivated in different agro-ecologies both in irrigated and rain fed production systems. Damage and yield loss due to diseases is high in vegetable crops are produced using irrigation particularly in hot dry periods. In such environment, growers rely on pesticides to combat disease and insect pest problems as the only solution. Diseases can cause 30-50% total yield loss, and their attack varies based on agro-ecologies, varieties, and cropping systems. Apart from yield reduction diseases also heavily reduce the qualities of produces thereby affect both local and export markets. Damage due to diseases may lead to market incompetence mainly in the export market. This is mainly due to reduction in quality of fresh products. Moreover, production cost of vegetable crops could be increased due to pesticide application for the control of diseases. The majority of small-scale vegetable farmers frequently applied different pesticides without the knowledge of type of disease and kind of pesticide to be applied. This is mainly due to lack of technical know-how on diseases and the type of chemical pesticides to apply. Frequent applications of chemical pesticides also adversely affect the marketability of fresh vegetables crops due to pesticide residue level. In such environment, growers rely on pesticides to combat disease problems as the only solution. This perception has led to misuse and abuse of pesticides. As a result, a decline in efficacy of recommended pesticides fast is common due to among others development of pesticide resistant pest population Hence Knowledge on diseases recognition and management is a key to mitigate damage and yield loss both by previously known and new emerging diseases. Growers need to be advised by crop protection personnel and agricultural extension experts to practice preventive and non-chemical direct control measures to reduce diseases pressure based on principles of integrated disease management (IDM) before considering pesticides for controlling the diseases. When pesticide use is necessary, only those registered in the country should be used. Therefore, this note provides information on major vegetable crops diseases and associated management options that are proven in Ethiopia and other experiences from other countries.

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

Integrated Disease Management (IDM) as applied to vegetable diseases 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 behaviour of farmers (traditional preferences, risk behaviours' 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 disease 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 diseases (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 disease and arthropod pest is useful to mitigate damaged and yield losses on vegetables 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 soil-borne 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 soil borne 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 of the 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 soil borne pathogens, including ***Phytophthora*** spp. and ***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 unfavourable 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 Fusarium wilt on tomato. 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.

Polyethylene mulch can be used as a physical barrier between soil and aboveground plant parts. This is an important practice for fruit rot control in the field for vegetables. Highly UV-reflective (metalized) mulches repel some insects that transmit viruses as vectors. It is beneficial to use metalized mulch during certain times of the year when insect vectors of some viral diseases are prevalent. TSW incidence and associated thrips populations have been demonstrated to be effectively reduced by using metalized mulches on tomatoes. Metalized mulches cannot be used during winter in southern Florida and early spring in northern Florida because soil temperatures do not reach desirable levels. Sanitation practices aimed at excluding, reducing, or eliminating pathogen populations are critical for management of infectious plant diseases. It is important to use only pathogen-free transplants.

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. For example, sclerotia of ***Sclerotinia sclerotiorum*** and ***Sclerotium rolfsii*** are transported primarily in contaminated soil. 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 Phytophthora blight of pepper and Fusarium wilt of watermelon, but longer rotation periods (up to 5–7 years) may be needed. Land previously cropped to alternate and reservoir hosts should be avoided whenever possible. Vegetable 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 vegetable viruses. Eliminating weeds might reduce primary inoculum. Non-host cover crops help to reduce weed populations and primary inoculum of soil borne pathogens.

3.12. Biological Control

The use of bio-control agents in vegetable disease management is increasing, especially among organic growers. These products are considered safer for the environment and the applicator than conventional chemicals. Examples of commercially available bio control 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 (post symptom). 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 bacterial spot and speck on tomatoes and is now used commercially.

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. Effective management of whiteflies, thrips, and aphids should be practiced to reduce the incidence and secondary infections of viral diseases vectored by these insects.

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 protectants. 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. Tomato diseases and their Management

Commonly occurring important diseases of tomato in Ethiopia include damping off, late blight, early blight, powdery mildew, septoria leaf spot, viruses and nematode. The highlights of major diseases of tomato described as follows.

4.1 Damping off

Damping off is a major problem at the early stage of vegetable seedlings on the seedbed. The disease can be caused by a complex of fungal pathogens (*Phytophtora* sp., *Fusarium* sp., *Pythium* sp. and *Rhizoctonia* sp.). All pathogens are known to be soil borne and stay for longer time in the soil. The disease can cause post and pre emergence seedling mortality. Apart from seedling infection, some of the important diseases can be transferred from the seedbed to the production field during transplanting. The disease can attack all vegetable crops like tomato, pepper, onion beans etc. Therefore, maximum care should be taken during seed selection and production of seedlings. This is because once damping off is introduced along with the seedlings in production fields it requires expensive cost and time to manage it.

Symptoms

Germinating seedlings may be killed before or soon after they emerge from the soil. Affected seedlings show water-soaked lesion around the soil level. Latter seedlings show wilting symptom and die within short time. If infected seedlings are transplanted to the field, the disease can be transferred to the main production field and cause severe crop damage.

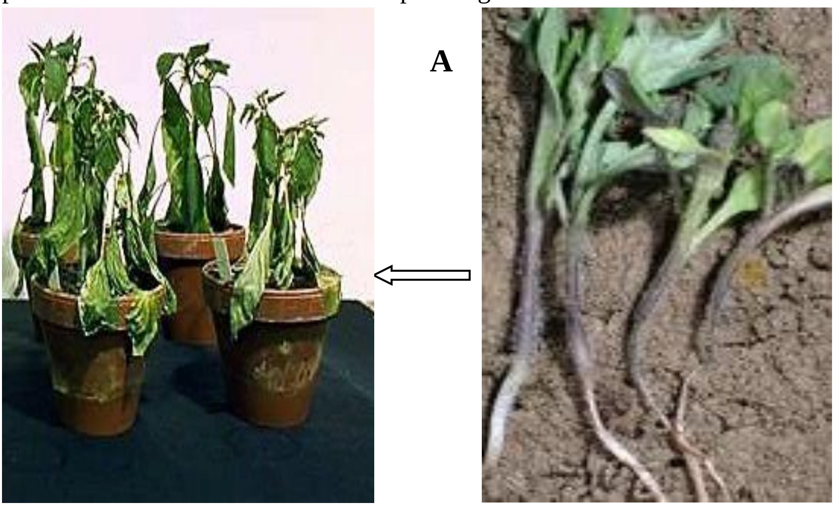

Figure 2. Symptoms of damping off on pepper and tomato (A-pepper, B-tomato)

Control measures

- Use of raised seedbed (this practice will not allow excess water to remain on the seedbed)

- Use of disease free or certified seeds
- Soil solarization using polythene sheets
- Burning of fire wood or stalks of sorghum/maize on the seedbed
- Seed treatment using seed dressing fungicides (Apron star, Thiram)
- Fungicide spray (Ridomil Gold, Agrolaxyl)

4.2. Late blight

Late blight of tomato caused by a fungus *Phytophthora infestans* is a major production constraint wherever tomato and potato are grown. The disease is more severe during high rainfall and humidity. Yield loss due to late blight can reach up to 50-70% during favorable weather conditions.

Symptoms

Figure 3 Damage symptoms of late blight (*Phytophthora infestans*) on tomato

Late blight of tomato can appear at any stage of the crop starting from seedling to fruit maturity stage. Infected seedlings on the seedbed show black discoloration near to the soil level. Latter seedlings become wilted and die.

Under field condition, infected plants showed blight symptom at the edge of the leaves. On the underside of the leaves, often white fungal growth (mycelium) can be observed especially in the morning. During favourable weather conditions and severe infection, total crop loss is quite common.

Control measures

- Transplanting of healthy seedlings
- Crop rotation with non-solanaceous crops
- Avoidance of alternate hosts such as solanaceous weeds
- Use of resistant/tolerant varieties
- Application of registered fungicides (Ridomil Gold, Agrolaxyl, Mancozeb). Research result in centeral rift valley shows that Metalaxyl 4% +Mancozeb 64% (Ridomil Gold 68 WP) 350 g/100liter, fungomil 250 gm/100 liter and Mancozeb+Metalaxyl (mancozeb72 %) 250 g/100 liter were found effective in controlling late blight on tomato.

4.3. Powdery mildew

Powdery mildew **(*Leveillula taurica* L**.) is a common disease of tomato and pepper in warm arid and semi-arid regions of the country. Yield reduction of tomato due to powdery mildew ranges between 10-90%. The devastating nature of this disease is heavy leaf defoliation followed by exposing the fruits to sun light, which causes sun scorching effect. Scorched tomato fruits do not have market value.

Symptoms

The most common symptoms are bright yellow lesion on the upper side of the leaf. Necrotic spots with concentric rings may develop in the center. A light white powdery covering will be observed on the lower surface of the leaf. During favorable weather condition, leaves may defoliate and fruits exposed to sunlight and become sun scorched.

Figure 4. Symptom of powdery mildew (*Leveillula taurica*) on tomato

Control measure

All commercial varieties of tomato are susceptible to powdery mildew. This disease is more problematic during the off season on irrigated tomatoes. Application of locally registered fungicide is recommended. Bayleton is one of the locally registered and widely used fungicide against powdery mildews.

4.4. Early blight

Early blight **(*Alternaria solani*)** is one of the major diseases of tomato wherever the crop is grown. The disease occurs in humid climates in semiarid climates where frequent dews provide sufficient moisture to permit disease development. It causes severe yield and quality reduction of tomatoes in different parts of the world.

Symptoms

Early blight occurs on the foliage, stem and fruit of the tomato plant. The disease can cause severe damage during all developmental stages of tomato. It is first observed as small brownish black lesion on older leaves. Infected leaf tissue surrounding a spot may become yellow. Under favourable conditions, infected plants may become defoliated, exposing the fruits to sunscald.

Stem lesions on seedlings are small, dark and slightly sunken. They enlarge to form circular or elongated lesions with concentric rings.

Figure 5.Symptom of early blight (*Alternaria solani*) on tomato leaves

Control measures

- Crop rotation using non solanaceous crop species
- Use of tolerant/resistant varieties
- Use of pathogen free seed
- Seed treatment using seed dressing fungicides (Apron star)
- Application of registered fungicides (such as Ridomil Gold, Agrolaxyl)

4.5. Septoria Leaf Spot.

Septoria leaf spot has been known as one of the most destructive disease of tomato foliage. It is widely distributed throughout the world. The disease is caused by *Septoria lycopersici* Speg, fungus.

Symptoms

Symptoms of septoria leaf spot usually appear on the lower leaves after the first fruit sets. Lesions may appear on stems, petioles and calaxy. The disease spreads from upward from oldest to youngest growth. If lesions are numerous, some infected leaves turn yellow and then brown, and they weather. Fruit infection is rare. The fungus can be spread by wind, rain, and irrigation- water and by cultivation. Disease causing fungus can survive in or on seed, in or on debris from diseased plants and in infected perennial weeds

Control **measures**

- Crop rotation using non solanaceous crop species
- Use of tolerant/resistant varieties
- Use of pathogen free seed
- Seed treatment using seed dressing fungicides (Apron star)
- Application of registered fungicides (such as Ridomil Gold, Agrolaxyl)

4.6. Viruses

Figure 6 Symptoms of Septoria leaf spot on tomato Leaf

A number of viruses are attacking tomato in many parts of the world. Different viruses are also registered as major production problem of tomato in Ethiopia. Among others, tomato mosaic virus (ToMV), tobacco mosaic virus (TMV), tomato yellow leaf curl virus (TYLCV) are the most important ones. Depending on the kind of virus and severity of infection, viruses can cause complete crop failure on tomato and pepper.

Symptoms

Since a complex of viruses is associated with the tomato plant, symptoms are also varied accordingly. Viruses can attack tomato at all developmental stages. Early infection (before flowering) can cause total crop loss. The major visible symptoms due to virus infection on tomato include:

- Stunting or dwarfing of plants
- Yellowing of leaves
- Curling or rolling of leaves
- Malformed/deformed leaves

Figure 7. Symptoms of tomato yellow leaf curl virus (TYLCV)

Control measures: No chemical treatment is available for the control of plant viruses

- Use of healthy seedlings
- Discourage tobacco smokers during seedling raising and cultivation
- Rouging of virus infected plants
- Crop rotation
- Avoidance of volunteer solanaceous crops and weeds
- Application of insecticide against insect vectors (virus transmitters)

4.7. Tomato nematode

Root-knot nematode is caused by species of meloidogyne, which are obligate sedentary parasites of vascular plants. The disease is widely distributed in tomato growing areas of the world. Root-knot nematode causes heavy economic damage on different cultivated crops including vegetables. If environmental conditions are favorable the disease can survive on many weeds particularly broadleaf species.

Symptoms

Severe infestation results in stunted plant growth and induce high root-shoot ratio. The normal transfer of nutrients and water could be blocked due to the excessive gall formation on root system this results in stunting growth, wilting and nutrient deficiency symptoms.

Figure 8 Invasion and damage symptoms of root-knot nematode on tomato roots (A). invasion of the root system; B-formation of root galls).

Control measure

Since root-knot nematode is soil invader pathogen it is recommended to use crop rotation with non-host plant such as cereals and other grass species. Fallowing is also play a role in reducing nematode population. Soil fumigants or non-volatile registered nematicides are also proved to reduce nematode population.

5. Pepper Diseases and their Management

All major diseases of tomato (damping off, late blight and powdery mildew) are also attack pepper **(**hot Pepper) (*Capsicum annum*). Therefore, the type of symptoms they cause and all the management practices mentioned on tomato are also applied for hot pepper too.

5.1. Fusarium wilt

Fusarium wilt **(***Fusarium oxysporum***)** is a very common problem of pepper and tomato throughout the year both in irrigated and rain fed agriculture. Many of the small holder farmers are not growing pepper due to fear of this diseases. Fusarium wilt of pepper is commonly found in the major pepper growing areas of the central rift valley areas like Wonji, Melkassa, Meki, Ziway, Alaba, Mareko areas. The epidemic of fusarium wilt is pronounced with high rainfall, excessive irrigation and poor water drainage system.

Symptoms

Disease symptoms on tomato and pepper are characterized by an initial slight yellowing of the foliage and wilting of the upper leaves. The vascular systems of the plants discolored particularly lower stem and root systems. High temperature and wet soil conditions favor disease development. The disease is most likely occurring in poorly drained areas of the field. on tomato one sided wilting is common.

Figure 9 Symptom of Fusrium wilt on Pepper
(a) Internal discoloration (b) and codia of of *fusarium spp*

Control measures

1. Since the pathogen is soil borne, crop rotation for 2-3 years using non solanaceous crops is important
2. Proper cultural practice (drainage of excessive water, leveling of fields, optimum irrigation water, timely weeding, and avoidance of alternate solanaceous weeds) are important practices to reduce pathogen build up.
3. Use of resistant/tolerant varieties
4. Thoroughly disinfect equipment before moving from infested to clean fields.
5. Application of bio control agents like *Trichoderma viridae* or *Trichoderma harzianum* along with FYM at the time planting (1 kg mixed with 200 kg of FYM for one acre of land)

5.2. Powdery mildew

With this warm weather, capsicum farmers better be on the lookout for powdery mildew. This is one of those dangerous fungal diseases that spreads like bush fire in your fields. A severe infestation on your fields can cause a lot of damages to your expected yields. This disease primarily affects leaves of the capsicums. Other parts mostly affected are stems and flowers. It occurs at any stage of crop development with the most common affected stage being the fruiting phase or just before onset of the fruiting phase. Pepper is the main crop affected by this disease, but the same isolates of *L. taurica* may attack tomato, eggplant, and cucumber. Many cycles of infection may occur during the growing season.

Symptoms

The disease infects the lower leaf surface as small, whitish powdery-like colonies. The upper surface of the foliage develops yellow spots that become more prominent as *L. taurica* develops. There are no symptoms on either the fruit or root tissues. As the disease develops, the older colonies of the fungus may turn a dirty white color with age. The severely affected leaves turn yellow, then brown and fall off. Generally, the older leaves are affected first and the disease gradually moves up the plant. Crop yields and fruit quality may be reduced through loss of foliage. The main method of spreading the fungus is by wind, but rain splash will also spread the spores. Insects such as thrips, aphids and whiteflies are considered minor sources of spread. Workers handling affected plants may cause spores to be disseminated to neighboring plants. The fungus survives from season to season on living pepper plants or alternative hosts. The fungus is not found on or within pepper seed. The disease is favoured when large day/night temperature and humidity fluctuations occur, which promote periods of leaf wetness. Development of *L. taurica* is favoured by warm (25°C) and dry (less than 80% RH) days followed by humid (greater than 85% RH) nights. Temperatures of 25°C are associated with a higher rate of disease development than temperatures of 18–20°C. Young plants are less susceptible than older plants. Other factors such as close plant spacing and luxuriant plant growth arising from high nitrogen levels are likely to foster greater disease development.

Figure 9.Powdery mildew symptom on pepper leaf

Control

Prevention – The disease is difficult to prevent because the fungus infects many different hosts and its spores are disseminated by wind. Nevertheless, avoid excessive rates of nitrogen since they make plants more susceptible to

infection. Avoid crowding and shading plants, which favor development of leaf wetness. Monitor the undersides of leaves for mildew development and act promptly when symptoms appear. Avoid planting young pepper plants while diseased plants remain nearby. Control weeds around the planting site since *L. taurica* has a wide host range and could persist on these plants during the growing season or during the off-season.
Chemical – Sulfur and other protectant fungicides are available. Ensure good spray coverage with protectant fungicides, particularly on the under surface of the foliage and the lower plant canopy. Avoid applications during very warm, sunny weather to prevent phytotoxicity. Application in the evening using high volumes of water will prevent this. Prevent development of resistance in *L. taurica* to certain fungicides by rotating with sulphur or other materials, if available.
Resistance – Currently, all pepper varieties are susceptible but resistant plant material has been identified in recently released pepper varieties.

6. Onion Diseases and their management

6.1. Purple blotch

Purple blotch **(***Alternaria porri*) is the major production constraint of onion wherever the crop is grown. The disease is favored by frequent rainfall and high humidity during the active growth stages of the crop. Yield losses caused by purple blotch can reach 30-40% around the central rift valley area. The disease attacks the foliage and consequently affects the quality and productivity of the crop.

Symptoms

Initial symptom of purple blotch is white spots on the leaves. During favorable weather conditions these spot enlarged and become purplish or brown in color. At the latter stage of crop infection, all leaves may dry and collapse. Severe infection causes smaller bulb size and not fit to the market.

Figure 10. Symptom of Purple blotch (*Alternaria porri*) of onion

Control measures

- Use of disease-free seeds
- Crop rotation
- Seed treatment (Apron star)
- Application of registered fungicide (Ridomil Gold, Mancozeb). Research result at Melkassa indicate Mancozeb 50% WP at 3 kg/ha as protective and Ridomil Gold MZ 68 % WP at 2.5 kg/ha as curative reduced severity of Purple blotch.

6.2. Downy mildew

Downy mildew **(*Peronospora destructor*)** of onion is a major and widespread problem of onion in areas with high and frequent rainfall. Apart from onion, the disease attack shallot in the highland areas characterized with high rainfall and relative humidity. The disease spreads rapidly during cool and wet weather. Some varieties of onion have the fungus during winter also in storage. Dew collects on the plant at night by which the spores germinate and enter the onion leaf.

Symptoms

At the beginning of infection, symptoms appear as gray masses of fungal growth. When the disease progresses, infected parts turn to brown to purplish color. During severe infection, leaves get dry and bulb size reduced.

Figure 11.Early damage symptom of downy mildew (*Peronospors destructor*) on onion

Control measures

- Crop rotation
- Use of disease-free seedlings
- Application of registered fungicides (Ridomil Gold, Agrolaxyl, Dithane, Stamina)
- Grow resistant varieties. ii. Spray Zineb, about 6-10 application at an interval of 6 to 8 days. iii. Remove diseased plants and burn them.

6.3. Bulb rot

Bulb rot caused by a fungus *Sclerotium cepivorum* is the most destructive disease of Allium species. The disease is highly pronounced in areas with high rainfall, humidity and excessive soil moisture. The pathogen can survive in the soil for longer period. Currently, this disease is widespread in Allium production areas of north and north-west part of Ethiopia.

Symptoms

The disease attack onion, garlic shallot and leek. Plants may be infected at any stage of growth provided environmental conditions are favorable. Infection of seedlings occasionally occurs; however, the first infections are normally detected in plants bearing three to five leaves. Initial stages of infection are confined to the host root system and base plate. The first above-ground symptoms of infection include a yellowing of leaves beginning at the tips and progressing downward. A gradual decline in the plant continues for some days or weeks and in the case of young plants may constitute a rapid wilt and collapse of aerial parts. Ultimately the entire plant is killed. On underground parts the fungus itself is visible as superficial, fluffy white mycelium. The roots are gradually destroyed and the fungus causes a soft, watery decay of the bulb commencing at the base plate. Black spherical sclerotia, normally 200-500 µm diameter, are formed on the bulb base and within decaying root and stem tissue. Above-ground symptoms are not normally evident until the pathogen has colonized and partially rotted the stem and leaf sheaths. Roots frequently extend horizontally, providing a direct path for mycelial growth to nearby plants.

Figure 12.Symptom of bulb rot (*Sclerotium cepivorum*) on onion

Control measures

Chemical Control

Fungicides are among the more effective short-term solutions to Allium white rot, but cannot be relied upon in the long term due to problems such as development of resistance by the pathogen, build-up in the soil of fungicide-degrading microorganisms, and withdrawal of chemicals from the market on safety grounds. Chemically treated produce may contain residues and is less marketable in many parts of the world.

Host resistance

Use of resistant/tolerant varieties of onion is the most effective and economical way of controlling onion bulb rot.

Crop rotation

The pathogen causing bulb rot (*Sclerotium cepivorum*) is a soil borne fungi that can survive in the soil for a long time. Hence, rotation of non-allium crops for 2-3 years is important to reduce pathogen build up.

7. Head cabbage diseases and their Management

7.1. Black rot

Black rot (*Xanthomonas campestris*) is the most important disease in all cabbage growing areas of the world. The disease is favored by excess moisture and high relative humidity. The disease is known to be seed borne/transmitted. All cabbage growing areas in Ethiopia are severely affected by the disease.

Symptoms

An initial symptom of cabbage black rot appears as 'V' shaped necrosis at the edge of the leaves. During favorable weather conditions the leaves get symptoms of water-soaked lesions and finally the plant rot. Rotted cabbage has got unpleasant odor.

Figure 13.Symptom of black rot (*Xanthomonas campestris*) of cabbage

Control measures

- Crop rotation with non-host
- Use of resistant varieties
- Seed treatment
- Application of registered fungicides (Copper fungicides)