TVET CERTIFICATE IV IN CROP PRODUCTION

Field plant pests and diseases identification

CRPPD401

Perform field plant pests and diseases identification

Competence

Credits: 6

Learning hours: 60

Sector: Agriculture and Food processing
Sub-sector: Crop Production

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Purpose statement

This module provides skills and knowledge required to identify pests and disease on plants. It is important for a trainee to be able for identifying pests and disease in order to increase the production in terms of quality and quantity.

Total Number of Pages: 55

Learning Unit 1 – Select the site and materials

LO 1.1 – Proper selection of tools to be used

Accurate identification is the first step in an effective pest management program. Never attempt a pest control program until you are not sure of what the pest is. The more you know about the pest and the factors that influence its development and spread, the easier, more cost-effective, and more successful your pest control will be. Correct identification of a pest allows you to determine basic information about it, including its life cycle and the time that it is most susceptible to be controlled.

- **Content/Topic 1 : Materials tools and equipment used to identify crop pets and diseases and their utilization**

A. Tools and materials

Essential equipment that an authorized officer will find useful for the collection of pest, disease and contaminant specimens include:

1. Sample tubes filled with 70% ethanol (ethyl alcohol) (approximately 3 parts alcohol: 1 part water).

2. Methylated spirits should only be used as a last resort small brush a good quality torch

3. A scraper and or probe for recovering residues

4. Zip lock bag for plant material

5. A pair of forceps (tweezers) suitable for collecting the larger species

6. Pencils for labelling tubes (pens aren't suitable as alcohol dissolves most ink).

B. Other tools:

B.1 Secateurs: are hand tools used to cut a part (branches, stems) of plant to identify the pests and diseases that may occur in these parts.

B.2 Hoe: is a hand tool used to cut or dig the soil to identify the pests and diseases that can attack the roots of a crop or plant

B.3 Magnifying glass: it is used to increase the size of pest for better description

B.4 Pest traps:

Example - Pheromone trap: A pheromone trap is a type of insect trap that uses pheromones to lure insects. Sex pheromones and aggregating pheromones are the most common types used.

B.5 Knives: are tools used to cut/peel hard or ligneous stems and braches to identify pets and diseases.

B.6 Razor blade: it is a tool used to cut herbaceous stems and leaves in order to identify the symptoms caused by pests and diseases.

B.7 Bleach: A chemical, such as sodium hypochlorite or hydrogen peroxide, or a preparation of such a chemical, used for disinfecting or whitening.

C. Equipment:

1. Microscope

A microscope is an instrument used to see objects that are too small to be seen by the naked eye**.**

- **Content/Topic 2: Criteria for selecting tools**

The selection of tools depends on the following parameters:

- ✓ The type of crop attacked

The selection of tools will depend on size and morphology of plant or crop. For example, the tools and equipment required to identify pests and diseases on vegetables will differ from that one's needed for fruits.

- ✓ Causal agents

On this side, the materials, tools and equipment can be selected due to the symptoms observed on the plant. Plant health can be disturbed by abiotic and biotic agents

- ✓ Infected parts of plants

The diseases that attack the plant or crop can be categorized depending on the part of plant to be attacked:

- Root diseases
- Stem diseases
- Foliar diseases
- Fruit diseases
- Floral diseases

✓ Cost

One of the major factors affecting tools, materials and equipment selection is the cost. The most they are cheapest, the most they are useful.

✓ Accuracy or precision

Accuracy is the measurement tolerance, or transmission of the instrument and defines the limits of the errors made when the instrument is used in normal operating conditions.

✓ Complexity

When the tool or equipment is sophisticated in its design, it requires a skilled person to operate and interpret the results.

✓ Test to be conducted

The test to identify crop diseases determine the procedures, tools and materials.

LO 1.2 – Adequate identification of field

- **Content/Topic 1: Scouting and selection of infected field**

Scouting and monitoring are crucial steps in making informed decisions about pest and disease management, which can go beyond pest control and affect other important practices (e.g. identifying nutrient deficiencies, water issues etc.).

Proper scouting and monitoring must achieve the following goals:

✓ Detect problems, pests and diseases, as early as possible, before the pest or disease are established and control becomes difficult

✓ Identify the pest correctly

✓ Rank the severity of the problem, e.g. low, moderate, severe, or numerical ranking.

✓ Plan and implement a safe and effective treatment program

✓ Assess treatment efficiency

- **Scouting patterns**

Growers usually develop their own scouting patterns, depending on their experience and knowledge of their crop, variability in the field and common problems.

Some common scouting patterns include U shape, Z shape or W shape.

Scouting tools, aids and techniques

When scouting, it is recommended to use tools and techniques that can help detecting and identifying the pest.

For example:

- ✓ Use a magnifier glass
- ✓ White paper sheet –Tapping flowers over a white sheet of paper may to detect thrips
- ✓ Inspect both upper and lower side of the leaves, don't leave out stems and stem bases

In greenhouses you can use dedicated tools:

Yellow sticky traps attract adult whiteflies, leaf-miners, cabbage loopers.

- ✓ Blue sticky traps attract thrips.
- ✓ Electric insect killer catches butterflies, moths.

Other tools can that be used anywhere, include sweep nets and pheromone lures (for monitoring some species of moths).

In large open fields, precision agriculture tools can be used, such as satellite imagery, GPS, drones etc. Today, remote-sensing technologies can help in detecting and identifying pests and diseases. The most commonly used index is NDVI (Normalized Difference Vegetation Index), which is used to detect changes in biomass. Near infra-red cameras are used in order to obtain this index. Camera which are standard cameras that capture images and videos, are also used for pest and disease detection.

- **Record keeping**

- ✓ Record keeping format

Keeping records of the scouting findings is essential in order to evaluate the efficiency of the treatment and to predict problems in future seasons.

Records must include at a minimum:

- Crops scouted
- Date
- Findings – identification of the pest, development stages, Severity of infestation
- Treatment applied
- Findings of follow up monitoring

✓ Tools and equipment used in record keeping

- Computer
- Camera
- Storage devices

✓ Pests and diseases record keeping methods

- Manual method
- Electronic methods

Content/Topic 2: Factors determining the choice of the field

The factors determining the choice of the field are:

- Severity or incidence of diseases

Once the degree of prevalence and intensity of pests and diseases is known, one would like to know how severe the incidence or pest infestation is. This can be determined by measuring the severity of incidence due to different diseases. Such methods don't exist for measuring the severity of infestation of the pests. However, the severity of pest infestation can be measured by counting the number of eggs, larvae, pupae or flying insects, or by determining the percentage of infested leaf, if possible.

The formulae in calculating percentage of disease severity and incidence are:

Disease Incidence=Total no. of infected plant/Total no of plant assessedX100

Disease severity= sum of individual ratingsX100/no of plant assessed X maximum scale

The maximum rating scale (0-5) which is used for calculating the percentage of disease severity is: Rating Scale: Disease percentage 0 (No infection), 1 (1-5% infection), 2 (5-25% infection), 3 (25-50% infection), 4 (50-75% infection), 5 (75-100% infection).

- Pests available

The choice of the field will depend on available pests such as: insects, mites, rodents, animals and birds. The choice of field will focus on occurrence or frequency of one the pests as described.

- Period/time

It is recommended to start scouting immediately after the crop emerges. Different pests and diseases may appear in different times along the growing season. Knowing the life cycle of each common pest or disease that might affect the crop, and when they may appear, helps to determine what to look for and when.

Ask questions about how the damage developed. Did it appear suddenly or over time? Has the damage spread or stayed in the same location? Progressive development and spread over time often indicate damage caused by pathogens. In contrast, damage that does not spread and where there are clear lines of delineation separating sick plants from healthy plants, typically indicates damage caused by an abiotic factor. The science of how disease develops over time is called epidemiology. The more time that passes, the more severe the disease will be.

Content /Topic 3: Actual pests and diseases devastating the crops in the region

- Maize and sorghum

The study reports that maize, the most important staple crop in eastern Africa, is affected by several invasive species:

As much as $450 million is lost to smallholders each year to the spotted stem borer, Chilo partellus, a caterpillar which feeds inside the growing maize plant, reducing its yield. This pest also attacks other important crops such as sorghum. A biological control agent (*Cotesia flavipes*) released against this pest is playing an important role in reducing the crop losses suffered by smallholder farmers.

Maize Lethal Necrosis Disease (MLND) is caused by a dual viral infection and leads to the production of deformed maize ears which can result in total crop loss.

Current smallholder losses to this disease are estimated to be up to $339.3 million each year, but are likely to increase significantly with the ongoing spread of the disease.

The invasive famine weed, *Parthenium hysterophorus,* affects farmland and pasture, reducing production levels in a variety of crops and having human and animal health impacts. The weed is most widespread in Ethiopia, but is increasing its range in Kenya, Tanzania and Uganda. Current smallholder losses in maize for the region are estimated to be as high as $81.9 million annually, but can be expected to rise with the ongoing march of this damaging weed.

The South American tomato leaf miner, *Tuta absoluta*, has had a devastating impact since its recent introduction to Africa, frequently causing total crop loss and leading to three-fold increases in tomato prices. Losses to eastern African smallholders are estimated at up to $79.4 million per year at present, but this figure is expected to grow substantially with the rapid spread of this pest.

Ethiopia, Kenya and Somalia are dealing with desert locust swarms of “unprecedented size and destructive potential” that could spill over into more countries in East Africa, the United Nations Food and Agriculture Organization (FAO) warned on Monday 20, January, 2020.

- Roots, tubers and Banana

Potato (Solanum tuberosum) is the third most consumed food commodity worldwide after rice and wheat and has hence been recommended as a food security crop by the Food and Agriculture Organization of the United Nations *(FAO) (Devaux et al. 2014)*. Potato bacterial wilt (PBW), also called potato brown rot, caused by Ralstonia solanacearum, was considered the second most important disease in potato production in Rwanda after late blight (caused by Phytophthora infestans) *(Bicamumpaka and Haverkort 1983; Devaux et al. 1987; Scott 1988)* but a recent study reported that, according to the farmers, the damage caused by PBW is more severe than those caused by late blight *(Muhinyuza et al. 2012).*

✓ **Some of the most important pests and diseases limiting production of roots, tubers and bananas in the East and Central African region**

Crop	Type of Harmful Organism	Economic Importance (Yield and Economic Losses) of Pest
Potato	Insects 1. The potato tuber moth (*Phthorimaea operculella* [Zeller]) 2. Leafminer flies (*Liriomyza* spp.) 3. Aphids (*Aphis gossypii* Glover, *Aphis fabae* Scopoli, *Macrosiphum euphorbiae* Thomas, and *Myzus persicae* Sulzer)	Tubers infested with P. *operculella* often initiate tuber infestation in potato stores causing losses of tubers of up to 70%.
	Pathogens/diseases 1. Late blight caused by *Phytophthora infestans* (Mont.) de Bary 2. Bacterial wilt caused by *Ralstonia solanacearum* (Smith 1896) 3. Potato viruses (Potato Virus S (PVS), Potato Virus (PVY), Potato Virus X (PVX) and Potato Leaf Roll Virus (PLRV))	Yield reductions in Rwanda and Burundi can reach 75% for late blight if no control measures are taken. For bacterial wilt, reductions in yield range from 70–100%, depending on the inoculum density. Seed degeneration due to viral diseases have been reported to cause yield reduction of up to 90%.
Sweet potato	Insects 1. The African sweetpotato weevil (*Cylas puncticollis* Boheman and C. *brunneus* Olivier), 2. The sweetpotato butterfly (*Acraea acerata* Hew) 3. The sweetpotato whitefly *Bemisia tabaci* (Gennadius)	Root yield losses due to C. *puncticollis* alone can reach 100% during prolonged dry seasons.
	Pathogens/diseases 1. The sweetpotato virus disease (SPVD), 2. *Alternaria* leaf and stem blight and 3. Fungal root rots	Root yield losses due to SPVD ranges between 30–40% at on-farm.

Crop	Type of Harmful Organism	Economic Importance (Yield and Economic Losses) of Pest
Banana and plantain	**Insects** 1. Banana weevil (Cosmopolites sordidus Germar) Banana aphid (*Pentalonia nigronervosa Coquerel)*	Yield losses of 30–50% in fertile soils and over 75% in poor soils. Direct feeding by large colonies of the banana aphid reduces market value due to blemishes on the fruit. The secretion of honeydew by aphid colonies provides a substrate for sooty mold fungus, which reduces banana yields and market value.
	Nematodes 1. *Radopholus similis* (Cobb) Thorne, 2. *Pratylenchus goodeyi* Sher and Allen, *Helicotylenchus multicinctus* (Cobb) Golden 3. *Meloidogyne* spp.	
	Pathogens/diseases 1. *Xanthomonas* wilt of banana (BXW) caused by *Xanthomonas campestris* pv. *musacearum* 2. Fusarium wilt caused by *Fusarium oxysporum* f. sp. *Cubense* 3. Banana bunchy-top disease (BBTD), caused by the banana bunchy top virus (BBTV)	Up to 100% yield loss if control of BXW is delayed. Economic losses worth US$200–295 million/year due to BXW were estimated in Uganda. Annual production losses due to BXW valued at US$10.2 million and US$2.95 million in Tanzania and Rwanda, respectively. Reduction in fruit sales by 35% and a doubling of bunch prices due to BXW. Severe effects of BXW on ecosystem health of banana-based agro-ecosystems. Losses of up to 100% due to BBTD in Burundi and eastern DR Congo.
Cassava	**Insects** 1. Cassava mealybug (*Phenacoccus manihoti* Matile-Ferrero). 2. Cassava green mite (*Mononychellus tanajoa* Bondar) and 3. Cassava whitefly (*B. tabaci* (Genn.)).	No data could be accessed.
	Pathogens/diseases 1. Cassava brown streak disease (CBSD) 2. Cassava mosaic disease (CMD) 3. Cassava bacterial blight (CBB)	Africa-wide losses to CMD have been estimated at more than US$1 billion annually. Loss estimate for CBSD in East and Central Africa is greater than US$75 million per year.

- **Major insect pests and diseases on rice in Rwanda**

The production of rice is done in the marshlands of the distributaries of Akanyaru and Nyabarongo rivers on the upstream part of Nile basin of Rwanda. With increasing urbanization in the country, the rice crop is becoming an important major staple crop which is gaining more importance in many parts of the country where it is grown; moreover, it is both food and cash crop, having a reliable market and source of family income. Because of development of irrigation infrastructures, and possibility of double crops per year on continuous cropping system, pests and diseases are expected to increase. The current major pests and diseases problems observed and reported by farmers include: (a) Rice blast (Pyricularia oryzae), (b) stalk-eyed borer (Diopsis thoracica), (c) birds, and (d) rats. The first two are often controlled using pesticides.

The pest status of rice blast is very high. As disease of significant economic impacts it attacks all aerial parts, leaves, culms, branches of panicles and floral structures. Its main host is the rice plant (Oryza spp) and a few wide ranges of other Graminaceous plants, and is widely distributed in all rice growing areas in Rwanda. The current management of rice blast is

mainly by use of resistant varieties Kigori, Yuni and Zongeng or moderately tolerant varieties like“Intsinzi, Gakire, and Intsindagirabigega” combined with varietal rotation. The application of cultural practices is also possible but not sufficient by itself and sometimes it is combined with fungicide use (e.g., Kitazine/IBP). The pest status of stalk-eyed borer (Diopsis thoracica) is not clear, as it depends on age of attack. The early infestation stimulates tillers production and as a result increases crop yield. It is required to establish pest status of stalk-eyed borer in Rwanda.

- **Major insect pests and diseases on maize in Rwanda**

Maize crop is an important staple crop in Rwanda both as a food and source of income. It is mainly produced in the marshlands along Akanyaru River and its distributaries, Eastern and Northern provinces. All these parts are in the basin part of Rwanda. The crop has a list of pests and diseases which are generally considered to be major constraint in production; however, their pests status (economic importance) varies according to environmental conditions and cultural practices applied by farmers. The major pests and diseases of maize include maize stalk borers (eg Busseola fusca), maize streak virus, leaf blight, striga weeds and storage pests. The diseases like maize streak,leaf blight are currently controlled using resistant varieties and cultural practices.

The storage pests like greater grain weevils (Sitophilus spp.) and tropical warehouse moth (Ephestia cautella.) are not yet a threat, probably because of low maize production which does not need to be stored for long period. The surplus production which needs storage can be handled by hermathic.

In addition, there is also striga weed (Striga asiatica or Striga hermontheca) which is expanding in the Eastern province where it is reported to cause up to 100% yield loss, and is renamed as Kulisuka (meaning zero yield). This will be controlled by using “push-pull” technology as an IPM tool.

Nevertheless, maize pests and diseases are manageable using cultural practices and resistant varieties as components of IPM tools. The current maize production systems, such as crop rotation with legumes or potatoes, flooding in marshlands “like “Akanyaru” where large quantities are produced” reduce pests and diseases problems. In addition, the current hermetic grain storage (renamed known as “cocoons”) promoted by Rwanda’s Ministry of agriculture and Animal Resources helps to reduces storages losses from pests through suffocation, in Sitophilus zeamais in maize, bean bruchids in beans etc. It is a good IPM tool.

However, storage of grains of maize or beans which are not well dried may lead to the growth of moulds and destroy the whole stock. Care must be taken to ensure moisture content of lower than 12%.

- **Major insect pest and diseases on potato**

The current major pests and diseases problems of potatoes in Rwanda are

(1) Late blight

(2) Bacterial wilt

(3). Potato tuber moths

(4). Aphids are serious during low rainfall season.

The potato crop is one of the major crops in the country and it is produced in rotation with maize in the Northern Province. Among the major pests and diseases, the late blight is the most serious and is continuously controlled using fungicides (e.g., Dithane M45 or Ridomil) in combination with resistant varieties. It is a major disease which cause up to 100% yield loss when no control measures are applied. To date there is no record of resistance to Ridomil because it is not used regularly. It is applied only when rainfall is continuous and heavy rains can wash out protectants on leaves.

- **Major insect pest and diseases on Cassava**

In Rwanda cassava production is currently constrained mainly by cassava mosaic disease (CMD) which has devastated major growing areas in the country. Therefore, among the biotic factors, the cassava mosaic disease (CMD) is the most important. Epidemics are particularly ravaging with root yield losses as high as 100%. CMD is caused by at least three geminiviruses, which include the African cassava mosaic virus (ACMV), the East African cassava mosaic virus (EAMV) and the Uganda variant of the EACMV (EACMV-UgV), which is a hybrid virus of EACMV and ACMV. The CMD is commonly found in many fields of cassava, and farmers who cannot follow good crop management such as rogueing out of the infected plants and cannot access the CMD free cuttings are at high risk.

The use of resistant cassava planting materials would be the best alternative for the smallholder farmers in Rwanda. Currently these varieties are still not enough and are most expensive to buy, as each hectare would need 10000 cuttings. Combined efforts of ISAR, LVEMP, and farmers organizations (Ingabo and Imbaraga) are ongoing to avail to farmers, sufficient amount of healthy cuttings.

- **Current major insect pests and diseases on tomato**

Tomato crop is attacked by a variety of insect pests and a wide range of diseases attack leaves, fruit and roots, particularly in the rainy season when high humidity favours insects and pathogen development and transmission. The major insect pests include: Bollworm (Helicoverpa armigera), Leafminer (Liriomyza spp.), and Cutworm (Agrotis spp.) African Spider Mites (Tetranychus spp.), Aphids (Myzus persicae & Aphis gossypii), Whitefly (Bemisia tabaci), Root-Knot Nematode (Meloidogyne spp.); while the major diseases include: Late Blight (Phytophthora infestans), Damping Off (Pythium spp. & Rhizoctonia solani), Early Blight (Alternaria solani), Fusarium Wilt (Fusarium oxysporum f. sp.lycopersici), Verticillium Wilt (Verticillium dahliae), Powdery Mildew (Leveillula taurica), Septoria Leaf Spot (Septoria lycopersici), Anthracnose (Colletotrichum spp.), Leaf Mould (Fulvia Fulva), Bacterial Wilt (Pseudomonas solanacearum also known as Ralstonia solanacearum, Tomato Yellow Leaf Curl Virus (TYLCV), Tomato Mosaic Virus (TMV) and Blossom End Rot. Farmers possess little knowledge of these pests. It is important to monitor the use of pesticides on tomatoes otherwise farmers may overuse them. Among these diseases, the late blight (Phytophthora infestans) is much more the most serious and is currently controlled using fungicides Such as Dithane M45/Mancozeb or Ridomil/Metalaxyl. Both fungicides are category U and III respectively which are acceptable and are unlikely to cause major problem to farmers, consumers and environment.

Tomato is one of the most important vegetables, relatively easy to grow, important source of nutrition (vitamin A and C) and income for smallholders. Tomato varieties can be divided into two main types.

(1) First are Bushy type varieties (also called determinate cultivars) which can usually grow without support (e.g. Roma variety),

(2) Second are Vine type varieties (also called indeterminate cultivars such as Money maker) which need to be supported by stakes, and usually pruned to leave only one or two main stems.

Staking practice helps to avoid diseases by improving air circulation in the crop, and preventing plant parts and fruits from touching the soil. Tomatoes are usually grown in seedbeds and then transplanted when they have grown to a height of about 10 to 15cm. As with many crops, it is better sowing seeds thinly and to remove competing weeds to produce vigorous plants which are more likely to withstand pests and diseases.

- **Major insects' pests and Diseases on banana**

The banana production in Rwanda is found in highlands, above 1500 masl. Currently, the major threat of bananas in the basin in Rwanda is the banana bacterial wilt, which is spreading in all banana growing areas and its management does not require the use of pesticides. The second most important disease in the country is the Fusarium wilt (Fusarium oxysporum fs musae) which is soil borne disease and remain in the soil up to 30 years. It is not easily controlled by pesticides. It is very serious on exotic banana cultivars such Gros Michel etc. However, there are resistant new exotic cultivars under dissemination by MINAGRI and ISAR. The others pests of banana are not important; however, they require close monitoring since their severity is limited by temperature due to high altitude above 1400 masl. Basing on climate change threat which may adjust local climate, it is important to establish robust pests and disease monitoring. These pests include banana weevils (Cosmopolites sordidus), nematodes (like Pratylenchus goodeyi, Helicotylinchus multicinctus, and Radopholus similis and Meloidogyne spp.) and leaf spots (yellow sigatoka, black sigatoka and cladosporium etc) are not a threat because of altitude effect. These pests are threat below 1400 m above sea level, while major banana growing areas in Rwanda are above this altitude. Even if they occur, the use of pesticides is not economical.

- **Current major insects' pests and Diseases in beans**

The beans (Phaseolus vulgaris) are among the major crops produced in Rwanda. It is the major source of protein for majority of people (both urban and rural areas). Bean crop has many pests (insects and diseases) both in the field and in the store. Some diseases are seed born and are easily transmitted through infected seeds. The major insects pests and diseases attacking bean are as follows:

(i) Beans fly or bean stem maggot (Ophiomyia spp.)

(ii) Angula leaf spot (Phaeoisariopsis griseola)

(iii) Bean anthracnose (Colletotrichum lindamuthianum),

(iv) Common blight (Xanthomonas campestris pv phaseoli),

(v) Halo blight (Pseudomonas syringae pv phaseolicola),

(vi) Bean common mosaic virus. These diseases are seed born and are managed through clean seed or treated seed

(vii) Bean bruchid (Bruchid spp.) as storage pest

- **Major insects pests and diseases in coffee**

Coffee is an import cash crop for Rwanda. It is attacked by many pests (about 850); however, only few of them are major pests which needs control. They include coffee leaf rust (Hemilea vastatrix) and coffee berry disease.

Coffee leaf rust (Hemilea vastatrix): The coffee leaf rust causes damage on leaf, and as a result, it reduces photosynthetic capacity of infected leaves and causes premature defoliation or leaf drop associated with high infection levels. Vegetative growth and berry growth and size are reduced depending on the amount of rust in the current year. The impact of rust, however, can be long lasting. Leaf rust associated defoliation and the strong carbohydrate sink of the berries cause shoots and roots to starve and consequently to dieback, thereby reducing the number of nodes on which coffee will be produced next year. Since next year's production of coffee occurs on wood produced this season, the tip and shoot dieback caused by the rust can seriously reduce the following season's crop. On average, losses are believed to be about 15% annually.

Resistance varies with leaf age, particularly for susceptible varieties, young leaves being more susceptible than older leaves on the same plant. Plants with incomplete resistance, however, usually display the opposite response, with high resistance in young and low resistance in older leaves. Cultivars derived from Timor hybrid and the Icatu cultivar display this pattern (Eskes and da Costa, 1983; Eskes and Toma-Braghini, 1982). The important factors influencing leaf rust are planting density, host susceptibility, and predisposition of host due to high prior year yields. Disease severity is correlated with planting density and with berry yield. Generally, the lower the host density; the slower the rate of disease development. Rain plays the most important role in disease development. It provides moisture for spore germination and aids in dispersal. Seasonal variation in disease incidence is largely due to variation in rainfall patterns. Temperature also influences rust development. The lower limit for germination is 15 C.

Light intensity influences cultivar reactions. Leaves exposed to high light intensity are generally more susceptible to rust, varying up to 10 fold depending upon pre- and post-inoculation light intensity. Overbearing coffee may exacerbate rust intensity; leaves supporting rapidly growing coffee berries are more susceptible to infection than leaves that only support vegetative growth. High yielding coffee varieties are more susceptible than low yielding varieties.

Coffee berry disease (Colletotrichum coffeanum). The disease was first discovered in Kenya in 1920 and is caused by the virulent strain of Colletotrichum coffeanum. The fungus lives in the bark of the coffee tree and produces spores which attack the coffee cherries. Spraying has been determined to be the best way to avoid the coffee berry disease. Captafol and copper-based fungicides have been effective. The Kenyan coffee hybrid Ruiru 11 is resistant to both coffee berry disease and coffee leaf rust.

Where the virulent strains of CBD occur, serious losses have been reported. The loss of up to 80% has been reported. More conservative estimates of losses are 20%. Successful fungicide control programs frequently double or triple yields. Hedgerow planting and improved pruning practices to open the canopy improves fungicide penetration and coverage. The more open canopy is also less conducive to prolonged wetting and spore exudation and spread, resulting in lower CBD incidence.

Antestia Bug (*Antestiopsis spp.)*. The antestia bug is a major pest of coffee and there are different species of this bug throughout Africa. It attacks flowers buds, green berries, and growing tips of coffee. As they feed, they inject saliva containing the spores of the fungus *Ashbya*. This fungus is thought to cause the taste defect, i.e. marked "potato" (very similar to a freshly cut raw potato) or "green, pea/peasy" taste defect.

Content /Topic4: Determination of economic injury level

Economic injury level. The smallest number of insects (amount of injury) that will cause yield losses equal to the insect management costs.

EIL Calculation:

The EIL can be thought of as the break-even point between economic loss from the pest and the costs of managing the pest. Because economic conditions (e.g. commodity market value, management costs) fluctuate, the EIL will fluctuate. This can be illustrated by considering how a typical EIL is calculated.

The EIL equals the pest management costs (C) divided by the commodity market value (V) times the yield loss per pest (DI) times the proportion of the pest population controlled (K), or

EIL = C/(V x DI x K.)

If management costs (C) increase, then it takes more pests to justify control action, so the EIL increases.

Similarly, if market values (V) decrease, then more pests can be tolerated and again the EIL increases.

Or, if you can expect to get better than standard coverage when you spray, and therefore can expect to kill a higher percentage of the pest (K), then the EIL increases.

Anything that changes any of the EIL variables will change the EIL. The EIL can also be thought of as a "Tolerance index". That is, it indicates how many pests we can tolerate, given a specific set of costs, benefits, and plant response to injury. If the crop is of high value and/or susceptible to a particular pest injury, the EILs will tend to be low, indicating we can tolerate few pests before we incur economic damage.

If the crop is of lower value and/or tolerant of a particular pest injury, the EILs will tend to be high because we can tolerate a higher number of pests before incurring economic damage. Ideally, management action should be taken before a pest population reaches the EIL to avoid economic damage that could otherwise be prevented.

LO 1.3 – Proper recognition of plant species

- **Content/Topic 1: Groups of crops**

✓ **Vegetables**

- Leafy or stem vegetables:
- Artichokes
- Asparagus
- Cabbages
- Cauliflowers & broccoli
- Lettuce
- Spinach
- Fruit-bearing vegetables
- Cucumbers
- Eggplants (aubergines)
- Tomatoes
- Watermelons
- Cantaloupes and other melons
- Pumpkin, squash and gourds
- Root, bulb, or tuberous vegetables
- Carrots
- Garlic
- Onions (incl. shallots)
- Mushrooms and truffles

✓ **Fruits**

- Tropical and subtropical fruits:
- Avocados
- Bananas & plantains 2
- Dates
- Figs
- Mangoes
- Papayas
- Pineapples
- Citrus fruits
- Grapefruit & pomelo
- Lemons and Limes
- Oranges
- Tangerines, mandarins, clementine
- Grapes
- Berries
- Currants
- Gooseberries
- Kiwi fruit
- Raspberries
- Strawberries
- Nuts
- Almonds
- Cashew nuts
- Chestnuts
- Hazelnuts
- Pistachios
- Walnuts

✓ **Root/tuber crops with high starch or inulin content**

- Potatoes
- Sweet potatoes
- Cassava
- Yams

✓ **Leguminous crops**

- Beans
- Broad beans
- Chick peas
- Cow peas
- Lentils
- Lupins
- Peas
- Pigeon peas

✓ **Cereals**

- Wheat
- Maize
- Rice
- Sorghum
- Barley
- Rye
- Oats
- Millets

- **Content/Topic 2: Growth stage of crops**

✓ **Sprout**

Each seed contains a small parcel of nutrients that is all they need to germinate and begin growing their first pair of leaves.

✓ **Seedling**

As plants' roots develop and spread, a boost of quickly absorbed, well-balanced nutrients fuels the rapid growth from spindly seedling to healthy plant.

✓ **Vegetative**

Nitrogen is a key component of chlorophyll, the green pigment in plants, so it's the critical nutrient when their energy is focused on growing stalks and foliage.

✓ **Budding**

Phosphorus is in extra high demand at the start of a plant's' reproductive cycle, the transition from growing leaves to forming buds.

✓ **Flowering**

Potassium plays a primary role in producing and transporting the sugars and starches plants use up as they develop healthy flowers and fruit.

✓ **Ripening**

When flowers and fruit are verging on full maturity, they need a week or two of just water without nutrients, a process known as "flushing," so they can use up all of the nutrients they have already absorbed.

LO 1.4 – Proper recording of available information

- **Content/Topic 1: Soil borne pests and diseases**

Soil harbors a variety of disease causing organisms for both plants and animals. These include microorganisms (fungi, bacteria, actinomyces, phytoplasmas, protozoa and viruses), and larger soil organisms such as nematodes as well as insects (e.g. ants, aphids) and small animals (e.g. slugs, snails, rodents).Plant pathogens may also be spread from plant to plant via insect vectors or by soil animals such as nematodes.

By far the most damage is caused by fungal pathogens which are responsible for a wilts, root rots, club rot & blight. The life cycle for many fungal plant pathogens can be split between above ground on the leaves and shoots (phyllosphere) and below ground in the soil. Many live as saphrophytes, not causing disease, for part of their life cycle whilst others are totally obligate pathogens. Fungal pathogens can be differentiated on the basis of their action on

the host; they can either destroy the hosts' tissue (necrotrophs), such as damping-off caused by *Pythium*, live as parasites deriving some nutrient/energy from the host (e.g. downy mildew) for possibly long periods or, display properties of both (hemibiotrophs) such as apple scab.

Toxins may be produced by the pathogen as well as chemicals which regulate the hosts' metabolism. Bacteria often take advantage of damage such as wounds or natural openings such as stomata to gain entry into the hosts' tissues.

Some diseases cause swellings as a result of their infection to bring about distinct anatomical changes to the plant for example *Agrobacterium radiobacter* var. *tumefaciens*, a bacterial infection of sugar beet causes characteristic swellings to the root tissue brought on by the transfer of DNA from the invading bacterium to the host.

For some plant diseases, soil can be considered a reservoir for the disease organism with the organisms residing in the soil until the right opportunity arises. However, depending on their life cycle and biology, the time that they can survive in the soil without a suitable host may be limited from a few days to many years.

Soil conditions play an important part in plant disease affecting the survival of the pathogen, movement through the soil to a potential host or interaction with an antagonist. The amount of water can affect some disease organism more than others. Above ground, very humid conditions tend to promote infection promote downy mildew. Below ground, high levels of water due to poor drainage promote anaerobic conditions which deplete the amount of oxygen available thereby reducing root health leading to greater susceptibility to infection and also to greater movement of pathogen.

Content/Topic 2: Field suitability assessment and Selection of Crop options

The major factors to consider in crop selection include the following:

a. Prevailing farm conditions

An environmental scanning should first be conducted. This involves a thorough ocular inspection and other methods to obtain information on the biotic factors that can affect plant

growth and yield, soil and climatic conditions prevailing in the area, and accessibility. Here the guiding rule is: know your farm first then select the right crop.

The biotic factors refer to living organisms including ruminant animals, insect and other pests, disease pathogens and weeds, as well as organisms having beneficial effects like civet cat population for the production of *civet coffee* and the abundance of pollinators. Where there is prevalence of a disease in a locality, susceptible crops may be excluded or a resistant variety may be selected.

The topographic features of the land like elevation, slope, terrain and aspect (the direction that a sloping land faces); and the physical and chemical properties of the soil such as texture, color, organic matter content, pH and fertility levels will determine the crops that are naturally suited.

Also, the various climatic factors, such as prevailing climate type, temperature, rainfall, relative humidity, incidence of light, and frequency of typhoons will limit the choice of crops. A stable supply of water within the farm will allow wide possibilities in crop selection.

In addition, the accessibility of the farm to and from the market will influence the choice of crops. For example, cassava and oil palm should be preferably grown in farms with good roads and as close as possible to the market because the harvest is bulky and must be transported immediately due to rapid rate of degradation. Having a farm-to-market road is likewise important in stocking the farm with supplies.

b. **Resistance to pests and diseases**

Regardless of the purpose of farming, it is important to be able to select a crop and variety with wide resistance to important pests and diseases. The use of susceptible varieties may result to high cost of production or, worst, total crop failure.

c. **Available technology**

The technology for the growing of the crop must have been well established or easy to learn and apply. Likewise, certain crops are preferred because technical assistance is available locally.

d. Farming system

Crop selection is affected by the system of farming employed, that is, whether purely crop farming or integrated with livestock animals. Likewise, the particular crop species to be grown will depend on the crop production practices such as monoculture, multiple cropping, hedge row-strip cropping, and planting patterns.

Learning Unit 2 – Conduct sampling activity

LO 2.1 – Select sampling methods

Content/Topic 1: Sampling methods

1. Random sampling

Random sampling is a part of the sampling technique in which each sample has an equal probability of being chosen. A sample chosen randomly is meant to be an unbiased representation of the total population. If for some reasons, the sample does not represent the population, the variation is called a sampling error.

2. Systematic sampling

Is a type of probability sampling method in which sample members from a larger population are selected according to a random starting point but with a fixed, periodic interval. This interval, called the sampling interval, is calculated by dividing the population size by the desired sample size.

Despite the sample population being selected in advance, systematic sampling is still thought of as being random if the periodic interval is determined beforehand and the starting point is random.

LO 2.2 – Localize symptoms/signs

- **Content/Topic 1: Plant diseases diagnosis**

The process may vary with different diseases and conditions but the overall process is relatively consistent. The steps all require careful observations and questions.

- **The steps to conduct plant diagnosis**

a. Proper plant identification

Identification of affected plants is one of the first steps in diagnosing a plant disease. Both scientific and common names of the plant should be noted. Common names should not be relied upon since some distinctly different plant species may have the same common name, and the common name used in one area may be used for a completely different species in another area.

b. Recognize healthy plant appearance

It is important to know the normal appearance of the plant species you are investigating. Each plant species has special growth habits, colors and growth rates. If you do not know what to expect of the plant you cannot recognize when something is wrong. Does the plant normally have new foliage that is yellow or red and becomes darker green as the foliage ages? Many ornamental shrubs have been developed and marketed for the ornamental value of such brightly colored new growth. These plants are highly prized for this coloration; however, if an individual does not know that this coloration is the normal appearance of the plant, he/she may think that the plant is diseased.

It is important to know what the normal appearance of a plant is before you decide there is a problem. It is also important to remember that appearance can vary with different cultivars.

Some plant cultivars have naturally yellow to pale green leaves which at first glance appear to have symptoms of under-fertilization, root stress or soil pH problems.

c. Identify characteristic symptoms

Describing the characteristic symptoms exhibited by a specimen can be very difficult to do accurately. Because of this, it is often difficult, if not impossible, to determine what is wrong with a plant when a person is describing symptoms over the phone. As a test of this you may want to take a plant exhibiting symptoms and have three different individuals describe the symptoms that they observe on a sheet of paper. Next, compare the descriptions. Do the

descriptions vary significantly? Could you visualize the symptoms by the way any one of the individuals described the diseased plant? Symptoms can often be grouped as follows:

- ✓ **Underdevelopment of tissues or organs.** Examples include such symptoms as stunting of plants, shortened internodes, and inadequate development of roots, malformation of leaves, inadequate production of chlorophyll and other pigments, and failure of fruits and flowers to develop.
- ✓ **Overdevelopment of tissues or organs.** Examples include: galls on roots, stems, or leaves, witches' brooms, and profuse flowering.
- ✓ **Necrosis or death of plant parts.** These may be some of the most noticeable symptoms, especially when they affect the entire plant, such as wilts or diebacks. Other examples include shoot or leaf blights, leaf spots, and fruit rots.

d. Identify Plant Part Affected - Are symptoms associated with specific plant parts?

It is important to note if the symptoms observed are associated with specific plant parts. For example, is a wilt observed correlated with a disruption of the vascular system which may be indicated by browning of the vascular system or are the roots of the plants abnormal including rots, decreased feeder roots, etc.; are necrotic lesions observed strictly on younger leaves? The symptoms of some diseases are most commonly seen on specific plant parts and this observation can be important in diagnosis.

e. Laboratory Tests

Sometimes neither symptoms nor signs provide enough specific or characteristic information to decide the cause of an infectious plant disease. In such cases, it may be necessary to bring a sample back to the laboratory for further tests to isolate and identify the causal agent. This can be a time-consuming and labor-intensive process that takes specialized skills.

- **Difference between a healthy plant and abnormal plant**

Healthy plants grow strongly. The leaves are firm. Flowers, fruit and root systems are well formed. They have no signs of pests and diseases. Pests, diseases, and environmental factors can all affect the health of plants.

Unhealthy plants show these signs:

- ✓ Leaves wilt, curl or change color
- ✓ Stems and roots are stunted or dead
- ✓ Flowers and fruit are not well formed

Figure: Healthy tomato plant

Figure: Diseased tomato plant

Once the "normal" appearance of the specific plant is determined, several comparisons can be made between the problem plants and healthy plants.

Compare characteristics such as overall size, shape, and coloration; leaf shape, size, coloration, and distribution; root distribution and coloration; and bark, stem or trunk texture and coloration. It is also important to note normal events, such as leaf drop, that may occur in a healthy plant. For example, some holly species normally drop leaves in the spring.

The affected parts of the plants should also be noted. Are there symptoms on the roots, leaves, stems, flowers, or fruit? Is the entire plant involved? Is only one limb or side of a plant involved? Answers to these questions can assist in the identification of the problem.

- **Commonly observed symptoms and signs of some field crop diseases**
  - **a. Fungal leaf spots**

spots usually vary in size. Generally are round and occasionally elongate on stems. Zones of different color or texture may develop giving the spot a "bull's eye" effect. Spots are not limited by leaf veins.

Figure. Target spot lesion on tobacco caused by *Rhizoctonia solani* .

b. Bacterial leaf spots

spots are often angular due to limitation by leaf veins. Color is usually uniform and no signs of plant pathogen are evident. Tissue may appear initially as being water soaked but may become papery as it dries.

Figure. Bacterial leaf spot on greenleaf lettuce caused by *Xanthomonas campestris* pv. *vitians*.

c. Vein banding

Vein banding occurs when there is a band of yellow tissue along the larger veins of the leaf. This symptom is observed with viral diseases and is in contrast with nutrient deficiencies which may cause a dark green band along leaf veins.

Figure. Pea infected with Red clover vein mosaic virus exhibiting a vein chlorosis and banding.

d. Mosaic and Ring spot.

Mosaic and ring spot are used to describe an irregular patchwork of green and yellow areas over the surface of a leaf. In some cases leaves may also become distorted. Often these symptoms are associated with viral pathogens. There is not a sharp margin between the affected and healthy areas. Distinct margins may indicate a nutritional problem or genetic variegation.

Figure. Mosaic symptoms exhibited caused by Tomato spotted wilt virus on leaves of squash.

Figure. Peanut leaf with concentric ring spots

e. Leaf Distortion

Leaves of the infected plant may be distorted from their normal shape and size. Leaves may be elongated, smaller size, or thickened. This type of symptom can be associated with viral, fungal or bacterial infections as well as insect and mite infestations.

f. Powdery mildew

can affect leaves, stems, flowers and fruits with a white to gray surface coating of mycelia which can be rubbed off. Black specks may later develop in the mycelia. These specks are mature cleistothecia, the overwintering fungal structures which contain ascospores. Tissue may turn yellow, reddish or remain green under the mycelia and some leaf distortion may be observed especially on actively growing tissues.

Figure. Powdery mildew on apple blossom cluster caused by *Podospaera leucotricha*

g. Presence of Spores/Spore Structures

Several fungal diseases can be easily identified based on the presence of spores or spore structures on the leaf surface. Some examples of this are rusts which are often recognized by the rusty brown to black spores and smuts which are identified by the black spores which often replace the seed structure.

Figure. Stem rust on barley. Caused by *Puccinia graminis*.

h. Chemical spray or air pollutant injury

Spots associated with injury are relatively uniform in color and the interface between the affected and healthy area is usually sharp. Distribution on plant may be associated with where spray or pollutant comes in contact with the plant.

Figure. Injury of beans caused by drift of the herbicide

i. Cankers

Cankers are localized necrotic lesions which are often sunken in appearance. Cankers can result from mechanical injury (e.g. trees which have been damaged by collisions with cars or lawnmowers), and various fungi or bacteria. In the spring, ooze may be observed on the surface of bacterial cankers and fruiting bodies may be observed on the surface of fungal cankers.

Figure. Canker on apple caused by *Nectria galligena*.

j. Fruit Decays and Rots

Various fungi and bacteria can cause rots of fruit. These are often distinguished by the color, lack of firmness of tissue, and signs of spores or fruiting bodies.

Figure. Brown rot of peach caused by *Monilinia fructicola*

k. Fruit Discoloration

Discoloration of fruit is often associated with viral infections (Figure 19). This discoloration may be similar to mosaic and ringspot symptoms observed on leaves.

Figure . Mosaic symptoms on yellow crookneck squash. Normal appearance is completely yellow fruit.

Figure Ringspot symptoms on peach fruit due to Plum pox virus.

l. Wilts.

Wilts are characterized by a general loss of turgidity of leaves or possibly entire plants due to the loss of water. The loss is most often caused by a blocking of the water flow through the xylem.

This blockage can be caused by the presence of various bacteria (*Erwinia, Ralstonia*) and fungi (*Fusarium, Verticillium*) in the xylem. Wilts may also be observed when there is a destruction of the root system due to nematodes or root-rotting fungi (*Armillaria, Phytophthora, Pythium*) or an acute water shortage in the soil.

Figure. Verticillium wilt of cucumber caused by *Verticillium dahliae*.

m. Shoot dieback or blights

Sudden dieback of a shoot usually indicates climatic or chemical injury rather than parasitic problems.

If the line between affected and healthy bark is sharp, a soil chemical should be suspected. If dieback is somewhat more gradual and there is a cracking or splitting of the bark and wood, cold injury should be suspected along with bacterial blights caused by *Pseudomonas* or *Erwinia*.

Figure. Shoot growth of apple with fire blight, *Erwinia amylovora*, showing typical shepherd's-crook at the tip of the shoot.

n. Overall Stunting or Decline

These symptoms can be caused by several very different factors. Systemic viral infections can result in stunting or decline, but such viral infections are often accompanied by other aboveground symptoms such as shortened internodes. In many cases, overall stunting of a plant may be due to problems associated with the root system.

Figure. Healthy 'Mandalay' chrysanthemum (left) and plant infected with *Fusarium oxysporum* f. sp. *chrysanthemi* (right) which exhibits stunting without other observable symptoms.

o. Damping-off

This term describes the rapid death and collapse of young seedlings. Often the seedlings will appear to be almost broken at the soil line.

It may be observed in flats of plants begun in greenhouses and can result from infection of the seedlings by the fungal organisms *Fusarium, Phytophthora, Pythium, Rhizoctonia*, or *Thielaviopsis.*

Figure . Soybean seedlings exhibiting symptoms of Pythium damping-off. Note thinning and browning of stem growth near the soil line.

Figure. Damping-off of vinca (Catharanthus roseus) due to Rhizoctonia solani.

LO 2.3 – Procedure sampling

- **Content/Topic 1: Plant sampling for Pets and Disease identification**

When investigating a potential plant disease problem, good observational and detective skills are necessary. The sample should be fresh material with several examples of visual symptoms expressed from healthy to infected tissue.

Examples of observations a collector should make include:

- ✓ pattern of disease in the crop;
- ✓ frequency of the disease symptoms; and
- ✓ Inspect the interior of roots and stems to identify if internal symptoms exist.

A. Procedure for Sample Collection, Packaging and Submission

The following procedures for obtaining, packaging and submitting the sample are suggested.

1. Obtain a fresh sample with several examples ranging from healthy to infected tissue.
2. Include as much of the plant as is practical, especially the root system. Place root system in a separate plastic bag to avoid drying out and soil contaminating the leaves.
3. A leaf and potato tuber sample should be large enough to give a good indication of the problem: approximately 10 to 20 leaves of tubers.
4. Place samples in appropriate bags: tubers in paper bags and leaf tissue in plastic bags with a moist paper towel and air.
5. Keep samples cool and moist, protected from crushing, freezing and heat.
6. Label the sample with the pertinent information required.
    a. Name of Grower
    b. Date of Collection
    c. Variety
    d. Statement of Problem
    e. Growers' Telephone Number

B. Information required to submit the sample

Background Information

1. Identify the crop, variety and any information on management practices that may have adversely affected the plant; for example fertilizer rates, pesticides applied.
2. Identify environmental conditions preceding and during disease development: temperature, humidity, ventilation.

3. Note the rate of disease development, coincident with any treatment or environmental event.

Notice: A concise, accurate plant diagnosis can only be completed when a fresh, representative sample of the disease problem is submitted to the laboratory.

C. Time and place to submit samples

Samples can be submitted at the Plant Health Lab

Learning Unit 3 – Perform visual characterization of plant pests and diseases

LO 3.1 – Differentiate causal agent

Content/Topic 1: Source of Plant pathogens

A. BIOTIC FACTORS

Plant problems are caused by living organisms either micro-organisms or macro-organisms.

- **Micro-organisms**
  - **a. Fungi**

Fungi are the most common causal agent of plant disease. These microscopic organisms lack chlorophyll and are visible as mats of threadlike filaments called hypha that make up the mycelium, which are "resting structures" that include rhizomorphs and sclerotia. Many fungi reproduce by spores and produce conspicuous fruiting bodies that can aid in identification. These fruiting bodies are called the signs of the pathogen.

  - **b. Bacteria**

Bacteria are single-celled organisms that lack chlorophyll and reproduce by cell division. Bacterial cells often multiply quickly and clump together to form colonies.

  - **c. Viruses**

Virus particles consist of a small amount of genetic material within a protective protein coat called a capsid. Viruses are so small that individual particles cannot be seen with a common

light microscope. When a plant cell becomes infected with a virus, that cell replicates new viral particles that prevent normal plant cell function.

- **Macro-organisms**
  a) Nematodes
  b) Insects
  c) Mites
  d) Animals

B. ABIOTIC/ENVIRONMENTAL FACTORS

Abiotic disorders are caused by nonliving factors, such as drought stress, sunscald, freeze injury, wind injury, chemical injury, nutrient deficiency, or improper cultural practices, such as overwatering or planting conditions.

Various environmental factors can be divided into following two groups:

- **Climatic Factors**

These are related to the aerial environment of the organisms e.g. light, precipitation, temperature, atmospheric humidity, wind and air.

- **Edaphic Factors**

They include the factors related to the soil. E.g. soil composition, organic matter, soil water, soil air, soil organisms and pH.

C. TYPES OF PESTS

1) Insect

These are important and major pests. Insects have three pairs of legs, two pairs of wings, segmented body and characteristic compound eyes and antennae. Insects are tricky and cause damage in different ways viz. sucking (suckers) sap from plants, biting (Biters) plant parts, boring in to fruits, twigs and leaves, attacking roots, barks and blossoms etc. The damaging stages of different insect pests are larvae, adults and nymphs.

- **Chewing and biting pests**

Chewing and biting pests bite into and chew the leaves, stems, buds, flowers, and even the roots of plants. Damage caused by these insects includes holes in the leaves or stems; semicircular holes along the edges of the leaves; discoloration on the surface or the edges of the foliage and flower petal; severed stems and leaves; and plant wilting.

The caterpillars of some of these pests are very destructive and difficult to control for a number of reasons including the development of resistance to chemicals, rapid population increases, and the practical difficulties of achieving complete spray coverage in some at-risk crops (e.g. sweet corn, Brassica vegetables, and lettuce).

Examples include:

Chewing and biting pests include Helicoverpa and diamondback moth (DBM), caterpillars, beetles, and slugs and snails.

- **Sucking Insects**

✓ The mouthparts of sucking insects are developed for piercing and sucking. These pests damage plants by inserting their mouthparts into plant tissue and removing juices. Heavily infested plants become yellow, wilted, deformed or stunted, and may eventually die. Some sucking insects inject toxic materials into the plant while feeding, and some transmit disease organisms. The following are some examples of sucking insects:

✓ **Aphids:** Often called plant lice, are small, soft-bodied insects. They range in color from black to green to yellow. Their numbers may greatly increase in a short time. They may cover the entire surface of a leaf or stem. They can be vectors of viruses. Encourage natural predators, such as ladybird beetles or lacewing larvae. Lacewing eggs can be purchased from seed companies.

These eggs soon hatch and give good aphid control. Aphids can be washed off plants with a garden hose. Insecticidal soap or Malathion can be used to control aphids.

✓ **Leafhoppers:** Leafhoppers are small, green, wedgeshaped insects that attack many garden, forage and fruit crops. They suck out plant juices causing yellowing, leaf-curling and stunting. They also transmit several disease organisms, especially associated with yellows. Use pyrethrins or carbaryl (Sevin) as a control.

- ✓ **Stink bugs:** These bugs feed on the fruit of a wide range of plants including beets, beans, pears, squash, tomatoes and corn, causing the fruit to become shriveled and deformed. The most common species attacking home gardens are the green stink bug and the brown stink bug. Hand-picking may lower number sufficiently for damage control. To control, use pyrethrins or carbaryl (Sevin).
- ✓ **Tarnished plant bugs:** Tarnished plant bugs feed on the leaves of many plants, causing them to curl, reducing growth, and transmiting diseases. These pests also deform apples and cause corky, deformed strawberries. To control, use pyrethrins or Malathion.
- ✓ **Squash bugs:** Mature squash bugs are about an inch long and are gray-black in color. While still immature, they are strikingly colored with white and black. Squash bugs suck juice from the leaves and stems of squash, pumpkins, melons and related plants, and thus spread disease. Hand-picking may be effective. Leaving boards or shingles out overnight between the rows of cucurbits is a way to "harvest" squash bugs. The bugs tend to use the boards and shingles for cover. They can easily be gathered and disposed of early in the morning. Eggs can be scraped off the foliage with your thumbnail. Insecticide options include insecticidal soap or carbaryl (Sevin).
- ✓ **Thrips:** Thrips are minute insects that feed on pollen and tender plant tissue. They typically hide in the cracks and crevices of leaf buds, junctures, and flowers. They rasp the tissue and suck up the exuding sap. The leaves take on a silvery appearance after the thrips feed, and plants become stunted and deformed. Thrips are usually a pest of seedling plants but may attack plants in any stage, especially gladiolus, onions and blueberries. Neem, horticultural oil, spinosad and pyrethrins are options for thrips management.
- ✓ **Spider mites:** Spider mites are not insects, but are closely related to ticks. They suck out juices from leaves and stems, causing plants to become deformed or have a bronze or yellow appearance. Hot and dry weather favors their development. Heavy infestations can cause leaf and flower bud drop and death of the plant. Use insecticidal soap to control spider mites.

These are creatures like insect but have soft body and four pairs of legs. These tiny creatures have red or pale yellow color. They suck the sap from the plant and attack the crops in huge number.

- **Boring pets**
  - ✓ Lesser cornstalk borer

The larvae of lesser cornstalk borers (Elasmopalpus lignosellus) attack roots and bore into the stems of young plants of peanuts, corn, sorghum, and other crops.

Figure: Lesser cornstalk borer

- ✓ Sugarcane rootstock weevil

The sugarcane rootstock weevil, Apinocis (Anacentrinus) deplanatus, infests sorghum sporadically, especially during dry years. Adult weevils feed on young sorghum plants and create pinpoint holes in the leaves. The larvae cause the most damage as they tunnel into the sorghum stalk just above or below the soil surface. The larvae are often found at nodes and near the outer surfaces of the stalk.

- ✓ Other borers

The sugarcane borer (Diatraea saccharalis), southwestern corn borer (Diatraea grandiosella), European corn borer, (Ostrina nubilalis), Mexican rice borer (Eoreuma loftini), and neotropical borer (Diatraea lineolata) are closely related insects that tunnel in the stalks of sorghum, corn, and other crops.

- **Nematodes**

A number of genera and species of nematodes are highly damaging to a great range of hosts, including foliage plants, agronomic and vegetable crops, fruit and nut trees, turfgrass, and forest trees. Some of the most damaging nematodes are: Root knot (Meloidogyne spp.); Cyst (Heterodera and Globodera spp.); Root lesion (Pratylenchus spp.); Spiral (Helicotylenchus spp.); Burrowing (Radopholus similis); Bulb and stem (Ditylenchus dipsaci); Reniform (Rotylenchulus reniformis); Dagger (Xiphinema spp.); Bud and leaf (Aphelenchoides spp.); and Pine Wilt Disease (Bursaphelenchus xylophilus).

4) Rodents

This group of pest eat away large amount of human food and also damage the crops on large scale. They are also responsible for heavy loss to stored grains on farms, in warehouses and houses.

Figure: Mouse

5) Animals

Animals like Wild Boar, Deer, Elephants, Wild Buffalo, Jackals, Monkeys, Squirrels cause direct damage to crop plants. They eat away the plants and by and large they waste huge amount of crops.

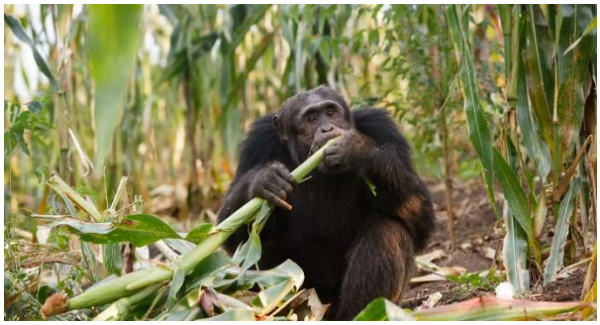


Figure: Monkey in maize field

6) Birds

Birds attack the crop plants for eating flowers and grains. Crow, Parrots and Sparrows are major among birds that attack the crops.

Figure: Maize bird's invasion

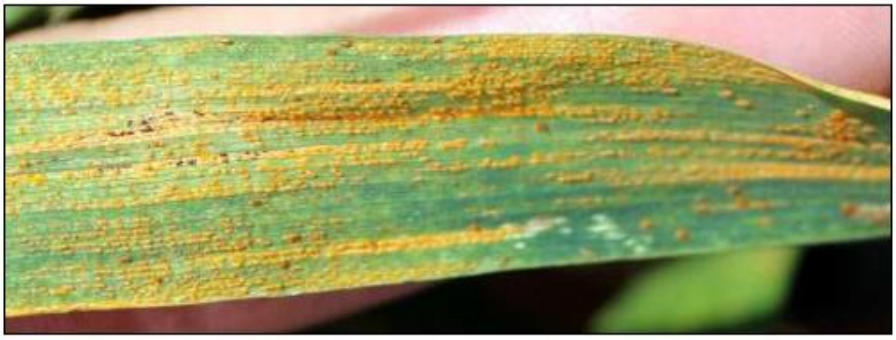
LO 3.2 – Describe symptoms of plant diseases pathogens

- **Content/Topic 1: Symptoms of some biotic pathogens**

A. Fungal Diseases

✓ **Fungal disease symptoms**

- Birds-eye spot on berries (anthracnose)
- Damping off of seedlings (phytophthora)
- Leaf spot (septoria brown spot)
- Chlorosis (yellowing of leaves)



B. Bacterial Diseases

Bacterial disease symptoms

- ✓ Leaf spot with yellow halo
- ✓ Fruit spot
- ✓ Canker
- ✓ Crown gall
- ✓ Sheperd's crook stem ends on woody plants

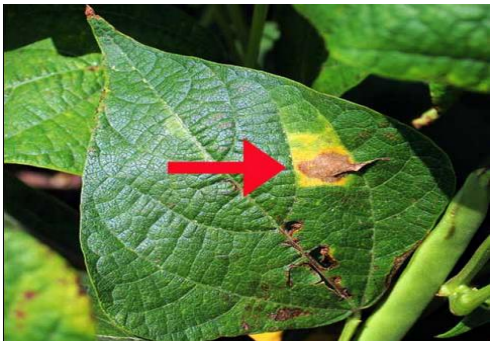


Figure: Dark red kidney bean leaf showing bacterial leaf spot symptom (brown leaf spot with yellow halo).

C. Viral Diseases

Viral disease symptoms

- ✓ Mosaic leaf pattern
- ✓ Crinkled leaves
- ✓ Yellowed leaves
- ✓ Plant stunting

Content/Topic 2: Symptoms of some abiotic factors

- **Plant physiological disorders**

a. Nitrogen deficiency

The typical symptom of nitrogen deficiency is the plant turns pale green; a 'V' shaped yellow coloration on leaves. This pattern starts from leaf end to leaf collar. The symptom begins from lower to upper leaves.

b. Potassium deficiency

the leaf margins turn yellow and brown coloration which appears like firing or drying. The symptoms progress from lower leaves to upper leaves.

c. Sulfur deficiency

Symptom appears on younger leaves where we will see yellow color striping or interveinal chlorosis.


d. Blossom end rot

Symptoms

Small water-soaked spots at the bottom end of the fruit which enlarge overtime into large blackish -brown sunken water - soaked areas. This is caused by a physiological disorder as a result of uneven levels for water application combined with a lack of calcium in the soil.

Content/Topic 3: Symptoms of some biotic pathogens

1. Aphids

✓ **Symptoms**

Heavy infestations can result in curled leaves and stunted plants; corn leaf aphids are blue-green in color, peach aphids are green-yellow in color; aphids may transmit viruses when feeding.

Infestation of corn leaf aphids

Aphids on maize tassel

2. Corn earworm

✓ **Symptoms**

Feeding damage to leaves, tassel and leaf; preferred feeding site is the ear and insect produces extensive excrement at the tip of the ear.

3. Cutworms (Black cutworm)

✓ **Symptoms**

Stems of young transplants or seedlings may be cut off at soil line; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris; larvae may exhibit a variety of patterns and coloration but will usually curl up into a C-shape when disturbed.


4. **Fall armyworms**

✓ **Symptoms**

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance.

5. **Flea beetles**

✓ **Symptoms**

Small holes in leaves that give the foliage a characteristic “shot hole” appearance; young plants and seedlings are particularly susceptible; plant growth may be reduced; if damage is severe the plant may be killed.

corn flea beetle feeding on leaf

corn flea beetle (Chaetocnema pulicaria) adult

6. Thrips

✓ **Symptoms**

If population is high leaves and may be distorted; edges of leaves may dry up and are speckled with black feces

7. Nematodes: Root knot nematode

✓ **Symptoms**

Below ground we can see galls on the roots due to female nematode feeding. Above ground the plants are stunted, yellow. Severely infested plant may die before harvest.

8. Mites: Spider mites

✓ **Symptoms**

Leaves may appear bronzed; webbing on underside of leaves; small kernel size; mites may be visible as very small moving dots on the webs or underside of leaves, best viewed using a hand lens; usually not spotted until there are visible symptoms on the plant; leaves turn yellow and may drop from plant.

9. Leaf miners

These are tiny yellow maggots that tunnel between the leaf surfaces.

✓ **Symptoms**

- Damage done by their feeding habits, which leave irregular trails on the leaves
- Yellowing and dropping of leaves
- Loss in yield

Figure: Leaf miner on tomato leaf

10. Rodents

✓ **Symptoms**

- Missing germinating seeds
- Missing hills
- Chopped young seedlings
- Missing plants
- Irregular cuttings of stem
- Chewed developing buds or ripening grains
- Tillers cut near base at 45° angle
- Retillering of stems
- Delayed grain maturity
- Missing grains
- Missing panicles

11. Animals

Animals can destroy crops through injuring or eating the leaves, fruits, stem and flowers.

12. Birds

Most of the time the birds destroy the flowers. In this case the yield is reduced due to the lack of pollination. The grains also can be eaten or destroyed.

13. White flies

✓ **Symptoms**

- Production of honey dew (and the growing of sooty mold on it);
- Chlorotic spotting and chlorosis of leaves; and /or
- The spotting of fruit, and the stunting and wilting of plants.

Figure: White flies on tomato leaf

LO 3.3 – Proper reporting and recommendation

- **Content/Topic 1: Phytopathological form**

Plant pathological form is a form used to study diseases in plants caused by pathogens (infectious organisms) and environmental conditions (physiological factors). Organisms that cause infectious disease include fungi, oomycetes, bacteria, viruses, viroids, virus-like organisms, phytoplasmas, protozoa, nematodes and parasitic plants. Not included are ectoparasites like insects, mites, vertebrate, or other pests that affect plant health by eating of plant tissues.

Plant pathological form Parts and filling

Phytopathological form contain the following parts and is filled according to the parts it has and pathogen to be studied.

- ✓ Date of Sighting
- ✓ Name of Suspected Pest/disease
- ✓ Client Information
- ✓ Submitter information
- ✓ Specimen Information and Additional Comments

Lab Specimen No. _____

Specimen Information Form

Plant Disease Clinic, Department of Plant Pathology

Please Complete All Sections of this Form

220 Buckhout Lab
University Park, PA 16802

Client Information

Name _____

Address _____

City, State, Zip _____ County _____

Phone _____ E-Mail _____

Submitter information

- ☐ Cooperative Extension Office for Commercial Grower/Company
- ☐ Cooperative Extension Office for Homeowner
- ☐ Homeowner
- ☐ Commercial Grower/Company
- ☐ Certified Organic

Specimen Information

Plant _____ **Variety** _____ **Date Collected** _____

Describe the problem and explain what concerns you:

_____

_____

_____

Plant Part Affected

- ☐ Leaves
- ☐ Roots
- ☐ Stems, branches
- ☐ Flowers

Symptoms

- ☐ Yellowing: ☐ Interveinal ☐ General ☐ Marginal
- ☐ Browning: ☐ Interveinal ☐ General ☐ Marginal
- ☐ Wilting ☐ Distortion ☐ Mottling ☐ Leaf Spots
- ☐ Other _____

Type of Planting

- ☐ Garden ☐ Nursery
- ☐ Yard ☐ Orchard
- ☐ Indoor/house ☐ Plantation
- ☐ Field ☐ Vineyard
- ☐ Forest ☐ Golf course
- ☐ Greenhouse ☐ High Tunnel
- ☐ Other _____

Disease Distribution

- ☐ General ☐ High areas
- ☐ Scattered plants ☐ Low areas
- ☐ Dry areas ☐ Foundation
- ☐ Wet areas ☐ Next to drive or road
- ☐ Shaded areas ☐ Near vents/fans
- ☐ Sunny areas ☐ End/Edge of planting
- ☐ Other _____

Soil Type

- ☐ Sandy
- ☐ Clay
- ☐ Loam

Soil Moisture

- ☐ Excessive
- ☐ Adequate
- ☐ Deficient

Drainage

- ☐ Good
- ☐ Moderate
- ☐ Poor

Terrain

- ☐ Sloped
- ☐ Level
- ☐ Low

When did the symptoms first appear? _____

Has the problem occurred before? _____ **When?** _____

Size of Planting _____ Acres
_____ Number of plants

Extent of Problem
_____ Percentage of plants affected *or*
_____ Number of plants affected

Previous Crop (name): _____

Trees/Shrubs: Approximate age: _____ Height: _____
How long has the plant been growing in the present site? _____

Treatments Applied This Season and Previous Year: (Fertilizer, Fungicide, Insecticide, Herbicide, Other)

Material	Rate	Date applied	Material	Rate	Date applied

Disturbances

☐ High winds ☐ Excavation, _____ ft away ☐ Other _____
☐ Hail recently ☐ Construction nearby
☐ Frost ☐ Gas or sewer lines ☐ None

Turfgrass: If sample is turfgrass, please describe the infection center:

☐ Grass killed ☐ No distinct pattern; irregular areas
☐ Grass thinned ☐ Definite pattern to affected areas:
☐ Circular areas Size _____
Size of affected area: _____ ☐ Rings Size _____

Greenhouse Specimens: If sample is a greenhouse specimen, please complete the following:

☐ Raised beds Heating system: _____
☐ Ground beds Irrigation system: _____
☐ Pots or containers Soil mixture: _____
☐ Growth regulators applied (list materials and date): _____
☐ Fertilizer used (list type and analysis):
Fertilizer application technique:
☐ soil incorporation ☐ foliar spray ☐ dry on surface ☐ liquid on surface
Temperature in production area: Days: _____ to _____°F Nights: _____ to _____°F

Additional Comments:

Diagnostic Lab Use Only:
Sample Condition Information Received Photo or digital image

Figure: An example of Phytopathological form

Content/Topic 2: Report writing

A. Introduction

An introduction section should explain the background, objectives and why the study is necessary to be conducted.

B. Development

This section should discuss:

- ✓ The signs and symptoms of present pathogens/records done on daily basis
- ✓ The methodologies used to fight against plant pests and diseases
- ✓ The skills of concerned technicians to diagnose the infected crops
- ✓ Photos of taken samples
- ✓ Infection rate
- ✓ Sampling methods
- ✓ Measure taken to reduce the rate of infestation
- ✓ Crops grown in the farm
- ✓ The status of the surrounding environment

C. Conclusion and recommendations

This section includes:

- ✓ The sustainable proposed solutions to handle the issue
- ✓ Future planning/Introduction of new technology

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