GreenEMPIRE

"We plant seeds of SUCCESS"

Licensure Examination in Agriculture Reviewer

(Lecture Manual and Review Questions)

CROP PROTECTION

Green Empire PH is an online support group providing basic knowledge in agriculture especially to those who are planning to take the Licensure Examination in Agriculture in the Philippines.

Interact with the team and get more updates via our official FACEBOOOK PAGE: *www.facebook.com/greenempireph* and TWITTER: ***@greenempireph***

GEKNOWLEDGEBANK

Link*: www.facebook.com/GEKnowledgeBank*

This is where GreenEmpire PH provides FREE and relevant review questions, topics, and study tips. Feel free to join our discussion, share your ideas and meet other examinees!

SUPPORT TEAM Basic Information:

Marcial S. Buladaco

Top 1 (87.17%) LEA 2014
BS Agriculture, University of the Philippines Los Baños
Univ. Research Associate at Agricultural Systems Cluster, UPLB
Contact details: msbuladaco@up.edu.ph; 09177034344

Maluz A. Belarma

cum laude
BS Agriculture, University of the Philippines Los Baños
Univ. Research Associate at University of the Philippines Los Baños
President, Handog-Aral Inc.
Contact Details: luzzybsoils@gmail.com; 09084979142

Michelle Ann M. Calubaquib

BS Agricultural Chemistry, University of the Philippines Los Baños
MS Soil Science, University of the Philippines Los Baños
Univ. Researcher at University of the Philippines Los Baños
Contact Details: mitch_calubaquib@yahoo.com; 09178930602

Lovely R. Luar

BS Agriculture, University of the Philippines Los Baños
Researcher at International Plant Nutrition Institute (IPNI)
Contact Details: lovely_luar@yahoo.com; 09269959075

Ma. Theresa V. Velasco

magna cum laude
BS Agriculture, University of the Philippines Los Baños
Researcher at International Rice Research Institute (IRRI)
Contact Details: t.velasco@irri.org; 09082932920

CROP PROTECTION

I. Plant pathology
- A. Etymology
- B. Definition
- C. The science and art of plant pathology
- D. Objective
- E. Economic importance
- F. Types of crop losses

II.

lant diseases
- A.

  oncepts of plant disease
- B. Classification of plant diseases
  - i. According to affected plant organ
  - ii. According to symptom
  - iii. According to type of affected plant
  - iv. According to type of causal pathogen
- C.

  ommon terms in plant pathology
- D. The Disease Triangle

III. Plant disease diagnosis
- A. Symptoms of plant diseases
  - i. Primary vs. Secondary Symptoms
  - ii. Localized vs. Systemic Symptoms
  - iii. Histological or Morphological Symptoms
  - iv. General classification of symptoms
  - v. Symptoms and Diseases
- B. Signs of Plant Diseases
  - i. 3 General Categories of Signs
    - (1) Vegetative structures
    - (2) Reproductive structures
    - (3) Disease products
- C. Koch's rules of proof of pathogenicity

IV. Non-parasitic agents of plant diseases: Abiotic diseases

V. Parasitic or biotic agents of plant diseases
- A. Virus
  - i. Virus characteristics
  - ii. Common symptoms of viral infection
  - iii. Entry into plants
  - iv. Means of transmission
  - v. Virus-vector relationship

P
- vi. Methods of identifying viruses
- vii. Control of virus diseases

C
- B. Viroids
  - i. Viroid characteristics
  - ii. Symptoms of viroid-infected plants
  - iii. Transmission and spread of viroids
  - iv. Control of viroids
- C. Bacteria
  - i. General characteristics

C
- ii. Characteristics of plant pathogenic bacteria
- iii. Genera and species of plant pathogenic bacteria
- iv. Symptoms caused by bacteria
- v. Control of bacterial diseases

- D. Mollicutes
  - i. Mollicutes characteristics
  - ii. Class Mollicutes
  - iii. Transmission
  - iv. Diseases caused by mollicutes
  - v. Management of diseases caused by mollicutes
- E. Fastidious vascular bacteria
  - i. FVB characteristics
  - ii. Important diseases caused by fastidious vascular bacteria
- F. Plant pathogenic protists

i. Protozoa-like protists
ii. Fungal-like protists

G. Nematodes
i. Nematode characteristics
ii. Nematode biology
iii. Groups of plant parasitic nematodes
iv. Stylet
v. Sampling theories
vi. Extraction techniques
vii. nematode diseases important in the Philippines

H. Fungi
i. Characteristics
ii. The four phyla with plant pathogens
iii. The imperfect fungi
iv. Fungicides

I. Parasitic higher plants

VI. Variability in plant pathogens
A. General concepts
B. Mechanisms of variation
i. Sources of variation in the fungi
ii. Sources of variation in bacteria
iii. Sources of variation in nematodes
iv. Sources of variation in other pathogens
C. Genetics of host-parasite interactions

VII. Disease cycle
A. Inoculation
B. Dissemination of inocula
C. Penetration or ingress
D. Infection
E. Colonization/invasion
F. Incubation
G. Survival

VIII. Mechanisms of pathogenicity and host response
A. Malfunctioning of the normal physiology
B. Hormones associated with plant diseases
C. Enzymes associated in plant diseases
D. Toxins in plant diseases
E. Non-host specific fungal toxins

IX. Mechanisms of disease resistance
A. Pre-formed resistance
B. Induced resistance

X. Epidemiology of plant disease
A. Terminology
B. Elements of an epidemic
C. Factors that affect the development of epidemics
D. Analysis of epidemics

XI. Principles and methods of plant disease control
A. Exclusion
B. Eradication
C. Protection
D. Resistance/immunization

XII. Rodents
A. Classification of rodents
B. Rodent pests in the Philippines
C. Food and feeding behavior
D. Population growth
E. Agricultural and domestic pests
F. Human disease carrier (60 diseases)
G. Ecological importance
H. Social importance
I. Rodent management

XIII. Mollusk as pest
A. Economic Importance
B. Feeding Habits
C. Biology and Life Cycle
D. Management of Golden Apple Snail

XIV. Weed science
A. Definition of a weed

B. Characteristics of a weed
C. Classification of weeds
   i. Based on outward appearance or gross morphology
   ii. Based on maturity period or life cycle
   iii. Based on manner of reproduction
   iv. Based on habit of stem growth
   v. Based on habitat or place for preferred growth
   vi. Based on the inflorescence or floral structure of the plant

XV. Crop and Weed Competition

A. Seed germination
B. Seedling growth and development
   i. Factors affecting seedling growth and development
      (1) Soil factors
      (2) Light
      (3) Adaptation to growing condition
      (4) Competitive power of the weed
C. Allelopathy
D. Dormancy
   i. Mechanisms of dormancy
   ii. Ways of breaking dormancy
E. Methods and techniques in weed management
   i. Preventive methods
   ii. Physical/cultural methods
   iii. Biological control
   iv. Chemical control

XVI. Principles of Entomology

A. Distinguishing characteristics of insects
   i. Body wall
   ii. Head
   iii. Mouthparts
   iv. Antennae
   v. Eyes
   vi. Thorax
   vii. Legs
   viii. Wings
   ix. Abdomen
B. Classification, Nomenclature and Identification of Insect
   i. The Class Insecta
   ii. Distinguishing insect orders
C. Insect metamorphosis
   i. Types of metamorphosis
   ii. Stages in metamorphosis
D. Reproduction in insects

XVII. The Concept of Pest

A. Pest Classification
   i. Based on origin
   ii. Based on abundance or number
   iii. Based on feeding habit
B. Insect pest control management
   i. Nature of insect damage
   ii. Integrated Pest Management (IPM)
   iii. Insecticides

XVIII. Pesticides calculation and calibration of application equipment

A. Calibration of Application Equipment
B. Pesticide calculations

CROP PROTECTION

I. PLANT PATHOLOGY

A. <u>Etymology</u>: Greek
"pathos"- suffering
"logos"- to study

B. <u>Definition</u>: Plant pathology or phytopathology
- It is the study of the organisms and of the environmental factors that cause disease in plants; of the mechanisms by which these factors induce disease in plants; and of the methods of preventing or controlling disease and reducing the damage it causes.

C. <u>The science and art of plant pathology</u>:
As a science
- It looks into the characteristics of diseases, their causes, plant-pathogen interactions, factors affecting disease development in individual plants and in populations, and the various means of controlling diseases.

As an art
- It deals with the application of the knowledge gained from studying the science.
    1. Diagnosis or recognition of particular a diseases
    2. Disease assessment and forecasting
    3. Control measures

D. <u>The raison d'etre or ultimate objective of plant pathology</u>:
- to prevent or minimize plant diseases not only to increase food production but also to maintain the quantity and quality of the harvested fresh commodity until it reaches the consumer

E. <u>The economic importance of plant diseases:</u>
Plant disease epidemics have caused human sufferings, deaths and upheavals.
- *potato late blight disease (1845-1846)*
    - Caused famine and death of more than a million people in Ireland
- *coffee rust in Ceylon (now Sri Lanka)*
    - Destroyed vast coffee plantations; tea was planted instead
- *ergot poisoning in Europe (875 AD)*
    - Acquired from eating bread made from infected rye grains; caused by the fungus *Caviceps purpurea which* produces sclerotia containing alkaloids that impede blood circulation

Diseases cause enormous economic losses.
- The following are examples of plant diseases in the Philippines that have caused enormous economic losses:
    a. *Cadang-cadang disease of coconut* - 1st observed in 1918; have caused the country a loss of over $200M
    b. *Downy mildew of corn* - the nemesis of corn
        - Loss can be as high as 95% amounting to over P170M annually
        - Now controlled by chemical seed treatment using metalaxy; discovered in 1978
        - Caused by the fungus *Peronosclerospora philippinensis* (weston) shaw
    c. *Rice tungro disease* - affected 70,000 has in 1971; 1.22 M cavans rough rice lost valued at P30,357,000
    d. *Coffee rust* – Destroyed the coffee industry in Batangas province

e. *Citrus decline* – Destroyed coffee plantations in Batangas

F. Types of crop losses:

- Reduction in yield
  - Leaf spots/blights reduce photosynthetic capacity of plants
  - Root pathogens
  - Fruit rots and fruit spots - reduce quantity of harvestable and marketable fruits
- Losses from deterioration during storage, marketing or transport
  - The amount of food lost daily is enough to feed the world's population.
- Reduction in quality of produce
  - Citrus fruits with scabs
  - Moldy cereals and other commodities
  - Reduced strength and undesirable discoloration in wood pulp
  - Poor germination of infected seeds
- Losses from produce contaminated with toxins that cause various disorders and/or death to animals including man
  - Aflatoxin : produced by *Aspergillus flavus; c*arcinogenic to animals and man; commonly found in stored corn, sorghum, copra, root crops etc.
  - Ochratoxin: a mycotoxin produced by *A. ochraceous;* causes cancer of the liver
  - Yellow rice toxins: formed by *Penicillium* spp.; caused several deaths in Japan
  - Estrogenic factor in corn: produced by *Fusarium graminearum* ; causes testes of young male swine to have atrophy and the uteri of female pigs to enlarge and abort
  - Fumonisins: formed by *Fusarium* spp. in corn grains; caused esophageal cancer in man and toxic to animals like horses
- Losses due to predisposition of host to attack by other pathogens
  - Example: nematode injuries on roots serve as ports of entry for other pathogens
  - Leaf pathogens weaken plants which can become a host susceptible to root-rotting pathogens
  - Severely-defoliated trees can be readily attacked by *Armillaria mellea* and other fungi
- Losses from increased cost of production and handling
  - Cost of disease control is an added cost.
  - Cost of culling disease commodities for marketing and processing
  - Infected and stained wood chips need longer time to bleach to obtain white paper product.

II. CONCEPTS OF PLANT DISEASE

A. Concepts of plant disease:

- A "physiological malfunctioning caused by animate agents" (Whetzel, 1929). He called malfunctioning caused by nonliving or inanimate agents as "physiogenic disease".
- "Any deviation from normal growth or structure of plants that is sufficiently pronounced and permanent to produce visible symptoms or to impair quality or economic value" (Stakman and Harrar, 1957).
- A "malfunctioning process caused by continuous irritation" (Horsfall and Dimond). The authors emphasize the difference between disease and injury. A disease progresses over a period of

time while injury is an instantaneous action such as the breaking of a twig.

- "A dynamic interaction between an organism and its environment which results in abnormal physiological and often morphological or neurological changes in the organism" (Merril, 1980).
- "Any disturbance brought about by a pathogen or an environmental factor which interferes with manufacture, translocation or utilization of food, mineral nutrients and water in such a way that the affected plant changes in appearance and yields less than a normal healthy plant of the same variety" (Agrios, 1978).
- "Any malfunctioning of host cells and tissues that results from continuous irritation by a pathogen or an environmental factor and leads to the development of symptoms" (Agrios, 1998).

B. Classification of Plant Diseases

- A rational grouping of plant diseases is helpful in the identification and subsequent of a particular disease.

i. According to affected plant organ

- Related to the physiological processes affected.
- Examples: root diseases, foliage diseases, fruit diseases, stem diseases

ii. According to symptom

- Examples: leaf spots, rusts, smuts, anthracnoses, mosaics, wilts, fruit rots

iii. According to type of affected plant

- Examples: vegetable diseases, diseases of forest trees, diseases of field crops, diseases of ornamentals.

iv. According to type of pathogen that causes the disease

a. Infectious diseases

Examples:

- Diseases caused by fungi
- Diseases caused by mycoplasmas
- Diseases caused by bacteria
- Diseases caused by viruses
- Diseases caused by viroids
- Diseases caused by protozoa
- Diseases caused by parasitic flowering plants
- Diseases caused by nematodes

b. Non–infectious diseases

Examples:

- Diseases caused by non–parasitic or abiotic agents such as
  - Extremely high or excessively low temperatures
  - Unfavorable oxygen relations
  - Unfavorable moisture conditions
  - Nutrient deficiencies
  - Mineral toxicities
  - Air pollution
  - Toxicity of pesticides, etc.

Note: Classification according to type of pathogen is preferred by many workers because of the etiological or causal basis. Knowledge of the causal agent of a particular disease gives one an idea of how the disease develops and spreads as well as of the control measures that are most likely to be effective.

C. Common Terms in Plant Pathology:

a. **Pathogen** - any agent (biotic or abiotic) that causes a disease. The term is generally used to refer to a living organism, such as a fungus, or bacterium, that causes disease.

b. **Parasite** - an organism which depends wholly or partly on another living organism for its food. Most parasites are pathogens.

c. **Obligate parasite** – an organism that is restricted to subsist on living organisms and attacks only living tissues.

d. **Facultative parasite** – an organism which has the ability to become a parasite although it is a saprophyte.

e. **Saprophyte** – an organism that lives on dead organic or inorganic matter.

f. **Facultative saprophyte** – an organism that has the ability to become a saprophyte but is ordinarily a parasite.

g. **Host** – a plant being attacked by a parasite. A food relationship with a parasite (pathogen) is implied.

h. **Suscept** – a plant that is susceptible to a disease whether or not the pathogen is parasitic.

i. **Pathogenicity** – the capacity of a pathogen to cause disease.

j. **Pathogenesis** – disease development in the plant.

k. **Virulence** – refers to the quantitative amount of disease that an isolate of a given pathogen can cause in a given group of plants in terms of size of lesions or number of lesions.

l. **Aggressiveness** – measures the rate at which virulence is expressed by a given pathogenic isolate.

m. **Disease resistance** – inherent ability of an organism to overcome in any degree the effects of a pathogen.

n. **Susceptibility** – opposite of resistance; the inability to overcome the effects of a pathogen.

o. **Tolerance** – ability of plant to withstand the severe effects of the pathogen without experiencing a severe reduction in yield.

p. **Masked symptoms** – symptoms not expressed due to unfavorable condition.

q. **Symptomless carrier** - a host that do not show symptom irrespective of environment.

D. <u>Disease Triangle</u> - illustrates that the following are requisites for disease development to occur:

- ✓ Susceptible plant
- ✓ The pathogen
- ✓ Favorable environment

* The absence of one or more of these factors will produce no disease.

III. PLANT DISEASE DIAGNOSIS

- Identification of specific plant diseases through their characteristic symptoms and signs including other factors that may be related to the disease process.
- Correct plant disease diagnosis is necessary for recommending appropriate control measures, and in plant disease surveys.
- Diagnoses based on symptoms alone are not very reliable because some diseases exhibit the same symptom although their pathogens are different.
- The presence of signs of the disease increases the reliability of the diagnosis.

Note: Secondary invaders and saprophytic microorganisms may be found on or in invaded tissues and may be mistaken for the primary pathogen.

A. Symptoms of Plant Diseases:

- Refer to the expressions by the suscept or host of a pathologic condition by which a particular plant disease may be distinguished from other plant diseases.
- Include visible response by the suscept as well as any measurable host response to infection, such as, increased respiration, increased leaf temperature.
- Symptoms vary according to the environment, the host variety, and the race of the pathogen involved.
- Different pathogens may cause the formation of identical symptoms.

i. Primary vs. Secondary Symptoms

- Primary symptoms refer to the immediate and direct results of the causal agent's activities on invaded tissues.
- Secondary symptoms refer to the effect on distant and uninvaded plant parts.

ii. Localized or Systemic Symptoms

- Localized symptoms are distinct and very limited structural changes usually in the form of lesions such as canker, leaf spot and gall.
- Systemic symptoms are more generalized pathological conditions such as mottling, mosaic and wilting.

iii. Histological or Morphological Symptoms

- Histological symptoms are internal; seen only upon dissection of diseased plant portion and examination under the microscope. Examples: abnormality in cell content, structure or arrangement; cell enlargement and vascular discoloration.
- Morphological symptoms are malformations and other changes visible to the naked eye.

iv. General classification of symptoms

1. Plesionecrotic symptoms – pre-necrotic "near dead"; changes before actual death of protoplast or cell; involves protoplasmic disorganization and degeneration.
   Examples: silvering, yellowing, and wilting.

2. Necrotic symptoms – involve death of protoplast, cells or tissues.
   Examples: spot, blight, scorch, canker, and die-back.

3. Hypoplastic symptoms – inhibition or failure in the differentiation or development of some aspect of plant growth.
   Examples: stunting, chlorosis, mosaic, curling and rosetting.

4. Hyperplastic symptoms – excessive, multiplication, enlargement or overdevelopment of plant organs including abnormal prolonged retention of green color.
   Examples: gall formation, fasciation, scab, premature defoliation or fruit drop or greening.
   a. Hypertrophy - Overdevelopment due to the increase in the size of cells
   b. Hyperplasia - Abnormal increase in the number of cells

v. Symptoms and Diseases

1. *Abscission* – premature falling of leaves, fruits or flowers due to the early laying down of the abscission layer.
2. *Blast* – term applied to the sudden death of young buds, inflorescence or young fruits.
3. *Bleeding* – flow of plant sap from wounds.
4. *Blight* – an extensive, usually sudden, death of host tissue, such as leaf blight.
5. *Blotch* – large, irregular spots on leaves or fruits with necrotic injury of epidermal cells.

6. *Callus* – an overgrowth of tissue formed in response to injury in an effort of the plant to heal the wound.
7. *Canker* – an often sunken necrotic area with cracked border that may appear in leaves, fruits, stems and branches.
8. *Chlorosis* – yellowing cause by some factor other than light, such as infection by a virus or a mycoplasma.
9. *Curling* – abnormal bending or curling of leaves caused by over–growth on one side of the leaf or localized growth in certain portions.
10. *Damping off* – rotting of seedlings prior to emergence or rotting of seedling stems at an area just above the soil line.
11. *Die–back* – a drying backward from the tip of twigs or branches.
12. *Etiolation* – yellowing of normally green tissues caused by inadequate light.
13. *Fasciculation or fasciation* – clustering of roots, flowers, fruits, or twigs around a common focus.
14. *Flecks* – extremely tiny spots on leaves, fruits, stems, etc.
15. *Gumming or gummosis* – oozing out of viscid gum from wounds in bark.
16. *Leak* – the host's juices exude or leak out from soft–rotted portions.
17. *Mosaic* – the presence, usually on leaves, of variegated patterns of green and yellow shades with sharply defined borders.
18. *Mottling* – the variegation is less defined than mosaic and the boundaries of light and dark variegated areas are more defused.
19. *Mummification* – an infected fruit is converted to a hard, dry shriveled mummy.
20. *Phyllody* – metamorphosis of sepals, petals, stamens, or carpels into leaf–like structures.
21. *Pitting* – define depressions or pits are found on the surface of fruits, tubers and other fleshy organs resulting in a pocked appearance.
22. *Rosetting* – shortening of the internodes of shoots and stems forming a crowding of the foliage in a rosette.
23. *Rotting* – the disintegration and decomposition of host tissue. A dry rot is a firm, dry decay whereas a soft rot is a soft, watery decomposition. Any plant part may suffer from rot such as fruit rot, stem–end rot, blossom–end rot, stalk rot, root rot
24. *Rusetting* – a superficial brownish roughening of the skin of fruits, tubers or other fleshy organs usually due to the suberization of epidermal or subepidermal tissues following injury to epidermis.
25. *Sarcody* – abnormal swelling of the bark above wounds due to the accumulation of elaborated food materials.
26. *Savoying* – the cupping or pocketing of parts of the leaf; also curling or puckering; due to underdevelopment of veins of leaf margins.
27. *Scab* – slightly raised, rough, ulcer–like lesions due to the overgrowth of epidermal and cortical tissue accompanied with rupturing and suberization of cell walls.
28. *Shot–hole* - a perforated appearance of a leaf as the dead areas of local lesions drop out.
29. *Spot* – a localized necrotic area also referred to as a lesion, may be circular, angular or irregularly shaped. Several spots may run together or coalesce forming large necrotic areas.
30. *Streak or stripe* – long, narrow necrotic lesions on leaves or stems.
31. *Vein clearing* – the leaf veins are translucent or pale while; the rest of the leaf is its normal color.
32. *Virescence or greening* – development of chlorophyll in tissues or organs where it is normally absent.

33. *Wilting* – may be due to an infectious agent or to lack of water. Wilting caused by the latter is often temporary and plant recovers upon the application of enough moisture unless the drought is prolonged and the plant dies. Wilting by an infectious agent often leads to death of the plant unless controlled in time.

B. Signs of Plant Diseases

- Structures of the pathogen found associated with the infected plant part.
- Some of these structures may not always be present in diseased plants because their formation depends on environmental conditions.
- Most of these signs are best seen and distinguished under a microscope.

i. 3 General Categories of Signs:

1. Vegetative structures - function primarily in absorption and storage of nutrients.
    a. *Felt* – a densely woven mat of mycelium.
    b. *Haustorium* – an absorbing organ of a fungus which penetrates a host cell without penetrating the plasma membrane.
    c. *Mycelium* – a mass of fungal threads or hyphae.
    d. *Pathogen cells* – masses of bacterial cells generally.
    e. *Plasmodium* – naked mass of protoplasm.
    f. *Rhizomorph* – cordlike strand of fungal hyphae.
    g. *Sclerotium* – a hard, compact, resting body composed of fungal hyphae.
2. Reproductive structures – those pathogen structures that function in reproduction of the organism.
    a. *Acervulus* – a mat of hyphae, generally associated with a host, forming erumpent lesions with short, densely packed conidiophores.
    b. *Apothecium* – open, cuplike, ascus–containing fruiting body.
    c. *Ascus* – sac-like structure containing ascospores formed as a result of karyogamy and meiosis.
    d. *Basidium* – characteristically club–shaped structure on which basidiospores are produced as a result of karyogamy and meiosis.
    e. *Cleistothecium* – a closed ascus–containing fruiting body.
    f. *Conidiophore* – specialized hyphal branch on which conidia are produced.
    g. *Conk* – woody shelf-like structure characteristic of many woody–rotting fungi.
    h. *Mildew* – cobwebby or powdery growth usually on leaves
    i. *Mold* – woolly of furry surface growth of mycelium.
    j. *Mushroom* (toadstool) – umbrella–shaped fruiting structure of many Basidiomycetes.
    k. *Perithecium* – characteristically flask–shaped, ascus–containing fruiting body with a small opening (ostiole) and a wall of its own kind.
    l. *Pseudothecium* – fruiting body bearing asci in locules within a stroma.
    m. *Pycnidium* – asexual, hollow fruiting body containing conidia.
    n. *Seed–bearing plants* – higher plants that parasitize trees.
    o. *Sorus* – mass or cluster of spores borne on short stalks

p. *Sporangium* – enlarged tip of specialized hyphal branch in which sporangiospores are borne.
q. *Spore* – general name for a single to several- celled propagative unit in fungi and other lower plants; examples of spores with specific names are conidia, ascospores, basidiospores, zoospores, oospores, sporangiospores, aeciospores, urediospores, chlamydospores and teliospores.
r. *Sporodochium* – cushion–shaped stroma covered with condiophores.
s. *Stroma* – compact mass of fungal hyphae on or within which fruiting structures are formed.
t. *Worms* – generally nematodes which are microscopic, wormlike animals that can cause disease.

3. Disease products – gases and exudation products resulting from disease.
   a. *Odor* – characteristic smell associated with some host–pathogen interactions.
   b. *Ooze* – viscid mass made up of plant juices and often pathogen cells.

Signs of fungal diseases: mycelia, spores, fruiting bodies, etc.
Signs of bacterial diseases: bacterial cells, bacterial ooze
Signs of nematode diseases: eggs, juveniles, adult nematodes
Signs of virus diseases: virus particles, inclusion bodies
Signs of viroid diseases: RNA fragments
Signs of diseases caused by parasitic flowering plants: seeds and the plant itself

C. Koch's rules of proof of pathogenicity

- the set of rules used to prove the pathogenicity of facultative parasites

Steps:

- The suspected pathogen must always be present in the plant when the disease occurs;
- The organism which is believed to be the cause of the disease must be isolated and grown in pure culture;
- The pure culture of the organism must produce the symptoms and signs of the disease when inoculated into a healthy plant; and
- The suspected causal organism must be reisolated in pure culture from the inoculated plant and must be identical to the original organism.

Note: Koch's rules of proof should be modified when dealing with obligate parasites (ex: viruses, nematodes) as well as abiotic or non-living agents.

IV. NON-PARASITIC AGENTS OF PLANT DISEASES

Abiotic diseases or injury

1. Injury caused by too low temperatures
   - *Freezing injury* – when temperature is below 0°c, ice crystals form within or in-between cells
   - *Chilling injury* – low temperatures slightly above freezing (below 12.5°c causes many tropical fruits and vegetables to have a pitted and water-soaked symptoms.
2. Injury caused by too high temperature
   - *Sunscald* – tissues a light-colored and blistered, due to prolonged exposure to high temperature and bright sunlight.
   - *Heat necrosis of potato* – potatoes grown in light soils where it is hot and dry exhibit yellow or brown discoloration in the vascular system.

3. Stress caused by lack of oxygen
   - At oxygen below 2%, normal respiration cannot proceed which results in anaerobiosis.
   - *Blackheart disease of potato*
4. Too much or too little light
   - too much light scorches or scalds leaf tissues; too little light produces plants that are etiolated.
5. Injury caused by adverse meteorological conditions
   - strong winds, heavy rains, lightning can also cause various disorders in plants.

6. Injury caused by air pollutants
   - mainly gases and particulates (soots, dusts, ashes)
   - *Ethylene* – essential plant hormone, also from vehicle emissions
   - *Nitrogen oxides* – from automobile emissions, also produced from the combustion of coal, gasoline, natural gas and fuel oil
   - *Peroxyacetyl nitrates (pans)* – formed from nitrogen oxides undergoing a phytochemical reactions with gaseous hydrocarbons.
   - *Ozone* – constituent of smog, also formed in the same way as pans
   - *Particulates* – lime and cement dusts, ash and soot
   - Other air pollutants like chlorine (Cl_2), sulfur dioxide (SO_2), fluorides, hydrogen chloride, etc.
7. Mineral deficiencies/mineral excesses
8. Unfavorable soil pH
9. Excessive pesticide levels
10. Improper agricultural practices
11. Lack or excess of soil moisture
12. Naturally occurring toxic chemicals

- Ex. Hydrogen sulfide at toxic levels may be formed in the presence of ferrous ion in flooded rice fields under anaerobic conditions causing disease of rice.

V. PARASITIC OR BIOTIC AGENTS OF PLANT DISEASES

- agents that cause infectious diseases of plants
- include the viruses, viroids, bacteria, mollicutes, fungi, nematodes, parasitic flowering plants, insects, protozoa and few other minor parasites.

A. Virus

i. Virus characteristics

- ✓ Obligate parasites of submicroscopic size
- ✓ Consist of segments of double or single-stranded RNA or DNA encased in protein structures
- ✓ Lack the machinery for the production of energy through respiration, and for at least some viruses the isolated nucleic acid genome is infective.
- ✓ Components:
  - Protein coat
    - Provide a protective sheath for the nucleic acid
    - Facilitate movement of virus from cell to cell
    - For transmission of viruses
    - Determines the kinds of symptoms it causes
  - Nucleic acid - infective component
- ✓ Most plant viruses have single-stranded RNA genomes.
- ✓ *Bacteriophages* – viruses that attack bacteria
- ✓ *Satellite virus* – a virus that must be associated with an autonomous virus before it can cause infection.

ii. Common symptoms of viral infection

- One or more symptoms may appear on diseased plants.

- Virus infected plants are generally stunted; the yield is less and the produce is of poor quality.
- A plant may appear healthy without apparent external symptoms though infected by a virus
- The following are common viral symptoms:
    1. Mosaic
    2. Ring spot
    3. Excessive branching-witches' broom
    4. Vein clearing
    5. Color breaking
    6. Stunting
    7. Chlorosis
    8. Leaf curling

iii. Entry into plants

- Virus enters through wounds made mechanically or by vectors
- Virus enters by deposition into an ovule of an infected pollen grain

iv. Means of transmission

1. Infected pollen, seeds and other planting materials
2. Grafting
3. Mechanical
4. Via vectors
    a. Nematodes
    b. Soil-borne fungi
    c. Mites
    d. Insects

Note: Insects are the major means of virus spread.

v. Virus-vector relationship

1. Non-persistent (stylet-borne) - transmit the virus within seconds or minutes after acquisition then losses the ability to transmit it.
2. Semi-persistent (foregut-borne) – viruses can stay in the vector for days.
3. Persistent - insect transmits the virus after a latent period has elapsed after acquisition; vector capable of transmission for days.
    a. Stylet-borne - for viruses that adhere to and are borne on stylet of an insect that feeds on infected plant.
    b. Circulative - viruses are swallowed by an insect, passed thru the blood and are returned to the salivary glands before they can be transmitted by the insect.
    c. Propagative – viruses multiply in the body of the vector. Transmission may take hours to days after acquisition but once infective, it can transmit the virus for life.

vi. Methods of identifying viruses

1. Transmission studies using indicator hosts (local lesion hosts)
2. Electron microscopy – for virus morphology (size and shape)
3. Serological tests – for virus relationships; done by mixing antibodies with an antigen
   Example: elisa : enzyme-linked immunosorbent assay
4. Microscopy for the presence of inclusion bodies in young infected tissues.
5. Symptomatology and host range
6. Physical properties
    b. Thermal inactivation point (tip) – exposure of the virus for 10 minutes to a specific temperature; the lowest temperature at which virus is inactivated
    c. Longevity of the virus *in vitro* (liv)
    d. Dilution end point (dep) – the dilution of a virus in crude extract at which it can still cause infection.

vii. Control of virus diseases

1. Preventive measures – key to control of virus diseases
    a. Quarantine
    b. Certification

c. Use of virus-free seeds and planting materials

2. Eradicative measures
   a. Rouging and destruction of infected plants
   b. Cut and burn diseased plants
   c. Hot water treatment of plant propagative organs - The temperature must inactivate the virus but Should not destroy host tissues.
3. Protective measures
   a. Control of vectors – nematodes and insects
4. Cross-protection - inoculation of healthy plant with a mild strain of a virus to protect it from infection of a more virulent strain that can cause a more severe symptom.
5. Genetic engineering - confers resistance through the introduction of the pathogen's coat protein gene- interferes with the infection process.
6. Early detection and subsequent destruction of infected plants.

B. Viroids

i. Viroid characteristics:

- ✓ Stable "naked (no protein coat)" RNA that infect plants
- ✓ Smaller than viruses
- ✓ Closely associated with nuclei of infected cells especially the chromatin.

ii. Symptoms of viroid-infected plants:

1. Yellowing of leaves - cadang-cadang disease of coconut
2. Stunting - chrysanthemum stunt disease
3. Rolling and twisting of leaves – potato spindle tuber
4. Mottling and chlorosis – chrysanthemum chlorotic mottle
5. Vertical breaking of bark - *Citrus exocortis*

iii. Transmission and spread of viroids:

- Thru infected sap in contaminated tools and hands or by alighting and chewing insects.
- Thru vegetative propagating materials

iv. Control of viroids:

- Prevention is the best means to control viroids
- Generally resistant to heat; hot water treatment not applicable.
  a. Thorough washing and disinfestations of tools used in handling infested plants
  b. Use viroid-free seedlings and other planting materials
  c. Early detection and destruction of infected plants

C. Bacteria

i. General characteristics:

- Prokaryotic microorganisms; largest group; no well-defined nucleus and nuclear membrane
- Typically one-celled
- Have unit membrane and rigid cell wall
- Reproduce asexually by binary fission
- Gene transfer is accomplished through:
  - Transformation: change in cell through uptake and expression of additional genetic material
  - Transduction: transfer of genetic material from one bacterium to another by means of a bacteriophage
  - Conjugation: transfer of genetic material from a donor cell to a recipient cell through direct cell-to-cell contact.
- Some with plasmids
  - Extracellular, closed, circular genetic components
  - Self-replicating; can be integrated into the bacterial chromosome and replicated with it
  - Cells may express new genetic characteristics through plasmids
- Advantages imparted by plasmids to bacteria:
  - Carry determinants for:
  - Drug resistance
  - Phage resistance

- UV resistance
- Survival in secondary habitats
- For pathogenesis

- Shapes
  - Spherical (cocci)
  - Rod-shaped (bacilli)
  - Spiral-shaped (spirilla)
  - Some rods and spirilla possess flagella :
- Types of flagellation
  - monotrichous
  - Lophotrichous
  - amphitrichous
  - peritrichous

ii. Characteristics of plant pathogenic bacteria:

- Most plant pathogenic bacteria are:
  - Rod-shaped
  - Aerobic
  - Flagellated
  - Gram negative
  - Non-spore forming
- Exceptions:
  - *Streptomyces* spp. - filamentous like a mold but their biochemical and physiological properties like bacteria
  - Genus Corynebacterium is Gram positive
  - Clostridia is anaerobic and spore-forming

iii. Genera and species of plant pathogenic bacteria

There used to be only five major genera:

1. *Pseudomonas*
2. *Xanthomonas*
3. *Agrobacterium*
4. *Corynebacterium*
5. *Erwinia*

Now, there are 29 known genera of plant pathogenic bacteria:

1. Acetobacter
2. Acidovorax
3. Agrobacterium
4. Arthrobacter
5. Bacillus
6. Brenneria
7. Burkholderia
8. Clavibacter
9. Clostridium
10. Corynebacterium
11. Curtobacterium
12. Enterobacter
13. Erwinia
14. Gluconobacter (Rhizomonas)
15. Nocardia
16. Pantoea
17. Pectobacterium
18. Pseudomonas
19. Ralstonia
20. Rathayibacter
21. Rhizobacter
22. Rhodococcus
23. Sphingonomas
24. Serratia
25. Spiroplasma
26. Streptomyces
27. Xanthomonas
28. Xylella
29. Xylophilus

iv. Symptoms caused by bacteria:

1. **Leaf spot-** bacteria in sub stomatal cavities and parenchyma cells of leaves causing localized lesions.
   Examples:
   Xanthomonas campestris pv . *Vesicatoria* – leaf spot of tomato and pepper
   Pseudomonas syringae pv. *Mori* - leaf spot of mulberry
2. **Soft rot** – bacteria produce hydrolytic enzymes that degrade the middle lamella and cell walls of the host resulting to soft, slimy, watery decay.
   Examples:
   Pectobacterium carotovorum subsp. *Carotovorum* - bacterial soft rot of vegetables
3. **Blight**- general necrosis due to rapid growth and advance of bacteria.
   Examples:
   Pseudomonas syringae pv. *Tabaci* – tobacco wildfire
   Xanthomonas axonopodis pv. *Dieffenbachiae* - bacterial blight of anthurium
   Xanthomonas oryzae pv. Oryzae - bacterial leaf blight of rice

4. **Gall** – due to hypertrophy and hyperplasia of meristematic and parenchymatous tissues.
   Examples*:*
   Agrobacterium tumefaciens – crown gall of roses
5. **Canker** – phloem and parenchyma tissues become sunken, dry up and die.
   Example*:*
   Xanthomonas axonopodis pv. *Citri* – citrus canker
6. **Wilting** – a result of vascular disorders; bacteria multiply and block normal flow of water.
   Example*:*
   Ralstonia solanacearum – wilt of solanaceous and non-solanaceous plants.
   Pantoea stewartii subsp. *Stewartii* – bacterial wilt of corn
7. **Scab**
8. **Chlorosis**
9. **Streak -***Xanthomonas oryzae* pv. *Oryzicola* – bacterial leaf streak of rice

v. Control of Bacterial Diseases:

a. **Cultural** - sanitation to reduce inoculum levels crop rotation for bacterial pathogens that o not have a wide host range; proper watering and drainage to inhibit infection and drainage.
b. **Seed treatment** – soak seeds in weak acid solution or sodium hypochlorite
c. **Use antibiotics** - ex: streptomycin, oxytetracycline; disadvantage: bacteria soon develop resistance to chemicals
d. Use resistant cultivar

List of names of bacteria plant pathogens and the disease they cause in the Philippines.

New Name of Causal Bacterium (Former name/names)	Disease
Acetobacter aceti	Pink disease of pineapple
Agrobacterium tumefaciens	Crown gall of roses
Clavibacter xyli subsp. *Xyli*	Ratoon stunting disease of sugarcane
Enterobacter dissolvens (Erwinia dissolvens)	Stalk rot of corn
Erwinia tracheiphila	Bacterial wilt of cucurbits
Gluconobacter oxydans	Pink disease of pineapple
Pantoea stewartii subsp. *Stewartii (Erwinia stewartii)*	Bacterial wilt of corn
Pectobacterium carotovorum subsp. *Atrosepticum (Erwinia carotovora* subsp. *Atrosepticum)*	Potato black leg
Pectobacterium carotovorum subsp. *Carotovorum (Erwinia carotovora* subsp. *Carotovora)*	Soft rot of vegetables
Pectobacterium chrysanthemi pv. *Zeaes*	Stalk rot of corn
Pseudomonas avastoni subsp. *Phaseolica (pseudomonas syringae* pv. *Phaseolicola) (pseudomonas phaseolicola)*	Halo blight of beans
Pseudomonas syringae pv. *Tabaci (pseudomonas tabaci)*	Tobacco wildfire disease or leafspot of tobacco
Ralstonia solanacearum	Bacteria wilt of solanaceous

(Burkholderia solanacearum) (pseudomonas solanacearum)	and non-solanaceous crops
Streptomyces scabies	Potato scab
Streptomyces albilineans	Sweet potato scab
Xanthomonas albilineans	Red stripe of sugar cane
Xanthomonas axonopodis pv. *Citri (Xanthomonas citri) (Xanthomonas campestris* pv. *Citri)*	Citrus canter
Xanthomonas campestris pv. *Dieffenbachiae (Xanthomonas | dieffenbachiae)*	Bacteria blight of anthurium
Xanthomonas axonopodis pv. *Manihotis (Xanthomonas campestris* pv. *Manihotis)*	Cassava leaf blight
Xanthomonas axonopodis pv. *Phaseoli (Xanthomonas campestris* pv. *Phaseoli) (Xanthomonas phaseoli)*	Blight of lima bean
Xanthomonas axonopodis pv. *Vignicola (Xanthomonas campestris* pv. *Vignicola) (Xanthomonas vignicola)*	Leaf of spot of cowpea
Xanthomonas campestris pv. *Campestris (Xanthomonas campestris)*	Black rot of crucifers
Xanthomonas campestris pv. *Vesicatoria (Xanthomonas vesicatoria)*	Leaf spot of tomato and pepper
Xanthomonas oryzae pv. Oryzae	Bacteria leaf blight of rice
(Xanthomonas campestris pv. *Oryzae) (Xanthomonas oryzae)*	
Xanthomonas oryzae pv. *Oryzicola (Xanthomonas campestris* pv. *Oryzicola) (Xanthomonas oryzicola) (Xanthomonas translucens)*	Bacteria leaf streak of rice
Xanthomonas vesicatoria (distinct from X.c pv. *Vesicatoria*	Leaf spot of pepper

D. MOLLICUTES

i. Mollicutes characteristics:

1. Prokaryotic
2. No cell walls but have a unit plasma membrane; 9-12 nm thick
3. Pleomorphic – due to absence of cell wall, hence, sensitive to osmotic change
4. Contain both RNA and DNA
5. Pathogenic on plants, arthropods, other animals including man
6. Cause diseases n plants in several ways:
    a. Blocking translocation in the phloem
    b. Interfering with plants' hormonal balance
7. Common symptoms:
    a. Yellows
    b. Virescence
    c. Stunting
    d. Phyllody
    e. Production of axillary shoots and adventitious roots
8. Resistant to penicillin but sensitive to tetracycline and chloramphenicol

ii. Class Mollicutes

Order Mycoplasmatales

2 plant pathogenic taxa:

a. Phytoplasmas
b. Spiroplasmas

a. Phytoplasmas

- Formerly called mlos or mycoplasma-like organisms
- Generally found in the phloem
- Varied shape but generally spherical or ovoid; may also appear mucoid or filamentous
- Nutritionally fastidious; very difficult to culture in artificial media
- Reproduce by budding and by binary transverse fission of cells

b. Spiroplasmas

- Helical or spiral-shaped during certain phases of growth
- Relatively easy to grow
- Require sterol for growth
- Larger than phytoplasma.

iii. Transmission

- By insect vectors
  a. Mainly by leafhoppers, planthoppers, psyllids
  b. Insect acquire the mollicutes in the phloem sieve tubes of the plant
  c. Incubation period from acquisition feeding: 10-45 days
- Mechanical transmission e.g. budding and grafting

iv. Diseases Caused by Mollicutes

In 1967, Doi and co-workers observed mollicutes to be associated with aster yellows, mulberry dwarf and potato witches' broom.

Examples of diseases:

Lethal yellowing of coconut trees – phytoplasma causes death of flowers and leaves; blight kills trees in 6 months or less.

Citrus stubborn disease – spiroplasma affects leaves, fruits and stems; stunting, die-back, bunchy growth of twigs and branches, mottling, leaf chlorosis.

Corn stunt – spiroplasma causes leaf chlorosis, stunting, and bunchy top appearance

v. Management of Diseases Caused by Mollicutes

1. Use resistant cultivars or hybrids
2. Proper control of insect vectors
3. Use of mollicute-free planting materials
4. Eradication of alternative hosts- ex. Weeds
5. Use of tetracycline antibiotic – if economically feasible and no danger of residue on edible plant parts
6. Sanitation – cutting and burning diseased plant parts during early stages of infection

E. Fastidious vascular bacteria (rickettsia-like organism or RLO)

- cannot be grown on simple culture media in absence of host cells
- Fastidious phloem-limited bacteria - observed in 1972 in phloem of clover and periwinkle plants affected with clover club leaf disease. Later observed in citrus plants affected with the greening disease.
- Fastidious xylem-limited bacteria - observed in 1973 in xylem vessels of grape plants affected with Pierce's disease (*Xylella fastidiosa*) and alfalfa affected with alfalfa dwarf.

i. FVB Characteristics

1. Generally rod-shaped
2. Measures 0.2 to 0.5 um in diameter by 1 to 4 um in length
3. Bounded by a cell membrane and a cell wall

4. No flagella
5. Cell is usually undulated or rippled
6. Nearly all fastidious vascular bacteria are gram negative.
7. Several xylem-limited bacteria are placed in the recently created genus *Xylella.*
8. Only xylem-limited – inhabiting bacteria causing sugarcane ratoon stunting and Bermuda grass stunting are gram positive; Classified as members of the genus *Clavibacter* (formerly *Corynebacterium)*
9. None of the phloem- inhabiting bacteria (cause of clover club leaf and citrus greening) has been grown in culture.
10. All xylem-inhabiting fastidious bacteria can be grown in culture in complex nutrient media; growth is slow and colonies produced are tiny (1-2 mm).
11. All fastidious vascular bacteria are unable to grow on conventional bacteriological media.
12. Fastidious vascular bacteria are sensitive to tetracycline and penicillin and to high temperature.

ii. Important diseases caused by fastidious vascular bacteria:

1. Fastidious xylem-limited gram negative bacteria: (caused by forms of the bacterium *Xylella fastidiosa*)
    a. Pierce's disease of grapes
    b. Citrus variegation chlorosis
    c. Phony peach disease
    d. Almond leaf scorch
    e. Plum leaf scald
2. Fastidious xylem-limited gram positive bacteria:
    a. Ratoon stunting disease of sugarcane – caused by *Clavibacter xyli* subsp. *xyli*
3. Fastidious phloem-limited bacteria – cause of the important citrus greening disease and minor diseases of clover and periwinkle.

F. Plant pathogenic protists

- They are not considered as fungi anymore but protozoa-like or fungi-like
- Their cell walls are not made up of chitin but of cellulose and other glucans

i. Protozoa-like protists - unicellular, plasmodial, or very simple multicells, phagotrophic (feeding by engulfing food)

1. Phylum Myxomycota or slime molds – form naked, amorphous plasmodia.
    Genera: *Fuligo, Mucilago, Physarum*
2. Phylum Plasmodiophoromycota or endoparasitic slime molds - fungal-like
    Examples:
    Plasmodiophora brassicae – clubroot of cabbage and other crucifers
    Spongospora subterranea – powdery scab of potato tubers
3. Flagellate protozoa – reported in laticiferous plants particularly in the sieve tubes
    Example:
    Phytomonas leptovasorum – phloem necrosis of coffee in Surinam.
    Heart rot disease of coconut and oil palm

ii. Fungal-like protists - have mycelia and conidia but cell walls are made up of cellulose and glucans, not chitin as true fungi would have.

Phylum Oomycota
  Class Oomycetes
    Order Peronosporales
      Families:
        a. Pythiaceae - causes damping-off, root rots of vegetables
            i. Genus: Phytium (damping off, rots of vegetables, turf diseases)

ii. Genus: Phytophthora (root rots, rots of fleshy tissues)

b. Peronosporaceae - downy mildews
c. Albuginaceae - white rust

G. Nematodes

Etymology: Greek words "nema/nematos" = thread,
"edos"= resembling or likeness

i. Nematode characteristics

Nematodes are thread-like unsegmented worms which are usually elongated and cylindrical in shape.
They may be saprophagous, predaceous or plant parasitic depending on their sources of food.

Saprophagous nematodes – feed on other nematodes and on other minute animals.

Phytonematology - deals with nematodes that parasitize plants

Turbatrix aceli - wheat gall nematode; first plant parasitic nematode described
Caenorhabdilisi elegans - used as a model organism for genetic and physiological studies

Plant parasitic nematodes (ppn) – feed on all forms of plant life including seed plant and algae; some feed on fungi and bacteria.

- Mostly are obligate parasites; dependent on the living host for survival as they feed and reproduce only in their hosts.
- Most ppn have a **stylet –** a hollow, needle-like spear; others have a **modified solid spear**.

ii. Nematode Biology

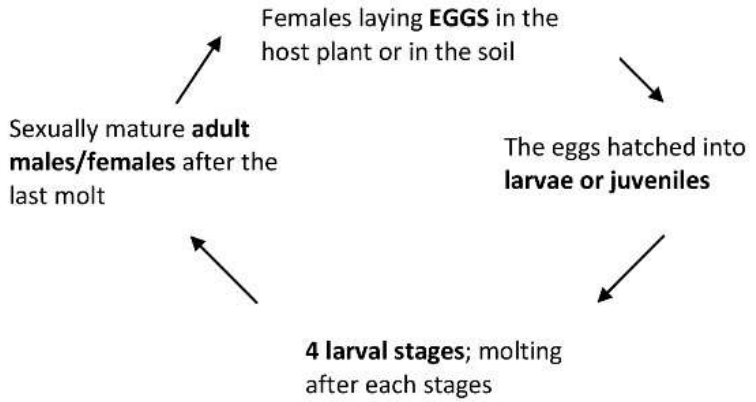


Fig. 1. Life cycle of a nematode.

1. **Life Cycle:** Zygote - Juvenile Stage - Adult
   2nd Juvenile (J2) - *The feeding or infective stage*
2. **Reproductive stage:**
   a. **Amphimixis -** mode of reproduction where males are needed
   b. **Parthenogenesis -** mode of reproduction wherein only females are produced and offsprings are clone of the female
   c. **Sex reversal -** observed in juvenile stage of parthenogenetic species of Meloidogyne during unfavorable condition
3. **Survival Strategy**
   Dormancy - lowered metabolism
   Types of Dormancy

a. **Diapause** - state of arrested development which persist until specific requirements for development are satisfied even if favorable condition return
b. **Quiescence** - spontaneous reversible response to unpredictable unfavorable condition

Egg stage - the survival stage of nematodes

iii. Groups of plant parasitic nematodes

1. According to feeding position
   a. Ectoparasites
      - Feed from the outside and only the stylet enters the plant
      - They do not enter the roots
      - Feed mainly on root hairs and root tips; resulting to roots may form many lateral branches and stop growing
      - Ex. The genera *Xiphinema, Trichodorus,* and *Tylenchorynchus*
   b. Semiendoparasites
      - Feed by burying the front part of the body into the host cells while the posterior portion is outside the host
      - Ex. *Rotylenchulus reniformis* (reniform nemas), *Tylenchulus semipenetrans* (citrus nemas), and *Helicotylenchus* (spiral nemas)
   c. Endoparasites
      - The entire nematode body enters the plant cells while it feeds
      - Ex. *Meloidogyne* (root knot nemas), *Heterodera* (cyst nemas), and *Pratylenchus* (lesion nemas which feed on the root cortex of many plants)
2. According to movement while feeding
   a. Migratory
      - Move from one part of the plant to another portion of the host
      - Move from the plant to the soil and back
      - Ex. *Radopholus* (burrowing nemas), *Pratylenchus, Ditylenchus dipsaci* (stem and bulb nemas), and *Aphelenchoides* (foliar and seed nemas)
   b. Sedentary
      - Attach themselves to the roots or burrow into the root; in each case they remain sedentary
      - Ex. *Meloidogyne, Rotylenchulus,* and *Tylenchulus*

iv. Stylet

- is a protrusible structure in the mouth of nematodes which distinguishes plant parasitic from living forms. It is the structure they use for puncturing plant cells and withdrawing their contents.

Three types of stylet:
Stomato stylet - with distinct cone, shaft and knobs, inside is hallow (Order Tylenchida)
Odontostylet - hallow spear (Order Dorylaimida)
Onchiostylet - bent solid needle-like stylet (Order Triplonchida)

iv. Sampling theories

1. **Spatial Distribution –** nematode distribution within the field is generally patchy owing to their small size and slow rate of active movement
2. **Vertical Distribution-** refers to the dispersal of nematodes in a soil profile.
3. **Temporal/seasonal distribution-** influenced by climatic pattern (wet and dry) and availability.

Nematode density is highest during near harvest stage of crop.

iv. Extraction techniques

Motility-dependent/active methods: extract slender and active stages of nematodes

Examples: Baermann funnel and its modification and H_2O incubation method

Motility-independent/passive methods: extracts even sluggish (slow moving nematodes)

Examples:

Wet sieving method (by nematode size)
Maceration-sieving (by nematode size)
Elutriation method (by sedimentation difference of nematode and soil particle)
Centrifugal flotation (by specific gravity)

v. Nematode Diseases important in the Philippines

- Slow decline of citrus - *Tylenchulus semipenetrans*
- Spreading decline of citrus - *Radopholus similis*
- Toppling disease of banana - *Radopholus similis*
- Root knot - *Meloidogyne* sp.
- False root knot - *Naccibus* spp.
- Ufra disease of rice - *Aphelenchoides besseyi*
- Rice root knot - *Hirschmaniella oryzae*
- Yellow dwarf disease of black pepper - *Radopholus similis*
- Red ring disease of coconut - *Radinaphelenchus cocophilus*

H. Fungi

i. Characteristics

- Form a mycelium
- Cell walls contain **chitin and glucan**
- No chloroplast
- Nutrition: by absorption; heterotrophic; depend upon other living plants for food (food derived from organic matter)
- Reproduction: usually by means of **spores**, which are very small seed-like structures (germinate and produce threadlike filaments through the plant's natural opening like the stomates, hydathodes, and lenticels)
- Has a specialized structure, **appressorium**, used for attachment and penetration to an intact host
- Has a structure called **haustoria** which takes food needed for its growth
- Survival: in the form of spores or threadlike parts (mycelia or fruiting bodies) in some dead parts of plants or decaying materials
- Primary stored carbohydrate: **Glycogen**

ii. The Four Phyla with Plant Pathogens

1. CHYTRIDIOMYCOTA
2. ZYGOMYCOTA
3. ASCOMYCOTA
4. BASIDIOMYCOTA

1. **Phylum CHYTRIDIOMYCOTA** – have zoospores with one posterior flagellum; only member of fungi that form motile cells (zoospores or gametes)

a. Class CHYTRIDIOMYCETES

ex. *Physoderma maydis* – causes brown spot of corn
Synchytrium psopocarpi – causes orange galls of winged bean
Olpidium brassicae - root disease of crucifers

2. **Phylum ZYGOMYCOTA** – no zoospores; have asexual spores in sporangia; produce zygospores which are nonmotile sexual resting spores

a. Order: Mucorales
   - Rhizopus
     Ex. *Rhizopus nigricans, R. stolonifer* – causes soft rot of fruits and vegetables
   - Mucor
   - Choanephora
     Ex. *Choanephora cucurbitarum* – causes soft rot of squash

b. Order: Glomales (mycorrhiza)
   - Glomus
   - Gigaspora

3. **Phylum BASIDIOMYCOTA** – the club and mushroom fungi; sexual spores, called basidiospores or sporidia, are produce externally on a one - or four-celled structure called a **basidium**.

a. Order Ustilaginales (the smut fungi)
   Ex. *Ustilago maydis* – causes corn smut
   Urocystis cepulae – causes smut of onion

b. Order Uredinales (the obligate rust fungi)
   - Attacks mostly leaves and stems; some form swellings and even galls
   - Most rust fungi are very specialized; attack only certain genera, varieties

   Formae speciales
   Ex. *Puccinia graminis f.sp. tritici* – attacks wheat only
   Puccinia graminis f.sp. hordei – attacks barley only

   Pathogenic (physiologic) race - P.g. f.sp. *tritici* attacks some varieties of wheat (within crop species)

Examples of rust diseases:
Uromyces phaseoli – causes rust of beans
Hemileia vastatrix – causes coffee rust
Puccinia polysora - Peanut rust
Puccinia polysora - Corn rust

c. Order Agaricales (mushrooms)

4. **Phylum ASCOMYCOTA** – the **sac fungi**; produce sexual spores called **ascospores** in groups of eight within a sac known as **ascus**.

a. Class ARCHIASCOMYCETES
b. Class SACCHAROMYCETES
   ex. *Galactomyces* sp. – causes sour rot of citrus fruits
c. Class PLECTOMYCETES
d. Class PYRENOMYCETES
   ex. *Claviceps purpurea* – causes ergot of rye
   Ceratocystis paradoxa – causes pineapple black rot
   Ceratocystis fimbriata – causes root rot of sweet potato
   Magnaporthe grisea – causes rice blasts
e. Class LOCULOASCOMYCETES
   ex. *Mycosphaerella fijiensis* – causes black sigatoka leafspot of banana
   Capnodium sp. – sooty mold fungi on a variety of crops
   Blumeria graminis – causes powdery **mildew** of grasses
f. Class DISCOMYCETES
   ex. *Diplocarpon rosae* – causes black spot of roses

Teleomorph - the sexual or perfect stage of ascomycetes
Anamorph - the asexual or conidial or imperfect stage

iii. Deuteromycetes or Imperfect Fungi

➢ The imperfect stage of Phylum Ascomycota

➢ sexual reproduction and sexual structures are lacking or unknown

3 Groups of Deuteromycetes or imperfect fungi

a. Hypomycetes- Fungi that produce conidia on free conidiophores or groups of conidiophores
   i. *Alternaria* – cause of leaf spots and blights on many crop plants
   ii. *Bipolaris* – leaf spots in cereal plants
b. Coelomycetes - Fungi that produce acervuli or pycnidia that bear conidia and conidiophores
   i. *Diplodia* – fruit rots
c. Mycelia sterilia - No asexual nor sexual spores
   i. *Rhizoctonia* – rotting of leaves, stems and roots
   ii. *Sclerotium* – seed, root and stem rots and seedling diseases

iv. Fungicides

Kinds of fungicides:

1. **Protective fungicides** – as foliage and fruit sprays or dusts to keep disease-causing fungi from penetrating plants. Ex. Zineb
2. **Eradicant fungicides** – kills or inhibits fungi after they have penetrated the plants. Ex. mercury chloride
3. **Protective and eradicant fungicides** – controls foliage and druit diseases; as seed treatment. Ex. Captan
4. **Systemic and curative fungicides** – absorbed by roots and distributed within the plants to control certain diseases; applied to seeds or soil. Ex. Benlate, Apron 35

I. <u>Parasitic Higher Plants</u>

Classification:

Hemiparasites – contains chlorophyll but without roots so it depends on host for water and minerals

Examples: Witchweed
True mistletoe and leafy mistletoe
Loranthus sp.

True parasite – have little or no chlorophyll and no roots either so entirely dependent on host for water and minerals.

Examples: Dodder
Broomrapes
Bunga ng tubo (*Aeginetia indica*)

VI. VARIABILITY IN PLANT PATHOGENS

A. <u>General Concepts</u>

➢ Plant pathogenic microorganisms like other organisms, continually undergo changes.
➢ The shorter the generation time and the larger the numbers of reproductive units formed in each generation, the greater are the chances of producing genetic changes over a given period of time.
   - Bacterial populations - can double their numbers every 20 minutes during favorable environmental conditions.
   - Fungus – can form millions of spores within a few days.
➢ The changes that a pathogen undergoes may involve an increase or decrease in its pathogenicity. Thus, new races capable of attacking new host varieties may be formed; or some races may lose their virulence.
➢ Terms used in grouping organisms below the species level:
   a. *Biotype*

- Population of life forms that is identical in all inheritable traits; genetically homogeneous.
- If an organism from one biotype mates with one from another biotype, a different group is formed as a result of hybridization.

b. *Pathovar*
- (among bacterial plant pathogens) A strain or group of strains at the infrasubspecies level, with identical or similar characteristics based on pathogenicity, symptoms, or signs and host range.

c. *Pathogenic race*
- Another subdivision of the subspecies level which is made up of one or more biotype with morphologically identical members. The development of pathogenic races is enhanced by the following:
  (1) absence of susceptible varieties
  (2) presence of resistant varieties
  (3) sexual reproduction of pathogen
  (4) obligate parasitism
  (5) narrow host range
  D. *Formae speciales* or *special form*
- Based on the ability to attack different genera of crop plants.
- Ex. *Puccinia graminis* with members that infect different cereal crops with forma speciales *tritici* attacking wheat only and f. sp. *Avenae* attacking oat only.
- Each forma speciales may contain different races that attack different varieties of the host.

B. Mechanisms of Variation

➢ Microorganisms naturally undergo genetic changes through hybridization, mutation, and a variety of sexual-like and asexual processes.

i. Sources of Variation in the Fungi

a. Heterokaryosis
- The presence of different nuclei in the same mycelium.
- Each nucleus in a heterokaryon is independent of the other nuclei although the behavior and phenotype of the microorganism are controlled by the kinds of genes present and by the proportion of each kind.
- It is an important method of producing new fungal strains or races with a concomitant change in pathogenicity.

b. Parasexual process
- Parasexuality was first observed by Pontecorvo and Roper while working with *Aspergillus nidulans.*
- It mimics sexual reproduction in that genetic recombination occurs but it is mitotic recombination within vegetative heterokaryotic hyphae.
- It starts with the formation of a heterokaryon, followed by karyogamy or diploidization of nuclei, the multiplication of these nuclei and finally, the restoration to the haploid state.

c. Mutation
- A discontinuous heritable change of the genetic material which may arise spontaneously or through the action of mutagenic agents.

d. Cytoplasmic variation
- It has long been recognized that the nucleus does not have a monopoly on heredity as the cytoplasm also carries heredity determinants.
- These extrachromosomal particulate elements can multiply and be transmitted asexually through hyphal anastomosis or sexually.

e. Sexual reproduction

- This results in hybridization through segregation and genetic recombination.

ii. Sources of Variation in bacteria

a. Mutation

b. Transformation
   - A sexual-like process through which bacterial cells absorb and incorporate in their own cells heritable genetic materials that are released by other bacteria.
   - The agent is believed to be DNA which the recipient bacteria acquire from the growth filtrate of the donor bacteria.

c. Transduction
   - Occurs when a bacteriophage (a virus that infects bacteria) transfers genetic material from its former host bacterium to its next host.

d. Conjugation
   - There is transfer of genetic material from one bacterium to another when two compatible cells come in contact with each other.

iii. Sources of Variation in nematodes

- Nematodes form new pathogenic races through hybridization and mutation. Pathogenicity varies according to the degree of resistance/susceptibility of the host.

iv. Sources of Variation in other pathogens

- All pathogens which reproduce sexually utilize hybridization as a means of variation.
- Recombination may also occur if two or more virus strains are present in the same plant.
- Mutation is universal among organisms and may occur even in the viruses and viroids.
- Variations are expressed not only through direct changes in pathogenicity but also through alterations in:
  1. Growth rate
  2. Longevity
  3. Host range
  4. Optimum temperature or pH

C. Genetics of Host-Parasite Interactions

The development of infectious plant diseases is dependent on the resistance or susceptibility of the host plant and the virulence of the pathogen.

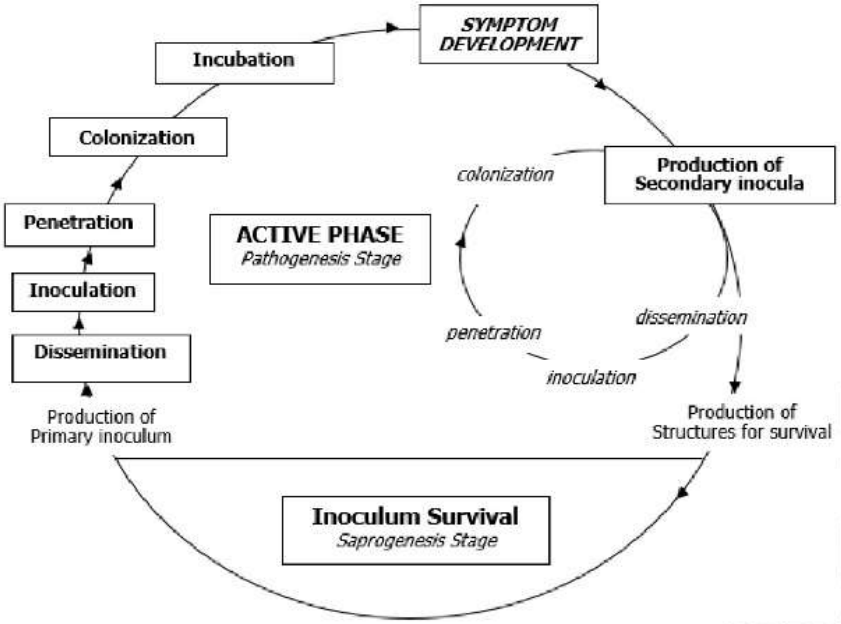
There are a number of genes in the plant that determine its resistance or susceptibility and a number of genes in the pathogen that determine its virulence. This is the reason for the common observation that that various physiologic races of the pathogen vary in their ability to attack a host variety and that different host cultivars vary in their response to a physiologic race.

Plants and their respective plant pathogens have co-existed and have evolved together in nature. Through the centuries, a dynamic equilibrium of resistance and virulence has been maintained between the pathogen and its host so that both may survive. An unrestrained virulent pathogen would have eliminated the host plant; a 'super resistant' plant would have made the pathogen extinct. This stepwise evolution of resistance and virulence is explained by the **gene-for-gene concept.**

Gene-for-gene concept

- "For each gene in the host that confers resistance, there is a corresponding gene in the pathogen that confers virulence. Thus, to infect a variety with resistance genes a, b, or c, the pathogen must have the corresponding virulence genes a, b, or c, respectively. This has been shown to be true for many diseases in which resistance is simply inherited or involves only one or few genes.

VII. DISEASE CYCLE



The development of disease in a single plant or in plant populations goes through a sequence of events called the disease cycle. The cycle includes the activities of the pathogen while it is on and within the suscept as well as those while the pathogen is away from the host. The disease cycle should be distinguished from the life cycle of the pathogen.

Different diseases caused by various pathogens exhibit disease cycles that vary in details. Some pathogens survive adverse conditions in the soil and in dead plant refuse, others in weed hosts, still other in seeds. Some diseases have numerous secondary cycles whereas the secondary cycle may be insignificant in certain diseases.

The following corresponds to the parts of the disease cycle:

A. Dissemination of Inocula

After the symptoms have advanced, signs or pathogen structures are usually formed on the colonized surface of the host. These structures which can serve as inoculums later are disseminated or spread by insects, wind, water and other agents. If the inoculums lands in or an infection court, inoculation is effected, penetration may proceed on a recently diseased plant is called secondary inoculums which initiates the secondary disease cycles. Several secondary cycles may occur within the growing season of a plant.

By Wind

Major means of spreading air-borne pathogens such as fungal spores of leaf, stem, and fruit pathogens.

Take-off: Inoculum gets into the air
Flight: Inoculum move with the wind
Deposition: Settling of the inoculum from the atmosphere

Not disseminated by wind:

Viruses, viroids and mycoplasmas
Nematodes (occasional)
Bacteria (via soil particles)

By Rain

Fungal spores and bacterial cells are carried to short distances by rain splashes.

By Insects
Plant to plant via insects: Viruses, Bacteria and Fungi. As insects feed on a plant, the inoculum that they carry is deposited and is left on the injured portions where the insects had just fed on.

By seed and planting materials
Infected planting materials possess viruses, viroids, mycoplasmas and many bacteria internally.
Infested planting materials carry fungal spores, bacterial cells or nematodes externally or on the surface.

By man
Man is a major long-distance disseminator of plant pathogens.
- Carrying of infected and infested planting materials.
- Shipping crates and equipment used for agricultural products usually carry all kinds of inocula.

B. Inoculation
- Contact of pathogen with the host
- Deposition of inoculum into an infection court

Infection Court - the susceptible part which could be natural opening, a wound or intact plant surface

Inoculum is composed of pathogen structures capable of initiating disease production.

Types of Inoculum:
Fungi - Asexual or sexual spores, mycelia fragments, sclerotial bodies, rhizomorphs, and dormant mycelia in seeds
Nematodes - Eggs, larvae and adults
Bacteria - Phytoplasma cells, protozoan cells
Others - Bacteria and mycoplasmas, rickettsia, virus particles, viroid entities and seeds of parasitic flowering plants

Sources of Inoculum:
a. infected living plants
b. plant debris
c. infested soil
d. infected seed and vegetative propagating materials
e. contaminated containers, storage areas and equipment
f. insects, nematodes and other living agents that carry inocula

Pathogens may survive over adverse conditions by:
(1) surviving as saprophyte in dead plants debris in the soil
(2) forming thick-walled resistant structures for survival
(3) surviving in weeds and other hosts,
(4) surviving in vectors
(5) surviving in the seed

This is the deposition of inoculums unto or into an infection court. Inoculum is any part of the pathogen that can initiate disease. The infection court may be a natural opening (stomata, lenticels, hydathode, growth crack), a wound, or the intact host surface.

C. Penetration or Ingress
- Entrance of pathogen into the host
- Penetration does not imply successful infection
- Penetration is completed when the pathogen has passed through the initial cell wall or entered the intercellular areas so that the pathogen is within the plant.

Entry Points
1. Natural openings
    a. Stomatal openings, lenticels, hydathodes, nectarthodes
2. Intact host surface
3. Wounds

Direct penetration is through intact epidermis. Bacteria and viruses cannot penetrate directly

2 Types of Penetration

1. *Passive* if the pathogen plays no active part in it, as when bacterial cells are carried by a film of water through stomata into the host tissues.
2. *Active* when the pathogen directly participates as when the fungal spore germinates, forms a germ tube, an appressorium for attachment, and penetrates through the intact host surface by forming an infection hypha or penetration peg.

D. Infection

- Occurs when the pathogen has become established in the plant tissues after penetration and obtains nutrients from the host.

  Latent infection - the state in which the host is infected with the pathogen but does not show any symptoms

  Following infection, the pathogen continues to grow and colonize the host. Colonization is the growth or movement of the pathogen through the host tissues.

E. Colonization/Invasion

- Is the active or passive movement of the pathogen through the host tissues
  - Active: when the pathogen does something as when a fungal pathogen, for instance, grows as it passes from cell to cell;
  - Passive: if the pathogen is merely carried through the transpirational stream, as are some viruses.
- Produce harmful chemicals like enzymes, toxins, hormones, etc.

Colonization by Viruses, Viroids and Mollicutes

- Viruses, viroids and mollicutes are intracellular parasites. Viruses colonize the epidermal cells, the palisade cells, the spongy mesophyll, and the vascular system.

Colonization by Bacteria

- Intracellular: In xylem and phloem vessels, ex. gall formations, vascular wilts.
- Intercellular: in between cells

Colonization by Nematodes

- Sedentary endoparasite, Migratory endoparasite

Colonization by Phtyoplasma

- Binary fission, budding, etc. to produce more cells

Colonization by Fungi

- Colonization on the host surface
- External colonization with haustoria inside the host cells
- Intercellular colonization without haustoria
- Intercellular colonization with intracellular haustoria
- Intracellular colonization
- Intercellular and intracellular colonization

F. Incubation

- Incubation period has been used to mean the time from inoculation to the production of visible symptoms. Others use it to refer to the time from the first response of the plant to the formation of visible symptoms.

G. Survival

- Some pathogen structures may not land on a susceptible plant and certain environmental factors may not favor their continued growth and development.

VIII. MECHANISMS OF PATHOGENICITY AND HOST RESPONSE

Plant pathogens cause disease or bring about the "malfunctioning of the normal physiology" of the affected suscept by participating in something that impairs or interferes with the plant's normal processes and has adverse effect on its normal functioning.

A. Malfunctioning of the normal physiology

i. Interference with the uptake of water and inorganic elements from the soil.

- Root-rotting microorganisms
- Colonization of xylem vessels
- Crushing of xylem by gall forming nematodes
- Formation of tyloses: enlarged xylem parenchyma cells
- EPS and vessels macromolecules resulting from breakdown of cell walls
- Ex. Fungi and bacteria that colonize the xylem vessels interfere with the translocation of water, gall-forming nematodes (such as *Meloidogyne)* in roots.

ii. Interference with translocation of organic compounds

- Phloem necrosis by viruses
- Yellowing
- Unfilled grains or small tubes

iii. Reduction of the plant's photosynthesis capacity

- Reducing the effective surface for photosynthesis
- Ex. Leaf spots, blight, mosaic, mottle, canker, scab, dieback, wilt, etc.

iv. Increased transpiration

- Powdery mildews, downy mildews and the rust pathogen destroy the cuticle and epidermis
- Increase the permeability of the leaf cells
- Detrimental water loss through increased transpiration
- Wilt

v. Changes in growth of the suscept

- Plant growth involves a series of well-regulated and coordinated processes as metabolism is controlled by growth regulating hormones and feedback mechanisms

vi. Changes in the reproduction of the host plant

Phyllody - mycoplasma causes flowers to transform into a green leafy structure.

vii. Death of cells and tissues

Necrotic diseases brought about by fungi, bacteria, viruses and other pathogens cause disintegration of cell walls as well as of protoplasm.

B. Hormones associated with plant diseases

1. Auxin (IAA) and cytokinins

- Required for cell division and differentiation

- Inc. auxin when plants are infected with diseases

2. **Gibberellins**
   - Stimulate stem elongation by stimulating cell division and elongation
3. **Ethylene**
   - Natural aging and ripening hormone, physiologically active in trace amounts
   - Excess induces: Epinasty, Premature, Senescence, and Shedding of leaves

C. Enzymes associated in plant diseases

- Enzymes are large protein molecules that catalyze all interrelated reactions in the cell
- Enzymes involved degrade the plant cell wall that is composed primarily of polysaccharides (pectic substances, cellulose, and hemicellulose), structural gylcoproteins and lignin

Pectic enzymes

- Assist in the penetration of the host
- Expose the cellulose and hemicellulose fractions of cell wall
- Degradation results in the weakening of cell walls or tissue maceration which facilitates inter- and intracellular invasion of the tissues
- Provide nutrients to the pathogen in infected tissues
- Involved in the induction of vascular plugs and occlusion in vascular wilt disease

D. Toxins in Plant Diseases

Toxins - chemicals that act directly on living host protoplasts, seriously damaging or killing cells resulting in necrosis

*Extremely toxic, effective in low concentrations
*Affect permeability of membranes
*Inactivate or inhibit enzymes
*Induce deficiency for an essential growth

Host Specific Toxins

- Toxic only to hosts of the pathogen producing the toxin
- Virulence of the pathogenic strains varies with their capacity to produce the toxin
- Has a role in the establishment of the pathogen in the host
- Examples:
  HS toxin (Helminthosporoside) – cause of eye spot of sugarcane
  HV toxin (Victorin) – foot or root rot and leaf blight of oats
  T toxin – southern corn leaf blight
  HC toxin - Leaf spot of corn
  PC toxin – Milo disease of sorghum

E. Non-host specific fungal toxins

- Produces all or part of disease syndrome on host plants and non-host plants; Not selective
- Examples of non-host fungal toxins
  i. Fusarial wilt toxins: Fusaric acid, Phytonivein, Phytolycopersin, Lycomarasmin
  ii. Ophiolobolin
  iii. Helminthosporal
  iv. Fusicoccin
  v. Pyricularin

IX. MECHANISMS OF DISEASE RESISTANCE

Resistance is a characteristic of host that inhibits or suppresses the growth and development of the parasite/ pathogen.

A. <u>Pre-formed Resistance</u> - present in plant even without the presence of the pathogen

i. External Physical Barriers:

- Trichomes
- Cuticle - offers a physical as well as a chemical barrier to penetration by most pathogens. Young tissues are generally more prone to infection because their cuticle is thinner than those of mature tissues
- Stomata
- Root Cap and Mucilage
- Thick Seed Coat and Epidermis
- Waxy layers - induce water on inclined leaf and fruit surfaces to run off, thus limiting the formation of infection droplets.

ii. Internal Physical Barriers:

- Suberized tissues
- Lignified tissues
- Cellulosic walls
- Middle Lamella
- Deposition of Gums, Resins and Tannins
- Deposition of Silicic acid
- Structural features if the vascular elements

iii. Defense through lack of essential factors in the host

- Lack of recognition between host and pathogen
- Lack of host receptors and sensitive sites for toxins
- Lack of essential nutrients for the pathogen

iv. Pre-formed Chemical Factors

- Phenolics - pyrocatechol
- Tannins - such as caffeic acid, chlorogenic acid and hydroquinones have fungitoxic properties. These are found to be powerful inhibitors of the pectolytic and hydrolytic enzymes.
- Saponins - naturally occurring chemicals that bind to sterols in fungal cell membranes; alters permeability
  - Ex. Avenacin and Tomatine
- Enzymes involved in resistance

B. <u>Induced Resistance</u> - active only in the presence of inducers

i. Active defense mechanisms to pathogen establishment

- Active defense mechanisms are those resorted to by the host in response to the activities of the pathogen.

ii. Mechanical barriers to pathogenesis

- Some plants lay down a corky layer around an infected area to seal off the pathogen from healthy tissues. The corky tissue should be formed rapidly enough (faster than the invading organism) to be effective.

iii. Hypersensitivity

- Hypersensitivity is the rapid localized death of host cells around the pathogen. This results in the confinement or

even death of the pathogen if it is an obligate parasite, as it becomes surrounded by dead cells. The hypersensitive plant is resistant in the sense that only small localized necrotic lesions appear which do not further develop.

- It has been found that in a hypersensitive reaction, compounds called **phytoalexins** are formed by the plant cells in response to infection.

iv. Plant Immunization

- An active immune system like that which is present in animals is absent in plants as the latter do not produce antibodies. However, through genetic engineering, mouse genes have been incorporated in the genome of plants. These animal genes are expressed in the transgenic plants and produce antibodies called **plantibodies** against certain pathogens in the transgenic plant. An example is the production of plantibodies against virus coat proteins.

v. Other post-infectional toxic substances

- Aromatic compounds such as phenolic glucosides, polyphenols, flavonoids, anthocyanins, aromatic amino acids and coumarin derivatives are said to accumulate around infection sites where they are believed to inhibit the pathogen. Polyphenol oxidases oxidize fungistatic phenolics (of host or pathogen origin) to quinones which could be more toxic.

X. EPIDEMIOLOGY OF PLANT DISEASE

A. Terminology

Epidemiology - study of epidemics or study of the increase of disease in a population and the factors that influence them

Epidemic

- Any increase of disease in a population
- Occurs when a pathogen spreads to and affects many individuals within a population over a relatively large area and within a relatively short time.

Epiphytotics - refers to epidemics of plant diseases

Endemic disease - one that is native or indigenous to a particular place

Exotic disease -none which had been introduced from some other area

Pandemic disease -bone of worldwide or widespread occurrence throughout a continent or a region

Sporadic disease - one that occurs at irregular interval

B. Elements of an Epidemic

- Plant disease epidemic develop as a result of the timely combination of the same elements that result in plant diseases:
    1. Susceptible host
    2. Virulent pathogen
    3. Favorable environment
    4. Intervention by Man

- Humans may help to initiate and develop epidemics through some of their activities, e.g. topping or pruning plants in wet

weather; introduction of new pathogen from other areas through contaminated planting materials, etc.

C. Factors that affect the development of epidemics

1. Host Factors

a. Levels of genetic resistance or susceptibility of the host
   - ➢ Host plants carrying major or minor genes for resistance less likely to develop an epidemic than host plants with no genes for resistance.

b. Degree of uniformity of host plants
   - ➢ When genetically uniform host plants, particularly with regard to the genes associated with disease resistance, are grown over large areas, a greater likelihood exists that a new pathogen race will appear that can attack other genome and result in an epidemic.

c. Type of crop
   - ➢ In annual crops such as corn, vegetables, rice, etc.; epidemics generally develop much more rapidly (usually in a few weeks) than they do in diseases of perennial woody plants.

d. Age of host plants
   - ➢ Younger plants are generally more susceptible than adults (adult resistance)

2. Pathogen Factors

a. Levels of virulence
   - ➢ Virulent pathogens capable of rapidly infecting the host ensure faster production of larger amounts of inoculum.

b. Quantity of inoculum near host
   - ➢ Amount of initial inoculum

c. Ecology of the pathogen
   - ➢ Pathogens that produce inoculum on the surface of the aerial parts of the plants can disperse with ease and are more responsible for epidemics than internal pathogens.

d. Mode of spread of the pathogen
   - ➢ Aerially dispersed pathogen cause more of the epidemics

3. Environmental Factors

a. Moisture

b. Temperature

4. Human Factors

a. Site selection and preparation

b. Selection of propagative materials

c. Cultural practices

d. Disease control measures

e. Introduction of new pathogens

D. Analysis of epidemics

➢ The increase in the amount of disease at any one time is dependent on the ff.:

- the initial amount of disease or initial inoculum
- the rate of disease increase
- the duration of disease increase or the period of time involved

"Compound interest" diseases
- those wherein the pathogens are readily spread from plant to plant during the disease cycle
- repeating cycles occur with several generations of the pathogen

"Simple interest" diseases
- those where no plant to plant spread occurs during the primary cycle.
- only one generation occurs during the growing season

Van der Plank

- Epidemic always starts with the first diseased plant in the population
- During ideal conditions for disease development, the amount of disease in a susceptible population increases logarithmically in the beginning until the remaining uninfected plant population decreases
- If disease incidence is plotted against time, one gets the sigmoid curve
  - ✓ epidemic starts at that point where the sigmoid curve begins to leave the horizontal line and to approach the vertical line;
  - ✓ soon after the onset of the epidemic, disease incidence becomes logarithmic until the amount of susceptible plant tissues decreases;
  - ✓ epidemic ends when all infection courts have been eliminated or some factor in the environment prevents further increase in the amount of disease;
  - ✓ the sigmoid curve levels off at this stage.

❖ **Zadoks and Schein (1979)**

- 3 phases of epidemic: exponential or logarithmic phase, logistic phase, and terminal phase

XI. PRINCIPLES AND METHODS OF PLANT DISEASE CONTROL

The raison d'etre of the science of plant pathology is the control of plant diseases.

The 4 general principles in plant disease control principles are graphically presented as follows:

CONTROL AIMED AT	
SUSCEPT	PATHOGEN
1. Protection – shield suscept with chemical or physical barrier. 2. Immunization – change suscept's reaction to disease.	1. Exclusion – kept pathogen out. 2. Eradication – destroy or eliminate the pathogen.

Control measures can be aimed at the suscept or at the pathogen. A susceptible plant can be shielded by a chemical or physical barrier which prevents the pathogen from invading the plant. We call this the principle of **protection**.

Geneticists and plant breeders often change the disease reaction of a plant to make it resistant to a pathogen. This principle is termed **immunization**. Aiming our sights now at the pathogen, it is sometimes possible to keep pathogens out of a country, province, farm or field by employing practices based on the principle of **exclusion**. And if the pathogen has unfortunately eluded us and has become established in a field, on a farm, etc., it is sometimes practical to destroy, remove or eliminate it by adopting measures based on the principles of **eradication**.

A. <u>Exclusion Principle</u>

- Prevention of a "new pathogen" from being introduced into a locality where it is currently unknown.

Methods of plant Disease control

a. Quarantine - regulatory actions to prevent the introduction or dispersal of non-native organism (exotic diseases), legal methods

b. Inspection and seed certification
c. Use of pathogen-free propagating materials

B. Eradication Principle

- Elimination of pathogen that have become established within the plant or in an area.

i. Physical
   1. Heat treatment (Hot air, hot water, soil sterilization, soil solarization)
   2. Irradiation – UV rays, X rays, and Gamma rays
   3. Light wavelengths that prevent sporulation
   4. Drying stored grain

ii. Chemical
   1. Systemic chemicals
   2. Soil fumigants
   3. Disinfestation of warehouse
   4. Control of insect vectors

   Issues related to use of chemicals
   - Pathogen resistance
   - Risk of poisoning humans and animals
   - Contamination of livestock products
   - Harm beneficial insects and microflora
   - Contamination of food products, waterways and soil

iii. Biological

   Mechanism of biological control
   1. Parasitism
   2. Predation
   3. Competition
   4. Induced resistance
   5. Production of antimicrobial substance

iv. Cultural
   1. Roguing or removal
   2. Removal of alternate host
   3. Sanitation
   4. Crop rotation
   5. Creating unfavorable conditions

C. Protection Principle

Prevention of infection through
1. Chemical barrier
2. Biological control
3. Crop management
4. Manipulation of environment

Putting chemical barrier between the pathogen and the host
1. Before inoculation
2. To prevent spore germination
3. Or kill germinating spores

D. Resistance/Immunization Principle

- Involves modifying certain physiological or physical features of the host so that it can repel infection

Resistance is the relative ability of the plant to overcome the effects of a pathogen.

Methods in resistance
1. Improving the growing conditions of plants (cultural management)
2. Use of resistant varieties
   Vertical resistance (few major genes)
   Horizontal resistance (many minor genes)

Resistant varieties developed by/used:
1. Selection
2. Gene pyramiding- involves incorporation of several resistance genes in one host variety.

3. Multiline varieties- a mixture of several lines with similar agronomic characteristics but with different genes for resistance.

XII. RODENTS

- Most populous mammal
- Animal with back-bone and mammary glands
- 42% of all mammals are rodents
- Flourish in close association with humans.
- Rodents have only a single pair of incissor in both the upper and lower jaws
- No canine
- Incisors grow continuously
- Incisors can wear away by rubbing the lower against the upper set

A. Classification of Rodents

- The Order Rodentia are classified based on the skull characteristics.
- The rodent pest is belong to the myomorphs which all generally have elongated heads and pointed snout

Order: Rodentia
Sub-Order: Myomorpha
Family: Muridae
Sub-Family: Murinae
Genera: a) Mus
b) Rattus
Species: a) musculus
b) norvegicus

B. Rodent Pests in the Philippines

1. ***Rattus tanezumi*** Temminck
- Formerly given the name *Rattus rattus mindanensis* Marns
- Distributed all over the country in croplands as well as storage
- Medium-sized rat averaging about 175 g
- Tail uniformly dark usually longer than the head plus body
- Mammary formula: 2 + 3 = 10

2. ***Rattus argentiventer*** Robinson and Kloss
- Prevalent in some crop areas in Mindanao and Mindoro
- Generally smaller than *R. tenezumi*
- Tuft of orange hair near base of ear
- Tail shorter than head plus body
- Mammary formula: 3 + 3 = 12

3. ***Rattus exulans*** Peale
- agile climber and smaller than *Rattus tenezumi* and *R. argentiventer*
- Tail nearly as long as head plus body
- Mammary formula: 2 + 2 = 8

4. ***Rattus norvegicus*** (Berkenhout)
- Commonly called Norway rat
- Found all over the Philippines commensal with man
- Urban pest creating problems in public health and sanitation, food and grain storage, structural damage, fire hazards, and garbage disposal
- Generally larger and heavier than the 3 species mentioned above
- Has thick tail, shorter than head plus body
- Long vibrissae on snout
- Mammary formula: 3 + 3 = 12

5. ***Mus musculus castaneous*** Waterhouse
- Common house mouse and is an important pest in urban areas
- It gnaws wood structures and feeds on grains
- Smaller than *R. Exulans*
- Weigh 12 g
- Tail length about equal to or longer than head plus body

C. Food and Feeding Behavior
- Commensal rodents have taste patterns similar to those of human beings
- They are omnivorous, consuming food waste, stored foods, growing crops and other food items
- Adult rats eat about 8-10% of their body weight
- In general, rats have more regular feeding habits than mice and the former prefer cereals.

D. Population Growth
- High reproductive rate
- Young develop rapidly
- Pregnancy period 19-21 days
- Can give birth every three weeks
- Young mature at about 6 weeks of age
- Average litter size about 12
- One female can produce 36 young/rice seasons
- In intensive rice growing areas breeding is linked to rice cropping cycles.
- Extension in cropping season positively influence population size

E. Agricultural and Domestic Pests
- Major competitor with humans for food
- Cause significant losses to crops in fields and in storage
- Rice is one of the preferred crops.
- Cut and pull rice seedlings
- Cut tillers
- Cut and store ripened panicles

F. Human Disease Carrier (60 diseases)
- Bubonic plague or black plague
- Salmonellosis
- Leptospirosis
- Rat-bite fever
- Tsutsugamushi disease or Scrub typhus
- Angiostrongyliasis cantonensis
- Oriental schistomiasis

G. Ecological Importance
- Integral part of the ecosystem
- Important food source for predators - owls, snakes, cats, dogs, etc.
- Some are predator - feed on insects
- Some scavengers - help in nutrient cycling

H. Social Importance
- Important place in literature, mythology and history
- Experimental animals for medical, biological, and psychological research
- Used for drug testing
- Important pets
- Serves as food for humans

I. Rodent Management
i. Points for Management Approach
- Most rats live outside the field.
- Farm holdings are small and scattered.

- Rodents are highly mobile.
- Control in individual field is not enough.
- Community or Ecosystem based management is needed

ii. Cultural control

- Make rice field and its surroundings unsuitable for nesting and breeding.
- Clean cultivation - foster unfavorable conditions for rodents.
- Habitat reduction - Narrow and low bunds are not suitable for nesting
- Synchronous planting - Synchronous planting and harvesting can dilute damage

iii. Physical/mechanical control

- Digging burrows - digging burrows to collect stored rice and kill rats
- Smoking and watering - Drive rats out of burrows by smoke or water (net)
- Irrigation and plowing after harvest - Force rats to come out of the tunnels and kill
- Community trap barrier system(CTBS)

-Attract rats to a field with ripening rice.
-Rice planted in 20-50 m^2 about 2-3 weeks ahead as lure crop.
-Lure crop enclosed by ABS or TBS.
-Lure crop draws rats as far as 200 meters.
-A single CTBS can protect crop of 10-15 ha.
-CTBS removes rats during their breeding season.
-Cost effective if expected crop damage is 10% or more.
-Use of cultural control makes CTBS more effective.

iv. Biological control

Natural enemies play a vital role in population control of rodents.

Predators

- Lizards
- Snakes
- Birds (owls, kestrels, hawks, kites, falcons, eagles, and buzzards)
- Mammals (mongoose, cats, dogs, foxes, jackals)

v. Chemical control

Rodenticides - Most widely used

a. Acute poison
   - Highly toxic
   - Single dose killer
   - Kills within few hours
   - Zinc phosphide, barium carbonate, arsenious oxide etc.
   - Baits with <2% zinc phosphide.
   - Rats develop "poison aversion" or "bait shyness"
   - Per-baiting and "one-shot baiting" (mixture of with and without poison baits) minimize bait shyness.

b. Chronic poison / anticoagulants
   - Interfere with the blood clotting mechanism.
   - Rodents die due to internal or external bleeding.
   - Slow acting thus bait shyness does not develop.
   - Multiple-dose and single- dose anticoagulants.
   - Warfarin, fumarin, calciferol
   - Baits with 0.025% to 0.0375% concentrations.
   - Saturation baiting" and "sustain baiting" necessary.
   - Bait point needs to be replenished until feeding stopped.

c. Fumigants/ toxic gas
   - Fumigants produce lethal gas.
   - Calcium cyanide, ethylene dichloride, carbon tetrachloride, methyl bromide, aluminum phosphide.
   - Effective only in airtight situation.
   - Need special equipment for application.
   - Not much suitable to use in the field.
   - Aluminum phosphide pellets offer some potential to use in rat burrows.

d. Repellents

- Use Endrin as a rodent repellent to protect seeds.
- Malathion may act as repellent against *R. rattus*.
- Rats avoid areas that contain Cycloheximide.

e. Special Notes on Rodenticide Use
- Rodenticides are also lethal to humans and domestic animals.
- Special precautions are needed while using rodenticides.
- Use baiting stations to protect rodenticides from rain, sun, wet soil.
- Baiting in and around the household is potentially dangerous for domestic animals, birds, and humans.

XIII. MOLLUSK AS A PEST

Classification of Golden Apple Snail
Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Genus: Pomacea
Species: canaliculata

A. Economic Importance

1. Pest of agricultural crops
- Golden kuhol is an important pest of rice and other aquatic plants
- On rice, golden kuhol feds on transplanted rice
- 14 to 24 day old seedlings are more susceptible to golden kuhol snail attack
- Beyond 6 weeks, seedlings are hardly eaten

2. Snails are carries of parasites of man and animals
- They are the host of internal fluke, lungworm and other parasites causing diseases in man

B. Biology and Life Cycle

- Adult female lays an average of 300 pink eggs/mass during night time about 1 foot above the ground
- Eggs hatch 12 to 15 days after egg laying
- Maturity ranges from 2 to 3 months with 3 to 3.5 cm shell diameter
- Female starts to lay eggs 75 to days after hatching
- Adult live for 2 to 3 years
- Breeds twice a month

C. Management of Golden Apple Snail

1. Chemical control – the use of registered molluscicide
2. Mechanical control – use of wire screen to prevent transfer of kuhol from one field to the other
3. Biological control – using ducks and other agents
4. Use of botanical extracts

XIV. WEED SCIENCE

- Study of weeds and their control. It is an off-shoot of plant physiology having evolved from the study of plant growth regulators. Its main goal is the formulation of most effective, economical, and satisfactory methods of controlling weeds.

A. Definition of a weed

Various authors defined a weed as:
- A plant growing where it is not wanted
- A plant whose potentialities for harm far outweighs its potentialities for good
- A plant whose virtues have not been discovered
- A plant or plant part interfering with the objectives of man in a specific situation.
- A misfit

Why weeds as pest are not recognized early?

- The damage caused by weeds are not visible as those caused by insects and diseases.
- Seldom results to total crop failure.
- Crops and weeds are always associated together.

B. Characteristics of a weed

A unique characteristic of a weed is its excellent adaptation to the disturbed environment. They are able to occupy the ecological spaces left open in those environment altered by man for his use.

Other characteristics:

1. They have rapid vegetative growth. In grasses, this may be manifested by fast and numerous tiller production, in sedges, by rapid tuber and shoot formation and in broadleaves, by faster stem elongation and branching. There is also rapid leaf production which allows rapid photosynthetic activity.
2. They reproduce rapidly and mature early. The means of reproduction can be asexual and sexual. In annual weeds which reproduce mainly by seeds, there is rapid vegetative growth manifested by profuse tillering and/or branching which contribute to the numerous seed production.
3. Most weeds are very prolific and produce abundant seeds.

   Rottboellia cochinchinensis, for instance, can produce more than 700 tillers and branches which are capable of producing inflorescence.

   Scirpus maritimus, a perennial sedge, can produce more than 100 dormant and non-dormant tubers in one cropping season in irrigated paddy rice.
4. They have the ability to survive and adapt to adverse conditions. Some species have the ability to germinate and grow under a wide range of environmental conditions. They possess mechanism to resist drought and excessive moisture stress.
5. Propagules possess dormancy or can be induced to become dormant under unfavorable conditions.

   Dormancy is one mechanism that enables the species to survive under unfavorable conditions including control operations. Flashes of annual weed seed germination under field conditions require more weeding operations or more persistent control agents.
6. Adapted to crop competition - Have propersynchronize germination, rapid establishment and growth of seedlings, and quick response to available moisture and nutrient.

C. Classification of weeds

Generally, there are

Common weeds

- Weeds that are more or less found in every farm but not exceptionally injurious and are readily controlled by good farming practices.

Noxious weeds

- Weeds that are particularly undesirable because of their certain undesirable characteristics, like the presence of an extensive perennial underground system which enable to resist the most determined effort to control.

Specifically, weeds are classified:

i. Based on outward appearance or gross morphology

Grasses

- Are members of the family Gramineae (Poaceae) which range from small, twisted, erect, or creeping annuals and perennials.
- Stems are called culms with well -defined nodes and internodes.

- Leaves arise alternately in two rows from the nodes.
- The leaf is composed of two parts, the leaf sheath and leaf blade.

Sedges

- Are members of the family Cyperaceae has a narrow elongated leaves but differs from grasses by their distinguishing triangular stem.

Broadleaves

- Are members of the family Dicotyledonae and monocotylidonae characterized by shorter but wider leaves with either parallel or netted venation like pickerel weed (parallel veins) or three-lobed morning glory (netted veins).

ii. Based on maturity period or life cycle

Annual weed – is one that matures in one growing season or within one year

Examples: barnyard grass and goose grass

Perennial weed – is one that matures in more than one growing season or year

Examples: purple nutsedge and bermuda grass

iii. Based on manner of reproduction

Sexual weed – is one that reproduces by means of seeds or seed **propagules** (is a plant part of which is capable of regenerating its own species)

Example: barnyard grass

Asexual weed – Is one that reproduces by means of vegetative propagules. Example of vegetative propagules are:

Rhizome – is a modified underground stem with buds and scales; Example: cogon grass

Stolon – is a modified aboveground stem that creeps and roots at the side; Example: bermuda grass

Tuber – is a short thickened underground stem; Example: purple nutsedge

Off-shoot – is a baby plant that arises from the mother plant Example: water lettuce

iv. Based on habit of stem growth

Erect – ex. Itch grass
Decumbent – ex. Goosegrass
Prostrate – ex. Jungle rice
Ascending – ex. Day flower
Creeping – ex. Bermuda grass
Twining– ex. Three-lobed morning glory

v. Based on habitat or place for preferred growth

Wetland weed – is one that grows well in lowland or moist soil; Examples: barnyard grass and water lettuce

Dryland weed – is one that grows well in upland or drier soil Examples: itchgrass and three-lobed morning glory

vi. Based on the inflorescence or floral structure of the plant

A ***Panicle*** is an inflorescence in the main axis with at least primary and secondary branching

Example: barnyard grass, the inflorescence is a panicle with numerous ascending green spikes

Digitate – is a compound structure whose members arise and diverge from the same point, like the fingers of the hand

Example: goosegrass, the inflorescence is digitate, terminal whorl of 3 to 6 spikes

Raceme – is more of less a conical inflorescence with flowers arising laterally from a common axis

Example: itchgrass, the inflorescence is a raceme at terminus of culm or branch

Umbel – is an inflorescence in which a number of divergent flowers arise from the same point
Example: purple nutsedge, the inflorescence is composed of terminal **umbels** which are reddish-brown when mature.

XV. CROP AND WEED COMPETITION

Weeds and crops interrelate during their growth. In many situations, the first one-third to one-half on the growth cycle of the crop is sensitive to weed competition. This stage is called the **critical period of competition.**

A. Seed germination

Germination refers to the resumption of growth of the embryo in the seed or of the young plantlet in the tuber, bulb or rhizome. It marks the beginning of the battle for the survival of the weed.

Steps involved in seed germination

1. Imbibition - absorption of water accompanied by swelling. This involves purely a physical process which involves the absorption of water by starch or non-living part of the seed and can take place in both living and dead seeds and a physiological process involving water absorption by the embryo. This marks the initiation and progress of starch hydrolysis.
2. Period of rapid metabolic activity - cell division and cell elongation proceed at a fast rate supported by a rapid synthesis of materials. The end result is the perceptive growth of the embryo.
3. Emergence of root. Under field condition the radicle or root-like structure break through the seeds and grow into the soil.
4. Emergence of the shoot - commonly, this is considered the first sign of weed growth, the shoot grow above the ground. In some weeds, germination may be:
   - **Hypogeal** - cotyledons remain below or at the surface of the ground as in grasses and sedges. In both species plumule is enclosed in the coleoptile
   - **Epigeal** - cotyledons are carried above the ground as in the case of some legumenous species
5. Period of independent growth - the dependence on food reserve ceases and the seedling start to manufacture its own carbohydrate. From this stage on, the seedling is on its way to establishment.

B. Seedling growth and development

- Seedling stage is the most important stage in weed establishment.
- It is the most sensitive stage to environmental influences.
- The demand for nutrients and water is high at this stage so that in a crop weed association the weed seedling competes strongly for these factors with the crop seedlings.

The seedling stage of most species is:

- The most vulnerable and most practical stage for control.
- The stage where damage against the crop is at the low level and any control measure can take advantage of the sensitivity of the weed seedling.
- Most susceptible stage to herbicide action. Most pre-emergence herbicides are effectively absorbed through the tender tissues of the mesocotyl, coleoptile, hypocotyl or

radicle. Other inhibits growth at the emergence of the shoot.

- Leaves at the early seedling stage are tender succulent, lack cutin and waxes allowing easy penetration of the herbicide.
- Roots of seedlings have still thin epidermal walls making herbicide absorption more efficient.

i. Factors affecting seedling growth and development

1. Soil factors

a. Nutrient level - seedling stage is characterized by rapid metabolic activity which creates a big demand for the needed soil resources. Most weeds are more efficient than the crops in drawing nutrients from the soil. Amaranthus accumulates calcium, Cleome and Pistia accumulate potassium.

b. Salinity - salinization of areas near sea shore appear to favor weeds than crop.

2. Light

-Shading reduces the amount of light available to the plant reducing photosynthetic activity and consequently reducing dry matter production.

- Shading increases relative humidity in the area above the shaded species causing decrease transpiration and slow nutrient uptake from the soil.
- High relative humidity can also cause higher incidence of diseases.
- Some species are sensitive to shading such as Cynodon dactylon, Imperata cylindrica, Pistia stratiotes and Cyperus rotundus.

3. Adaptation to growing condition

The ability to adapt to adverse conditions is responsible for the rapid spread and wide distribution of weeds.

4. Competitive power of the weed

Most weeds derived their competitive power from their rapid development manifested by:

a. Rapid root growth and development
b. Rapid leaf production
c. Multiple shoot development
d. Formation of large and expansive foliar-type of cotyledon allowing early photosynthetic function.
e. Formation of toxin, which may be toxic to other higher plants as in Imperata and Rottboellia or toxic to microorganisms as in *Tagetes erecta*

The seedling stage is the most competitive stage being characterized by a high demand for soil nutrients, water and light in order to sustain a rapid phase of growth.

The weeds associated with the crop usually have vegetative growth shorter than that of the crop, thus their demands for environmental resources are greater.

C. Allelopathy

- Greek words: *allelon* (of each other); *pathos* (to suffer)
- It includes both detrimental and beneficial biochemical interactions among all classes of plants, including microorganisms.
- The term allelopathy is coined by H. Molisch in 1937, Father of Allelopathy.
- Rice (1984) published a book on allelopathy. Defined as "any direct or indirect harmful or beneficial effects by one plant (including microorganisms) on another through the production of chemical compounds that escape into the environment"

Classification of allelopathic substance

1. Antibiotic – substance produced by a microorganism and effective against another microorganism.
2. Marasmin – substance produce by a microorganism and toxic against higher plants.
3. Phytoncide – substance produce by a higher plant and effective against a microorganism.
4. Koline – substance produce by higher plants and effective against another higher plant.

D. Dormancy

– is the inability of the seed or any vegetative propagule to germinate under favorable conditions.

- it can be acquired as the seed or organ develops or matures (primary or natural dormancy), or
- induced through encounter with unfavorable conditions (induced or secondary dormancy).

i. Mechanisms of dormancy

1. *Physical* – this involves the impermeability of the thick seed coat to imbibe water and oxygen, hence even the embryo is viable it will not germinate because of the barrier.
2. *Physiological* – can be accounted to immaturity of the embryo or to the presence of substances inhibitory to the germination of weed seeds

ii. Ways of breaking dormancy

1. Microbial action
2. Treatment with acid (sulfuric acid)
3. Passage through the alimentary tract of animals
4. Dehulling or scarification
5. Exposure to alternate wet and dry conditions
6. After ripening process (lapse of time required for the plant to overcome the physiological barrier for germination
7. Treatment with germination promoters (KNO_3, GA, Auxin)
8. Exposure to light to inactivate the inhibitors
9. Stratification or low temperature treatment
10. Use of suitable germination medium for germination that can adsorbed the inhibitors

E. Methods and techniques in weed management

i. Preventive methods or approaches that reduce production and germination of weed seeds and vegetative propagules and minimize their establishment and spread

- Use of high quality and disease and weed seed-free planting materials.
- Control of weeds before they produce seeds or vegetative propagules

ii. Physical/cultural methods directly destroy weeds or involve the manipulation of the environment in the field to control weeds.

a. **Land preparation and management of weed seeds and vegetative propagules reserve banks in the soil**
   - Initial plowing buries weeds and stubbles from the previous crop, however, the process allows a batch of weed seeds to germinate which is called a weed flush

b. **Hand weeding/slashing** – weeds are controlled by uprooting or with the use of various small local hand implements by slashing

c. **Hoe weeding** – this method can be accomplished in less time compared with uprooting of weeds

d. **Interrow cultivation** – this may be done with animal or tractor-drawn implements

e. **Mulching** – provides considerable control of some weeds by reducing light available to the crops and serving as a barrier to weed emergence

f. **Water management or flooding** – this method is effectively used in transplanted lowland rice

g. **Use of competitive crop varieties or cultivars** – a variety adapted to the locality which is characterized by an early rapid growth provides some measure of weed control through its competitive advantage

h.**Multiple cropping** – this may involve spatial (intercropping) or temporal (crop rotation or sequential cropping) combinations of crops in an area in one year

iii. Biological control – is the deliberate use of a weed's natural enemies, such as insects or pathogens, to suppress the growth or reduce the population of the weed. The types of biological control are:

a. Classical approach – use of the host-specific damaging biotic agents from the country of origin of the imported problem weed species
b. Inundative approach – this includes augmentation and bioherbicide approaches

Augmentation approach –natural enemies already present in the area where the problem weed species occur often do not cause sufficient damage to effect adequate control of the weeds because their population is low.

Bioherbicide/mycoherbicide approach

– involves the application of inoculum of a weed pathogen in a manner analogous to a chemical herbicide.

- 2 mycoherbicides, devine and collego, are commercially available for the control of specific weeds in the USA

1. Devine, marketed by Abbott Laboratories, is a liquid formulation of chlamydospores of *Phytophthora palmivora* for the control of milkweed or strangle vine (*Morrenia odorata*) in citrus groves of Florida
2. Collego, marketed by Upjohn Company, is a wettable powder formulation of dried spores of *Colletotrichum gloeosporioides* f. *Aeschynomene*. Collego is sprayed postemergence, aerially or with land-based sprayers.

iv. **Chemical control** – involves the use of herbicides for selective control of weeds with minimum or no injury to the crop

- The use of herbicides substantially reduces the labor requirement for weed control and provides early season control of weeds within crop rows.
- Safety precautions on the label should be strictly observed
- Improper use of herbicides may result in crop injury, poor or ineffective weed control and drift or residue problems

Herbicide Classification:

a. **Time of application**
   1. **Preplant herbicide** – herbicide applied after land preparation but before the crop is planted. The herbicide is volatile and needs to be incorporated in the soil before planting.
   2. **Preemergence herbicides** – the chemical is applied after the crop is planted but before the weeds of the crop emerge.
   3. **Postemergence herbicides** – the herbicide is applied after the crop or the weeds have emerged.
b. **Movement in plants**

1. **Contact herbicides** – herbicide whose phytotoxic effects are manifested at the sites of the plants where the spray droplets are deposited.
2. **Translocated/systemic herbicides** – herbicides whose phytotoxic effects are manifested at and away from the sites on the plant where the spray droplets are deposited. The herbicide is moved to other parts of the plant.

c. **Selectivity**
1. **Non-selective herbicides** – herbicide that kills all plants
2. **Selective herbicides** – herbicides that kill some plants leaving others practically unharmed.

XVI. PRINCIPLES OF ENTOMOLOGY

Entomology – the study of insects

Insects
- Are animals belonging to phylum Arthropoda or simply arthropods
- Most abundant and diverse group of organisms on earth
- Are segmented, bilaterally symmetrical and possess hard chitinous exoskeleton and paired jointed appendages

Products from insects

Apiculture – refers to the rearing of honeybees (*Apis mellifera*), originally for honey, wax and other products (royal jelly, swarms)
Sericulture – refers to the rearing of silkworm (*Bombyx mori*) for the production of silk
Shellac – sticky brown resinous substance produced from the thick scale of the lac insect (high quality polish, manufacture of insulators, buttons, sealing wax, hairsprays).
Cochineal – is a red dye produced from the dried and powdered bodies of the cactus mealybug (used in foodstuff coloration, cosmetics).
Chitin - act as anticoagulant or haemostatic agent for tissue repair in humans

A. Distinguishing Characteristics of Insects

Insects may be distinguished from other arthropods by the following characteristics:
1. Body with three distinct regions: HEAD, THORAX and ABDOMEN
2. One pair of antennae
3. Three pairs of legs (a few insects are legless and some larvae possess additional leglike appendages (such as prolegs) on the abdominal; segments.
4. Often one or two pairs of wings, borne by the second and/or the third of the three thoracic segments
5. The postoral appendages of the head typically consisting of mandibles, a pair of maxillae, labrum and labium

i. The insect body wall - composed of three parts
1. **Epidermal cell** – cellular layer of the body wall; secretes molting fluid involved in the growth process
2. **Cuticle** – non-cellular layer of the body wall; covers the entire body surface and also lines the insects' air tube lining, salivary glands and parts of the digestive tracts.
   3 layers of cuticle:
   1. Epicuticle – outermost thin layer which contains cuticulin, wax, and cement.
   2. Exocuticle – middle part which gives the cuticle its characteristics strength and resilience; It is formed of chitin (a resistant substance insoluble to water, alcohol, alkali, and dilute acids.

3. Endocuticle – innermost thick layer of cuticle

3. **Basement membrane** – separates body wall from internal organs

ii. Head – comprises the globular to capsule like anterior body segment of an insect which bears the eyes, antennae and mouthparts

Classification based on head position in relation to the long axis of the body

1. **Hypognathous head**
   – condition wherein the mouthparts are at the right angle to the body axis
   Examples: grasshoppers, roaches, mantids, larvae of moths and butterflies
2. **Opisthognathous head**
   – condition wherein the mouthparts are projecting backward between the legs
   Examples: cicada, bugs, leafhoppers
3. **Prognathous head**
   – mouthparts is in line to the body axis.
   – commonly seen in carnivorous and/or forms that burrow in wood or soil
   Examples: termites, ground beetle

iii. Mouthparts – vary in type depending on the kind of food the insects eat.

The following are the mouthparts of insects:

1. **Mandibles**
   - Tooth-like structure used for chewing, grinding, tearing or pinching-off solid food
   - Heavily sclerotized, paired and unsegmented
2. **Maxillae**
   - Helps in putting the food into the mouth
   - Paired segmented structures used for mastication and lie directly behind the mandibles
3. **Labrum** – "upper lip " which is movable and flap-like structure
4. **Labium** – "lower lip" found posterior to the maxillae
5. **Hypopharnyx** – a central tonguelike which drops from the membranous floor of the head, and bears the opening of the salivary ducts.

Types of Insect Mouthparts

a. **Mandibulate or Chewing type** – the mandibles cut off and grind solid food, and the maxillae and labium push it into the esophagus

b. **Cutting-Sponging type** – the mandibles are produced into sharp blabes, and the maxillae into long probing style.

c. **Sponging type** – the mandibles and maxillae are non-functional and the remaining parts form a proboscis with a sponge-like apex called **labella.**

d. **Chewing-Lapping type** – the mandibles and labrum are of chewing type and are used for grasping prey, molding wax or nest materials.

e. **Piercing-Sucking type** – the mouthparts of this group are modified to pierce tissues and suck juices from them.

f. **Siphoning type** – the food either nectar of liquid food already are sucked up by means of a long proboscis composed only of a united galea of each maxillae.
   Examples: moths and butterflies

g. **Rasping- Sucking type** -has a cone-shaped beak formed from clypeus, labrum, parts of the maxillae and labium.

iv. Antennae

- Elongated, segmented structures of varying designs and sizes
- Are used for sensory purposes and sometimes for defense

Three main parts:

1. Scape – basal segment
2. Pedicel – second segment
3. Flagellum – whiplike part beyond the pedicel

Types of Antennae

a. **Setaceous** – bristlelike, segments taper distally
   Examples: green leafhopper, damselfly, dragonfly
b. **Filiform** – threadlike, segments nearly uniformly cylindrical in size
   Examples: grasshoppers, crickets, roaches, tiger and ground beetle
c. **Moniliform** – beadlike, segments similar in size and nearly spherical in shape.
   Example: termites
d. **Serrate** – sawlike, the distal half or 2/3 of the antennal segments more or less triangular. Example: click beetles
e. **Pectinate** – comblike, most segments with long slender lateral process
   Example: fire- colored beetles
f. **Clavate** – clubbed, segments gradually increase in diameter distally
   Example: ladybird beetle
g. **Capitate** – having a head, terminal segments suddenly enlarged
   Example: sap beetle
h. **Lamellate** – leaflike, terminal segments expanded laterally to form rounded lobes
   Example: june beetle
i. **Geniculate** – elbowed, the first segment is long and the following segments are small and going off at an angle to the first
   Examples: ants, chalcid wasps, bees
j. **Plumose** – feathery, most segments with whorls of long hair
   Example: male mosquitoes
k. **Aristate** – the last segment enlarged and bears a conspicuous dorsal bristle called **arista**
   Example – house fly
l. **Stylate** – the last segment with an elongated terminal style like or finger like process, the style
   Example: robber fly, snipe fly

v. Eyes

1. Compound eyes – located on each side of the head of most adult insects, which consist of many hexagonal elements known as facets or ommatidia

2. Simple eyes or ocelli – are located between compound eyes on the front of the head

vi. Thorax

- the middle region of the insect body which is connected from the head by a flexible membranous neck (cervix)
- contains 3 distinct segments: prothorax, mesothorax and metathorax
- each thoracic segment bears a pair of jointed legs, and in most adult insects the mesothorax and metathorax each have a pair of wings
- each thoracic segment is composed of hardened plates that give it rigidity, such as:
  a. Notum – upper plate
  b. Sternum – lower plate
  c. Pleuron – side/lateral plate

vii. Legs are articulated appendages comprising five segments.

Five segments:

a. **Coxa** – the proximal segment that is usually short and stout
b. **Trochanter** – connects the coax with the femur
c. **Femur** – the stoutest and sometime the largest segment of the leg, in some instances, it is armed with strong spines
d. **Tibia –** is often a long, slender structure with downward-pointing spines that aid in climbing.
e. **Tarsus** – usually made up of several subsegments called tarsomeres, terminate in a pretarsus.

Types of insect legs:

1. **Raptorial legs** – grasping forelegs of preying mantis.
2. **Cursorial legs** – running legs of roaches.
3. **Fossorial legs** – digging forelegs of mole crickets.
4. **Saltatorial legs** – jumping hindlegs of grasshoppers and fleas.
5. **Natatorial legs** – swimming legs of aquatic insects.
6. **Pollen basket for gathering pollen** – hindlegs of honeybees.
7. **Clinging legs** of lice
8. **Clasping legs** of aquatic beetles.

viii. Wings

Insect wings show much diversity, varying in shape, texture, and coloration. Some specific types of wings are used to identify insect orders, such as:

1. **Elytra** – forewing of beetles (Coleoptera);
   - Are thick and hard with uniform texture which is used to protect the soft abdomen
2. **Hemelytra** – forewing of true bugs (Hemiptera)
   - Are a combination of thick and soft , flexible and almost transparent apex or posterior part.
3. **Fringed type** – wings of thrips (Thysanoptera)
   - Are hair-like along the margins of the central using structure.
4. **Membranous type** – wings of caddisflies (Trichoptera)
   - Are soft, flexible, translucent or transparent with prominent wing viens.
5. **Halteres** – hindwings of flies and mosquitoes (Diptera)
   - are small knob-like structures which are use for balancing instead of flight.
6. **Tegmina** – forewing of grasshoppers, roaches (Orthoptera)
   - are leathery frontwings which serves to protect the membranous hindwings and soft abdomen.

ix. Abdomen

- This is third body region and usually the largest part especially among females.
- It is primarily for reproduction, excretion and digestion because the abdomen bears the genitalia, the anus, outwardly, and the digestive system inside, respectively.

Other Important Parts of the Abdomen:

- ✓ **Spiracles** – these are external openings of the respiratory system found along the side of the thorax and the abdomen.
- ✓ **Tympanum or "ear"** – this is located on the first abdominal tergite in grasshoppers but may be found elsewhere in the body of other insects.
  - It is the main auditory organ.
- ✓ **Cerci** – slender, pointed structures found on the eleventh segment of the abdomen

B. Classification, Nomenclature, and Identification Of Insect

Definition of Terms:
Classification – ordering of an organism into a hierarchy of categories.
Nomenclature – Naming of organisms ("Nomen" – name; "calare" – to call)
Identification – major application of classification
Keys - comprise a sequence of paired statements and questions that allow the user to eliminate alternative options and eventually associate the unknown specimens with a name.
Taxonomy – involves the theoretical basis for classification and the study of classification schemes.

i. The Class Insecta

The class Insecta is divided into orders on the basis of the structure of the wings and mouthparts, the metamorphosis and on various other characteristics.

Subclass Apterygota – primitively wingless insects
Order
1. Protura – proturans
2. Collembola – springtails
3. Diplura – diplurans
4. Thysanura – bristletails, silverfish

Subclass Pterygota – winged and secondarily wingless insects
Division Exopterygota – simple body change during growth (incomplete metamorphosis)
5. Ephmeroptera – mayflies ("**Ephemero**" – short-lived or for a day; "**ptera**" – with wings)
6. Odonata – dragonflies and damselflies ("**Odon**" – tooth)
7. Plecoptera – stoneflies ("**Pleco**" – folded or plaited)
8. Dermaptera – earwigs ("**Derma**" – skin)
9. Orthoptera – grasshoppers, crickets, roaches, mantids, walking sticks ("**Ortho**" – straight)
10. Isoptera – termites ("**Iso**" – equal)
11. Embioptera – webspiner ("**Embio**" – lively)
12. Zoraptera – zorapterans ("**zor**" – pure; "**aptera**" – wingless)
13. Psocoptera – psocids ("**Psoco**" – rub small)
14. Mallophaga – chewing lice ("**mallo**" – wool; "**phaga**" – to eat)
15. Anoplura - sucking lice ("**anol**" – unarmed)
16. Thysanoptera – thrips ("**Thysano**" – fringe)
17. Hemiptera – bugs ("**Hemi**"- half)
18. Homoptera – aphids, scale insects, hoppers, cicadas, pyllids, whiteflies ("**Homo**" – alike, uniform)

Division Endopterygota – complex body change during growth (complete metamorphosis)
19. Neuroptera – alderflies, antlions, dobsonflies, fishflies, lacewings, snakeflies, owlflies ("**Neuro**" – nerve)
20. Coleoptera – beetles ("**Coleo**" – sheath)
21. Strepsiptera – twisted-winged parasites ("**Strepsi**" – twisted)
22. Mecoptera – scorpionflies
23. Trichoptera – caddisflies ("**Tricho**" – hair)
24. Lepidoptera – moths and butterflies ("**Lepido**"- scale)
25. Diptera – flies ("**Di**" – two)
26. Siphonaptera – fleas ("**Siphon**" – tube; "**aptera**" – wingless)
27. Hymenoptera – ants, bees, wasps, sawflies ("**Hymeno**" – membrane)

ii. Distinguishing insect orders – using morphological characteristics
1. Order Protura – contains microscopic and elongated insects
   Have piercing- mouthparts
   No antennae, cerci and compound eyes and metamorphosis

2. Order Diplura – contains microscopic, wingless and elongated insects
   Have cerci and chewing mouthparts
   No compound eyes and metamorphosis
3. Order Thysanura – are small to moderate-sized insects, primitively wingless, elongated with three tail-like filaments
   - Their bodies are covered with gray silvery scales
   - No metamorphosis
4. Order Collembola – are microscopic, primitively wingless with six (6) segmented abdomen
   - Presense of abdominal forked or furcula
   - No metamorphosis
5. Order Ephemeroptera – are small to moderate-sized with four delicate membranous wings
   - Presence of setaceous antennae and long multi-segmented cerci
   - Short-lived, most die in 1-2 days
   - Mating takes place in swarms; males die shortly after mating and female dies after laying eggs in water
6. Order Odonata – are quite large insects with large compound eyes, strong chewing mouthparts, setaceous antennae
   - Elongated abdomen with small cerci
   - Have 2 suborders
     I. Suborder Anisoptera – dragonflies (wings extended horizontally when at rest)
     II. Suborder Zygoptera – damselflies (wings held vertically above the abdomen when at rest
7. Order Orthoptera – moderate to large insects (over 1 foot long)
   A. Forewings are leathery (tegmen) whereas hindwings are membranous
   B. Have chewing mouthparts and most of them are phytophagous
8. Order Isoptera – also known as white ants, soft-bodied, small to medium sized with winged and wingless form
   - Winged forms have four(4) membranous wings that are exactly alike
   - Prognathous head, chewing mouthparts and moniliform antennae.
9. Order Plecoptera – are moderate-sized insects
   - Naiads are abundant under stones in creeks or streams
   - Plaited wings which refer tot eh hindwings which are larger than the frontwings and folded in plait above the abdomen.
   - Long filiform antennae, chewing mouthparts and long and multisegmented cerci
10. Order Embioptera – are small insects with depressed and elongated body
    - Have four membranous wigs with foretarsi enlarged and with silk gland
11. Order Psocoptera – are small insects with filiform and long antennae
    - Hindwings are smaller than frontwings that held rooflike over their body when at rest
    - With chewing mouthparts
12. Order Dermaptera – elongated and moderately sized insects with four wings
    - Forewings are very small and leathery
    - Hindwings are folded lengthwise and crosswise
    - Forcep-like cerci are located at the tip of the abdomen forming like a pair of scissor.
    - Many earwigs are predatory to major pests such as corn borer
13. Order Mallophaga – are small (1.5 mm), wingless insects whose head is broader than the thorax

- Have chewing mouthparts, prominent claws and reduced eyes with no ocelli
- Parasitic on birds by feeding on feathers and dried blood.

14. Order Anoplura – are small, wingless insects with dorsal spiracles
    - Dorsoventrally flattened bodies
    - Live as ectoparasites on bodies of mammals
    - Legs are adapted for clinging on hairs
    - Eggs are called nits attached singly on hair
    - Life cycle from egg to adult is about 3 weeks
    - Well-fed adult lice may live for more than a month
15. Order Thysanoptera – extremely elongated and minute insects
    - Rasping-sucking mouthparts with conical beak
    - Four membranous wings are fringed with long hair
16. Order Hemiptera – are small to moderate-sized insects with four wings
    - Frontwings or hemelytra have a thickened and leathery basal part while the apical portion is membranous
    - Hindwings are entirely membranous
    - Piercing-sucking mouthparts arise from the anterior end of the head extend ventrally, sometimes reaching the base of the hindlegs
17. Order Homoptera – are small with four membranous or leathery wings sloping at the sides of the body when at rest
    - Piercing-sucking mouthparts arise from the posterior side of the head somewhat near the first pair of legs
    - Many species are transmitters or vectors of plant viruses and other plant disease causing agents.
18. Order Coleoptera – most numerous which constitute 40% of the total number of known insects.
    - Presence of hard or thickened front pair of wings called **elytra**
    - Membranous hindwings are used for flight
    - Have chewing mouthparts with well-developed mandibles.
19. Order Lepidoptera – constitute the most attractive and colorful groups of insects
    - Adults have siphoning mouthparts while larvae (caterpillar) have chewing type mouths and feed on roots, stems, and leaves of plants
    - Scaly wings
20. Order Diptera – contains a pair of functional membranous forewings
    - Hindwings are modified into slender, knob-like structure called **halteres** used for balancing instead of flight.
    - Mouthparts varied from sponging type (housefly) to cutting-sponging type (horseflies, deerflies)
21. Order Hymenoptera – contains most of the beneficial insects
    - Both wings are membranous, the smaller hindwings are interlocked with the larger forewings by means of a hook-like structure called **hamuli**
    - Have chewing-lapping type of mouthparts
    - Parthenogenesis is common
    - Ovipositor is adapted for sawing, piercing or stinging
22. Order Siphonaptera – are small, wingless and body compressed laterally
    - Hindlegs are enlarged adapted for jumping
    - Piercing-sucking mouthparts
    - Ectoparasites (blood suckers) of mammals including human
23. Order Neuroptera – are small to medium sized insects with four membranous wings with numerous veins and cross veins
    - With chewing type of mouthparts

- Predatory and some species (lacewings) are used to control insect pests

24. Order Mecoptera – medium-sized with four membranous wings
    - Head is modified into beak with chewing mouthparts
    - Predatory insects
25. Order Trichoptera – are small to medium-sized with four membranous wings covered with hair
    - Adult mouthparts are not developed
26. Order Strepsiptera – are very small endoparasitic insects, which considered true parasites
    - Only males have wings
    - Forewings are reduced to club-shaped appendages
    - Hindwings are fan shaped and are large compared to the body

C. Insect Metamorphosis

Metamorphosis – the change in form during the development period after the embryonic development.

Ecdysis/Molting – the process by which an insect shed off old skin (cuticle) to provide enough space to grow.
- most insects molts at least three or four times during normal development

Exuviae – old skin (cuticle) left after molting

Stadium – is the total period between any two molts

Instar – is the actual insect during a stadium.

i. Types of metamorphosis

1. **Ametabolous/No metamorphosis**
   – There is no change in the appearance of the young compared to the adult, except in size and development of reproductive structures or genitalia.
   - Stages of this type are egg, young, adult
   - Examples are: Collembola, Protura, Diplura and Thysanura

2. **Paurometabolous** – simple, gradual or direct metamorphosis in which the immatures (nymph) resemble the parent (adult) except size, wings and genitalia development.
   Examples are: hemiplera, isoptera, hemoptera, orthoptera, thysanoptera, dermaptera, etc.

3. **Hemimetabolous** – incomplete metamorphosis in which accessory organs like gills are present in immature which is called naiads
   - naiads looks differently from adults which have wings and terrestial
   - naiads and adults are predatory but feed on different foods
   - stages are egg, naiad adult. Examples are: Odonata, Ephemeroptera, Plecoptera

4. **Holometabolous** – complete metamorphosis where all stages differ in appearance
   - the stages are egg, larva, pupa, adult. Examples are: Opidoptera, Coleoptera, Hymenoptera, Neuroptera, Diptera, etc.

ii. Stages in Metamorphosis

1. **Eggs** – all insects produces from eggs, which consists of the following:
   a. **Yolk** - supplies nourishment to the developing egg.
   b. **Vitelline membrane** – a sheath that covers the yolk
   c. **Chorion** – or shell which gives protection to the egg

d. **Micropyle** – consists of one or more very minute openings thru which the male sperm enters and fertilization takes place

e. **Operculum** – a lid or cap thru which the young escape

2. **Larva** – the young proceeding from the egg
   - Characterized as the growing feeding and developing stage that usually cover the longest period in the life cycle
   - The most damaging stage to the crop

Types of larvae

a. **Eruciform** – caterpillar-like
   - Body cylindrical, the head well develop but with very short antennae
   - With thoracic legs and abdominal prolegs
   - Examples are: lepidoptera, mecoptera and some hymenoptera

b. **Scarabeiform** – grub-like
   - Usually curved, the head well developed
   - With thoracic legs but no abdominal prolegs
   - Relatively sluggish and inactive
   - Examples are: Coleoptera (Scurabidae)

c. **Campodeiform** – resembling bristle tails in the genus Campodea.
   - Body elongated and somewhat flatteres
   - Cerci and antennae usually well developed
   - Thoracic legs well developed
   - Larvae usually active and predaceous
   - Examples are: Neuroptera, Coleoptera (Cocconelidae)

d. **Elateriform** – wireworm-like
   - Body elongated, cylindrical and hard shelled
   - The legs short and the body bristles reduced
   - Examples are: Coleoptera (Elateridae)

e. **Vermiform** – maggot-like
   - Body elongated and wormlike, legless
   - With or without well-developed head
   - Examples are: Diptea, Siphonaptera, most Hymenoptera and in some Coleoptera

3. **Nymphs** – the active developing stage in paurometabolous insects
4. **Pupa** – the resting (inactive/quiescent) or reorganization stage of holometabolous insects

Types of Pupa

- **Obtect**
  - With the appendages more or less glued to the body
  - Examples are Lepidoptera and some Diptera (Nematocera)
  - The pupa in many Lepidoptera is covered by a silken cocoon formed by the larva before it molts to the pupal stage.
- **Exarate**
  - With the appendages free and not glued to the body
  - Such pupa looks much like a pale, mummified adult, and is usually not covered by a cocoon.
  - Occurs in most insects except lepidoptera and some diptera.
- **Coarctate**
  - Essentially like an exarate pupa, but remaining covered by the hardened exuviae of the next to the last larval instar, which is called a puparium
  - Occurs in Diptera

5. **Adult or imago** – the final instar in the development of an insect in which all of the external characteristics are well defined
   - the internal systems fully matured or complete

D. Reproduction in insects

Insects reproduce in several ways:

1. **Bisexual reproduction** – both males and females are required.
   - Eggs will develop if fertilized by sperm
   - Most insects reproduce this way
2. **Parthenogenesis** – only females are required to reproduce the young
   - The egg will develop without fertilization (example aphids in the tropics)
   - In temperate areas, aphids undergo bisexual reproduction sometime in the year and parthenogenesis during summer months.
3. **Paedogenesis** – is a special type or an exceptional type of reproduction where the larvae of some hymenopterans are capable of reproducing

Most insects produce eggs and are called **oviparous**, the eggs are laid and left unattended to hatch. Some insects care or watch over their eggs against parasites and predators (example is rice black bug where she sit over the egg). Other insects produce live young and are called **viviparous** insects. Aphids during the parthenogenesis stage in the tropics are viviparous.

XVII. THE CONCEPT OF PEST

Pest

- are species whose existence conflicts with people's profit, convenience or welfare; Such organisms include principally certain insects, nematodes, bacteria, fungi, weeds, birds, rodents, or any terrestrial or aquatic plant or animal life.
- are living organisms causing economic harm to us and our resources (crops, animals, buildings, clothing and other properties)

A. Pest Classification

i. based on origin

a. **Exotic pest –** are those pests that are introduced from outside the locality

b. **Endemic pest –** are those pests that are local in origin.

ii. based on abundance or number

a. **Key or major pest** – are usually introduced (exotic pest)
   - Are always present in the field every season at a very high population
   - Are always causing economic damage
   - Usually do not have biological control agents because their natural enemies are left in their original place of origin.
   - Examples: rice stemborers, corn borer, green leafhopper, diamond back moth, mango hopper etc.

b. **Potential or minor pest** – are usually endemic species that are always found in the field at a low population
   - They do not cause economic damage because their populations are being controlled by many natural enemies
   - Examples: rice whorl maggot, rice skippers

c. **Occasional pest** – are usually strong fliers that cam migrate from one place to another
   - They came usually after a long drought
   - Examples: armyworms and cutworms, locusts

**Storage pests: classification according to number*

1. Major insect pest – are found frequently in abundance or in great number

Examples: rice weevils, flour beetle

2. Minor insect pest – are usually encountered in small number

iii. based on feeding habit

1. **Phytophagous insects (herbivores)** – feeding on living plants
   - **Leaf feeders** – Orthopterans, most larvae of Lepidoptera
   - **Leaf miners** – Agromyzid flies
   - **Stem and root borers** – Pyralid larvae and cerambycid larvae
   - **Root feeders** – root grubs, mole cricket
   - **Gall makers** – gall wasps
   - **Sap feeders** – leafhoppers, planthoppers, bugs, aphids
2. **Saprophagous** – feeding on dead organic matter
   - **General scavenger** – cockroaches
   - **Dung feeders** – scarabaeid beetles
3. **Mycetophagous** – feeding on fungus
   - **Fungus feeder** – mycetophagid beetles
4. **Zoophagous (carnivorous)** – feeding on living plants
   - **Parasites** – lives on other animals
     A. Living on warm-blooded animal – sucking lice
     B. Living on other insects – Hymenopterous wasps of family ichneumonidae, braconidae, etc.
     C. Blood feeders – mosquitoes
   - **Predators** – prey on other insects – ladybird beetle, water striders

B. <u>Insect Control Management</u>

i. Nature of insect damage

1. Direct damage – occurs when the insect pest causes visible harm to the host organism.
   A. Foliage feeders
   B. Sap feeders
   C. Stem borers/feeders
   D. Root feeders
   E. Stalk feeders
   F. Fruit feeders
2. Indirect damage – transmit plant, animal and human diseases

Economic Injury Level (EIL) – is defined as the lowest number of insect pest that will cause economic damage

Economic Damage – occur when the value of damage is greater than the cost of controlling the pests.

Economic Threshold Level (ETL) – also called **action threshold** which indicate the number of insect pest (density or intensity) that should trigger management activity to prevent from reaching the EIL.

ii. Integrated Pest Management (IPM)

– a strategy in combating pest using integration of many components: Varietal Resistance, Good Cultural and Sanitation Practices; Use of Biocon, Synchronous Planting, and Cropping Patterns, Crop Rotation, Use of Trap Crops, Attractants, Repellants and Insecticides.

1. **Varietal resistance** – crops have been bred for resistance to pests ; e.g. 15 rice varieties have increased level of resistant to borers, 9 varieties are resistant to BPH

2. **Sound cultural practices** - sanitation or removal of weeds, synchronous planting and crop rotation

3. **Biocon** – use of natural parasites, predators and parasites against pests
e.g. *Trichogramma evanescens* – parasitizes eggs of corn borer
T. chilonis – against cotton bollworm
T. japonicum – against rice stemborers
Bacillus thuringiensis – against corn borers, rice stem borer and DBM of cabbage
Diadegma semiclausum – against DBM in cabbage
Epidinocarsis manihoti – controls cassava mealy bugs

*detasseling of corn (leaving 2 rows intact for every 4 rows) before pollen shedding to control corn borers

4. **Use of trap crops and intercropping** – e.g. cabbage and tomato; white potato and corn
5. **Use of light traps, attractants** (female sex pheromones) against adult moths and potato weevil
6. **Use of vertebrate biological agents** – ducks against GAS and weeds
7. **Use of insecticides**

iii. Insecticides

Kinds of insecticides:

a. **Contact insecticides** – penetrates exoskeletons of insects; pose dangers to non-target and beneficial organisms (spiders)
b. **Systemic insecticides** – be applied on plants or to the soil in the presence of water in the soil

Classification of insecticides based on structure:

1. **Organochlorines or chlorinated hydrocarbons** – DDT, dieldrin, endrin, endosulfan, heptachlor, chlordane and lindane
DDT – most widely used insecticide ever manufactured; discovered by **Paul Mueller** of Geigy Chemical Company in Switzerland. It was banned in 1972 in the USA and other countries.
2. **Organophosphates** – These are esters of phosphoric or phosphorochloic acid which are nerve poisons – e.g. phosdrin, dimethoate, malathion, parathion. These chemicals are non-persistent in the environment and do not bioaccumulate.
3. **Carbamates** – similar to the organophosphates and are widely used in agriculture, forestry, health, verterinary practice and in the homes.– e.g. carbofuran (Furadan), aldicarb, carbaryl and pirimicarb
4. **Pyrethroids** – has a synthetic structure resembling natural pyrethrins derived from pyrethrum flowers which are relatively safe to the spray operators – eg. Permethrin, cypermethrin and bioremethrin
5. **Insect growth regulators** – juvenile hormones which was first elucidated in 1967 which kills insects by inhibiting the molting process or interfering with chitin synthesis. – e.g. methoprene, fenoxycarb, benzoylphenyureas, diflubenzuron and chlorfluazuron
6. **New classes of chemicals** – for control of arthropods – eevernectins, chloronicotinyls, pyrroles, phenypyrazoles and spinosyns.
7. **Botanical insecticides** – naturally existing compounds in plants which have insecticidal properties. Commercial products are extracted from plant sources.
Pyrethrum - from *Chrysanthemum cinerariaefolium* flower heads
Rotenone - from *Derris elliptica* or tubli
Nicotine - from *Nicotiana tabacum*
Azadirachtin – extracted from *Azadirachta indif*

XIII. PESTICIDES CALCULATION AND CALIBRATION OF APPLICATION EQUIPMENT

- These two activities are a "must" to complete the requirements of safe and effective application of pesticides in the field.
- When combined with proper selection of application equipment, the desired biological activity can only be achieved by correct pesticide calculations and calibrating the applicator that will be used for the application of a pesticide preparation in order to achieve the desired result.

A. Calibration of Application Equipment

Calibration is defined as the process of determining the amount of spray solution delivered by a specific equipment.

The following are the steps in the calibration of knapsack sprayer

1. Check the sprayer to make sure that there are no leaks, the nozzle is clear and the parts are in good condition.
2. Stake out a test area in the field
3. Place a known amount of water into the sprayer tank.
4. Established the spray swath.
5. Enter the test area and make the test run, spraying the area at the recommended pressure and speed.
6. After spraying the test area measure the length of the test area sprayed.
7. Calculate the application rate in liters per hectare:

$$\text{Area sprayed (ha)} = \frac{\text{Swath established} \times \text{Distance traveled (m)}}{10{,}000\ m^2}$$

$$\text{Application rate} = \frac{\text{Volume sprayed}}{\text{Area sprayed}}$$

Example: Spray swath = 4 m
Distance traveled = 40 m
Volume sprayed = 5.0 liters

$$\text{Area sprayed} = \frac{4 \times 40\ m}{10{,}000\ m^2} = 0.016\ ha$$

$$\text{Application Rate} = \frac{5.0\ liters}{0.016\ ha} = 313\ liters/ha$$

8. Next calculate the amount of pesticide needed in each sprayer load.

Example: You have a 10-liter sprayer and you want to apply 313 liters of spray solution/ha. You want to apply 0.5 kg ai of pesticide/ha and the formulated pesticide is 25 EC (25% emulsifiable concentrate)

a. First, calculate number of sprayer loads/ha

$$\text{Number of sprayer load/ha} = \frac{\text{liters of spray solution/ha}}{\text{sprayer capacity in liters}}$$

$$= \frac{313}{10}$$

$$= 31$$

b. Next, calculate the amount of commercial formulation to be applied/ha:

$$\text{Amount of commercial formulation to be applied/ha} = \frac{\text{rate in kg/ha}}{\text{\% ai in the formulation}} = \frac{0.5}{0.25} = 2.0 \text{ kg/ha}$$

c. Divide the amount of commercial formulation to be applied/ha by the number of sprayer loads/ha:

$$\text{Amount of commercial formulation to be applied/sprayer load} = \frac{\text{amount of commercial formulation}}{\text{number of sprayer load}}$$

$$= \frac{2.0}{31}$$

= 0.065 kg of the commercial pesticide formulation per sprayer load

Proper calibration of sprayers will ensure that pesticides are uniformly distributed and the crop is covered adequately. This will improve pest control and save money

B. <u>Pesticide calculations</u> – is the determination of the required amount of pesticide needed in a given area.

Simple conversion factors:
Area: 1 hectare (ha) = 10,000 square meters (m^2)
Weight: 1 kilogram (kg) = 1,000 grams (g)
Volume: 1 liter = 1,000 milliliters (ml)
1 gallon (gal) = 3.8 liters
1 tablespoon = 10 ml
To convert liter to % divide by 10
To convert pound (lb) US gallon to % multiply by 12
To convert lb imperial gallon to % multiply by 10

Information needed to calculate spray volume in liters per hectare:

a. size of sprayer (liters)
b. area of field (ha)
c. number of sprayer load
d.

Example: You have a 10-liter sprayer and you apply 6 loads to a 0.2 hectare field. What is your spray volume (liters/hectare) in the field?

Solution:

$$\text{Liter of Spray/ha} = \frac{\text{10 liters (size of the sprayer) x 6 loads}}{\text{0.2 ha}} = \frac{60}{0.2} = 300 \text{ liters/hectare}$$

To determine how many sprayerloads are necessary to achieve a certain spray volume (liters/ha), use the equation:

$$\text{No. of Loads} = \frac{\text{desired spray volume (liters/ha) x area of field (ha)}}{\text{size of sprayer (liters)}}$$

Example: You have a 10-liter sprayer, and wish to apply a spray at a rate of 250 liters/ha in a 0.4 ha field. How many spayerloads do you need to apply?

Solution:

$$\text{No. of loads} = \frac{250 \text{ (desired spray volume in liters/ha)} \times 0.4 \text{ ha (area of the field)}}{10 \text{ liters (size of the sprayer)}}$$

Calculation of rate when % concentration is known
Necessary information:

a. recommended rate (% concentration ai)
b. volume (liters of spray desired/treated area)
c. % ai in commercial formulation
d. area (ha) to be treated

Example: You wish to apply 320 liters of spray solution/ha to a 0.5 ha area. The recommended spray concentration of the 45% EC pesticide is 0.04%. How many liters of commercial formulation are required for the treatment?

Solution:

1. Calculate the amount of spray volume needed for the treated area = 320 liters x 0.5 ha = 160 liters

2. Calculate the amount of Commercial formulated Product

$$= \frac{\text{volume of spray required} \times \text{\% recommended spray concentration}}{\text{\% active ingredient in the formulation}}$$

$$= \frac{160 \times .04}{45}$$

$$= 0.142 \text{ liter}$$

3. Calculate the amount of Commercial material Per sprayer load

$$= \frac{\text{liters of commercial formulation} \times \text{capacity of sprayer (liters)}}{\text{amount of spray required (liters)}}$$

If you have an 8-liter sprayer:

$$= \frac{0.142 \times 8}{160}$$

$$= 0.007 \text{ kg}$$

Calculation of rate when recommendations are based on kg ai/ha
Necessary information:

a. recommended rate (kg ai/ha)
b. % ai in the formulation
c. area (ha) to be treated

Example: You wish to apply 320 liters/ha of spray solution to a 0.5 ha area. The recommended rate of the 70% wettable powder pesticide is 0.75 kg ai/ha. How many kilograms of the commercial formulation are required to treat the 0.5-ha area? What is the volume of spray needed for the treated area? How much materials are applied per sprayer load?

Solution:

1. Commercial Formulation (kg) $= \frac{\text{recommended rate (kg ai/ha)} \times \text{area to be treated (ha)} \times 100}{\text{\% ai in commercial formulation}}$

$$= \frac{0.75 \times 0.5 \times 100}{70} = 0.536 \text{ kg}$$

2. Volume of spray needed For the treated area $= 320 \text{ liters/ha} \times 0.5 \text{ ha}$

$$= 160 \text{ liters}$$

3. Amount of materials = Sprayerload (kg)

$$= \frac{\text{kg of commercial formulation} \times \text{capacity of sprayer (liters)}}{\text{Amount of spray required (liters)}}$$

If you have an 8-liter sprayer:

$$= \frac{0.536 \times 8}{160}$$

$$= 0.027 \text{ kg or } 27 \text{ g/sprayerload}$$

Applying pesticide granules
Necessary information:

a. recommended rate (kg ai/ha)
b. area to be treated (ha)
c. % ai in the granular formulation

Example: You wish to apply pesticide granules at a rate of 0.6 kg ai/ha to a 2-ha field. The granules contain 3 % ai. How many kilograms of commercial formulation are needed to treat this area?

Solution:

$$\text{Commercial Formulation (kg)} = \frac{\text{recommended rate (kg ai/ha)} \times \text{area to be treated (ha)} \times 100}{\%\text{ ai in commercial formulation}}$$

$$= \frac{0.6 \times 2 \times 100}{3}$$

$$= 40 \text{ kg}$$

COMMON INSECT ORDERS

Order	Type of Development	Type of Antenna	Mouth type or feeding organ	Type of wings	Other distinguishing Characteristics	Examples
Odonata	Hemimetabolous	Setaceous	Adult: Chewing, Naia: Chewing	Membranous	Long,slender abdomen, Compound eyes large, Occupying most of head	Dragonflies
Orthoptera	Paurometabolous	Filiform	Adult: Chewing, Nymph: Chewing	Tegmen, Membranous	Many with well-developed cerci and ovipositor, Jumping hindlegs, digging hindlegs	Grasshopper, crickets, mole crickets
Blattodea	Paurometabolous	Filiform	Adult: Chewing, Nymph: Chewing	Tegmen, Membranous	Body dorso-ventrally flattened pronotum shield-like walking/running legs	Cockroaches
Phasmatodea	Paurometabolous	Filiform or moniliform	Adult: Chewing, Nymph: Chewing	Tegmen, Membranous	Body: twig-like or leaf-like	Walking sticks Leaf insects
Mantodea	Paurometabolous	Filiform	Adult: Chewing, Nymph: Chewing	Tegmen, Membranous	Grasping forelegs	Preying mantids
Isoptera	Paurometabolous	Moniliform	Adult: Chewing, Nymph: Chewing	Membranous	2 pairs of similar wings	Termites
Dermaptera	Paurometabolous	Filiform	Adult: Chewing, Nymph: Chewing	Tegmen, Membranous	With a pair of forcep-like cerci Short wings	Earwigs
Hemiptera	Paurometabolous	Filiform or setaceous	Adult and Nymph: Piercing-sucking	Hemelytron (true bugs), Membranous		True bugs, cicada, leafhoppers, Aphids, Mealybugs
Thysanoptera	Paurometabolous	Filiform	Adult and Nymph: Rasping-sucking	Fringe	Minute, Slender-bodied	Thrips

COMMON INSECT ORDERS

Order	Type of Development	Type of Antenna	Mouthtype or feeding organ	Type of wings	Other distinguishing Characteristics	Examples
Lepidoptera	Holometabolous	Bipectinate or clavate	Adult: Siphoning Larva: Chewing	Scaly		Butterflies, Moths, Caterpillars
Coleoptera	Holometabolous	Lamellate	Adult: Chewing Larva: Chewing	Elytron, Membranous		Beetles, Grubs, Weevils
Hymenoptera	Holometabolous	Geniculate or filiform	Adult: Chewing Larva: Chewing	Membranous w/hamuli	Some with ovipositor modified into a string	Bees, Wasps, Ants
Diptera	Holometabolous	Aristate	Adult: Sponging(fly), Piercing-sucking(mosquito) Larva: Mouthhooks	Membranous, haltere		Houseflies, Mosquitoes, Maggots
Neuroptera	Holometabolous	Filiform or moniliform	Adult: Chewing Larva: Chewing	Membranous	Wings with many cross-veins	Antlions, Lacewings

MAJOR PEST OF IMPORTANT CROPS

CEREALS

RICE

1. **Green leafhopper** *(Nephotellix virescens/ Nephotellix nigropictus)* [Homoptera] – transmit tungro virus
2. **Brown planthopper** *(Nilaparvata lugens)* [Hemiptera] – causes "Hopperburn", transmits grassy (excessive tillering and stunted growth)and ragged stunt (ragged/twisted) virus
3. **Rice bug** *(Leptocorisa oratorius)* [Hemiptera]
4. **Stemborers** [Lepidoptera]: - "Deadheart symptom" of young leaves and growing point, "Whitehead" empty panicles
   a. Striped stem borer – *Chilo suppressalis*
   b. Yellow stem borer- *Scirpophaga incertulas*
   c. Pink stem borer- *Sesamia inferens*
   d. White stem borer – *Scirpophaga innotata*
5. **Golden apple snail** *(Pomacea canaliculata)* [Megastropoda]

CORN

1. **Asiatic corn borer** *(Ostrinia furnacalis)* [Lepidoptera]
2. **Corn semi-looper** *(Chrysodeixis chalcites)*
3. **Corn seedling maggot** *(Atheriogona oryzae)* [Diptera]
4. **Corn earworm** *(Helicoverpa armigera)* [Lepidoptera]
5. **Whitegrub** *(Leucopholis irrorata)* [Coleoptera]

STORED GRAINS

1. **Rice weevil** *(Sitophilus oryzae)* [Coleoptera]
2. **Corn weevil** *(Sitophilus zeamais)* [Coleoptera]
3. **Rice moth** *(Corcyra cephalonica)* [Coleoptera]

SUGAR CROP
SUGARCANE

1. **Root grub** *(Leucopholis irrorata)* [Coleoptera]
2. **Sugarcane dead heart borer** *(Tetramoera schislaceana)* [Lepidoptera]
3. **Yellow tip borer** *(Chilo infuscatellus)* [Lepidoptera]

VEGETABLE CROPS

Crucifers (pechay, cabbage, cauliflower, radish, etc)

1. **Diamond backmoth** *(Plutella xylostella)* [Lepidoptera]
2. **Cabbage worm** *(Crocidolomia binotalis)* [Lepidoptera]
3. **Cutworm** *(Spodoptera litura)* [Lepidoptera]

CUCURBITS (BOTTLE GOURD, AMPALAYA, SQUASH, PATOLA)

1. **Yellow squash beetle** *(Aulocophora similis)* [Coleoptera]
2. **Melon fruitfly** *(Bactrocera cucurbitae)*

SOLANACEOUS CROPS (TOMATO, EGGPLANT, PEPPER, ETC)

1. **Tomato fruitworm** *(Helicoverpa armigera)* [Lepidoptera]
2. **Tomato lady beetle** *(Epilachna vigintisexpunctata philippinensis*) [Coleoptera]
3. **Eggplant fruit and shoot borer** *(Leucinoides orbonalis)* [Lepidoptera]

MALVACEOUS CROPS (COTTON, OKRA, KENAF)

1. **Cotton stainer** *(Dysdercus cingulatus)* [Hemiptera]
2. **Cotton bollworm** *(Helicoverpa armigera)* [Lepidoptera]

LEGUMES (COWPEA, MUNGBEAN, SOYBEANS, BUSH SITAO)

1. **Beanfly** *(Ophiomyia phaseoli)* [Diptera]
2. **Aphids** *(Aphis craccivora)* [Homoptera]

3. **Bean pod borers** *(Marucca testulalis* and *Etiella zinckinella)* [Lepidoptera]
4. **Leaffolders** *(Homona coffearia)* [Homoptera]
5. **Leafhopper** *(Empoasca ricei)* [Homoptera]
6. **Bean Lycaenid** *(Euchrysops cnejus)* [Lepidoptera]

ROOTCROPS

1. **Sweet potato weevil** *(Cylas formicarius formicarius)* [Coleoptera]

FRUITCROPS

MANGO

1. **Leafhopper** (*Idioscopus niveosparus/Idioscopus clypealis*) [Hemiptera]
2. **Philippines fruitfly** *(Bactocera philippinensis)* [Diptera]
3. **Mango twig borer** *(Niphonuciea albata/ Niphonuciea capito)*

BANANA

1. **Banana leafroller** *(Erionatha thrax)* [Lepidoptera]
2. **Banana weevil** *(Cosmopolitus sordidus)* [Coleoptera]
3. **Abaca aphid** *(Pentalonia nigronervosa)* [Hemiptera]

COCONUT

1. **Asiatic palm weevil** *(Rhynchoporus ferrugineus)* [Coleoptera]
2. **Coconut rhinoceros beetle** *(Oryctes rhinocerus)* [Coleoptera]

COFFEE

1. **Coffee berry borer** *(Hypothenemus hampei)* [Coleoptera]
2. **Leaffolder** *(Homona caffearia)* [Lepidoptera]

CACAO

1. **Pachyrrynchid beetle** *(Pachyrrhynchus moniliferus)* [Coleoptera]
2. **Pink mealybugs** *(Planococcus lilacinus)* [Hemiptera]
3. **Cacao pod borer** *(Conopomorpha cramerella)* [Lepidoptera]
4. **Mosquito bugs** *(Helopeltis collaris/ Helopeltis bakeri)* [Hemiptera]

NATURAL ENEMIES

A. **Parasitoids** – includes organisms that require only one host to complete their life cycle. A parasitoid is usually smaller than the host (pest). It could either be an endoparasitoid (found inside the body) or ectoparasitoid (found outside the host body).

Ex. ***Trichogramma evanescens*** (Hymenoptera) – parasitizes eggs of the corn borer
Xanthopimpla stemmator (Hymenoptera) – parasitizes larvae of striped stem borer
Diadegma semiclausum/insulare **–** preys on diamondback moth (DBM)
Cotesia glomerata/ plutellae **(small dark colored wasps)-** preys on DBM, Asian corn borer

B. **Predators** – include organisms that feed on several prey (pest) to complete their life cycle.

Ex. **Coccinelid beetle** (Coleoptera): *Cheilomenes sexmaculatus* and *Micraspis discolor* – feed on aphids
Brown lacewing (Neuroptera): *Pseudomicromus igorotus* – feeds on aphids
Wolf spiders (Araneae): *Lycosa pseudoannulata*- preys on aphids, leafhoppers, planthoppers, larvae
Earwigs (Dermaptera): *Euborellia annulata* – preys on eggs, larvae and pupa of lepidopterans, coleopterans and dipterans.
Flower bug (Hemiptera): *Orius tantillus* – preys on eggs and larvae of lepidopterans
Preying mantids (Mantodea): *Tendora sp.* – preys on other insects

C. **Pathogens** – include microorganisms that cause disease on other organisms.

Ex. ***Metarrhizium anisophilae*** – a fungus that infects rhinoceros beetle grubs (pest of coconut)
Bacillus thuringiensis – a bacterium that produces toxins that kills larvae of diamond-back moth (pest of cabbage)

MAJOR WEEDS OF THE PHILIPPINES

SEDGE	COMMON NAME	MODE OF REPRODUCTION	LIFE CYCLE	ENVIRONMENT
Cyperus iria	rice flatsedge	sexual	annual	lowland
Cyperus difformis	flat flower umbrella plant	sexual	annual	lowland
Cyperus rotondus	purple nutsedge	asexual	perennial	upland

GRASS	COMMON NAME	MODE OF REPRODUCTION	LIFE CYCLE	ENVIRONMENT
Echinocloa colona	jungle rice	sexual	annual	lowland
Echinocloa crusgalli	barnyard grass	sexual	annual	lowland
Echinochloa glabrescens	barnyard grass	sexual	annual	lowland
Fimbristyllis littoralis	fimbristyllis	sexual	annual	lowland
Ischeamum rugosum	samoratta grass	sexual	perennial	lowland
Scirpus maritimus	bulrush	asexual	perennial	lowland
Paspalum distichum	knotgrass	asexual	perennial	lowland
Leptochloa chinensis	sprangletop	sexual	annual	lowland
Cynodon dactylon	bermuda grass	asexual	perennial	upland
Digitaria ciliaris	crabgrass	sexual	annual	upland
Rottboellia conchinchinensis	itchgrass	sexual	annual	upland
Paspalum flavidum	paspalidum	sexual	annual	upland
Imperata cylindrica	cogon	asexual	perennial	upland
Eluesine indica	goose grass	sexual	annual	upland

BROADLEAF	COMMON NAME	MODE OF REPRODUCTION	LIFE CYCLE	ENVIRONMENT
Ludwigia octovalvis	water purslane	sexual	annual	lowland
Monochoria vaginalis	pickerel weed	sexual	annual	lowland
Pistia stratiotes	water lettuce	asexual	perennial	lowland
Sphenoclea zeylanica	gooseweed	sexual	annual	lowland
Amaranthus spinosus	spiny amaranth	sexual	annual	upland
Amaranthus viridis	slender amaranth	sexual	annual	upland
Ageratum conyzoides	tropic ageratum	sexual	annual	upland
Bidens pilosa	beggarsticks	sexual	annual	upland
Euphorbia hirta	garden spurge	sexual	annual	upland
Cleome rutidosperma	spindle top	sexual	annual	upland
Commelina benghalensis	dayflower	asexual	perennial	upland
Commelina diffusa	spreading dayflower	asexual	perennial	upland
Vernonia cinerea	little ironweed	sexual	annual	upland
Portulaca oleracea	common purslane	sexual	annual	upland
Trianthema portulacastrum	horse purslane	sexual	annual	upland
Lantana camara	lantana	asexual	perennial	upland
Ipomea triloba	three-lobe morning glory	sexual	annual	upland
Mimosa pudica	senstive plants	asexual	perennial	upland
Chromolaena odorata	devilweed	sexual	perennial	upland

Review Questions in CROP PROTECTION

1. Among the invertebrates, only insects have this characteristics
   a. segmented body
   b. antennae
   c. wings
   d. 3 pairs of jointed legs
2. Where are the cerci located in insects?
   a. antennae
   b. thorax
   c. abdomen
   d. legs
3. Where are the wings found in insects?
   a. head
   b. thorax
   c. legs
   d. thigh
4. Where are the genitalia found in insects?
   a. antennae
   b. thorax
   c. abdomen
   d. hindleg
5. Where are the prolegs/pseudolegs located in caterpillars?
   a. thigh
   b. thorax
   c. abdomen
   d. pseudothorax
6. Which of the following encloses the stylets in insects with piercing-sucking mouth type?
   a. labium
   b. hypopharynx
   c. labrum
   d. epipharynx
7. Which of the following is not a characteristic of arthropods?
   a. radial symmetry
   b. exoskeleton
   c. jointed legs
   d. segmented body
8. This sensory organ is not found among insects
   a. mouthpart
   b. antennae
   c. chelicera
   d. eye
9. The first segment of the insect antenna is called
   a. scape
   b. pedicel
   c. flagellum
   d. clavola
10. The second segment of the insect antenna is called
    a. scape
    b. pedicel
    c. flagellum
    d. clavola
11. The shape of the majority of plant pathogenic bacteria is
    a. spherical
    b. rod
    c. helical
    d. filamentous
12. He developed the substage condenser for the microscope
    a. Leeuwenhoek
    b. Berkeley
    c. Abbe

d. Pasteur

13. He showed that fire blight of pear and twig blight of apple were caused by a bacterium
    a. Erwin Frank Smith
    b. Demetri Iwanowski
    c. Martinus Willem
    d. Thomas Jonathan Burrill
14. Which among the following does not belong to the five major genera of phytopathogenic bacteria
    a. Bacterium
    b. Xanthomonas
    c. Pseudomonas
    d. Erwinia
15. This part is not found in the cell envelope of a Gram positive bacteria
    a. inner cytoplasmic membrane
    b. outer membrane
    c. peptidoglycan layer
    d. periplasmic space
16. Antibiotic that interferes with peptidoglycan synthesis and prevents cell wall synthesis in growing bacterial cells
    a. kanamycin
    b. cycloheximide
    c. penicillin
    d. streptomycin
17. A bacterial surface appendage responsible for motililty
    a. cilia
    b. fimbrae
    c. flagella
    d. pili
18. This part is missing in mollicutes
    a. cell membrane
    b. cytoplasm
    c. cell wall
    d. ribosomes
19. Flagellation pattern characterized by the presence of a single flagellum
    a. peritrichous
    b. monotrichous
    c. ampitrichous
    d. polytrichous
20. Refers to the genetic material of bacteria
    a. hydrochloric acid
    b. ribonucleic acid
    c. phosphatidic acid
    d. deoxyribonucleic acid
21. A fungal mycelium appearing on rotten fruit is an example of
    a. symptom
    b. sign
    c. pathogen
    d. disease
22. Aflatoxin is formed by
    a. *Aspergillus flavus*
    b. *Aspergillus rhizopus*
    c. *Aspergillus scabies*
    d. *Aspergillus ipomeae*
23. Fungi in the Philippines reproduce mainly by forming
    a. sexual spores
    b. asexual spores
    c. mycelia
    d. endospores
24. Fungal pathogens are often isolated using this technique

a. serial dilution
b. tissue planting
c. spore trapping
d. Baermann funnel

25. Group of microorganisms that can directly penetrate the intact host surface
    a. fungi
    b. bacteria
    c. viruses
    d. viroids
26. A fungal structure used for attachment to the host surface
    a. penetration peg
    b. germ tube
    c. haustorium
    d. appressorium
27. Some fungal pathogens form this structure to obtain nutrients from the host
    a. germ tube
    b. sporeling
    c. infection hypha
    d. haustorium
28. In the absence of the plants in the field, fungal pathogens will not survive in
    a. plant debris
    b. soil
    c. seeds
    d. human beings
29. A characteristic of fungi
    a. eukaryotic
    b. prokaryotic
    c. chlorophyll bearing
    d. photosynthetic
30. The presence of different nuclei n the same mycelium is termed as
    a. heterotrophism
    b. hermaphrodite
    c. heterokaryosis
    d. heterothallism
31. Some nematodes serves as _____ and transmit plant viruses which contributes in disease development.
    a. predator
    b. Pathogens
    c. Vectors
    d. Parasites
32. For annual crops, the maximum number of nematodes parasites can be recovered during
    a. seedling stage
    b. flowering stage
    c. vegetable stage
    d. near harvest stage
33. This is the outer non-cellular layer covering the nematode body and is shed-off during molting
    a. Exoskeleton
    b. Endoskeleton
    c. Skin
    d. Cuticle
34. Refers to the possession of both functional male and female reproductive organ
    a. Amphimictic
    b. Hermaphroditic
    c. Parthenogenetic
    d. Oviviparous
35. The term for eggs hatching within the uterus followed by expulsion of living young
    a. Amphimictic

b. Oviparous
c. Parthenogenetic
d. Oviviparous

36. The casual organism of the root knot of most vegetables is
    a. *Plasmodiophora brassicae*
    b. *Meloidogyne incognita*
    c. *Radopholus similes*
    d. *Phytophythora infestans*
37. This does not a characterize a root-feeding nematode
    a. Feeds on roots, bulbs, and rhizome
    b. Possesses stylet
    c. Causes death of plants as a typical symptom
    d. Prefers sandy soil texture
38. Which among the following is not a type of root feeding nematodes
    a. Endoparasites
    b. Ectoparasites
    c. Semi-ecto/semi-endoparasites
    d. Necrotrophic parasite
39. Number of molting in plant parasitic nematodes
    a. 1
    b. 2
    c. 3
    d. 4
40. The infective stage of root knot nematode is during
    a. First stage juveniles
    b. Second stage juveniles
    c. Third stage juveniles
    d. Fourth stage juveniles
41. Which is not included in Koch's postulates?
    a. association
    b. isolation
    c. inoculation
    d. colonization
42. A yellowing caused by some factor other than light, such as by a virus or mycoplasma
    a. Necrosis
    b. Chlorosis
    c. Chlorophyllosis
    d. Mottling
43. Which of the following is a barrier to virus movement through the plant?
    a. Movement from the first infected cell
    b. Movement out of parenchyma cells into vascular tissues
    c. Movement out of the vascular tissue into the parenchyma of an invaded leaf
    d. Movement out of the stylet of the vector among epidermal cells of the plants
44. A seed with a virus is an important source of infection since the seed introduces
    a. The virus into the crop at a very early stage
    b. A concentrated foci of infection throughout the crop
    c. The virus into the crop at all stages of the crop
    d. The virus into the crop during its reproduction stage
45. The main components of plant viruses are
    a. DNA + glycoprotein + lipids
    b. simple protein + lipids
    c. DNA + protein + lipids
    d. either DNA or RNA + protein
46. Plant pathology is the study of ____.
    a. pests
    b. plant diseases
    c. weeds
    d. insects
47. He is considered the father of plant pathology.
    a. Heinrich de Bary
    b. Theophrastus
    c. Herodotus

d. Pliny the Elder

48. A blight pathogen will affect the plant's capacity to
    a. reproduce
    b. Photosynthesize
    c. replicate
    d. repair its cells
49. The Autogenetic Theory of Disease states that:
    a. Diseases are very infectious.
    b. Diseases are caused by 'germs" or microorganism.
    c. Pathogens are outgrowths of the disease and not the cause
    d. Disease is caused by unfavorable weather and infertile soil
50. Rye may induce this kind of affliction
    a. respiratory diseases
    b. Skin rashes
    c. St. Anthony's Fire
    d. Tetanus
51. The pest population density in which the cost of control is much higher than the expected cost of harvest of the protected crop
    a. Economic injury level
    b. Economic threshold level
    c. equilibrium level
    d. damage level
52. The man-directed control of insect pests by employing the use of natural enemies
    a. mechanical control
    b. cultural control
    c. biological control
    d. antibiosis
53. The term given for crop destruction, injury or loss of value caused by the feeding activity of different pests
    a. characteristic damage
    b. pest infestation
    c. threshold
    d. damage indicator
54. A kind of damage caused by the feeding of an insect through the removal of plant sap or plant parts in contrast with the damage caused by disease-transmitting insects
    a. indirect damage
    b. direct damage
    c. damage indicator
    d. action threshold
55. A biological control organism that usually lives inside the body of its host and consumes only one host to complete its life cycle
    a. parasite
    b. predator
    c. vector
    d. pathogen
56. The most destructive avian pest that attacks rice and other small grains
    a. Philippine weaver
    b. Philippine eagle
    c. Philippine oriole
    d. Philippine bird
57. A serious pest of corn that attacks all parts of the plant except the roots
    a. cutworm
    b. cornstalk borer
    c. corn semi looper
    d. corn borer
58. Synchronous planting is an example of
    a. mechanical control
    b. biological control
    c. chemical control
    d. cultural control

59. Mummification of fruits is an example of
    a. sign
    b. suscept
    c. symptom
    d. host
60. A diseased plant is considered a
    a. specimen
    b. parasite
    c. suscept
    d. abiotic
61. Which among the following does not describe what weeds are?
    a. unwanted
    b. harmful
    c. important
    d. out-of-place
62. Which among the following is not true about the characteristics of weeds?
    a. rapid vegetative growth
    b. reproduce efficiently
    c. not adapted to competition
    d. cause damage even at low densities
63. Weeds that originate from other areas and are introduced to the area where they are found
    a. endemic
    b. exotic
    c. native
    d. local
64. Weeds that grow and complete their life cycle under dry or wet condition of the soil
    a. lowland
    b. aquatic
    c. floating
    d. upland
65. Lowland weeds with their roots attached to the soil but the shoots are aerial/above-water
    a. submerged
    b. emerged
    c. loafing
    d. aquatic
66. Weeds that reproduce mainly through seeds, and grow within a year
    a. annuals
    b. simple perennials
    c. creeping perennials
    d. biennials
67. Weeds which are members of Family Gramineae
    a. sedges
    b. broadleaves
    c. grasses
    d. annuals
68. Weeds that belong to Family Cyperaceae
    a. sedges
    b. broadleaves
    c. grasses
    d. annuals
69. Weeds with rounded hollow stems and fibrous root system
    a. sedges
    b. broadleaves
    c. grasses
    d. annuals
70. Weeds with triangular stems and parallel leaf venation
    a. sedges
    b. broadleaves
    c. grasses
    d. annuals
71. A toxic substance which is readily available and kills pest instantly
    a. insecticide

b. pesticide
c. rodenticide
d. weedicide

72. A group of rodenticides that are slow-acting and are usually referred to as anti-coagulant rodenticides
    a. severe sterilants
    b. chronic rodenticides
    c. baits
    d. acute rodenticides
73. The ability of populations of pests to survive doses of an insecticide which are normally lethal
    a. insecticide resistance
    b. overdose
    c. insecticide threshold level
    d. insecticide mismanagement
74. An insecticide that is absorbed by and translocated in the plant and the insect acquire the poison through feeding
    a. contact insecticide
    b. stomach insecticide
    c. systemic insecticide
    d. surfactant
75. A liquid pesticide formulation that does not dissolve in water but is dissolved in organic solvents
    a. emulsifiable concentrates
    b. dust
    c. aqueous concentrates
    d. aerosols
76. A solid pesticide formulation applied undiluted where the active ingredient is combined with inert ingredients such as clay to form particles about the size of a coarse sugar
    a. dust
    b. water soluble powder
    c. wettable powder
    d. granule
77. Pesticide category symbolized by a red band and a skull and crossbones
    a. Category I
    b. Category II
    c. Category III
    d. Category IV
78. Which is not an expression of active unit in pesticide labels?
    a. percent
    b. g / kg
    c. ml or g/ liter
    d. ppm
79. A universally accepted name given a pesticide by an appropriate professional organization
    a. trade name
    b. common name
    c. proprietary name
    d. brand name
80. This is an effective seed treatment fungicide against corn downy mildew
    a. mancozeb
    b. metalaxyl
    c. captan
    d. benomyl
81. In the chewing type of mouthparts, this component cuts and grinds the food
    a. labrum
    b. mandible
    c. maxilla

d. labium

82. This body region bears the legs and wings of the insect
    a. head
    b. thorax
    c. abdomen
    d. cephalotorax
83. The basal segment of an insect leg
    a. trochanter
    b. tibia
    c. tarsus
    d. coxa
84. Termites have this type of antenna
    a. geniculate
    b. moniliform
    c. filiform
    d. lamellate
85. This type of antenna is found among scarabaeid beetles
    a. bipectinate
    b. clavate
    c. filiform
    d. lamellate
86. This elbow-like type of antennae is found among ants
    a. geniculate
    b. clavate
    c. lamellate
    d. plumose
87. An insect that feeds on a number of unrelated species of plants
    a. polyphagous insect
    b. phytophagous insect
    c. monophagous insect
    d. entomophagous insect
88. The collective term for parasitic and predatory insects
    a. polyphagous insect
    b. phytophagous insect
    c. monophagous insect
    d. entomophagous insect
89. The growth stage/s of the rice plant that is/are most preferred by the rice bug
    a. seedling stage
    b. soft dough stage
    c. milk stage
    d. both b and c
90. Substances such as sex pheromones that lure insects and can be used as a means of control
    a. anti-feedants
    b. repellants
    c. attractants
    d. chemo-sterilants
91. Protein synthesis occurs in _____.
    a. lysosomes
    b. ribosomes
    c. mesosomes
    d. chromosome
92. Bacteria cannot enter the plant through
    a. stomata
    b. hydathodes
    c. lenticels
    d. intact host surface
93. Published the first book on pytobacteriology "Bacteria in Relation to Plant Diseases"
    a. Thomas Jonathan Burril
    b. Erwin Frank Smith
    c. Charlotte Elliot

d. Martinus Willem

94. The main means of reproduction of bacteria
    a. Budding
    b. Binary fission
    c. Spore
    d. Transverse fission
95. The five-carbon sugar compound of DNA
    a. Ribose
    b. Maltose
    c. Deoxyribose
    d. Dextose
96. The building blocks of proteins is called
    a. fatty acids
    b. Nucleic acid
    c. Peptides
    d. Amino acid
97. Metabolic pathway that converts glucose to pyruvate
    a. Glycolysis
    b. Hydrolysis
    c. Gluconeugenesis
    d. Photosynthesis
98. A group of pathogens that infect a set of plant varieties
    a. Species
    b. Pathovar
    c. Race
    d. Blovar
99. A virus that infects bacteria
    a. Prophage
    b. Bacteriophage
    c. Baculovirus
    d. Macrophage
100. A microbial product other than an enzyme which causes obvious damage to plant tissues, and which is believed to be involved in disease development
    a. Phytoalexin
    b. Cutin
    c. Phytotoxin
    d. Suberin
101. An example of asexual spores is
    a. teliospores
    b. zygospores
    c. oospores
    d. conidia
102. The walls of fungi generally contain
    a. chitin
    b. glucan
    c. chitin and glucan
    d. pectin
103. He demonstrated that fungi are the cause and not the result of plant diseases
    a. de Bary
    b. Prevost
    c. Kuhn
    d. Burril
104. Fungi like *Aspergillus flavus* and *A. parasiticus* infecting cereal and legume seeds produce a carcinogenic toxin which is
    a. mycotoxin
    b. aflatoxin
    c. fumonisin
    d. tabtoxin
105. Which among the following phyla belongs to the kingdom of true fungi
    a. Oomycota
    b. Zygomycota
    c. Myxomycota
    d. Plasmodiophoromycota

106. Fungi belonging to Class Oomycetes are commonly called the
    a. rust fungi
    b. plasmodiophoroid fungi
    c. powdery mildew fungi
    d. downy mildew fungi
107. A known non-spore forming fungi is
    a. *Fusarium*
    b. *Aspergillus*
    c. *Rhizoctonia*
    d. *Pyricularia*
108. The asexual stage of fungi is also known as the
    a. pleomorph stage
    b. anamorph stage
    c. teliomorph stage
    d. holomorph stage
109. A fungus merely covering the surface of the plant without necessarily parasitizing it
    a. sooty mold
    b. slime mold
    c. powdery mold
    d. grey mold
110. Fungi that only reproduce asexually
    a. Ascomycetes
    b. Zygomycetes
    c. Deuteromycetes
    d. Basidiomycetes
111. Also known as the burrowing nematode and causes the toppling disease of banana
    a. *Meloidogyne incognita*
    b. *Radopholus similes*
    c. *Globodera pallida*
    d. *Criconomoides* sp.
112. Called the golden cyst nematode of Irish potato
    a. *Meloidogyne incognita*
    b. *Globodera pallida*
    c. *Radopholus similes*
    d. *Criconomoides* sp.
113. Which among the following is not a typical nematode disease symptoms
    a. Chlorosis
    b. Wilting during hot part of the day
    c. Reduction in the root system and root gall
    d. Leaf mosaic
114. Not a method of isolating plant parasitic soil nematodes
    a. Baermann funnel technique
    b. Sieving method
    c. Centrifugal flotation method
    d. Trapping technique
115. The following are insect vector of plant disease except
    a. Nematode
    b. Leafhoppers
    c. Thrips
    d. Aphids
116. Nematodes as plant pathogens were first observed by Needham in
    a. Tomato root knot
    b. Corn galls
    c. Wheat kernel galls
    d. Rice root knot
117. The kind of nematodes feeding only on root hairs and root tips
    a. Endoparasitic
    b. Ectoparasitic
    c. Sedentary
    d. Migratory
118. The kind of nematodes which move within the host tissues and/or between the soil and the host
    a. Sedentary endoparasites

b. Migratory endoparasites
c. Sedentary ectoparasites
d. Migratory endoparasites

119. The genera of nematodes which causes root knot
a. Hetemdera
b. Pratylenchus
c. Criconemoides
d. Meloidogyne

120. This is an example of foliar nematode
a. Ditylenchus
b. Meloidogyne
c. Pratylenchus
d. Hoplolaimus

121. He wrote the first textbook in Plant Pathology
a. Julius Kuhn
b. Franz Unger
c. Heinrich Anton de Bay
d. Pier Antonio mcheli

122. Submicroscopic entities which could pass through bacterial-proof filters are called
a. Viroids
b. mycoplasma
c. bacteria
d. virus

123. This refers to an organism which has the ability to be a parasite although it is ordinarily a saprophyte
a. pathogen
b. facultative parasite
c. obligate parasite
d. saprophyte

124. The expression of a diseased plant with certain characteristics
a. Symptoms
b. conditions
c. signs
d. indications

125. This refers to the pathogen associated with the infected plant
a. pathogen
b. facultative parasitic
c. obligate parasite
d. saprophyte

126. When a tomato plant has a root and stem rot disease, which leads to wilting, the wilting symptoms are classified as
a. Primary symptoms
b. Localized symptoms
c. Secondary symptoms
d. Systematic symptoms

127. The overdevelopment of plant cells, tissue or plant parts is called
a. hyperplastic symptoms
b. necrotic symptoms
c. local symptoms
d. systematic symptoms

128. This symptom is also called a lesion.
a. spot
b. blight
c. blast
d. hypertrophy

129. This refers to an extensive, usually sudden death of host tissue
a. Hypertrophy
b. Blast
c. Blight
d. Spot

130. The rotting of seedlings prior to emergence is termed
a. damping off
b. blight
c. blast
d. resetting

131. This may not cause disease in plants
a. abiotic factors

b. parasites
c. infectious agents
d. worms

132. Quiescent or latent infection is often associated with
a. soft rot diseases
b. die-back
c. blights
d. anthracnose

133. This is not a source of pathogen inoculum
a. soil
b. infected weeds
c. plant debris
d. uninfected plant

134. A group of substances secreted by pathogens that interfere with the permeability of protoplast membrane
a. enzymes
b. growth regulators
c. toxins
d. suppressors

135. The causal agent of mango anthracnose is
a. *Lasiodiplodia theobromae*
b. *Diplodia natalensis*
c. *Sphaceloma fawcetti*
d. *Colletotrichum gloeosporioides*

136. *Peronosclerospora philippinensis* is the causal agent of
a. corn downy
b. downy mildew of grapes
c. downy mildew of crucifer
d. downy mildew of cucurbits

137. The causal agent of corn rust is
a. *Uromyces phaseoli*
b. *Bipolaris maydis*
c. *Puccinia polysora*
d. *Ustilago maydis-zeae*

138. *Gibberella fujikuroi* is the causal agent of
a. rice blast
b. bakanae of rice
c. rice sheath blight
d. brown spot

139. The DA Special Order number which embodies the provisions on Integrated Pest Management
a. 492
b. 493
c. 494
d. 495

140. The year when the DA Special Order on Integrated Pest Management was signed
a. 1996
b. 1997
c. 1998
d. 1999

141. Weeds having expanded leaves with netted venation
a. sedges
b. broadleaves
c. grasses
d. annuals

142. The following are vegetative propagules except
a. seeds
b. tubers
c. rhizomes
d. off-shoots

143. Most weed seeds in the soil are found within the
a. upper 5 inches
b. upper 40 inches

c. upper 15 inches
d. upper 30 inches

144. The phenomenon when weed seeds fail to germinate even under favorable conditions
a. quiescence
b. dormancy
c. viability
d. longevity

145. The following are physical causes of weed seed dormancy except.
a. presence of inhibitors
b. thick hull
c. impermeable seedcoat
d. hard seedcoat

146. The mechanism which controls sprouting of *Cyperus rotundus* tubers that are attached to the mother plant
a. dormancy
b. quiescence
c. apical dominance
d. resistance

147. The stage of growth when the weed is most affected by weed control measures
a. seed stage
b. seedling stage
c. vegetative stage
d. reproductive stage

148. The following are means by which weeds are dispersed from one area to another, except
a. wind
b. water
c. fire
d. animals

149. Which among the following is not a weed dispersal unit?
a. leaves
b. seeds
c. tubers
d. stem cuttings

150. Described as the struggle between two or more plants for a limited resource
a. allelopathy
b. dispersal
c. interference
d. competition

151. The color band of highly toxic pesticides
a. blue
b. red
c. yellow
d. violet

152. The first organic herbicide that revolutionized chemical weed control
a. butachlor
b. gramoxone
c. 2,4-D
d. glyphosate

153. When was the first organic and selective herbicide developed?
a. 1930s
b. 1940s
c. 1950s
d. 1960s

154. The first organic herbicide belongs to what chemical family of herbicides?
a. phenoxys
b. diphenyl ethers
c. phenols
d. triazines

155. The general term used to describe any chemical used to control pests
a. herbicide

b. pesticide
c. fungicide
d. viricide

156. The inherent property of a herbicide to kill some plants but not other plants
a. resistance
b. toxicity
c. sensitivity
d. selectivity

157. The ability of some plants to survive a herbicide treatment that would normally kill other plants
a. resistance
b. toxicity
c. sensitivity
d. selectivity

158. The innate property of a chemical to produce harm
a. toxicity
b. hazard
c. selectivity
d. resistance

159. The risk of likelihood of an adverse effect due to exposure to a harmful chemical
a. toxicity
b. hazard
c. selectivity
d. resistance

160. The component of a pesticide which is responsible for its toxic effect
a. acid equivalent
b. active ingredient
c. inert ingredient
d. surfactant

161. The author of the milestone of Philippine Entomology is
a. Antonio S. Sedeno
b. Emiliana N. Bernardo
c. Julio C. Martinez
d. Bernardo P. Gabriel

162. He was the first Filipino to obtain a doctoral degree in entomology in 1922
a. L.B. Uichanco
b. L.B. Sanchez
c. G.O. Ocfemia
d. S.M. Cendana

163. The first monographic treatment of Philippine mosquitoes by Delfinado in 1966 included all genera except
a. Anopheles
b. Culex
c. Aedes
d. Malaria

164. This is the study of insects
a. entomology
b. entomophobia
c. entomologists
d. pathology

165. The earliest insect found during the Middle Devonian period, *Rhyniella praecursor*, belong to the insect order
a. Thysanura
b. Collembola
c. Protura
d. Diplura

166. The nearest relative of the class Insecta is
a. Class Crustacea
b. Class Chilopoda
c. Class Diplura
d. Class Diplopoda

167. When the mouthparts are directed anteriad, this is known as
a. prognathous
b. opisthognathous

c. hydrognathous
d. agnathous

168. The lateral sides of the middle segment of the insect thorax is known as
a. mesosternum
b. mesonotum
c. pleuron
d. mesopleuron

169. The ventral portion of the thorax and abdomen is known as
a. sternum
b. sternopleuron
c. sternites
d. pleurites

170. The part of the mouthparts without a palpus
a. Labium
b. mandibles
c. maxilla
d. all of the above

171. A general necrosis caused by the rapid growth and advance of the causal bacteria through leaves and stems
a. Wilt
b. Blight
c. Blast
d. Rot

172. It is the only genus of plant pathogenic bacteria that produces spores
a. Xanthomonas
b. Agrobacterium
c. Pseudomonas
d. Streptomyces

173. The pathogen that gained worldwide recognition especially during the 1960s because of its extreme effectiveness in controlling lepidopterous pests especially diamondback moth.
a. Fungi
b. Bacteria
c. Virus
d. Nematodes

174. Which among the following may be colonized by plant Pathogenic bacteria
a. Xylem
b. Phloem
c. Intercellular spaces
d. All of the above

175. The following are Gram negative bacteria except
a. Pseudomonas
b. Xanthomonas
c. Agrobacterium
d. Corynebacterium

176. The plant disease first shown to be caused by bacteria
a. Potato late blight
b. Rice bacterial blight
c. Fireblight of apples and pear
d. Taro blight

177. A disease caused by fastidious vascular bacteria
a. Citrus exocortis
b. Aster yellows
c. Cadang- cadang
d. Pierce's disease of grapes

178. The slimy, whitish secretion containing bacterial cells
a. Mycelium
b. Ooze
c. Gum
d. Sclerotium

179. Which is not a mechanism of bacteria penetration to the host?
a. Direct penetration
b. Through hydathodes
c. Through stomata
d. Through wounds

180. Which of the following is not a mechanism of variation in bacteria?
    a. Conjugationn
    b. Heterokaryosis
    c. Transduction
    d. Transformation
181. In a life cycle of a typical myxomycete, the myxamoeba are usually formed during
    a. dry condition
    b. humid condition
    c. hot condition
    d. sunny condition
182. The naming of newly discovered fungal species is based commonly on
    a. location
    b. host
    c. distinct structural character
    d. well-known mycologist
183. Non-parasitic fungi which are present on plant parts with deposit of insects, particularly aphids and scale insects
    a. downy mildew fungi
    b. powdery mildew fungi
    c. sooty mold fungi
    d. slime molds
184. Growth of germ tube towards hosts or substrates may be due to chemicals. This response is called
    a. thigmotropism
    b. phototropism
    c. chemotropism
    d. aerotropism
185. Phylogenetic classification of fungi is based on
    a. character sets
    b. ultrastucture features
    c. hyphal arrangement
    d. evolutionary relationship
186. A fungal insect parasite
    a. Metarrhizium
    b. Curvularia
    c. Gilmaniella
    d. Choanepora
187. The most common infectious agents of plant disease
    a. bacteria
    b. fungi
    c. nematodes
    d. phanerogams
188. Sigatoka is a fungal disease of what crop?
    a. mango
    b. banana
    c. citrus
    d. rice
189. This is the rice fungal disease that caused Bengal famine in 1943
    a. rice blast
    b. rice tungro
    c. brown spot
    d. sheath blight
190. The fungal disease which greatly affected the coffee industry of Batangas
    a. coffee rust
    b. twig blight
    c. Fusarium wilt
    d. Sclerotium rot
191. The mouthpart of a nematode that is inserted inside a plant cell thru which the plant juices are withdrawn and sucked
    a. Esophagus
    b. Digestiive gland

c. Stylet
d. pharynx

192. A disease which is aggravated by the presence of root knot nematode
a. Bacterial wilt of tomato
b. Bacterial pustule of tomato
c. Bacterial spot of tomato
d. Leaf mold of tomato

193. An isolation technique used to separate nematodes from the soil
a. Tissue planting technique
b. Pour planting
c. Dilution technique
d. Baermann funnel technique

194. The infective stage of cyst nematodes is
a. 1st juvenile stage
b. 2nd juvenile stage
c. 4th juvenile stage
d. Mature stage

195. Nematodes that move from plant to plant and only their stylet enter the plant cells are called
a. Sedentary ectoparasite
b. Sedentary endoparasite
c. Migratory ectoparasite
d. Migratory endoparasite

196. Eggs of rootknot nematodes are deposited
a. Inside the zone of elongation
b. Inside female body
c. Inside a gelatinous matrix
d. In the soil

197. Which of the following does not affect the completion of the life cycle of nematoodes?
a. Species
b. Host
c. Soil moisture
d. Temperature

198. When nematodes form disease complex with another pathogen, it usually
a. Predispose host to disease
b. Follow up disease formation
c. Act as vector
d. Cause disease alone

199. The only plant pathogen belonging to Kingdom Animalia
a. earthworms
b. nematodes
c. phanerogam
d. fruitfly

200. This is considered to be the most destructive nematode to worldwide Agriculture
a. *Xiphinema*
b. *Trichodorus*
c. *Meloidogyne*
d. *Radopholus*

201. The four rules of proof that are used in identifying certain plant diseases
a. the Central Dogma
b. Koch's Rules
c. Koch's Postulate
d. the disease Proofs

202. Conditions caused by inanimate agents are also called
a. symptoms
b. diseases
c. physiological disorders
d. maladies

203. Which characterizes viroids?
a. Ultramicroscopic, obligately parasitic entities that are made up of a nucleic acid core and a protein coat,
b. Tiny entities composed of stable and free ribonucleic acids that can infect plant cells.

c. Unicellular microorganisms that reproduce asexually by binary fission.
d. Non-motile, nonspore-forming, polymorphic microorganisms that lack cell walls and are bound by a triple-layered unit membrane.

204. These pathogens are commonly disseminated by insects
a. Ultramicroscopic, obligately parasitic entities that are made up of a nucleic acid core and a protein coat.
b. Tiny entities composed of stable and free ribonucleic acids that can infect plant cells
c. unicellular microorganisms that reproduce asexually by binary fission,
d. non-motile, non-spore-forming, polymorphic microorganisms that lack cell walls and are bound by a triple-layered unit membrane.

205. This refers to the sequence of events that leads to and is involved in the production of disease
a. Incubation
b. Disease
c. Disease cycle
d. Life cycle

206. This occurs when the pathogen has become established in the plant tissues and obtains nutrients from the host.
a. Infection
b. Disease
c. Disease Cycle
d. Life Cycle

207. Which of the following is now a survival structure?
a. Phanerogram seeds
b. Chlamydospores
c. sclerotial bodies
d. Spores

208. What is the term for the plant disease epidemics that occur throughout the world?
a. Pandemic
b. Endemic
c. Sporadic
d. Natural

209. Considered father of Philippine phytopathology and dean of Filipino plant pathologists
a. Gerardo Ocfemia
b. Dioscoro Umali
c. Leopoldo Ulchanco
d. Faustino Orillo

210. He invented the microscope
a. Robert Hooke
b. Louis Pasteur
c. H. Robert Kock
d. Anton de Bary

211. He was the first Filipino Acarologist who spearheaded the research on mites in the Philippines in 1961
a. F.F. Sanchez
b. C.R. Baltazar
c. L.C. Rimando
d. V.P. Gapud

212. The physical removal of insect pests from the infested plants is an example of
a. mechanical control
b. biological control
c. chemical control
d. cultural control

213. Includes all adverse effects exerted by the plant in the insects survival, development and reproduction
a. antibioisis
b. host evasion
c. tolerance
d. non-preference

214. Which of the following rice pests possesses chewing type of mouthparts during the destructive stage?
    a. green leafhopper
    b. rice bug
    c. stemborer
    d. brown planthopper
215. An insect which carries and transmits a disease -causing organism to a plant
    a. predator
    b. parasite
    c. vector
    d. symbionts
216. The causal agent of soft rot of vegetables is
    a. *Pseudomonas solanacearum*
    b. *Pectobacterium carotovorum*
    c. *Xanthomonas campestris pv. campestris*
    d. *Pseudomonas syringae pv. glycinea*
217. The causal agent of bacterial wilt of tomato is
    a. *Pectobacterium carotovorum*
    b. *Xanthomonas vesicatoria*
    c. *Ralstonia solanacearum*
    d. *Pseudomonas syringae pv. syringae*
218. The corn disease incited by Bipolaris maydis may be controlled by
    a. insecticides
    b. antibiotics
    c. fungicides
    d. miticides
219. A common symptom of diseases caused by fungi
    a. mosaic
    b. sarcody
    c. spot
    d. yellowing
220. The use of oil is a _____ type of method against insect pests
    a. physical
    b. cultural
    c. chemical
    d. mechanical
221. The effects of one plant on another plant due to the chemicals that it releases
    a. allelopathy
    b. dispersal
    c. interference
    d. competition
222. The term that collectively describes the effects of both competition and allelopathy
    a. interference
    b. harmful
    c. dispersal
    d. critical
223. The point during the life cycle of a crop when it most affected with the competition by weeds
    a. critical period of competition
    b. critical threshold level
    c. crop-weed competitive threshold
    d. density effect
224. The weed density, higher than which significant yield losses will be observed
    a. critical period of competition
    b. critical threshold level
    c. crop-weed competitive threshold
    d. density effect
225. The weed density and duration when the crop is most affected
    a. critical period of competition
    b. critical threshold level
    c. crop-weed competitive threshold

d. density effect

226. The process of decreasing weed population to minimize competition
    a. weed evaluation
    b. weed control
    c. weed science
    d. population management
227. The study of weeds and their control
    a. Weed Evaluation
    b. Weed Control
    c. Weed Science
    d. Population Management
228. Chemicals that are used to kill weeds
    a. weedicides
    b. insecticides
    c. herbicides
    d. fungicides
229. The world's worst weed based on distribution
    a. *Rottboellia cochinchinensis*
    b. *Amaranthus spinosus*
    c. *Cyperus rotundus*
    d. *Echinochloa crusgalli*
230. These genera of weeds resemble rice at its seedling stage
    a. Cyperus
    b. Eleusine
    c. Monochoria
    d. Echinochloa
231. The component of a pesticide that act as surface active agents
    a. acid equivalent
    b. active ingredient
    c. inert ingredient
    d. surfactant
232. The presidential decree number which created the Fertilizer and Pesticide Authority
    a. 1144
    b. 3256
    c. 1433
    d. 6454
233. The year when the FPA was promulgated
    a. 1975
    b. 1976
    c. 1977
    d. 1978
234. The color code of the least toxic pesticides
    a. yellow
    b. blue
    c. green
    d. red
235. Herbicides with the blue band belong to what category?
    a. 5
    b. 3
    c. 2
    d. 6
236. How many categories of pesticides are there based on toxicity?
    a. 4
    b. 5
    c. 6
    d. 7
237. The word 'CAUTION' is the signal word for what category of pesticides?
    a. 3
    b. 4
    c. 5
    d. 6
238. The chemical family to which 2,4-D belongs
    a. phenoxy
    b. dinitroanilines
    c. ureas

d. bipyridiliums

239. This group of insecticides inhibits the cholinesterase enzyme of insect pests
    a. IGRs
    b. chlorinated hydrocarbons
    c. carbamates
    d. microbial insecticides
240. Buthachlor or Machete EC belongs to this group of herbicide
    a. triazines
    b. ureas
    c. amides
    d. uraclis
241. The anteriomost vein of an insect forewing is
    a. jugum
    b. anal
    c. costa
    d. radial
242. The Pterygote insects include the following except
    a. Odonata
    b. Ephemeroptera
    c. Thysanura
    d. Orthoptera
243. *Nephotettix virescens* belong to the Suborder
    a. Hemiptera
    b. Homoptera
    c. Heteroptera
    d. Phthiraptera
244. The insect order characterized by having scales on its membranous wings
    a. Trichoptera
    b. Orthoptera
    c. Hymenoptera
    d. Lepidoptera
245. The third segment of the dorsal part of abdomen is
    a. T3
    b. t2
    c. te III
    d. t1
246. The injury caused by a "putakti" comes from this body region of the insect
    a. head
    b. thorax
    c. cephalothorax
    d. abdomen
247. The rips belong to this order
    a. Thysanoptera
    b. Trichoptera
    c. Termitidea
    d. Thripidae
248. Human louse's life cycle is
    a. paurometabola
    b. ametabola
    c. hemimetabola
    d. holometabola
249. Naiad is a part of this metamorphosis
    a. ametabola
    b. paurometabola
    c. hemimetabola
    d. holometabola
250. Nymph is a part of this metamorphosis
    a. ametabola
    b. paurometabola
    c. hemimetabola
    d. holometabola
251. Fungal pathogens that do not produce any spores
    a. Oidium and Cladosporium
    b. Rhzoctonia and Sclerotium
    c. Fusarium and Helminthosporium

d. Colletotrichum and Gloeosporium

252. Macroconidia and microconidia are formed by
   a. *Colletotrichum* spp.
   b. *Fusarium* spp.
   c. *Alternata* spp.
   d. *Cercospora* spp.

253. A character of hyphae that is found only in the basidiomycetous fungi
   a. Pseudpsepta
   b. Septal pore
   c. Cross walls
   d. Clamp connections

254. An ascocarp in fungi with a pore at the top and the wall of its own
   a. Apothecium
   b. Cleistothecium
   c. Pycnidium
   d. Perithecium

255. Which is not a district characteristic of Class Loculoascomycetes of fungi
   a. Ascocarp in ascostroma
   b. Monolocular ascostroma
   c. Asci in locules
   d. A single-walled ascus

256. Spores produced from fragmentation of hyphal cells
   a. Chlamydospores
   b. Arthrospores
   c. Catenate Culture
   d. Basidiospores

257. The primary reproductive structures of fungi are
   a. Filaments
   b. Mycelium
   c. Spores
   d. Fungus

258. The Formae specialis is a sub-specific classification of fungi, which is based on
   a. ability to attack different genera of crop plants
   b. ability to attack different variety or cultivars
   c. morphological characteristics of the fungus
   d. cultural characteristics of the fungus

259. Which among the following is not a fungi?
   a. Rusts
   b. Smuts
   c. Mushrooms
   d. Algae

260. Which is not a characteristic of true fungi?
   a. Eukaryotic
   b. No chlorophyll
   c. Cell wall composition is cellulose
   d. Majority non-motile, some have motile reproductive cell

261. This is the outer non-cellular layer covering the nematode body and is shed-off during molting
   a. skin
   b. exoskeleton
   c. cuticle
   d. endoskeleton

262. A feeding structure that distinguishes plant parasitic from non-plant parasitic nematodes
   a. denticles
   b. mural tooth
   c. stylet
   d. all of the above

263. Where are the eggs of root-knot nematode deposited?
   a. outside the root
   b. inside the root
   c. in the soil
   d. in a gelatinous matrix

264. The typical life cycle of *Meloidogyne incognita*

a. sedentary ectoparasite
b. sedentary endoparasite
c. migratory endoparasite
d. migratory ectoparasite

265. Which of the following is not typical of nematode injury to plants
a. mechanical damage to cells
b. death of cells
c. transmission of virus
d. death of plant

266. Plant parasitic nematodes are diagnosed by examining
a. leaves
b. stems
c. flower
d. soil and roots

267. What is the typical number of juvenile stages in the life cycle of a nematode?
a. 1
b. 2
c. 3
d. 4

268. These are nematodes which produce eggs that hatch after being laid
a. oviparous
b. ovoviviparous
c. parthenogonetic
d. hermaphroditic

269. Nematode species that require the presence of both male and females for reproduction to occur
a. amphimictic
b. ovoviviparous
c. parthenogonetic
d. hermaphroditic

270. Nematodes possessing both functional male and female reproductive organs
a. amphimictic
b. ovoviviparous
c. parthenogonetic
d. hermaphroditic

271. Author of the "Germ Theory of Disease"
a. Robert Hooke
b. Louis Pasteur
c. H. Robert Koch
d. Anton de Bary

272. Proposed "The Sun Spot Cycle Theory" in relation to locust outbreaks
a. Cendana
b. Uichanco
c. Capco
d. Ela

273. This is not a characteristic of plant viruses
a. Obligate
b. Nucleoprotein
c. Inhabit intercellular spaces
d. Transmissible

274. This is the component of plant viruses
a. RNA
b. DNA
c. Protein
d. All of the above

275. A disease caused by a plant viroid
a. Cadang- cadang disease of coconut
b. Tobacco mosaic
c. Peanut mottle
d. Citrus decline

276. This is not a morphological shape of plant viruses
a. Rigid rods
b. Branched filamentous
c. Bacilliform or bullet – shaped

d. Spheres in chains

277. Which among the following may transmit plant viruses
   a. Fungi and fungal – like organisms
   b. Insects and mites
   c. Nematodes and dodder plants
   d. All of the above

278. Which among the following are symptoms of a plant virus
   a. Moderate to severe dwarfing
   b. Leaf deformities
   c. Flower variegation
   d. All of the above

279. This is not a type of plant viruses according to persistence in their insect vector
   a. Non persistent
   b. Invasive viruses
   c. Circulative viruses
   d. Propagative viruses

280. This is not a method of plant virus diseases diagnosis
   a. Enzyme-linked immune-sorbent assay
   b. Use of indicator plants
   c. Culture of nutrient media
   d. Serology

281. Which of the following pests is not an arthropod?
   a. golden apple snail
   b. santol gall mite
   c. mango fruitfly
   d. cotton bollworm

282. *Bactrocera dorsalis* is a pest of this fruit crop
   a. eggplant
   b. mango
   c. watermelon
   d. tomato

283. A cultural practice against pest utilized to enhance the activities and survival of natural enemies
   a. trap crops
   b. habitat diversification
   c. biological control
   d. cultivation

284. The use of adhesive substance is a _____method used against pests
   a. cultural control
   b. physical control
   c. chemical control
   d. mechanical control

285. Early harvest is a _____type of control against pests
   a. cultural control
   b. physical control
   c. chemical control
   d. mechanical control

286. Cold storage could also be used against pests and is considered a _____method of control
   a. cultural control
   b. physical control
   c. Chemical control
   d. mechanical control

287. Water management can be categorized under all methods of control except
   a. cultural
   b. physical control
   c. chemical control
   d. mechanical control

288. IPM employs a variety of tactics, and the least type of method that could be used is
   a. cultural method
   b. HPR
   c. chemical method
   d. autocidal

289. A category of pest cause no significant damage under the conditions currently prevailing, however, this can be a key or occasional pest if conditions in the field are disrupted
    a. key
    b. potential
    c. occasional
    d. migrant
290. The term used for non-resident pests is
    a. key
    b. potential
    c. occasional
    d. migrant
291. This method involves manipulation of the cultural management practices to suppress the weeds
    a. mechanical
    b. chemical
    c. cultural
    d. none
292. Grassy weeds (Poaceae) locks similar to sedges except that their stem called culm is ___.
    a. Triangular
    b. Polyhedral
    c. Cylindrical
    d. Hexagonal
293. The hairy membranous outgrowth in between leafs heat and leaf blade in grasses is called
    a. Leaf blade
    b. Ligule
    c. Petiole
    d. Auricle
294. A weed considered as a true-parasite
    a. *Portulaca oleraceae*
    b. *Plantago major*
    c. *Cuscuta* sp.
    d. *Digitaria setigera*
295. This is an example broad-leaf weed
    a. *Impereta cylindrica*
    b. *Commelina benghalensis*
    c. *Cyperus rotundus*
    d. *Leersia hexandra*
296. This is an example of a grass weed
    a. *Digitaria setigera*
    b. *Cyperus kylingia*
    c. *Peperomia pellucida*
    d. *Portulaca oleraceaue*
297. Which among the following weed species is a perennial grass
    a. *Cenchrus echinatus*
    b. *Echinochloa colona*
    c. *Imperata cylindrica*
    d. *Rottboellia cochinchinensis*
298. Which among the following weed species reproduces by seed alone?
    a. *Commelina diffusa*
    b. *Chromolaena odorata*
    c. *Pistia stratiotes*
    d. *Synedrella nodiflora*
299. Which among the following weeds are spread easily by wind?
    a. *Echinochloa glabnescens*
    b. *Mimosa pudica*
    c. *Tridax procumbens*
    d. *Sphenoclea zeylanica*
300. Major weeds of crops deposited in the soil seedbank are estimated to be
    a. 1-5%
    b. 10-20%
    c. 50-70%
    d. 70-90%

301. An adjuvant or surfactants that improve absorption of herbicide by raising the humidity or spray film and leaf surface
    a. emulsifiers
    b. dispersing agent
    c. humectants
    d. fertilizer additives
302. A broad spectrum gaseous chemical used for management of plant parasitic nematodes that is thought to be damaging to the
    a. Metam-sodium
    b. Methyl bromide
    c. Carbanate
    d. All of the above
303. The discovery of DDT on this year is considered as one of the major event in the history of crop protection
    a. 1959
    b. 1935
    c. 1937
    d. 1939
304. A quick acting poison which cause death to rats shortly after ingestion.
    a. Acute poison
    b. Anticoagulant
    c. Chronic
    d. None of the above
305. Mode of action of insecticides?
    a. Strangulations
    b. Decapitation
    c. Neurotoxicant
    d. Scratching
306. A component of mycoherbicide
    a. Bacterial spores
    b. Eggs of nematodes
    c. Fungal spores
    d. Virus particles
307. Which of the following is a broad-spectrum chemical pesticide, which can be used for soil fumigation to kill insects, fungi and nematodes in the soil?
    a. Antibiotics
    b. Benzimidazoles
    c. Chloropicrin or tear gas
    d. Carbamates
308. The point of entry of a fumigant insecticide
    a. Integument
    b. Mouth
    c. Spiracles
    d. Tympanum
309. An example of organochlorine insecticide
    a. Chlordane
    b. Lannate
    c. Malathion
    d. Baygon
310. The following are botanical insecticides except
    a. Juvenoids
    b. Nicotinoids
    c. Pyrethroids
    d. Rotenoids
311. This pertains to the winged segments of the insect's thorax
    a. mesothorax
    b. prothorax
    c. Pterothorax
    d. cepalothorax
312. This functions as air storage of the insect's respiratory system
    a. atrium
    b. air sac
    c. valves
    d. taenidium
313. This functions to control the influx of air within the insect's respiratory system

a. taenidium
b. air sac
c. valves
d. atrium

314. This functions to guide the air flow within the insect's respiratory system
a. valves
b. taenidium
c. atrium
d. air sac

315. This is referred to as thickened tracheoles
a. atrium
b. taenidium
c. valves
d. air sac

316. This part of the digestive system functions as center of absorption in absorbing nutrients in the hemocoele
a. crop
b. anus
c. mouth
d. malpigian tubules

317. Cockroaches belong to this insect order
a. Phasmatodea
b. Ortho
c. Mantodea
d. Blattodea

318. This wing type belongs to Orthopterans
a. membranous
b. hemelytron
c. elytron
d. tegmen

319. Insects became pests because of
a. man
b. mouthparts
c. its voraciousness
d. sting

320. The type of metamorphosis for exopterygotes is
a. holometabola
b. ametabola
c. paurometabola
d. hemimetabola

321. This may be a part of a germinating conidium of a pathogenic fungus
a. Germ tube
b. Appresorium
c. Infection peg
d. All of the above

322. The colonization of plant tissues by hyphae could be
a. Intercellular
b. Intracellular
c. Inter- and intracellular
d. All of the above

323. This is not a sexual process in fungi
a. Paleontology
b. Plasmogamy
c. Karyogamy
d. Melosis

324. This is not a sexual spore of fungi or fungal-like organisms
a. Ascospore
b. Zygospore
c. Basidiospore
d. Melospore

325. The following are signs of fungal diseases except
a. Mycella
b. Ooze
c. Sclerotial bodies
d. Fruiting bodies

326. The majority of plant disease are caused by

a. Viruses
b. Fungi
c. Bacteria
d. Nematodes

327. The threadlike vegetative fungal structure
a. Ooze
b. Sclerotium
c. Mycelium
d. Exudates

328. Which is not a sign of fungi?
a. Sclerotia
b. Seeds
c. Hyphae
d. Spores

329. Which among these pathogens can directly penetrate intact hosts?
a. Bacteria
b. Fungi
c. Mycoplasma-like organisms
d. Virus

330. The following are fungal inocula except
a. Bacterial ooze
b. Rhizomorphs
c. Sclerotial bodies
d. spores

331. A phenomenon in nematodes when males and females have entirely different morphology
a. sexual mutation
b. sexual dimorphism
c. sexual evolution
d. sexual diversity

332. This category of chemicals has been traditionally used as control management against plant parasitic nematodes
a. fumigants
b. biocon
c. carbamates
d. mebendazoles

333. The practice of incorporating fresh plants or plant materials into the soil to control plant parasitic nematodes
a. biological control
b. mulching
c. biofumigation
d. organic fertilization

334. When the field is left unplanted for a certain period, the population of nematodes decreases because they are deprived of their plant hosts. This practice which also allows soil rejuvenation is called
a. sanitation
b. conservation
c. crop rotation
d. fallowing

335. This fungus is present in commercial products BIOCON and BIOACT which parasitizes *Radopholus similis,Rotelenchulus reniformis, Meloidogyne* spp.
a. *Rhizoctonia solani*
b. *Arthrobotrys oligospora*
c. *Paecilomyces lilacinus*
d. *Verticillium chlamydosporium*

336. What is the common pattern of nematode spatial distribution in the field?
a. uniform
b. patchy
c. random
d. cannot be determined

337. The most preferred site for root penetration of the infective stage of *Meloidogyne* spp. is the
a. root hair
b. root cap
c. zone of elongation
d. zone of differentiation

338. Plant parasitic nematodes generally prefer this soil texture
    a. clayey
    b. sandy
    c. silty
    d. muddy
339. Which life stage of the nematode will not be killed by a systemic nematicide?
    a. females feeding inside the root
    b. females feeding on the root surface only
    c. juveniles
    d. eggs
340. Some planting materials can be subjected to a hot water treatment to control nematodes that are possibly present. The following planting materials can be treated this way except
    a. banana corm
    b. rice seeds
    c. seed potato
    d. onion bulb
341. The concept that explains the step-wise evolution of virulence and resistance
    a. Hybridization
    b. Parasexual process
    c. Gene-for-gene
    d. Cytoplasmic
342. The plant pathogen present in Collego
    a. Cercospora
    b. Colletotrichum
    c. Curvularia
    d. Helminthosporium
343. The art of plant pathology which determines the severity and prevalence of diseases
    a. Disease monitoring
    b. Disease assessment
    c. Disease forecasting
    d. Disease diagnosis
344. The ultimate objective of plant pathology is to
    a. Minimize plant diseases
    b. Identify plant diseases
    c. Survey plant disease
    d. Measure plant disease
345. A correct diagnosis is a prerequisite to the
    a. Classification of diseases
    b. Disease incidence
    c. Formulation of control measures
    d. Disease development
346. Scientific studies in plant pathology began with the invention of the
    a. Compound microscope
    b. Electron microscope
    c. Lenses
    d. Fungicides
347. This is a proteinaceous infectious particle, in which its protein is encoded by a chromosomal gene of the host
    a. Virus
    b. Prion
    c. Viroid
    d. Mollicute
348. One of the following diseases is not due to viroid
    a. Potato spindle tube
    b. Tobacco mosaic
    c. Cadang-cadang
    d. Citrus exocortis
349. A kind of symptom that is a direct result of the causal agent's activities
    a. Secondary
    b. Localized
    c. General
    d. Primary

350. A kind of symptom that is distinct and very limited
    a. Systemic
    b. Localized
    c. General
    d. Primary
351. Pests that are focal point of pest management systems because their population equilibrium is always above the economic threshold level
    a. key
    b. potential
    c. occasional
    d. migrant
352. A type of pests that are only present part of the time
    a. key
    b. potential
    c. occasional
    d. migrant
353. Prediction technology is useful to prevent this pest's outbreak
    a. key
    b. potential
    c. occasional
    d. migrant
354. A modern approach to minimize damage by pests with ultimate goal of population management rather than eradication
    a. Integrated pesticide management
    b. integrated pest management
    c. Pest control strategies
    d. Biological control
355. A control method whereby synthetic toxic substances or bioactive plant products are used to combat pest population
    a. Use of resistant varieties
    b. Chemical control
    c. Cultural control
    d. IGR
356. An unwanted organism which competes with man for food and shelter or threatens their health comfort or welfare
    a. Pest
    b. Weed
    c. Insect
    d. Pathogens
357. The relative amount of heritable qualities in plants that influence the ultimate degree of damages by the pest
    a. Host plant resistance
    b. Tolerance
    c. Insecticide resistance
    d. Host evasion
358. A toxic substance which is readily available and kills pest instantly
    a. Insecticides
    b. Rodenticide
    c. Pesticides
    d. Weedicide
359. A vertebrate pest which is a perennial problem in crop production that usually demands a unified, coordinated and sustained community action to gain an effective control,
    a. Birds
    b. Rodents
    c. Snakes
    d. Snails
360. The symptom of stemborer damage during the reproductive stage of the rice plant characterized by the pale appearance of the unfilled grains
    a. Deadheart
    b. Wilting
    c. Whitehead
    d. False smut
361. Which among the following is sedge?
    a. Beggarstick
    b. Bulrush

c. Little iron weed
d. dayflower Spreading

362. The following are common bases of classifying weeds except
a. Gross morphology
b. Habitat
c. Growth habit
d. Anatomy

363. Itchgrass is the common name of
a. *Echinochloa colona*
b. *Eleusine colona*
c. *Echinochloa glabrescens*
d. *Rottboellia cochinchinensis*

364. The following are vegetative structure of a weed except
a. Flowers
b. Branches
c. Tillers
d. Leaves

365. Crop-weed interaction involves competition for these factors except
a. Light
b. Nutrients
c. Water
d. Vitamins

366. Allelopathic substances are equated to
a. Allelochemicals
b. Allosomes
c. Mesosomes
d. Allesomes

367. Weed occupies which trophic level?
a. 1st tropic level
b. 2nd tropic level
c. 3rd tropic level
d. 4th tropic level

368. The suspended growth of the embryo is due to propagule
a. Dormancy
b. Germination
c. Respiration
d. Photosynthesis

369. The physical form of dormancy is brought about by the presence of
a. Inhibitor in the seed coat
b. Inhibitors in the embryo
c. Immature embryo
d. Thick seed coat

370. The following are considered growth habit of weeds except
a. Tree
b. Vine
c. Shrub
d. Woody

371. Contact, stomach and fumigant poison are classification of insecticides based on
a. Mode of action
b. Mode of entry
c. Origin of the active ingredient
d. type of formulation

372. The insecticide that kills a wide array of insect pest species
a. Broad spectrum
b. Narrow spectrum
c. Specific
d. Aerobic

373. The fungicides that can be translocated to the different parts of the plant are also called
a. Contact fungicides
b. Localized insecticides
c. Non mobile insecticides
d. Systemic fungicides

374. How many square meters can a 50 ml of a 40% formulation be covered if the recommended rate is 700 g a.i. /ha?

a. 300.15 sq. m.
b. 250.75 sq. m.
c. 280.75 sq. m.
d. 285.71 sq. m.

375. Three kilograms of insecticide AB is required for the insect pest in a two hectare tomato farm. The recommended rate is half kilogram a.i./ha. What is the % a.i. formulation of the insecticide?
a. 30.33%
b. 33.33%
c. 31.33%
d. 32.33%

376. What is the percent concentration of an insecticide with 300 g thiamethoxam per kilogram of the formulated product and a recommended dosage of 3 g / 16 L of water?
a. 5%
b. 20%
c. 25%
d. 30%

377. How many sprayer loads which can hold up to 8 liters are required to spray the half hectare of the cabbage farm if the spray volume required is 320 L/ha?
a. 22.5
b. 21.5
c. 20.5
d. 20.0

378. The upperlimit of a recommendation for using an insecticide with active ingredient of 750g cyromazine per kilogram formulated product is 7 g / 16 L of water. If a farmer needed 150 L spray solution, how many kilograms of the insecticide should he use?
a. 1.066 kg
b. 0.567 kg
c. 0.066 kg
d. 0.0047 kg

379. How much insecticide CD with 40% EC is needed to cover 750 sq. m of mustard farm with the recommend rate of half kilogram a.i. /ha?
a. 1.0 L
b. 0.15 L
c. 0.1 L
d. 2.0 L

380. Broad spectrum fungicides which inhibit mitosis by preventing polymerization of beta tubulin, resistance risk is high.
a. Benzimidazoles
b. Triazoles
c. Phenylamides
d. Beta-methoxyacrylates

381. The type of metamorphosis for endopterygotes is
a. holometabola
b. ametabola
c. paurometabola
d. hemimetabola

382. From which character was the name "Arthropoda" derived?
a. segmentation
b. antennae
c. wings
d. jointed legs

383. Where would you least likely find insects?
a. South Pole
b. Caliraya lake
c. A rainforest
d. Cebu strait

384. Which of the following pests is not an Arthropod?
a. Asiatic corn borer
b. rice black bug
c. field rat
d. Cotton stainer

385. Which statement is not true of all insects?

a. they have antennae
b. they have three body regions
c. they have wings
d. they have three pairs of legs

386. A material used in pesticide formulation to counteract the chemical characteristics of a substance which may normally cause phytotoxic effects
a. carrier
b. diluent
c. spreader
d. safener

387. The setaceous type of antennae is found among
a. Butterflies
b. Dragonflies
c. Grasshoppers
d. Houseflies

388. The elbow-like type of antennae found among ants
a. Geniculate
b. Lamellate
c. Clavate
d. Plumose

389. Preying mantis use this type of forelegs to catch their prey
a. Grasping
b. Walking
c. Clinging
d. Digging

390. Headlice use this type of legs to anchor themselves on the host
a. Grasping
b. Walking
c. Clinging
d. Digging

391. The symptom characterized by perforations in leaf as lesions drop out
a. Shot hole
b. Leaf spot
c. Blight
d. Scab

392. The symptom characterized by sunken dead area with cracked border
a. Mottle
b. Canker
c. Mosaic
d. Rot

393. The symptom that shows dry or soft decomposition of tissues
a. Chlorosis
b. Mummification
c. Rot
d. Blight

394. The symptom that has pale or translucent veins
a. Vein-clearing
b. Vein-banding
c. mosaic
d. Wilting

395. The symptom characterized by an extensive necrotic area
a. Lesion
b. Spot
c. Blast
d. Blight

396. All of the following are symptoms except
a. Yellowing
b. Ooze
c. Galls
d. Etiolation

397. The identification of specific plant diseases through their characteristic symptoms and signs
a. Detection
b. Diagnosis
c. Control

d. Assessment

398. The non-parasitic agents of plant disease are characteristically
   a. Living
   b. Non-living
   c. Infectious
   d. Virulent

399. They are pleomorphic microorganisms without cell walls
   a. Bacteria
   b. Mollicutes
   c. Viroids
   d. Fungi

400. The usual means of spread of viruses in the field
   a. Fungi
   b. Insects
   c. Nematodes
   d. Bacteria

401. Diseased plant is a
   a. suscept
   b. host
   c. both a and b
   d. Pathogen

402. One of the functions of this agency is to quarantine
   a. UPLB
   b. FPA
   c. BPI
   d. IRRI

403. The regulatory method of insect control is closely related to this
   a. Cultural control
   b. Biological control
   c. Quarantine control
   d. Physical control

404. Education, quarantine, using certified planting materials, checking suspect materials before planting and cleaning equipment, are examples of what type of management
   a. Prevention
   b. Eradication
   c. Protection
   d. All of the above

405. Refers to the control of pest by living organisms under either natural or artificial environment
   a. Cultural Control
   b. Behavior Control
   c. Biological Control
   d. Autocidal Control

406. The kind of interaction between two organisms where both are adversely affected is called
   a. Competition
   b. Amensalism
   c. Parasitisrn
   d. Commensalism

407. Which of these are density-independent mortality factors?
   a. Parasites
   b. Food Supply
   c. Predators
   d. Drought

408. Legal actions intended to exclude potential pests and to prevent spread of those already present
   a. Eradication
   b. Suppression
   c. Containment
   d. Quarantine

409. Comprise the total complex of organism is a cropped area together with all aspects of the environment as modified by the activities of man,
   a. Ecosystem
   b. Agroecosystem
   c. Pathosystem
   d. Crop system

410. These pathogens are known to cause the cadang-cadang of coconut
   a. bacteria
   b. spiroplasma
   c. viroids
   d. mycoplasma
411. The following are classification of weeds based on gross morphology except
   a. Epiphytic
   b. Sedge
   c. Grass
   d. Broadleaf
412. The sedges possess the following traits except
   a. Triangular stem
   b. Parallel leaf venation
   c. Single cotyledon
   d. Hollow stem
413. Allelopathic substances include the following except
   a. Koline
   b. Marasmin
   c. Phytoncide
   d. Meristem
414. These structures are found in grasses except
   a. Ligule
   b. Node
   c. Internode
   d. Netted venation
415. The purple nutsedge is characterized by the
   a. Presence node
   b. Presence of ligule
   c. Hollow stem
   d. Presence of tuber
416. The almost pure material in the pesticide as it is first manufactured by the company before the formulation
   a. active ingredient
   b. acid equivalent
   c. toxicant
   d. technical material
417. The following are steps in the germination process except
   a. Inhibition
   b. Rapid metabolism
   c. Root emergence
   d. Shoot emergence
418. The underground vegetative propagule that can be used for weed propagation
   a. Seed
   b. Stolon
   c. Tuber
   d. Twig
419. Asexual reproduction of weeds is greatly affected by the following factors except
   a. Light
   b. Minerals
   c. Soil type
   d. Wind
420. An example of a weed dispersal agent
   a. Animal
   b. Rhizome
   c. Tuber
   d. Light
421. To reduce phytotoxicity, _____should be added to the fungicides
   a. Detergents
   b. Starch
   c. Oils
   d. Calcium carbonate
422. Water-soluble fungicides in powder form that contain inert diluents and wetting agent is classified as
   a. Granules

b. Wettable powders
c. Emulsifiable concentrates
d. Dusts

423. The type of herbicide (based on the time of application) that is considered most efficient against weed seedlings is___.
a. Preplant
b. post-emergence
c. preemergence
d. post-directed

424. This herbicide adjuvant reduces surface tension and thereby increases contact between spray droplets and sprayed surface is
a. Dispersing agents
b. Sticking agents
c. Spreading agents
d. Humectants

425. The number 3 from the Furadan 3G in the container label refers to the
a. weight of the inert material
b. Quantity of the active ingredient
c. recommended rate to use
d. Weight of the insecticide

426. A group of insecticides that seldom contains carbon
a. Organic insecticide
b. Flourides
c. Inorganic insecticide
d. Organophosphate

427. An example of carbamate insecticide is
a. Dipel
b. Sherpa
c. Sabidong
d. Sevin

428. Coumatetralyl or racumin is an example of
a. Acute poison
b. Anti-coagulant
c. Blanket system
d. Baiting
e. Botanical poison

429. Which statement is true for the volume of spray solution delivered?
a. increases with higher pressure
b. decreases with faster speed of travel
c. increases with larger nozzle size
d. all of the above

430. This characterizes the 2,4-D
a. non selective preemergence herbicide
b. selective post emergence herbicide
c. non selective contact herbicide
d. non selective systemic herbicide

431. In what type of insect development has the larval and pupal stage?
a. ametabolous
b. paurometabolous
c. hemimetabolous
d. holometabolous

432. The most problematic insect in crucifer plants.
a. common cutworm
b. Aphids
c. Diamondback moth
d. Cutworm

433. Which do not conform to the principle of entomology?
a. All insects have 3 pairs of legs
b. Not all insects have antennae
c. All insects are winged
d. All insects have 3 body regions

434. The term for the larval stage of the insects in the order Lepidoptera
a. Grubs
b. Pupa

c. Caterpillar
d. Immature stage

435. Leathery, horny and membranous part of the insect body is called
a. Mouth
b. Wings
c. Abdomen
d. Legs

436. This is the part of the insect body which is constricted with forcep like cerci.
a. Wings
b. Abdomen
c. Mouth
d. Legs

437. The forewing is leathery while the hind legs are modified for jumping.
a. Odonata
b. Ephemeroptera
c. Orthoptera
d. Phasmatodea

438. Has forewings that are highly sclerotized
a. Phthirhaptera
b. Strepsiptera
c. Coleoptera
d. Neuroptera

439. The order category in insect classification where most of the representative insects are natural enemies.
a. Coleoptera
b. Hemiptera
c. Diptera
d. Hymenoptera

440. Which of the types of insect development referred to as complete?
a. Paurometabolous
b. Hememetabolous
c. Ametometabolous
d. Holometabolous

441. Wide-scale appraisal of the severity and prevalence of disease in a country, a region, or a continent
a. Disease surveys
b. Disease diagnosis
c. Disease monitoring
d. Disease incidence

442. Stage in a disease cycle when the pathogen has become established in the plant tissues and starts to damage the host.
a. Colonization
b. Incubation
c. Infection
d. Penetration

443. Refers to the time from inoculation of the pathogen to the production of visible symptoms
a. Colonization
b. Incubation period
c. Infection
d. Latent period

444. The biotic factor at the inoculation site that may affect pathogen penetration
a. Antagonistic microorganisms
b. Temperature
c. Oxygen tension
d. Relative humidity

445. Which of the following pathogens are generally transmitted by insect vectors?
a. Bacteria
b. Fungi
c. Nematode
d. Virus

446. A soil that contains a variety of antagonistic microorganisms that produce toxic metabolites against the pathogen and cause pathogen starvation

a. Acidic soil
b. Basic soil
c. Favorable soil
d. Suppressive soil

447. The tumor inducing principle of *Agrobacterium tumefaciens*, the crown gall bacterium
a. Plasmid bluescript
b. Ri-plasmid
c. Ti-plasmid
d. Bacterial chromosome

448. A quiescent parasitic relationship which delays symptom expression but which may change into an active one.
a. Latent period
b. Latent infection
c. Incubation period
d. Cross protection

449. The usual effect of root rotting pathogen in pants is on the
a. Change in reproduction in the host
b. Increased transpiration
c. Interference with uptake of water and inorganic elements from the soil
d. Translocation of organic compounds through the phloem

450. The following are induced defences of the host in response to pathogen attack except
a. Formation of abscission layers
b. Hypersensitive reaction
c. Thick cuticle
d. Systemic acquired resistance

451. The formulation of this substance became among the foundation of chemical disease control of plant diseases.
a. fungicide
b. pesticides
c. Bordeaux mixture
d. benlate

452. Which of the following is not a definition of plant disease?
a. a physiological malfunctioning caused by animate objects
b. any deviation from normal growth or structure of plants that is sufficiently
c. a malfunctioning process caused by continuous irritation
d. any agent which causes a disease

453. The type of resistance the plant has if the insect exhibit abnormal development if not immediately killed after feeding.
a. None preference
b. Tolerance
c. Antibiosis
d. mechanical basis of resistance

454. The gestation period of rodents is
a. 25 days
b. 21 days
c. 30 days
d. 31 days

455. This type of pheromone ants have
a. Alarm pheromone
b. Dispersal phenomones
c. aggregation pheromones
d. Trail phermones

456. He first discovered viroid as causal agent of plant disease
a. Theodor Deiner
b. Y. Doi et al.
c. A.C. Goheen et al.
d. Berkeley

457. It causes bacterial wilt of tomato and other solanaceous crops, banana, and ginger in the Philippines
a. *Xanthomonas oryzae*
b. *Ralstonia solanacearum*
c. *Agrobacterium tumefaciens*
d. *Pectobacterium carotovorum pv carotovorum*

458. It causes common bacterial soft not of vegetables in the Philippines
   a. *Xanthomonas oryzae*
   b. *Ralstonia solanacearum*
   c. *Agrobacterium tumefaciens*
   d. *Pectobacterium carotovorum pv carotovorum*
459. It causes the bacterial leaf blight of rice
   a. *Xanthomonas oryzae*
   b. *Xanthomonas campestris*
   c. *Xanthomonas vesicatoria*
   d. *Xanthomonas yectonae*
460. It causes crown gall and is used in genetic engineering of plants
   a. *Xanthomonas oryzae*
   b. *Ralstonia solanacearum*
   c. *Agrobacterium tumefaciens*
   d. *Pectobacterium carotovorum*
461. The technical term for the presence of chloroplast in the vascular bundle sheath of efficient plants is called
   a. Krazy
   b. Krantz
   c. Kruntzy
   d. Krebz
462. The oldest form of weed control
   a. Biological
   b. Chemical
   c. Manual
   d. Mechanical
463. Efficient plants are characterized by the
   a. Absence of chloroplast in the vascular bundle
   b. Low light saturation point
   c. High light saturation point
   d. High water requirement
464. The type of competition existing between rice and jungle rice
   a. Intraspecific
   b. Interspecific
   c. Ultraspecific
   d. Extraspecific
465. Less efficient plants are known by the this characteristic
   a. Presence of chloroplast in the vascular bundle
   b. High light saturation point
   c. Low light saturation point
   d. High water requirement z
466. The only link between generations in sexually propagated weed
   a. Bulb
   b. Corn
   c. Seed
   d. Tuber
467. The most number of weeds belong to the plant family
   a. Asteraceae
   b. Cyperaceae
   c. Poaceae
   d. Convulvulaceae
468. The critical period of competition is generally about
   a. 1/5 of the crop life cycle
   b. ¼ of the crop life cycle
   c. 1/3 to ½ of the crop life cycle
   d. ¼ to 1/8 of the crop life cycle
469. Imbibition process involves absorption of
   a. Oxygen
   b. Nitrogen
   c. Water
   d. Light
470. In germination, the period of rapid metabolic activity is best characterized by
   a. Faster rate of reproduction
   b. Faster photosynthetic activity
   c. Faster rate of senescence
   d. Faster cell division and elongation

471. A post emergence herbicide is applied
    a. after land preparation
    b. after the weeds or crops have emerged
    c. after irrigation
    d. after harvest
472. Type of formulation in which the active material is readily dissolve in water but not in organic solvents
    a. aqueous concentrates
    b. emulsifiable concentrates
    c. flowables
    d. water soluble powders
473. In emulsifiable concentrates, these are being added to the organic solvents carrying the active material such that if the mixture is shaken with water, it will break up into small droplets that will remain dispersed in water to form an emulsion
    a. benzene
    b. xylene
    c. water
    d. emulsifying agents
474. Most pesticides are effective in very small quantities. A problem that consequently arise in using them is
    a. the cost per gram
    b. the size of sprayer to use
    c. the technique of applying small quantities evenly over large areas
    d. the nearest source of the pesticide
475. The following are auxillary materials mixed with the active component in the formulation process of pesticide, except one
    a. carrier
    b. diluents
    c. toxicant
    d. water
476. Identify which of the following choices is not an active component manufactured in the basic production of a pesticide
    a. active ingredient
    b. toxicant
    c. technical material
    d. surfactant
477. In pesticide preparation, this is the written material or graphic design printed on the container of the pesticide. This is considered a legal document which requires a government approval.
    a. bar code
    b. manufacture date
    c. color band
    d. pesticide label
478. Why is it that in water soluble powders (WSP) pesticide formulation, the active material is finely ground into a powder form?
    a. to increase the total weight
    b. to reduce the container size needed
    c. to increase the rate in which it will dissolve in water
    d. to increase the application rate per minute
479. This pesticide formulation is a suspension of a milky liquid in which the powder is suspended in water in the presence of a dispersing agent.
    a. water soluble powders (WSP)
    b. wettable powders (WP)
    c. fumigants
    d. flowables
480. Some pesticides are seldom formulated as Dusts because of this problem
    a. cost per gram
    b. high toxicity
    c. respiratory problems
    d. drift problem
481. Which of the following inset order is wingless
    a. Lepidoptera
    b. Isopteran
    c. Anoplura

d. Coleopteran

482. Which of the following insect species is commonly used in genetics studies
   a. *Chiconomoides* sp.
   b. *Drosophila melanogaster*
   c. *Arabidopsis thaliana*
   d. *Agrobacterium tumefaciens*
483. Which insect has siphoning mouthparts
   a. Grass hoppers
   b. Aphids and bugs
   c. Skippers
   d. Bees
484. Identify the item that does not belong to the group
   a. Thorax
   b. Abdomen
   c. Tympanum
   d. Head
485. Refers to the theoretical yield of parent acid from the active ingredient content of pesticide formulation
   a. acid equivalent
   b. technical material
   c. toxicant
   d. emulsifier
486. Which among the following orders have social habits
   a. Odonata
   b. Coleopteran
   c. Lepidoptera
   d. Hymenoptera
487. The breathing organ of insect is
   a. Tympanum
   b. Circus
   c. Ecdysis
   d. Spiracles
488. Which is a major or key pest of mango?
   a. Black bug
   b. Leafhopper
   c. Seedling maggot
   d. Brown planthopper
489. Which of one of the following is not due to insect damage?
   a. Annoyance
   b. Miyasis
   c. Disorientation
   d. Vectors of plants/animal diseases
490. Insect mouthpart that is not generally causes damage to plants
   a. Piercing sucking
   b. Chewing
   c. Siphoning
   d. Sponging
491. The rapid death of cells immediately surrounding the point of infection thereby walling-off the pathogen and the activation of a cascade of biochemical reactions in the attacked and surrounding plant cells
   a. Hypersensitive response
   b. Oxidative burst
   c. Phytoalexin production
   d. Systemic acquired resistance
492. Toxic antimicrobial substances produced in appreciable amounts in plants only after stimulation by various types of phytopathogens or by chemical or mechanical injury
   a. Antibiotics
   b. Elicitors
   c. Phytoalexins
   d. Tooxins
493. A non-specific or generalized resistance that spreads systematically and develop in distal untreated parts of the plant after the plant has been challenged by the pathogen
   a. Durable resistance
   b. Hypersensitive response

c. Race-specific resistance
d. Systemic acquired resistance

494. The study of the increase of disease in a population and the factors that influence them
a. Demography
b. Epidemiology
c. Plant pathology
d. Phytobacteriology

495. Which of the following is not a component of an epidemic?
a. Avirulent pathogen
b. Favorable environment
c. Man as manager of the system
d. Susceptible

496. A plant disease epidemic would most likely develop in this situation
a. Mature plants
b. Monoculture
c. Planting multilines or mixtures
d. Trees in tropical rain forest

497. Plant disease epidemic would less likely develop in this situation
a. Dense planting
b. Planting multilines or mixture
c. Lenient quarantine regulations
d. Prolonged or repeated high moisture

498. Substances produced by one microorganism that are toxic to another microorganism
a. Antibiotics
b. Copper compounds
c. Fungicides
d. Growth regulators

499. A tool that unlocks the door to identification of an unknown organisms
a. Key
b. Nomenclature
c. Systematics
d. Taxonomy

500. The following are characteristics of a parasitoid except
a. Kills host gradually
b. Lives inside or outside the host
c. Bigger that its host
d. Requires one host to complete development

501. It causes coffee rust
a. *Peronosclerospora philippinensis*
b. *Hemeleia vastatrix*
c. *Magnaporthe grisea*
d. *Colletotrichym glocosporoides*

502. It causes rice blast
a. *Peronosclerospora philippinensis*
b. *Hemeleia vastatrix*
c. *Magnaporthe grisea*
d. *Colletotrichym glocosporoides*

503. The common cause of damping-off of vegetables in the Philippines
a. *Pythium* spp.
b. *Phytopthora*
c. *Bipolaris maydis*
d. *Fusarium moniliforme*

504. It transmits the grassy and rugged stunt virus
a. *Nephotettix virescens*
b. *Nephotettix nigropictus*
c. *Nilaparvata lugens*
d. *Nilaparvata nigropictus*

505. A major pest of eggplant
a. *Epilachna philippinensis*
b. *Leucinodes orbinalis*
c. *Dysdercus cingulatus*
d. *Helicoverpa armigera*

506. Also known as Asiatic palm weevil, the adults bore through cabbage while the legless larvae feed on the soft bud of the coconut resulting on the destruction of the whole crown.

a. *Cosmopolites sordidus*
b. *Erionata thrax*
c. *Rhynchophorus ferrugineus*
d. *Oryctes rhinoceros*

507. Sheath blight of rice and corn is caused by
a. *Helminthosporium maydis*
b. *Rhizoctonia solani*
c. *Cercospora cruenta*
d. *Cercosporidium personatum*

508. Sweet potato is the host plant of *Cylasformicarius* commonly known as
a. Sweet potato weevil
b. Sweet potato sphinx moth
c. Sweet potato fly
d. Gabi sphinx moth

509. This control method requires host specificity to be effective
a. physical
b. Biological
c. Chemical
d. Cultural

510. Good recommendation against golden kuhol
a. Water management
b. Water management
c. Removal of weeds
d. All of the above
e. None of the above

511. The structure that facilitates efficient dispersal of aquatic weed
a. Periderm
b. Pericarp
c. Meristem
d. Pericardium

512. The allelopathic substance produced by plants which are effective against another plant
a. Antibiotic
b. Koline
c. Marasmin
d. Phytoncide

513. The weed control strategy which involves the use of mycoherbicide
a. Cultural
b. Mechanical
c. Manual
d. Biological

514. The term allelopathy came from the Greek words
a. Lello and pathos
b. Pathy and allelon
c. Allelon and pathos
d. Allela and pathos

515. The specific chemical intended for weed control is
a. Acaricide
b. Insecticide
c. Herbicide
d. Molluscicide

516. Exposure of weed seeds to low temperature to overcome dormancy
a. Stratification
b. Scarification
c. Mineralization
d. Germination

517. Which of the following is not an example of phanerogam?
a. Witchweed
b. Broomrape
c. Dwarf mistletoe
d. Goosegrass

518. A grassy weed capable of producing contractile roots and arrested shoot growth when subjected to extremely dry condition
a. itch grass
b. large crab grass
c. spiny amaranth

d. water lettuce

519. This is the vegetative propagule that allows reproduction of *Pistia stratiotes*
   a. off shoot
   b. shoot
   c. rhizome
   d. tuber

520. Some of the benefits that animals can derive from weeds is
   a. food and cover for wildlife
   b. hostplant to pathogens
   c. source of prohibited drugs
   d. competition with nutrient sources

521. This pesticide formulation usually contain 4 – 10 % active ingredient and are applied in dry form
   a. Dusts
   b. granules
   c. fumigants
   d. flowables

522. In this pesticide formulation, the active ingredient is in dry solids or liquids which upon mixture with another substance will liberate the toxic material in the form of gas,smoke or finely divided particles.
   a. Dusts
   b. granules
   c. fumigants
   d. flowables

523. In this pesticide formulation, the active ingredient is suspended in a container under pressure
   a. aerosols
   b. granules
   c. fumigants
   d. flowables

524. In the preparation of the active materials in a pesticide, which among the following characteristics are being considered and altered to achieve stability of the chemical
   a. solubility
   b. volatility
   c. toxicity
   d. all of the above

525. In pesticide formulation, this material is used to facilitate creeping or spreading over a surface so that the area covered id increasingly greater
   a. spreader
   b. sticker
   c. surfactant
   d. carrier

526. In pesticide formulation , this material can be a gas, liquid or solid substance used to dilute, propel, or suspend an active material during application
   a. spreader
   b. sticker
   c. surfactant
   d. carrier

527. Refers to the material in the pesticide mixture which would not prevent damage or destroy pests if used by itself
   a. safener
   b. inert ingredient
   c. active ingredient
   d. carrier

528. The following, except one, are functions of a deflocculating agent when added into a pesticide mixture
   a. to prevent flocculation
   b. to assure dispersion
   c. to increase per unit cost
   d. to regard settling of a slid within a liquid

529. This adhesive material increases the tenacity of substances in the pesticide mixture
    a. sticker
    b. spreader
    c. emulsifier
    d. surfactant
530. Refers to the material in the pesticide mixture which improves the emulsifying,dispersing,spreading,wetting or other surface modifying properties of liquids
    a. sticker
    b. spreader
    c. emulsifier
    d. surfactant
531. The process by which an insect accommodates growth
    a. Stretching of skin
    b. Ecdysis
    c. Metamorphosis
    d. Miyasis
532. The part of the mouthparts without a palpus
    a. Labium
    b. Maxilla
    c. Mandibles
    d. None of the above
533. The thrips to this order
    a. Embiina
    b. Megatoptera
    c. Trichoptera
    d. Thysanoptera
534. Termites have this type of mouthparts
    a. Chewing-sucking
    b. Piercing-sucking type
    c. Sponging type
    d. Siphoning type
535. Thysanopterans have this type of mouthparts
    a. Piercing-sucking
    b. Sucking
    c. Rasping-sucking
    d. Chewing lapping
536. Adult moths and butterflies have this type of mouthparts
    a. Chewing type
    b. Siphoning type
    c. Sponging type
    d. Chewing lapping type
537. Bees and wasps have this type of mouthparts
    a. Chewing type
    b. Siphoning type
    c. Sponging type
    d. Chewing lapping type
538. These are elongated, segmented structures of varying designs and are used for sensory purposes
    a. Ocell
    b. Tympanum
    c. Thorax
    d. Antennae
539. The characteristics mode of life of a species or its place in the environment, its relation to food, enemies, etc.
    a. Oviparity
    b. Insect ecology
    c. Habitate
    d. Niche
540. Insects belonging to this order are short-lived and die in 1-2 days
    a. collembolla
    b. diplura
    c. odonata
    d. ephemeroptera
541. A mechanism of insect resistance that is described as refractory to guests
    a. Anitibiosis

b. Antixenosis
c. Diagnosis
d. Tolerance

542. This is an example of an egg parasitoid
a. *Corcyra cephalonica*
b. *Hippotion celerio*
c. *Menonchilus sexmaculatus*
d. *Trichogramma chilonis*

543. The time over which the pathogen fruiting body or lesion continues to produce new inoculum
a. Incubation period
b. Dormant period
c. Infectious period
d. Latent period

544. Its quality, intensity, and duration affect the growth of both host and the pathogen
a. Wind
b. Light
c. Moisture
d. Nutrition

545. A group of pathogens that infect a set of plant varieties
a. Species
b. Pathovar
c. Race
d. Blovar

546. Abscission layer is an example of
a. Passive defense structure
b. Active defense structure
c. Historical defense structure
d. Intermediate defense structure

547. What is wax in plant leaves for?
a. Active defense
b. Inducible defense
c. Passive defense
d. All of the above

548. What is the molecular weight of the RNA of viroids?
a. 10,000,000
b. 1,000,000
c. 110,000
d. 111,000

549. A type of parasitoid that develop in or on non-parasitic host
a. Parasite
b. Pathogen
c. Primary parasitoid
d. Hyperparasitoid
e. Secondary parasitoid

550. An area that includes all organisms there in and their physical environment
a. Ecology
b. Ecosystem
c. Environment
d. Demography

551. The following are examples of cultural methods except
a. Choice of variety
b. Flooding
c. Mulching
d. Use of rotary weeder

552. Moldy grains that are discolored and carry-off odors suffer a reduction in
a. Quantity
b. Quality
c. Loss
d. Disease

553. The disease first reported to be caused by mycoplasma-like organisms in Japan
a. Peach yellows
b. Aster yellows
c. Cadang-cadang

d. Corn stunt

554. One of the first plant diseases studied in the Philippines
   a. Wheat rust
   b. Rice bacterial blight
   c. Coffee rust
   d. Bacterial wilt

555. The cause of coconut bud rot is
   a. *Pythium ultimum*
   b. *Sclerotium rolfsii*
   c. *Rhizoctonia solani*
   d. *Phytophthora palmivora*

556. Corn downy mildew disease was completely controlled in 1978 by
   a. Chemical seed treatment
   b. Hot water treatment
   c. Burning
   d. Sanitation

557. A harmful alteration of the normal physiological and biochemical development of a plant.
   a. Injury
   b. Disease
   c. Pathogenesis
   d. Colonization

558. A symptom characterized by a sharply defined variegated pattern
   a. Mottle
   b. Mosaic
   c. Chlorosis
   d. Etiolation

559. The structure of the pathogen that are found associated with the infection host
   a. Symptoms
   b. Spores
   c. Mycelia
   d. Signs

560. A kind of symptoms involving the death of protoplasts, cells, or tissues
   a. Necrotic
   b. Hyperplastic
   c. Hypertrophic
   d. Histological

561. This weed is toxic to animals because of the diarrhea it can cause when ingested
   a. *Chromolaena odorata*
   b. *Pistia stratiotes*
   c. *Cyperus rotundus*
   d. *Elusine indica*

562. Water lettuce is considered an "evergreen" or a perennial weed reproducing by this vegetative propagule
   a. stolon
   b. off shoot
   c. rhizome
   d. tuber

563. Seed dispersal through water runoff is common among weeds mainly because
   a. there are many water bodies in the country
   b. seeds are light weight and possess film enabling them to float
   c. seeds are impermeable to water
   d. many areas have high precipitation

564. In weeds-crop association, allelophaty causes
   a. the weeds to grow taller than the crop
   b. the crop to be a stronger competitor for space
   c. the weeds to secrete substances that may stimulate or retard the growth of the associated crop
   d. weeds to harbor more pest than usual

565. This grass was initially introduced to Southeast Asia as a turf grass but then grow more luxuriantly as a weed
   a. *Cynodon dactylon*
   b. *Eleucine indica*

c. *Echinochloa colona*
d. *Digitaris* spp.

566. This is considered the most competitive stage of the weed plant
a. juvenile stage
b. early stage
c. seedling stage
d. mature stage

567. Which among the following weeds is both a monocot and a broadleaf?
a. *Imperata cylindrical*
b. *Monochoria vaginalis*
c. *Sphenoclea zeylanica*
d. *Bidens pilosa*

568. Refers to the measure of the adaptive potential of a weed enabling it to survive in an environment continuously disturbed by man is
a. persistence
b. natural selection
c. adaptability
d. evolution

569. The lifecycle classification of a weed that germinates, grows vegetatively, produce seeds and live year to year
a. annual weed
b. continuous weed
c. perennial weed
d. terrestrial weed

570. The weeds found in temperate areas differ from those found in the tropics mainly because of
a. the difference in climatic conditions
b. the difference in soil properties
c. the difference in staple crops grown
d. the difference in cultural practices

571. A Biological control agent is said to be successful if
a. a highly effective biocontrol strain can be obtained or produced
b. its production and formulation is inexpensive
c. its delivery and application methods permit its full expression
d. all of the above

572. The following are major weeds in lowland rice. Which among them is not an annual grass?
a. *Echinochloa glabrescens*
b. *Echinochloa crusgalli*
c. *Echinochloa colona*
d. *Cyperus iria*

573. The following are common major weeds in vegetable crops. Which among them is not an annual broadleaf?
a. *Trianthema portulacastrum*
b. *Cyperus rotundus*
c. *Amaranthus spinosus*
d. *Amaranthus virilis*

574. Dysdercus cingulatus is an insect pest of cotton which causes the cotton bolls to be deformed and fibers discoloured by nymphs and adults. What is the common name of this pest?
a. cotton nymph
b. cotton bollworm
c. cotton stainer
d. cotton cutworm

575. This mango fruitfly causes brown punctures on ripe fruits with eggs or maggots inside. The infested mango fruits will eventually rot.
a. *Typhlocyba nigrobilineata*
b. *Bactrocera dorsalis*
c. *Idioscopus niveosparsus*
d. *Idioscopus clypealis*

576. In this insect pest of coconut commonly called Asiatic palm weevil, the female beetles lay eggs on wound at the crown while the larvae destroys the growing point.
a. *Rynchophorus ferrugineus*
b. *Oryctes ehinoceros*

c. *Idioscopus niveosparsus*
d. *Homona coffearia*

577. This disease in banana causes the shortening of internodes of shoots or branches resulting in crowding of foliage
a. sigatoka
b. anthracnose
c. bunchy top
d. toppling disease

578. Which among the following is commonly called the Mango anthracnose which shows symptoms of necrotic spotting of leaves from which diseased tissues soon drop out, leaving a hole.
a. *Typhlocyba nigrobilineata*
b. *Idioscopus niveosparsus*
c. *Idioscopus clypealis*
d. *Colletotrichum gloeosporiodes*

579. Which of the following management guidelines are being followed in the concept of Integrated Pest Management?
a. Growing a healthy crop
b. enhancement of natural control mechanisms
c. regular monitoring and adoption of community-based IPM
d. all of the above

580. Nematodes are sporadically distributed in the field as reflected on the patchy occurrence of stunted plants. This observation is attributed to
a. nematode's very slow active movement from the point of introduction to adjacent spots
b. nematode's tendency to gather around the rhizosphere of their host
c. nematode's tendency to multiply around the rhizosphere of their host
d. all of the above

581. Housefly and syrphidfly has this type of antennae
a. Geniculate
b. Plumose
c. Aristate
d. Stylate

582. Dragonflies and damselflies has this type of antennae
a. Setaceous
b. Filiform
c. Monoliform beetles
d. Serrate beetles

583. The genus of honeybees is
a. Aphis
b. Apis
c. Muscu
d. Elsnoe

584. Agromyzid fly is an example of an insect that
a. Skeletonizes the leaves
b. Destroy growing buds
c. Tunnel in the stem
d. Mines in the leaf tissues

585. One of these is not a predator of insect pest in rice
a. Dragonflies
b. Spidermites
c. Wolf spider
d. Lady bird beetle

586. Refers to the culture of silkworm and their uses
a. Floriculture
b. Apiculture
c. Sericulture
d. Mariculture

587. The white grub commonly as known as "ulalo" is in what stage of the insect ?
a. Egg
b. Larvae
c. Pupa
d. Adult

588. The most dominant group of animals on earth

a. Birds
b. Insects
c. Mammals
d. Reptiles

589. The following comprise the three theory body segments of an insect except
a. Abdomen
b. Cephalothorax
c. Head
d. Thorax

590. The locomotory region of an insect body
a. Abdomen
b. Head
c. Tail
d. Thorax

591. The pest management that the male pupa are fed with chemosterilants and allowed to mate with normal wild females. This technique is called___.
a. Pheromones
b. Physical control
c. Sterile male technique
d. Cultural control

592. Which of the following methods primarily determines a biological property of a plant virus?
a. positive reaction of certain hosts
b. ease of inoculation
c. positive reaction of certain stains
d. persistence in the host

593. A plant virus is considered unstable when
a. it has a vector
b. it has a wide host range
c. it infects only one host
d. it persists even in harsh environment

594. Which of the following is true of non-persistent viruses?
a. its vectors lose the ability to transmit them after molting
b. infects and multiplies in specific tissues/cells of the host
c. its vectors do not lose the ability to transmit the virus after molting
d. it is transmitted by both aphids and leafhoppers

595. In general, plants infected with persistent viruses show symptoms of
a. dwarfing/stunting only
b. dwarfing/stunting and yellowing/necrosis
c. dwarfing and leaf curling
d. dwarfing and leaf fall

596. Who is considered the Father of Virology?
a. Beijerinck
b. Newton
c. Galileo
d. Berkeley

597. An example of rod - shaped plant virus
a. rice tungro
b. banana bunchy top
c. citrus tristeza
d. tobacco mosaic

598. The early works on plant diseases due to viruses were based on this simple facts
a. they are very small but very infectious
b. they are transmitted by aphids
c. they are associated with leafhoppers
d. they cause mosaic symptoms

599. The plant viruses are considered as genetic parasites because they
a. allow continuous and uncontrolled cell division of their host cell
b. take over the genetic machinery of their host cells for their own reproduction
c. use the enzymes of the host cell for their own assembly
d. none of the above

600. Aphids is the most important vector of plant viruses because of
    a. the numerous viruses they transmit
    b. the economic importance of the crops affected
    c. the number of crops affected
    d. all of the above
601. The following are hypoplastic symptoms except
    a. Canker
    b. Mosaic
    c. Curling
    d. Stunting
602. Organisms that thrive on dead organic matter
    a. Facultative saprophyte
    b. Facultative parasite
    c. Obligate parasite
    d. Saprophyte
603. The ability of the parasite/pathogen to cause disease is called
    a. Aggressiveness
    b. Pathogenic
    c. Pathogenicity
    d. Pathogenesis
604. Refers to the sequence of events that gives rise to disease
    a. Aggresiveness
    b. Pathogenic
    c. Pathogenicity
    d. Pathogenesis
605. A principle of plant disease control that involves the prevention of infection by putting a barrier (mechanical or chemical) between the pathogen and the suscept
    a. Eradication
    b. Exclusion
    c. Immunization
    d. Protection
606. A principle of plant disease control which are intended to eliminate inhibit or kill the pathogens tat become established within the plant or in area
    a. Eradication
    b. Exclusion
    c. Immunization
    d. Protection
607. Rouging virus-infected plants in the field falls under what principle of plant disease control?
    a. Eradication
    b. Exclusion
    c. Immunization
    d. Protection
608. Control of disease through crop rotation falls under what method of plant disease control?
    a. Biological method
    b. Cultural method
    c. Physical method
    d. Chemical method
609. Irradiation of fruits with gamma rays falls under what method of disease control?
    a. Biological method
    b. Cultural method
    c. Physical method
    d. Chemical method
610. Soil fumigation to control Moko disease of banana falls under what method of control?
    a. Cultural
    b. Chemical
    c. Physical
    d. Sanitation
611. In an herbarium, the complete plant parts of a weed are also being collected because
    a. they are needed to complete the collection

b. they are good specimen
c. they will facilitate easier identification of weeds
d. it would not be attacked by storage pests

612. Imperate cylindrical has this as the primary propagule for reproduction
a. rhizome
b. tuber
c. seeds
d. stolon

613. Weeds that live annually can be present in the field every season despite of good control measures because
a. their seeds are not dormant
b. all of them have vegetative propagules
c. they developed resistance
d. enormous amount of their seeds are added into the soil annually

614. The best time to collect weeds for herbarium is during
a. early morning
b. late afternoon
c. evening
d. full moon

615. This refers to the number of weeds in a given unit area
a. weed density
b. weed biomass
c. weed count
d. weed frequency

616. Which among the following weeds can be easily spread by wind alone?
a. *Mimosa pudica*
b. *Echinochloa glabrescens*
c. *Tridax procumbens*
d. *Sphenoclea zeylanica*

617. More than 95% of the weeds that infest crops come from
a. neighboring farms through irrigation water
b. neighboring farms brought by wind
c. the soil
d. crop residues

618. This cultural practice can control weeds in a transplanted irrigated rice
a. use of high quality seeds
b. thorough land preparation
c. flooding
d. all of the above

619. Factor that determine the distribution and abundance of the weed
a. climate
b. rainfall
c. edaphic
d. all of the above

620. A plant is considered a weed when
a. it is out of place
b. it is undesirable
c. it has harmful effects outweighing its beneficial effects
d. all of the above

621. *Trichoderma* spp. is a microbial agent against the following plant pathogens,except one, through competition for substrates and hyperparasitism
a. *Pythium* spp.
b. *Rhizoctonia solani*
c. *Fusarium* spp.
d. *Pseudomonas* spp.

622. *Diadegma* species are larval parasitoids belonging to the family of Ichneumonid wasps which prefer to lay eggs on the second and third instar of this host
a. diamondback moth
b. cabbage looper
c. common cutworm
d. cabbage earworm

623. The spores of this microbial agent enter through the body openings or adhere to the cuticle of the nematode, germinate and penetrate making it strongly parasitic on all stages of development of common plant parasitic nematodes, especially the eggs.
    a. *Gigaspora* spp
    b. *Paecilomyces lilacinus*
    c. *Glomus* spp.
    d. *Glomus musae*
624. Which among the following is a disadvantage of using cultural control against pest and diseases?
    a. cheap
    b. less disruptive to the environment
    c. do not provide effective control to some pests
    d. compatible with other control methods
625. Refers to the increase of the amount of substance within a single organism
    a. bioaccumulation
    b. biofumigation
    c. biomagnification
    d. proto-cooperation
626. Refers to the increase of the amount of substance across trophic levels
    a. bioaccumulation
    b. biofumigation
    c. biomagnification
    d. proto-cooperation
627. Which among the following substances cannot bioaccumulate?
    a. those with affinity for fat
    b. those not soluble in water
    c. 1st generation organochlorine
    d. those with bigger molecules
628. Which of the following describes bioaccumulation?
    a. accumulation of organic chemicals in an organism
    b. accumulation of substances in the environment before they are taken in by the first organism in the food web
    c. the concentration of the substance in the organism becomes greater than the one in the environment
    d. all of the above
629. Which of the following substances can biomagnify ?
    a. novel organic substances i.e. POPs
    b. Mercury
    c. Cadmium
    d. all of the above
630. Rachel Carson published this book in 1962 which tackled the environmental impacts of agriculture particularly the concentration of the popular pesticide DDT in tissues and how it can get passed on in the food chain
    a. Silent Spring
    b. No More Spring
    c. DDT in Spring
    d. The Previous Spring
631. The process of hardening of the insect integument is called ____.
    a. Melanization
    b. Pigmentation
    c. Oviposition
    d. Sclerotization
632. The appendages not found in the thorax are
    a. Legs
    b. Wings
    c. Legs and wings
    d. Cerci
633. The saltatorial type of insect leg is modified for
    a. Clinging
    b. Jumping
    c. Grasping
    d. Swimming

634. The type of wing in which the 2/3 or ¼ of the forewing is parchment-like while the remaining distal part is membranous
   a. Elytron
   b. Hemyletron
   c. Humeral
   d. Tegmen
635. The thickened highly sclerotized, leathery or horny forewings of Coleoptera and Dermaptera
   a. Elytra
   b. Fringe
   c. Hemyletra
   d. Tegmina
636. Refers to the change in the form of the insect during postembryonic development
   a. Ecdysis
   b. Metamorphosis
   c. Oviposition
   d. Sclerotization
637. Refers to the fundamental unit of classification. This is the smallest group capable of reproduction and production of fertile offsprings
   a. Family
   b. Genus
   c. Order
   d. Species
638. All are morphological characteristics used to distinguish insect orders except
   a. Antennae
   b. Mouthparts
   c. Wings
   d. Body wall
639. The insect order of lacewings
   a. Diptera
   b. Ephemeroptera
   c. Neuroptera
   d. Embioptera
640. The insect order of earwigs
   a. Coleoptera
   b. Dermaptera
   c. Megaloptera
   d. Phasmatodea
641. The biological properties of a virus are reflected through infectivity assays in which
   a. only infectious particles cause infections
   b. only purified viruses can be tested
   c. both purified and viruses in sap can be tested
   d. infectious and non infectious particles are necessary
642. From the site of inoculation, plant viruses spread through the plant in a slow cell-to-cell spread through
   a. phloem
   b. stomata
   c. xylem
   d. plasmodesmata
643. The survival and spread of certain plant viruses depend on
   a. its degree of stability
   b. persistence in its vector
   c. amount of virus produced in infected tissues
   d. all of the above
644. Which among the following viruses will most likely to survive?
   a. a virus that will not infect and cause disease
   b. a virus that does not replicate in plant
   c. a virus that causes only mild or moderate disease that allows the plant to survive and reproduce effectively
   d. a virus that kills its host plant with a rapidly developing systemic disease
645. This practice will most likely not contribute to plant virus disease epidemics
   a. multicropping
   b. monocropping

c. planting of cash crops but susceptible hosts
d. presence of active and mobile vectors

646. Roguing as a virus disease control strategy is effective if the disease spread is
a. occurring at random in the field
b. occurring uniformly in the field
c. occurring rapidly relative to the life cycle of the crop
d. occurring slowly relative to the life cycle of the crop

647. A virus preparation which is not pure (it contains host components) when used to immunize a rabbit, the rabbit will
a. produce antibodies to both the virus and host component
b. produce antibodies against the virus only
c. produce antibodies against the host component only
d. not produce any antibody

648. This shows a form of susceptible response by the plant to a virus infection
a. slow virus multiplication and spreading
b. slow appearance of symptoms
c. relatively fast appearance of symptoms
d. production of local lesions

649. Which of the following is a characteristic of virus as an antigen?
a. a virus will react to all kinds of antibodies produced
b. a virus induces only the production of antibodies produced by warm-blooded animals
c. a virus will not be recognized by antibodies in immunized animals
d. a virus induces the production of antibodies and reacts specifically to the antibodies

650. This is among the early definitions of a virus
a. smaller than the pore size of bacterial filters
b. it possesses RNA as genetic material
c. it causes mosaic symptoms
d. it is an obligate parasite

651. What principle of plant disease control is exemplified when one is required to leave at the airport the planting materials carried from abroad?
a. Exclusion
b. Eradication
c. Immunization
d. Protection

652. The capacity of the host plant to become infected and harbor the disease without much effect on yield
a. Immunity
b. Susceptibility
c. Resistance
d. Tolerance

653. The race—specific type of resistance is also called
a. Horizontal resistance
b. Minor gene resistance
c. Polygenic resistance
d. Vertical resistance

654. The non-specific resistance is also called
a. horizontal resistance
b. major gene resistance
c. qualitative resistance
d. monogenic resistance

655. Spraying of plants with a plant defense activator such as salicylic acid and dichloroisonicotinic acid falls under what principle of plant disease control?
a. Eradication
b. Exclusion
c. Immunization
d. Protection

656. Protection offered by inoculating a mild virus strain against a virulent strain of the virus
a. Cross protection
b. Immunity

c. Tolerance
d. Resistance

657. The phenomenon wherein genetically susceptible plants do not become infected because the three factors necessary for disease (susceptible host, virulent pathogen and favorable environment) do not coincide and interact at the proper time or for sufficient duration
a. Disease escape
b. Durable resistance
c. Immunity
d. Tolerance

658. These are major insect pests of beans except
a. Black bean aphid
b. Podborer
c. Stink bug
d. Leafminer

659. The most important quarantined insect pest of mango
a. Fruit fly
b. Mango planthopper
c. Mealybug
d. Twig borer

660. The following are advantages of biological control except
a. Safe
b. Self perpetuating
c. Environment-friendly
d. Slow acting

661. The first report of an insect (a housefly) resistance to DDT was recorded in this country
a. Philippines
b. China
c. Sweden
d. Ireland

662. In the Golden Age of Biology (1840 – 1900 AD), the study of plant diseases and their control were intensified which led to the discovery and introduction of the following, except one
a. Bordeaux mixture
b. Paris green
c. lead arsenate
d. DDT

663. In 1732, during the Renaissance Period, farmers begin to grow crops in row
a. to increase yield
b. to save space
c. to facilitate weeding
d. to reduce labor

664. In the mid of 20th century (1972) there was an epidemic of this disease in the US which was attributed to their corn hybrid breeding
a. Southern blight of corn
b. corn borer
c. army worm
d. corn cutworm

665. Refers to all forms of legislations and regulation preventing the entry, establishment and spread of a pest organism
a. biological control
b. regulatory control
c. mechanical control
d. physical control

666. This is the process of evaluation to determine whether a pest should be regulated, thus serves as a basis for imposing quarantine action.
a. Pest Risk Analysis (PRA)
b. memo of agreement
c. legislation
d. SPS agreement

667. This refers to the Plant Quarantine Act of 1922
a. RA 3030
b. RA 3028
c. RA 3027
d. RA 3029

668. Which among the following pathogens are declared under Quarantine/Regulation in the Philippines?
   a. papaya ringspot virus
   b. banana panama disease
   c. coconut lethal yellowing disease
   d. all of the above
669. Which among the following insect pests are declared under Quarantine/Regulation in the Philippines?
   a. Mexican fruitfly
   b. rice black bug
   c. Mediterranean fruitfly
   d. all of the above
670. Which of the following are declared to be under the Containment Program in the Philippines with the aim of preventing the spread of an introduced pest that cannot be irradicated?
   a. Soccoro wilt of coconut in Mindoro
   b. Cadang-cadang in Bicol
   c. Papaya ringspot virus in Luzon
   d. all of the above
671. All are damages produced by chewing insects except
   a. Entire leaf missing
   b. Leaf mines
   c. Portion of leaf missing
   d. Leaf curling
672. Popular hymenopterous parasitoid as biocon agent of cornborer
   a. *Apanteles* sp.
   b. *Scelio* sp.
   c. *Trichogramma* sp.
   d. none of the above
673. When did V.P. Gapud spearhead the research on mites in the Philippines?
   a. 1959
   b. 1960
   c. 1958
   d. 1961
674. The first written document on Philippine insects was recorded by
   a. Pigaffeta
   b. Guissepi
   c. Philippi
   d. Mardon
675. The genus of the starling locally known as "Martinez" which was imported from Southern China to control locust
   a. Aetheopsar
   b. Halcyon
   c. Microhierax
   d. Brahminy
676. Armyworms and cutworms prefer to pupate in the
   a. Leaves
   b. Panicle
   c. Soil
   d. Stem
677. The field of entomology that deals with the interrelationship of insects in their environment.
   a. Insect pest management
   b. Insect ecology
   c. Insect physiology
   d. Insect taxonomy
678. The class of arthropa that has four pairs of walking legs and body is fused into two regions.
   a. Collembola
   b. Crustacea
   c. Protura
   d. Arachnida
679. The field of entomology that deals with the study of honey bees.
   a. Sericulture
   b. Apiculture
   c. Taxonomy
   d. Morphology

e. Physiology

680. The field of entomology that deals with the classification and nomenclature of insects.
   a. Insect morphology
   b. Insect ecology
   c. Insect systematics
   d. Insect classification

681. The biggest among the species of rats destructive to agricultural crops
   a. Asian field rat
   b. Bush rat
   c. Common rice field rat
   d. Norway rat

682. The following are factors affecting the population dynamics of rodents except
   a. Birth rate
   b. Emigration
   c. Fumigation
   d. Immigration

683. Also known as the urban rat
   a. *Rattus argentiventer*
   b. *Rattus exulans*
   c. *Rattus norvegicus*
   d. *Rattus ratttus mindanensis*

684. A cultural practice against pest utilized to enhance the activities and survival of natural enemies is
   a. trap crops
   b. habitat diversification
   c. biological control
   d. cultivation

685. The interest of the concern party is to locate natural enemies in foreign countries for collection
   a. Importation
   b. Mass production
   c. Colonization
   d. Exploration
   e. Field release

686. Integrated Pest Management does not encourage this practice
   a. frequent, non judicious use of pesticides
   b. combination of two or more control measures
   c. optimization of control methods
   d. utilization of natural enemies

687. Refers to the pest control method that includes tactics causing pests to contribute to the destruction of their own species
   a. biological control
   b. behavioural control
   c. autocidal control
   d. genetic control

688. This principle of crop protection is exhibited when the host is manipulated to resist pest attack
   a. immunization
   b. protection
   c. host evasion
   d. avoidance

689. According to Smith (1969), this phase in the sequential development of crop protection is characterized by serious pest outbreaks due to excessive use of pesticides and finally the collapse of pest control program
   a. Integrated pest control
   b. Crisis phase
   c. Disasater phase
   d. Overuse phase

690. Which of the following is an autotroph?
   a. plant pathogen
   b. insect vector
   c. parasite
   d. weed

691. Which of the following exemplifies the Suppression Program of sudden pest outbreak over a wide area that cannot be controlled by individual effort only
   a. locust control campaign
   b. rat control campaign
   c. both a and b
   d. none of the above
692. Refers to an Apparent Mechanism in Host Plant Resistance due to geographical barriers, meteorological barriers. One example is when the soil is not conducive to plant pathogen
   a. Host Escape
   b. Host Evasion
   c. Induced resistance
   d. Antixenosis
693. Which among the following are strategies to cope up when there is a breakdown of resistance
   a. sequential varietal release
   b. multiline mixture/varietal mixture
   c. refuge crop/variety
   d. all of the above
694. Which of the following are transgenic crops in the US?
   a. Bt corn
   b. Bt potatoes
   c. Bt cotton
   d. all of the above
695. Which is true for the function of the body regions in insects?
   a. head is for sensory purposes
   b. thorax is for mobility
   c. abdomen is for protection of visceral organs
   d. all of the above
696. A type of mimicry in insects in which the palatable species copy the distasteful/harmful ones
   a. Batesian mimicry
   b. Mullerian mimicry
   c. Wasmannian mimicry
   d. none of the above
697. A type of mimicry in insects in which the unpalatable species copy another unpalatable species
   a. Batesian mimicry
   b. Mullerian mimicry
   c. Wasmannian mimicry
   d. none of the above
698. Refers to the beneficial species of insects which feed or attack other insects
   a. natural enemies
   b. pest
   c. pathogen
   d. prey
699. This theory of plant disease considers the pathogen as an outgrowth of the infected host plant
   a. Germ theory
   b. Disease triangle
   c. Autogenetic theory of disease
   d. none of the above
700. Refers to the active or passive movement of the pathogen through the host tissues
   a. colonization
   b. attack
   c. inoculation
   d. spread
701. This is a concoction of lime, copper sulphate and water which had been accidentally fund to have fungicidal activity
   a. Bordeaux mixture
   b. liming material
   c. Paris Green
   d. copper fungicide
702. In the principle of pest exclusion, the pest is
   a. kept away from the host

b. killed once it is inside the host
c. killed at once upon introduction
d. quarantined

703. This attribute of modern agriculture can aggravate pest and disease problems
a. planting of high yielding varieties (HYVs)
b. excessive use of chemical inputs
c. continuous monocropping
d. all of the above

704. This crop is a heavy user of fungicide worldwide
a. banana
b. apple
c. citrus
d. grape

705. This pesticide group is excessively used in the Philippines
a. insecticide
b. nematicide
c. rodenticide
d. fungicide

706. Which among the following is a physical control method required to eliminate fruit flies on mango and papaya for export to Japan?
a. Refrigeration
b. UV radiation
c. Vapor Heat Treatment
d. Hot water treatment

707. This pesticide group is excessively used worldwide
a. herbicide
b. insecticide
c. fungicide
d. nematicide

708. To achieve a sustainable agriculture, a practice or method should aim to make agriculture
a. ecologically sound
b. socially just
c. economically viable
d. all of the above

709. In the development of crop protection, this phase is characterized by the use of traditional varieties and natural pest control methods
a. Disaster phase
b. Crisis phase
c. Subsistent phase
d. Exploitation phase

710. This type of cultural practice tends to reduce both the initial pest population or sources of infestation and reproductive ability of the pest
a. tillage
b. furrowing
c. crop rotation
d. pruning

711. The principle of immunization is achieved through
a. improving the nutrition of the host
b. application of pesticide
c. pruning infected plant parts
d. providing physical barriers

712. The Romans traditionally performed this rite to appease the goddess associated with cereal rust disease
a. Robigalion
b. Robicon
c. Robigalia
d. Robigus

713. Which of the following is a factor involved in disease production?
a. intervention measures by man
b. duration and intensity of various environmental factors
c. plant susceptibility ad pathogen virulence
d. all of the above

714. An epidemic is most likely to occur when
a. plants are predisposed by excessive fertilization or injuries
b. the environment is favourable for disease development

c. monocropping of a single variety is being practiced over a wide area
d. all of the above

715. Rice tungro can be effectively managed by application of insecticide. In here, disease management is achieved through
a. controlling the vector
b. making the host resistant
c. reducing the rate of inoculum production
d. changing the host of the vector

716. The presence of this material in the nucleus or cytoplasm of the cell of an infected plant may indicate viral infection
a. starch inclusions
b. fat bodies
c. inclusion bodies
d. antibodies

717. In disease assessment, this refers to the proportion of plant units diseased in relation to the total number of units examined
a. disease spread
b. yield loss
c. disease severity
d. disease incidence

718. The clubroot disease of cabbage is widespread in the Mountain Province which can be attributed to the area's
a. poor fertility of the soil
b. wet and humid condition
c. elevated farms
d. wind direction

719. Coconut planting materials from Bicol region are being quarantined to manage this disease
a. cadang-cadang disease
b. coconut bud rot
c. bunchy top
d. bugtok

720. This disease is not visible when the fruit is still unripe ut begin to manifest its symptoms when ripening has started
a. citrus scab
b. soft rot of carrots
c. stem end rot of avocado
d. fruit blotch of watermelon

721. Which among the following insect has setaceous antennae?
a. Grasshopper
b. Beetle
c. Cicada
d. Butterfly

722. The insect which can be best controlled by thorough land preparation is
a. Aphids
b. Cutworm
c. Whiteflies
d. Diamondback moth
e. Cabbage butterfly

723. The pest of mango prioritized by the Philippine Nuclear Research Institute to control using the sterile male technique method
a. Mango pulp beetle
b. Mango hoppers
c. Fruit fly
d. Vinegar fly

724. The genus of mosquito that serves as a vector of malaria disease
a. Anopheles
b. Culex
c. Mansonia
d. Aedes

725. If the performance of the natural enemy is measured, the process is termed as
a. Introduction
b. Colonization
c. Evaluation

d. Mass production
e. Exploration

726. The type of pheromones that stimulates insect to locate their mate
a. Sex pheromones
b. Alarm pheromones
c. Dispersal pheromones
d. Aggregation pheromones
e. Alert pheromones

727. A cultural control used in controlling soil insect like caseworm
a. Land preparation and tillage
b. Waste management
c. Irrigation and water management
d. Sterile male technique

728. The first record of Philippine insects was in
a. Laguna
b. Palawan
c. Panay Island
d. Mactan Island
e. Mt. Makiling

729. Refers to the sexual-like process occurring in bacteria
a. Heterokaryosis
b. Heteroploidy
c. Parasexualism
d. Transduction

730. The bacterial disease which affected 41 M people in Asia in the 14^{th} century
a. Bubonic plague
b. Dengue
c. Leptospirosis
d. Malaria

731. Microorganisms that undergo change and remain genetically homogenous are called
a. Biotype
b. Pathovar
c. Physiologic race
d. Forma speciales

732. Which of the following is not a fungus?
a. *Cercospora*
b. *Colletotrichum*
c. *Fusarium*
d. *Meloidogyne*

733. The following are mechanisms or variation in fungi except
a. Heterokaryosis
b. Heteroploidy
c. Parasexualism
d. Transduction

734. The following are chemicals used to control fungi except
a. Antibiotics
b. Benzimidazoles
c. Organophosphate
d. Organic sulfur compounds

735. Macroconidia and microconidia are formed by this group of organism
a. *Colletotrichum* spp.
b. *Fusarium* spp.
c. *Alternata* spp.
d. *Cercospora* spp.

736. In nematology, a variety is said to be resistant if it
a. its leaves appear normal
b. suppresses the multiplication of nematodes
c. produce good yield despite nematode infestation
d. produce many roots despite nematode infestation

737. In nematology, a variety is considered tolerant if
a. its leaves appear normal
b. suppresses the multiplication of nematodes
c. produce good yield despite nematode infestation
d. produce many roots despite nematode infestation

738. This refers to the permanent nurse cells induced by root knot nematodes
   a. giant cells
   b. galls
   c. syncytia
   d. nodules
739. The citrus disorder caused by *Tylenchulus semipenetrans*?
   a. citrus tristeza
   b. toppling disease
   c. root knot
   d. citrus decline
740. Considered to be the most serious and widespread nematode pest of citrus in the Philippines
   a. *Tylenchulus semipenetrans*
   b. *Rhizoctonia solani*
   c. *Arthrobotrys oligospora*
   d. *Paecilomyces lilacinus*
741. These are subunits which make up the capsid of virus
   a. amino acids
   b. capsomeres
   c. protein coat
   d. polypeptides
742. Which among the following are the main components of plant viruses?
   a. Transfer RNA + protein + lipids
   b. DNA + glycoprotein + lipids
   c. either DNA or RNA + protein
   d. RNA + glycoprotein + lipids
743. Viruses can have either the two types of nucleic acids, DNA or RNA, which is best differentiated by their
   a. sequence
   b. phosphate groups
   c. appearance
   d. nitrogen bases
744. The plant virus capsid is made up of structural protein component. On the other hand, the non-structural protein component has this function
   a. mediate replication of the genome
   b. protect the nucleic acid
   c. protect the capsid also
   d. determine the kind of vector
745. This refers to the study of the antibody and antigen in vitro
   a. Hematology
   b. Serology
   c. Virology
   d. Immunology
746. This characterizes a persistently transmitted virus
   a. typically has no latent period
   b. has a long latent period
   c. induces foliar symptoms like stunting
   d. is lost by the vector immediately
747. A virus will not persist in its insect vector if
   a. it is lost after molting of the vector
   b. it is not lost after molting of the vector
   c. it is transmitted after several hours to few days after vector feeding
   d. it only infects specialized cells
748. Refers to the quantitative amount of disease that an isolate of a given pathogen can cause in a given group of plants in terms of size of lesions or number of lesions
   a. severity
   b. virulence
   c. aggressiveness
   d. disease extent
749. Which of the following are signs of nematode disease
   a. eggs
   b. juveniles
   c. adult nematode

d. all of the above

750. The following are climatic factors, except one, which can cause symptoms that may be confused with crop damages brought about by pests and pathogens
   a. drought
   b. excess moisture
   c. fertilizer burn
   d. strong wind

Answer Key to Review Questions in Crop Protection

1	d	26	d	51	a	76	d	101	d	126	c	151	b	176	c
2	c	27	d	52	c	77	a	102	c	127	a	152	c	177	d
3	b	28	d	53	b	78	d	103	a	128	a	153	b	178	b
4	c	29	a	54	a	79	b	104	b	129	c	154	a	179	a
5	c	30	c	55	a	80	b	105	b	130	a	155	b	180	b
6	a	31	c	56	a	81	b	106	d	131	d	156	d	181	b
7	a	32	d	57	a	82	b	107	c	132	d	157	a	182	c
8	c	33	d	58	d	83	d	108	b	133	d	158	a	183	c
9	a	34	b	59	c	84	b	109	a	134	c	159	b	184	c
10	b	35	d	60	c	85	d	110	c	135	d	160	b	185	d
11	b	36	b	61	c	86	a	111	b	136	a	161	d	186	a
12	c	37	c	62	c	87	a	112	b	137	c	162	a	187	b
13	d	38	d	63	b	88	d	113	d	138	b	163	d	188	b
14	a	39	d	64	d	89	d	114	d	139	d	164	a	189	c
15	b	40	b	65	b	90	c	115	a	140	b	165	b	190	a
16	c	41	d	66	a	91	b	116	c	141	b	166	a	191	c
17	c	42	b	67	c	92	d	117	b	142	a	167	a	192	a
18	c	43	a	68	a	93	b	118	b	143	c	168	d	193	d
19	b	44	a	69	c	94	b	119	d	144	b	169	a	194	b
20	d	45	d	70	a	95	a	120	a	145	a	170	b	195	c
21	b	46	b	71	b	96	d	121	a	146	c	171	b	196	c
22	a	47	a	72	b	97	a	122	d	147	b	172	d	197	c
23	b	48	b	73	a	98	c	123	b	148	c	173	b	198	a
24	b	49	c	74	c	99	b	124	a	149	a	174	d	199	b
25	a	50	c	75	a	100	c	125	a	150	d	175	d	200	c

Answer Key to Review Questions in Crop Protection

201	c	226	b	251	b	276	b	301	c	326	b	351	a	376	d
202	c	227	c	252	b	277	d	302	b	327	c	352	c	377	a
203	b	228	c	253	d	278	d	303	d	328	b	353	b	378	c
204	a	229	c	254	d	279	b	304	a	329	b	354	b	379	c
205	c	230	d	255	d	280	c	305	c	330	a	355	b	380	a
206	a	231	d	256	b	281	a	306	c	331	b	356	a	381	a
207	a	232	a	257	c	282	b	307	c	332	a	357	a	382	d
208	a	233	c	258	a	283	b	308	c	333	c	358	c	383	a
209	a	234	c	259	d	284	b	309	a	334	d	359	b	384	c
210	a	235	b	260	c	285	a	310	a	335	c	360	c	385	c
211	c	236	a	261	c	286	b	311	c	336	b	361	b	386	d
212	a	237	a	262	c	287	c	312	b	337	c	362	d	387	b
213	a	238	a	263	d	288	c	313	d	338	b	363	d	388	a
214	c	239	c	264	b	289	b	314	a	339	d	364	a	389	a
215	c	240	c	265	d	290	d	315	b	340	c	365	d	390	c
216	b	241	c	266	d	291	c	316	d	341	c	366	a	391	a
217	c	242	a	267	d	292	c	317	d	342	b	367	a	392	b
218	c	243	b	268	a	293	b	318	d	343	b	368	a	393	c
219	c	244	d	269	a	294	c	319	a	344	a	369	d	394	a
220	a	245	a	270	d	295	b	320	d	345	c	370	d	395	d
221	a	246	d	271	b	296	a	321	d	346	a	371	b	396	b
222	a	247	a	272	b	297	c	322	d	347	b	372	a	397	b
223	a	248	b	273	c	298	d	323	a	348	b	373	d	398	b
224	b	249	c	274	d	299	c	324	d	349	d	374	d	399	b
225	c	250	b	275	a	300	d	325	b	350	b	375	b	400	b

Answer Key to Review Questions in Crop Protection

401	c	426	c	451	c	476	d	501	b	526	d	551	d	576	a
402	c	427	d	452	d	477	d	502	c	527	b	552	b	577	c
403	c	428	b	453	c	478	c	503	b	528	c	553	b	578	d
404	a	429	d	454	b	479	b	504	c	529	a	554	c	579	d
405	c	430	b	455	d	480	c	505	b	530	d	555	d	580	d
406	a	431	d	456	a	481	c	506	c	531	b	556	a	581	c
407	d	432	c	457	b	482	b	507	b	532	c	557	b	582	a
408	d	433	c	458	d	483	d	508	a	533	d	558	b	583	b
409	b	434	c	459	a	484	c	509	b	534	a	559	d	584	d
410	c	435	b	460	c	485	a	510	b	535	c	560	a	585	b
411	a	436	b	461	b	486	d	511	b	536	b	561	a	586	c
412	d	437	c	462	c	487	d	512	b	537	d	562	b	587	b
413	d	438	c	463	c	488	b	513	d	538	d	563	b	588	b
414	d	439	d	464	b	489	b	514	c	539	d	564	c	589	b
415	d	440	d	465	c	490	c	515	c	540	d	565	a	590	d
416	d	441	a	466	c	491	a	516	a	541	b	566	c	591	c
417	a	442	c	467	c	492	c	517	d	542	d	567	b	592	a
418	c	443	b	468	c	493	d	518	b	543	c	568	a	593	c
419	b	444	a	469	c	494	b	519	a	544	b	569	c	594	a
420	a	445	d	470	d	495	a	520	a	545	b	570	a	595	b
421	d	446	d	471	b	496	b	521	a	546	c	571	d	596	a
422	b	447	c	472	a	497	b	522	c	547	c	572	d	597	d
423	b	448	b	473	d	498	a	523	a	548	c	573	b	598	a
424	b	449	c	474	c	499	a	524	d	549	c	574	c	599	b
425	b	450	c	475	c	500	c	525	a	550	b	575	b	600	d

Answer Key to Review Questions in Crop Protection

601	a	626	c	651	a	676	c	701	a	726	a
602	d	627	d	652	d	677	b	702	a	727	c
603	c	628	d	653	d	678	d	703	d	728	b
604	d	629	d	654	a	679	b	704	b	729	d
605	d	630	a	655	c	680	c	705	a	730	a
606	a	631	d	656	a	681	d	706	c	731	a
607	a	632	d	657	a	682	c	707	a	732	d
608	b	633	b	658	d	683	c	708	d	733	d
609	c	634	b	659	a	684	b	709	c	734	a
610	b	635	a	660	d	685	d	710	d	735	b
611	c	636	b	661	c	686	a	711	a	736	b
612	a	637	d	662	d	687	c	712	c	737	c
613	d	638	d	663	c	688	a	713	d	738	a
614	b	639	c	664	a	689	c	714	d	739	d
615	a	640	b	665	b	690	d	715	a	740	a
616	c	641	a	666	a	691	c	716	c	741	b
617	c	642	d	667	c	692	a	717	d	742	c
618	d	643	d	668	d	693	d	718	b	743	d
619	d	644	c	669	d	694	d	719	a	744	a
620	d	645	a	670	d	695	d	720	c	745	b
621	d	646	d	671	d	696	a	721	c	746	b
622	a	647	a	672	c	697	b	722	b	747	a
623	b	648	c	673	d	698	a	723	c	748	b
624	c	649	d	674	a	699	c	724	a	749	d
625	a	650	a	675	a	700	a	725	b	750	c