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TRANSMISSION AND SPREAD OF DISEASES AND ARTHROPOD PESTS

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Outline

- Definitions
- Methods of transmission/spread of diseases
- Methods of spread of insect pests

Definitions

- **Transmission:** ability to pick up a pathogen from one plant and pass it on to another plant. Insects /nematodes have that ability to obtain, carry and deliver a pathogen which without the presence of insects would not have been able to move
- **Spread**: movement from an infected/ infested plant /area to a non infected plant or area
- **Prevention**: keep from becoming a problem
- **Suppression**: reduce its increase and effect on the host plant
- **Eradication:** use methods and destroy pests

Introduction

- Most crops are subject to damage by pests and diseases
- All parts are affected and the genetic potential is interfered with
- All plant parts are damaged : seeds, roots, stems, leaves and fruits
- When plants are affected there is reduced plant vigour and in some cases plant death and crop loss occurs

Introduction

- Plants cannot move from one place to another except by being swayed by wind side to side
- Diseases and pests affecting plants must therefore be brought in to infect or infest (primary inoculation)
- Diseases and pests must have a way of moving from plant to plant within the field (secondary infection)
- There are different modes of movement of these pests and diseases

Modes for movement of pests and diseases

- Wind (weed seeds, fungi, insects/mites)
- Seed (weed seeds, fungi, bacteria, viruses, nematodes)
- Infected soils : with fungi, bacteria, nematodes or larval or pupae stages of an insects
- Rain splash /hailstorms (bacteria, fungi, nematodes)
- Infected irrigation water (fungi, bacteria, nematodes)

Modes for movement of pests and diseases

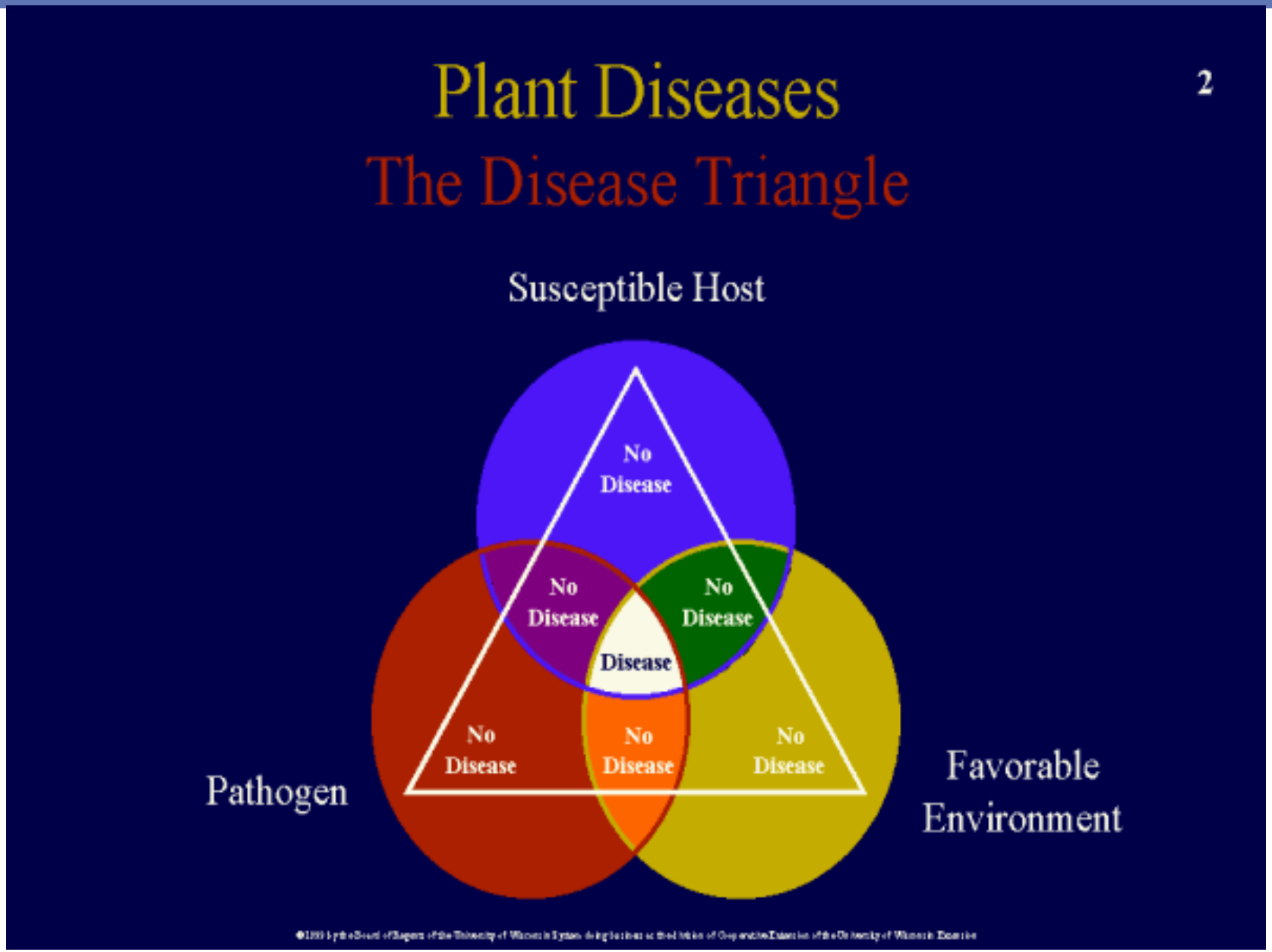
- Farm implements (soil, plant parts, left over seeds)
- Movement of vegetative plant parts
- Animals (birds, mammals (hair/fur), rodents)
- Man (trade, movement of seed, insects on farm working cloths, weed seeds attaching on cloth, shoes /boots from one field to another

Dispersal

- Dispersal of pathogen, pollen, and seed
  - Pathogen: effective dispersal depends on traits of spores (size, moisture, UV susceptibility) and threshold number needed for infection
  - Longer movement sometimes through stepping stones
  - Usually infection shows patterns of aggregation (clustering). It is an easy way to show infectious disease

Determinants of spread

- Amount of inoculum or abundance of organisms(insects, PPNs, spores,)
- Location of inoculum
- Susceptibility of the host
- Favorable environmental conditions (temperatures (18-30^{o}C), RH% (50-95%), wind direction and speed, soil moisture, host stage (susceptible) and plenty of food resource



Disease triangle

Pathogen

Does it need a wound to infect a host?

Can it survive in the environment without a host?

- soil, water
- on alternate host

How does it move around?

- airborne/waterborne
- animal vectors
- humans

Virulence + reproductive potential=transmission

Host

Must be physically present with pathogen

Must be physically compatible with pathogen

Must provide window of opportunity for infection

Tolerance

losses where infected

but ability to redirect resources

What type of resistance?

simple= one gene

complex=several genes

Environment

Climatic changes

Climate patterns match pathogen biology
(high RH, rainfall when needed, temperature range for growth: thermophilic vs. psychrophilic organisms, Max-min temperatures)

Host phenology: synchrony between pathogen and Host (is it the host's most susceptible time period)

Examples of diseases transmitted (bacterial pathogens)

Bacterial wilt

- seed borne (survives for many years), survives on plant debris and susceptible weeds
- Spread by surface irrigation, hailstorms, can infect host through wounds, through movement of infested soils

Other bacteria can be carried on insect legs and mouth parts, implements, mans movement passively

Common blight of beans

- Seed borne, spread via natural openings and wounds, wind driven rain, hailstorms, insects and farm implements

Halo blight

- Seed borne, spread by splattering rain water, hailstorms, wind blown rain

Examples of diseases spread (fungal pathogens)

- Fungi (Alternaria leaf spot):
  - Spores disseminated by wind,rain, insects, and fungus is also found in seed
- Fungi (Fusarium root rot):
  - Spread by drainage water or irrigation water, movement of infected soil, man, farm implements, soil in touch with seed
- White mould:
  - Spread by sclerotia on seed, air borne ascospores,
- Fungi (Rhizoctonia):
  - Soil borne fungus spread by soil movement from one place to another (shoes, potting soils)

Examples of diseases (nematodes and viruses)

Plant parasitic nematodes

- through infested soils, eggs on seeds or plant parts, vegetative planting materials, insects **e.g RKNs, Cyst ematode**

Common mosaic

- In weed hosts where inoculum is picked by insects (aphids) or mechanically spread by plants rubbing against one another or against weed hosts, through infected seed, can be spread in pollen

Golden mosaic of beans

- Not seed transmitted, but is mechanically transmitted, and by whitefly vectors

Plant pathogen spread by vectors

- This involves an interaction of
  - Plant (susceptible host)
  - Pathogen (inoculum –spores) ,
  - insect vector,
  - Environment (weather, cultural practices in the field, farming operations, agroecosytem)

(Remember disease triangle)

Contributing factors to the spread of diseases

- Environmental changes (Narok vs Naivasha MLND expts)
- Microbial adaptation
- Human populations and behaviour
- Technology and economic development
- International travel and commerce

Ways of disease spread by vectors

- Passive or mechanical : occurs when the insect/vector carries /transfer the pathogen from one plant to another. In this method the pathogen is kind of given a ride, there is no effect on the vector (legs, mouthparts, bodies)

- Active or biological transmission : in this method the pathogen undergoes some change within the vector. It may multiply or develop into infectious form after which it is transmitted to a new host

Contd ways of spreading disease by vectors

- Inoculation: the pathogen is injected onto the host in saliva while the vector is feeding,
- Regurgitation: the pathogen multiplies within the vectors gut to a point where it interferes with feeding and hence it is vomited into the new host,
- Feacal contamination: the insect deposits feacal matter with the pathogen on a wound on the host or the pathogen may infect a new wound created while the insect is ovipositing

Categories of insect vectored pathogens

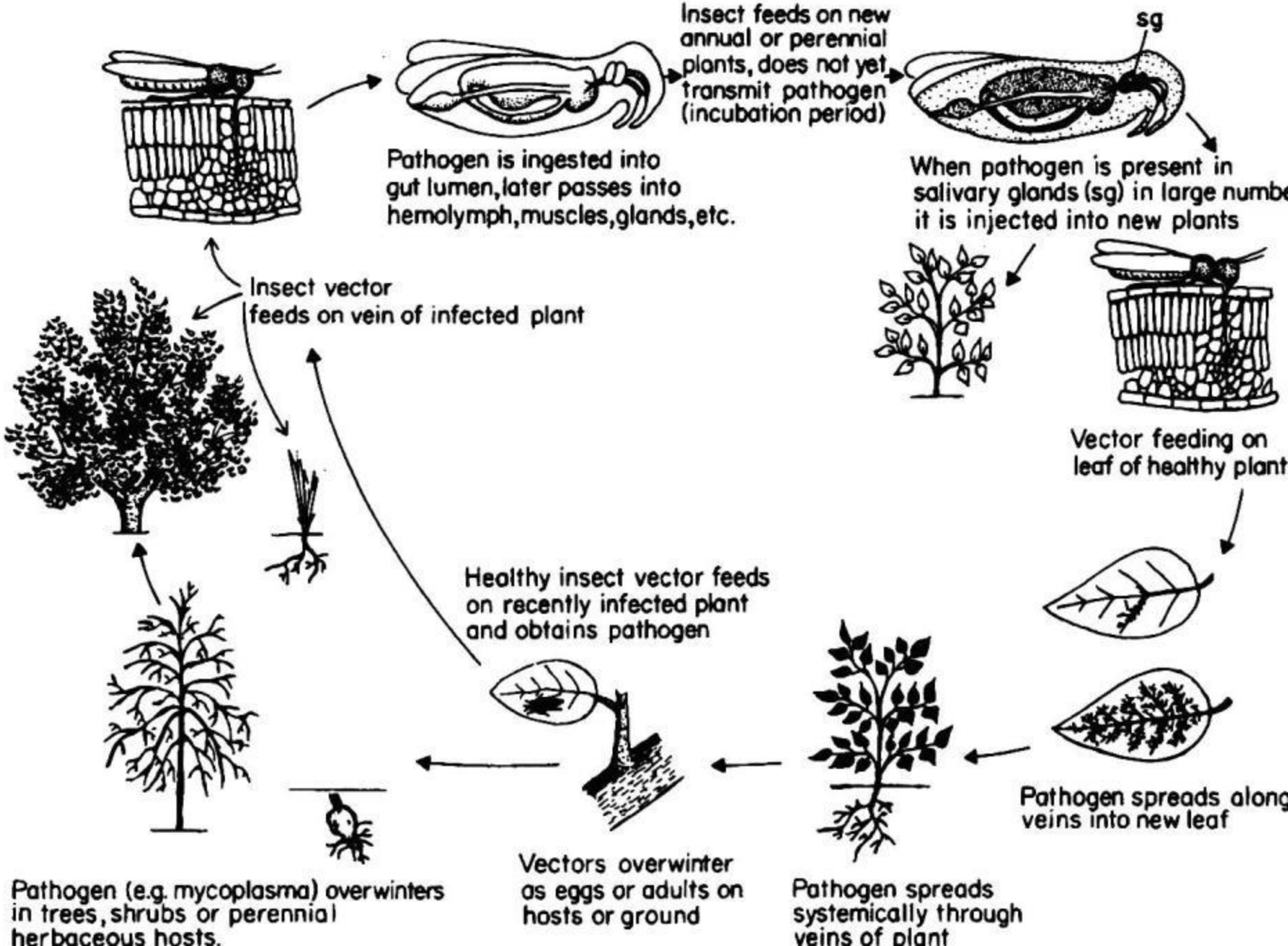
- Pathogen spread
  - Primary (brought into field first round) vs Secondary (spreads within field after the first innoculation)

Modes of primary infections:

Primary infection plant diseases are recognized as:-

- Soil borne (bacterial pathogens)
- Seed borne, including diseases carried with planting material e.g smuts on cereals especially maize, wheat, bacteria in tubers, viruses in seed, tubers.
- Wind borne
- Insect borne

Is also direct transmission which can be internal or external


Insect feeds on new annual or perennial plants, does not yet transmit pathogen (incubation period)
sg
Pathogen is ingested into gut lumen, later passes into hemolymph, muscles, glands, etc.
When pathogen is present in salivary glands (sg) in large numbe it is injected into new plants
Insect vector feeds on vein of infected plant
Vector feeding on leaf of healthy plant
Healthy insect vector feeds on recently infected plant and obtains pathogen
Pathogen spreads along veins into new leaf
Pathogen (e.g. mycoplasma) overwinters in trees, shrubs or perennial herbaceous hosts.
Vectors overwinter as eggs or adults on hosts or ground
Pathogen spreads systemically through veins of plant

Secondary infections

- Pathogen spreads itself by way of its persistent growth or certain structures carried independently by natural agencies like wind, water, animals, insects, mites, nematodes, birds

- Pathogen spreads within the field

Categories of insect vectored pathogens

- Vector residency on plant
  - Transient (passing by) vs residential (settles down feeds and reproduces)
- Vector dispersal
  - Trivial (not organized and vector moves randomly searching for hosts to feed) vs migration (vector purpses to move into a new area to search for food or reproduce

Examples of insect vectors that spread disease

True bug, leaf hopper, plant hopper

Aphids, mealy bug, psyllid, whiteflies,

Homoptera pests

Insects pests of different orders

Fruit fly (*R. pomonella)*

thrips

Cabbage fly- maggot

leafminer

Leaf beetles

Bark beetles

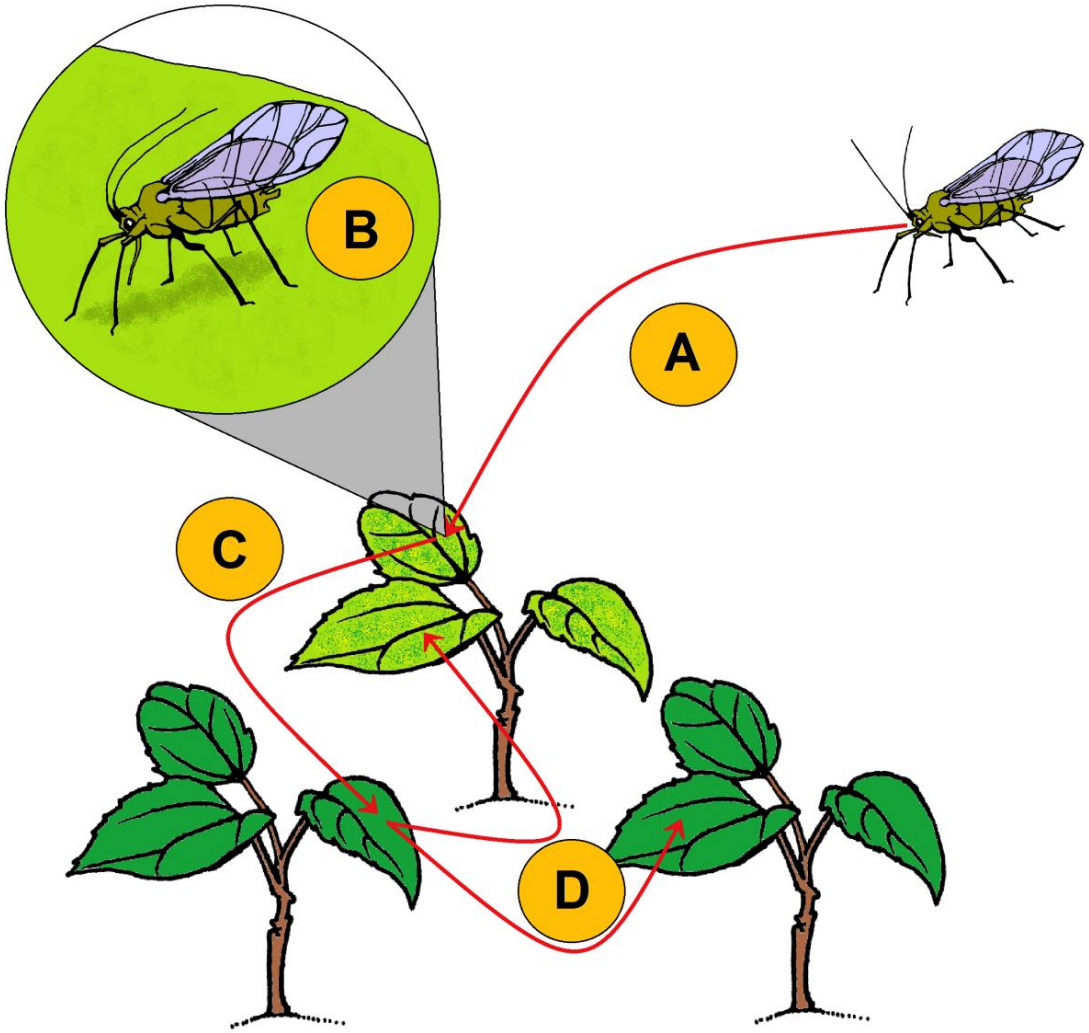
Insects pests of different orders

Plum beetle

Bee *Apis mellifera*

Ants

Plant Virus Infection and Vector Behavior



Types of interactions

- Circulative (2 forms)
  - Systemic :movement within body
  - Propagative :Replication within body – transovariol

- Non circulative (stylet borne)
  - No replication particles attached to mouth parts during feeding and pathogen released during feeding through saliva

Types of pathogen transmission

- Non persistent (Stylet borne)
- Persistent (circulative, propagative and transovariol)
- Semi persistent (partly circulative)

Non persistent vs persistent

Non persistent

- Acquisition time - short (seconds)
- Inoculation time –short
- Latent period –zero
- Retention time – minutes to hours

Persistent

- Acquisition time - minutes
- Inoculation time –minutes
- Latent period – one or more days
- Retention time – through moult or for life
- Vector specificity high

Categories of vectors

- **Transient vectors**
  - Do not colonize host
  - Non persistent spread of diseases
  - Not usually important for persistent disease spread

- **Resident vectors**
  - Colonize crop
  - Important for all types of disease spread
  - Most important for persistent transmission of diseases

To determine transient populations: use traps such as sticky traps, water pans, pheromone traps, etc

Vector dispersal

- **Trivial flights**
  - Random movement among selected hosts
  - Important for secondary spread
  - Important for non persistent spread of disease
- **Insect migration**
  - Long distant obligatory flights
  - Important for all transmissions
- Primary spread acquired from outside source and brought in to the field e.g through seed or immigrating insects such as thrips
- Secondary spread infections within the field

Thank you ! Questions

Scouting for insect pests, diseases and weeds of target crops

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Mealybugs

On leaves

On stems

On flowers

Death due to infestation

Clavigralla nymphs

Riptortus spp

Pod bugs

Nezara spp

Outline

- Importance of field scouting
- Definition and objectives
- Effect of biotic and abiotic factors
- Sampling pattern
- Sampling techniques and tools
- Limiting factors
- Time to scout

Introduction

What is scouting/surveillance/monitoring

- Regular visits to a crop field to make visual observations within the farm (growth and development, plant health, any happenings outside the expected) and estimate/measure pest levels

Objectives for scouting (two)

- Short term: to determine the need for control, assess the effectiveness of actions taken
- Long term: to collect information/data that is used to make future predictions and decisions or evaluate pest management strategies used

Introduction

- Scouting is key in a pest management programme
- It relies heavily on the ability to identify pest problems / or situations out of the ordinary which could be taking place in the field ‘Hence the necessity of visual observation’
- Reminder: groups of pests that infest crops include fungi, bacteria, viruses, phytoplasmas, insects, mites, parasitic plants, weeds and animals (man included)

General Impact of Pests – Injury to plants

- Consumption of plant parts
- Chemical toxins, elicitors, and signals
- Physical damage
- Loss of harvest quality
- Cosmetic damage
- Vectoring of pathogens
- Direct contamination
- Low germination ability of seeds

Abiotic factors cause similar effects (altering growth and development of plants)

- Environment (climate/weather changes, temp, RH%, rainfall,)
- Nutrient deficiency (N, P, K, Mg, Ca, B, Mn, Fe, Cu, S,
- Cultural practices(plant debris left on soil, tillage methods, cropping systems,)
- Soil conditions (pH, moisture, OM content,)

Resultant effects of biotic and abiotic factors on plants

- Colour change
- Change in form and shape
- Growth disturbance
- Premature drop of leaves or fruits
- Appearance of premature ripening
- Localized death of tissue (necrosis, lesions, spots)
- Rots and eventual death

Scouting is meant to help

- Prevent serious plant health problems
- Determine the cause of the problem
- Determine where the problem occurs
- Decide on the most economic al control option
- Provide evidence for the effectiveness of pest management programme followed

Scouting :What is it?

- It involves walking through the field stopping at pre-determined locations and making observations (visual)/sampling

  - To identify yield limiting problems (pests and the damage being caused (accurate)
  - Recording vital information in the field
  - Analyzing the cause of the symptoms and/or damage
  - Making informed decisions for pest management decisions based on the data collected

Scouting :What is it?

Involves looking for physical evidence of :

- damage of insect feeding, symptoms/signs of disease , effect of weeds on crop; e.g Exit holes, fruss, webbing, lesions, necrosis, galls, spots, weak crop,
- Or presence of visible insects, fungi/pathogens, weeds
- Or general damages such as oozes of gum, bacteria
- Or other growths on crop/ trees (galling)

How is it done? Techniques

- In the field map out problematic areas and purpose to take samples from those positions **but** scouting only in the problem areas may give the wrong impression of infestation/infection

How is it done? Techniques

- Look at the field and move in a certain pattern to represent the whole farm and stop in the locations for visual observation
- If field is long and narrow: a Zig zag pattern is preferred
- If field is square /rectangular: can use diagnols or ‘M’/’W’/’U’ shapes
- Can also use transect or stepwise movement to pick representative samples
- In store, draw representative samples and weigh, look for physical damage, count insects if present dead or alive and the young

Remember: Scouting techniques vary with the pests involved/ stage of development AND Early detection of problem is key

At the locations

- Make counts/estimates to determine infestation rate, pest and degree of infestation/severity
- Make notes on crop/produce and environmental information
- Collect samples for identification

Sampling techniques

- Shake and beat method on white sheet or container that would enable one to observe and count
- Knock down (spray plant and collect all insects that fall
- Bait station e.g germinate grain and place them in soil to attract larvae (grubs, wireworms) and beetles,
- Mites : brush off from leaves
- Make observations of symptoms and pick samples , preserve and take to lab for identification
- For weeds count the numbers per given area ($0.5m^2$ or $1m^2$) and identify species, plant height,

Sampling tools

- Sweep nets
- Traps (various)-sticky, coloured, light, pheromone
- Khaki paper bags
- Plastic polythene tubes
- Trays, sieves, spears for stored produce

Sweep net sampling for insects
Photo credit: Norman E. Rees

Yellow and blue traps for adult flying insects

Pheromone trap for trapping adult insects, specific to insect and sex

Pheromone trap in a pigeon pea crop

Sample Data Sheet											
Date	**Field #**	**Time**		**Crop**			**Growth Stage**				
Weather/field observations:											
Plant #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Pest 1 *[Name]*											
Larvae											
Adults											
Parasite/Predator *[Beneficial Insect Name]*											
Parasite/Predator *[Beneficial Insect Name]*											
Parasite/Predator *[Beneficial Insect Name]*											
Notes:											
Plant #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Pest 2 [Name]											
Larvae											
Adults											
Parasite/Predator *[Beneficial Insect Name]*											
Parasite/Predator *[Beneficial Insect Name]*											
Parasite/Predator *[Beneficial Insect Name]*											
Notes:											

Record keeping sample data sheet

Influencing factors

- Timing when the sampling is done
- pest involved and its development
- Weather changes
- cultural practices

How often should it be done?

- For most pests and diseases it is weekly to provide early warning of problem and allow for making decisions for action
- For most pests it is weekly and season long because various pests attack at different times during the growing period
- Also gives a field record that can be used for early warning of pest problems

Management decisions are based on scouting results

- Pests present
- Pest numbers/population observed
- Is the population increasing or not?
- The damage taking place
- Is it acceptable or not?
- Effect of abiotic factors (weather patterns) on the pests
- Presence of the natural enemies and the effect/impact on the pest population

Choices of management to be made are:

1.Take no action

Take action only when crop is threatened

2. Reduce crop susceptibility

3. Reduce the abundance of the pest/disease

4. Combine reduction of crop susceptibility and reduction of the pest population /inoculum

Examples of insects

- Thrips: weekly field checks to observe population dynamics, sample 5 plants/ leaves or flowers and bag to count the numbers or use traps
- Whiteflies: weekly checks, use sticky traps , inspect leaves underneath and estimate nymph numbers
- Aphids: weekly field checks after planting, check hot spots along the margins, use traps(yellow water traps to determine flight activity

Aphids infected by a fungal pathogens can be detected while scouting

Examples of insects

- Can do destructive sampling for cereals such as sorghum , maize to look for the pest in stem such as the stem borers or the shoot fly larvae

Grass sawfly larvae

- Bean fly: first two weeks any yellowing seedlings should be uprooted and checked whether it is the insect or fungal problem

Diseases

- Blight/virus diseases

Weekly checks in the field, mark 5-10 randomly selected plants per location and estimate the disease progression. Use a scale (1-9) based on the percent area of leaf/plant affected to estimate and record the disease or the increase in infection within the field (severity)

- RKNs can also be done on a monthly basis in random spots within the problematic and non problematic areas and record the numbers
- but can also uproot plants (destructive sampling) and carry to lab and process the roots to count the numbers

Weeds

- Every two weeks or pre- determined time periods, using a quadrat of known measurements. One is able to count the number of weeds in the area and the species within identified , the plants can be dried and preserved for identification if unknown

- The quadrats are thrown in random locations to get representative samples for the field

- Can also measure target plant height to determine whether the crop is being affected by the presence of weeds

Pod fly adult

Aphids

Pod fly maggots

Leaf webber

Pod fly pupae

THANK YOU

Overview of options for managing insect pests, diseases and weeds

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Outline

- Reasons for management
- Approaches to management
- Options for management
- Action thresholds
- Summary of the management options available

Reasons for management

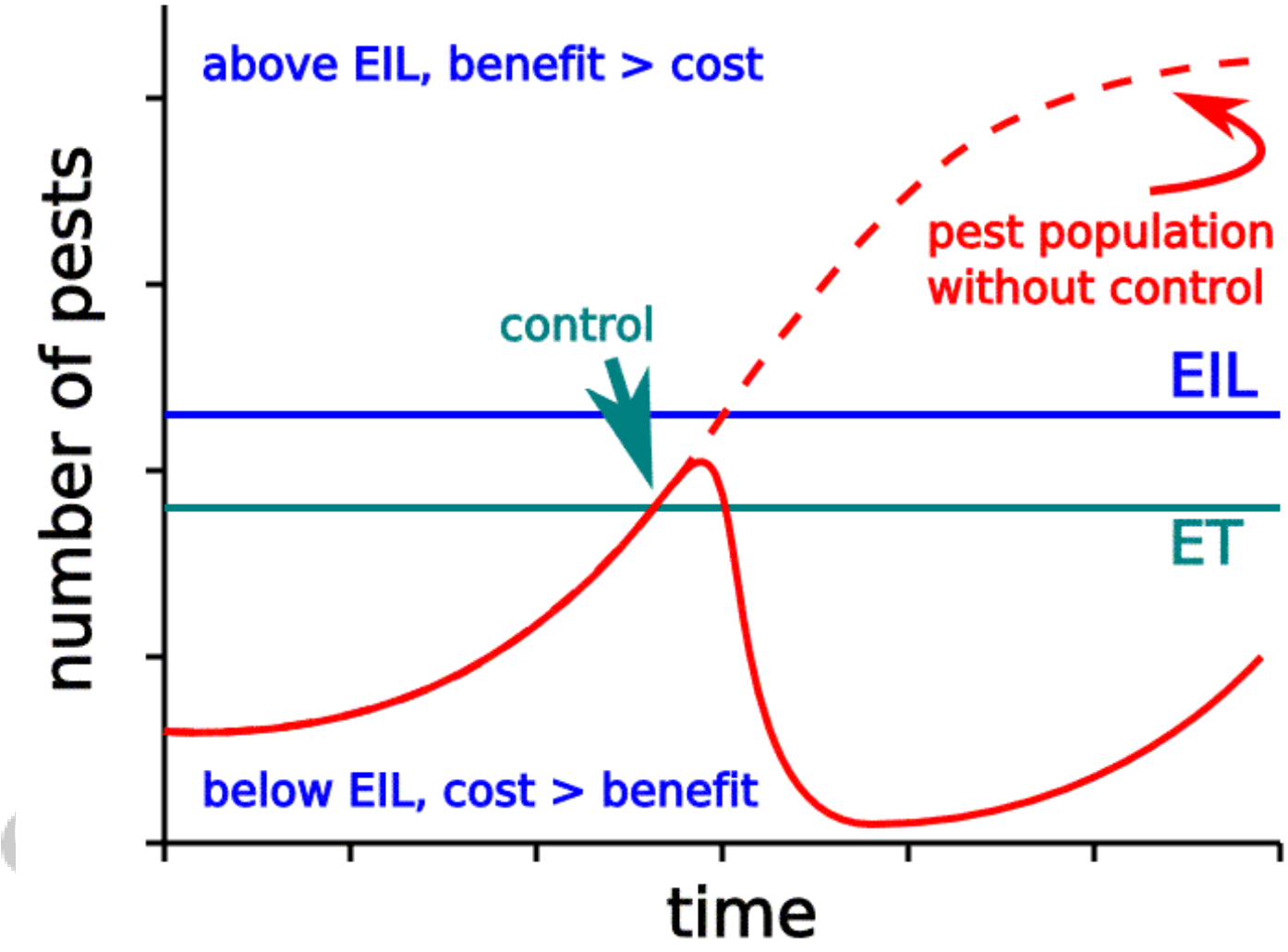
- To reduce crop losses incurred from the effects of pests
- To prevent /suppress damage
- To prevent / suppress disease spread
- To prevent /suppress weeds

Approaches to management

- Host plant manipulation - isolate crop in time and space
- Reduce pathogen sources
- Manipulate vector populations
- Block disease transfer

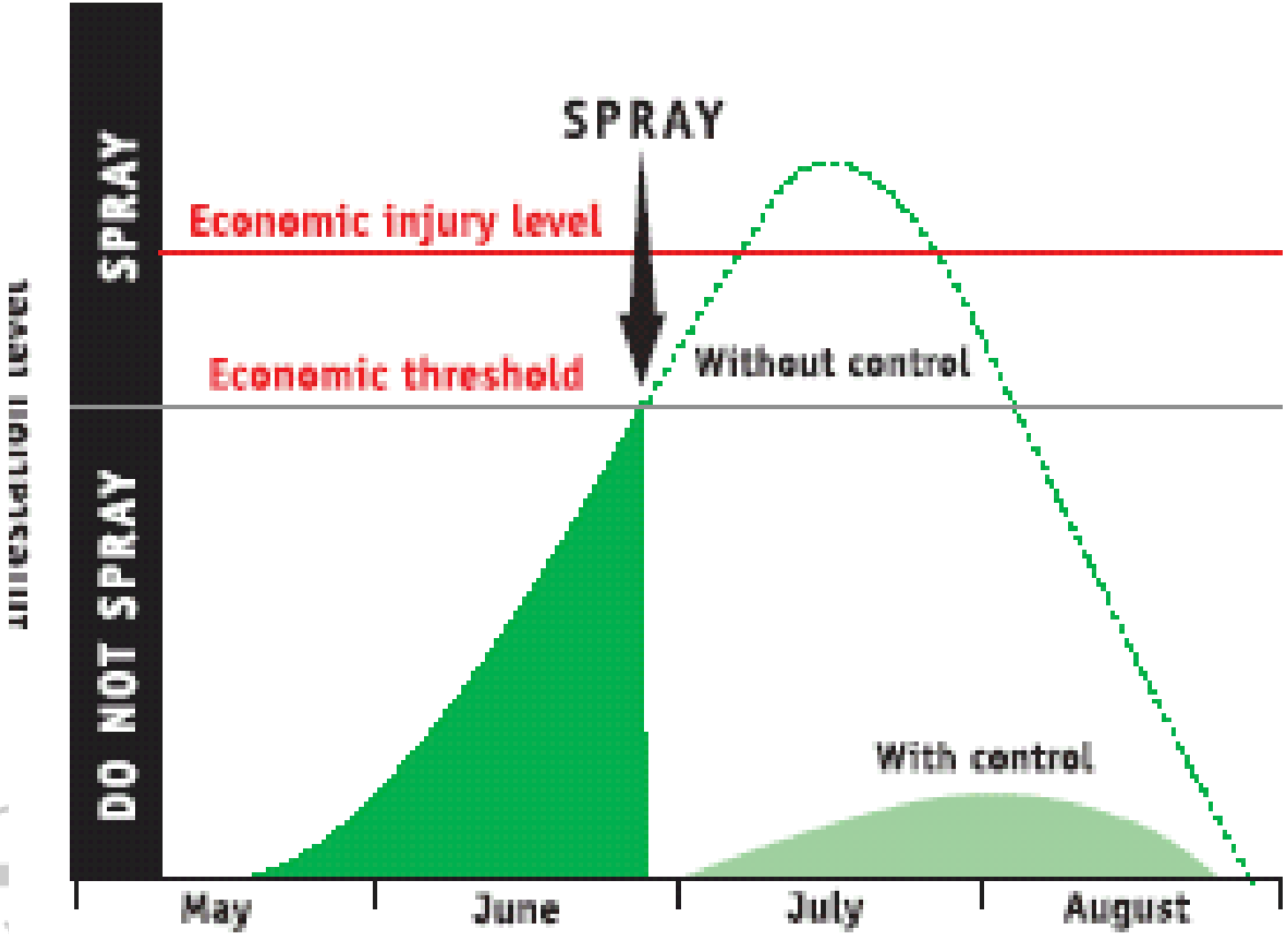
Options for management

- Cultural practices
- Physical/mechanical
- Biological
- Host plant resistance
- Chemical
- Genetic control
- Legislative



EIL definition “the pest population at which pest control measures must be taken to prevent the pest population from rising to the economic injury level."

Figure credit: Ed Zaborski



Relationship between the economic injury level (EIL), economic threshold (ETh), and seasonal pest population growth. The time to take control action (apply pesticide) is when pest density reaches the ETh value; pesticide application

Action threshold

Economic Injury Level (EIL) is defined as that pest population level at which the cost of crop yield loss to the pest begins to exceed the cost of the recommended control measures for the pest.

The Economic Threshold (ET) is that level of pest population at which the pest, if left untreated, is likely to reach or exceed the EIL. Therefore, the ET is always a little lower than the EIL, and is considered the point at which the farmer should take action against the pest. Therefore, the ET is sometimes called an Action Threshold (AT).

Action threshold can be set either through experience or experiments

Cultural practices

- Activities carried out in the farm to reduce the rate at which pests colonize or affect a crop in the field

OR

- Activities that make the crop environment less suitable for pest survival

- They are several: crop rotation, changing planting dates, mulching, cultivation/ tillage methods, irrigation, sanitation, soil amendment, nutrition

Host plant resistance

- The inherent ability of the crop to fight back diseases or pest infestation or withstand competition with weeds. Three levels are recognized under specified conditions
- Resistant – the crop will grow and produce acceptable yield under pressure of high pest abundance
- Moderately resistant/tolerant- the crop will grow and produce yield under pressure of high pest abundance
- Susceptible- the crop will succumb to pressure of high pest abundance with little or no yield
- **Resistance is relative. It is influenced by presence or absence of resistance genes and environmental conditions (temp, pest abundance)**
- In relation to weeds the crop is said to be competitive than the weed pressure it is exposed to

Approaches for breeding for resistance

- Antibiosis : suppression of pest growth and reproduction on a plant e.g aphids on soybean

- Antixenosis (non –preference): Inability of an insect to find and /or feed on a plant

- Tolerance: the ability of a plant to grow and yield despite pests feeding on it

AND NOW

- The ability to insert genes into plants, creating transgenic hybrids, giving a whole new meaning to plant resistance

Biological control

- Utilization of live organisms to manage pests and diseases. The organisms utilized are mainly insects, pathogens and entomopathogenic nematodes (All referred to as biological agents –BCAs). The insects are in two groups
- Parasitoids which are mainly parasites that lay eggs on/in host and develop within or on host and emerge as adults and in the process kill the host (pathogens for of parasites feed on plant to multiply)
- Predators which search and eat the prey (pests within the field)
- Pathogens : fungi able to control other fungi and insects e.g *Metarhizium, Beauvaria, Lecanicillium, Verticillium spp*, Bacteria able to control insects or other bacteria eg Bt, OR viruses able to control insects
- Nematodes: able to control insects e.g *Steinernema spp*

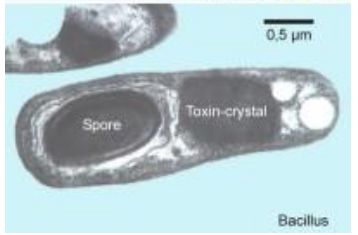
Biological control:

- Natural enemies of pests cause mortality;
- Can maintain pest population at below-threshold levels

Predators

Parasitoids

Pathogens



Chemical control

- Products/materials with inherent ability to poison and kill organisms (pathogens, insects , mites and nematodes). They are capable of causing harm such as Environmental pollution, harm to man and the non target organisms such as fish, bees, birds, wildlife

- Apart from causing harm, a resurgence of pests is likely to occur, resistance of pests to certain molecules is likely to occur,

Problems with insecticides:

- Kill or disrupt natural enemies
- may be the cause of Secondary pests
- Leave Residues on produce
- Build-up of resistance – insecticide "treadmill"
- Environmental concerns (health to man and non-targets)

Chemical control

Desired chemicals for use should have the following characteristics :

- Least toxicity to man and environment,
- Be most specific to the target pest and
- Least harmful to non-target organisms

Physical/mechanical

Use of physical means to prevent pests from reaching the target crops such as

- Border crops
- Nets,
- Trenches,
- Traps
- Pruning
- Sticky barriers
- Cover crops
- Change of temperature

Border cropping or strip cropping or habitat manipulation

Genetic control

- Changing the genes within the pest or pathogen to ensure that its survival rate and reproduction is minimal

- In insects there is a technique referred to as Sterile insect technique where the insects reared in the laboratory are sterilized using radiation or a special chemical.

- The sterile insects are then released in the environment (agro-ecosystem) to breed with others with a hope that no progeny will be produced thereby reducing the pest population. E.g. fruit flies infesting fruits, tsetse flies that bite and spread trypanosomiasis in animals especially cattle

Legislation

- Use the law of the land to prevent entry and spread of pests and diseases in an area.
- It is applied when certain pests are declared quarantine pests/invasive species
- Quarantine pests are those pests that are not within an area/ country and the introduction is likely to affect the economic standing of the area or country
- The pest is likely to invade and replace other s (biodiversity)
- The pest is likely to spread and replace others and change the whole environment where a country is unable to cope

Considerations for Choosing Control Methods

- Determine damage level you can withstand
- Determine desired control outcomes
  - Prevention of pest outbreaks
  - Suppression to acceptable level
  - Eradication of all pest organisms
- Manage pesticide resistance
- Estimated costs
  - Monetary
  - Environmental impacts

THANK YOU