زانکۆی سەلاحەدین - هەولێر
Salahaddin University-Erbil

CIHAN UNIVERSITY

RESISTANCE IN PLANTS TO INSECTS

AN OVERVIEW OF MECHANISMS AND INTERACTIONS

Prepared by

Dr. Wand Khalis Ali
Salahaddin University
College of Education-Biology Department

outline

-The resistance concept and Definition

-Level of plant resistance

-Type of resistance

-Mechanisms of Resistance

-Advantages to the Use of Insect-Resistant Crop Varieties

-Limitation on the use of host plant resistance

When plants are exposed to biotic or abiotic stress, varying degrees of damage may occur, but many plants manage to protect themselves. Collectively, their defense mechanisms make up what is referred to as **plant resistance**. **so**

Plant –pathogen relationship

Pass through four stages:

1-contact

2-penetration

3-establishment

4-development

PLANT RESISTANCE TO PATHOGENS (bacteria, fungi , nematode , insects…etc)

- Before infection(1-contact,2-penetrationm3-establishment

Resistance to establishment of the pathogen (Resistance due to inhibition of infection)

(passive resistance or constitutive resistance)

pre-existing defense mechanism

1-pre-existing structural defense(cuticle&wax , epidermal cell wall, number of natural openings, internal cell s thickness and hardness)

- **2-pre-existing biochemical defense**

a.(antifungal and antimicrobial compounds released by the plant in its environment)

b.(inhibitors or antimicrobial compounds present in the plant cell)

c.(lack of essential substances for the growth of the pathogen)

After infection

Resistance to an established pathogen

(Resistance due to growth inhibition)

(inducible resistance)

Post infection mechanical defense

A. Post infection Structural defense

1-histological defense (lignin biosynthesis ,Cork layer , Tyloses ,Gum deposition)

2-cytoplasmic defense reaction

3-necrotic or hypersensitive reaction

B. Post infection Biochemical defense

1-toxic materials produced in response to infection(phenolic compounds , phytoalexins)

2-defense through induced synthesis of proteins &enzymes (phenol oxidizing enzyme)

3-formation of substrates resistant to enzymes of pathogen

4-defense through altered biosynthetic pathway

5-hypersensitivity

- Plant resistance is normally **defined as**

the heritable ability of plants to escape attacking enemies, partially or fully, thus minimizing the amount of damage

(Painter, 1951; Mitchell et al., 2016).

The Resistance Concept (resistance to insects)

- The resistance concept has its roots in plant breeding research (e.g., Painter 1958;Maxwell and Jennings 1980).

- Painter's 1958 definition focuses on damage to the plant; any plant characters that minimize damage will contribute to resistance, Thus, he viewed compensation, or tolerance, as one component of resistance, and others after him have adopted this view

- Traditionally, resistance has been considered as genetically determined, while

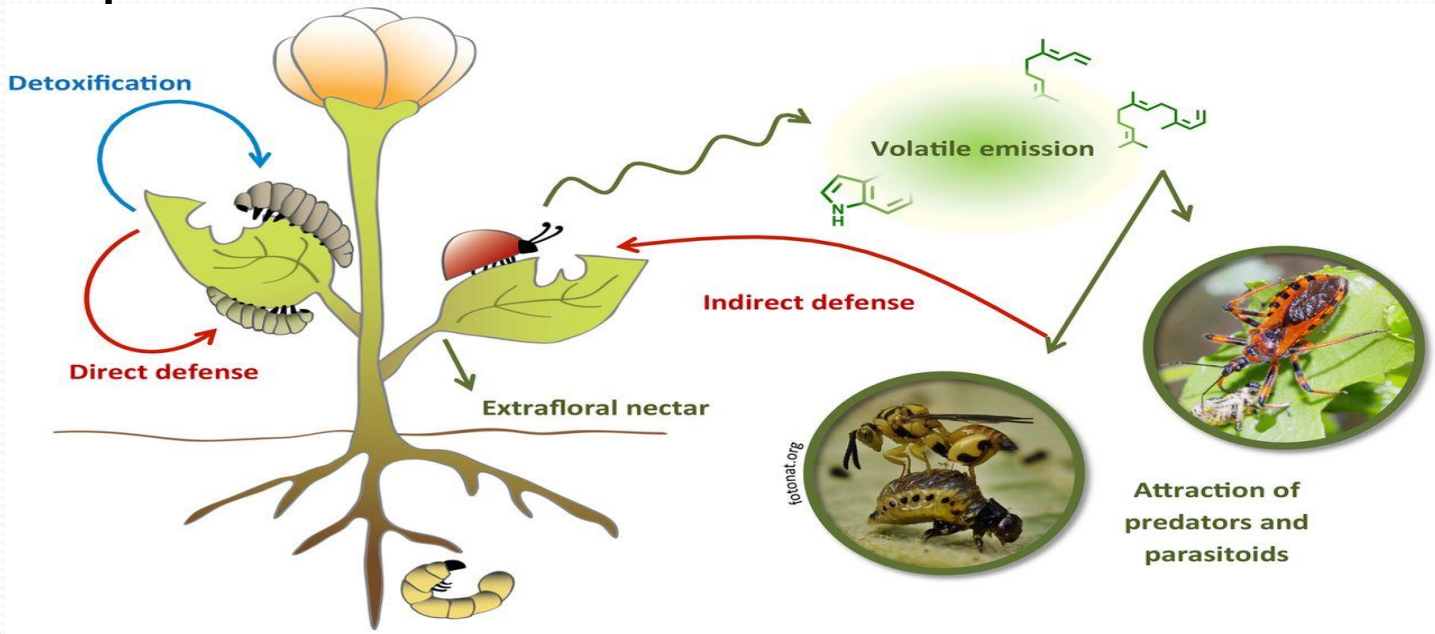
- Ecologists have increasingly used resistance more broadly. Especially when it comes to tree/insect interactions the term resistance is frequently referred to as a phenotypic feature possibly shaped by biotic as well as abiotic factors

- It is important to separate the concept of resistance into its two parts,

-the plant component, the resistant trait

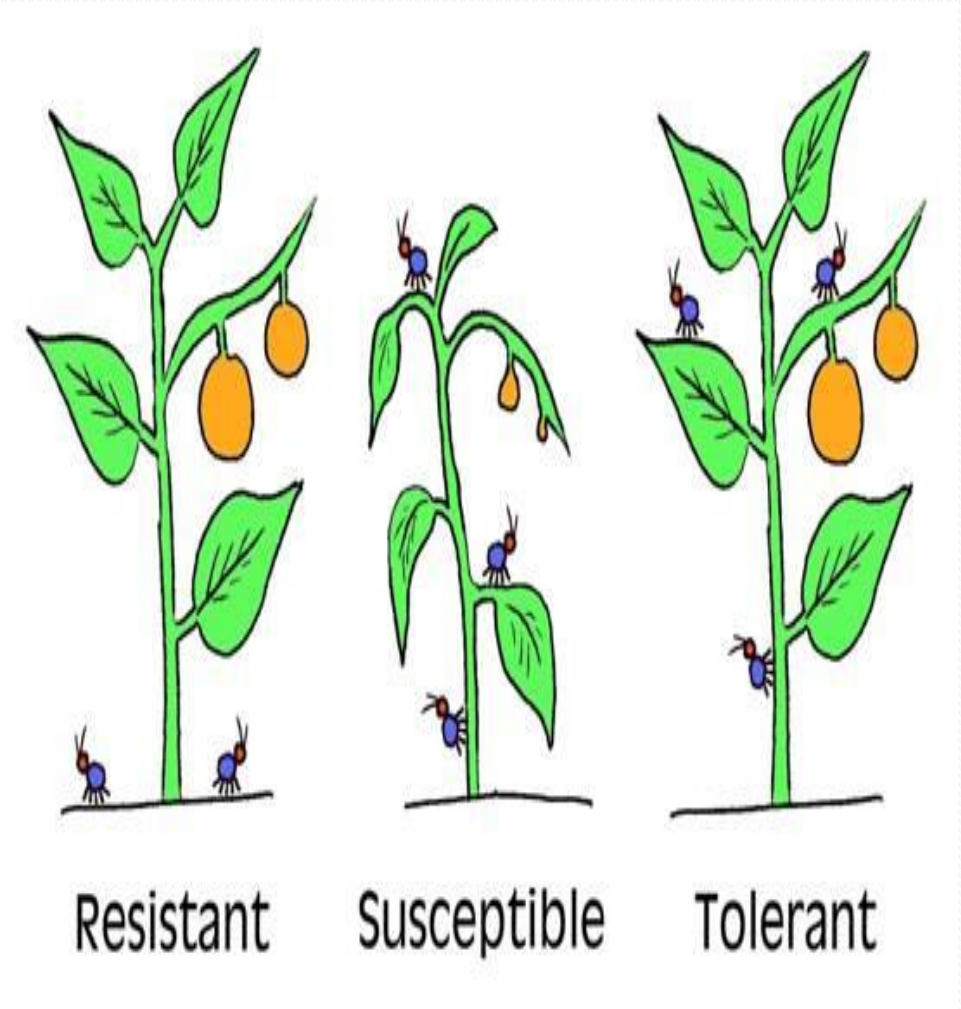
-the insect response (behavioral or physiological) to this trait.

- the interaction between the plant trait and the insect response is important to constitute the mechanism of resistance



Level of plant resistance

- Immune
- High resistance
- Low resistance
- Susceptible
- High susceptible



- Resistance varies according to:

environmental conditions,
genetic,
number of pests,
plant age.

- Resistance may be expressed at any stage of the life cycle from seedling through maturity.

Mechanisms of Resistance

plants can resist insects through one or more of the following mechanisms

Non-preference(Antixenosis)
Tolerance,
Antibiosis.

Non-preference. (Also know as antixenosis.)

Non-preference plants either provide stimuli that are **unattractive** to the pest (color, odor, texture such as downy hairs) or fail to provide stimuli that are **attractive** to the pest.

In this way, non-preference plants affect the behavior of pests.

Non-preference could be related to:

Plant morphological Factors

Plant physiological Factors

Biochemical Factors

(chemicals product of plant metabolism

Plant morphological characteristic

foliage size

Leaf shape

Shape

- Acicular — needle shaped
- Falcate — hooked or sickle shaped
- Orbicular — circular
- Rhomboid — diamond-shaped
- Acuminate — tapering to a long point
- Flabelate — fan shaped
- Ovate — egg-shaped, wide at base
- Rosette — leaflets in tight circular rings
- Alternate — leaflets arranged alternately
- Hastate — triangular with basal lobes
- Palmate — like a hand with fingers
- Spatulate — spoon-shaped
- Aristate — with a spine-like tip
- Lanceolate — pointed at both ends
- Pedate — palmate, divided lateral lobes
- Spear-shaped — pointed, barbed base
- Bipinnate — leaflets also pinnate
- Linear — parallel margins, elongate
- Peltate — stem attached centrally
- Subulate — tapering point, awl-shaped
- Cordate — heart-shaped, stem in cleft
- Lobed — deeply indented margins
- Perfoliate — stem seeming to pierce leaf
- Trifoliate/Ternate — leaflets in threes
- Cuneate — wedge shaped, acute base
- Obcordate — heart-shaped, stem at point
- Odd Pinnate — leaflets in rows, one at tip
- Tripinnate — leaflets also bipinnate
- Deltoid — triangular
- Obovate — egg-shaped, narrow at base
- Even Pinnate — leaflets in rows, two at tip
- Truncate — squared-off apex
- Digitate — with finger-like lobes
- Obtuse — bluntly tipped
- Pinnatisect — deep, opposite lobing
- Unifoliate — having a single leaf
- Elliptic — oval-shaped, small or no point
- Opposite — leaflets in adjacent pairs
- Reniform — kidney-shaped
- Whorled — rings of three or more leaflets

Margin

- Ciliate — with fine hairs
- Crenate — with rounded teeth
- Dentate — with symmetrical teeth
- Denticulate — with fine dentition
- Doubly Serrate — serrate with sub-teeth
- Entire — even, smooth throughout
- Lobate — indented, but not to midline
- Serrate — teeth forward-pointing
- Serrulate — with fine serration
- Sinuate — with wave-like indentations
- Spiny — with sharp stiff points
- Undulate — widely wavy

Venation

- Arcuate — secondary veins bending toward apex
- Cross-Venulate — small veins connecting secondary veins
- Dichotomous — veins branching symmetrically in pairs
- Longitudinal — veigns aligned mostly along long axis of leaf
- Palmate — several primary veins diverging from a point
- Parallel — veins arranged axially, not intersecting
- Pinnate — secondary veins paired oppositely
- Reticulate — smaller veins forming a network
- Rotate — in peltate leaves, veins radiating

colour


Oaks
Red, brown or russet
Hickories
Golden bronze
Dogwoods
Purplish red
Beech
Light tan
Red maples
Brilliant scarlet
Sugar maples
Orange, red
Black maples
Glowing yellow
Aspen, birch, yellow poplar
Golden yellow
Source: U.S. Department of Agriculture


Leaves taken off of the tree and kept in the dark
Leaves left on the tree in the light
Leaves left on the tree but kept in a dark bag from September 22 - October 12

Glandular secretions , pubescence

Leaves on certain plant species have trichomes with glands containing secondary metabolites

- Such glandular secretions affect insect feeding and movement also may trap or deter the insect.

Tissue toughness

- The toughness of plant structures is a serious barrier for many herbivorous insects.

- Toughness of leaves on woody plants varies
- among taxa
- within taxa
- among habitats and among
- age classes within a species

- Most likely, tough leaves block many non-adapted insects from initiating feeding, although this source of resistance is difficult to separate from chemical traits. Even adapted insects find it difficult to feed on the tough leaves of certain plants.

Physiological Factors:

- Some physiological factors such as osmotic concentration of cell sap and leaf exudates are associated with insect resistance.

Biochemical Factors

usually involve chemicals products of plant metabolism

Primary metabolic products
(enzyme , hormones , lipids , proteins , carbohydrate , phosphor compound….)
Promote growth and reproduction
in plant and its related to insect as feeding stimulants
Nutrients
Toxicants

Secondary metabolic products (allelochemics : allomons , kairomons)

Some examples are given below:

1. In rice, high **silica** content in the shoot resistance to stem borer.

2. In wheat and barley, resistance to green bugs is associated with high concentration of **benzyl alcohol.**

3. In cotton, resistance to several insect pest is associated with high concentration of **gossypol**, a phenolic compound. High **tannin** content is also associated with bollworm resistance in cotton.

4. In alfalfa high concentration of **saponin** in the leaves and stem confer, resistance to spotted alfalfa aphid and pea aphid.

5. In maize, resistance to European corn borer is associated with high concentration of **DIMBOA** (2,4 dihydroxy, 7 methyl, 2H-1, 4- benzoxoxazin, 3(4 –H)-one).

6. Leaves of wild tomato (Lycopersicon hirsutum var. glabratum) contain highly active **ethanol soluble compound** which is lethal to tomato fruit worm and tobacco flea beetle.

- **Semiochemicals** are natural substances produced and used by animals and plants to communicate.
- The term "Semio" comes from Greek and means "sign".
- Examples of semiochemicals are insect pheromones (substance produced by an insect to attract members of its own species or notify members of its own species that danger is present - an alarm) and
- **allelochemicals** (used for communication between individuals belonging to different species, such as plants and insects or plants and other plants)

(kairomones)

- favorable to the receiver but not the emitter

(allomones)

- favorable to the emitter but not the receiver

(synomones).

- favorable to both emitter and receiver

Antibiosis

Antibiosis is a type of resistance in which the host plant causes injury, death, reduced longevity, or reduced reproduction of the pest.

Often both a resistant and susceptible variety will have the same basic response to a pest, but the resistant variety will respond more quickly or more dramatically than the susceptible variety, reducing the amount of damage the pest causes. Plants that express antibiosis affect the biology of pests.

Its effect the insects because of:

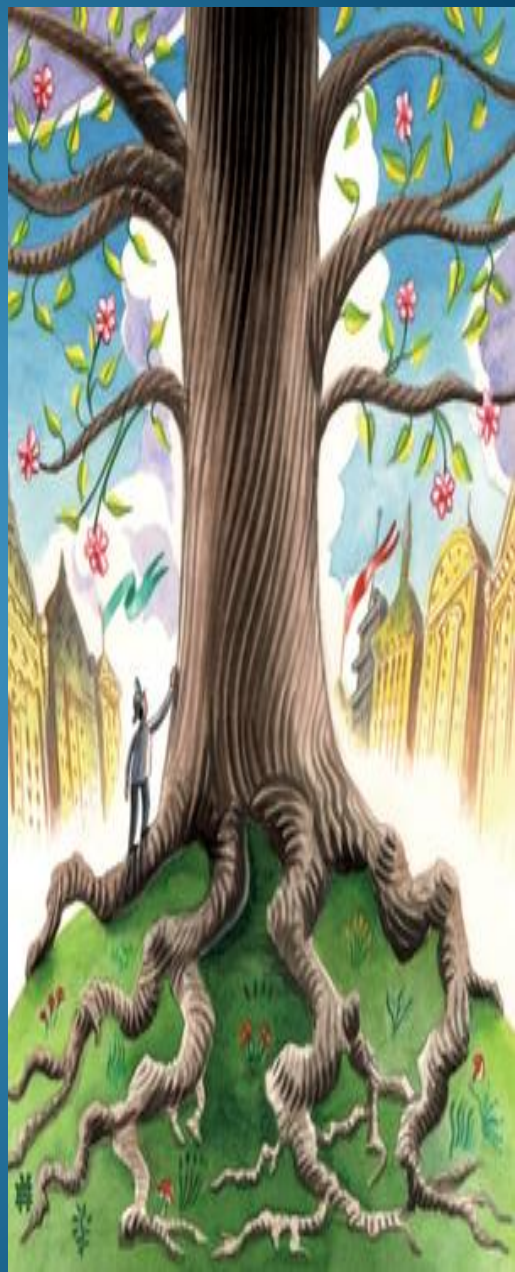
The deleterious effect of specific chemicals
The lack of specific food materials including vitamins
The lack of specific proteins and minerals
The lack of available food (quantities)

Tolerance

Host plants that express tolerance are resistant to pest damage because they can remain healthy and yield well despite the damage. These plants must also be able to heal wounds and fight diseases that enter through wounds.

Plant with repair and recovery and strong root

It place no selective pressure on insect population



- Research during the last decade has emphasized the importance of tolerance as a plant strategy to reduce negative effects of herbivory(insects)

- Still, our understanding of tolerance lags behind that of resistance, although tolerance may be much more important than generally acknowledged

measuring plant resistance to herbivores insects.

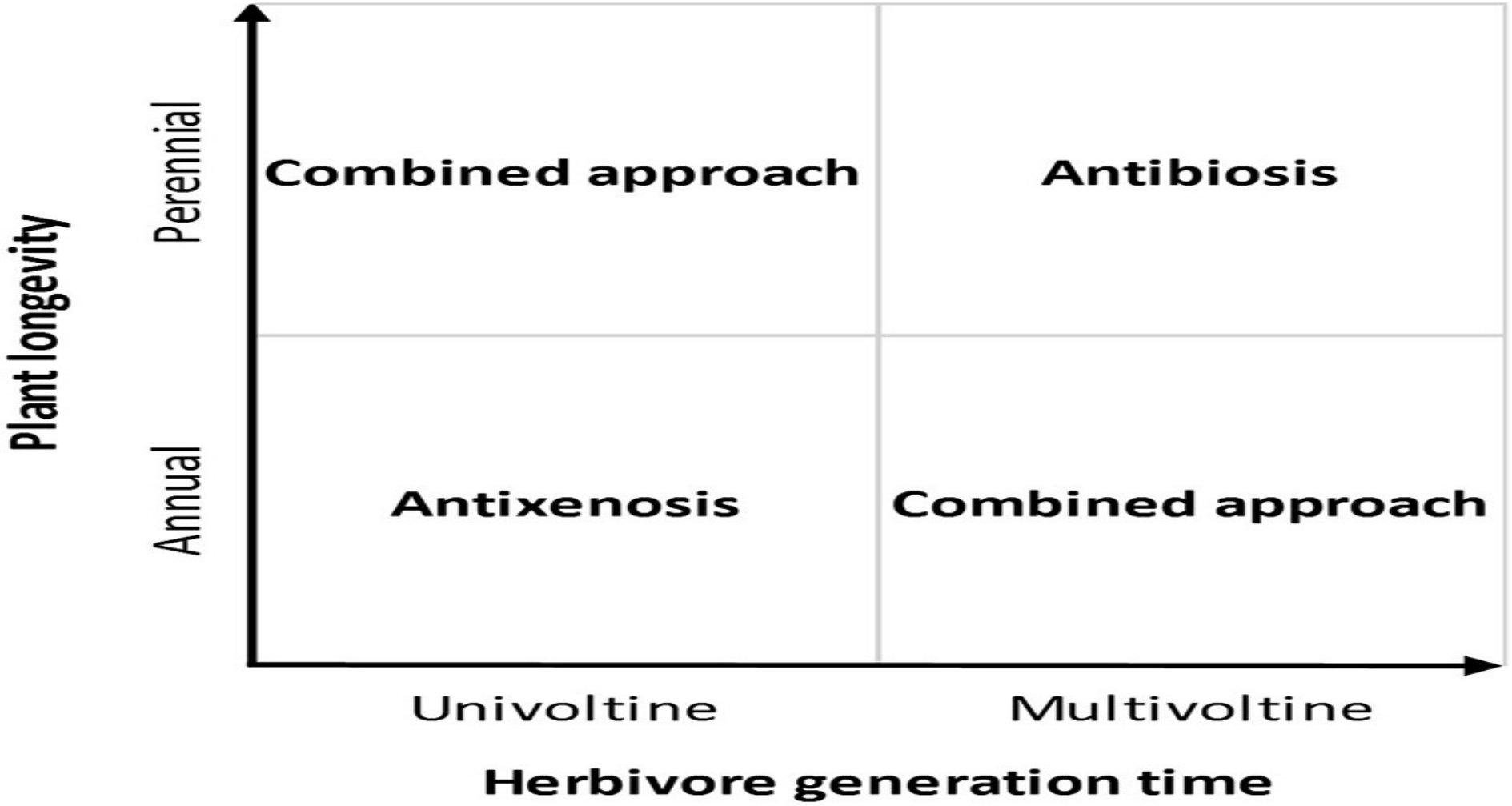
- Two principal approaches to measuring plant resistance to herbivore insects.

1. Antibiosis (how suitable the plant is for the insect)

- (a) insect fitness or performance (e.g., fertility rate or larval development time)
- (b) Intrinsic plant traits (chemical) underlying insect fitness.

2. Antixenosis (how much damage or how many insects a plant attracts)

- (a) insect presence (number of eggs, larvae, or adults)
- (b) insect damage (e.g., percentage leaf area removed).



Schematic showing which approach for measuring plant resistance would be most appropriate depending on the longevity of the crop plant (or culture) and the generation time of the herbivore.

Advantages to the Use of Insect-Resistant Crop Varieties

- Use of insect-resistant crop varieties is economically, ecologically, and environmentally advantageous.

- **Economic benefits** occur because
- crop yields are saved from loss to insect pests
- and money is saved by not applying insecticides that would have been applied to susceptible varieties.
- In most cases, seed of insect-resistant cultivars costs no more, or little more, than for susceptible cultivars.

- **Ecological and environmental benefits** arise from increases in species diversity in the agro ecosystem, in part because of **reduced use of insecticides.** Increases in species diversity increase ecosystem stability which promotes a more sustainable system far less polluted and detrimental to natural resources.

Limitation on the use of host plant resistance

- Difficulty in searching to find a resistance plant
- plant with immune level may not found
- The resistant plant without commercial characters
- Time required for develop of resistant varieties may be as long as 15 to 20 years
- in some case Resistance breakdown could happen

Thank you