Ministry of Agriculture
Republik Indonesia

Non-Aligned Movement Centre for
South-South Technical Cooperation

INTEGRATED PEST MANAGEMENT CONTROL TACTICS

"Back To Nature, Support Sustainable Agriculture"

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LEARNING OBJECTIVES

From this topic the participants:

- Be able to define integrated pest management.
- Understand the control strategies that used in IPM
- Understand about botanical pesticides.

BACKGROUND

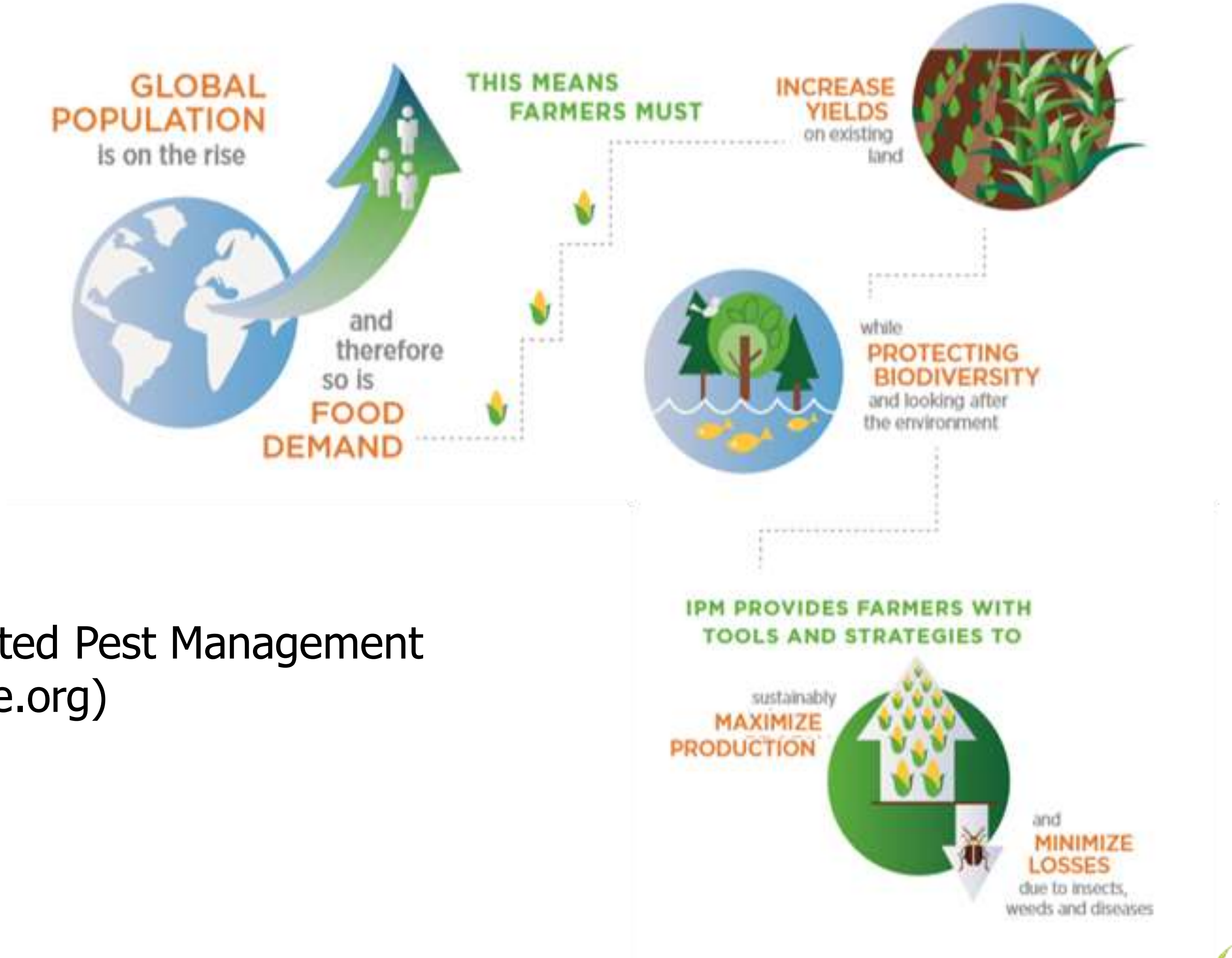


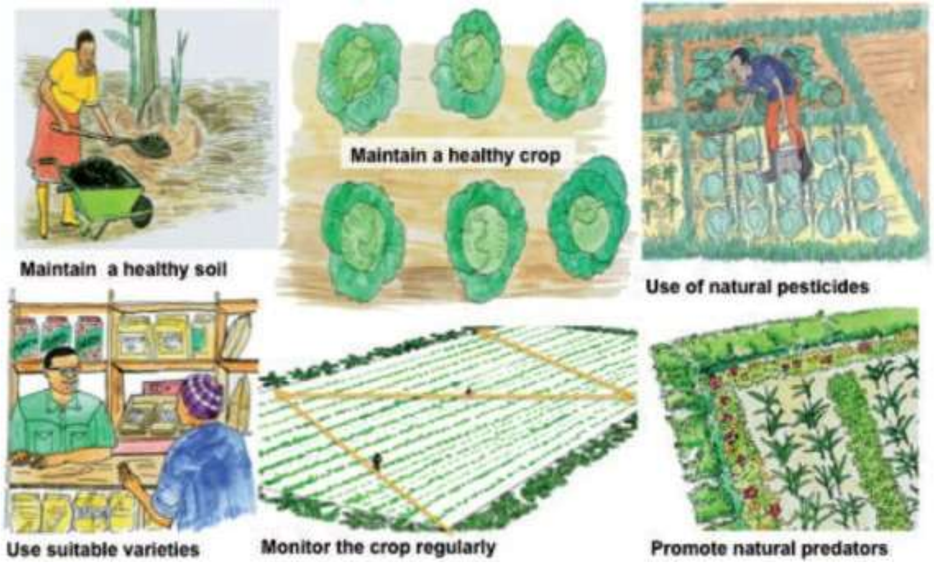
Figure 1 : Concept of Integrated Pest Management
(www.croplife.org)

INTEGRATED PEST MANAGEMENT

The goal of IPM is to use all appropriate tools and tactics to keep pest populations below economically damaging levels and to avoid adverse effects to humans, wildlife, and the environment.

These tools : cultural, physical, biological, and chemical control methods.

Management decisions are based on information gathered about the pest problem and crop. Then you use a combination of control measures that best suits the problem

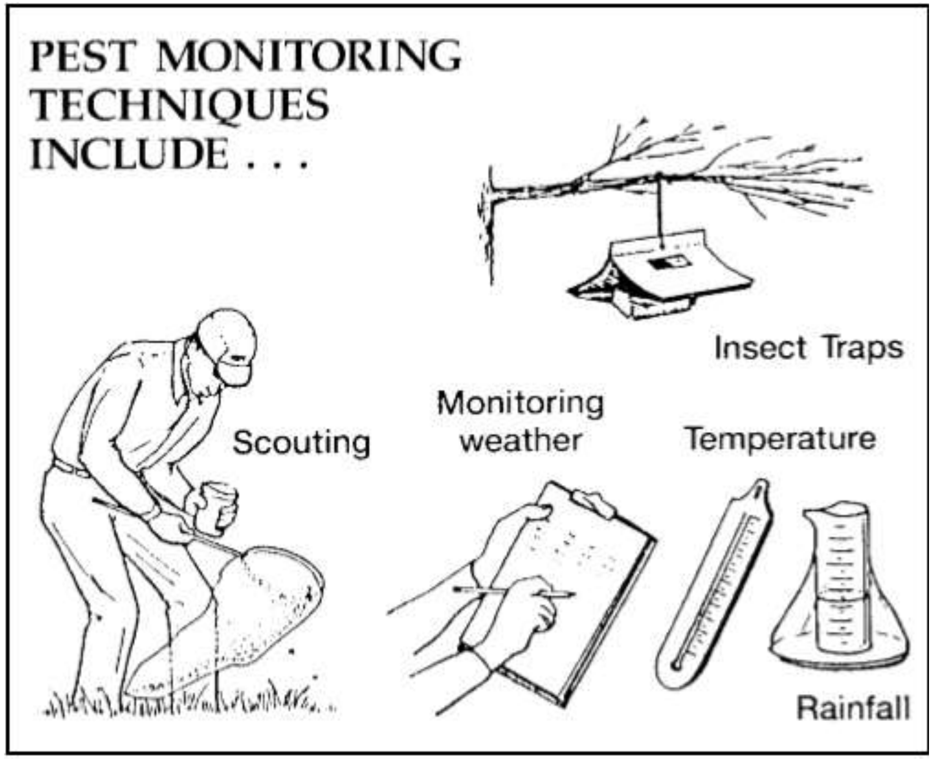


FIELD SCOUTING, MONITORING

Field scouting is an important part of any IPM program because it helps define the pest problems

A scouting trip through a field reveals

- what pests are present
- the growth stage of the pests and the crop
- the location of the pest in the crop
- whether the pests are parasitized or diseased
- the pest population, if the population is increasing or decreasing,
- crop condition.



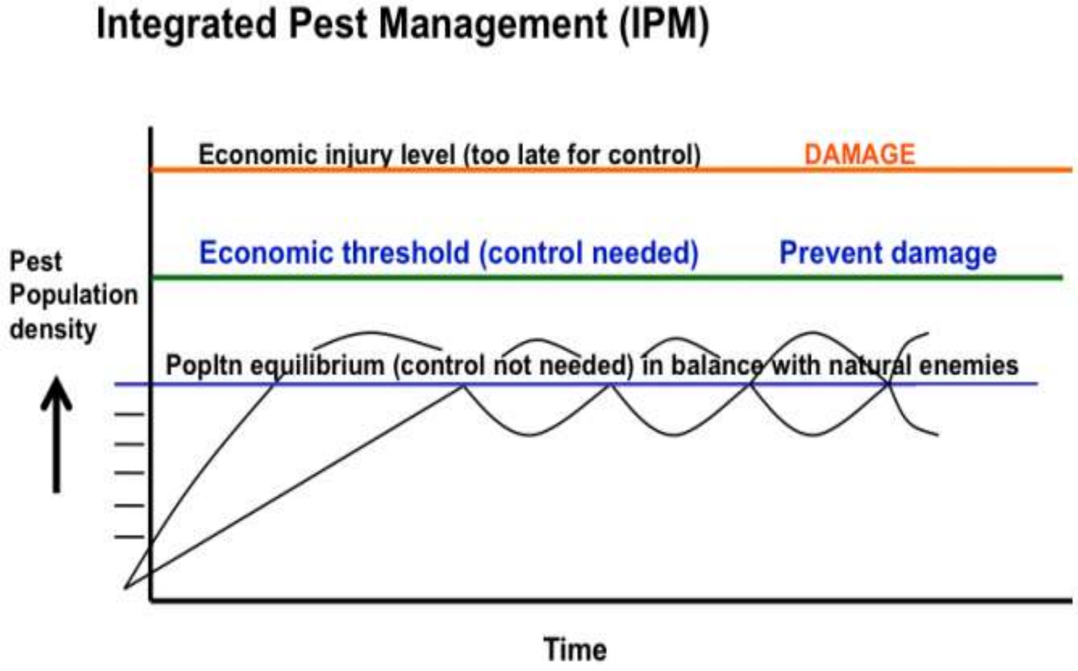
(Hines, 2015)

ECONOMIC THRESHOLDS

An economic threshold : the pest density at which action must be taken to prevent the pest population from increasing and causing economic damage.

Economic thresholds are constantly changing. They vary between fields, varieties, and crop growth stages. Economic thresholds are a function of crop value and cost of control. In general, a high-value crop will have a lower economic threshold; less pest damage will be accepted and control measures must be taken sooner.

Economic thresholds are often referred to as **action thresholds.**



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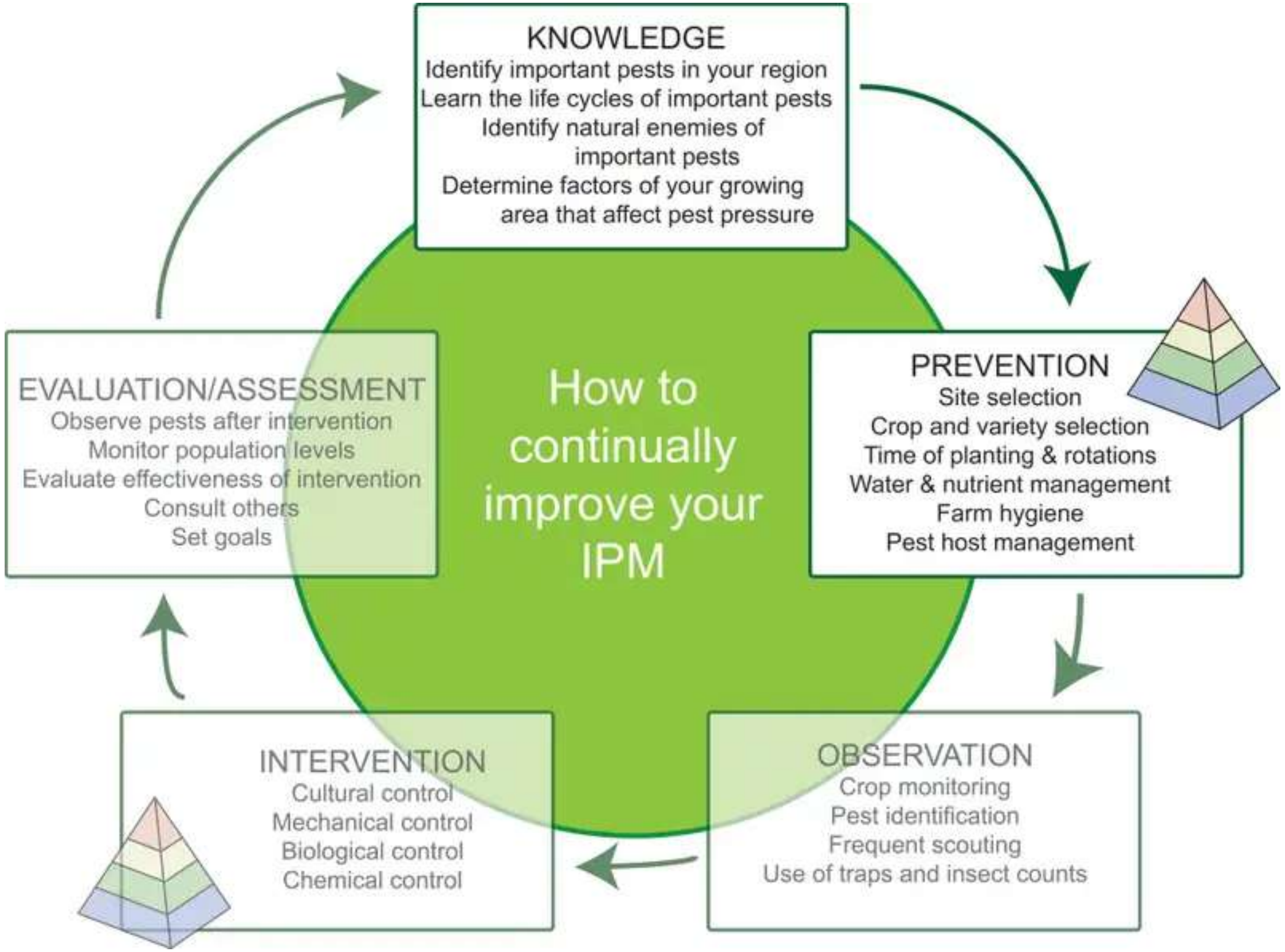


Figure 5. Stages of an example IPM cycle.
Planning can start at any stage of the cycle, and the order of stages is flexible.
(Swartz, S. 2019)

CULTURAL CONTROL

Cultural control uses farming practices to reduce pest populations.

Implementing a practice such as tillage or crop rotation at the correct time can kill or reduce pest numbers or slow pest development. Like all other control strategies, cultural control requires an understanding of the pest and the crop. **Generally, cultural control methods are preventive actions rather than curative actions.**

Cultural control methods work in three ways:

1. Prevent the pest from colonizing the crop or commodity.
2. Create adverse conditions that reduce survival of the pest.
3. Reduce the impact of pest injury.

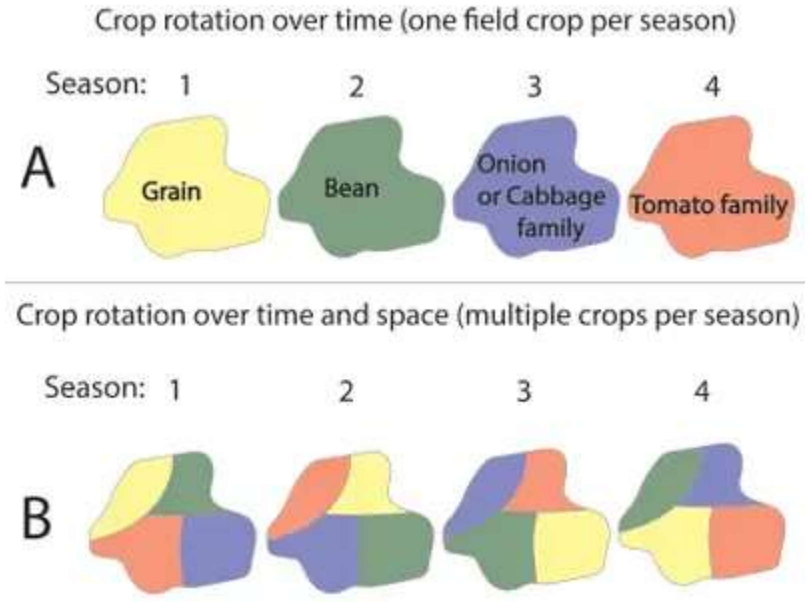


Figure 7. Crop Rotation (Swartz, S. 2019)

PHYSICAL CONTROL

Physical control methods in crop protection comprise techniques that limit pest access to the crop/commodity, induce behavioral changes, or cause direct pest damage/death, where the pest is actually attacked and destroyed (Vincent et al., 2009)

Modes of Action and Classification

1. **Passive methods :** cause changes in the immediate environment and have a more lasting effect; although with no residual action after they are removed
2. **Active methods** : used to destroy, injure, or induce stress in crop pests or to remove them from the environment, and can be classified according to the mode of energy use

BIOLOGICAL CONTROL

Biological control is the use of living organisms to reduce a pest population.These beneficial (good) organisms are referred to as natural enemies. Predators, parasitoids, and pathogens are the most common natural enemies.

- **Predators** : organisms that eat the pest. Predators are usually not specific about what they eat -they will eat a variety of pests
- **Parasitoids** : organisms that must live in or on another organism to develop. A parasitoid is usually an insect that develops and feeds inside another insect. Common parasitoids include tiny wasps and flies. They are usually host specific.
- **Pathogens** : disease-causing organisms such as bacteria, viruses, and fungi that infect and kill the pest

Examples of insect biological control agents (natural enemies).

Natural Enemy	Pests Controlled
PREDATORS	
Lady beetles	aphids, scale insects
green lacewings	aphids, mites, others
spined soldier bug	Colorado potato beetle, Mexican bean
minute pirate bug	beetle corn earworm eggs, mites
PARASITOIDS	
tachinid flies	beetles, caterpillars
ichneumonid wasps	caterpillars, leafrollers, weevils, others
braconid wasps	caterpillars, beetles, aphids
Trichogramma wasps	eggs of moths, such as European corn borer
PATHOGENS	
Bacillus thuringiensis	caterpillars, some beetle larvae
Nuclear Polyhedrosis Viruses (NPV)	caterpillars
Beauveria bassiana (fungus)	caterpillars, grasshoppers, aphids
Nosema (protozoan)	caterpillars, beetles, grasshoppers

CHEMICAL CONTROL

Chemical control reduces a pest population through the application of pesticides.

The decision to use a pesticide as part of an IPM program should be based on a scouting program, pest identification, economic thresholds, and the crop/pest life stage. When used properly, pesticides provide effective and reliable control of most pest species. Pesticides are considered curative, and generally should be used as a last resort.

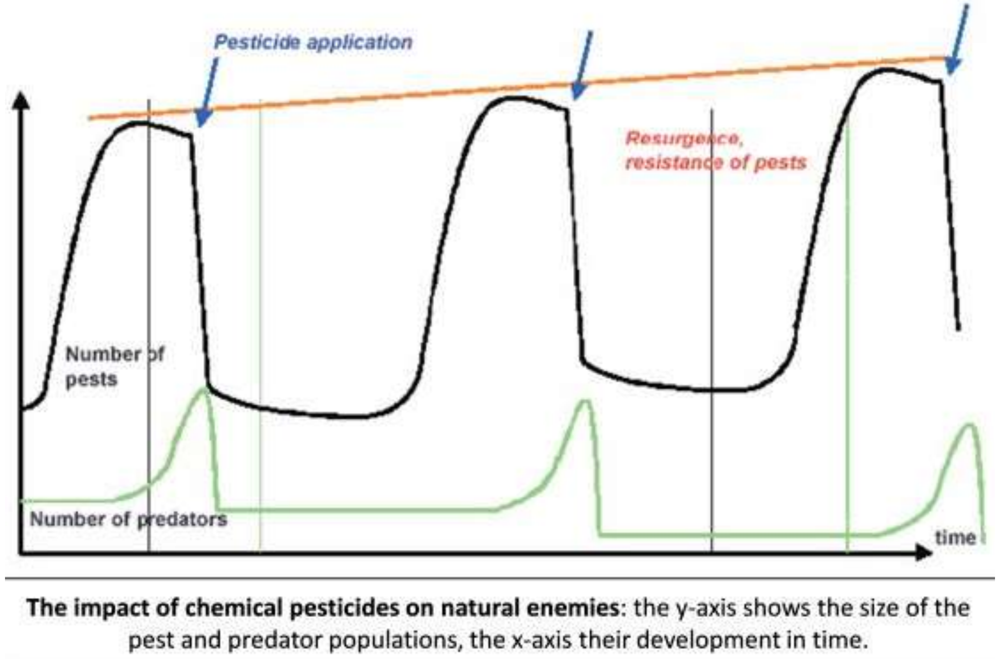


Figure 8. The impact of chemical pesticides on natural enemies

https://teca.apps.fao.org/teca/en/technologies/8372

BOTANICAL PESTICIDES

The problems caused by synthetic pesticides and their residues have increased the need for effective biodegradable pesticides with greater selectivity.

Botanical Pesticides are organic pesticides derived from plants, that have naturally occurring defensive properties (**secondary metabolite**).

Botanical pesticides have long been touted as attractive alternatives to synthetic chemical pesticides for pest management because botanicals reputedly pose little threat to the environment or to human health.

SECONDARY METABOLITE

Secondary metabolites also called specialised metabolites, toxins, secondary products, or natural products, are organic compounds which are not directly involved in the normal growth, development, or reproduction of the organism.

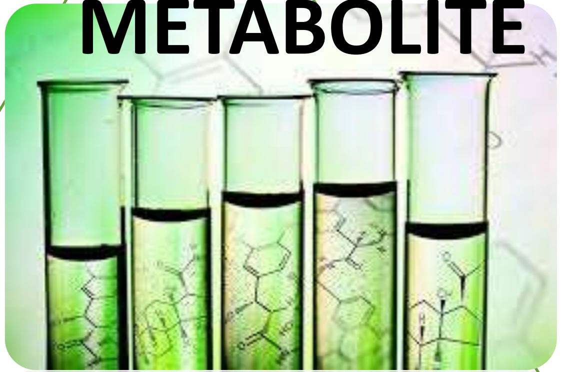
Secondary metabolites often play an important role in plant defense against herbivory and other interspecies defenses.

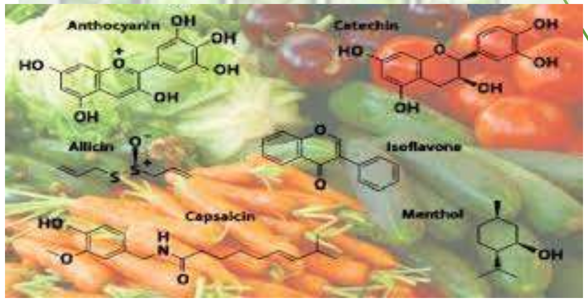
Secondary metabolites are produced at a certain growth rate or under certain conditions. This group of compounds is produced in limited quantities, not continuously and only for specific purposes.

Function:

Attractant, protect from environmental stress, protection from pests/diseases (phytoalexin), protection against ultraviolet rays, as a growth regulator and to compete with other plants (allelopathy).

SECONDARY METABOLITE





Alkaloids are a diverse group of nitrogen-containing basic compounds. Many alkaloids affect the central nervous system of animals by binding to neurotransmitter receptors.

Phenolic are a chemical compound characterized by the presence of aromatic ring structure bearing one or more hydroxyl groups. Phenolics are the most abundant secondary metabolites of plants

Terpenoids constitute a large class of natural products which are composed of isoprene units. Terpenoids are a group of compounds that give plants their taste, smell, and color.

Plant Families That Have Insecticidal Activity (Koul, 2016)

Family	Number of Species	Family	Number of Species
Annonaceae	12	Meliaceae	>500
Apiaceae	23	Moraceae	26
Apocynaceae	39	Myrtaceae	72
Asteraceae	147	Pinaceae	52
Bignonaceae	13	Poaceae	27
Piperaceae	14	Ranunculaceae	55
Cryptogram	58	Rosaceae	34
Cupressaceae	22	Rubiaceae	38
Euphorbiaceae	63	Rutaceae	42
Fabaceae	217	Solanaceae	52
Lamiaceae	76	Verbenaceae	60

1600 plants have biological activity

Medicinal and Aromatic Plants, which can be used as Botanical Pesticides

English name	Scientific Name	Family Name
Lantana	*Lantana camara* L.	Verbenaceae
Eucalyptus	*Eucalyptus globulus* Lab.	Myrtaceae
Lemon grass	*Cymbopogon citratus* Stapf.	Graminae
Datura	*Datura stramonium* L.	Solanaceae
Nerium	*Nerium oleander* L.	Apocynaceae
Althea	*Althaea officinalis* L.	Malvaceae
Neem	*Azadirachta indica* A. Juss	Meliaceae
Visnaga	*Ammi visnaga* L.	Apiaceae
Basil	*Ocimum basilicum* L.	Lamiaceae
Pipermint	*Mentha pipermita* L.	Labiatae
Spearmint	*Mentha spicata* L.	Lamiaceae

English name	Scientific Name	Family Name
Acacia	*Acacia arabica* L.	Fabaceae
Capsicum	*Capsicum frutescens* L.	Solanaceae
Garlic	*Allium sativum* L.	Liliaceae
Castor Bean	*Ricinus communis* L.	Euphorbiaceae
Thymue	*Thymus vulgaris* L.	Lamiaceae
Marjoram	*Majorana hortensis* L.	Lamiaceae
Chamomile	*Matricaria chamomile* L.	Astearaceae
Pelargonium	*Pelargonium graveolens* L'Her	Geraniaceae
Pomegranate	*Punica granatum* L.	Punicaceae
Melissa	*Melissa officinalis* L.	Lamiaceae

Botanical insecticides vs. *S. frugiperda* Rioba and Stevenson (2020):
Review of insecticidal activity in 30 plant families in South America against *S. frugiperda*

Family	Palnt Species	Action
Annonaceae	*Annona squamosa* L.	Decrease pupa weight, increased larval mortality
Apiaceae	*Foeniculum vulgare* Mill	Sublethal effect
Asteraceae	*Ageratum conyzoides* L	Insecticidal (70% mortaility)
Asteraceae	*Tagetes erecta* L.	Antifeedant effect causing 50% reduction of larval weight, 40-80% pupal moratality, 48-72%n larval mortality
Caricaceae	*Carica papaya* L	90% Mortality
Euphorbiaceae	*Ricinus communis* L	Insecticidal and insectistatic, larvacidal, growth inhibition
Euphorbiaceae	*Jatropha curcas* L	High mortality

Family	Plant Species	Action
Euphorbiaceae	*Euphorbia pulcherima* Wild Ex Klotzsch	58,5% mortality, reduced larva and puape weight, increased larva period, reduced egg viability
Lamiaceae	*Ocimum basilicum* L	Toxicity, non preference, knockdown
Lamiaceae	*Ocimum gratissimum* L	Sublethal effect
Meliaceae	*Azadirachta indica* Juss	Reduced insect growth, increased development period, mortality, low egg laying, antifeedant activity, growth regulating activity, mortality laravacidal
Rutaceae	*Citrus limon* L	Antifeedant
Rubiaceae	*Morinda citrifolia* L	Decreased pupa weight, increased larval moratlity

Family	Plant Species	Action
Poaceae	*Cymbopogon citratus* (DC) Stapf	Mortality
Poaceae	*Cymbopogon nardus* L	Decreased pupa weight, increased larval mortality
Verbenaceae	*Lantana camara* L.	High mortality

information about plants can be accessed at *plants of the world online (http://www.plantsoftheworldonline.org) or e-Prosea (http://proseanet.org/prosea/eprosea.php).*

Botanical Pesticides used to Control Different Insect Pests

Botanical Pesticides	Insect Pests
Nicotine	Aphids, thrips, caterpillars
Rotenone	Bugs, aphids, potato beetles, spider mites, carpenter ants
Ryania	Codling moths, potato aphids, onion thrips, corn earworms, silkworms
Sabadilla	Grasshoppers, codling moths, armyworms, aphids, cabbage worms, beetles
Pyrethrum	Caterpillars, aphids, leafhoppers, spider mites, bugs, cabbage worms, beetles
Essential oils	Caterpillars, cabbage worms, aphids, white flies, land snails
Neem products	Armyworms, cutworms, stemborers, bollworms, leaf miners, caterpillars, aphids, whiteflies, leafhoppers, psyllids, scales, mites, and thrips
Synthetic pyrethroids	Caterpillars, aphids, thrips

Neem (*Azadirachta indica*) : Meliaceae

- Neem is a plant that has been known to have broad spectrum pesticide properties (127-200 species).
- Leaves and seeds, but the active ingredients are more in seeds. The oil content in the seeds ranges from 35 to 45%.
- Active compounds: azadirachtin, meliantriol, salanin, nimbin and nimbidine
- As an insecticide, fungicide, bactericide, nematicide and molluscicide.

Mode of Action :
inhibits and interferes in groups, eating activities, growth and reproduction and inhibits the formation of adult insects, suppresses egg production, deflects insects, disrupts the mating process, inhibits laying and reduces the rate of hatching

- Neem can affect insect behavior and physiologically the insects become stressed and cause starvation in insects exposed to neem's biological pesticides

Cabbage caterpillar (*Crocidolomia pavonana)* failure molting due to neem extract

C. pavonana caterpillar without treatment (control)

Deformed *Crocidolomia pavonana* pupa due to neem extract (left) and normal pupa (right)

Imago *Crocidolomia pavonana* failed to get out of the skin of the pupa (left) and the imago was deformed (center) due to neem extract. (right: normal imago)

(*Melia azedarach*) : Meliaceae

Common Name : Chinaberry tree, and Indian lilac

Chemical content:
saponins, flavonoids, polyphenols, alkaloids

Mode of action:

- repellent
- stomach poison
- contact poison
- inhibition fungal growth

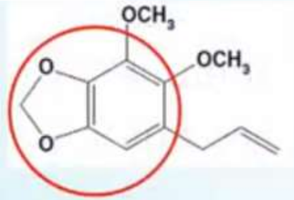
antifedant → nerve function (taste receptors) so that it loses stimulation and reduces muscle coordination so that it experiences death.

Azadirachta indica   *Melia azedarach*

Melia azedarach   *Azadirachta indica*

Examples of simple botanical pesticide preparation:

1. Synergistic mixed formulations with better contact effect.. For example, a mixture with *Piper* spp. or *Annona squamosa* L
2. Plant that can inhibit the breakdown of botanical pesticides on the plant surface, for example *Sapindus rarak, Aloevera*, etc.



Dilapiol (gol. fenilpropanoid/lignan) dari sirih hutan (*Piper aduncum*)

Examples of active compounds in *Piper* spp .:

Pipericide (Polyamide/unsaturated isobutylamide) from *Piper* spp.

- It works like pyrethrin, including having a fast knockdown effect
- Pipericides and dilapiols have a methylenedioxifenyl group (**circled in red)** so they have the potential to be synergistic

Plant That Can Inhibit The Breakdown Of Botanical Pesticides on The Plant Surface

Aloevera

Sapindus rarak

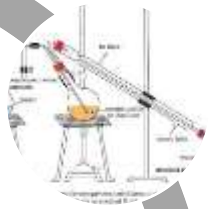
Cotton tree *: Ceiba pentandra)*

Chayote (*Sechium edule*)

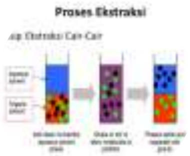
Castor Bean : *Ricinus communis*

BOTANICAL PESTICIDES

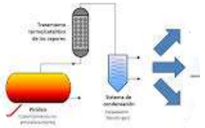
METHODS



A. DISTILLATION



B. EXTRACTION



C. PYROLYSIS

A. Distillation

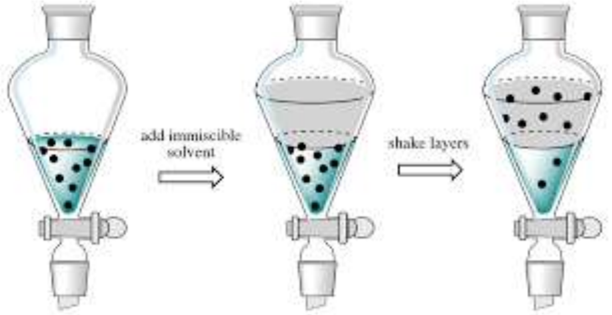
Distillation is a separation process of liquid mixtures based on their boiling points or relative volatility

Types of Distillation

a. simple distillation,
b. fractional distillation
   (different volatile 'fractions' are collected as they are produced),
a. destructive distillation
   (usually, a material is heated so that it decomposes into compounds for collection)

B. Extraction

Extractions are a way to separate a desired substance when it is mixed with others. The mixture is brought into contact with a solvent in which the substance of interest is soluble, but the other substances present are insoluble.



Maceration:
An extraction process that consists of maintaining contact between the plant and a liquid (solvent) for a period of time.
In order to increase contact between the plant material being extracted and the liquid (solvent), the plant needs to be cut into small pieces.

C. Pyrolysis

3R (Reuse, Recycle, Reduce)

Pyrolysis is the heating of an organic material, such as biomass, in the absence of oxygen. Because no oxygen is present the material does not combust but the chemical compounds (i.e. cellulose, hemicellulose and lignin) that make up that material thermally decompose into combustible gases and charcoal.

The biomass used to produce liquid smoke comes from waste. This biomass, as a raw material, consists of **cellulose, hemicellulose, lignin, and smaller amounts of other organic compounds**. There is an abundance of biomass resources throughout the world; most biomass is obtained from palm oil, coconut shell, corn cob, rice husk, wood, and sugarcane, etc

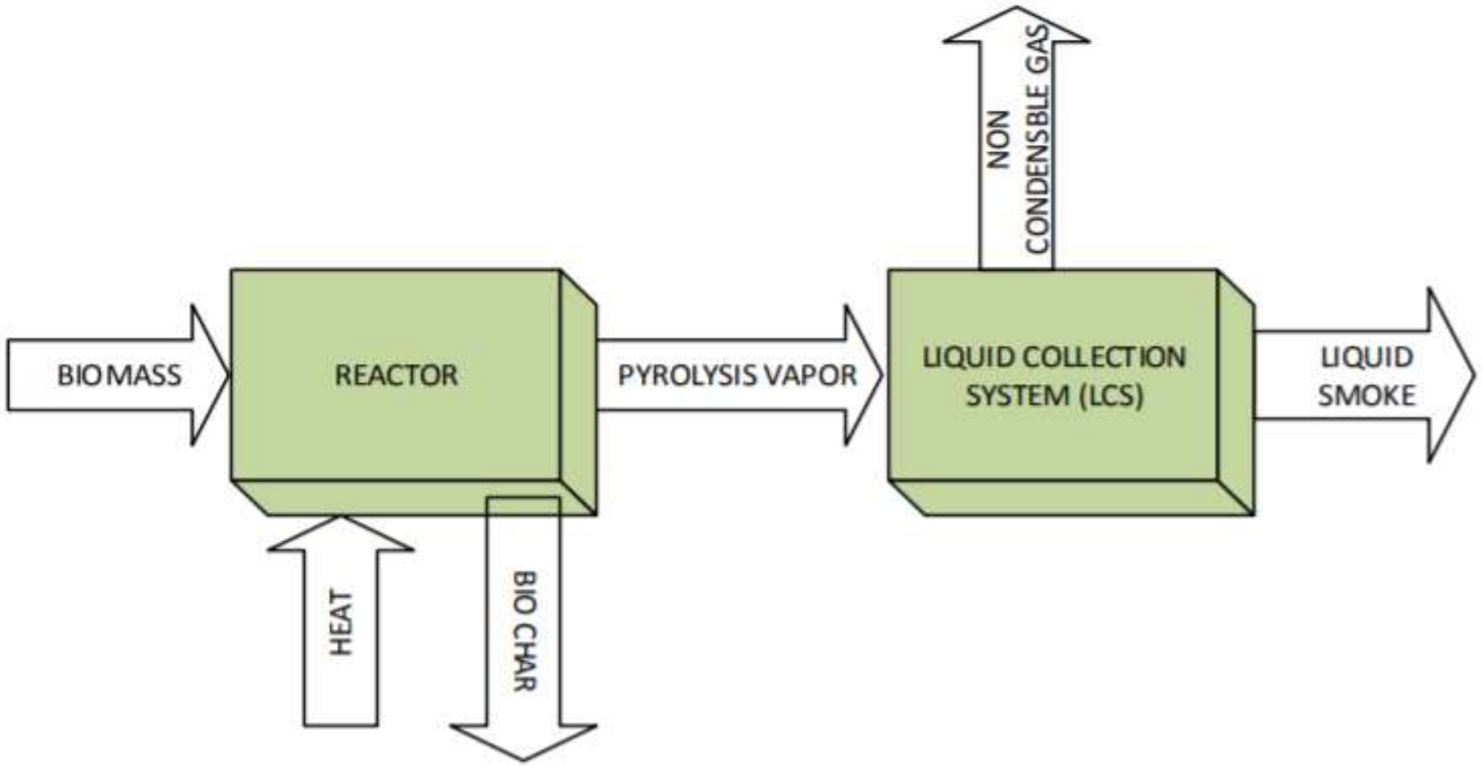


Figure 1 Production schematic of liquid smoke

Starting with the raw-material preparation, next comes a reactor for generating pyrolysis vapor, then a cyclone to separate the solid particles from the vapor, and finally the pyrolysis vapor is liquefied, for which the a part of the equipment is the LCS. The products of this process are liquid smoke, non condensable gas, and charcoal.

PIROLISATOR

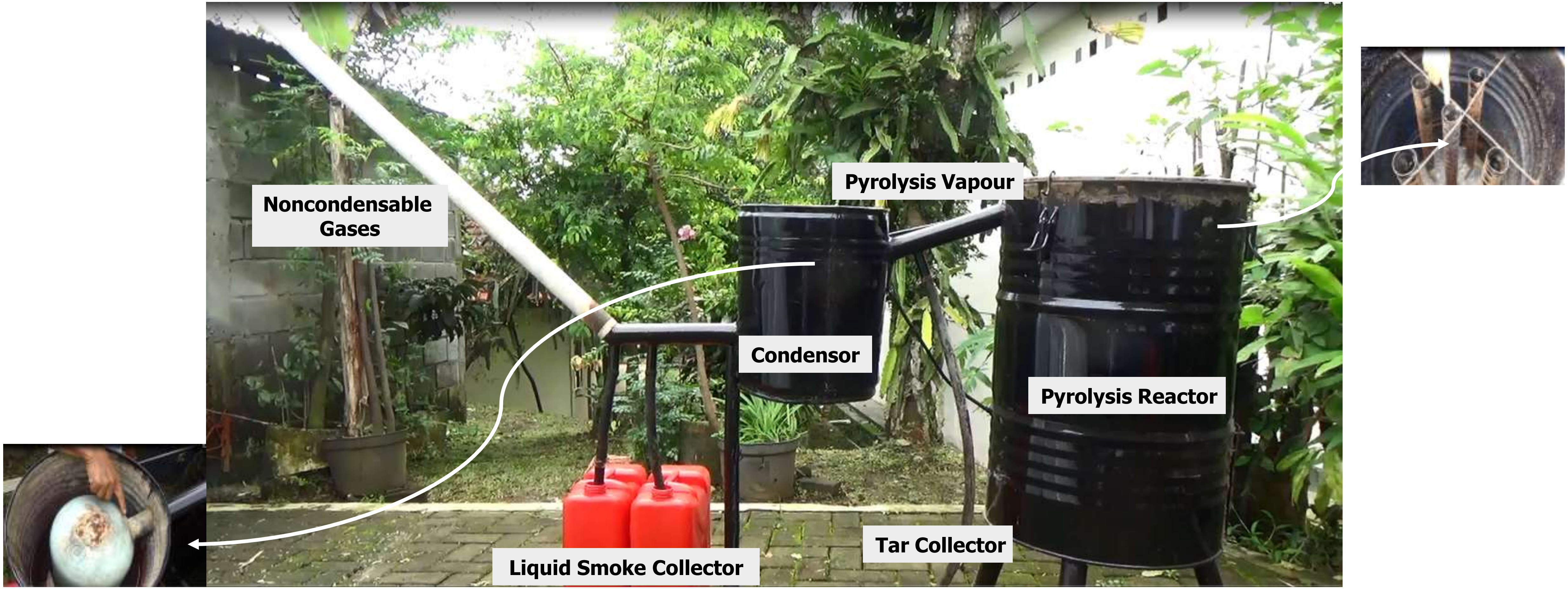
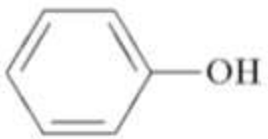
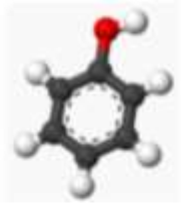


Table 1. Liquid Smoke Chemical Compounds

Chemical Compounds	Coconut Shell	Rice husk
Acetic acid (CAS) Ethylic acid	53,00	72,22
Phenol, 2-methoxy-(CAS) Izal	14,34	-
Phenol (CAS) Izal	-	0,47
Phenol, 2-methoxy-(CAS) Guaiacol	4,61	7,49
Phenol,2,3-dimethyl-(CAS) 2,3-Dimethylphenol	0,26	-
Phenol,2,6-dimethoxyl-(CAS)2,6-Dimethoxyphenol	0,73	1,34
Phenol,2-methyl-(CAS) o-cresol	0,47	0,21
Phenol,3-ethyl-(CAS) m-ethylphenol	-	2,61
2-Propanone,1-hydroxy-(CAS) Acetol	7,33	-
2(3H)-Furanon,dihydro-(CAS) Butyrolactone	0,16	0,87
2-methoxy-4- methylphenol	1,17	2,84
2.5-Dimethoxytoluene	0,42	0,90
9- Octadecenoic acid (Z)-(CAS) Oleic acid	0,99	0,61
Benzenesulfonic acid,4-hydroxy-(CAS) Benzenesulfonic acid,p-hidroxy	12,70	-
Carbamic acid, phenyl ester (CAS) Phenyl carbamate		
2,5-Dymethoxybenzyl alcohol	-	0,78
Acetic acid anhydride with formic acid		
2,5-Dymethoxybenzyl	-	0,26
4-Hexen-2-one,3-methyl	-	4,34
3-nonynoic acid (CAS)	-	0,26

Phenol

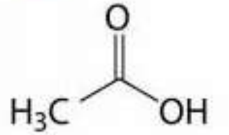




- Phenol (C6H5OH) is a colorless crystalline substance which has a characteristic odor
- It tends to be acidic because it can release H + ions from the –OH group

Mechanism:
Causes bacterial cell damage, protein denaturation, activates enzymes, and causes cell leakage, inhibition of bacterial and fungi growth, inhibition formation of spores (Corn and Stumf, 1976)

Acetic Acid



- Acetic acid systematically named ethanoic acid is a colourless liquid organic compound with the chemical formula CH3COOH

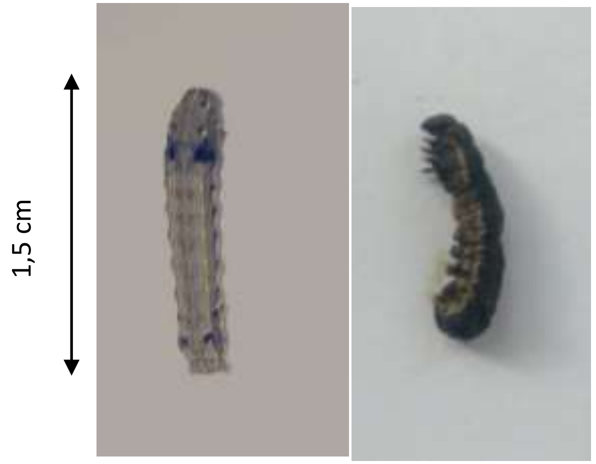
- Acetic acid may influence the permeability of cuticle layer and breaks up cell membranes and makes them leak, causing the insect to dry out and die.

Application

- Thrips & apids in chilli plants, caterpillars on tomato and rice plants, bird, and being able to control anthracnose and wilt disease at a dose of 200 ml per tank (15 liters)
- Liquid smoke is effective in controlling the locust and caterpillar *Prodenia litura*, stinky bugs, mealybugs (*Ceratovacuna lanigera*), Phytoptora sp with a ratio of 1:15.
- Liquid smoke effectively controls termites, mosquitoes, ants at a dose of 15-20 ml/L every three days in the affected area.
- Liquid smoke is effective in accelerating plant growth vegetatively, with a dose of 20 ml/L every 2 weeks sprayed on the leaves or root feeding.
- Liquid smoke is effective as fertilizer, by spraying liquid smoke with a concentration of 1: 1,000 over the leaf surface of young plants.

Mortality on *S. litura* larvae

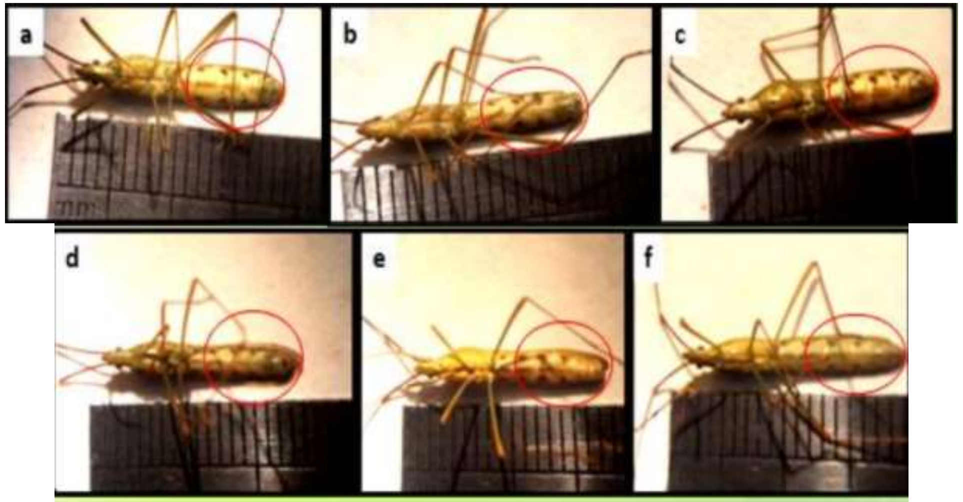
Liquid smoke cause mortality of *S.litura* larvae due to the synergistic effect by inhibiting acetylcholine enzyme activity in the nervous system which results in paralysis or paralysis of the larvae.



The *S.litura* larvae treated with liquid smoke had a darker brown color than the control

Rice Stink Bug (*Leptocorisa oratorius*)

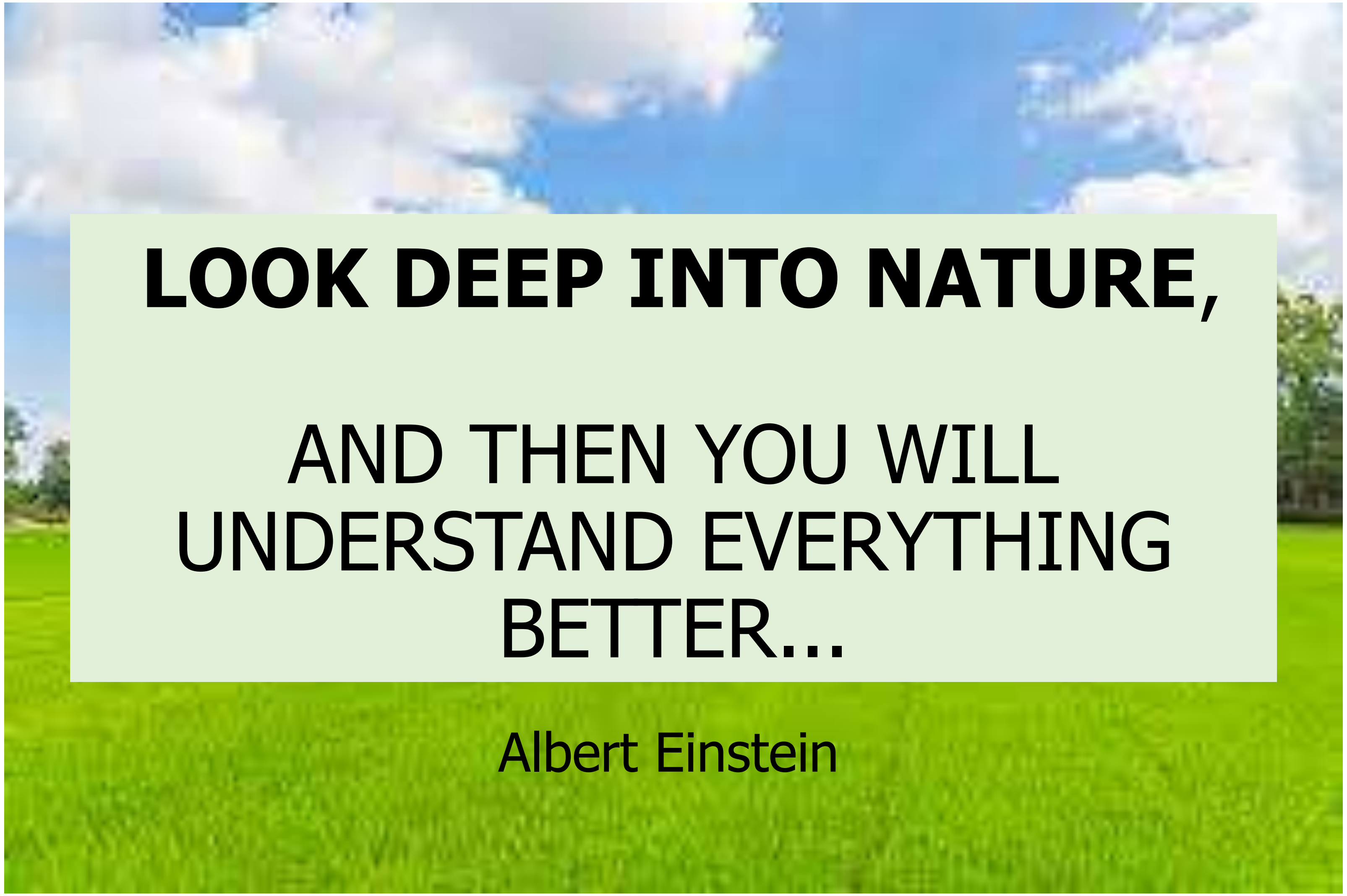
Coconut shell liquid smoke has the potential to control the rice stink bug (*Leptocorisa oratorius* F). The highest percentage of mortality and antifeedant was at a concentration of 1.5% with a mortality value 80% and an antifeedant value 68.88%.



APPLICATION OF LIQUID SMOKE AGAINST
***Colletotrichum capsici* CAUSES OF ANTRACNOSE DISEASE**
ON CHILI PEPPER (*Capsicum annum* L)

APPLICATION OF LIQUID SMOKE AGAINST *Colletotrichum capsici* CAUSES OF ANTRACNOSE DISEASE ON CHILI PEPPER (*Capsicum annum* L)

In vitro test shows that 3-7% liquid smoke caused inhibition of fungal growth. Meanwhile, in vivo test shows that the best treatment is at 5-7%.


LOOK DEEP INTO NATURE,

AND THEN YOU WILL UNDERSTAND EVERYTHING BETTER...

Albert Einstein

THANK YOU