# (Insect Control & Toxicity of Pesticides)

## 402ش

## (الجزء النظري)

## الفصل الدراسي الثانى

**إعداد**

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**كلية العلوم**

**قسم علم الحيوان**

**2023-2022**

# بيانات الكتاب

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**الكلية: العلوم**

**الفرقة: الرابعة**

**التخصص: علم الحشرات**

**تاريخ النشر: الفصل الدراسي الثانى**

**2023-2022**

## رؤية كلية العلوم

التميز في تعليم العلوم الاساسية والبحث العلمي للمساهمة في التنمية المستدامة

## رسالة كلية العلوم

تقديم تعليم مميز في مجالات العلوم الاساسية وانتاج بحوث تعليمية تطبيقية للمساهمة في التنمية المستدامة من خلال اعداد خريجين متميزين طبقاً للمعايير الاكاديمية القومية وتطوير مهارات وقدرات الموارد البشرية وتوفير خدمات مجتمعية وبيئية تلبي طموحات مجتمع جنوب الوادي وبناء الشراكات المجتمعية الفاعلة .

## رؤية القسم

خريجون وباحثون متميزون علمياً وبحثياً في دراسة ضرر ونفع الكائنات الحيوانية خدمة للمجتمع وتنمية للبيئة

## رسالة القسم

يسعى قسم علم الحيوان والحشرات بكلية العلوم جامعة جنوب الوادي من خلال ما يقدمة من برامج تعليمية باستخدام الوسائل العلمية والتعليمية المتطورة والتي تكشف عن المزيد من ضرر ونفع الكائنات الحية وباحثين وخريجون متميزين علمياً وبحثياً ينتفع بهم المجتمع وترتقي بهم الامة .

# INSECT CONTROL

**History of Pest Management**

Worst Historical Pest

- *Schistocerca gregaria* (desert locust)

a pest since biblical times, they fly in unexpectedly, strip a field bare in an hour and consume a very wide range of crops.

**Locust swarms may vanish for many years**, only to break out of their endemic regions after periods of abnormally high rainfall.

**(فَأَرْسَلْنَا عَلَيْهِمُ الطُّوفَانَ وَالْجَرَادَ وَالْقُمَّلَ وَالضَّفَادِعَ وَالدَّمَ آيَاتٍ مُّفَصَّلاَتٍ فَاسْتَكْبَرُواْ وَكَانُواْ قَوْماً مُّجْرِمِينَ)** [الأعراف: 133].


Most Expensive to Control

- *Diabrotica vergifera vergifera* (western corn rootworm): $ 2 billion annually

In terms of the amount of pesticides once used to control and the expense of developing a resistant GM-strain, ***Diabrotica virgifera virgifera*** **beetle is a strong contender**.

Greatest Human Impact

- *Phytophthora infestans* (potato blight)

**Caused the Irish potato famine** (1845-1852), one million people died and a further million emigrated from Ireland, causing the population to decrease by about 24%.


Greatest Human Impact

- *Hemilaea vastatrix* (coffee leaf rust)

a fungus that devastated coffee production in Sri Lanka (Ceylon) in the 19th Century and famously led to a switch to tea drinking in the UK.

Worst Climate Change Threat

- *Dendroctonus ponderosae* (mountain pine beetle)

The **cumulative effect of the current outbreak** of *Dendroctonus ponderosae* in British Columbia, Canada, has killed 13 million hectares of lodgepole pine forest and released an estimated 270 million tonns of carbon, converting the forest from a carbon sink to a large net carbon source.

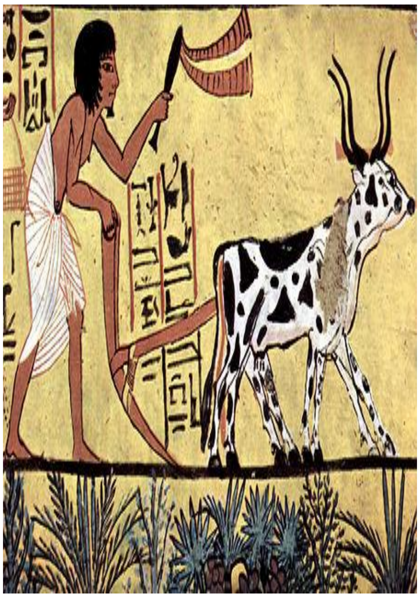

Most Resilient Pest

- *Leptinotarsa decemlineata* (Colorado potato beetle)

is a strong candidate for this award, having managed in the space of about 50 years to develop resistance to 52 different compounds belonging to all major insecticide classes (including cyanide).

This **beetle therefore has effectively beaten the chemists**.


# A Brief History of Pest Control



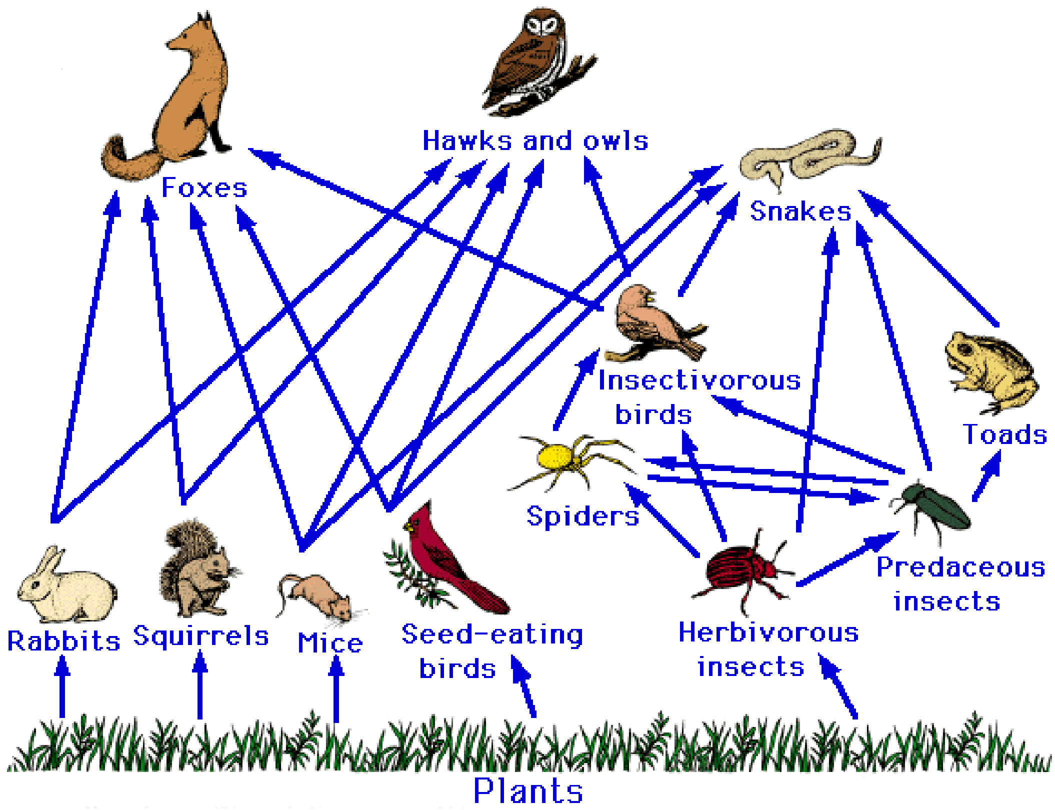
8000 BC – the beginnings of agriculture

# Pest Management History

- Era of traditional approaches (ancient-1938)
- Era of pesticides (1939-1975)
- Era of integrated pest management (1976-now)

## Passage from Chinese text, 3rd century AD:

"A factor which increases the abundance of a certain bird will indirectly benefit a population of aphids because of the thinning effect which it will have on the coccinellid beetles which eat the aphids but are themselves eaten by the bird."




Consequences of Agricultural Revolution (19th century):

- The potato blight in Ireland, England, and Belgium (late 1840's)
- Fungus leaf spot disease in coffee
- Powdery mildew outbreak in European grapes (1850's)
- Grape phylloxera invades Europe from the US (1848-1878)

**Early 20th Century** – 5 major approaches to pest control are well established:

1) Biological control
2) Cultural/Mechanical control
3) Chemical control
4) Resistant varieties
5) Legal control, through the use of inspections and quarantines, is established in the US in 1912 by the Plant Quarantine Act.

Insecticide Era (1939)

- Development of new synthetic insecticidal compounds.

1939 Discovery of the insecticidal properties of DDT
1940s Organophosphates in Germany
Carbamates in Switzerland

DDT (**d**ichloro**d**iphenyl**t**richloroethane):

- First synthesized in 1873 by a German grad student
  - Paul Müller, a Swiss chemist with the Geigy Corporation, discovered its insecticidal properties in 1939

The End of the Insecticide Era

- The beginning of the end… the earliest hint of impending disaster was the evolution of *resistance*.
    - 1946 - The first reported case of tolerance to DDT in the house fly in Sweden.
    - Within 20 years 224 species of insects and mites were resistant to at least one major insecticide.

The End of the Insecticide Era

- The beginning of the end…
    - Pest *resurgence* following applications of broad-spectrum pesticides due to the elimination of natural enemies.
    - *Secondary pest outbreak* – herbivores which were previously not a pest outbreak following pesticide applications.

The Pest

A pest is "a plant or animal detrimental to humans or human concerns (as agriculture or livestock production)

**Types of Pests**

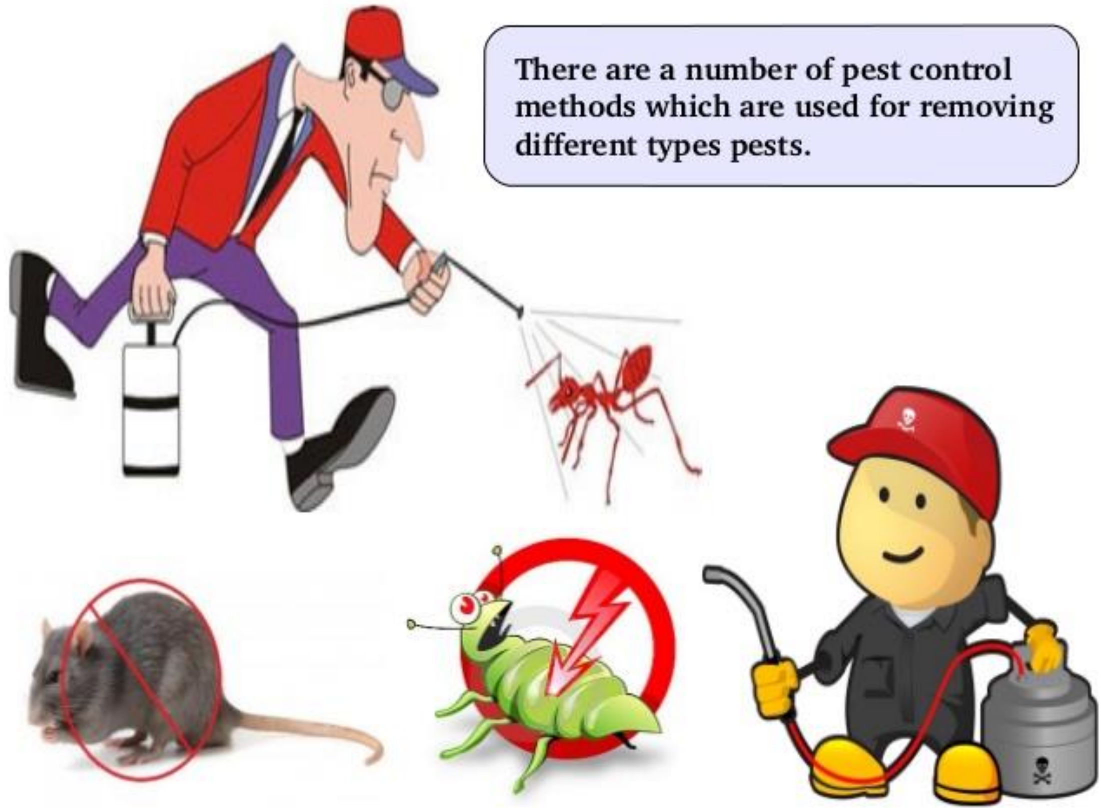
- **Insects (insecticides)**
  - **beetles, caterpillars, aphids**
- **Insect-like organisms**
  - **spiders, ticks, mites**
- **Microbial organisms (fungicides)**
  - **bacteria, fungi, nematodes, viruses, mycoplasmas**
- **Weeds (herbicides)**
  - **plant growing where it is not wanted**
- **Mollusks**
  - **snails, slugs**
- **Vertebrates (rodenticides, predicides)**
  - **rats, mice, birds, coyotes**
- Pest control is the process of minimizing or removing a wide range of undesirable insects and other pests from spaces occupied by people.

Control a pest only when it is causing or is expected to cause more harm than is reasonable to accept.

Use a control strategy that will reduce the pest numbers to an acceptable level.

Cause as little harm as possible to everything except the pest.

**Methods of Control**




**NATURAL CONTROL**

**Topographical influence of the seasons changes, changing temperatures, rainfall, soil, atmospheric humidity and other natural factors also shows their effect on insects and their hosts.**

**ARTIFICIAL CONTROL**

**Artificial control of pest have been developed by man.**

**These methods can be categorized as Mechanical, Cultural, Legislative, Biological, Chemical and Intgrated controls**

**Mechanical control:**

**By using manual labour as well as mechanical devices for collection or destruction of pest. like hand picking, burning, trapping are employed for the destruction of eggs, larvae and adult insects**

**Culture control:**

**It is the oldest method.**

**It includes deep ploughing for eradication of weeds and early stages of insects.**

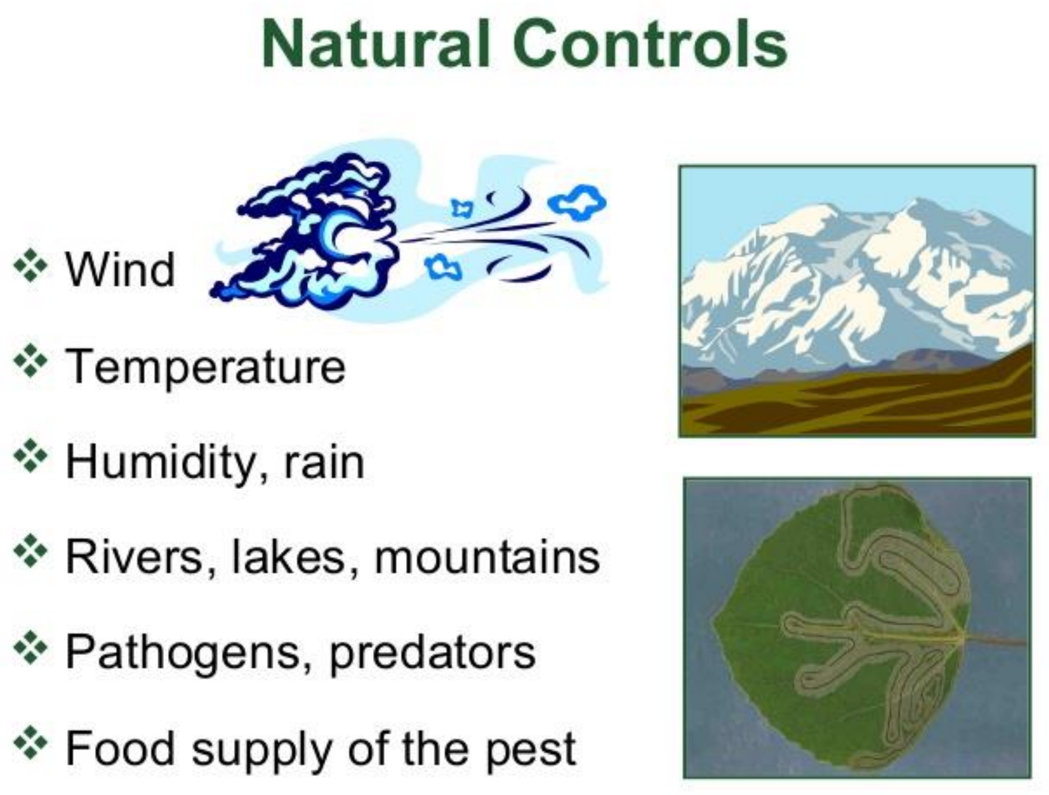
**Alternative crop rotation of changing environmental conditions are some methods which lead to obstruction of the life cycle of pests.**

**Biological control:**

**Biological control by using plant or animal materials for controlling many harmful pests**

**Chemical control:**

**Chemical agents are used for killing pests or for protecting crops, animals or other properties against the attack of the pest. Like DDT,Alderin, Endrin**




Physical methods are the most common methods in farming and agriculture. This is the method of physically keep insects from reaching their hosts. Hence, the barriers include window screens, plant collars, etc. are using as physical control methods. This helps to keep the nuisance and health-threatening pests out of the crop. Traps are also some kind of physical control. Various types of traps are also using to analyze the nature of the situation and severity of the pest problem.

Physical pest control encompasses the many mechanical ways to block, kill, or remove pests from an environment, without the use of pesticides, sprays, or other similar products. This can range from physically using your hands, to using barriers, traps, or other materials to reduce a pest population and/or protect crops.

**Handpicking**

- Handpicking is an excellent method of controlling pests especially when only a few plants are infested. It is the easiest and direct way to kill the visible and slowly moving pests. By handpicking the adults before they have the chance to lay their eggs and by crashing the eggs before they hatch prevent the pests' build-up and the resulting damage.
- However, it also has equal disadvantages as it must be performed before damage to the plant has been done and before the key development of insects

**Manual Removal is effective against these pests:** Aphids, cabbage loopers, cabbage white butterfly caterpillars, snails, slugs, squash bugs, and many other insects – when you can find and catch them.

REMINDERS!!!

1. Visit your plants daily or several times in a week to monitor the presence of pests.

Look out for the pests that fly or crawl into your graden and those that come out from the soil.
2. Look also for the pests' possible hiding places, like under the plant debris and on the soil.
3. Always inspect the underside of the leaves. Remove the eggs, larvae, pupae and adults.
4. Know the beneficial insects and be able to identify them so that you will not kill them by mistake.
5. You cannot completely get rid of the plant pests but you can reduce their population.

**Bagging fruits**

**Bagging fruits**

- Bagging prevents insect pests, especially fruit flies, from finding and damaging the fruits. The bag provides physical protection from mechanical injuries (scars and scratches) and prevents female flies' laying activities, latex burns, and fungal spots on the fruits. Although laborious, it is cheaper, safer, easier to do, and gives you a more reliable estimate of your projected harvest.

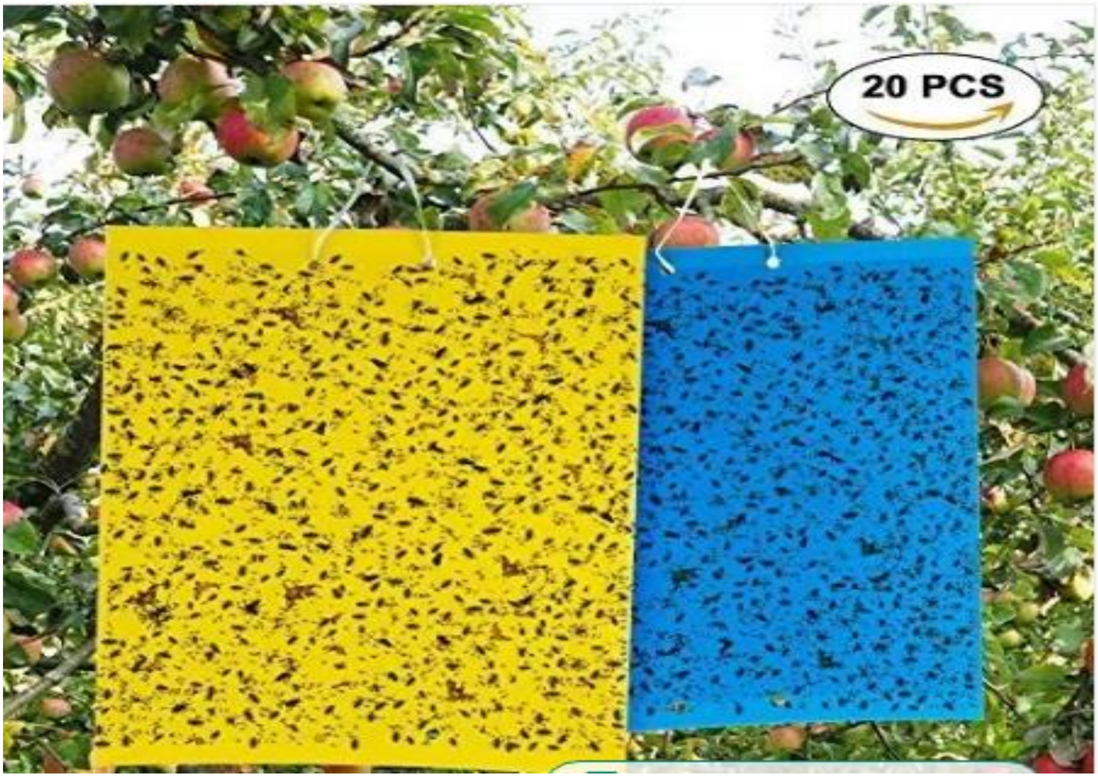
Attractant Traps

**Light trap**

Light trap is a device used at night in the field to collect moths and other flying insects such as:

Armyworm
Bugs
Cutworm
Flies
Gnats
Heliotis/Helicoverpa
Leafhoppers
Planthoppers
Stem borers

**Sticky board traps**
**Sticky traps, glue traps or glue boards are inexpensive, disposable, non-toxic cardboard or plastic trays with special glue on one side to capture pests**
Flying insects are attracted to bright yellow, blue, and white colors. Traps, consisting of square pieces of cardboard or hard plastic coated with sticky substances placed throughout the growing area among the plants, attract them. Strips of yellow or blue sticky plastic can also be used around or inside the growing ranges.




**Fruit fly traps**

- Traps with baits are used to monitor and to lessen the population density of fruit flies infesting the fruits.
- **Fruit fly baits**
- Ripe banana peel cut into small pieces and mixed with sugar, flour, and water (Mulcrone, 1998).
- Mixture of 1 tsp vanilla essence, 2 tbsp ammonia, Å“ cup sugar, and 2 liters water (Mulcrone, 1998).
- Mixture of 1 cup vinegar, 2 cups water, and 1 tbsp honey (ECHO, 2003).
- Mixture of sugar, soya sauce, and ammonia (Better Homes and Gardens, 2004).


Credit: Faith Durand / Kitchn

**Pheromone traps**

- A **pheromone trap** is a type of insect trap that uses pheromones to lure insects. Sex pheromones and aggregating pheromones are the most common types used. A pheromone-impregnated lure, as the red rubber septa in the picture, is encased in a conventional trap such as a bottle trap, Delta trap, water-pan trap, or funnel trap. Pheromone traps are used both to count insect populations by sampling, and to trap pests such as clothes moths to destroy them.
- Pheromone traps are very sensitive, meaning they attract insects present at very low densities. They are often used to detect presence of exotic pests, or for sampling, monitoring, or to determine the first appearance of a pest in an area. They can be used for legal control, and are used to monitor the success of the Boll Weevil Eradication Program and the spread of the gypsy moth

**Trenching the field (Barriers)**

- Pest like army worm, grasshoppers march from one field to other which can be prevented by trenching in field.

**Sieving and winnowing**

- These method are commonly used against stored grain pest. Some insects, e.g. Red flour beetle are destroyed by collecting them through sieving and some insects. e.g. Rice weevil are destroyed by collecting them winnowing.

Burning

Burning is most effective for the management of pests that over winter in the field and attack plants in both the sprout year and the crop year. When fields are burned properly some of these pests are suppressed or even controlled.

**Cultural Control**

ž Cultural method is the prevention or reduction of injurious insect pest by utilizing or changing various farm practices in an intelligent manner. Cultural method of insect control comprise the regular farm operations so performed as to destroy the insect or to prevent them from causing injury.

ž For the achievement of cultural control the following agricultural practices are to be done:

# Tillage(Plowing)

- Tillage can help minimize damage from soil-dwelling insects by directly killing the insect, exposing insects to predation by birds or other predators, and by helping the plant grow more rapidly (this is not a guaranteed outcome). The principle behind this approach is that the sun will warm up the soil around the plants faster and allow them to outgrow the pest's feeding.
- **cultivation, tillage:** this approach can help in the control of soil inhabiting forms of field crop pests by:
- i) bringing larvae and pupae onto the soil surface, thereby exposing them to desiccation and predation, freezing and thawing;
- ii) damaging the pest in its soil inhabiting phase, e.g., wireworms;
- iii) destroying crop residues, which might harbour pests that could invade new crops;
- iv) burying residues so deep that emergence from eggs or pupae is made impossible.

**Soil solarization**

- Soil solarization is a non-chemical technique that will control many soil-borne pathogens and pests, including root and foliar diseases and some weeds.
- In soil solarization, clear plastic mulch is applied to bare soil for an extended period of time (4–6 weeks) during the warmest, sunniest time of year to disinfest soil. The clear plastic allows the sun's energy to heat the soil below to temperatures over 100°F. This method is not selective, so heat sensitive beneficial organisms will also be destroyed.

*Soil solarization can be an effective alternative to costly pesticides and lengthy crop rotations.*

**Crop rotation**

- **Crop rotation** replaces a crop that is susceptible to a serious pest with another crop that is not susceptible, on a rotating basis. For example, corn rootworm larvae can be starved out by following corn with one to two years of a non-host crop such as soybeans, alfalfa, oats, or other crops. Crop rotation works best in larger areas where the insects can not readily move from the old crop location to the new, therefore, this technique has limited applicability to garden insect pests.

- There are two processes that contribute to this gain. First, the rapid rate of organic matter decomposition from tillage is stopped under the sod crop. This benefit, of course, is also gained when a no-tillage cropping system is employed. Second, grass and legume sods develop extensive root systems that continually grow and die off. The dead roots supply a source of fresh, active organic matter to the soil, which feeds soil organisms that are involved in building soil aggregation.

**Sanitation**

**Sanitation** refers to keeping the area clean of plants or materials that may harbor pests. Examples include removal of weeds in greenhouses that may harbor mites, aphids, or whiteflies; destruction of crop residues such as corn stubble, squash vines, or fallen apples that may be overwintering sites for pests; cleaning of equipment that can spread pests from one area to another.

**Pruning**

- Most trees and shrubs need some pruning for size, shape and continued good growth. Pruning should also be used to remove limbs damaged by environmental stress, disease or insect pests. Removing dead, diseased or insect-infested branches promptly will reduce damage and spread of the pest or disease to other trees and shrubs in the area. Pruning can also improve light and air circulation, reducing wetness and humidity which lead to many disease problems.

# fertilization, liming and manuring:

- i) plant nutrition can influence the feeding, longevity and fecundity of phytophagous pests; the common fertilizer elements (nitrogen, phosphorous and potassium) can have direct and indirect effects on pest supression. In general, nitrogen in high concentrations has the reputation of increasing pest incidence, particularly of sucking pests such as mites and aphids. On the other hand, phosphorous and potassium additions are known to reduce the incidence of certain pests, e.g., in low phosphorous soils wireworm populations often tend to increase;

- ii) fertilization promotes rapid growth and shortens the susceptible stages. It gives better tolerance to, and opportunity to compensate for, pest damage. Trace mineral and plant hormones sprays (e.g., from seaweed extracts) have been found to reduce damage by certain pests, particularly sucking pests such as some aphids and mites.

water arrangement

**irrigation, drainage:** moisture is an important limiting factor that affects the survival of some pests. Where sufficient water is available, flooding is sometimes used for insect and nematode control, e.g., flooding of infested soils in the northwestern part of the United States has been used to eliminate certain species of wireworm within three days. Certain other wireworm species are unable to withstand desiccation. Where these wireworms occur, drying out the soil is an effective control measure.

**Using of some plants as attractants**

Intercropping is a prime example of such a practice. Practices that rely on on-farm ecology can reduce pesticide use, allow farmers to better understand the interplay of organisms on their farm, and are often more cost effective to the farmer.

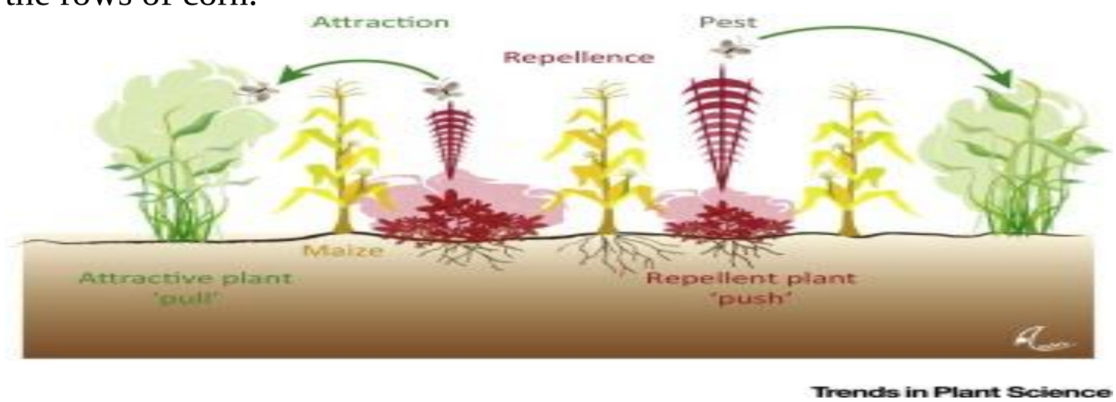
The use of intercropping systems provides an option for insect control for organic farmers that are limited in their chemical use. Additionally, intercropping systems can be attractive to conventional growers as a cost-effective insect control solution.

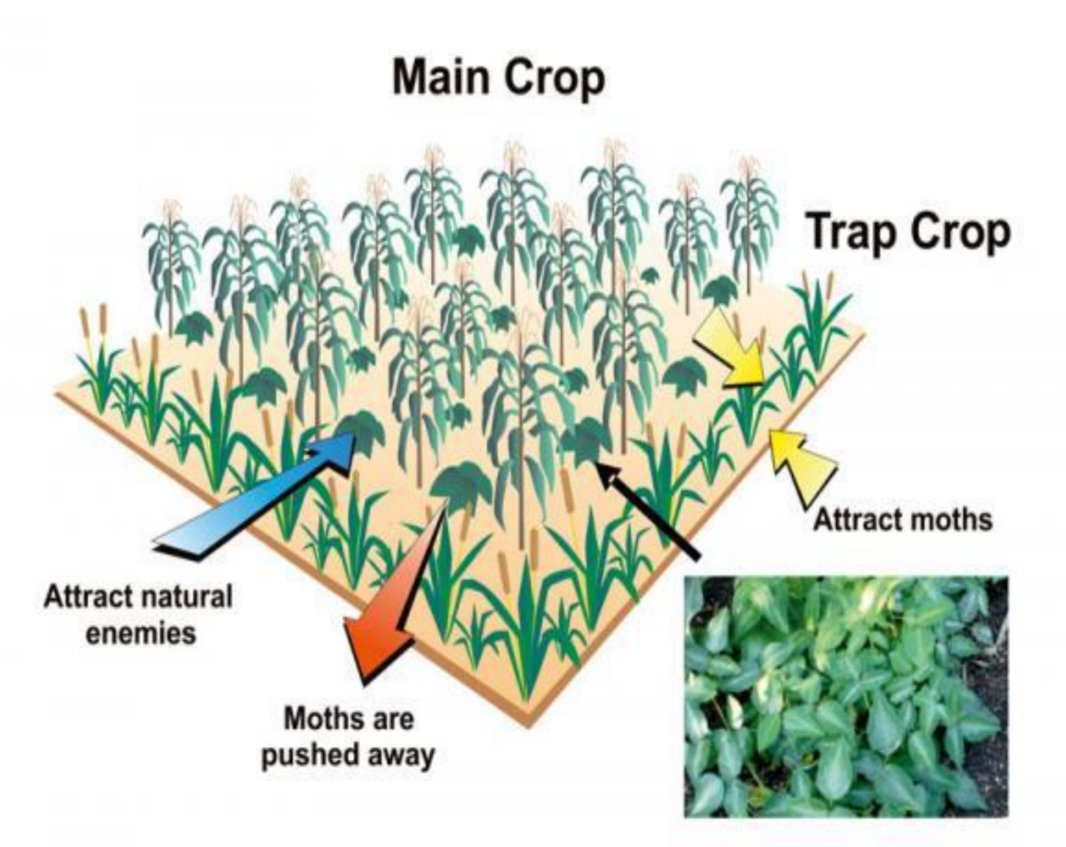
**Trap cropping**: A system that uses an attractant crop planted close to the production crop is called trap cropping. The plant that is used as an intercrop (trap crop) is more attractive than the production crop to the insect, so the insect is drawn to the trap crop.

**Repellant intercrops:** An intercrop that has a repellent effect can also be used for insect pest control. This often requires more rows of the intercrop to be planted than in a trap crop system. In this system, the repellent intercrop masks the production crop from the insect pest, deterring the insect from its host crop.

An example of repellant intercrops can be seen in a recent study that showed that intercropping leeksالكرات with beans (host plant) had a repellent effect on the bean fly.

- **Push-pull cropping:** A combination of repellent and attractant crops can be used in an intercropping system for insect pest control. This type of system was developed in Africa and is called a push-pull system. The attractant crop draws the insect in (acts as the "pull") and the repellent crop deters the insect (acts as the "push"). The push-pull system that was developed in Africa protects corn from stem boring moth larvae by planting a grass that is more attractive to the moths, Napier grass, as a border and planting a repellent crop, *Desmodium* (a legume), in between the rows of corn.






**Separation of hosts**

**crop isolation:** the location of crops with respect to one another and their degree of isolation can affect their likelihood of being invaded by pests. Isolation from old crops of the same type, and from closely related indigenous host-plants that act as sources of pests, is one way of reducing the probability of attack. The chance of invasion occurring will, however, increase with time. Hence, this practice is most appropriate for annual crops, especially when climatic conditions are not ideal. Separation of sequentially planted crops in time to disrupt host-plant continuity and prevent easy pest dispersal may be useful, e.g., for carrot fly control.

LEGAL CONTROL METHODS - DEFINITION - PEST INTRODUCTIONS - QUARANTINE - PHYTOSANITARY CERTIFICATE PEST LEGISLATION LEGAL CONTROL/LEGISLATIVE CONTROL/REGULATORY CONTROL

**Definition**: Preventing the entry and establishment of foreign plant and animal pest in a country or area and eradication or suppression of the pests established in a limited area through compulsory legislation or enactment

**Quarantine**

Isolation to prevent spreading of infection

**Plant Quarantine**

Legal restriction of movement of plant materials between countries and between states within the country to prevent or limit introduction and spread of pests and diseases in areas where they do not exist

**PEST LEGISLATIONS**

1905 - 'Federal Insect Pest Act' - first Quarantine act against San Jose scale
1912 - 'US Plant Quarantine Act'
1914 - 'Destructive Insects and Pests Act' of India (DIPA)
1919 - 'Madras Agricultural Pests and Diseases Act'
1968 - 'The Insecticides Act

**Phytosanitary certificate** is issued by State Entomologist and Pathologists to the effect that the plant or seed material is free from any pest or disease

a. Fumigation of imported plant material based on need

b. Taking care of pests of quarantine concern in India

**Biological control or biocontrol** is a method of controlling pests such as insects, mites, weeds and plant diseases using other organisms (Natural enemies ).
It can be an important component of integrated pest management (IPM) programs.
Natural enemies of insect pests, also known as biological control agents, include predators, parasitoids, pathogens, and competitors.

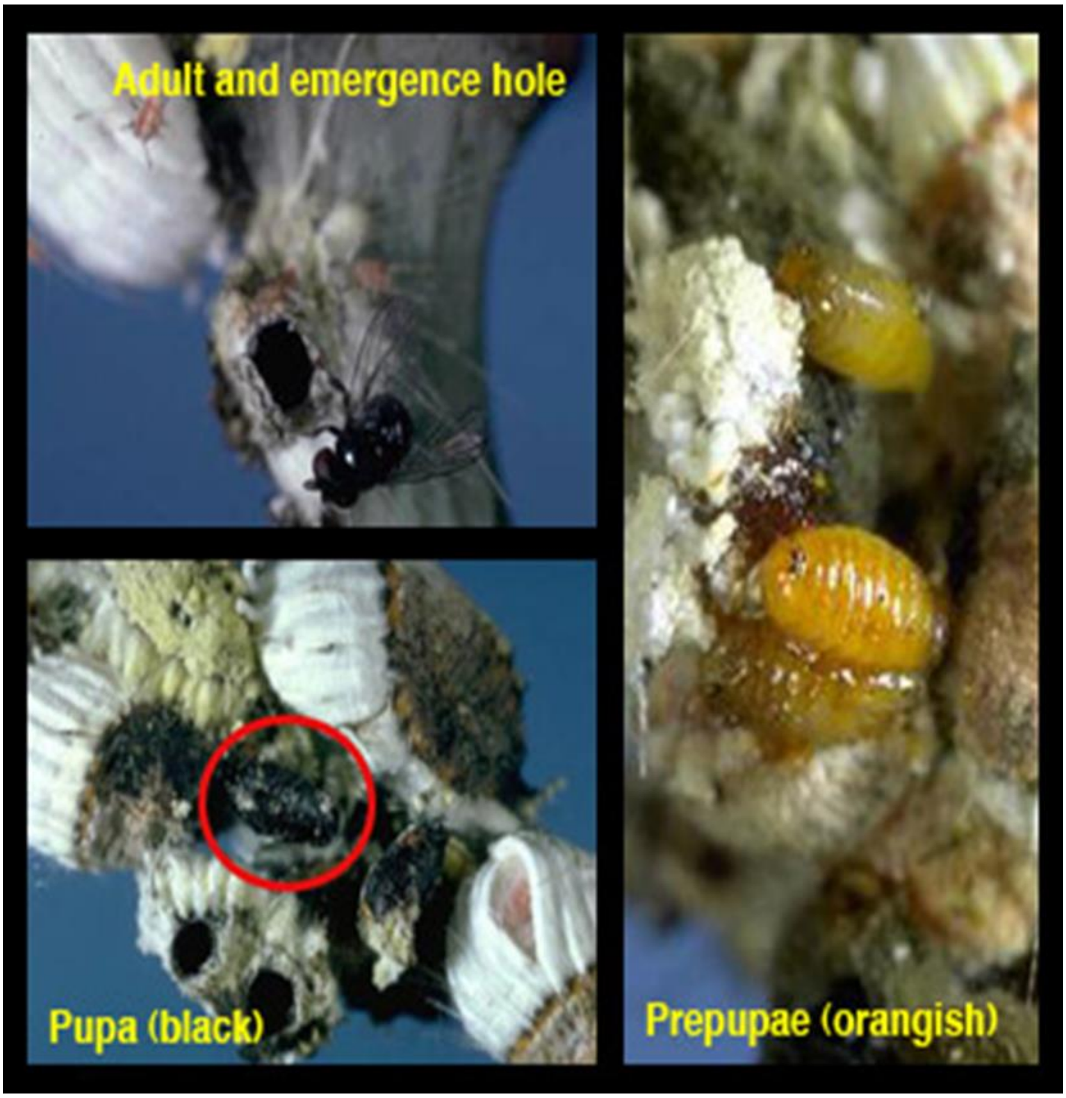
**There are three basic biological pest control strategies:**

**1-** Importation (classical biological control)
2- Augmentation
3- Conservation.

## Importation

- Importation or classical biological control involves the introduction of a pest's natural enemies to a new locale where they do not occur naturally.
- To be most effective at controlling a pest, a biological control agent requires a colonizing ability which allows it to keep pace with changes to the habitat in space and time.
- Control is greatest if the agent has temporal persistence, so that it can maintain its population even in the temporary absence of the target species.


*Rodolia cardinalis*, the vedalia beetle, was imported from Australia to California in the 19th century, successfully controlling cottony cushion scale.




**Parasitic fly Cryptochaetum iceryae (Diptera: Cryptochaetidae) is a natural enemy of Cottony Cushion Scale, Icerya purchasi (Hemiptera: Margarodidae). Biological control concept**

**Augmentation**

— Augmentation involves the supplemental release of natural enemies that occur in a particular area, boosting the naturally occurring populations there.

— In inoculative release, small numbers of the control agents are released at intervals to allow them to reproduce, in the hope of setting up longer-term control, and thus keeping the pest down to a low level, constituting prevention rather than cure.

— In inundative release, in contrast, large numbers are released in the hope of rapidly reducing a damaging pest population, correcting a problem that has already arisen. Augmentation can be effective, but is not guaranteed to work, and depends on the precise details of the interactions between each pest and control agent.

An example of inoculative release occurs in the horticultural production of several crops in greenhouses. Periodic releases of the parasitoidal wasp, *Encarsia formosa*, are used to control greenhouse whitefly.


## Conservation

The conservation of existing natural enemies in an environment is the third method of biological pest control. Natural enemies are already adapted to the habitat and to the target pest, and their conservation can be simple and cost-effective.
-For example: As when nectar-producing crop plants are grown in the borders of rice fields. These provide nectar to support parasitoids and predators of planthopper pests and have been demonstrated to be so effective (reducing pest densities by 10- or even 100-fold) that farmers sprayed 70% less insecticides and enjoyed yields boosted by 5%.

Agents of biological control:

I. Predators
II. Parasites
III. Pathogens


**I. Predators:** free-living organisms that feed on other animals (prey).

- Feed on any or all stages of prey (egg, larva/nymph, pupa, adult)
- Can be predaceous as immatures only, adults only, or both
- Host range: monophagous (single species, specialists), oligophagous (multiple species within the same genus or family, restricted), polyphagous (wide range of prey, generalists)

**I. Predators:**

- Coleoptera
- Hymenoptera
- Hemiptera
- Neuroptera
- Diptera

**II. Parasites:** an animal that lives on or within a larger animal (host).

- Parasite feeds on host, weakens it, sometimes kills it
- Requires only one host to reach maturity
- Can have one or many parasites on a single host
- Common parasites for biological control:

    A. Parasitoids
    B. Nematodes

**A. Parasitoids:** insects that are parasitic in their immature stages and free-living as an adult

- Always kill the host
- Require only one host to complete development, may indirectly kill many by laying eggs
- Exhibit full host range from monophagy to polyphagy, but skewed more toward monophagy
- A given parasitoid species generally attacks a single stage of its host (can be egg, larva, pupa, adult)
- Some parasitoids will attack one stage, but kill host in a later stage

**A. Parasitoids:** insects that are parasitic in their immature stages and free-living as an adult

Parasitoids have been found in 6 orders of insects:

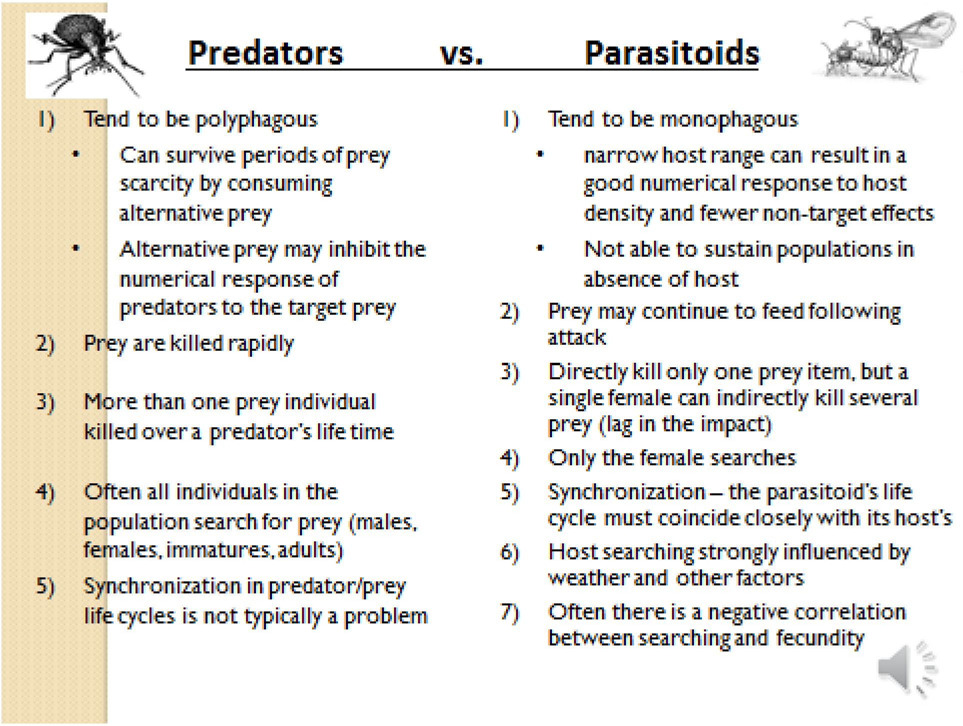
- Coleoptera
- Diptera
- Hymenoptera
- Lepidoptera
- Neuroptera
- Strepsiptera

>95% of parasitoids occur in two orders:

- Hymenoptera
- Diptera

**Most insect parasitoids are Wasps :**

- **Brachonid wasps**: which attack caterpillar and wide range of other insects including green fly.
- **Chalcid wasps**: which parasitises eggs and larvae of green fly , white fly , cabbage caterpillars and scale insects.
- **Tachanid fly**: which parasitise a wide range of insects including caterpillars, adult, larval beetles and true bugs.




Microbial Insecticides

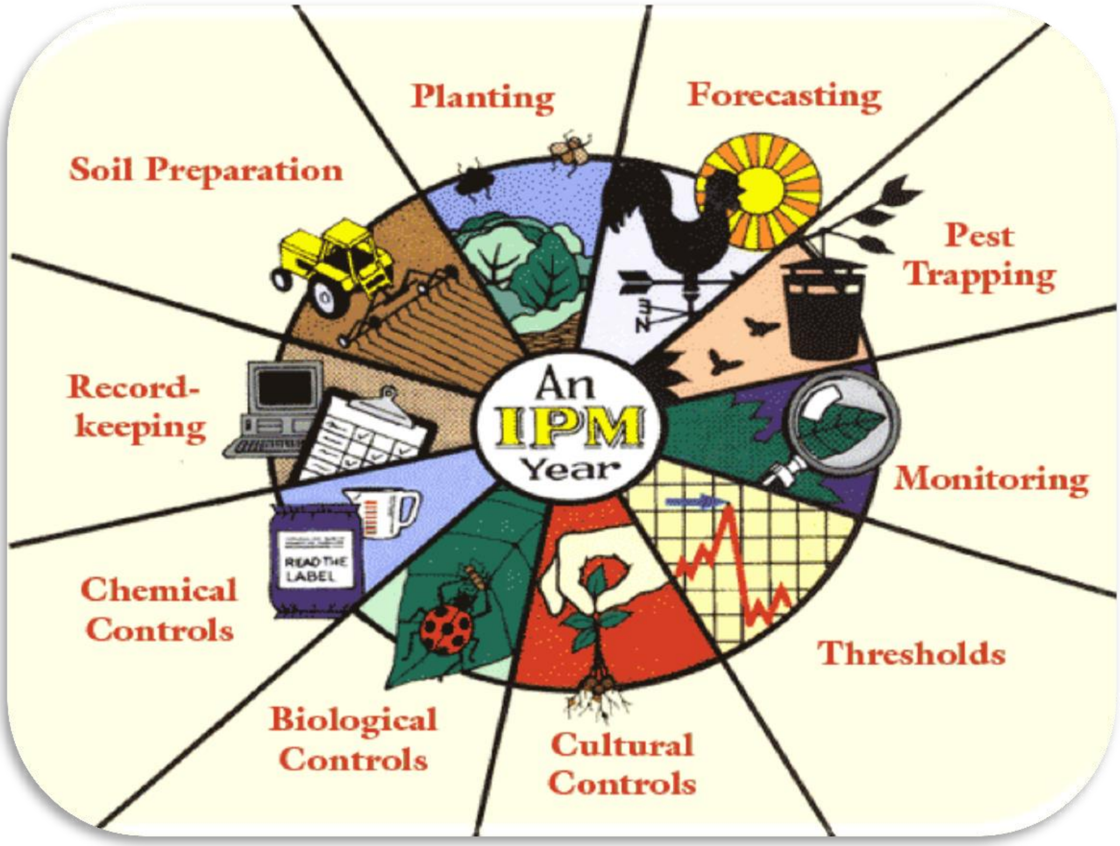
- Insecticidal toxin of *Bacillus thuringiensis*
- Genetic engineering of *Bt* toxin genes
- Baculoviruses as biocontrol agents
- Insecticidal toxin of *Bacillus thuringiensis*
- Current market for pesticides is $30 billion/year
- *B. thuringiensis* is a gram positive soil bacterium that produces a toxin or crystal protein (Bt toxin or Cry) that kills certain insects
- The Bt toxin or Cry is produced when the bacteria sporulates and is present in the parasporal crystal
- Several different strains and subspecies of *B. thuringiensis* exist and produce different toxins that kill specific insects (Table 16.1)
- Used as alternative to DDT and organophosphates since the 1920s
- Bt toxin is used as specific insecticides under trade names such as Dipel and Thuricide
- Target insects for Bt toxin

Cry toxins have specific activities against insect species of the orders Lepidoptera (moths and butterflies), Diptera (flies and mosquitoes), Coleoptera (beetles), Hymenoptera (wasps, bees, ants and sawflies) and nematodes.

- Table 16.1 Some properties of the insecticidal toxins from various strains of *B. thuringiensis*
- The Cry protein: mode of action
- The Cry protein is made as an inactive protoxin
- Conversion of the protoxin (e.g., 130 kDa) into the active toxin (e.g., 68 kDa) requires the combination of a slightly alkaline pH (7.5-8) and the action of a specific protease(s) found in the insect gut
- The active toxin binds to protein receptors on the insect gut epithelial cell membrane
- The toxin forms an ion channel between the cell cytoplasm and the external environment, leading to loss of cellular ATP and insect death

- Isolation & genetic engineering of Cry genes
- The Cry (or protoxin) genes are encoded by plasmid DNA, not by chromosomal DNA in *B. thuringiensis*
- Cry genes were expressed in *B. thuringiensis* under the control of the $p^{tet}$ promoter (rather than its sporulation-specific promoter) and provided increase yield
- Constructs have also been produced to enhance toxin action and/or expand its specificity
- A potential problem with Cry: development of insect resistance (and how to prevent it)
- Production of hybrid Bt toxins
- Stacking of Bt toxin genes
- Use of Bt toxins in combination with other insecticidal proteins such as chitinase and Cyt1A
- In plants, the planting of crop buffer zones with non-genetically engineered Bt plants to maintain an insect susceptible population
- Baculoviruses as Biocontrol Agents
- Baculoviruses are rod-shaped, double stranded DNA viruses that can infect and kill a large number of different invertebrate organisms
- Immature (larval) forms of moth species are the most common hosts, but these viruses have also been found infecting sawflies, mosquitoes, and shrimp.
- Baculoviruses have limited host ranges and generally do not allow for insect resistance to develop
- Slow killing of target insects occurs
- In order to speed killing (enhance effectiveness), several genes can be expressed in the baculovirus including diuretic hormone, juvenile hormone esterase, Bt toxin, scorpion toxin, mite toxin, wasp toxin, and a neurotoxin (see Table 16.7)
- Electron Micrograph of a Baculovirus Occlusion Body
- Baculovirus is also used as an expression system for foreign proteins
- See http://www.invitrogen.com/site/us/en/home/Products-and-Services/Applications/Protein-Expression-and-Analysis/Protein-Expression/Insect-Expression/Bac-to-Bac-Baculovirus-Expression-System.html
- “Our new Bac-to-Bac® Baculovirus Expression Systems deliver quick, robust and proven method to produce recombinant baculovirus, expressing your gene of interest in insect cells.”

# Integrated Pest Management (IPM)




Integrated pest management, or IPM, is a process you can use to solve pest problems while minimizing risks to people and the environment. IPM can be used to manage all kinds of pests anywhere–in urban, agricultural, and wildland or natural areas.

Definition of IPM

IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control ‹habitat manipulation ‹ modification of cultural practices ‹and use of resistant varieties . Pesticides are used only after monitoring indicates they are needed according to established guidelines ‹and treatments are made with the goal of removing only the target organism .Pest control materials are selected and applied in a manner that minimizes risks to human health ،beneficial and nontarget organisms ،and the environment.

**How Does IPM Work?**

—IPM focuses on long-term prevention of pests or their damage by managing the ecosystem

—With IPM, you take actions to keep pests from becoming a problem, such as by growing a healthy crop that can withstand pest attacks, using disease-resistant plants, or caulking cracks to keep insects or rodents from entering a building.

—Rather than simply eliminating the pests you see right now, using IPM means you'll look at environmental factors that affect the pest and its ability to thrive. Armed with this information, you can create conditions that are unfavorable for the pest.

—In IPM, monitoring and correct pest identification help you decide whether management is needed

—Monitoring means checking your field, landscape, forest, or building—or other site—to identify which pests are present, how many there are, or what damage they've caused. Correctly identifying the pest is key to knowing whether a pest is likely to become a problem and determining the best management strategy.

—After monitoring and considering information about the pest, its biology, and environmental factors, you can decide whether the pest can be tolerated or whether it is a problem that warrants control. If control is needed, this information also helps you select the most effective management methods and the best time to use them.

—**IPM programs combine management approaches for greater effectiveness**

The most effective, long-term way to manage pests is by using a combination of methods that work better together than separately. Approaches for managing pests are often grouped in the following categories.

**Biological control**

—Biological control is the use of natural enemies—predators, parasites, pathogens, and competitors—to control pests and their damage. Invertebrates, plant pathogens, nematodes, weeds, and vertebrates have many natural enemies.

**Cultural controls**

—Cultural controls are practices that reduce pest establishment, reproduction, dispersal, and survival. For example, changing irrigation practices can reduce pest problems, since too much water can increase root disease and weeds.

**Mechanical and physical controls**

—Mechanical and physical controls kill a pest directly, block pests out, or make the environment unsuitable for it. Traps for rodents are examples of mechanical control.

Physical controls include mulches for weed management, steam sterilization of the soil for disease management, or barriers such as screens to keep birds or insects out.

**Chemical control**

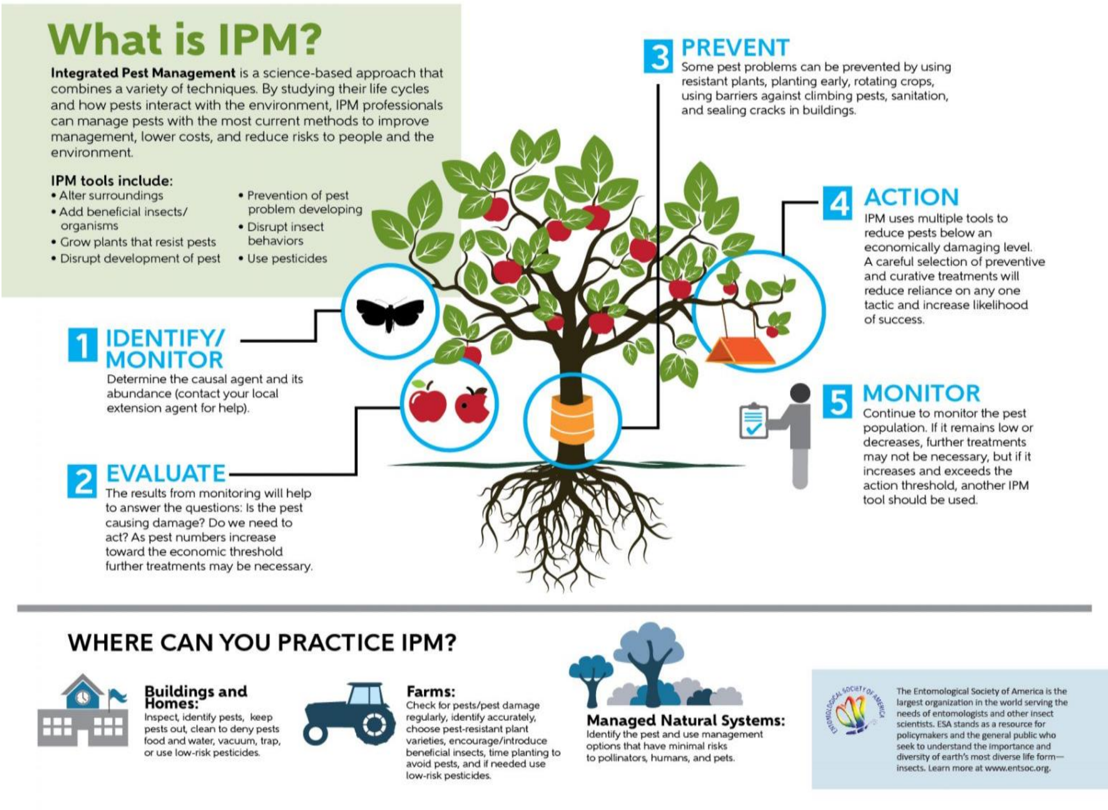
—Chemical control is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Pesticides are selected and applied in a way that minimizes their possible harm to people, nontarget organisms, and the environment. With IPM you'll use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality; use pesticides in bait stations rather than sprays; or spot-spray a few weeds instead of an entire area.

—IPM Programs

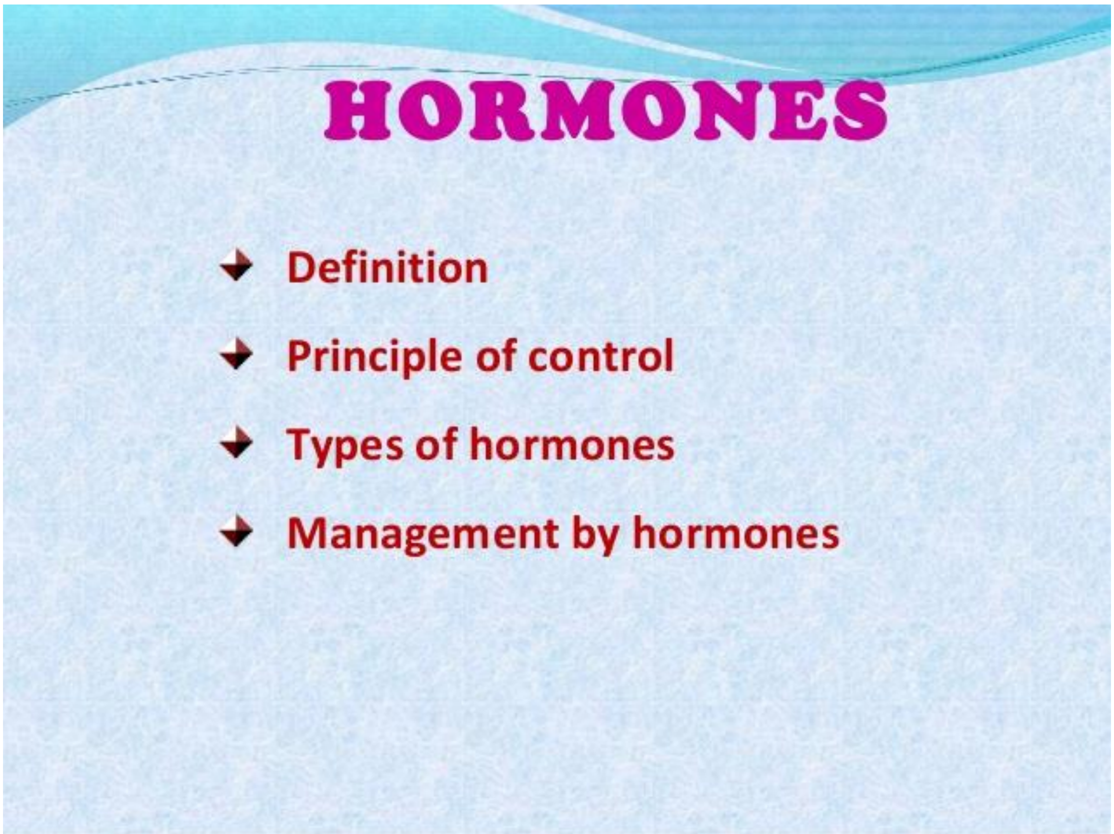
These IPM principles and practices are combined to create *IPM programs*. While each situation is different, six major components are common to all IPM programs:

1. Pest identification
2. Monitoring and assessing pest numbers and damage
3. Guidelines for when management action is needed
4. Preventing pest problems
5. Using a combination of biological, cultural, physical/mechanical and chemical management tools

6. After action is taken, assessing the effect of pest management




BEHAVIOURAL CONTROLOF INSECT PESTS


1. Definition

“Hormones are the secretion of internal ductless glands, which regulate the growth and development of the insect” (Dhaliwal, G.S.,2006).

•Means to ‘excite’ and endocrine in origin.

•Connection link between nervous system and endocrine system.

•Recognised as ‘third generation pesticides’ (Prof. C.M. Williams, 1967).

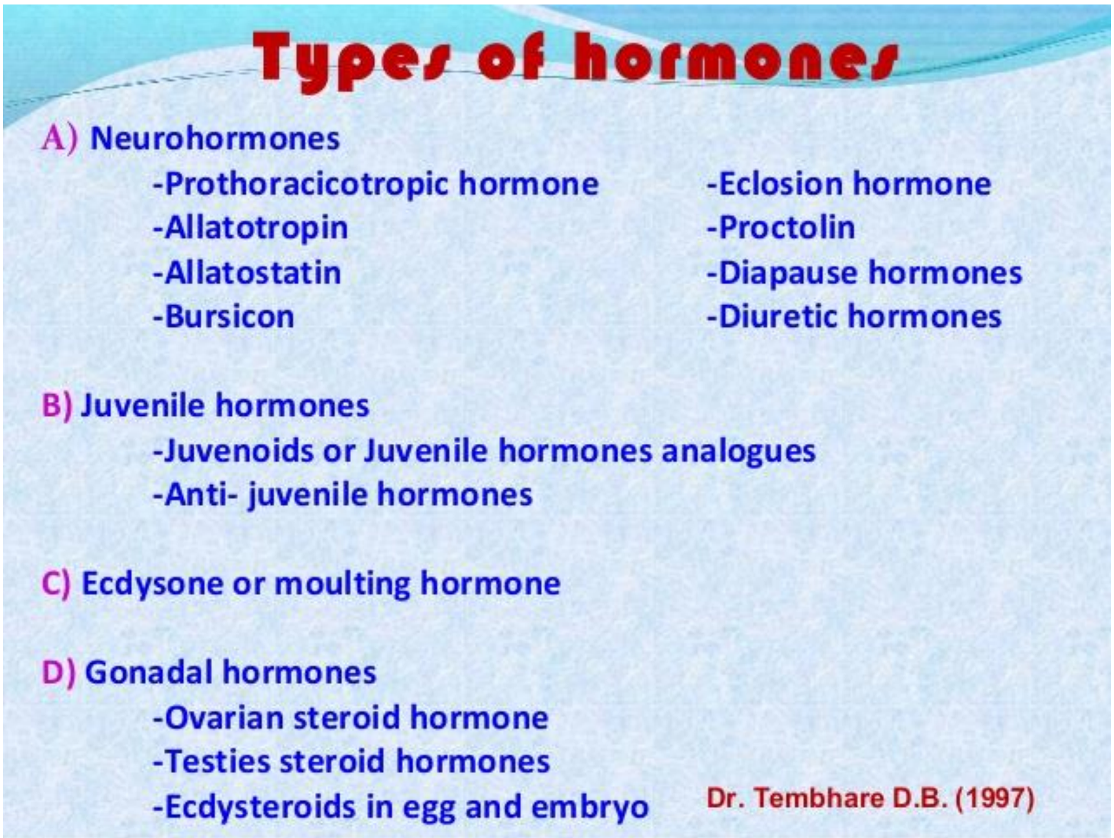
Principle of control

—Stefan Kopec (1917,22) reported, brain of larva of gypsy moth Lymantria dispar produces a hormone which induces pupation.

—Hormone is chemical signal sent from cells in one part to cells in another parts of same individual.

—Regarded as chemical messengers.

—Their effect may be stimulatory or inhibitory.




Juvenile Hormones

—Produced by CA

—synthetic analogues are called as Juvenoids or JH mimics .

—Anti-JH agents which cause mortality in insects

Ecdysone Hormones

—or moulting hormone

— produced by prothoracic gland

— synthetic analogues are called as Ecdysteroids

—consist of two forms α-ecdysone and β- ecdysone

—moult inhibitors or chitin synthetic inhibitors also useful.

PEST MANAGEMEN T BY HORMONES

Pest management by Juvenoids

They cause mortality in insect-pest by

1. Antimorphic effect
2. Larvicidal effect
3. Ovicidal effect
4. Diapause disrupting effect
5. Inhibiting embryogenesis

**Field Application of JHa**

| JHAs | Pest Species |
|---|---|
| Methoprene<br>Trade name 'altosid' | Mosquitoes, Horn fly (Haematobia irritans), Greenhouse homopterans, Dipterous leaf minor |
| Fenoxycarb | Fruit pest- Grape moths, Plum moth, Codling moth , Summer fruit tortrix |
| Fenoxycarb<br>(foliar application) | Helicoverpa zea, American boll worm (Heliothis virescens) |
| Priproxyfen | Sucking pest – White fly, |
| Diofenolan | Lepidopterous pest and Scale insect of fruit crops |
| NC-196<br>(derivative of benzyl pyridazinone) | Brown plant hopper of rice |

Dhaliwal G. S. (2006) & T.V. Sathe (2003)

PHEROMONES

—Principle of behavioral control

— Introduction

—Classification

—Pheromone traps

—Mode of pheromone application

— Management by pheromones

Pheromone

Is a chemical or mixture of chemical released by an organism to outside (environment) that cause specific reaction in a receiving organisms in same species.

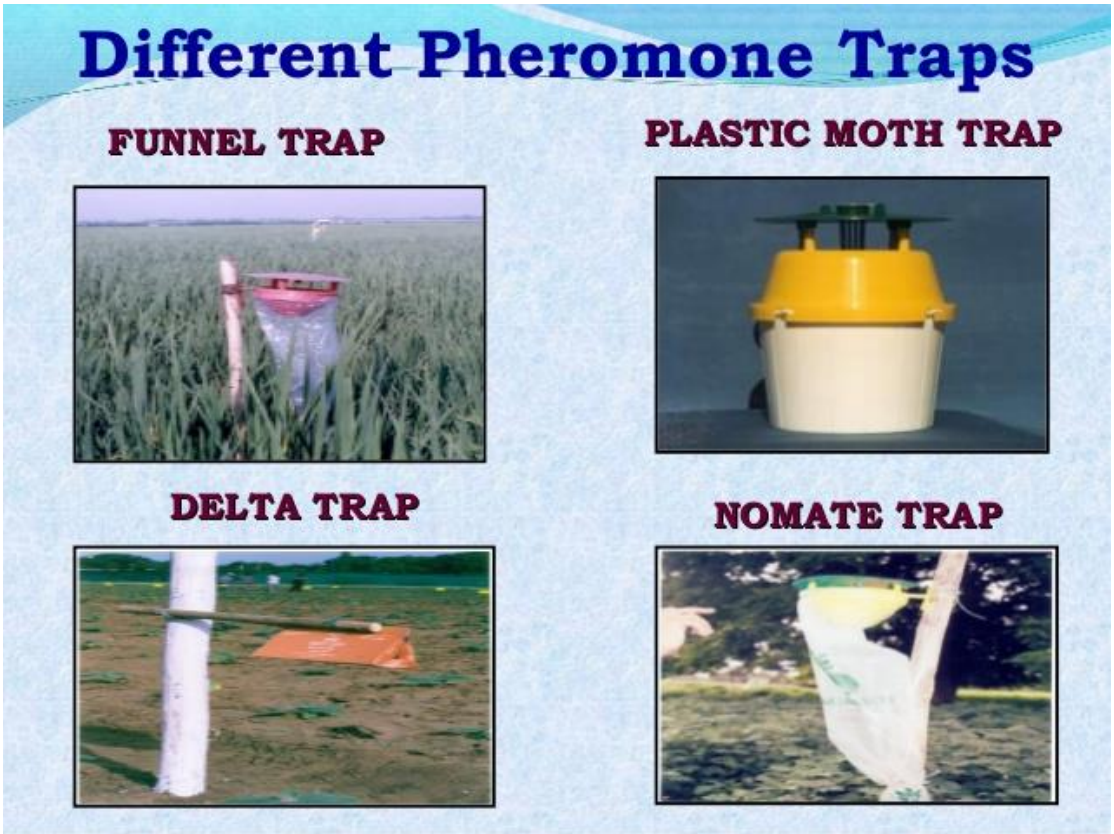
• Karlson and Butenandt coined the term Pheromone ,1959.

• ‘Pherein’ means to carry or transfer.

• also called as ectohormones.

• Pheromones – Exocrine in origin.

• Volatile in nature serving as chemical means of communication.




Pheromone Used For…

• Monitoring insect population.

• Control of urban pests.

• Monitor movement of exotic pests.

• Mass trapping of insects from breeding and feeding potential.

• Disruption in mating of insect population

ADVANTAGES

Effective in minute quantities.

Highly species specific.

Biodegradable, Non-persistent and non-polluting.

Non toxic to man, animals and plants.

Affects many aspects of insect development and physiology.

Labour saving.

Easy monitoring of pest population.

Best suited in IPM

Reduces risk of insecticide residues

CONCLUSION

Eco-friendly and economically based IPM

Hormonal control effective against specific stages and periods

Needs popularization among farmers

Hormone analogues are unstable

Limits commercial viability, no quick result

Used effectively only at low population density

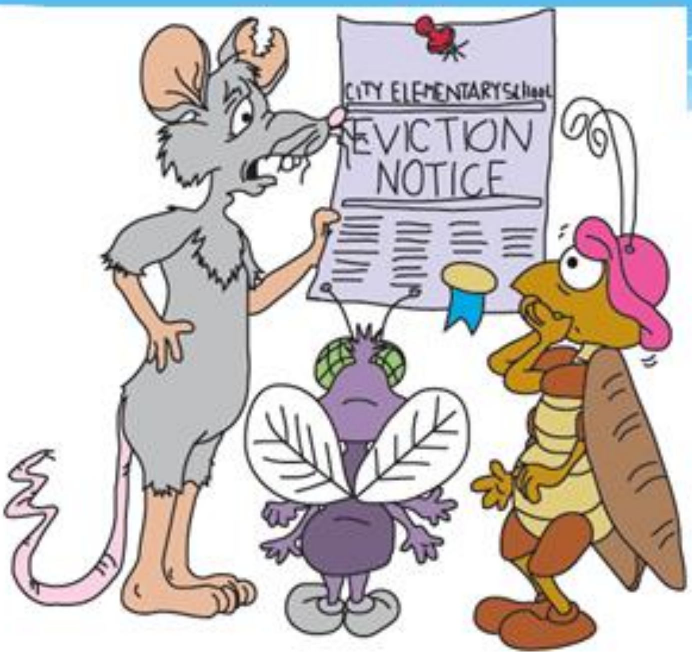
Control of all pests to be investigated with greater efforts

New trapping system need to ensure lure longevity and trap efficiency

**autocidal control**

A type of biological control in which the pest population contributes to an increase in its own mortality rate (e.g. the release of sterilized males leads to the laying of infertile eggs and, therefore, a reduction in the population).

# Pesticides



- A pesticide is any chemical, natural or human-made, that is designed to kill another organism.

## General Properties of Insecticides

1. Pesticides are generally available in a concentrated form which are to be diluted and used except in ready to use dust and granules.
2. They are highly toxic and available in different formulations.

## Properties of an ideal insecticide

1. It should be freely available in the market under different formulations.
2. It should be toxic and kill the pest required to be controlled.
3. It should not be phytotoxic to the crops on which it is used.
4. It should not be toxic to non target species like animals, natural enemies etc.
5. It should be less harmful to human beings and other animals.

# Classification Of Insecticides

**1. Based on chemical composition**

**2. Based on the mode of entry of insecticides into the body of the insect**

**3. Based on mode of action**

**4. Based on toxicity**

**5. Based on stage specificity**

## 1. Based on Chemical composition

**Inorganic insecticides** | **Organic Insecticides**

- **Inorganic insecticides: Comprise compounds of mineral origin and elemental sulphur. This group includes arsenate and fluorine compounds as insecticides. Sulphur as acaricides and zinc phosphide as rodenticides**

- **Organic Insecticides:**

**1. Insecticides of animal origin: Nereistoxin isolated from marine annelids, fish oil rosin soap from fishes etc.**
**2. Plant Origin insecticides or Botanical insecticides: Nicotinoids, pyrethroids, Rotenoids etc.**
**3. Synthetic organic insecticides: Organochlorines , Organophosphorous, Carbamate insecticides etc.,**
**4. Hydrocarbon oils etc.**

## 2. Based on the mode of entry of the insecticides into the body of the insect

- Contact poisons
- Stomach poisons
- Fumigants
- Systemic insecticides

• **Contact poisons:** These insecticides are capable of gaining entry into the insect body either through spiracles and trachea or through the cuticle itself. Hence, these poisons can kill the insects by mere coming in contact with the body of the insects. Eg: DDT .

• **Stomach poisons:** The insecticides applied on the leaves and other parts of plants when ingested act on the digestive system of the insect and bring aboutthe kill of the insect. Eg: Calcium arsenate, lead arsenate.

•**Fumigants:** A fumigant is a chemical substance which is volatile at ordinary temperatures and sufficiently toxic to the insects. Eg: Aluminium phosphide,Carbon disulphide.

•**Systemic insecticides:** Chemicals that are capable of moving through the vascular systems of plants irrespective of site of application and poisoning insects that feed on the plants. Eg: Methyl demeton, Phosphamidon , Acephate.

## 3. Based on mode of action

- Physical poisons
- Respiratory poisons
- Chitin inhibitors
- Protoplasmic poisons
- Nerve poisons
- General Poisons

**Physical poisons:** Bring about the kill of insects by exerting a physicaleffect. Eg: Heavy oils, tar oils etc. which cause death by asphyxiation. Inert dusts effect loss of body moisture by their abrasiveness as in aluminium oxide or absorb moisture from the body as in charcoal.

**Protoplasmic poisons:** A toxicant responsible for precipitation of protein especially destruction of cellular protoplasm of midgut epithelium. Eg. Arsenical compounds.

**Respiratory poisons:** Chemicals which block cellular respiration as in hydrogen cyanide (HCN), carbon monoxide etc.

**Nerve poisons:** Chemicals which block Acetyl cholinesterase(AChE) and effect the nervous system. Eg. Organophosphorous, carbamates.

**Chitin inhibitors:** Chitin inhibitors interfere with process of synthesis of chitin due to which normal moulting and development is disrupted. Ex Novaluron, Lufenuron ,Buprofezin

**General Poisons:** Compounds which include neurotoxic symptoms after some period and do not belong to the above categories. Eg.Chlordane, Toxaphene

## 4. Based on toxicity

| Extremely toxic | Highly toxic | Moderately toxic | Less toxic |
|---|---|---|---|
| Colour:- Red | Colour:-Yellow | Colour:- Blue | Colour:- Green |
| Toxicity:- Skull & Pioson | Toxicity:- Pioson | Toxicity:- Danger | Toxicity:- Caution |
| Oral LD50 :- 1-50 | Oral LD50 - 51-500 | Oral LD50 - 501-5000 | Oral LD50 - >5000 |
| DermalLD50 :- 1-200 | DermalLD50 - 201-2000 | DermalLD50 - 2001-20,000 | DermalLD50 - >20,000 |
|  |  |  |  |

## 5. Based on stage specificity

- Ovicides
- Larvicides
- Pupicides
- Adulticides

**Ovicides:-** A Substance or agent that kills eggs, especially the eggs of insects, mites, or nematodes.

**Larvicides:-** A larvicide is an insecticide that is specifically targeted against the larval life stage of an insect

**Pupicides:-** A pupicide is an insecticide that is specifically targeted against the pupa of an insect

**Adulticides:-** A pesticide designed to kill adult insects rather than their larvae.

# PHTOTOXITICITY

- **Meaning:-** Ability of a substance to Injure the plant.
- The application of pesticides or insecticides on plants is intended to control the pests without causing adverse or harmful effects to plants. It is common to see some adverse insecticides in fields which is called phytotoxicity.

## Types:-

1. Temporary phytotoxicity which allows the plant to recover after showing phytotoxicity.

2. Permanent phytotoxicity leading to the death of the effected part or whole plant.

## Important Points Of Phytotoxicity:-

- Most insecticides are not phytotoxcity at ordinary/ recommended concentrations but show temporary / permanent phytotoxcity when applied indiscriminately at much higher concentrations.

- However, some plants/crops are highly sensitive to certain insecticides and show phytotoxicity when applied.

- So thorough knowledge of phytotoxicity of chemicals and dosages at which they are to be applied is essential for plant protection people.

## Phytotoxicity can occur when:

- ❖ A material is properly applied directly to the plant during adverse environmental conditions.
- ❖ A material is applied improperly.
- ❖ A spray, dust, or vapor drifts from the target crop to a sensitive crop.
- ❖ Use of Insecticides in large amount.
- ❖ Residues accumulate in the soil or on the plant.

## Symptoms Of Phytotoxicity

1. Chlorosis

2. Bronzing of leaves

3. Necrosis

4. Scorching

5. Curling of leaves

6. White spots on leaves

7. Burning effects on leaves

8. Mottled leaves

## APPLICATION TECHNIQUES OF SPRAY FLUIDS

- The pesticide application plays important role in pest management.
- The main purpose of pesticide application technique is to cover the target species and safety to the non target organisms and the environment.
- The complete knowledge of pest is essential for correct time of application.
- Most of the pesticides are applied as sprays.

### Spraying is classified on the basis of the droplet size of the spray as :-

| Spray Type | Droplet size (μ - microns) |
|---|---|
| 1. Very Coarse spray | > 500 μ |
| 2. Coarse spray | 400 μ – 500 μ |
| 3. Medium spray | 250 μ – 400 μ |
| 4. Fine spray | 100 μ – 250 μ |
| 5. Mist | 50 μ – 100 μ |
| 6. Fog | 05 μ – 50 μ |
| 7. Aerosol | 0.1 μ – 5 μ |

## On the basis of Volume of spray fluid per unit area, Spraying is classified as:-

1. High volume sprays

2. Low volume sprays

3. Ultra – low volume sprays

4. Aerial spraying

## 1. High volume sprays

- Pesticide is diluted with water and droplet size is larger.
- These are used to spray fluid of 450 to 1000 liters.

These are categorized into:-

- Manually Operated
- Power Operated

# Manually Operated

## Knapsack Sprayer

- This type of sprayer has a flat or bean shaped tank.
- The tank has a capacity of 10 to 20 liters and is made of galvanized iron, brass stainless steel or plastic.
- It is used for spraying field crops vegetables and nurseries.
- The area covered per day is 0.8 to 1ha.

## Rocker Sprayer

- It consists of a pump assembly, a rocking lever, pressure chamber, and suction hose with a strainer, delivery hose, cut-off valve and spray lance with nozzle.
- By rocking movement of the lever pressure can be built in the pressure chamber and this helps to force the liquid through the nozzle.
- There is no built in tank.
- It can be used for spraying trees and tall field crops.
- It covers about 1.5 to 2 hectares of area in a day.

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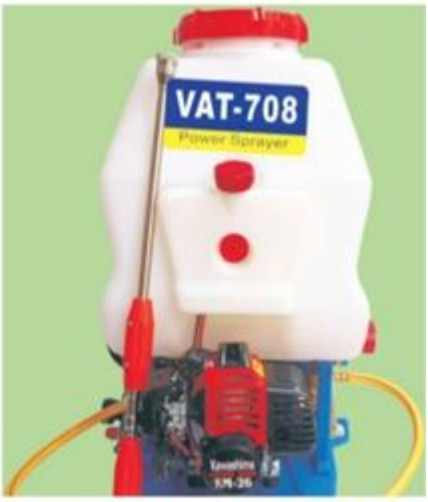
# Power Operated

## POWER OPERATED KNAPSACK SPRAYER




- 2 Stroke, easy start engines for heavy work.
- 18 Feet height of spray for orchards and also used for field crops
- Upto 125 mtrs hose can be attached with different type of nozzles available.

## Tractor Mounted Boom Sprayer

- Boom sprayer connected to the three point linkage of tractor and getting drive from (P.T.O) are used for multipurpose plant protection.
- With these sprayers all kind of field crops could be sprayed.
- Full UV & chemical resistant virgin polyethylene tank. Solid color means no algae growth inside the tank.
- Spring loaded boom sections which avoid deflection of plants.

## 2. Low Volume Sprayers

- Since in these sprayers the spray fluid is atomized with the help of an air stream at high velocity.
- These are called mist blowers or power sprayers.
- The tank in these is made of a thick polyethylene and has a capacity of 10 liters.
- The fuel tank capacity is 1.0 to 1.5 liters. It is provided with 1.2 to 3.0 hp petrol engine.
- The area covered by these sprayers is about 2 ha in a day.

## Power Operated Mist blower

- Mist blower allow to effortlessly and precisely spread pesticides over large and difficult areas.
- Vines, fruit trees and vegetable patches are all tended to in a short time.

## 3. Ultra-Low Volume Sprayers

- The pesticide in ULV formulation is used undiluted at a quantity less than 6 liters/ha and usually at 0.5 to 2.0 liters/ha for field crops.
- The droplet size varies from 20-150 micron with ground spraying equipment for ULV spray an area of 5 ha can be covered in a day.
- E.g. Controlled Droplet Applicator (CDA)

## Controlled Droplet Applicators (CDA)

- ❖ These applicators use a spinning disk (or cup) that breaks the liquid into uniformly sized droplets by centrifugal force.
- ❖ The droplets may be carried to the target by gravity or by an airstream created by a fan.
- ❖ Power to spin the disk or cup is provided by a small electric or hydraulic motor.
- ❖ Most CDA's do not use a pump.
- ❖ CDA's range in size from a small hand-held type to large tractor-mounted units.

## 4. Aerial Spraying

- ❖ Aerial air crafts has been employed for application of agricultural and public health pesticides.
- ❖ It is used for spraying, dusting and application of baits. However, Spray formulations are more suitable than dusts because of wind speed should not be more than > 5 KMPH.
- ❖ It has to be done at low heights and in the early hours of the days to ensure uniform deposition of dust particles.

Pesticide Label

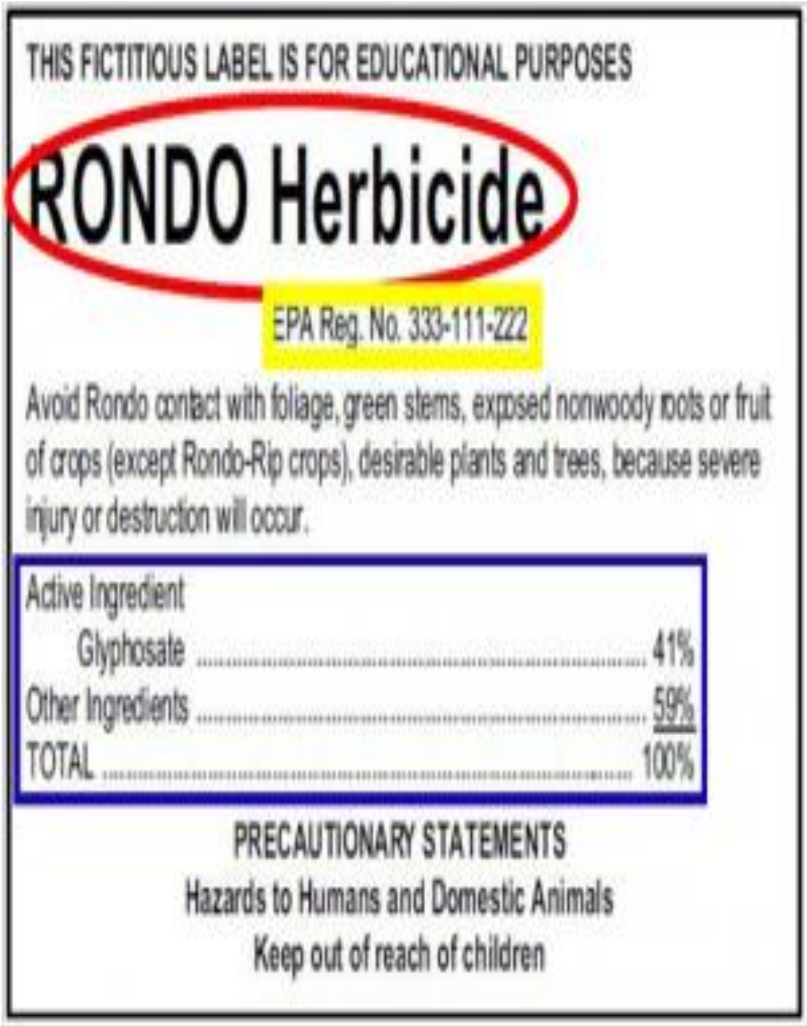
How to Read the Label

1. The pesticide label is your best guide to using pesticides safely and effectively.
2. The directions on the label are there primarily to help you achieve maximum benefits – the pest control that you desire – with minimum risk.
3. Follow the label each time you mix and use the pesticide, and follow the label when storing or disposing of the pesticide.
4. ***Use of any pesticide in any way that does not comply with label directions and precautions is illegal.*** It may also be ineffective on the pests and, even worse, pose risks to users or the environment.

**<u>The main sections of a pesticide label are described below:</u>**

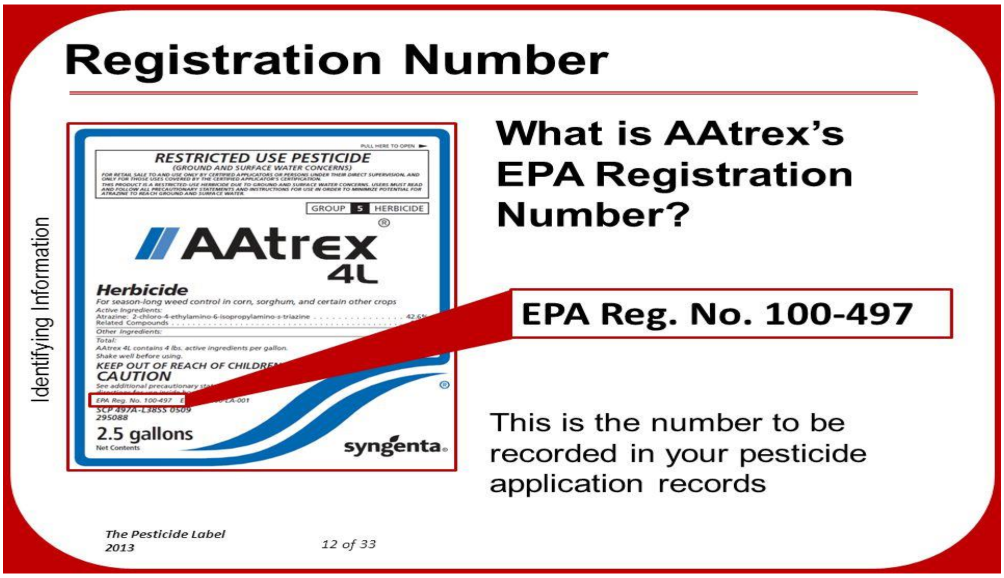
**<u>1-Brand Name</u>**

- The brand or trade name is the name on the front panel of the label that you commonly use to identify the product, such as Roundup or Sevin.
- ***Products with the same active ingredient, may have completely different brand names*** depending on the manufacturer or company that registers the pesticide with the Environmental Protection Agency (EPA).
- Likewise, very ***similar brand names used by two different companies may contain different active ingredients***.




## 2- EPA Registration Number

This number tells you that EPA has reviewed the product and determined that it can be used with minimal or low risk ***if you follow the directions on the label properly***.

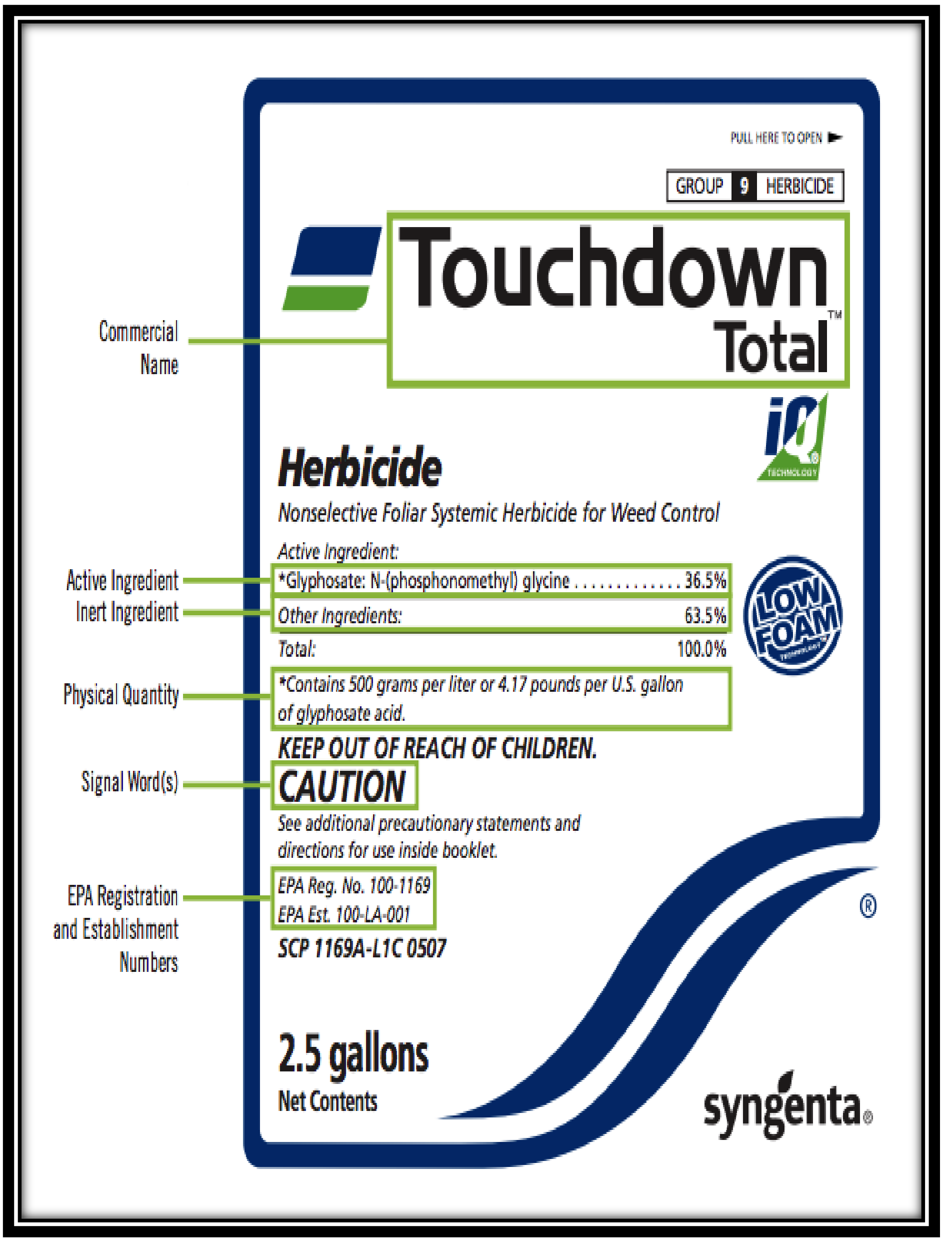



## 3- Ingredients Statement

A- Active ingredients are the chemicals in the pesticide that kill or control the target pest(s).

B-Inert ingredients often improve the effectiveness or safety of a pesticide.

C- This section provides the chemical name of each active ingredient, the percentage by weight of each active ingredient, and the percentage by weight of all inert ingredients. Inert ingredients are not listed individually nor identified by name.




## 4- Signal Words

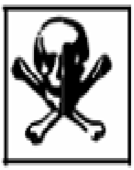
The signal words – **Caution**, **Warning**, or **Danger** – indicate the acute toxicity of the product to humans, based on one or more potential routes of exposure. The statement "keep out of reach of children" must also appear with signal words on the label of all pesticides.

Signal word Warning on label

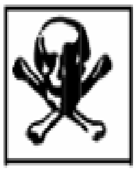
**CAUTION — (slightly toxic & relatively nontoxic)**

**WARNING — (moderately toxic)**

**DANGER — Very poisonous or irritating and should be used with extreme care because they can severely burn your skin and eyes..**



STOP – Read the label before use.
KEEP OUT OF REACH OF CHILDREN



DANGER POISON

PELIGRO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle.
(If you do not understand the label, find someone to explain it to you in detail.)

For MEDICAL And TRANSPORTATION Emergencies ONLY Call 24 Hours A Day 1-800-334-7577
For PRODUCT USE Information Call 1-866-99BAYER (1-866-992-2937)

## 5- Precautionary Statements

This part describes the protective clothing, such as gloves or goggles that you should wear when using the pesticide. The section also tells you how to protect children or pets by keeping them away from areas treated with pesticides.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER

Fatal if swallowed. May be fatal if inhaled. Harmful if absorbed through skin. Causes moderate eye irritation. Do not breathe dust or spray mist. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash clothing before reuse.

## 6- First Aid Instructions (Statement of Practical Treatment)

The label tells you what to do if someone is accidentally poisoned by the pesticide. These instructions are only first aid. ALWAYS call the emergency number listed on the label, a doctor, or the poison center , if someone is accidentally poisoned by the pesticide. You may have to take the person to a hospital right away after giving first aid. Remember to take the pesticide label or container with you.

**KEEP OUT OF REACH OF CHILDREN**

**CAUTION**

**Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle.**
**(If you do not understand the label, find someone to explain it to you in detail.)**

| FIRST AID | |
|---|---|
| **IF SWALLOWED:** | • Call a poison control center or doctor immediately for treatment advice.<br>• Have person sip a glass of water if able to swallow.<br>• DO NOT induce vomiting unless told to do so by a poison control center or doctor.<br>• DO NOT give anything to an unconscious person. |
| **IF ON SKIN OR CLOTHING:** | • Take off contaminated clothing.<br>• Rinse skin immediately with plenty of water for 15-20 minutes.<br>• Call a poison control center or doctor for treatment advice. |
| **IF IN EYES:** | • Hold eye open and rinse slowly and gently with water for 15-20 minutes.<br>• Remove contact lenses, if present, after first 5 minutes, then continue rinsing eye.<br>• Call a poison control center or doctor for treatment advice. |

**HOT LINE NUMBER**

Have the product container or label with you when calling a poison control center or doctor or going for treatment. In case of an emergency endangering life or property involving this product, call day or night 1-800-432-9400.

## 7- Personal Protective Equipment (PPE)

The label lists PPE needed to prevent exposure to the pesticide.

The EPA defines PPE as: coveralls, apron, gloves, footwear, headgear, eyewear, and respirators

Be sure to read this section before purchasing the pesticide.


## 8- Agricultural Use Requirements (Use of pesticides in producing agricultural plants)

The “Agricultural Use Requirements” box printed on the label of pesticides refers to the requirements of the Worker Protection Standard (WPS) that must be complied with in the production of an agricultural plant (crop) on an agricultural establishment.

**AGRICULTURAL USE REQUIREMENTS**

**Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment, restricted-entry intervals and notification of workers.**

## 9- Environmental Hazards

Environmental hazards statements This section indicates if the product can cause environmental damage – if it’s harmful to wildlife, fish, pollinators, endangered plants or animals, or water bodies such as ponds, lakes, rivers and wetlands.

Directions for Use. Make sure that the product is labeled for use against the pest(s) that you are trying to control. (For example, products labeled only for termites cannot be used to control fleas.) Use only the amounts indicated, and follow the directions exactly.

Note: It is a violation of Federal law to use a product in any manner inconsistent with its labeling. Protective Equipment (PPE)

The label lists PPE needed to prevent exposure to the pesticide. Be sure to read this section before purchasing the pesticide.

> **ENVIRONMENTAL HAZARDS**
> This product is extremely toxic to aquatic and estuarine invertebrates.
> Do not contaminate water by cleaning equipment or disposal of wastes.
>
> **BEE CAUTION: MAY KILL HONEYBEES IN SUBSTANTIAL NUMBERS.**
> This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area.

## 10-Physical or Chemical Hazards

This section of the pesticide labeling will tell you of any special fire, explosion, or chemical hazards the product may pose. For example, it will alert you if the product is so flammable that you need to be especially careful to keep it away from heat or open flame or if it is so corrosive that it must be stored in a corrosion-resistant container. When pesticides are flammable, smoking while handling them is extremely hazardous.

## 11- Storage and Disposal

Read carefully and follow all directions for safe storage and disposal of pesticide products. Always keep products in the original container and out of reach of children, in a locked cabinet or locked garden shed. Disposal of pesticide containers in a manner not listed by the label could lead to contamination of the environment or harm to other people.

**Storage and Disposal**

**Storage:** Store in a cool, dry, well-ventilated area, but not below 32°F.

**Pesticide Disposal:** Do not contaminate water, food or feed by storage or disposal. Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA regional office for guidance.

**Container Disposal:** Triple rinse (or equivalent). Then puncture and dispose of in a sanitary landfill, by incineration or, if allowed by State and local authorities, by burning. If burned stay out of smoke.

## Formulations of Pesticides

## Why Formulate Pesticides ?

## A pesticide is rarely used or applied in its pure form.

Formulation is the processing of a pesticidal compound by any method that will improve its properties of

Storage

Handling

Application

Effectiveness

Safety

**Terminology for Formulations**

• AI = active ingredient, chemicals that are responsible for the pesticidal effect

• Inert ingredient = any substance in a pesticide formulation having no pesticidal action

• Formulation = the way a pesticide is prepared for practical use

• Carrier = inert liquid or solid added to an active ingredient to prepare a pesticide formulation

• Diluent = any liquid or solid material used to dilute an active ingredient. In liquid formulations, water or oil is used; in dry formulations, talc, clay or other fine dust is used

• Emulsifier = a chemical that aids in suspending one liquid in another

• Emulsion = a mixture of one liquid in another liquid

• Wetting agent = a chemical which causes a liquid to contact surfaces more thoroughly

• Suspension = a mixture of fine solid particles in a liquid

• Soluble = dissolves in a liquid

• Surfactant = increases the emulsifying, dispersing, spreading, and wetting properties of a formulation

## Types of Formulations

1. Emulsifiable concentrates
2. Wettable powders
3. Solution
4. Dusts
5. Aerosols
6. Granular formulations
7. Baits
8. Microencapsulated products
9. Fumigants

# 1-Emulsifiable Concentrates

• Designated by E or EC

– Examples are Dursban 2E, Prevail TC, Gentrol, Dursban Pro, Archer, Dragnet

• AI + solvent + emulsifier = EC

• EC + water = emulsion

• Emulsion is a fine suspension of oil droplets in water and appears milky in color

• They do not require constant agitation prior to each application

• Advantages

– Bind well to fabrics and fibers in carpet.

– Easy to mix and use

– Spreads evenly over foliage

– Binds well to soil particles

• Disadvantages

– Mild to strong odors

– Absorption onto porous surfaces( phytotoxicity)

– Potential burning of plant material (flammable)

– Errors in mixing the concentrate with water

– Some surfaces such as plastic or tile may be damaged

– Can easily penetrate skin

2-Wettable Powders

• Desginated by W or WP

• AI + carrier + wetting agent = WP

• WP + water = suspension

• Suspensions are fine particles suspended in water

• Suspensions require constant agitation prior to each application

– Examples of wettable powders are Demon WP, and Tempo WP

• Advantages

– Low to no odor

– Little hazard of burning plants

– Little hazard of penetrating skin

– Do not absorb into porous surfaces, when water evaporates, powder sits on surface and is readily picked up by insects

• Disadvantages

– Inhalation of particles while mixing concentrate

– Constant agitation of suspension prior to and during application

– Large mesh strainer must be used (>50 mesh) in sprayers

– Pumps and nozzles can be damaged by abrasion of the particles

– Visible residues can occur on dark surfaces


3-Solution
(Water-Miscible Liquids, SC)
(Water-Soluble Powder, SP)

• Technical pesticide + diluent = solution

• Designated with SP = Soluble Powder, or SC = Soluble Concentrate

• Advantage is also a solution

• Form clear liquids for spraying

• Example Premise SC, Termidor SC, Bora- Care


4-Dusts

• Designated by D

• Technical pesticide + dry carrier = dust

• Common carriers are clay, talc, silica gel, or diatomaceous earth

• Dusts cannot be mixed with water and must be applied dry

• Some dusts are the insecticide themselves like boric acid or diatomaceous earth

– Examples of dusts are Deltadust, Ficam D, Drione, Sevin D, and malathion D

• Advantages

– Long lasting

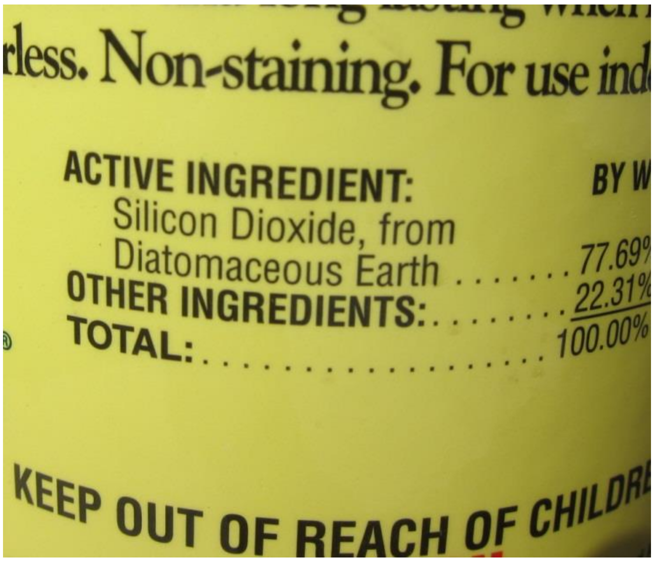
— they often do not break down

– Low odor

– Easy to apply

– Not absorbed into surfaces and are readily picked up by pests

– If spilled, dusts can be easily cleaned up




• Disadvantages

– Readily become airborne and can contaminate non-target surfaces

– Readily inhaled by the applicator, technicians should wear a respirator for application

– Can be abrasive, and eye protection should be worn

# 5-Aerosols

- **AI + solvent + propellent + nozzle = aerosol**

**• Technical insecticide + propellent = aerosol**

**• Propellents may be butane**

**• Examples of aerosols are Wasp Freeze, ULD-BP-50, Ultracide, UltraGuardian**


• Advantages

– Ease of use

– Ease of storage

– No dilution or storage of concentrates

• Disadvantages

– Expensive

– Odor of solvents

– Atomized droplets are easy to inhale and drift to non- target surfaces

**6-Granules**

• Designated by G

• Technical pesticide + clay = granules

• Examples of granular formulations are Dursban G, Talstar G


**•Advantages**

–Low drift

–Ease of application

–Long residual life outdoors

**•Disadvantages**

–Water is required to release the insecticide

–Limited to outdoor application

–Application equipment must be calibrated often

7-Baits

• AI + food base = bait

– Food base can be liquid, meal, seed, pellet, bait block, or gel

• Examples of baits are MaxForce FC, Siege, Recruit, Drax, Dual Choice, Firstline, Niban, Amdro


• Advantages

– Easy to use

– Little or no mixing

– Readily control pests moving into or out of an area

• Disadvantages

– Other food sources compete with baits

– Very specific for certain species of pests

– Can be attractive to children or pets

**8-Microencapsulated products**

• Often referred to as ME (microencapsulated emulsion), FM (flowable microencapsulated), CS (Capsulated suspension)

• AI + plastic polymer + emulsifiers = ME

– The capsules enclose the insecticide and protect it from degradation and release the insecticide slowly

• Examples of MEs are Demand CS


**• Advantages**

**– Long term control**

**– Low odor**

– Safety— if swallowed the capsules do not release the insecticide

– No absorption into surfaces

• Disadvantages

– Require constant agitation

– May leave visible residues on dark surfaces

– Not effective in wet areas

**9-Fumigants**

• Gaseous insecticides usually packaged under pressure and stored as liquids (methyl bromide (Meth-o-gas)

• Examples of fumigants are sulfur fluoride (Vikane) and), Phostoxin (aluminum phosphide)


• **Advantages**

– Toxic to a wide variety of pests

– Good penetration of target areas

– Single treatment will usually kill al pests in treated area

• Disadvantages

– Treated area must be closed or tented to prevent gas from escaping

– Highly toxic to people

CLASSIFICATION OF INSECTICIDES BASED ON CHEMICAL NATURE

**Classification of insecticides based on chemical nature**

1. Inorganic insecticides
2. Organic insecticides
3. Synthetic organic insecticides
4. Miscellaneous compounds

.1Inorganic insecticides are from mineral origin

* **Arsenicals :** Ex: Lead arsenates : Widely used against beetle and insect having a biting & chewing type of mouth parts

Calcium arsenate : It is a stomach poison, very effective against leaf eating insects

*** Fluorine compounds** :

Ex : Sodium fluoride : Used in baits against chewing insects & house hold pests

*** Other inorganic compounds**:

Ex : Sulphur: as a acaricidal and fungicidal action , available in dust & WP.

Zinc Phosphide : Used as rodenticide.

**Organic insecticides/ compounds**

| Oils & Soaps ( Kerosene, diesel, crude oil) | Insecticides of animal origin.<br>Ex : Nereistoxin | Insecticides of plant origin. |
|---|---|---|
| ➢ Used against household & orchard pests. | ➢ Isolated from marine annelid.<br>➢ Nerve poison. | |
| ➢ Used as a wetting agents, stabilizers & spreaders. | ➢ Cartap hydrochloride ( Padan) Effective against rice stem borer & DBM. | |

**2. Insecticides of plant origins**

1. Pyrethrum

2. Nicotine

3. Rotenone

4. Neem products

1. **Pyrethrum:**

ü Prepared from flowers of chrysanthemum.

ü Contact in action with rapid knock down action.

2. **Nicotine:**

ü Extracted from leaves of tobacco plant.

ü contain 40% nicotine.

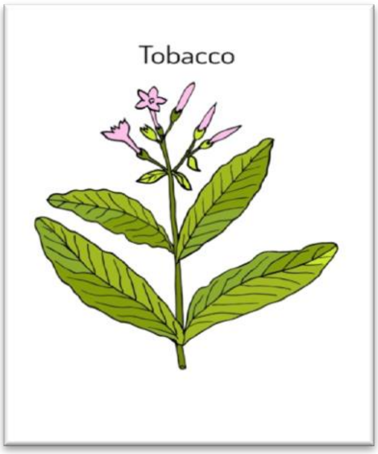
ü contact, stomach, & fumigant in action.

ü Used against sucking insects.

3. **Rotenone:** Extracted from roots of Derris elliptica.

ü Used against leaf eating insects.

**4. Neem products**: Ex : Neem oil, NSKE




**3. Synthetic Organic insecticides/ compounds**

**a) Chlorinated Hydrocarbons (Organochlorine)**

*These consist of Cl, H, C & Sometimes O2.

*They have a long residual stability.

* Both stomach & contact poison.

**Important organochlorine insecticides**

*DDT (Dichloro Diphenyl Trichloroethane)

* First synthesized by Othmer zeilder in 1874.

* Paul Muller found its insecticidal property in 1939.

* Nobel prize was awarded to Paul Muller in 1948.

* Stomach & Contact insecticides, Non phytotoxic except cucurbits.

*Long residual action, Oral LD50 for rat is 113-118mg/Kg.


**b) BHC (Benzene Hexachloride)** 1,2,3,4,5,6-Hexachlorocyclohexane

* First prepared by Michael Faraday in 1825

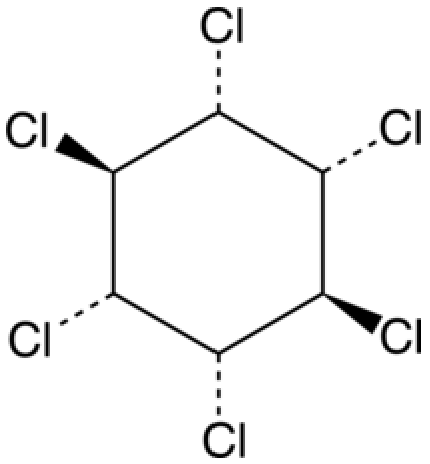
* Van De Linden discovered four isomers in 1912

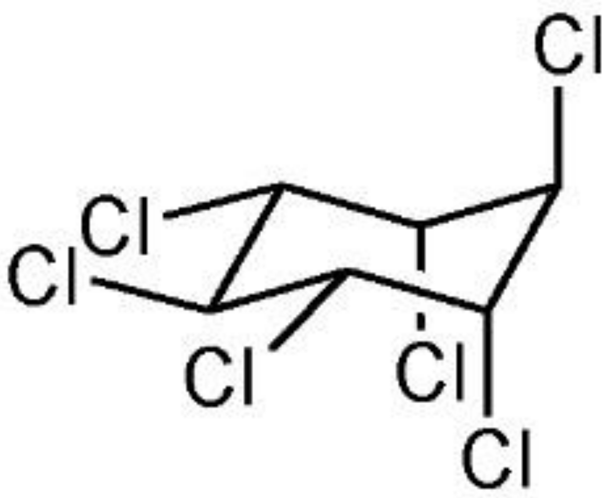
*Highly purified product containing 99% of gamma isomer of HCH (Hexa Chloro Cyclohexane) is known as **LINDANE** in honor of Van De Linden in 1949.

*Stomach & Contact insecticides.

*Lindane is more volatile than DDT & has fumigant action .

*Extensively used as a soil insecticides against termite, white grubs etc.




**c) Cyclodine compounds**

*It is a collective group of synthetic cyclic hydrocarbons.

*Act as neurotoxicants, Which disturb the balance of Sodium & Potassium ions within the neuron resulting tremors, Convulsions, Prostration & ultimately death of insects.

* Important insecticides : Chlordane, Heptachlor, Aldrin, Dieldrin, Endrin & Endosulfan.

**Aldrin** : Persistent & non systemic soil insecticides.
Formulation : 30%, Granule 5%, Dust5%.

LD50 : 80-110mg/Kg

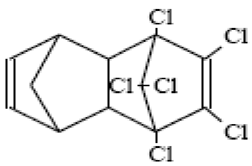
**Endosulfan (Thiodan)**

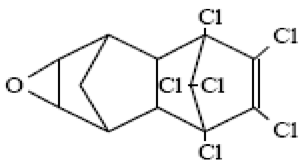
*Effective insecticide, acaricidal property & Toxic to fish.

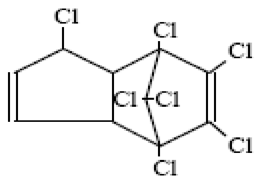
*Non-systemic, Contact poison with fumigant action.

*Effective against borers & Sucking pests.

*LD50 : 80-110 mg/Kg


Aldrin


Dieldrin


Heptachlor

Organophosphates

• Insecticidal action of OP compounds was discovered by Gerhard schrader in 1942 in Germany.

• Organophosphorus (OP) compounds are usually esters, amides or thiol derivatives of phosphoric acid .

• They decompose within days to weeks after application.

• They break down to phosphoric acid, alcohols, and thiols.

• Organophosphorus compounds are metabolized quickly by animals – no bioaccumulation.

• They tend to be more acutely toxic than organochlorines.

• They form a large family (> 50 000 compounds) of chemical agents with biological properties that have important, and sometimes unique, applications for the benefit of mankind.

• A large group of chemicals used for protecting crops, livestock, human health and as warfare agents.

• They are also been used as plasticizers, stabilizers in lubricating and hydraulic oils, flame retardants, and gasoline additives.

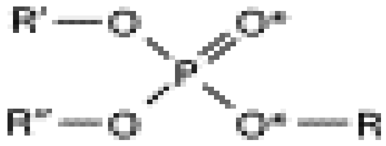
• some pesticides in this group are extremely toxic e.g. disulfoton and parathion, while others are relatively safe e.g. malathion.

• Some are rapidly degrading e.g. dichlorvos and mevinphos, while others are extremely persistent e.g. parathion, azinphos methyl.

• Some are systemic e.g. dimethoate, disulfoton, demeton-S-methyl, monocrotophos, and methamidophos while others are contact e.g. dichlorvos, and mevinphos.

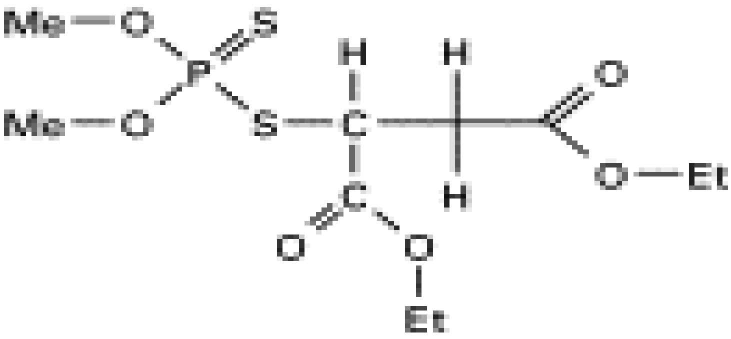
• Some have a fumigant action e.g. dichlorvos.

• Can be foliar or soil- applied, or can be used as a seed dressing e.g. chlorpyriphos and disulfoton.

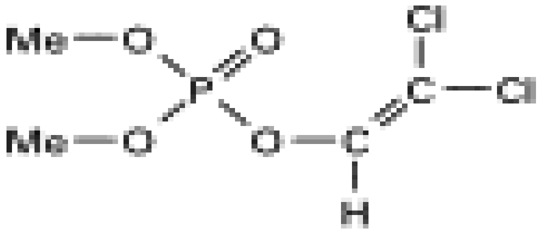


R' and R" usually Me or Et        O* may be O or S

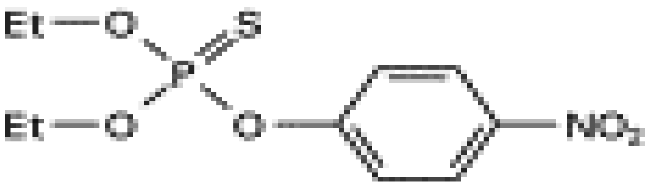
Organophosphate insecticides: general structure



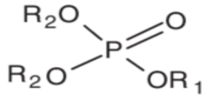
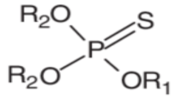
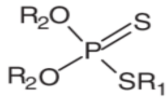
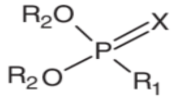
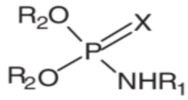
Malathion



Dichlorvos



Parathion

| Type | General structure | Pesticides |
|---|---|---|
| Phosphates |  | Chlorfenvinphos<br>Dichlorvos<br>Mevinphos<br>Monocrotophos<br>Tetrachlorvinphos |
| Thiophosphates |  | Chlorpyrifos<br>Diazinon<br>EPN<br>Ethyl-Parathion<br>Fenitrothion<br>Fenthion<br>Methyl-Parathion<br>Pirimiphos-methyl<br>Triazophos |
| Dithiophosphates |  | Azinphos-methyl<br>Dimethoate<br>Malathion<br>Phorate<br>Terbufos |
| Phosphonates |  | Trichlorfon |
| Phosphoramides |  | Acephate<br>Fenamiphos<br>Methamidophos |

[a]Where $R_1$ and $R_2$ are any alkyl groups and X may be S or O.

## Classification of OP insecticides

*** Phosphohalides & Cyanides** :

Ex : Sarine, Tabum, Soman.

*** Phosphorothioates/ Phosphorodithioates :**

Ex- Malathion, Phorate, Dimethoate, Disulfoton, Methyl Parathion.

***Phosphates :** Ex : Dichlorovas, Phosphomidon, Monocrotophos.

*** Phosphorothiolates :** Ex : Profenophos, Methyl parathion.

*** Phosphorothionate :** Ex : Chloropyriphos, Quinalphos, Fenitrothion. Diazinon etc.

***Phosphoroamidate** : Ex : Acephate, TEPP, Schradan.

*Among OP Dichlorovas shows a fumigant action.

* Chloropyriphos used against termite.

* Phorate widely used as Granular insecticides.

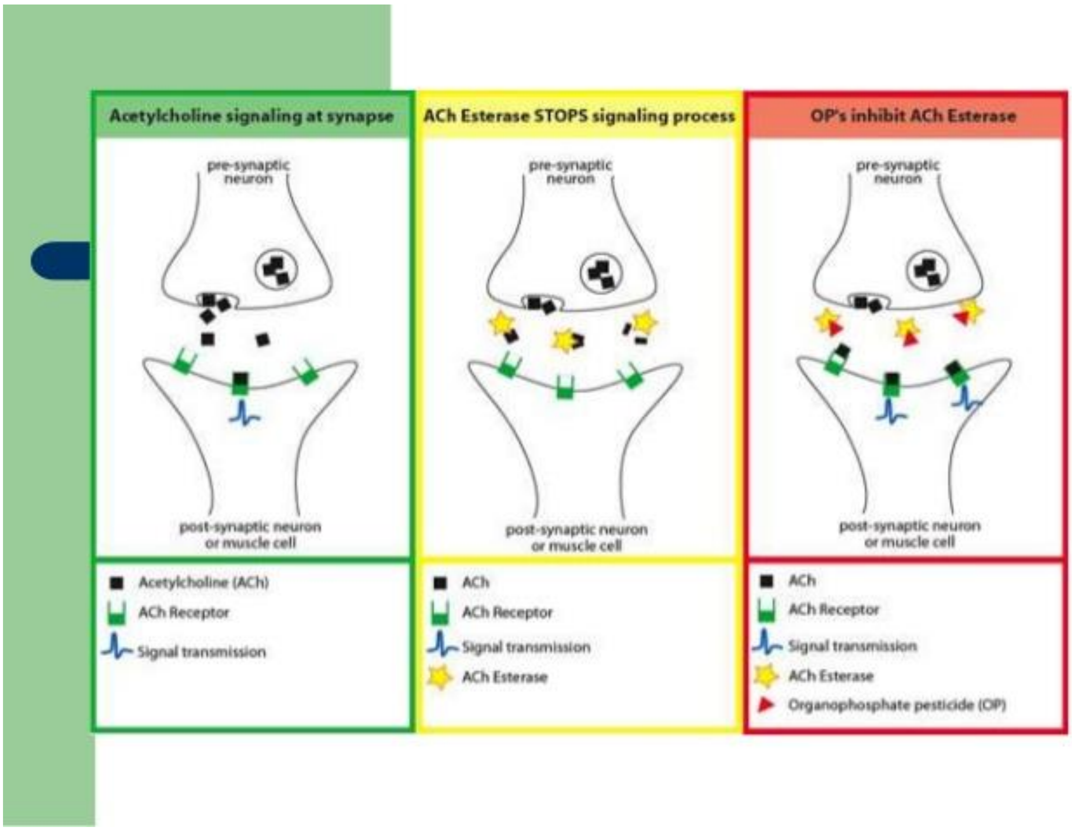
*Malathion- Safest insecticides.

Mode of Action of Organophosphate

The primary mechanism of action of organophosphate is inhibition of acetylcholinesterase (AChE).

*Phosphate radical of organophosphates interacts with active enzyme site forming a covalent bond leading to increase of Ach at the synapses and neuro-muscular junction.

* Once AChE has been inactivated, ACh accumulates throughout the nervous system, resulting in overstimulation of muscarinic and nicotinic receptors



**Carbamate insecticides**

* Carbamate insecticides are synthetic derivatives of Physostigmine commonly known as **Eserine.**

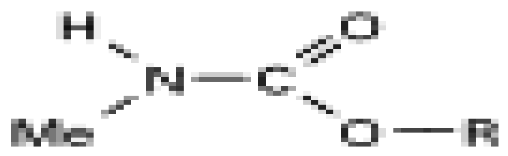
*They have systemic and contact action.

**Carbamate insecticides are classified into**

* Hetrocyclic carbamates : Ex- Isolan, Pyrolan.

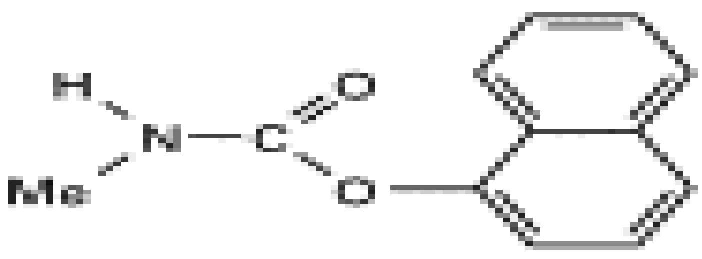
* Napthyl carbamates : Ex- Carbaryl. Ø Phenyl carbamates : Ex- Carbofuran.

*Oxime carbamates : Ex- Aldicarb, Methomyl.

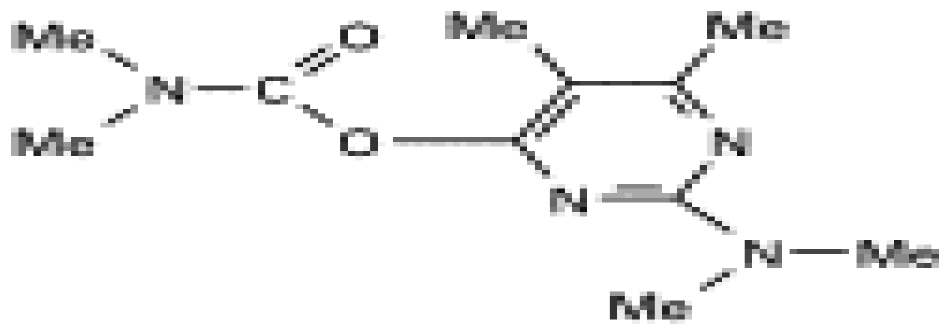


R is PhR' or N=CR'

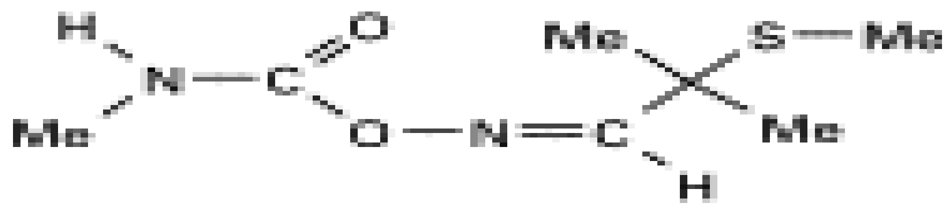
Carbamate insecticide: general structure



Carbaryl



Pirimicarb (an *N,N*-dimethyl carbamate)



Aldicarb (an *N*-methyl oxime carbamate)

- ❖ Widely used carbamate insecticide against borers- **Carbofuran.**
- ❖ Carbamate insecticide used against cockroach, flies, mosquitoes- **Propoxar.**
- ❖ Wide spectrum C. insecticide used against cotton pests- **Carbaryl.**

❖ Insecticide of Carbamate group which is highly toxic to mammals- **Aldicarb.**

❖ Carbamate insecticide which is used to control nematodes- **Carbofuran.**

**SYNTHETIC PYRETHROIDES**

* These are synthetic derivatives of natural pyrethrins.

* The main commercial source of pyrethrum is the mature flower of chrysanthemum .

*The high quality flowers contain up to 4 mg of pyrithrins.

* These are lipophilic compounds.

* Developed for the purpose of more stable in light & air and insecticidal activity.

*Synthetic pyrethroids have extremely high insecticidal activity at low doses & are bio-degradable in nature.

*Very less toxic to mammals.

*Pyrethroids are contact insecticides & less effective as stomach poison.

**CHRONOLOGY SEQUENCE OF DEVELOPMENT OF SYNTHETIC PYRITHROIDS**

| Group | Year developed | Pyrethroids developed | Remarks |
|---|---|---|---|
| 1st generation synthetic pyrethroids | 1949 | Allethrin | ❖ Low toxic to mammals (rapidly broken down in body)<br>❖ Decompose quickly in sun light.<br>❖ Little risk in environment. |
| 2nd generation synthetic pyrethroids | 1960-1973 | Resmethrin, Phenothrin, Bioallethrin. | ❖ Not toxic to mammals.<br>❖ Decompose rapidly in sun light.<br>❖ Not suitable for agri. Purpose. |
| 3rd generation synthetic pyrethroids | 1975 | Permethrin, Cypermethrin, Deltamethrin, Fenvalerate. | ❖ Not highly toxic to mammals.<br>❖ Do not decompose in sun light.<br>❖ Powerful insecticidal activity. |

**LIMITATIONS OF SYNTETIC PYRETHROIDS**

* These are not effective as soil insecticides.

*Causes resurgence of several insect(Whitefly & Aphids)

*Development of resistance in many insect pests.

*Poor acaricidal property.

**4. MISCELLANIOUS COMPOUNDS**

A. **Neo-nicotinoids :** They are synthetic analogues of nicotine developed by Bayer company.

**Neo- nicotinoids are classified into**:

**Chloronicotinyl compounds**:

Ex: Imidacloprid & Acetamiprid.

**Imidacloprid :**

* Inhibits nicotinic acetylcholine by binding with nicotine acetylcholine receptors.

* Used as a seed treatment, Soil & Foliar in application.

*Found effective against sucking pests (Aphid, plant hoppers etc.)

* Formulations : Imidacloprid 17.8%SL (Confidar), 70%WG (Admire), 70%WS (Gaucho).

**Acetamiprid** :

* Mode of action is same ass imidachloprid.

* Effective against sucking pests.

* Formulation: Acetamiprid 20 SP ( Pride, Ennova).

**Spinosyns** : Ex : Spinosad.

* Isolated from actinomycetes bacteria, Saccharopolyspora spinosa.

*The formulation contained a mixture of two metabolites. Spinosyns A & D called Spinosad (Tracer).

* It has both fumigant & Stomach action.

* Highly effective against Lepidoptera, Diptera, Thysanoptera & Coleopteran pests.

* Low mammalian, avian & fish toxicity.

* Safer for use of beneficial insects.

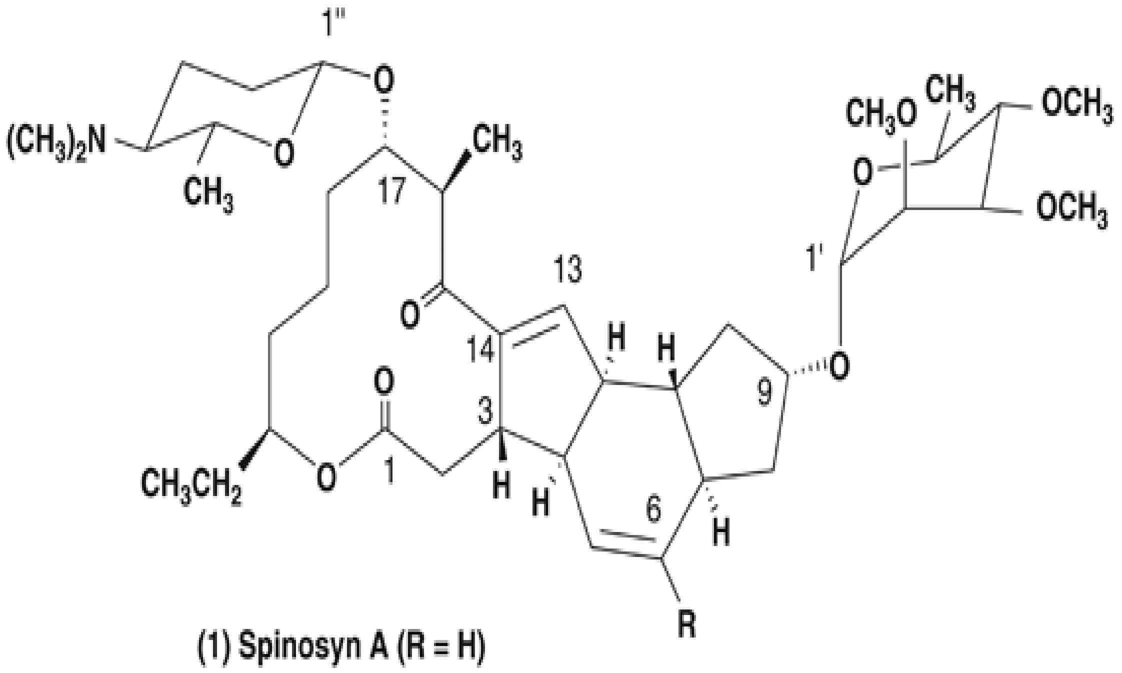
**Avermectins :** Ex : Abamectin (Vertimec, Avid, Agrimec)

* Isolated from soil bacteria, Streptomyces avermitilis.

*Effective against sucking pests, Leaf minor and Lepidopteran pests.

*Avermectins having nematicidal, acaricidal, insecticidal activities.

* Emamectin benzoate (Proclaim) and Abamectin (Vertimec) are two major compounds in this groups.




(1) Spinosyn A (R = H)
(2) Spinosyn D (R = $CH_3$)

**GENERATION WISE INSECTICIDES**

*** First generation** : Inorganic and Botanicals.

***Second generation** : Synthetic organics.

*** Third generation** : Chemicals for reproductive control.

Ex : Insect growth regulators viz; Moulting hormones, Juvenile hormones.

*** Fourth generation** : Synthetic pyrithroids.

*** Fifth generation** : Synthetic pyrithroids & Neo-nicotinoids.

# Toxicity of Pesticides

**Pesticides** are designed to control pests, but they can also be toxic (poisonous) to desirable plants and animals, including humans. Some pesticides are so highly toxic that very small quantities can kill a person, and almost any pesticide can make people ill if they are exposed to a sufficient amount. Because even fairly safe pesticides can irritate the skin, eyes, nose, or mouth, it is a good idea to understand how pesticides can be toxic so you can follow practices designed to reduce or eliminate your exposure and the exposure of others to them.

**How Pesticides Enter the Body**

—Before a pesticide can harm you, it must be taken into the body. Pesticides can enter the body orally (through the mouth and digestive system); dermally (through the skin); or by inhalation (through the nose and respiratory system).


**Oral Exposure**

—While ingestion (by mouth) is a less common way to be exposed, it can result in the most severe poisonings. There are numerous reports of people accidentally drinking a pesticide that has been put into an unlabelled bottle or beverage cup/container (including soft drink cans or bottles). Workers who handle pesticides may also unintentionally ingest the substance when eating or smoking if they have not washed their hands first.

—**Dermal Exposure**

Dermal (skin) exposure accounts for about 90% of the exposure pesticide users receive from nonfumigant pesticides. It may occur any time a pesticide is mixed, applied, or handled, and it often goes undetected. Both liquid pesticides and dry materials—dusts, wettable powders, and granules—can be absorbed through the skin.

The seriousness of dermal exposure depends upon:

—the dermal toxicity of the pesticide;

—rate of absorption through the skin;

—the size of the skin area contaminated;

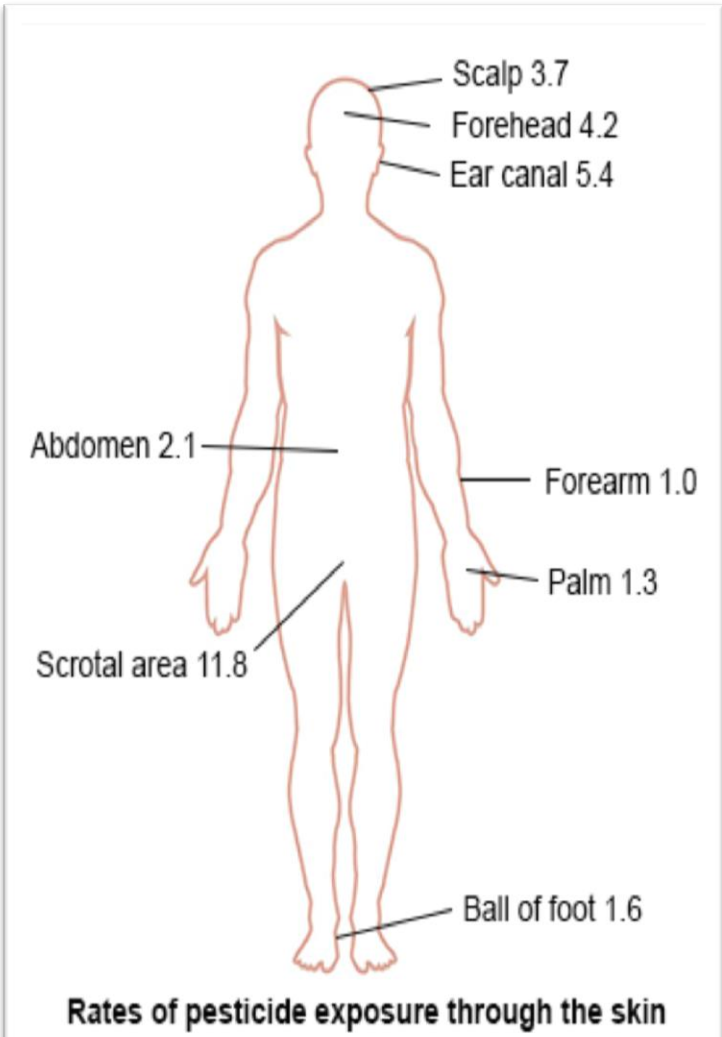
—the length of time the material is in contact with the skin

—the amount of pesticide on the skin.

Absorption continues to take place on all of the affected skin area as long as the pesticide is in contact with the skin. The seriousness of the exposure is increased if the contaminated area is large or if the material remains on the skin for a period of time.

Rates of absorption through the skin are different for different parts of the body. Usually, absorption through the forearm is the standard against which absorption rates in other areas of the body are tested. Absorption is over 11 times faster in the lower groin area than on the forearm (Table 1). Absorption through the skin in the genital area is rapid enough to approximate the effect of injecting the pesticide directly into the bloodstream.

**Table (1) Parathion absorption rates through the skin on various bodily regions.**



Rates of pesticide exposure through the skin

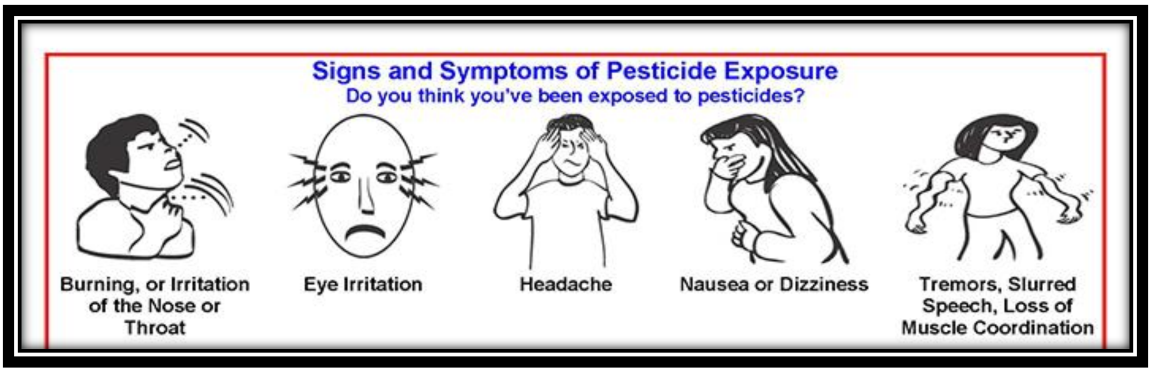
## Inhalation Exposure

—Inhalation exposure results from breathing pesticide vapors, dust, or spray particles. Like oral and dermal exposure, inhalation exposure is more serious with some pesticides than with others, particularly fumigant pesticides, which form gases.

—Inhalation exposure can occur by breathing smoke from burning containers; breathing fumes from pesticides while applying them without protective equipment; and inhaling fumes while mixing and pouring pesticides. Some pesticides will have statements on their labels requiring the use of a specified respirator. Another means of inhalation exposure is smoking tobacco products containing pesticide residues.

**Toxicity: What is it?**

—Toxicity refers to the ability of a substance to produce adverse effects. These adverse effects may range from slight symptoms such as headaches to severe symptoms like coma, convulsions, or death. Poisons work by altering normal body functions. Most toxic effects are naturally reversible and do not cause permanent damage if prompt medical treatment is sought. Some poisons, however, cause irreversible (permanent) damage.




Toxicity is usually divided into two types ،acute or chronic ، based on the number of exposures to a poison and the time it takes for toxic symptoms to develop .Acute toxicity is due to short-term exposure and happens within a relatively short period of time ،whereas chronic exposure is due to repeated or long-term exposure and happens over a longer period.

**Table 2. Types of toxicity.**

| **Type** | **Number of Exposures** | **Time for symptoms to develop** |
|---|---|---|
| Acute | usually 1 | immediate (minutes to hours) |
| Chronic | more than a few | one week to years |

## How Toxicity Is Measured

—All new pesticides are tested to establish the type of toxicity and the dose necessary to produce a measurable toxic reaction.

—In order to compare the results of toxicity tests done in different labs, there are strict testing procedures. Toxicity testing is extensive (involving many phases) and therefore expensive.

—Humans, obviously, cannot be used as test subjects, so toxicity testing is done with animals and plants. Since different species of animals respond differently to chemicals, a new chemical is generally tested in mice, rats, rabbits, and dogs.

—The results of these toxicity tests are used to predict the safety of the new chemical to humans.

—Toxicity tests are based on two premises. The first premise is that information about toxicity in animals can be used to predict toxicity in humans. Years of experience have shown that toxicity data obtained from a number of animal species can be useful in predicting human toxicity, while data obtained from a single species may be inaccurate. The second premise is that by exposing animals to large doses of a chemical for short periods of time, we can predict human toxicity from exposure to small doses for long periods of time. Both premises have been questioned

**Acute Toxicity**

—The acute toxicity of a chemical refers to its ability to do systemic damage as a result of a one-time exposure to relatively large amounts of the chemical. A pesticide with a high acute toxicity may be deadly if even a very small amount is absorbed. The signal words on the label (Table 3) are based on the acute toxicity of the pesticide. Acute toxicity may be measured as acute oral (through the mouth), acute dermal (through the skin) and acute inhalation (through the lungs or respiratory system).

**Acute toxicity measures and warnings**

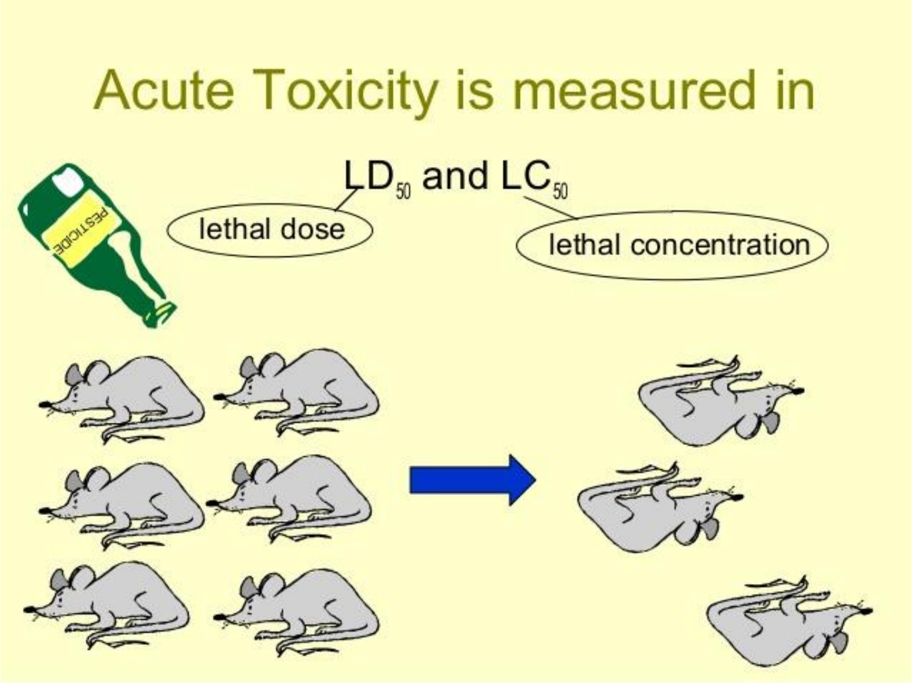
Table 3

| | | **Categories of Acute Toxicity** | | |
|---|---|---|---|---|
| | | **$LD_{50}$** | **$LD_{50}$** | **$LC_{50}$** |
| **Categories** | **Signal Word** | **Oral mg/kg** | **Dermal mg/kg** | **Inhale mg/l** |
| I Highly Toxic | DANGER, POISON (skull and crossbones) | 0 to 50 | 0 to 200 | 0 to 0.2 |
| II Moderately Toxic | WARNING | 50 to 500 | 200 to 2,000 | 0.2 to 2.0 |

| | | | | |
|---|---|---|---|---|
| III Slightly Toxic | CAUTION | 500 to 5,000 | 2,000 to 20,000 | 2.0 to 20 |
| IV Relatively Non-toxic | CAUTION (or no signal word) | 5000 + | 20000 + | 20 + |
| [1] Probable for a 150 lb.-person. | | | | |

**Acute Toxicity Measures**

— The commonly used term to describe acute toxicity is $LD_{50}$. LD means *lethal dose* (deadly amount) and the subscript 50 means that the dose was acutely lethal to 50% of the animals to whom the chemical was administered under controlled laboratory conditions. The test animals are given specific amounts of the chemical in either one oral dose or by a single injection, and are then observed for a specified time.




— The lower the $LD_{50}$ value, the more acutely toxic the pesticide. Therefore, a pesticide with an oral $LD_{50}$ of 500 mg/kg would be much less toxic than a pesticide with an $LD_{50}$ of 5 mg/kg. $LD_{50}$ values are expressed as milligrams per kilogram (mg/kg), which means milligrams of chemical per kilogram of body weight of the animal. *Milligram* (mg) and *kilogram* (kg) are metric units of weight. Milligrams per kilogram is the same measure as parts per million. To put these units into perspective, 1 ppm is analogous to 1 inch in 16 miles or 1 minute in 2 years.

— For example, if the oral $LD_{50}$ of the insecticide parathion is 4 mg/kg, a dose of 4 parts of parathion for every million parts of body weight would be lethal to at least half of the test animals.

— Acute inhalation toxicity is measured by $LC_{50}$. LC means *lethal concentration*. Concentration is used instead of dose because the amount of pesticide inhaled in the air is being measured. $LC_{50}$ values are measured in milligrams per liter. Liters are metric units of volume similar to a quart. The lower the $LC_{50}$ value, the more poisonous the pesticide.

***Chronic Toxicity***

- Chronic toxicity refers to harmful effects produced by long-term exposure to pesticides.
- Less is known about the chronic toxicity of pesticides than is known about their acute toxicity, not because it is of less importance, but because chronic toxicity is gradual rather than immediate and is revealed in much more complex and subtle ways.
- While situations resulting in acute exposure (a single large exposure) do occur, they are nearly always the result of an accident or careless handling. On the other hand, people may be routinely exposed to pesticides while mixing, loading, and applying pesticides or by working in fields after pesticides have been applied**.**
- Chronic toxicity is tested using animal feeding studies. In these studies, the pesticide under investigation is incorporated into the daily diet and fed to animals from a very young to a very old age. These, as well as the reproductive effects studies, are designed to arrive at a No-Observable-Effect-Level (NOEL); that is, a level in the total diet that causes no adverse effect in treated animals when compared to untreated animals maintained under identical conditions. This NOEL is expressed on a mg/kg of body weight/day basis.
- A Reference Dose (RfD), also known as Acceptable Daily Intake (ADI), is usually established at 1/100 of the NOEL, in order to add an additional margin of safety. The RfD (ADI) is the amount of chemical that can be consumed daily for a lifetime without ill effects.

**Chronic Toxicity Measures**

- There is no standard measure like the $LD_{50}$ for chronic toxicity. How chronic toxicity of chemicals is studied depends upon the adverse effect being studied. Chronic adverse effects may include carcinogenic effects (cancers), teratogenic effects (birth defects), mutagenic effects (genetic mutations), hemotoxic effects (blood disorders), endocrine disruption (hormonal problems), and reproductive toxicity (infertility or sterility).

**Carcinogenesis (Oncogenesis)**

- Carcinogenesis means the production of malignant tumors. Oncogenesis is a generic term meaning the production of tumors which may or may not be carcinogenic. The terms tumor, cancer, or neoplasm are all used to mean an uncontrolled progressive growth of cells. In medical terminology, a cancer is considered a malignant (potentially lethal) neoplasm. Carcinogenic or oncogenic substances are substances that can cause the production of tumors.

**Teratogenesis**

- Teratogenesis is the production of birth defects. A teratogen is anything that is capable of producing changes in the structure or function of an embryo or fetus exposed before birth. An example of a chemical teratogen is the drug thalidomide, which caused birth defects in children when their mothers used it during their pregnancies. Measles virus infection during pregnancy has teratogenic effects.

**Mutagenesis**

- Mutagenesis is the production of changes in genetic structure. A mutagen is a substance that causes a genetic change. Many mutagenic substances are oncogenic, meaning they also produce tumors. Many oncogenic substances are also mutagens.

**Reproductive Toxicity**

- Some chemicals have effects on the fertility or reproductive rates of animals. Males or females can be affected.

- For chronic toxicity there is no comparable set of signal words like those used for acute toxicity. Instead, a statement identifying the specific chronic toxicity problem is sometimes used on the label. Such a statement might read "This product contains (name of chemical), which has been determined to cause tumors or birth defects in laboratory animals." Chronic toxicity warning statements may be accompanied by label directions to wear certain kinds of protective clothing when handling or working with the pesticide to minimize or eliminate exposure to the pesticide.

— It is important to read the label to look for signal words identifying the product's acute toxicity and for statements identifying any chronic toxicity problem. A pesticide may be low in acute toxicity (signal word caution), but it may have a label statement identifying potential chronic toxicity.

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SAFETY
FIRST

# المقرر العملى

- Identification of common insect pests
- The scope of monitoring tools available, their pros and cons
- Practical experience in using non-toxic methods of controlling insects, including EFK units and traps – their pros and cons
- Practical use of sprayers, dusters, ULVs and bait application equipment
- Health and safety considerations when using insecticides including practical steps to help develop H&S paperwork including COSHH / Risk Assessment and maintenance checks
- The importance of maintaining and servicing equipment

1. طرق مكافحة الآفات
2. مبيدات الآفات
3. تجهيزات المبيدات
4. مستحضرات وصور استخدام المبيدات
5. ثبات المعلقات
6. المستحلبات والمواد المستحلبة
7. اختبارات التأكد من صلاحية المبيدات
8. انواع المياه المستخدمة في الحقل
9. آلات الـــــــــــــــرش والتعفير
10. التقييم الحيوى
11. برنامج تجارب اختبار فاعلية المبيدات الحشرية