4th Edition

INSECTICIDES

Toxicology and Uses

H.C.L. Gupta

PREFACE

The problem to control pests is as old as agriculture. In earlier times control on a large and effective scale was not possible. The shifting ecological balances of pests and other species led to levels of attack which varied widely from year to year. The earliest attempts to control pests were basically by the use of naturally occurring toxic substances, like plant extracts, arsenicals etc. The era of modern synthetic pesticides largely dates from 1939 when the insecticidal properties of DDT were discovered.

Insecticides, the chemicals used to control harmful insect pests play an important role in modern agriculture. Although they are used extensively for protection of agricultural crops against noxious pests yet they are thought to be major pollutants of food and environment.

This book furnishes a detailed account of insecticides, their formulations, properties, mode of action, biotransformation, toxicity evaluation, the problem of resistance, residues and environmental contamination. Stress has been laid on biopesticides, the ways and means towards safe use of insecticides to avoid insecticidal hazards and the intervention of insecticides in IPM programme. The Insecticides Act, 1968 which regulates the import, manufacture, sale, transportation, distribution and uses of insecticides is also explained. Thus, this book will be of great use to enlighten students, extension workers, traders, planners and all concerned with agriculture.

Though sufficient literature is available on insecticides I, have tried to compile few aspects on insecticides, toxicology and their uses, arranging them in a way for clear understanding of the readers.

I take this opportunity to thank my colleagues and students who provided valuable advice, criticism and assistance during the writing of the manuscript of this compendium. I owe my gratitude to my parents and all family members, who inspired me for writing and assisted me in various ways. I am also thankful to Agrotech Publishing Academy for the publication of this book.

I must stress, however, that I accept the responsibility for any errors that occur in the text.

Suggestions for improvement are welcomed.

(H.C.L. Gupta)

CONTENTS

1

Classification and Formulations of Insecticides

Pesticides have assumed great importance in today's high yielding and intensive agricultural system as well as public health programme, the world over. The word '**Pesticide**' is a very broad term. Literally it refers to killer of pests but it also includes substances used for controlling, preventing, destroying, repelling or mitigating any pest. Thus, the pesticides are of following categories.

- Insecticides - kill insects.
- Fungicides - Kill fungi.
- Bactericides - kill bacteria.
- Herbicides - kill weeds.
- Miticides or Acaricides - kill mites.
- Nematicides - kill nematodes.
- Rodenticides - kill rodents.
- Ovicides - destroy eggs.
- Moulluscicides - kill snails and slugs.
- Avicides - kill or repel birds.
- Algicides - kill algae.

- Larvicides - kill larvae.
- Piscicides - kill fish.
- Predicides - kill predators.
- Attractants - attract insects.
- Chemosterilants - sterilize insect and vertebrate pests.
- Growth regulators-stimulate or retard growth of plants or insects.
- Pheromone - attract insects.
- Repellents - repel insects.
- Defoliants - remove leaves.
- Disinfectants - destroy or inactivate harmful microorganisms.

The Indian legislation has given the term '**insecticide**' in the Insecticide Act, 1968 which is not only to regulate the one type i.e. insecticides but all above referred branches of pesticides. To describe all types of pesticides is a great task which needs a lot of labour and voluminous writing. In order to avoid these problems and considering feasibility, this volume deals with **insecticides**- the insect killers and all other substances used to suppress the insect population by one way or the other.

The earliest record of the use of insecticides dates back to the writings of Greeks, Romans and Chinese, some 3,000 years back. From early civilization till 1940 inorganic insecticides like arsenicals, soaps, petroleum oils and botanicals were used as insecticides. The discovery of insecticidal property of DDT in 1939 by a Swiss entomologist, Dr. Paul Müllar brought a significant change in the field of insect control. World over a large number of compounds have been synthesized showing insecticidal properties. In order to understand them, they can be classified on the following basis.

1. Based on toxicity,
2. Based on mode of entry,
3. Based on mode of action, and
4. Based on chemical nature.

Classification based on toxicity

Toxicity is the ability of a chemical to bring about changes in the biological system of the target animal. The toxicity is expressed in terms of **LD_{50}** values. The dose in terms of milligram of toxicant per kilogram of body weight (mg/kg) that kills 50 per cent of the test animals to which it is administered under experimental condition is termed as **LD_{50}**. It may be **oral** (fed to or placed directly in the stomach of rats), **dermal** (applied to the skin of rats or rabbits), and respiratory toxicity (inhaled). The size of the dose is also important. On the application of single dose if the symptoms of acute stage of poisoning appears, it refers to **acute toxicity**. The accumulating effect of repeated doses is considered as **chronic toxicity**. On the basis of these criteria, the insecticides can be classified as :

Toxicity categories	LD_{50} based on single oral dose to rats	LD_{50} based on single dermal dose to rats/ rabbits
Supertoxic	< 5	< 20
Extremely toxic	5-50	20-200
Very toxic	50-500	200-1000
Moderately toxic	500-5000	1000-2000
Slightly toxic	5,000-15,000	2,000-20,000
Practically non-toxic	> 15,000	> 20,000

Classification based on mode of entry

i Stomach poison-poison enters the body of insect through food.
ii. contact poison-poison enters the body of insect through cuticle.
iii. Fumigant -poison enters in gaseous state into the body of insects through spiracles and trachea.

Classification based on mode of action

i. Physical poison - kills the insect by exerting the physical effect.
ii. Protoplasmic poison - kills the insects by destruction of cellular

protoplasm.

iii. Respiratory poison- blocks the cellular respiration and renders the respiratory enzyme inactive.

iv. Nerve poison- affect the nervous system of insects.

Classification based on chemical nature.

1. Inorganic insecticides
2. Plant or animal originated insecticides
3. Synthetic insecticides.

Besides, all the above basis of classification the insecticides may be (i) systemic and (ii) non-systemic.

Systemic insecticide is a compound which enters the internal tissues of plants through roots, trunk, leaves, fruits and seeds, and applied directly to any of these parts but eventually gets distributed throughout the plant. In other words a compound that is capable of absorption in the plant sap becoming translocated and distributed in each part so that the insects feeding on them may be killed, while **non-systemic insecticides** are those which are not translocated but only the treated part of the plant is insecticidal.

Formulations of Insecticide

Insects occur as pests in almost all places and under various types of environments and locations. Insecticide applications need to be made under different circumstances. No single form of insecticide would effectively reach the target or remain effective for a desirable period. Obviously, an insecticide has to be in the desired form and concentration to be suitably applied under different conditions of application i.e. in air, water, soil, on or in the plant parts, dwelling houses, animal farms, stores, bakeries, food processing plants, etc.

Formulation involves processing of the technical grade insecticides for better storage, handling, measure, application and efficacy together with safety. The technical grade insecticides are

first bought by the commercial formulators. They prepare various commercial preparations and give their own trade names to such marketable formulations. Depending upon the mode of applications, **dry** (dusts, sprayable powders, granules etc) and **liquid** (sprayable, fumigant or liquid baits) formulations are common forms. They may also be classified as solid, liquid and gaseous formulations.

1. **Solid formulation** - dust, wettable or water dispersible powder, granules, capsules, baits and pellets etc.
2. **Liquid formulation** - solution, emulsifiable concentrate, ultra low volume formulations, suspension etc.
3. **Gaseous formulation** - fumigant, aerosol, foams, smokes, mists and fog.

Dusts (D)

Dusts, the simplest formulation, are the easiest to apply. Most often, dusts are available as ready to use material. These are formulated mechanically or by impregnation under operations of pre-blending, pulverising and post blending including aeging. The technical insecticide is thoroughly blended with or impregnated on inert dust carriers. The inert dust carrier may be of following type.

1. Minerals
   - i. Elements - Sulphur
   - ii. Oxides -
     - a. silicon, tripolite, diatomite
     - b. oxides of calcium and magnesium.
   - iii. Sulphates - gypsum, selenite.
   - iv. Phosphates - rock phosphate, apatite
   - v. Silicates - talc, pyrophyllites, clays.
     - a. Palygorskite group - attapulgite, sapiolite, palygorskite.
     - b. Kaolinite group - Kaolinite, china clay.
     - c. Montomorillonite group-montmorillonite, bentonite, saponite
     - d. Illite group - mica, vermiculite

vi. Carbonates - calcite, dolomite

vii. Indeterminates - pumice stone.

2. Botanicals -soybean, wheat, tobacco, walnut shell, wood, rice hull, corn cob, citrus pulp.
3. Synthetics -

   a. Precipitated hydrated calcium silicate

   b. Precipitated calcium carbonate

   c. Precipitated hydrated silicon oxide.

Straight dusts are prepared by grinding together of the technical insecticide and diluent (the inert dust carrier) to a desired fitness. **Impregnated dusts** are prepared by wetting or spray of the inert dust carrier with a solution of the toxicant in a solvent. The solvent is evaporated subsequently. Dust may be Undiluted like pyrethrum powder, calcium arsenate, sodium fluoride.

Particle size, specific gravity, bulk density, pH, adsorption and absorption properties, flowability, abrassive characters, cost etc. determine the choice and efficacy of the carriers and the final formulation.

The most effective size of the dust particles is 10 μ in diameter because it can get into the body segments of the insects and cause abrassion and desiccation, but in field the particles smaller than 20μ give a little deposit. Dusts may have particle size of 175μ (coarse), 40-175μ (medium) or less than 40 μ (fine). Usually, the dusts are fine enough to pass the size of 250-350 mesh. Silica aerogels which penetrates the waxy cuticle of insects have extremely fine particles (less than 400 mesh).

Leaf surfaces have negative charge and those particles having positive charge have better adhesion and make more lasting and effective formulation. Hard particles of the carrier are injurious to insects as they cause death by abrassion. Moisture absorbing capacity of the carrier affect the efficacy of formulation. Hygroscopic material absorb moisture from insect surface after abrassion. High sorptive materials are good dust carriers. Free flowing diluents are

suitable for dust formulation. High specific gravity of the carrier is helpful in dislodging the formulation from leaf surface. The activated materials like charcoal and kaoline are more effective because they are helpful in the removal of liquid from the insect cuticle.

Insecticidal dusts are formulated in the concentrations ranging from 0.1 to 25 per cent. The effectiveness of the dust is increased if applied early in the morning when the plants are wet with dew. Even slight winds may cause drift of dusts, therefore, they should be applied when the weather is calm. Once applied dusts remain effective as long as they remain dry. Some dusts get caked and become ineffective when they get moistened. Dusts act as contact poison and also as a stomach poison when licked by insects to clear the impregnated bodies.

Despite their ease in handling, formulation and application dusts are least effective as foliar application as compared to other formulations for want of uniform and thorough coverage, loss by drift and rains.

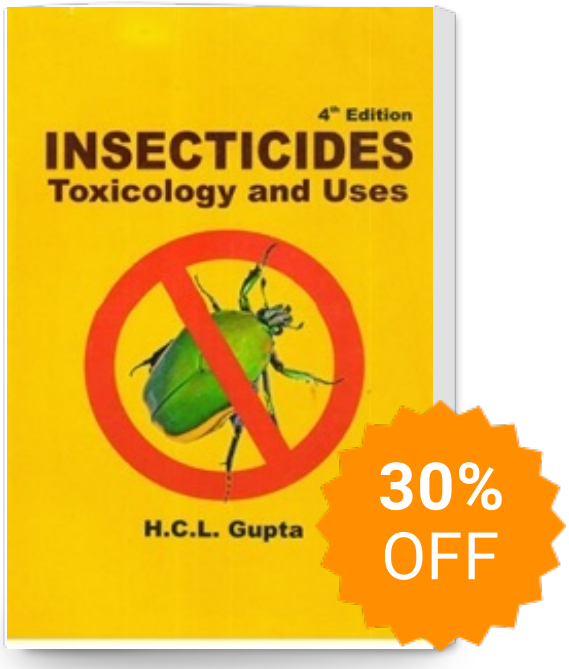
Granules (G)

Granules are small pellets of highly adsorptive inert material. Generally adsorbent carriers of inorganic origin like montmorillonites, kaolinites, bentonites, attapulgites, synthetic silicates are used. For special purposes lime, dolomite, talc, pyrophyllites and even sand particles are used. Organic carriers are exceptionally used. Granules may be formulated in different sizes such as 10/20, 15/30, 16/30, 18/35, 20/35, 20/40, 24/48 and 30/60. Size 20/40 implies that virtually all the granules will pass through a standard 20 mesh sieve but a few may pass through a 40 mesh sieve.

Efficacy of granules is influenced by type of carrier used, extent and thoroughness of its deactivation, the nature of solvent used to dissolve the toxicant, the method of drying, the size of granules, the speed of release of toxicant and aeging. Toxicants singly or in combination can be granulated with ease.

The toxicant content generally varies from 1 to 10% in the granules. They are formulated by impregnation of the carrier before pelleting ('extruded granules') or by surface coating of the inert

Insecticides: Toxicology And Uses



Publisher : Agrotech Publications

ISBN : 9788183212076

Author : Gupta HCL