USE OF CHEMICALS FOR PLANT PROTECTION

DR. ROHAN H. WICKRAMASINGHE,
Institute for Tropical Environmental Studies
41, Flower Road
Colombo 7

Introduction

Sri Lanka's population has grown from an estimated 890,000 in 1824 and 2.4 million in 1871 to a projected mid-year figure of 17.16 million in 1990. It is estimated that the population may eventually stabilise at around 26 million. The present level of available technology requires that the production of increasing amounts of food to feed the growing population necessitates the use of chemicals; although attempts are being made to encourage the use of biological and other non-chemical methods in Integrated Pest Management (IPM). The present account discusses some aspects of the use of chemicals for plant protection in agriculture and forestry, while excluding fertilizers and pheromones (and chemicals used for public health purposes and in households); but including plant growth hormones and wood preservatives registered under the Control of Pesticides Act No. 33.

Uses of Chemicals

Chemicals used as pesticides and for related purposes may be placed in one or more of various categories, such as acaricides, algicides, biocides, fungicides, herbicides (weedicides), insecticides (including, for example, termiticides), insect growth regulators, molluscicides, nematocides, plant stimulants, plant growth regulators, rodenticides, surfactants and wood preservatives.

Each of the above categories may be subdivided again according to their mode of administration or action. For instance, insecticides may be stomach poisons (which enter the pest by ingestion), contact poisons (which enter after the pest touches a treated surface), fumigants (which enter by way of the respiratory system), systemic poisons (which may, for instance, be absorbed through the roots and be transported through the plant to a part on which the pest feeds) and physical agents, such as dusts, which may cause suffocation, or oils, which damage a protective cuticle. Some chemicals, such as chlorfluazuron, may be Insect Growth Regulators.

Other groups of plant protection products may be composed of chemicals with other types of activities. The Control of Pesticides Act No. 33, also covers chemicals, such as 1-naphthylacetic acid and butralin, which are used as Plant Growth Regulators, and ethephon, which is used as a Plant Stimulant.

Chemical Groups

The different chemical groups differ widely in respect of their modes of action, toxicity, persistence in the environment etc. Some of the commoner groups are as follows:

a) Organochlorines : This group includes many well known pesticides, such as DDT, aldrin, chlordane, dieldrin and heptachlor. Organochlorines and their degraded products may accumulate in the fatty tissues of non-target animals (including human).

b) Organophosphates : This group contains the largest number of insecticides. They exhibit a wide range in characteristics, such as toxicity and persistence. For instance, parathion and disulfoton are extremely toxic and diazinon is relatively persistent. Organophosphates are nerve poisons and, unlike organochlorines, usually do not accumulate in the fatty tissue but are fairly rapidly excreted in the urine.

c) Carbamates : These (esters of carbamic acid) bear some resemblance to organophosphates in that they inhibit the cholinesterase enzymes of the central nervous system. They, also, are not stored in the fatty tissues but are usually readily metabolised and excreted. Chemicals, such as aldicarb and carbofuran,

are systemic insecticides with a long residual activity in the soil.

d) Pyrethroids : These resemble natural pyrethrins and have marked insecticiidal activity but are, usually, not very toxic to mammals. Pyrethroids, such as bioallethrin, which have a high volatility are useful against storage pests.

e) Dithiocarbamates and related chemicals : These (e.g. thiram disulphides) are used as agricultural fungicides and for seed preservation and have low acute toxicity to animals.

f) Dinitrophenols and pentachlorophenols : These often have several uses, including wood preservation, but are extremely toxic to animals if taken orally.

g) Phenoxyacetic acid : These are used against broadleaf weeds (for instance, in paddy fields) and include 2,4-D, 2,4,5-T, MCPA and MCPB.

h) Substituted ureas : Bromacil and other substituted ureas are used as herbicides, which are fairly non-toxic.

i) Triazines : Atrazine, prometryn and terbutryn are members of this group of selective herbicides.

j) Dipyridylliums : This group comprises diquat and paraquat, which are herbicides. They are very toxic to mammals if taken orally.

k) Guanidines and napthoquinones : These fungicides include dodine and dichlone.

l) *Trichlorobenzoic, trichloroacetic and trichloropicolinic acids* : TBA, TCA, picloram and other members of this group are herbicides, which are persistent in the soil.

m) Mercury compounds : Seeds are, sometimes, treated with mercury compounds to protect them from fungal attack. However, mercury compounds are highly toxic to mammals and are, also, accumulated in the food chain. They should be used with care.

n) Arsenicals : Arsenicals, such as methylarsonic acid, include contact herbicides for the control of grass weeds.

o) Plant insecticides : These "natural products" include nicotine, pyrethrins and rotenone. While the toxicity of pyrethrins to animals is very low, that of nicotine sulphate is high.

p) Anticoagulant rodenticides : These "rat poisons" of the coumarin-type or the 1,3-indandione type inhibit the cessation of internal bleeding; thus leading to death.

q) Acute rodenticides : These may be inorganic (e.g. arsenic trioxide and zinc phosphide) or botanical (e.g. red squill) and can be very toxic.

Formulations

While the preceding refers to the active ingredients, which have pesticidal properties, these chemicals have to be "formulated" into preparations that can be used in the field. While there are several reasons why "formulation" is necessary, two of the most important are the possible extreme toxicity of the undiluted ingredient and the need to spread it uniformly over a large area. "Formulations" may, also, contain constituents, which render the active ingredient more soluble or more effective by reducing the rate at which it is degraded within the pest.

When discussing formulations, the term "technical material" is used instead of the name of the chemical or "active ingredient", partly since the purity of the chemical used in pesticide formulations is, for reasons of economy, generally less than that required for laboratory analytical reagents.

The different types of formulations include the following:

a) Dry formulations

1. Dusts - The technical material is mixed intimately with a solid diluent such as finely powdered talc or clay. Plants are treated directly with the dusts. This operation may, however, result in the dust settling in the surrounding areas, as well.

2. Granules - The technical material may be mixed with larger grains of clay or sand and broadcast. A drawback with these formulations is that the

grains may be consumed by birds and other animals.

3. Wettable powders - The technical material is included in amounts of 15 to 95 percent in small, dry particles, which can be made into suspensions with water. The suspensions are then sprayed, as desired, onto the foliage.

b) Liquid formulations

1. Emulsifiable concentrates - These concentrates contain technical material, organic solvent and emulsifier together with other products (spreaders and stickers), which enable more effective application of the formulation.

2. Flowable formulations - These contain a suspension in liquid of fine particles of the pesticide.

c) Seed treatments - Preparations similar to "wettable powders" are used to protect seeds intended for use as planting materials. Care needs, however, to be taken to minimize the hazards these may pose to birds etc.

d) Plant drenches - The roots of young plants or rooted cuttings are immersed in a liquid containing a systemic pesticide to allow the latter to permeate the tissues before planting. This is often an effective and environmentally less hazardous means of plant protection.

e) Poisonous bait - These formulations, where the pesticides are mixed with food, are regularly used for rodent and bird control. Care needs to be taken in their use.

Residues in Foods

Safe practices should be followed to minimise the presence of hazardous levels of pesticides in our daily diet. These practices may include the banning of the import and use of certain pesticides and, for instance, specifying a minimum period of time, which must elapse between the last application of a pesticide and harvesting the crop. It may not be possible to achieve a zero presence of a pesticide in food. However, a legal limit or "maximum residue limit or tolerance " may be specified and "acceptable daily intake" determined, based on all available information.

Hazard Classification

The hazard or extent of toxicity of a pesticide to an animal depends on a number of factors additional to its chemical nature. These may include the species of animal under consideration, whether the chemical enters through the mouth, skin or lungs and whether the animal has (sometimes unknowingly) previously developed any resistance to the pesticide. The age, sex and diet of the animal are among the other factors, which may have an influence.

A commonly used index to assist the classification of the toxicity of a pesticide is the LD_{50} value. This stands for Lethal Dose 50 or the dose required to cause the death of 50 per cent of a group of test animals under a given set of investigative conditions. The conditions may include the animal species (such as rats, mice, rabbits or dogs), route of administration of the pesticide (oral, dermal or respiratory), dosage (milligrams of active ingredient per kilogram body weight of the test animal; usually given in a single dose). Many other factors, however, also need to be considered, when assessing the hazards associated with the use of a pesticide. These could, for instance, include long term effects and chronic exposure.

The Worrld Health Organisation has recommended the hazard classification of pesticides as Hazard Class IA (Extremely hazardous), Class IB (Highly hazardous), Class II (Moderately hazardous) and Class III (Slightly hazardous). As an indication, it may be noted that, as regards oral administration of liquid formulations of pesticides to rats, Class IA corresponds to an LD_{50} of 20 mg or less per kg body weight, Class IB to 20 to 200 mg/kg, Class II to 200 to 2000 mg/kg and Class III to over 2000 mg/kg.

Resistance to Pesticides

Irrespective of the toxicity of the pesticide, its incorrect use can result in pest populations building up a resistance or "tolerance" to it. Individuals may build up resistance during their lifetime (e.g. by increasing the amount of the cytochrome P-450-dependent liver enzymes, which metabolise pesticides) or the increasing resistance may be acquired genetically over

generations. An example is the immunity to DDT acquired by the malaria mosquito in Sri Lanka and the worry that this insect may develop a resistance to malathion if the latter pesticide continues to be used (illegally) for the protection of crops. (Malathion is reserved solely for anti-malaria work in Sri Lanka for this reason).

Resistance acquired by an animial to one pesticide may confer "cross-resistance" to anothr product, while the "bedding" in cages in which laboratory animals are housed may, also, influence the sensitivity of the animals to the chemicals being investigated.

Use of Pesticides in Sri Lanka

The use of pesticides in Sri Lanka comes under the 1980 Control of Pesticides Act No. 33 and relevant regulations. This Act is implemented by the Registrar of Pesticides, who comes under the Ministry of Agricultural Research and Development. A provisional permit (valid for one year) or a permanent licence (valid for three years) may be granted for a pesticide as recommended by the Department of Agriculture. Labelling and other information to be provided regarding the pesticide is specified and must be provided in Sinhala, Tamil and English.

The pesticides permitted, banned and under other forms of restriction in Sri Lanka are under regular review and the lists are revised, as necessary. As an indication, it may be noted that in 1987 registered pesticides included 405 products and 94 ingredients, including 50 insecticides, 17 herbicides and 27 fungicides. Chemicals, which are banned today, include 2,4,5-T, captafol, chlordimeform, DBCP, dichloropropene (a component of DD soil fumigant), DDT, EDB, endrin, heptachlor, leptofos, parathion, methyl parathion, PCNB (quintozene), thallium sulphate, arsenates and arsenites (prohibited for use as weedicides in agriculture but sodium salts are used in wood preservatives) and mercury compounds (prohibited for use in agriculture even as a seed dressing or as a panel dressing. However, organomercurial biocides are used in the paint industry).

Finally, it should be remembered that a pesticide may be lethal to honey bees and other insects, which are valuable for pollinating certain flowers. For this reason, insecticides are, sometimes, sprayed in the late evening in order to reduce the exposure of beneficial insects, as much as possible.

Acknowledgements

I am very grateful to Dr. Nalini de Alwis and Dr. R.A.P. Malalasekera for helpful discussions.

Further Information

1. R.H. Wickramasinghe, "Contemporary environmental challenges: A Sri Lankan reader", Institute for Tropical Environmental Studies, Colombo (1988) 125 pp.

2. R.H. Wickramasinghe, "The Cytochrome P-450 proteins: Environmental and general aspects", Lake House Investments Ltd., Colombo (1990) 295 pp.