Agrodok-series No. 29

Pesticides: compounds, use and hazards

CTA

partageons les connaissances au profit des communautés rurales

sharing knowledge, improving rural livelihoods

Agrodok 29

Pesticides: compounds, use and hazards

Jeroen Boland
Irene Koomen
Joep van Lidth de Jeude
Jan Oudejans

First edition: 1989
Second, fully revised edition: 2004

Authors: Jeroen Boland, Irene Koomen, Joep van Lidth de Jeude, Jan Oudejans
Editors: Jeroen Boland, Irene Koomen
Illustrators: Barbera Oranje, Mamadi Jabbi; CropLife International courtesy
Translation: Sara van Otterloo
Printed by: Digigrafi, Wageningen, the Netherlands

ISBN Agromisa: 90-77073-41-8

Foreword

Agromisa emphasizes that wherever possible, non-chemical protection measures are to be preferred against any threat of pest infestation or diseases to crops and domestic animals. In cases where pesticides are needed, Agromisa endeavours to make its expertise and best practices on pesticide use available for small-scale farmers.

This revised Agrodok edition takes into account the rapid changes in current agro-pesticide use and expected trends and developments in future use. It contains information on pesticide suppliers and retailers, for producers and consumers of crops, for agricultural advisors, field study groups, students, resource and documentation centres.

This Agrodok is a major revision of the 1989 edition by Wilma Arendsen et al., that was written at a time marked by the start of great changes in crop protection chemicals throughout the world. Since then the agro-industry, research institutes, consumer health organizations, FAO, WHO and other UN organizations, civil society organizations such as PAN and many other stakeholders have undertaken efforts that have led to major improvements in safety.

Nevertheless, major challenges still lie ahead. The risks and hazards related to toxicity of pesticides remain as serious as ever, in spite of the implementation of many programmes for enhancing safe use and wide distribution of practical extension materials.

The terms (*agro-*)*pesticide* and *crop protection product* are used synonymously in this Agrodok. The Agrodok adheres to the FAO Code of Conduct on the distribution and use of pesticides and is intended to complement national laws and regulations. Agromisa accepts no liability regarding the use of the information contained in this booklet, which is accurate to the best of our knowledge at the time of publishing.

Agromisa acknowledges Gerard Pesch for contributing his expertise and Kees Eveleens for his proofreading comments. It acknowledges CropLife International for use of illustrations from the *Guidelines* series.

Contents

1 Introduction

1.1 Responsible crop protection

Agromisa would like to stress from the start that use of chemical pesticides should be completely avoided wherever possible. All options for using alternative, non-chemical methods of crop protection should be explored first. Only if none of these are possible should chemical control be considered as a last resort.

It can be very difficult for an individual farmer or advisor in the field to gain a clear understanding of all the aspects of pesticide use. This Agrodok defines principles of correct and effective application for user, environment and consumer of the harvested product. Risks of human poisoning and risks of environmental damage can be minimized if everyone involved in the trade, distribution and application of pesticides knows how to handle and apply them safely.

Unfortunately, the sobering reality is that health and safety policies to convince pesticide users to operate safely under dangerous conditions have very often failed. Assumptions that information systems and health and safety measures are present and used, are often overrated and too optimistic. Very often the information has not reached the people who are applying the pesticides.

It is important that any user of pesticides, after being informed correctly, remains responsible for handling and applying these chemicals according to the instructions. If everybody assumes this responsibility at each level of the food production chain, then pesticides can be used with a minimum of negative effects for the user, environment and consumer. Farmers should combine the knowledge they have gained through experience with the information they receive on proper use of pesticides.

The effectiveness and hazards of most pesticide applications have been tested under temperate climate conditions. The risks of agrochemicals in general, and more specifically of pesticides, are greater in warm climates than in temperate climates, for both humans and domestic animals. This is because the effects of poisoning occur more

quickly in hot temperatures. In hot weather the human body tends to absorb toxic substances faster, especially when it is insufficiently protected by protective clothing. Protective clothing is often absent; Sometimes it is not used because the heat makes it uncomfortable to wear, or it is not used properly in accordance with the instructions. Farming in temperate climate zones is largely done by richer farmers who are generally less exposed to risks than farmers in the (sub)tropics.

1.2 History

The knowledge and skills for protecting crops against pests and diseases have greatly improved over the centuries. People have always employed botanical and inorganic chemicals in their efforts to restrict damage from pests and diseases in their crops and animals

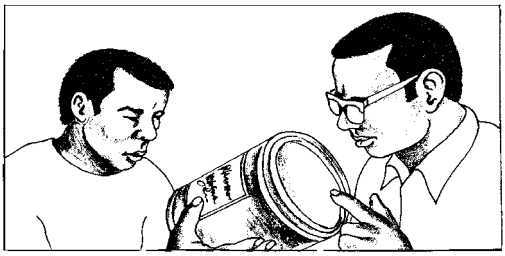

Figure 1: It is most important for a farmer to be properly informed about use of pesticides

A dramatic breakthrough in insect pest control was achieved in 1939 with the discovery of the insect-killing properties of DDT, which led to the development of chlorinated hydrocarbon and organophosphate pesticides during the Second World War (1940-45). Their remarkable efficacy in reducing the loss of human and animal lives and the increase in crop yields brought immediate commercial successes in the United States and Europe. When agricultural labour was scarce or expensive, herbicides saved farmers' time for laborious weed control. Since then pesticides have become widely accepted as essential in producing food for an expanding global population.

Chemical companies continued the synthesis of numerous new compounds and their screening on properties for pesticide use. They in-

vested heavily in marketing. From the early 1960s pesticide use also soared in Asia and South America, after international research institutes introduced high-yielding varieties of wheat, rice and maize in an effort to counter the regional food shortages. High-yielding varieties (HYV) were distributed to farmers on a large scale as part of subsidized Green Revolution input packages that contained HYV seeds, fertilizers, credit facilities and also pesticides. But insect and fungus attacks grew more serious, and more difficult to control, as a result of the application of nitrogen-fertilizers and the ensuing denser crop foliage. Also, some high-yielding varieties were strongly attacked by viruses, fungi and insects, because they were said to retain too little of the natural pest resistance found in parent varieties. Widespread pesticide use led to the decimation of natural enemies, and as other pest protection measures were neglected, outbreaks of these pests became more frequent.

Thus, a vicious circle seemed to develop, in which more frequent applications and higher dosages were seen as the unavoidable answer to increasing pest occurrence, 'the pesticide treadmill'.

During the 1950s, some scientists became aware of unexpected, dangerous consequences of unrestrained pesticide use. In 1962, Rachel Carlson roused public opinion with her book 'Silent Spring' that exposed the harmful impacts of modern pesticides on human and animal health, beneficial organisms and the environment. Her warning set off a chain of consumer-oriented actions and led to new research on hazard avoidance. Also governments and industry started to recognize that pesticides should be better targeted and their use more restricted. Treatment thresholds of pest infestation were introduced, mainly in Integrated Pest Management systems and programmes.

Measures included a reduction of the number of applications, development of less toxic, more selective pesticides, improvement of formulations and application technology and equipment, and the use of insect pathogens, pheromones and growth inhibitors. During the 1990s, governments and international agencies introduced policy guidelines for pesticide reductions and tightened the requirements for product registration and admission. As a result, the field of chemical pesticides has become much more strictly regulated. In view of the

current trends of globalization and international trade agreements, these developments have had consequences for all countries, including the less developed ones. As an example, we mention the International Code of Conduct on the Distribution and Use of Pesticides (see App. 1).
New pesticides are constantly being developed. Before these are admitted for marketing, rigorous testing is carried out and a registration process needs to be completed. Registration of pesticides is different for each individual country, but there are some international guidelines to which individual countries must adhere.
Summarizing, health and environmental problems arising from irresponsible pesticide use and storage in developing countries still require continuous attention. In addition to the direct harm pesticides can cause to human health and the environment, they also affect local economies and the workforce: medical costs are incurred for treatment and an increasing number of people are less able to live, work, care and earn an income in a sustainable way. It is to be hoped that these negative consequences of pesticide use will become better manageable in the future with the development of safer pesticides, the promotion of alternatives, and finally training, adequate information and extension for pesticide users.

1.3 Outline of contents and target group

The principles of pesticides and their safe application are explained to farmers and field workers in understandable language in this Agrodok. The booklet follows modern ideas on pesticide use combined with other effective traditional and new means of pest control: see also Agrodok 30, Integrated Pest Management. We cover application technology and equipment, while taking into account the limited supply of good products and sprayers in developing countries. We presume a serious lack of training opportunities for farmers, agricultural workers and pesticide dealers on modern agriculture, knowledge of crops, seeds and pest control. We also take into account shortcomings in the implementation of regulations, product quality control and an unreliable supply of essential agricultural inputs and funds.

2 Classification

2.1 What are pesticides?

'Pesticides' is the name used in this booklet to refer to the agro-chemicals that are used for crop protection purposes. A pesticide is a substance intended to prevent, destroy, repel or control any animal pest or disease caused by micro-organisms, as well as unwanted weeds. Pesticides can affect harmful pest animals and micro-organisms through direct contact, feeding or other kinds of effective exposure during stages of growth. Plant produce can be protected during conservation stages, storage, transport, distribution and processing. Products can be crops, harvested produce, agricultural commodities or animal feeds.

Some pesticides are used for killing insects that are harmful to man, e.g. mosquitoes, or administered to animals for the control of external (ecto-) parasites, e.g. ticks. These are not covered in this booklet. We also exclude the agro-chemicals that act on life processes in plants, such as crop-growth regulators, defoliants, desiccants, fruit thinning agents, sprouting inhibitors or wood preservatives.

Bio-pesticides can play an important role in pest management. These consist of beneficial micro-organisms, and can be bacteria, viruses, fungi and protozoa, beneficial nematodes or other safe, biologically based active ingredients. Benefits of bio-pesticides include effective control of insects, plant diseases and weeds, as well as human and environmental safety. In some areas pesticide resistance and environmental concerns limit the use of chemical pesticide products.

Pesticide names

The full chemical name of a crop protection product is often difficult to pronounce and to remember. The coded name is referred to as *active ingredient* (abbreviated as 'a.i'). This is generally a shortened version of the full chemical name. The active ingredient is the compound that is used to control the harmful organism. Its ability to kill, harm or deter a certain pest or disease has been proven and its use for this purpose is authorized through a registration process.

Many pesticides have difficult names that reflect their chemical structure. Therefore, they are often given a shorter name, called *common name*, to make them easier to identify.

Example:	carbaryl is the common name for 1-naphthyl N-ethylcarbamate.
Example:	a.i. glyphosate = chemical N-(phosphonomethyl)glycine

Different companies produce pesticides that contain the same active ingredient, so they may be sold under several trade names. The same common or chemical name must be printed on all the products containing the same active ingredient.
These names used for products are internationally agreed and standardized. The company that discovers or develops a new active ingredient is holder of the patent and for the first few years of marketing and use, it will usually be the only manufacturer of the active ingredient. This is called the *basic producer*.
Concentrates of the active ingredient can be supplied by the basic producer to other companies or formulators, that are then allowed to use it in various formulations (see section 2.3) under their own, different trade names.

Example: diazinon is the active ingredient in several trade products e.g. Basudin, Cekuzinon, Diazinon, Diaton in various formulations

2.2 Ways to categorize pesticides

Agricultural use

The hundreds of chemical agro-pesticides available can be classified according to type of pest or disease against which they are effective. See table 1.
We refer for all these categories to Appendix 2, a list of the most important categories of crop protection chemicals in agriculture, including the main type of organisms they control.

Some pesticides are effective only against one species of pest or disease: this is the *specificity* of a pesticide. Many pesticides are less specific or *selective*, or even *non-specific*. These can therefore harm or even kill a variety of insects, micro-organisms, animal or plant species. More specific insecticides are more effective against some insect orders, e.g. beetles, and less effective against others, such as bees and wasps. This is of importance when for instance biological control of caterpillars is carried out using these parasitic wasps.

Table 1: Agro-chemicals including pesticides (P) and their activity

Category	**Activity**
Algicide	Kills algae e.g. on wood
Anti-feedant	Prevents animals feeding on a crop or stored product
Attractant	Attracts pest animals
Bactericide (P)	Kills or inhibits bacteria growth
Fungicide (P)	Fungus disinfection
Fumigant (P)	Gas or smoke against pests or fungi in stored products
Herbicide	Kills or inhibits growth of weeds
Insect growth regulator	Modifies insect development stages or growth
Insecticide (e.g. aphicide) (P)	Kills or harms insects (e.g. aphids)
Miticide / acaricide (P)	Kills or harms mites (or spiders)
Molluscicide	Kills snails and slugs
Nematicide (P)	Kills nematodes
Repellent	Keeps away pest animals
Rodenticide	Kills rats, mice, rodents
Sterilizant	Sterilizes insects in chemical way
Termiticide (P)	Kills or harms termites

Some products are effective against more than one biological class:
- some insecticides also kill mites or nematodes;
- some fungicides are also effective against bacterial diseases;
- a few pesticides kill nematodes, insects, fungi and weed seeds.

Chemical origin

Agro-pesticides can be divided into inorganic compounds, synthetic organic chemicals and bio-pesticides.

Inorganic compounds are some of the earliest chemicals used for pest control. We mention application of sulphur, lead arsenate, copper and lime mixtures, borax and chlorates, and mercury compounds.
Inorganic pesticides are based on chemical elements that do not break down, and many of them therefore have very severe environmental and toxicological effects in their use. For example, some accumulate in the soil; lead, arsenic and mercury are very toxic.

Most *synthetic organic chemicals* are chemically derived from mineral oil products. After the introduction of insecticides and herbicides in the 1940s, their use spread rapidly throughout the world and continued to increase during the 1950s and 1960s. Increasingly sensitive tools for chemical analysis of the residual effects on crop parts, the environment and test animals were developed during the period 1960 to 1980, enabling detection of very small amounts of pesticide residues in food and the environment, down to less than one part per ten million. This exerted a strong influence on pesticide development, use and regulation.

Bio-pesticides are substances derived from plants or animals. They can even be the organisms themselves, and include fungi, bacteria, viruses and nematodes, plant-derived chemical compounds and insect pheromones. Some biological pesticides, e.g. nicotine, can be very toxic and their use is as hazardous as many inorganic or synthetic pesticides. Less toxic to man are the flowers of *Pyrethrum*, a root extract of *Derris elliptica* (Rotenone) and leaves and flowers of the Neem tree (*Azadirachta* spp.), which have been used for generations as effective insecticides. Other naturally occurring substances that are used include cow's urine and garlic juice; these and many more are described in the book 'Natural crop protection in the tropics; letting information come to life' (see Further Reading).

Pesticide manufacturers have now made synthetic versions of many naturally occurring botanical pesticides, by identifying the essential chemical mechanisms that kill harmful organisms for crop protection. Thus, chemical ingredients of synthetic organic pesticides are often copied from natural compounds, e.g. pyrethroid from *Pyrethrum*. For an overview of bio-pesticides, we refer to the 'Biopesticide Manual' (see Further Reading), which contains 273 bio-control agents used in the production of over 1000 commercial products.

Basics of formulations

A *formulation* is the name for the form in which a pesticide is sold for use. This is a practical and reliable crop protection product that includes all the necessary additives; see figure 2. Differences in properties between crop protection products which have the same active ingredient can often be attributed to differences in chemical and physical composition, based on the formulation. See Section 2.4.

The *concentration* is that part of the total formulation made up of the active ingredient, mostly expressed in percentage of weight, and stated on the label.

Each formulation has its own trade name. Pesticides have very many commercial names. 'The Agrochemicals Handbook' (see Further Reading) shows a full list.

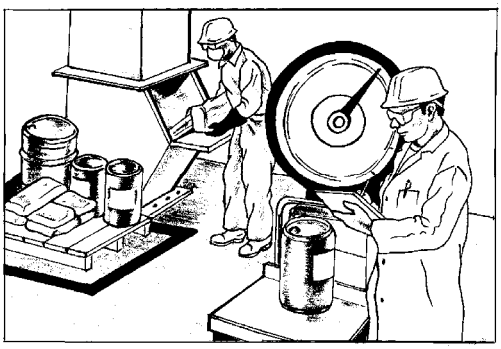

Figure 2: Production of agro-pesticides is a complicated process

2.3 Additives

The active ingredient cannot be used on its own, but needs additional diluting ingredients or additives to make it suitable for practical and effective use. Additives improve the effect of the active ingredient or

give the pesticide specific chemical of physical properties, e.g. to make it stick to plant leaves or animals, thus increasing the lasting effect of the product on the harmful organism or weed. There is a wide range of different types of diluting agents and additives.

Solvents are necessary when the active ingredient is to be applied in liquid form. Only few active ingredients can be dissolved in water; other solvents can also be used, such as oil, in which case the active ingredient is sold already dissolved in oil. Active ingredients that are soluble in water are bought in a concentrated form and dissolved when preparing the spraying solution.

Emulsifiers ensure that a concentrated liquid product can be easily diluted with water and they stabilize the mixture. When mixed, the pesticide is dispersed in tiny droplets distributed equally in the water: the emulsion. Water-soluble pesticides are almost always sold as a concentrated liquid that is diluted with water before use.

Wetting agents or *spreaders* are added if the liquid to be sprayed remains a droplet instead of spreading over the surface of the leaf of a plant. By adding a wetting agent, the droplet spreads out to moisten a larger surface area of leaf, thus helping the spray to penetrate everywhere. The effect is similar to what soap does to water.

Carriers are harmless, neutral substances that carry and dilute the active ingredient in dry formulations (powders, dusts or granules). The active ingredient attaches itself to the stable carrier.

Dispersing agents are added to any pesticide in powder form that needs to be dispersed in water before use, but is not water-soluble. The dispersing agent has the same function as the emulsifier: to stabilize the suspension of the powder in water. The dispersing agent ensures that the powder is evenly distributed throughout the water in tiny particles: a homogenous spray-ready liquid is obtained.

Adhesive agents or *stickers* are added to help the pesticide stick to the surface of the leaf. Hence when it rains, the active ingredient will be less rapidly washed off the leaves.

Colouring agents are added to reduce the chance of accidents; for example, by clearly showing the difference between treated seed (thus toxic and inedible) and untreated seed. Granular pesticides are sometimes coloured to make them clearly visible on the soil, so that one can see whether they have been evenly distributed.

Synergists are additives that enhance the chemical or pesticidal action of the active ingredient.

2.4 Formulations

The most common types of formulations and their advantages and disadvantages are discussed. The corresponding letter codes must be indicated on the labels of pesticide containers. Wet formulations and, sometimes, dry formulations or fumigants the active ingredient in effective physical contact with the pest or disease organisms.
Hazards in preparation or application of dry and wet formulations are also mentioned in the tables. Advantages are marked with ++, disadvantages with --.

Dry or solid formulations (see table 2)

Table 2: Dry or solid formulations

Physical state	Diluent	Formulation type	Acronym
Solids	carrier	dustable powder or dust	DP
		granule	GR
	water	wettable powder	WP
		soluble or dispersible powder	SP
		soluble or dispersible granule	SG / WG
	bran, grain	bait concentrate	B
	air	smoke, fumigant or gas	

Dustable powders or *dusts* are sold and applied to the crop in dry form. The active ingredient is adsorbed onto talc, dry clay or some inert powder.

++	Neither water nor spraying equipment is needed. Dustable powders can be especially useful in regions where water is scarce or has to be brought from far. Under favourable circumstances, the dust can penetrate the crop fairly well.
- -	Powders are wind sensitive when used. To reduce risks induced by this, they have a low concentration of active ingredient. This makes it necessary to use large quantities of powder, resulting in large containers and high transport and storage costs. The dust can be easily washed down by rains.

Granules or grains (GR) can be of different sizes, up to about 3 mm in diameter. They can be applied by hand, but gloves should always be worn. Granules can be crushed or they may disintegrate and still be blown about. They should not get wet during or before application, or be dissolved in water, as this releases the active ingredient, endangering the user.

++	Granules are hardly wind sensitive. They are simple to use and no special equipment is required.
- -	Granules are expensive and often contain a low percentage of active ingredient, leading to high transport and storage costs.

Wettable powders (WP) need to be mixed with water before use, as they do not dissolve spontaneously. These are formulated with a special dispersing agent causing the powder to permanently disperse uniformly in the water, forming a suspension. A *suspension* of a wettable powder as solid particles or tiny flakes in water is the same as an *emulsion* with liquid particles in water.

++	The concentration of the active ingredient in the formulation is high, resulting in small containers, and low transport and storage costs. The right amount can easily be weighed out.

- -	The powder can drift up when shaken out carelessly in water. The powder flakes, which float fairly evenly in the water directly after mixing, can slowly sink to the bottom after some time and become caked (in particular with low-quality formulations). The solution then contains less of the active ingredient and the spray nozzle can become blocked. The particles can be prevented from sinking by regularly shaking the tank. The concentrated product can be toxic to the plants.

Water soluble powders (SP) are sold in powder form but should be dissolved in water before use. The solution can then be sprayed, for which spraying equipment is needed.

++	The product is completely water soluble. No problems arise with sediment in the spray tank or blocking of the nozzle. The concentration of active ingredient is higher than in dustable powders, so package containers can be smaller and cheaper.
- -	Powder can drift up when it is shaken out of the container and mixed with water. Powders are more hazardous than dusts, because they contain a higher concentration of the active ingredient.

Water soluble granules (SG) have the same properties as water soluble powders.

++	Due to the granule formulation there is less danger of dust drifting up when the granules are shaken out of the container.

Water dispersible granules (WG) are sometimes called dry flowables: their properties are similar to those of wettable powders (SP).

Bait with a pesticide (B) attracts the pest animals to it. An example is rat poison mixed with food which rats find tasty.

++	The whole crop or stock does not need to be treated with pesticide.

- -	Rodenticides are very poisonous. Take great care when you are preparing the bait and make sure it is not mistaken for food. Keep the bait out of the reach of humans and domestic animals.

Wet or liquid formulations (see table 3)

Table 3: Wet or liquid formulations

Physical state	How applied	Diluent	Formulation type	Acronym
Liquids	diluted	water	suspension concentrate	SC
		water	emulsifiable concentrate	EC
		oil	low volume	LV
	undiluted		ultra low volume	ULV
			aerosol	A

Wet formulations are used more commonly than dry formulations. The active ingredient is mixed with water and sprayed on the crop. After application, the water evaporates and the pesticide remains on the plant, with a lasting effect. Emulsifiable concentrates divide into very fine droplets in water (= emulsions), which often have a regular, non-transparent colour, e.g. a milky colour.

Concentrated solutions contain a high percentage of the active ingredient and should be diluted with water before spraying. Some can simply be dissolved in water (suspension concentrates, SC); others emulsify in water or other liquids (emulsifiable concentrates, EC).
Suspension concentrates (SC) are in fact powders that are suspended in water with the aid of a dispersing agent. They are sold as a suspension, which must be diluted with water before spraying.

++ and - -	See wettable powders (WP)

Emulsifiable concentrates (EC) are formulated in such a way that diluting these with water causes few problems. A properly diluted active ingredient will not cause different concentrations in the spraying solu-

tion in the tank. Too low concentrations may be ineffective, too high concentrations may cause leaf scorch.

++	It is easy to measure out the right amount. There is no danger of powder drifting up during preparation. The containers are small, and transport and storage costs are low. The product does not sink to the bottom of the spray tank.
- -	These solutions are very dangerous due to the high concentration of the active ingredient. Be especially careful and accurate when pouring, diluting and measuring.

Ultra Low Volume Liquids (ULV or UL) are pesticides in liquid form that can be sprayed undiluted by using special ULV spraying equipment onto which the pesticide container can be directly screwed. Risk of toxic contamination is thus reduced.

++	No oil or water is needed to dilute the product. This makes it very suitable for use in dry climates. ULV spraying equipment produces very fine droplets, which increases the effectiveness of the pesticide application.
- -	The concentration of active ingredient is often high and therefore the formulation can be extremely toxic. In addition, the spray mist is highly wind sensitive.

Other types of formulations

Certain *fumigants, smokes, gases or vapours* are used as pesticides in enclosed spaces such as greenhouses, containers, stocks or warehouses. The closed spaces mean that the pesticides do not disperse far, therefore enhancing their effect. An *aerosol* is a suspension of small particles in gaseous form.

++	Highly effective because they easily penetrate everywhere.
- -	These products are generally extremely toxic and should only be applied by trained people. The use of filters or masks is essential (see Chapter 5).

3 Effective application

3.1 Aims of pesticide application

It is important to know how a pesticide actually kills or affects the pest. Insecticides, for example, can kill though dermal (skin) contact, act as a stomach poison, inhibit growth or repel the insect, and thus prevent it from feeding on the crop or stored product. Leaf-eating caterpillars become sufficiently contaminated with insecticide residues when they crawl and feed on leaves. Boring insects inside leaves and stems as well as certain sucking insects are more protected against direct contamination. They are, however, poisoned by feeding on sap and tissue inside plants that have been sprayed with systemic insecticides.

The aim of chemical control is to bring the toxic active ingredient in contact with the target animal pest or disease agent in such a way that these will be killed, or their growth and development will be inhibited.

Application of a crop protection product is *effective* if the physical and chemical formulation of the active ingredient can kill or harm an insect, fungus, bacteria or other harmful organism which causes crop damage. Effective application meets the following conditions:

- the right choice of crop protection product
- applied in the right dosage
- at the right time
- using an appropriate technique.

Correct dosage is not only dependent on pest level, but also on potential crop damage or expected harvest loss, and also on economic costs and benefits of crop protection. Potential damage to the crop may justify the application of the pesticide, but this must always done in accordance with the instructions on the label.

Application is economically efficient if the avoided damage and crop loss justifies application. A farmer should therefore estimate and compare the cost of applying pesticides with the rate of loss in yield or quality that (s)he finds acceptable.

Different aims of pesticide treatment: preventive or curative
A **preventive** pesticide treatment aims to protect crops or stored products beforehand against infection by diseases, infestation by animal pests or competition from harmful weeds.
A **curative** treatment aims to destroy or limit population development of harmful organisms.

Pesticides can be distinguished according to their effect:
Contact pesticides need to reach the harmful organisms directly in order to be effective. The finer the spray mist, the better it will penetrate the crop and thus kill the organism.
Systemic pesticides attach to and penetrate the plant surface, and then disperse through the whole plant. Pesticides that persist for some time in the soil and subsequently penetrate through contact with roots, are also systemic.
In order to be effective, these products do not need to be dispersed in a fine mist like a contact pesticide. Bigger droplets, smaller in number, can thus be dispersed over the crop, which makes treatment easier and less costly.

Chemical pesticides should only be used when they are really needed and suitable registered pesticide products are available. For this, it is necessary to watch crop condition closely, make a correct diagnosis of possible crop damage and monitor it regularly (figure 3). This subject is described in Agrodok 28. We strongly advise that Integrated Pest Management principles and methods are also implemented.

Figure 3: Before applying protection measures, first monitor and determine crop damage by harmful organisms

As a farmer, you often get the pesticide you need from the market in small containers such as a packet, a tin or a bottle. The pesticide liquid or powder generally contains a high concentration of the toxic active

ingredient. Therefore, the person who applies the pesticide should always handle the formulation package, whether it is full or empty, with great care to avoid getting poisoned. To enable an even application of the small package of concentrated pesticide over the crop or soil, the formulated product is diluted with water or with another diluting agent (see Chapter 2).

Since spraying pesticides onto field crops is the most common method of application, we shall deal with it first. Depending on the type of pest and crop, insecticide and fungicide formulations are usually applied as foliage sprays. Herbicides designed for pre-emergence or post-emergence application against weeds are sprayed onto the bare soil or onto the foliage of the weeds. Mobile organisms, like adult insects and larvae, come into contact with the pesticide automatically when moving through or over the plant, even if the droplet distribution is not very dense or even. It is therefore less costly and intensive to distribute bigger droplets than to cover all leaves with a thin layer. Against organisms that do not move, like pathogenic fungi on leaves, fruits and stems, a thin layer of pesticide deposit over all plant parts is effective. A spray of fine droplets, or a mist, is the way to apply the pesticide. For nematodes, soil insects, rodents or snails, other methods of chemical control may be more effective then spraying the entire crop. Spot application and baiting at deliberately chosen places and times may be a better way of controlling rodents and snails or migratory insects. Incorporation of the product in the soil by watering, injection or fumigation is frequently practised to control insects and nematodes that inhabit the soil.
Broad-spectrum insecticides are designed to control many species of insects and are therefore also dangerous to beneficial insects. A selective insecticide will control a few specific species but spare the natural enemies.

The control of storage pests requires different kinds of formulations, equipment and techniques, such as fumigation (see Agrodok 18: Protection of stored cereals, grains an pulses; as well as the CTA publication on storage protection, mentioned in Further Reading). In this

chapter, mostly in Section 3.5, technical indications and measurements are given, which are explained in the appendix: Weights and measures.

3.2 From spray liquid to droplet deposition

Spraying equipment is used to distribute liquid pesticides over crops. Sprayers atomize the liquid they spray into droplets by means of a nozzle.
The droplets formed are not of equal size; rather the spray contains a whole range of droplet sizes. The size of a droplet is its diameter measured in microns: 1µm or micron = 0.001 millimetre. For comparison: the diameter of a human hair is about 100 µm.
The distribution of droplet sizes, or droplet spectrum, of the emitted spray depends on the type of nozzle used in the sprayer.

A rough classification is: fine spray has a droplet spectrum of 50 – 200 microns, medium spray a spectrum of 200 – 300 microns and a coarse spray a spectrum of 300 – 600 microns. Most ground-based pesticide applications should perform well with a mean droplet size in the range of 500 to 1,000 microns, but larger drops will also do, as we will see below.

How can one distinguish the effect of a fine mist from coarse droplets?
A simple way to recognize a fine mist: put sunglasses in the crop and spray on the crop. This is done by waving the spray boom over the top. Then watch the glasses closely and try to judge their coverage with fine drops.
A method to assess the coverage of the soil is by spraying briefly on a flat tile or concrete floor. Then one can assess by looking closely how evenly it has been wetted.

Spray drift is the effect of a pesticide mist being carried by wind or gravity away from the target crop or organism to another spot within or outside the field. Fine spray may drift easily, even with very little wind. Droplets smaller than 100 microns also evaporate easily, causing the active ingredient to disappear in the environment before it is deposited on the crop. It is essential to minimize wind drift and evapo-

ration, or both. Therefore, outdoor pesticide applications with a fine spray spectrum should not be made during the hot hours or under windy conditions.

An advantage of using 30–150 micron droplets is that they give a good wetting of small and narrow targets such as flying insects and insects on foliage. Small droplets are also easily carried around the leaves by air currents. Thus, they may land on the underside of leaves where insects hide during the day. A fine spray also gives a deeper penetration into the leaf mass, or canopy, of the crop.

A coarser spray consisting of larger droplets provides good sedimentation on broader objects such as leaves and fruits. The reason is that large droplets move in a straight line from the nozzle onto the leaf or soil without getting deflected by air currents.

If too much spray liquid is deposited on the leaves or if the droplets are too large, the droplets may flow together at the tip and edges of the leaves causing them to drip off onto the soil and therefore loss of product. If the concentration of the spray solution is too high or if a wrong product or diluting agent is used, the product residue may cause scorching or burning of the leaf, regardless of the droplet size.

3.3 Hand-operated knapsack sprayers

A pesticide applicator should ideally be able to select an adequate type of sprayer and a correct nozzle. A nozzle is correct if it can produce the required spray droplet spectrum for each specific job. Small-scale farmers at the best have a simple knapsack sprayer with a standard nozzle fitted by the sprayer manufacturer. With this equipment the farmer must try to control harmful insects, diseases and weeds in the crop. By improving his knowledge and skills and by maintaining sprayer and nozzle well, the farmer can improve his results.

In subsistence and small-scale agriculture in developing countries, most pesticide treatments are made with small hand-operated knapsack sprayers with a simple pump mechanism. The two popular types are the lever-operated knapsack sprayer and the more expensive compression sprayer.

In places with the right technical facilities, motorized knapsack mist-blowers or hand-carried spinning disc sprayers are also used. For applying dust formulations, farmers normally employ a hand-operated rotary duster. For specific workings of these, we refer to the technical manuals.

Lever-operated knapsack sprayer

This type of sprayer consists of a tank of 10- to 20-litre capacity, a hand-operated pump, a pressure vessel, a hose and a spray lance with cut-off valve and one or more nozzles: see Figure 4. The sprayer is made of stainless steel, brass, hard plastic or an alternative corrosion-proof material. Pressure, which is built up in the pressure vessel by continuous pumping during application, forces the spray liquid through the nozzle opening, causing it to break up into small droplets

The tank itself is not pressurized and need not be airtight. All its welded seams, joints and threaded connections should be leak-proof.

The various brands of lever-operated sprayers differ widely in design. They may be equipped with either piston-type- or diaphragm-type pump systems, with the pump fitted inside or outside the tank. The lever can be attached underneath or at the top of the tank; this is only a practical difference. These sprayers are quite simple to operate and to maintain, relatively cheap in purchase and, hence, the most practical for smallholder agriculture.

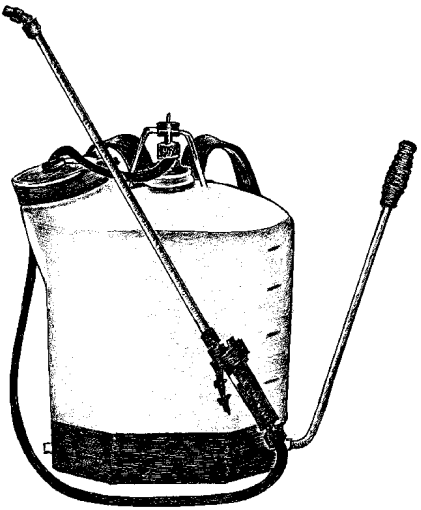

Figure 4: Lever-operated knapsack sprayer

Compression or pneumatic sprayer

The entire tank of the sprayer is airtight and acts as a pressure vessel. The sprayer is pumped before spraying starts. No pumping is done during actual spraying. These sprayers should be equipped with a pressure meter or gauge, indicating the pressure inside the tank..

Compression sprayers are available in different makes and sizes. Small hand-carried models hold 1 to 5 litres and the knapsack type 7.5 to 15 litres. Compression sprayers require intensive maintenance, in particular of the piston washer and sealing washer in the pump, which wear out fast due to the high air pressure.

Figure 5: Compression sprayer

Compression sprayers are commonly fitted with a delivery hose and a spray lance with cut-off valve and one or two nozzles at its end.

How to operate a compression sprayer

Stop pumping when the meter needle reaches the danger mark indicated on the scale. If capacity (in litres) of the tank and the number of pump strokes to achieve safe working pressure are not marked on the outside of the sprayer, ask for them from the manufacturer or retailer. While working, the pressure may drop too much before the sprayer is emptied, which results in a coarser droplet spectrum and therefore less penetration into the crop. If this happens, stop spraying and pump again to restore pressure in order to maintain a uniform flow of liquid to the nozzle. Mark the place in the plot where you stopped spraying

and restart in the same place after having restored the pressure in the tank.

Less expensive compression sprayers may have galvanized tanks that are susceptible to corrosion. Be careful with old sprayers because corroded tanks are weaker and may burst if pressurized. Also be aware that, after spraying, the emptied tank still holds air under pressure. Therefore, unscrew the lid of the tank partially to let pressurized air escape; it makes a hissing sound. This prevents the lid being blown off by force and thus endangering the operator.

Basic maintenance of knapsack sprayers

Spraying equipment should always be handled with care and properly managed. Do not forget to wear protective clothing when cleaning and checking the equipment, even when it has been emptied and dried.

Never put aside a sprayer without emptying the remaining pesticide solution inside. Despite careful calibration (see next text section) of the equipment and calculation of the right amount needed, a little spray solution may be left over after treatment. This may be kept until the following day, provided there is no warning to the contrary on the label. Remaining spray solution could exceptionally be sprayed broadly and evenly onto a field crop which has already been treated. However, it is best to avoid this if at all possible.

The spraying equipment should then be well cleaned and checked after use. Pesticide residues can cause rust spots and block tubes and nozzles. Therefore, cleaning and checking must be done with great care, especially if the equipment is not to be used for a while. Herbicide residues remaining in a knapsack tank or in the tubes or hoses from a previous treatment can cause crop damage on a following occasion with a different treatment, e.g. with an insecticide.

Clean the sprayer with water, but at all times avoid contaminating surface water e.g. in a canal or pond. Remove all moisture by letting the sprayer dry upside down. Check, repair or replace broken and leaking parts. Make sure of technical specifications before ordering or purchasing a spare part. Spare parts are often difficult to buy; it is therefore recommended that national agricultural services and private dealers limit the market supply to just a few well-tested sprayer models.

3.4 Sprayer nozzles

As mentioned before, the distribution of droplet size, or droplet spectrum, of the emitted spray is characteristic for the type of nozzle used in the sprayer. Nozzles are specially designed to produce sprays consisting predominantly of either small-sized droplets or of medium-sized droplets or of larger-sized droplets.

The most important part of a sprayer is the nozzle. The nozzle is the mouthpiece with a small opening, fitted at the end of the spray lance or hose. Figure 6 shows the parts of a nozzle that has been dismantled. In the knapsack sprayers mentioned above, simpler nozzles are usually used, only consisting of a spray tip, where a strainer is incorporated at another position in the spray lance.

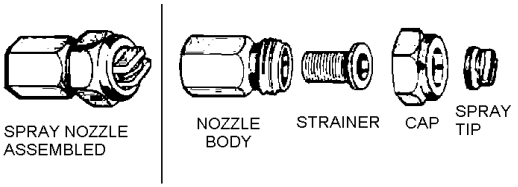

Figure 6: Parts of a sprayer nozzle. Left: full nozzle; right: detached parts

No nozzle will do every job. Selecting the correct nozzle for a spraying job is very important to obtain the desired droplet size and coverage. The indications given below for droplet spectrum and output of spray solution are only valid when they are operated and compared at the same pressure and at the same flow rate.

Manufacturers print a number on each cone nozzle; this specifies the combination of its type and hole diameters. Nozzle catalogues usually provide information to help the buyer select the correct tip. The catalogues should always be consulted for guidelines for sprayer component and tip selection, installation, operation and maintenance. Other technical information provided will help make the applications more efficient.

Elementary nozzles on hand-operated sprayers for spraying liquid by pressurized air, can be categorized in two main types:
1 cone nozzles
2 flat-fan nozzles

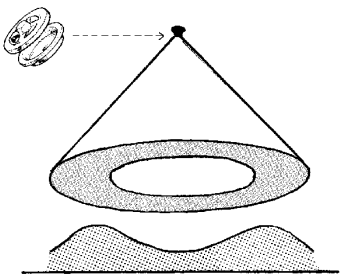

Figure 7: Hollow-cone nozzle + droplet pattern

Cone nozzles consist of a nozzle tip and a swirl plate. Pressure built-up in the sprayer tank causes a circular (conical) pattern of droplets.
A hollow-cone nozzle (figure 7) produces very fine droplets on the outer edge of the conical pattern with less droplets in its centre: hence the name hollow cone.
A solid-cone or full-cone nozzle (not shown) distributes bigger or coarse droplets over the whole circle, with the centre being filled too. Cone nozzles give maximum coverage in spraying row crops. Common sprayer types are mostly supplied with cone nozzles that may be interchangeable.

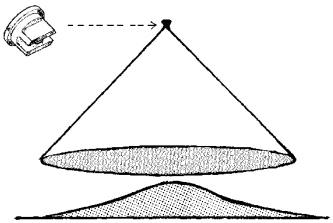

Figure 8: Regular flat fan nozzle + droplet pattern

Flat fan nozzles consist of one component: a nozzle tip with a central hole, which is locked onto the nozzle body with a screw cap.
A regular flat fan nozzle (figure 8) sprays a narrow, almost rectangular droplet pattern, with little effect of spray drift. This makes this nozzle ideal for spraying flat surfaces. On average the droplets are bigger than those produced by cone type nozzles.
Band or strip spraying requires an even distribution of liquid from a single nozzle across the entire width of the spray band or swath. For this application an even-spray flat fan nozzle is available (figure 9). It gives a more rectangular distribution of spray.

A flat-fan nozzle with a small-sized hole, operated at a higher pressure, produces a finer droplet spectrum which is needed for insecticide spraying. A flat fan nozzle with a bigger-sized hole, operated at a lower pressure, emits a coarser droplet spectrum, as needed for herbicide spraying.

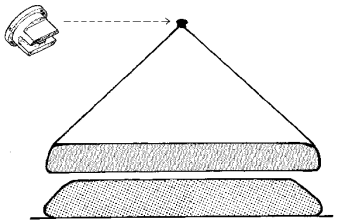

Figure 9: Even-spray flat fan nozzle + droplet pattern

Flat-fan nozzles have become very popular because of the wide choice of nozzle sub-types for various purposes. They require a lower amount of spray solution per hectare, thus reducing water use and transport.

Elementary maintenance of nozzles

Sieves prevent the fine nozzle openings from becoming blocked by dirt particles floating in the spray liquid. Water taken from a pond or irrigation canal must be filtered before pouring it into the spray tank. A clogged nozzle opening should be cleaned very carefully. Never use iron wire or nails that would damage the nozzle opening.

Spraying with clogged and old nozzles results in a very uneven spray pattern and, hence, in poor control. If a nozzle becomes blocked during use, never blow it clear by your mouth, but clear the nozzle opening with a small brush and water. Figure 10 shows how nozzles should be cleaned effectively, safely and without damage.

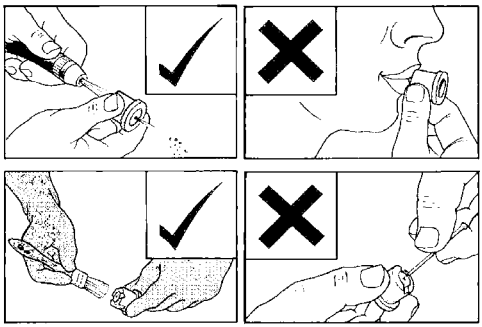

Figure 10: The do's and don'ts of nozzle cleaning

3.5 Dosage rate and calibration of equipment

The aim of a pesticide treatment is to deposit a sufficient amount of active ingredient evenly onto the crop to control the harmful pest. It is essential that farmers use an adequate product at the correct dosage rate. Mix it evenly and using a calibrated beaker: figure 11.

Each crop and pest situation requires a certain amount of an active ingredient. Some pest species are controlled by a lower dosage rate than other species. Generally, pest organisms in an early stage of growth are more sensitive than in a later stage.

The recommended dose is the amount of active ingredient which, by experimental testing, has been found to kill a given pest or micro-organism reliably and to a satisfying measure, but without waste. The person applying the pesticide must calculate the amount of liquid or dry pesticide formulation that he needs to apply on the plot by spraying liquid, dusting or spreading granules.

Figure 11: Always use a calibrated beaker to ensure the right dosage

The calibration of spraying equipment is described below in two steps. Calibration enables calculations of:

- the amount of spray liquid needed on a given surface;
- the amount of concentrated pesticide or commercial product per sprayer tank load.

The recommended dose for a specific pest and crop situation should be indicated on the product label and in the technical leaflets. Therefore, read the label to confirm that the product is suitable for controlling the pests that affect your crop and to know the recommended dosage rate. Look also for the toxicity rating and any warning that advises the use of protective clothing.

Before any calculation can be made, the following input data must be known:

- recommended dosage of active ingredient per hectare
- amount of spray liquid per hectare
- percentage of active ingredient in the commercial pesticide formulation
- area (plot size) expressed in hectares to be treated

The recommended dose is expressed either in

- percent (%) concentration of active ingredient in the spray solution
  or in
- weight (grams) or volume (litres) of active ingredient per hectare

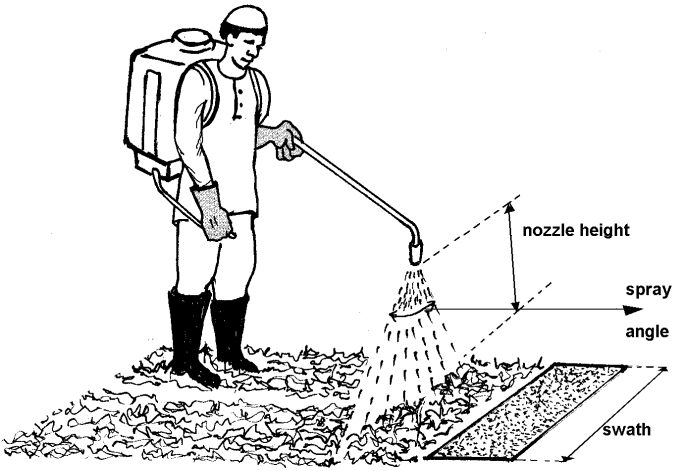

Figure 12: Calibration of spraying equipment is best done on a test plot with a known surface area

Step I: How to calibrate

First of all, the spraying equipment needs to be calibrated. This can be done by filling the sprayer with *water* and then spraying an even swath of the crop. The nozzle should be kept at a constant distance above the crop and be used in only a light swinging movement. Spray several metres into the crop in order to measure the width, in metres, of the spray swath. See figure 12.

1 Empty the spray tank and refill the tank with a known amount of water.
2 Place a stick and from there, make the test run until the tank is emptied, spraying the area at the recommended constant pressure and at a steady walking speed.
3 After spraying, measure the length (metres) of the test run.
4 Calculate the application rate in litres/hectare: see the box below.

Step II: Calculating the calibration

Area sprayed (ha) = $\frac{\text{width of spray swath x length of test run}}{10{,}000}$

Example:

Width of spray swath	= 1.5 m
Length of test run	= 50 m
Volume sprayed	= 2.5 litres
Area sprayed	= 1.5 m x 50 m / 10,000 m2 = 0.0075 ha This is the calibration output figure.

Calculation – example 1

This section gives two practical examples of calculating the pesticide amount needed per sprayer load.

Example 1 is based on the situation given in the section above.

In the above situation we get:

Application rate

$$= \frac{\text{volume sprayed}}{\text{area sprayed}}$$

= 2.5 litres/ 0.0075 ha
= 333 litres per ha

If the person spraying has a 10 litre-capacity sprayer, for 1 hectare he would need:

333 litres / 10 litres
= 33 spray loads

If the recommended dosage rate on the label reads 1.5 litre/ha (or 1.5 kg per ha), he has to dissolve this amount in 333 litres of water.

Thus, in each spray load of 10 litres, the person spraying should dissolve :

1.5 litres / 33
= 1,500 ml / 33
= 45.5 ml of liquid commercial product in each full sprayer load
or 45.5 grams of dry commercial product in each full sprayer load

Calculation - example 2

Example 2 shows how to calculate the amount of an emulsifiable concentrate formulation as used for foliar spraying.

Example 2 Input data required to do a calculation:
- recommended concentration of commercial product is 0.04 percent
- 320 litres per ha of spray liquid is required
- area to be sprayed is 0.5 ha

Problem: How many litres of pesticide are required to treat this 0.5 ha?

Solution: First calculate the total spray volume needed to treat the full area:
= 320 litres/ha x 0.5 ha
= **160** litres

Amount (in litres) of formulation needed for the full area
= (amount of spray required x percent spray concentration)
= 160 x 0.04
= 0.064 litre
= **64 ml**

The amount of commercial product needed per sprayer load in a **10**-litre sprayer:
= litres of formulation needed x capacity of sprayer
= (**10** / **160**) **x 64 ml**
= **4 ml** of formulation per sprayer load

Foliar spraying over a crop is a very common form of insecticide and fungicide application for field crops and horticulture.
Fungicides against leaf fungi are mostly sprayed as big, highly diluted volume, resulting in a low concentration of active ingredient in the spray liquid. A dosage of 1000 litres of fungicide spray liquid per ha, or 0.1 litres per square metre, will wetten most leaves sufficiently.
To deal with harmful insects in crops with a low canopy, about 200 to 500 litres of spray liquid per hectare will be needed to distribute sufficient active ingredient over the crop to control the insect larvae on it.

3.6 Timing of application

Before starting a pest control operation, a farmer should first see whether treatment is needed and if it is the right time to act. Determine the growth stage of the crop, the kind of pest threatening it and stage of development of the pest. Usually, certain insect species are most harmful in the early stages of crop growth and less damaging later. In a tall crop with an abundance of leaves the presence of leaf-eating caterpillars may have too little influence on the yield to justify the cost of spraying. The higher the crop and the larger the total leaf surface, the more spray liquid will be needed to give an effective coverage and deposit on the crop.
There are various ways to estimate the rate of an infestation. One way is to count the number of insects on one or several leaves of ten plants chosen at random along a diagonal line in the crop. While counting, observe the stage of development of these insects to see if they are in an active feeding stage or in a resting stage, such as eggs or pupae. In the case of boring insects, such as stem borers, count the living and dead larvae inside the fruits or stems. Determine also the presence of natural enemies, because a high population of beneficial insects may be sufficient to control the pest before it causes much yield loss.

Effect of insecticide treatment

Insect pests can become resistant to a certain pesticide. It is therefore very important to check the after-effects of the pesticide application (see text box).

Checking the effects of a pesticide application

1 Take a number of samples one day before applying the pesticide, e.g. make a count or estimate of the average number of insects per plant.
2 The insecticide will have reached its maximum effect three days after the application.
3 Then carry out another insect count.
4 Use these results to determine the effectiveness of the dosage used.
5 If more than a certain percentage of the pest insects or larvae are still alive the treatment should be repeated, preferably using the same dosage per hectare.
6 If most of the pest insects or larvae have survived even though the prescribed dosage rate was applied, the harmful organism *may* be resistant to the pesticide. Change to another measure, which need not necessarily be a chemical option.
7 Before trying to improve the result, you could first ask a more experienced pesticide user if mistakes have been made in the first treatment.

Traditional knapsack sprayers are often used with a spray lance fitted with a simple nozzle. The lance should be moved evenly and carefully from side to side. Try to avoid spray being deposited unevenly on the target crop, or being wasted on bare ground to the side or in waterways. If the pesticide is wasted it will not be effective on the crop, and may induce the person who applied the pesticide to repeat the spraying after a certain period, using a higher dosage. However, this is nearly always a wrong decision, certainly if there is some resistance. If resistance occurs, the only *chemical* option is to change to another more effective pesticide.

What often happens in practice, therefore, is that spraying is repeated erroneously at very short intervals and at higher dosage rates, and each time the result is unsatisfactory. This leads to the crop being contaminated with excessive residue levels. A second danger is that most types of pests can become resistant to pesticides. Repeated spraying of the same product, following poor control due to an irregular deposit pattern or at a lower dose (under-dosing) than prescribed on the label, may trigger the development of pesticide resistance in the pest organisms. When farmers react by applying the same product at ever shorter intervals and at higher dosages, other pests and natural enemies are also killed whilst the population of the now resistant pest may increase greatly; this causes a resurgence of the pest. A hitherto insignificant

pest may suddenly become epidemic; this is called a pesticide induced plague. Examples include the brown plant hopper (BPH) in rice and red spider mite in cotton.
An effective way to prevent the development of pesticide resistance in harmful organisms is to alternate products from different chemical groups, for instance by using a carbamate product for the first spraying round and an organophosphate or pyrethroid product for the second and third sprayings, if still needed.
Finally, we have to realize and remember that the risk of resistance is less if a farmer applies the recommended crop protection product at the right time in the prescribed concentration. Nevertheless, resistance can never be excluded, or may even have existed for a certain time without being recognized.

Effects of wind and rain in field conditions

If possible, spray at the time of the day when the harmful organism is most active. The measure is then most likely to be effective. If you do not know about the insect's behaviour, consult an agricultural extension officer. Keep an eye on the wind. Never spray against the wind; you will then be constantly walking in the spray mist and thus poison yourself. If at all possible, spray either in the morning or the evening, as it is usually less windy and the spray solution is less likely to evaporate.

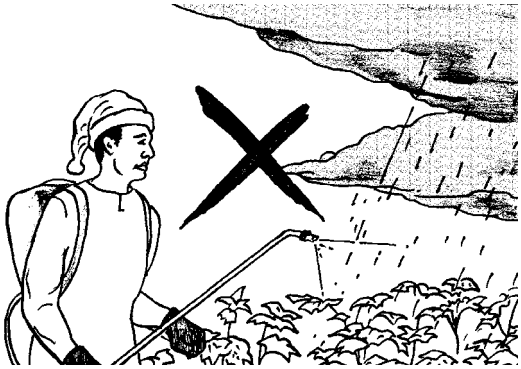

Figure 13: Avoid spraying when it is raining

If there is a strong wind, do not spray because the wind will cause the spray to drift onto yourself, another crop, or animals, people, soil and surface water in the vicinity. Do not spray during rain, or if rain is expected (figure 13). A shower of rain immediately after applying a pes-

ticide promptly washes it off the plants. This reduces the effect of the pesticide to a minimum and pollutes the environment.
If this nevertheless happens, it may be necessary to repeat the treatment. A little rain or drizzle does not pose a problem in the case of herbicides or nematicides which need to be applied to the ground. In fact, it helps to wash the pesticide into the soil.
Do not spray if there is no wind at all, or a very hard wind. When spraying a canopy crop, a very gentle wind will disperse the spray mist over the crop.
If possible, spray either in the morning or in the late afternoon, as it is generally less windy then, and the spray solution evaporates less. The effects of wind on safety are discussed in Section 5.5.

After spraying a field, pay attention to the following:
- mark the sprayed fields, keeping in mind the re-entry interval (see Section 5.1);
- keep a record of which fields have been sprayed, when, and the dosage per ha;
- keep a record of any peculiarities e.g. effects of wind or rain;
- take into account the safety period or pre-harvest interval between spraying and first (or next) harvest;
- Avoid spraying in the middle of the day, especially in strong sunshine.

Harvest interval

The persistence of a pesticide (see Section 4.4) plays a role in determining the length of the harvest interval. This is the number of days you have to wait between the last pesticide spraying and harvesting the product. The harvest interval should be written on the label of the pesticide, and depends on the product and the crop to be treated.
After spraying a pesticide, a deposit is left and may remain effective for a number of days. As time passes the pesticide is broken down by the effects of wind and sunlight, or it is washed off by the rain. How quickly a product breaks down, and therefore becomes inactive, depends on its chemical and physical properties. Some products have already been reduced to negligible amounts after three days, others may take up to three weeks to break down.

To prevent pesticide residues being present on the part of the crop that is harvested, the crop may not be harvested until the harvest interval has passed. The farmer must record the last date of pesticide application so that the exact number of days can be checked.
The harvest interval can sometimes lead to problems with crops that are continuously harvested, such as tomatoes. A situation may arise where a crop has to be sprayed during the harvest period. If this is the case, it is best to use a pesticide with the shortest waiting time so that the harvesting is disrupted as little as possible. Bear in mind that the part of the plant to be harvested, upon which a pesticide residue is found, may be for human or animal consumption.
If a crop is produced for export, we recommend that only pesticides are used that are registered in the country to which the product is to be exported. Shipments of fresh products are regularly rejected because of residues of pesticides that are not permitted in the importing country. See also Section 4.1.

3.7 Crop structure and growth stage

Sometimes there is some risk of insect damage to roots of seedlings. A systemic soil insecticide can be applied at the time of sowing to the root zone of young seedlings that are susceptible. If nematodes or fungi are a common problem in the soil, a pesticide solution can be sprayed or worked into the soil.
The easiest way to apply a pesticide to a low field-crop is to spray a fine mist over the crop: over-the-top treatment. This is sometimes also effective where the insect pests are found lower down on the plants. If the insects move around, sooner or later they will come into contact with the insecticide.
If an over-the-top treatment is not effective, the pesticide needs to be sprayed lower down on the crop. For this a systemic insecticide is more suitable.

Example of delayed contact effect
The white rice borer (*Scirpophaga innotata*) lays its eggs on the leaves and stems of the rice plant. Once the first-stage larva have emerged they spend some time crawling over the plant before they bore into the stem. While they are moving around the plant they come into contact with the deadly insecticide before they have a chance to start boring into the stem, where the insecticide would not be able to reach them.

If a non-selective insecticide is used for over-the-top spraying, all natural enemies present will also be killed. Bait spraying is a method of application which spares the natural enemies.

Example of bait spraying
Citrus crops affected by the Mediterranean fruit fly (*Ceratitis capitata*) are sprayed with a specific bait fluid in large droplets. The bait fluid contains sugar, proteins and the pesticide. The fruit fly is attracted to the droplets, feeds on them and is poisoned, but the natural enemies are not attracted to the bait.

Where mites and insects are predominantly found on the underside of leaves, systemic pesticides are the most effective. The product is sprayed over the upper side of the leaves, and then soaks into the plant tissue. A few days later the insects or mites that feed on the underside of the leaves will ingest the insecticide and be killed.
Where a tall field-crop, trees or shrubs are to be sprayed, it is better not to rely on a dosage per hectare, but to use a certain concentration of the product in water.
Where a concentration of 0.2% is indicated, 2 litres of the product should be mixed with 1000 litres of water. This means that a larger amount of pesticide will be used for one hectare of tall trees than for one hectare of low trees. In this way the pesticide will be more effectively spread over the crop and therefore the pest also more effectively dealt with.

4 Human and environmental hazards

Pesticide use involves direct risks for humans as well as for domestic and wild animals. The risks are greater in warm climates than in temperate climates. Most methods of application have been tested in temperate climate conditions and the resulting effectiveness and hazards were recorded under these circumstances.

You need to be aware of this for two reasons:

- Flow of blood in the skin and veins increases with higher temperature and therefore pesticides are more rapidly absorbed and transported to vital organs in the body.
- Protective clothing is worn less commonly or not at all, due either to the discomfort of wearing it in hot and humid conditions, or because it is not available, or in a bad state of maintenance.

Farmers and other pesticide users should always look first for non-chemical methods to control pests and diseases. This chapter aims to improve their behaviour, by raising awareness of the risks of poisoning by agrochemicals: these risks should be taken very seriously. We also give technical information and explanations to aspects mentioned in the table in Appendix 2.

4.1 What makes a pesticide hazardous?

Risk, danger and hazard

Hazards of pesticides to humans and animals are mainly related to the active ingredient. The additives are generally less toxic.

Pesticides are designed to control harmful organisms. An active ingredient that kills harmful organisms is usually also dangerous to beneficial organisms and can be hazardous to man and animals.

To assess the danger of actual exposure to a pesticide in a hazardous situation, it is very important to know its toxicity, how the person is exposed, and the route of entry of the pesticide.
In Chapter 2, we explained how toxicity of an active ingredient and the hazards of pesticide use are related. Different types of formulation lead to a higher or lower toxicity effect of the active ingredient and to a higher or lower risk in use. The risk of pesticide use affects the person applying the pesticide as well as the consumer of the treated product.
Pesticides should be handled with caution and according to the safety rules for handling, storage, transport and application. When working in the field, safety instructions on use and application are often not followed carefully, which exposes the worker to irresponsible health risks. Always read the label before opening a pesticide package. Handling of pesticides should always be done with utmost care. Use less hazardous pesticides whenever possible but follow the directions for use, and always take the necessary precautions.

Always keep this in mind when working with pesticides:
No single pesticide is without its hazards in application or handling!
If you do not obey basic safety principles, a pesticide may, under unfavourable conditions, become hazardous to your health and the environment.

Definition of toxicity and LD_{50}

The toxicity of the active ingredient is tested in laboratories by administering the active ingredient in different concentrations to test animals, mostly male rats. The percentage of animals that die when subjected to varying doses, during specific time periods, is determined this way. The statistical estimate of the dose of a chemical compound required to kill 50% of a population of test animals is called LD_{50} (lethal dose for 50%). The LD_{50} is expressed in mg of active ingredient per kg of body weight of the test animal. It is the expression used for acute toxicity.

Lower LD_{50} => higher toxicity !
An LD_{50} of 100 mg/kg of the active ingredient (a.i.) of a pesticide indicates that 100 mg of this compound per kilogram of body weight will statistically kill half of the number of a group of test animals.
If the LD_{50} is 200 mg/kg, twice as much of the a.i. is needed to kill the same number of test animals. This compound is thus less toxic.
To estimate the lethal dose for humans, the LD_{50} should be multiplied by the body weight in kg. Take, for example, an LD_{50} of 100 mg/kg: for a person weighing 60 kg, the lethal dose is approximately 60 x 100 mg = 6000 mg = 6 g. For a child of 20 kg, 2 g would already be lethal.

Active ingredients are classified by the World Health Organization (WHO) according to their oral toxicity (when taken through the mouth) and dermal toxicity (through skin contact) (see table 4).

Table 4: WHO classification for estimating acute pesticide toxicity

Classification	Designation	LD_{50} for the rat (mg / kg body weight)			
		Oral (mouth)		Dermal (skin)	
Class	Level of hazard	Solid	Liquid	Solid	Liquid
Ia	extremely hazardous	≤ 5	≤ 20	≤ 10	≤ 40
Ib	highly hazardous	5 -50	20 -200	10 – 100	40 – 400
II	moderately hazardous	50 - 500	200 - 2000	100 - 1000	400 - 4000
III	slightly hazardous	≥ 500	≥ 2000	≥ 1000	≥ 4000
U	acute hazard unlikely in normal use	≥ 2000	≥ 4000		

Note: ≤'less than or equal to'; ≥ 'more than or equal to'.

The WHO system was developed in the early 1970s and is the best known. The USA Environmental Protection Agency (EPA) scheme is similar. The EU Classification system for crop protection products (since 1978) is slightly different. Some countries also have national classification schemes; for more information see Further Reading (CropLife International). It is recommended that pesticides in the WHO classifications Ia and Ib should not be applied by untrained and inadequately protected people. Substances classified as Class II should not be applied using a knapsack sprayer.
There is a point at which the acute hazard posed by these compounds is so low as to be negligible, provided that the necessary precautions

are taken. WHO assumes that this point is an oral LD50 of 2000 mg/kg for solids and 4000 mg/kg for liquids. It categorizes these products as 'unlikely to cause acute hazard in normal use'.
For safety reasons, an extremely toxic chemical like aldicarb (LD50 for rats = 5) is only available as a 3-5% granule. More highly concentrated formulations are too hazardous for handling.

4.2 Human health and exposure hazards

Route of entry

In table 4 a distinction is made between oral intake and dermal contact. Figure 14 shows possible routes of entry of a pesticide. This can be through the nose (by inhaling vapour, smoke or gas), by mouth (swallowing by mistake or by eating contaminated food or fruits), or by skin contact with a formulation, a spray or by walking through a recently sprayed crop.
A pesticide may be swallowed by mistake if it is stored in a bottle. Therefore, one should never use old pesticide containers for storage of water and food; nor should food containers or beverage bottles be used for storage, preparation or transport of pesticides Powders, fine droplets and fumes can be inhaled. This can be extremely dangerous; therefore protective masks should be used. Absorption through the skin can also be very hazardous.
The head, neck, arms, legs and feet are easily exposed to a pesticide during spraying. Therefore one should always cover the body as far as possible while spraying (see section 5.2).

Exposure

Exposure is the extent to which a pesticide can affect humans or animals through direct or indirect contact. The degree of exposure is determined by the concentration of the toxic active ingredient, the skin surface exposed, the susceptibility of the organism, the duration of the contact and the frequency of repetitive contact. These together determine the risk of getting poisoned.

Repeated exposure to compounds such as organophosphates and carbamates increases the sensitivity of the body to these compounds. Someone who has been exposed to low doses over a long period is in greater danger when he or she is accidentally exposed to a large amount of the pesticide. Even if one only uses pesticides occasionally, one should always be concerned to avoid chronic effects.

Figure 14: Possible routes of entry of a pesticide into the body

Food safety

Another way in which one may absorb small amounts of pesticides over a long period of time is through food uptake. A food crop that has been sprayed contains pesticide residues. A residue is a portion of a chemical, or of its breakdown product, that remains on the crop, in crop parts or in the soil. Pesticides, especially persistent pesticides (see Section 4.4), can end up in milk or meat through feeding livestock with affected fodder. Food safety is the guarantee that preparation and consumption of food does not have any adverse effect on the health of the consumer. Physical, chemical or microbiological substances that can have a negative effect on the consumer should not be present in food. Chemical pollution of the environment may cause residues in food after harvest. For many pesticides there is a limit set for the amount of residual pesticide that is allowed to be present in the produce. This limit is referred to as the Maximum Residue Level or MRL. These limits are included in the *Codex Alimentarius* published by the FAO/WHO, a joint information database on MRLs in food and feed (see Further Reading).

The limits on allowable residues in food are set to protect the consumer. In addition to the MRL there is another measure to limit the total amount of a pesticide we may consume in a lifetime. This is the Allowable Daily Intake or ADI, based on daily intake of a pesticide. If the ADI is not exceeded, the pesticide should, according to current knowledge, not affect human health in the long term. Government and farmers are responsible for seeing that these residue levels are not exceeded. Since residues cannot be seen, the farmer has to apply pesticides correctly and observe the harvest interval. Only then is it possible for the MRL to be within its limits. The government can act through strict registration and inspection procedures; the farmer through safe and effective application of pesticides on the basis of the need for chemical control. For many governments this is extremely difficult though, because of the costs and discipline involved.

Summary - three important points:

- Pesticides are toxic and this toxicity is determined by the nature and concentration of the active ingredient as well as the method of application.
- This toxicity itself should not be cause for panic, because pesticides can be applied reasonably safely if one is very careful.
- One should always, however, be aware that pesticides are hazardous, from the moment that they are bought right up to the moment that the crop is consumed.

4.3 Poisoning by agro-chemicals

Poisoning may occur so slowly that at first it goes unnoticed. Whenever you or anyone in your vicinity uses pesticides you must always be on the alert for the signs and symptoms of poisoning.

Recognition of poisoning at an early stage enables an early treatment to be given promptly and a better chance of complete recovery. Swift treatment of poisoning is vitally important. Immediate first aid measures can save lives, but follow-up treatment should be supervised by trained medical personnel. For first-aid in the case of poisoning, Agromisa has an AgroBrief-brochure available; see Further Reading.

Make sure that you know the location of the nearest clinic or hospital and where to get transport in case of emergency. If grave poisoning occurs, consult a doctor as soon as possible.

If you take a victim of poisoning to a clinic:

- Take with you, if possible, the container of the pesticide involved.
- Supply the doctor with as much information as possible on the poisoning accident, such as time and circumstances, was swallowed or spilled on the skin, etc. (figure 15).

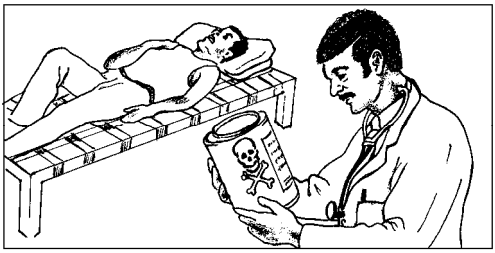

Figure 15: In case of poisoning, consult a doctor as soon as possible

Poisoning can be either acute or chronic. The symptoms of acute poisoning can appear within a few minutes to a few days following contact with the pesticide. In the case of chronic poisoning the effects take longer to become evident and may remain unnoticed for a long time.
Prevention is far better than cure. Without professional assistance, the treatment of moderate or severe pesticide poisoning is difficult and sometimes even impossible.

In many developing countries doctors are few and far between and there is usually a lack of the medicines needed for treatment. It is therefore very important to avoid the risk of poisoning when applying a pesticide. Watch for the symptoms of mild poisoning, like nausea, headaches, etc. If these appear, immediately stop working with the product. Avoid further hazard and consult a doctor.

Acute poisoning

Acute poisoning is caused by a pesticide following a single exposure to a high dose with immediate consequences. This usually occurs after accidents or as a consequence of poor precautionary measures during use, such as:

- a bottle of concentrated formulation is spilled on the skin
- a spray powder being mixed with water drifts up and is inhaled
- a pesticide is eaten or drunk by accident
- no face mask or protective clothing is worn whilst spraying with an highly toxic pesticide.

The WHO classification in table 4 is based on acute toxicity. In the case of acute poisoning, always take the victim to a medical doctor. For descriptions of specific symptoms and treatment of poisoning per chemical group, we refer to the Guidelines on *Emergency Measures in cases of poioning* (see Further Reading). This edition outlines the general symptoms of acute poisoning and the first aid measures applicable to all cases of poisoning. It then gives the specific symptoms related to the most significant chemical groups, and any additional treatment required.

General symptoms of acute poisoning

Symptoms of mild poisoning (also chronic):

- headaches
- dizziness
- tiredness
- loss of appetite
- diarrhoea
- excessive transpiration
- irritation of skin, eyes, nose and throat

Symptoms of severe poisoning:

- blurred vision
- constricted pupils
- stomach cramps
- vomiting
- difficulties with breathing
- profuse perspiration
- tiredness
- twitching
- tremors and jerking of the muscles
- heart failure

Symptoms of extremely grave poisoning:

- convulsions
- loss of consciousness
- breathing stops
- no pulse

It is particularly important to know to which chemical group the pesticide that caused poisoning belongs. When the chemical group is known, convey this information to the doctor. Active ingredients and their respective chemical group(s) are mentioned in Appendix 2.

Chronic poisoning

Chronic poisoning results from exposure over a long period to a dose that does not present an immediate danger on its own, but that is harmful in the long term. Although little or no effect may be detected in the short term, this may turn out otherwise in the long term. Chronic poisoning is therefore far more difficult to recognize than acute poisoning.

It can be caused by sustained or repeated contact with pesticides of a lower dosage than those causing acute poisoning. Chronic poisoning therefore occurs chiefly among operators and hired personnel, who frequently work with pesticides but who are inadequately protected. But also farmers who often use pesticides themselves may be at risk. Regular spraying of pest insects in the house or storeroom can also lead to chronic poisoning, because it may contaminate food or remain for in the air for some time, even if it can no longer be smelled.

Some effects of chronic poisoning have much in common with the symptoms of very mild acute poisoning.

Clinics, doctors and district hospitals in regions where pesticides are used routinely should be familiar with the specific treatment of poisoning and should be equipped for the necessary treatment. If this is not the case, detailed instructions may be obtained from a national poison centre; see the relevant address list. Head offices of the larger pesticide manufacturers and distributors in your country should make this information readily available to doctors.

General symptoms of chronic poisoning

- headaches
- tiredness
- diarrhoea
- irritation of skin, eyes, nose and throat
- dizziness
- loss of appetite
- excessive perspiration
- increased sensitivity to pesticides

Invisible hazards of chronic poisoning in the long term

- damage to the internal organs (e.g. liver, kidneys, lungs, stomach)
- effects on progeny

4.4 Hazards to the environment

During application not all pesticide droplets or particles are deposited on the crop. A large number of these fall on the ground. If the product does not break down rapidly, this may result in pollution of soil, open water wells or surface water. If spraying conditions are not optimal, some of the spray is transported by drift. Not only are the target organisms on the plant "hit", but other beneficial animals such as bees are sprayed and killed. Water organisms, birds and wildlife can be affected as well. Try to avoid side effects as much as possible! In this section the most important side effects are discussed in more detail.

Water pollution

After use in the field, pesticides can end up in surface water such as ditches, pools and wells. This can happen when irrigated crops are sprayed frequently, or when it rains a lot and a crop is flooded. The pesticide is partly washed off by the rain water and runs into pools or streams. This does not immediately endanger humans; the pesticide is, after all, well diluted. However, if the water flows slowly or is stagnant in pools or wells, it can become polluted. People can then ingest the pesticide through drinking water or bathing.

Figure 16: Keep away from surface water when working with agrochemicals

Try to avoid mixing or applying agrochemicals near open water or wells; always work carefully (see figure 16). Spillage cannot be cleaned up and may pollute ditches or rivers. Do not wash sprayers in open water, or dump empty packages. For safe disposal of packages without health risk or environmental hazard, see chapter 5.

Fish and shellfish, an important source of food, are much more sensitive to pesticides than humans. Even when water pollution is insignificant by human standards, water organisms might be affected. Pesticides must therefore be used with great care, especially in irrigated rice fields, which are often used as fish ponds. Appendix 2 indicates which pesticides are toxic to fish.

Damage to useful insects

Many insects do not cause damage, but on the contrary are most useful. Bees produce honey and are also important for the pollination of various crops, contributing to a good yield. Toxicity to bees should be indicated on the label (see Section 5.1 and Appendix 2.) If a particular pesticide is known to be toxic to bees, this is indicated in Appendix 2. These pesticides should not be sprayed when the bees are active in the crop at the time of day, or season, when it is flowering. Other useful insects are the so-called natural enemies of harmful insects. These are insects which feed on other insects or make them harmless in some other way. If these natural enemies are killed, a pest infestation can break out more easily. It may also happen that an insect which at first caused no trouble in the crop becomes a pest after spraying because its natural enemy was removed, even though this was not the intention. This is one more reason for not spraying more frequently then necessary. You could also enquire into alternative control methods, such as those mentioned in the introduction, or consider using pesticides which are selective in their action.

Persistence

Persistence is the property that enables an agro-chemical to remain effective for a long time. A pesticide is persistent if the active ingredient only disappears from the environment at a very slow rate. Persistent compounds can accumulate in the environment, in the soil or the food chain. Eventually, however, they also accumulate in meat, fish or milk. In this way humans also become exposed to the pesticide. A prime example of a persistent pesticide is DDT. Many persistent pesticides are included in the updated Dirty Dozen list in Section 4.3.

Resistance

Another effect of excessive spraying is that the harmful organism becomes tolerant (less sensitive) to the pesticide used. More and more pesticide must then be used to obtain the same degree of control, with all the harmful consequences involved for humans and the environment. Moreover, the resistance of the harmful organism simply increases so that it becomes necessary to use a different pesticide (often more expensive or unobtainable) to which the pest is not yet resistant.

To diminish the risks of persistence, never spray more often or use more pesticide than prescribed or recommended; use other methods of control where possible. If possible, alternate regularly between pesticides of different types.

4.5 Consequences for admission and use

The consequences of the maximum residue limits in food are big. In 2003, some 320 active ingredients were taken off the market in Europe as part of the European Commission's new approach to the evaluation of pesticides. More substances are likely to be withdrawn later. This move comes as part of a measure to improve safeguards for the environment and human and animal health; all active ingredients have been re-evaluated for these aspects. Only active ingredients deemed to be acceptable by these standards are put onto a positive list, known as 'Annex I'. Only the substances mentioned in Annex I are allowed to be used in the European Union (EU). The European Commission aims to take decisions on all substances by the end of 2008.

What are the consequences for producers in countries outside the EU? Firstly, pesticides might not be available any longer if producers of pesticides see their market shrink, and as a result the substance might be taken out of production. Secondly, and this is very important for exporters to the EU, substances banned in the EU have a MRL of zero, so no residues of the banned substances must be found on produce to be exported into the EU. For up-to-date information on these banned substances we refer to information provided by the Pesticides Initiative Programme of the EU (for Internet address, see Useful Addresses).

Case scenario
In Zimbabwe a proportion of smallholder farmers are involved in producing horticultural crops for export. They are enrolled in 'out grower schemes' whereby larger export farms buy the produce at harvest from the farmers.
One of these products is green beans. Aphids are a common problem on green beans. Two of the insecticides registered in Zimbabwe for control of aphids on green beans are demeton-S-methyl and mevinphos. Both these substances are now banned in the EU, which means that the farmer producing these beans should not use these products if they are intended for export. The MRL of these substances is 0, so no residues should be present on the beans. If residues are found, the whole shipment will be refused entry into the EU.
Zimbabwe is fortunate though, to have an organization called the Horticultural Promotion Council. This organization works with farmers and helps them to unravel the complicated issues of producing produce for export.

Many factors influence the risk of poisoning by pesticides. There are no general rules stating which particular pesticide should on no account be used. As mentioned before in 2.2, the more toxic pesticides should not be applied by untrained or unprotected people. The Pesticide Action Network has published a list of pesticides which should be avoided at all times; see text box below.

The Dirty Dozen (now Eighteen)

2,4,5-T	1,2-dibromoethane (EDB, ethylene dibromide)
Aldrin	Endrin
Aldicarb	HCH + isomeric mixture
Chlordane	Heptachlore
Chlordimeform	Lindane
Heptachlor	Paraquat
DBCP	Pentachlorophenol
DDT	Toxaphene (also known as Camphechlor)
Dieldrin	Methyl parathion and Parathion

NB : Pentachlorophenol is not being used as agro-pesticide

5 Safe and adequate use

This chapter explains the following aspects of safe handling of pesticides from purchase to storage or disposal after use:

- the product label
- protective clothing
- marketing, transport and storage
- precautionary measures on the farm
- dealing with pesticide spills

5.1 Product label

The label is the most important source of information on the pesticide, so read it fully and carefully before use, and ask for explanation, if needed. Here we give the types of information that a label on a crop protection product should give.

1 Trade name (brand name, commercial name) This is the most prominent name on the label. Pesticides with different commercial, brand or trade names can contain the same active ingredient, depending on the producer/manufacturer

2 Common or chemical name See section 2.1, 'Giving a pesticide a name', and Appendix 2. The use of the agreed common name of the active ingredient is preferred over the full chemical name.

3 Product composition or ingredient statement Every label must list the active ingredients present in the product, preferably on the front panel directly below the brand name. The concentration of each active ingredient may be given in several forms: as a percentage, as grams per litre, or as pounds per gallon. The active ingredient should be listed by its common name, if one has been agreed upon. Otherwise, it can be identified by its complex chemical name. Inert ingredients need not be named, but the label must state their weight or volume percentage.

4 Type of formulation The label must indicate what type of formulation the package contains as a same pesticide may be sold in various forms, such as powder (WP) or liquid concentrate (EC or SC), which require different methods of handling. The codes are explained in Chapter 2.

5 Name and address The manufacturer, formulator or distributor must put the name and address of the company on the label to enable inspection and complaints.

6 Registration/authorization or license number This number must appear on the front panel of the pesticide label. It shows that the product has been registered with the Government.

7 Net content The net content shows how much product is in the container expressed either in liquid measures (litres, pints, gallons) or dry weights (grams, pounds) or in local units.

8 Warning with signal words, symbols and colour codes per toxicity class (see table 5) Every label should carry a warning that the product is hazardous and the words "KEEP OUT OF REACH OF CHILDREN".

Table 5: Hazard warning used on a label

Indication in words	Indication of toxicity level	Sign	Colour code (FAO)
DANGER, POISON, TOXIC	extremely or highly toxic	skull and crossbones	bright red
WARNING, HARMFUL	moderately toxic	St Andrew's (diagonal) cross	bright yellow
CAUTION	slightly toxic	no symbol	bright blue
no signal word	relatively non-toxic	no symbol	bright green

Signal words are usually printed in bold type and preferably in local language(s) for users. The FAO International Code of Conduct and the manufacturers recommend the printing of a horizontal colour band across the width of the label to indicate the relative toxicity and haz-

ard. Some individual countries, however, tend to follow their own hazard and/or colour coding system. Check the local code practice first with the Ministry of Agriculture in your country.

9 Statement of practical treatment The label indicates what practical first aid measures are prescribed in case of poisoning from ingestion (intake by mouth), inhalation (breathing), and skin or eye contact. It must also indicate when medical treatment is needed and what antidote is recommended.

10 Pictograms for precautionary safety measures. Figure 17 shows pictograms of safety and protection measures to be taken by users.
These are precautionary statements indicating in which way the product may be poisonous to man and animal. Words, symbols or pictograms are used to indicate what special measures are needed, such as the wearing of protective clothing equipment and decontamination.

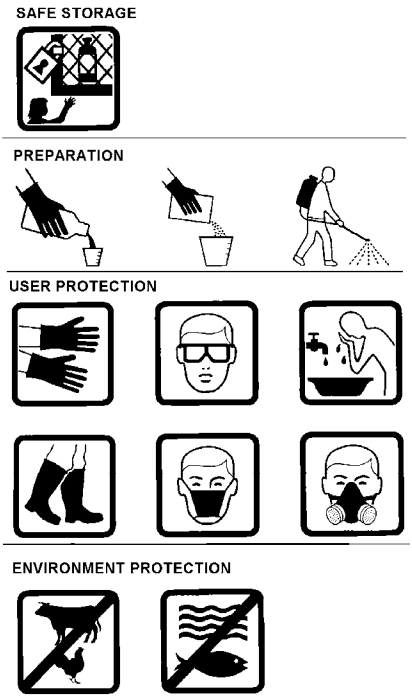

Figure 17: Pictograms for safety and protection (courtesy of CropLife International)

11 Environmental hazards. The label should contain environmental precautions, such as: 'This product is highly toxic to bees exposed to direct treatment or pesticide residues on crops' or 'Toxic to fish, do not contaminate bodies of water while spraying, cleaning sprayer or when disposing of leftover or waste materials'. See also the classification in Appendix 2 under 'hazard to bees', 'fish and 'birds'.

12 Physical or chemical hazards. This section uses words or pictograms to warn for special fire, explosion or chemical hazard posed by a highly inflammable, corrosive or gaseous product.

13 Misuse statement This is a reminder not to use a product on a crop or pest that is not listed on the label. Do not use it at a rate higher than the recommended dosage rate.

14 Re-entry statement The re-entry statement indicates how much time must pass before a pesticide-treated plot is safe for entry by a person not wearing protective clothing.

15 Storage and disposal directions These guidelines tell how to store and dispose of the product as well as the empty containers. See also section 5.6 below.

16 Use areas This section lists the crops, animals or other targets of application on which the product can be used.

17 Directions for use These important instructions indicate:
- pests for which the product is registered to control,
- crops or animals on which the product can be used,
- form in which the product should be applied ,
- how much to use; dosage or concentration, and
- where and when the product should be applied and how frequently.

18 Harvesting statement As toxic residues on the crop take time to break down, some product labels give a specific number of days before the crop can be cut, harvested or consumed by man or animal.

19 Warranty statement Each product label specifies to what degree the manufacturer or distributor limit their warranty and liability.

5.2 Protective clothing and masks

Most pesticides are designed to be toxic and can be dangerous if they are handled in a wrong or hazardous way. Protection against exposure requires the use of protective clothing or in some cases even special breathing masks. The toxicity and hazard differ for each pesticide chemical; even formulations with the same active ingredient differ in degrees of hazardousness.

The pesticide label gives information on the type of protective clothing to be worn and on the need for any special protective equipment. If the required protective equipment is not available, it is better to search for another available pesticide that can control the pest but does not require the use of such equipment.

In a hot climate, it is uncomfortable to wear heavy protective clothing, especially if humidity is high. Workers may take off their rubber gloves and face masks if they become hot and irritated. Therefore, select protective clothing and equipment that is comfortable to wear and do not use more than needed to do the job safely.

Basic protective clothing

Overalls

Light cotton overalls provide the minimum protection you need. If overalls are not available you should wear long trousers and a long-sleeved shirt. The shirt should be buttoned up right up to the neck, the sleeves should be rolled down and the cuffs fastened. Overalls, trousers and shirt should be washed immediately after use and be kept separate from other clothing. Do not wash contaminated clothes and equipment in water wells or fish ponds.

Apron

A long apron that reaches from the top of the chest down to the boots and wraps around the sides of the legs offers some protection when loading and mixing pesticides. However, it does not protect the arms, shoulder and back. Aprons must be cleaned carefully if contaminated by spills and splashes.

Raincoat

A water-proof raincoat that protects the shoulders, chest and back can also be used for mixing and handling toxic pesticides. The handling of very toxic pesticides (WHO classification IA and IB) requires a high degree of protection, such as wearing a pesticide-proof spraying suit. It is therefore better to have these pesticides applied by professionals; farmers should look for an alternative, less toxic, product.

Gloves

Gloves must be worn during mixing and handling of concentrated pesticides or whenever there is a risk of skin contamination. The gloves should be long enough to cover the full length of the hands and the wrists. It is very important to use the right kind of gloves. Use gloves made of synthetic materials such as polyvinylchloride (PVC), neoprene or polyethylene. Do not use natural rubber (latex) or nitrile gloves, as these materials can dissolve fairly easily in some chemicals.

Figure 18: Always use gloves to protect hands and arms when mixing undiluted pesticides

Never use damaged gloves or gloves made of materials that absorb pesticides such as cotton or leather. Wearing gloves such as these could be more dangerous than wearing no gloves at all because of the prolonged skin contact. Leaking or badly contaminated gloves must be cut up and burned to prevent re-use by someone else.

Re-usable gloves should always be cleaned thoroughly after use. First wash the outside of the gloves with soap before they are removed from your hands. Then take the gloves off, turn them inside out, wash them thoroughly on the inside, rub them dry and allow them to dry completely before storage. Dispose of the washing water in a shallow pit and then cover this over.

Rubber boots

People handling or preparing highly toxic pesticides should wear good boots or solid closed shoes. Wash boots with water before removing them from the feet. Put the boots or shoes upside down to dry. The footwear should be inspected before use for damage and leaking. Tears or holes may lead to pesticide contamination of the feet.

Head cover

Head cover is always needed because fine spray and dust particles are caught easily by hair and may then contaminate the very sensitive skin of the head (scalp). Wearing an easily washable cotton hat or scarf is recommended. A broad-brimmed hat, preferably waterproof, provides reasonable protection for the neck and face. The hat should not have a leather or cloth sweatband because this can absorb the pesticide and is difficult to keep clean. A plastic 'hard hat' is an alternative, as it can be easily cleaned and is comfortable to wear in hot weather.

Face shield

A face shield protects the eyes, mouth and face against spills and splashes during mixing, and against droplets from spray mist. A face shield gives no protection against toxic vapours. The advantage of a face shield is that it remains fairly cool and does not mist up as easily as safety goggles.

Figure 19: Use safety goggles when preparing a pesticide mixture

Safety goggles

Safety goggles fit closely against the skin and prevent pesticide fumes and particles from getting into the eyes, but they do not protect the lower part of the face and mouth from splashes and spray drift. Safety goggles can be worn over spectacles. Do not forget that the eyes are extremely sensitive to pesticide absorption.

Respiratory equipment

People working with pesticides must always be aware of the great risk that inhaling pesticide particles and toxic fumes poses to their health. Two types of respiratory masks are available:

Figure 20: Simple dust mask

Dust mask

This is a pad made of paper, synthetic material or gauze that only covers the mouth and nose.

Dust masks protect against dust, light vapours, spray droplets and aerosols. Discard the dust mask after a single use by burning or burying it; do not re-use such masks.

Half face mask

This type of disposable respirator covers the mouth, nose and chin, but not the eyes. For eye protection the half-face mask should always be worn in combination with goggles or face shield. The inhaled air passes through a container holding a filter pad and a cartridge that contains an absorbent material such as activated charcoal. The container, which is screwed onto the mask, filters out dust particles and vapours. Replace the filterpad and cartridge if you detect a slight smell of pesticide and follow the manufacturer's recommendations strictly. Dispose of the used cartridges by burying them at least 50 cm deep.

Figure 21: Half-face mask

Cartridges will have a limited product lifetime of a certain number of hours, which will be mentioned in the product manual. When this time period has lapsed, the cartridge should be disposed of and replaced by a fresh one.
It is dangerous to use half-face masks during fumigation or in places where the oxygen level of the air is low, such as in a non-ventilated storage room, silo or sewer.
Dangerous jobs, such as emergency control of fire in pesticide stores, require much better protection in the form of a full-face mask with chemical cartridge respirator and air supply from pressurized air cylinders. These operations should be left to experts who have both the necessary skills and the proper equipment.

5.3 Purchase of crop protection products

Chemical crop protection products should always be handled and used in accordance to the manufacturer's recommendations. Adhere strictly to label instructions to prevent harmful effects.
Commonly, farmers obtain the products they need from a shop-keeper. This retailer should be reliable and be able to give good, objective advice about the pesticides and application equipment in the shop. Customers have the right to be told whether the product is effective for controlling the pest and disease problems in their crops and how to apply it. Never let a pesticide dealer tempt you into buying more of a given pesticide than recommended by an expert.

The customer should check the container of the pesticide carefully and should not buy a product if the container is open, leaking or too old. Ideally, products should be sold in small-sized original containers with a proper complete label. If the dealer gets the product supplied in large-sized containers, he should repack the pesticide carefully in small, well-labelled containers which match the direct needs of the farmers. Buying the product in a larger quantity than required for one or few applications, leaves the farmer with the problem of storing the remaining part safely in or around the house.

Ask for explanation if the product that you buy does not carry an original label showing the information described in Section 5.1.

5.4 Transport, storage and stock-keeping

Transport

The distribution of pesticides from larger depots to retail outlets and finally, from the shop to the field, always involves the transport of concentrated, hazardous products. Special attention must therefore be given to avoiding accidents and mistakes, which could cause spills and serious contamination. Anybody transporting toxic crop protection products should make sure that the pesticide containers are undamaged and not leaking.

The vehicle used must be suitable and reliable; the driver and passengers should not be endangered.

When transporting crop protection products, make sure containers are loaded and unloaded carefully (see figure 23).

Figure 22: Refuse to buy a pesticide in a damaged or unsealed container

Figure 23: Unload pesticide containers carefully

Storage and stock-keeping

If your country has laws and regulations concerning the storage of crop protection products exist, the manufacturer's recommendations must comply with these. If there are none, we recommended the following:

Figure 24: Keep pesticides under lock and key where possible

General storage

Do not store pesticides in areas of the store, house or farm where people or animals live. Always try to store pesticides in their original container with intact labels. Never repack or keep toxic pesticides in food or drink containers, such as lemonade bottles.

Never store pesticides and empty pesticide containers near food, animal feed, seeds or clothing materials. Preferably, pesticides should be stored in a separate, lockable cupboard with fixed warning signs (figure 24). Keep rat bait and seed treated with pesticide separate from food to prevent mistakes. Keep pesticides out of the reach of children.

Stock-keeping and storage

Store pesticides in a dry, well-ventilated area. Beware of fire hazard resulting from cigarette smoking, use of open fire or direct sunlight coming in through glass windows. Keep pesticide stocks away from fire, in a well-ventilated no-smoking area, and avoid direct sunlight. Store herbicides separately form other crop protection products.

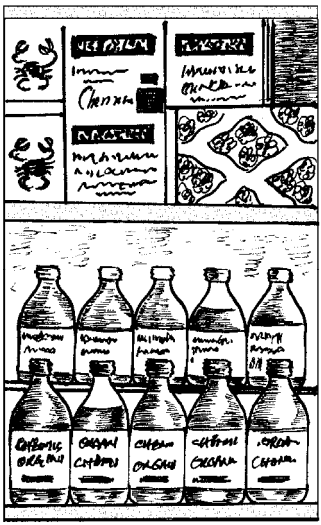

Figure 25: Storage of pesticides: liquids below dry formulations

Place dry crop protection products above liquids (figure 25). Keep a record of your pesticides indicating the quantity stored, the date of arrival and the expiry date of each product. Put the oldest products in front and use the oldest pesticide first according the rule of 'first-in/first-out'.Inspect stored containers regularly for signs of damage and leaks. Remove leaking and damaged containers and repack in clean containers if necessary. After damage or repacking, immediately put a new, full label on the replacement container.

5.5 Risk prevention before application

Preparing the spray solution

A primary rule is that every person who will handle crop protection products, prepare spraying solution or apply it in the field, should be trained in advance.
This way (s)he will know how to work more safely, to avoid polluting the environment and to select adequate protective clothing for the job. Try to use the product that is the least toxic, but still effective against the pest, disease or weed you want to control.

Read and respect the label instructions and warnings
Before opening the pesticide container first read the label completely and follow strictly the directions given on the label. Make sure that:
- the pesticide is suitable to control the pest problem in your crop
- you understand all safety measures and application instructions that must be followed
- you know how hazardous it is for fish, fowl, bees and natural enemies of insects in and around your field

Check the label for the correct amounts to be used and the instructions for preparing the spray solution at the correct dosage rate. Do not prepare more spray solution than needed. If you need to spray several times or during a period of days, make up a fresh batch of spray solution each day.

Dust formulations should be poured slowly from the package to avoid clouds of dust (figure 26). Stand with your back to the wind so that

dust particles are blown away from you. Close containers tightly after use to prevent accidents and store them safely afterwards. Be careful with mixing different pesticides on your own initiative. Ask for advice and, where possible, clear instructions from a qualified retailer or agricultural extension officer.

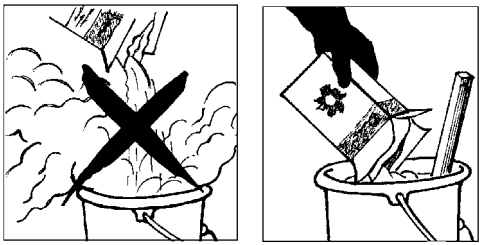

Figure 26: When preparing a spray from a powder, avoid dust clouds when mixing

Pour liquids slowly and carefully in order to prevent spilling and splashing. Avoid skin contact with the pesticide at all times. If you do, nevertheless, spill the pesticide, you should wash the contaminated skin immediately with soap and lots of water. Before use, check the sprayer for leaking seams and joints by filling it with water. See sections 3.5 and 3.6.

Preparation of the spraying equipment

Basic rules for good control results with a minimum of risk are as follows.

Prepare the spray solution outside, in the field. Keep children and animals away from the area. Mix and dilute the pesticides with the greatest caution because you are dealing with a concentrated and therefore very toxic form of the pesticide.

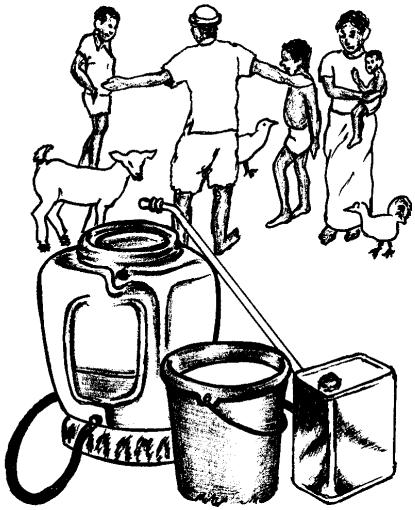

Figure 27: Keep children and animals away when preparing the spraying solution

After filling the spraying tank, wash the mixing equipment used, such as bucket and measuring beaker, thoroughly. If it is not too great a volume, the wash-water can be added to the spray solution. In exceptional cases, pour it into a hole in the ground far away from surface water, pools, streams or ditches.

When spraying in the field, make sure that the spray tank rests comfortably on your back. This way you get less tired and can work more carefully.

Every person working with the spraying equipment should be trained in advance (figure 28). When working with very toxic pesticides it is advisable to work in pairs so that help can be summoned promptly in the event of an accident. Keep other people and animals away from the area where you are spraying.

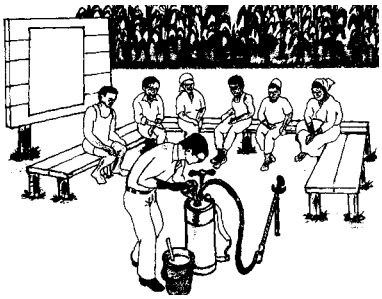

Figure 28: Safe field application of pesticides starts with the right instructions

A leaking knapsack sprayer causes the pesticide to touch the skin of the back and shoulders of the person spraying and this may result in poisoning (figure 29). Many compounds can easily and rapidly be absorbed through the skin. They can thus enter the bloodstream and vital organs.
Table 6 and table 7 show hazards that may occur in applying dry and wet formulations of pesticides. Most hazards are related to wind, causing dust to blow away, or making a spray mist drift.

Figure 29: Never work with leaking equipment; this is especially dangerous when the skin is left unprotected

Table 6: Hazards in applying dry formulations

General hazard	Formulation type+acronym	Specific problems or hazard	
Dust generated in handling the concentrate causes risk of poisoning	Dustable powder or dust (DP)	Operator exposed to concentrate	Drifts readily, watch the wind. Risk of inhalation.
	Granule (GR)		Minimal exposure of operator using special spreading equipment.
	Smoke, fumigant, gas		Risk of inhalation.
	Soluble or dispersible powder (SP)	Dilution diminishes toxicity in use	The mixer needs more protection than the operator. Large drops therefore moderate drift.
	Soluble or dispersible granule (SG)		
	Bait concentrate		Do not mistake bait for food.

Table 7: Hazards in applying wet formulations

General hazard	Formulation type+acronym	Specific problems or hazard	
Splashes adhere to clothes and skin	Suspension concentrate (SP)	Dilution diminishes toxicity in use	The mixer needs more protection than the operator.
	Emulsifiable concentrate (EC)		The mixer needs more protection than the operator.
	Ultra low volume (ULV) – diluted in oil		Mixer and operator still exposed to high concentration, and risk of inhalation of spray drift.
	Ultra low volume (ULV) – undiluted	Operator exposed to concentrate	Operator exposed to full concentration, and risk of inhalation of spray drift.
	Aerosol		Risk of inhalation.

5.6 Safety measures after application

After spraying a field:
- mark the sprayed fields
- keep a record of which fields have been sprayed, and when
- do not enter sprayed fields within re-entry interval (see Section 5.1)
- observe the safety period or harvest interval between spraying and first (or next) harvest.

Keep any left-over concentrated product in its original container, seal it well after use, and then store it away safely.
When a container of liquid pesticide is finished, rinse the remainder of the product out of the container into the mixing tank, or directly into the tank of the knapsack sprayer. Fill the container up to a quarter with water, close it tightly, shake it vigorously and pour the water into the tank. Do this three times. The container should then be disposed of as shown in figure 32.
The spraying equipment should be well cleaned and checked after use. Do not forget that here too, protective clothing must be worn. This must be done with great care, especially if the equipment is not to be used again for a while, as pesticide residues can cause rust spots and blockage of tubes and nozzles. Herbicide residues that remain in a knapsack tank or in the tubes or hoses from a previous treatment can cause crop damage if the same equipment is then used, e.g. for an insecticide treatment.
In spite of careful calibration of the spraying equipment and calculation of the amount needed, some spray solution may be left over after treatment. This can probably be used the following day, provided that there is no warning to the contrary on the label. Any remaining spray solution which is not needed to treat other fields or on the following day, can exceptionally be sprayed onto a field which has already been treated. However, you would better avoid this if at all possible.

When you have finished spraying, tidy the working area thoroughly. Do not leave empty containers lying about but dispose of these properly (see below). Wash the protective clothing and hang it up in a safe

place to dry. Wash yourself with soap and water. Never eat, drink or smoke during or directly after pesticide application. (See figure 30).

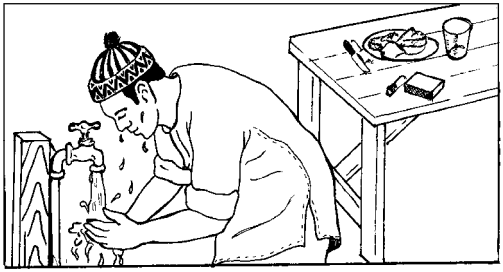

Figure 30: After spraying, wash hands, arms and face with soap

Never use empty pesticide containers to hold water or food, as it is impossible to clean them thoroughly and safely. Empty pesticide containers must not be dumped or burned in the vicinity of people, animals, crops and homes, places where children play or may play, or where food is stored (figure 31).

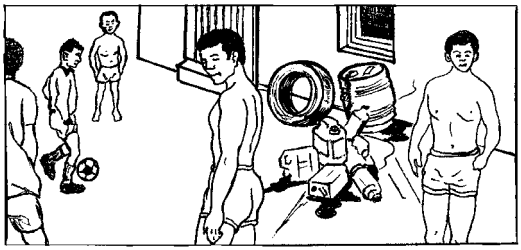

Figure 31: Do not dump empty pesticide containers carelessly

Most countries have regulations for the disposal of pesticide containers. The safest way to dispose of large pesticide containers is to take them to a registered disposal company that burns them for you.

If you burn pesticide packages, never stand in the path of the smoke from these fires, as it may be toxic – even if the active ingredient itself is not. Stay near the fire though until the containers are completely burned.

Containers of the pesticides listed in the box below should never be burned for safety and health reasons. This also applies to PVC containers, which may cause carcinogenic smoke.

Relatively safe ways of getting rid of smaller pesticide containers:

- *metal and glass containers and drums*: the stopper or lid can be removed from the container
- *metal containers*: make holes with a sharp object and flatten them
- *glass bottles*: crush these in a sack in order to prevent glass splinters from flying about
- *paper and plastic packages*: if possible, make holes in them and then burn them
- *aerosol spray cans*: never burned or crush these because of explosion danger. Bury these intact, deeply and in a safe place.

Pesticides of which the containers must never be burned

Name of active ingredient

- benasolin	- 2.4-D	- 2,4-DB	- dicamba
- dichlorprop	- fenoprop	- MCPA	- MCPB
- mecoprop	- picloram	- sodium chlorate	- 2,4,5-T
- 2,3,6-TBA	- mercury compounds		

Containers of the pesticides that should not be burnt, can be got rid of by burying these. Burn pesticide containers made of cardboard or plastic, at a site away from homesteads and other places where people gather or children play, or where crops are grown. Bury the ashes in a spot which is not regularly flooded and is far from surface water. Search for a common dumping site that you can use together with other pesticide users.

To bury any residues, dig a pit 1-1.5 m (3 to 5 feet) deep. Throw in the punctured and flattened containers and the ash, and cover completely with a layer of earth. For subsequent use, some of the earth can be removed before a new load is dumped. When the pit is filled up to 50 cm below ground level it must be closed. Ensure that the dumping site is fenced off to prevent children and livestock from digging in it. Mark the site with a warning sign of a skull and crossbones.

How to deal with pesticide spills

In the case of a pesticide spill, clean it up as soon as possible. Keep people and animals out of the area. Prevent smoking and open fires around the spot where the pesticide has been spilled. Remove damaged containers and put these on a piece of plastic or in an empty drum to prevent soil absorption.

Make sure the damaged containers are put in a position where further leaking can be contained. Use sand or sawdust to absorb pesticides in liquid and powder form, sweep it up very carefully, and avoid causing dust clouds. Bury the toxic sand or sawdust mixture in a place where there is no danger of contaminating wells, drainage canals, etc.
Always keep some clean empty containers and absorbing material ready in pesticide stores, as precaution for spills. If a pesticide spills during transport, the contaminated vehicle should be thoroughly cleaned with water. Avoid pollution of soil and surface water in the process. Always wear good protective clothing when cleaning up.

If food is contaminated, bury it or burn it. Burn or bury any contaminated foodstuff (figure 33). Never feed contaminated foodstuff to livestock.

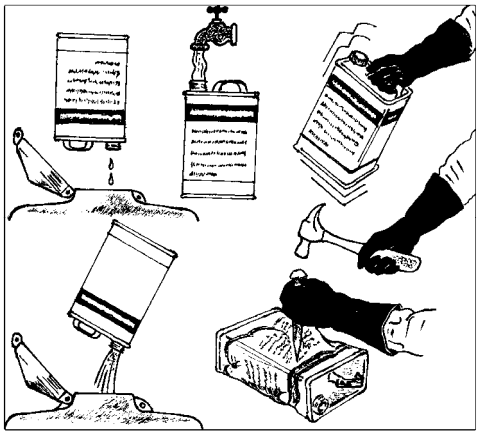

Figure 32: How to clean and destroy an empty pesticide container

Figure 33: Bury or burn any contaminated foodstuff

Appendix 1: FAO Code of Conduct

In 1985, the Food and Agriculture Organization of the United Nations (FAO) adopted the International Code of Conduct on the Distribution and Use of Pesticides. The objectives of the FAO Code are to set forth responsibilities and establish voluntary standards of conduct for all public and private actors engaged in or affecting the distribution and use of pesticides. In particular, the Code aims at situations where there is no national law or only an inadequate law to regulate pesticides. The most recent large revision was in November 2002.
Its specific aims are :

- to promote Good Agricultural Practice, thus ensuring efficient and safe use while minimizing health and environmental concern;
- to establish responsible and generally accepted trade practices;
- to assist countries which have not established controls designed to regulate the quality and suitability of pesticide products needed in that country;
- to ensure that pesticides are used effectively for the improvement of agricultural production and of human, animal and plant health.

The code also includes a section on Prior Informed Consent (PIC), a legally binding convention that enables governments to restrict import of certain banned and severely restricted hazardous pesticides. Under PIC,No international shipment of a pesticide, which has been banned or severely restricted by a country in order to protect human health or the environment, should proceed without the agreement of the importing country.
There is an underlying assumption that good practice will be adopted and that, under a mutual and shared responsibility, this in turn will address pesticide problems. The overall thrust of the FAO Code is to establish practical standards and thus secure the commitment of the pesticides industry. It is therefore supported by a comprehensive set of technical guidelines on all aspects of pesticide management and control, concerning: pesticide management and testing, reducing health and environmental risks, regulatory and technical requirements, avail

ability and use, distribution and trade. Furthermore, it aims to cover information exchange, labelling, packaging, storage and disposal, advertising and monitoring and observance of the Code of Conduct.

The practices outlined in it are elaborated in a series of more than 50 detailed FAO guidelines, which mention the international policy instruments in the field of chemicals management, environmental and health protection, sustainable development and international trade relevant to the Code. These aim to establish control and minimize risks of pesticides, from admission research up to the prohibition of obsolete and banned pesticides
Furthermore, the Code of Conduct recognizes that training at all appropriate levels is an essential requirement in implementing and observing its provisions. Therefore, governments, the pesticide industry, users of pesticides, international organizations, non-governmental organizations (NGOs) and other parties concerned should give high priority to training activities related to each Article of the Code.

The standards of conduct set forth in the Code encourage responsible and generally accepted trade practices. They assist countries which have not yet established regulatory controls on the quality and suitability of pesticide products needed in that country to promote the judicious and efficient use of such products and address the potential risks associated with their use.
The Code aims to promote practices which reduce risks in the handling of pesticides, including minimizing adverse effects on humans and the environment and preventing accidental poisoning resulting from improper handling. This can be done by ensuring that pesticides are used effectively and efficiently for the improvement of agricultural production and of human, animal and plant health.
The Code addresses all major aspects related to the development, regulation, production, management, packaging, labelling, distribution, handling, application, use and control, including disposal of all types of pesticides and of pesticide containers.

Appendix 2: Active ingredients

Part A: Explanation to the index in Part B

Introduction

A wide range of active ingredients used in crop protection products is presented in this Appendix. The index lists about 670 chemical compounds accepted as active ingredient in pesticide formulations.

The information given in the index is mainly derived from the Pesticide Manual, the Agrochemical Handbook and from WHO and FAO sources (see Further Reading). Not all chemicals might be registered for use in your country, check with extension services of the Ministry of Agriculture for up-to-date local information.

Here we present an explanation of the index in part B and guidelines for using it. First of all, a user should find out about the pesticide's active ingredient and all its properties by reading the package label. All relevant and necessary information should be written on the label (Section 5.1).

The index does not include biological pesticides, plant growth regulators, insect pheromones, pesticide safeners or pesticides used on cattle etc. The index does also not include chemical compounds that have been banned or have become obsolete and for which production has been discontinued. Stocks of obsolete pesticide might still be present and remain a danger in some countries. Pesticides containing any ingredient not mentioned in this list must be treated with great caution. They might be older pesticides that should not be used. Recently developed compounds, although safe to use, may not have yet been included in this index at the time of printing.

What if a cell in a column does not contain any comment?

It merely indicates that the authors have not found relevant information, or that WHO, FAO, PAN, or EU and specialized agencies might not have scientific, empirical or legislative information at their disposal, or that scientific information from research is ambiguous at the time of writing.

Explanation per column

The active ingredients of pesticides are listed in alphabetical order, under the names mentioned in the Pesticide Manual (see Further Reading). The numerical ranking in column 1 serves as a quick retrieval aid.

Column 2: name of the active ingredient

This is the preferred name of the active ingredient as approved by the International Organization for Standardization (ISO).

Trade names are not listed, since they are too numerous for this short booklet and trade names differ per country.

Column 3: type of pesticide

This indicates the pesticide's main activity.

WHO code	Type	Against
A	acaricide	mites
Al	algicide	algae
B	bactericide	bacteria
F	fungicide	fungi
H	herbicide	weeds
I	insecticide	insects
M	molluscicide	slugs and snails
N	nematicide	nematodes
R	rodenticide	rodents

Column 4: chemical group to which an active ingredient belongs

Chemical groups are given for a large number of the active ingredients listed. If fewer than five active ingredients belong to a chemical group, the name of that chemical group is not cited. It is be important to know the chemical group when medical treatment is required. It is also useful for avoiding a build-up of resistance against the pesticide.

Code	Chemical group		Code	Chemical group
AR	coumarin + analogues		IML	imidazolinone
ARA	aryloxyakanoic acid		NEO	neonicotinoid
ARP	aryloxyphenoxypropionate		OC	organochlorine compound
BEN	benzimidazole		OCA	oxime carbamate
BO	botanical compound		OP	organophosphorus compound
BU	benzoyl urea		OX	oxathiin
CA	carbamates		PY	synthetic pyrethroids
CHL	chloroacetamide		STRO	strobulirin
CO	cyclohexanedione oxime		SU	sulfon urea
DC /TC	(di)thiocarbamates		T	triazine derivatives
DEP	diphenyl etherdipyridilium derivatives		TP	triazole pyrimidine
IC	inorganic compounds		TRI	triazole
IMI	imidazole		U	urea

Column 5: EU directive 91/414/EC

I: chemicals listed as allowed for use in EU countries, June 2004
P: pending assessment 2005
X: active ingredient not allowed for use in EU countries

Column 6: toxicity classification according to WHO

WHO classification for estimating the acute toxicity of pesticides.

Ia: extremely hazardous
Ib: highly hazardous
II: moderately hazardous
III: slightly hazardous
U: product unlikely to present acute hazard in normal use
Fum: Fumigant

See Chapter 4 for definition and description of acute and chronic toxicity.

Column 7: toxicological hazard to fish

1 extremely harmful
2 harmful
3 slightly harmful

Column 8: toxicological hazard to birds

1 extremely harmful
2 very harmful
3 harmful
4 slightly harmful

Column 9: toxicological hazard to bees

Same classification as for column 8

Column 10: risks

These codes relate to hazardous effects for humans and are based on the EC risk symbols (EC directive 67/548/EEC).

Code	**Hazardous effect**
C	corrosive
N	dangerous for the environment
O	oxidizing
F	highly flammable
F+	extremely flammable
T	toxic
T+	very toxic
Xi	irritant
Xn	harmful

Column 11: other remarks

Additional information regarding the active ingredient.
Abbreviations: carc. = carcinogenic accum. = accumulation
poss. = possibly phyt. = phytotoxic

Part B: Index with active ingredients and properties

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
1	acephate	I	OP	X	III	3	4	1	Xn	
2	acequinocyl	A				3	4	4		
3	acetamiprid	I	NEO			3	3			
4	acetochlor	H	CHL	P	III	1	4	3	Xn,Xi,N	
5	acifluorfen-sodium	H	DE	X	III	3	4	4	Xn,Xi,N	
6	aclonifen	H		P	U	2	4	4	N	
7	acrinathrin	A,I	PY	P	U	1	4	2		
8	acrolein	H			Ib	1	2		F,T+,C	poss. carc.
9	alachlor	H	CHL	P	III	2	4	4	Xn	
10	alanycarb	I	OCA		II	2	4	2		
11	aldicarb	I,A,N	OCA	X	Ia	1	1	1	N,T+	poss. carc.
12	allethrin	I	PY	X	III	1	4	4	Xn	
13	alloxydim	H	CO		U	3	4	4		
14	aluminium phosethyl	F			III	3		4		
15	ametryn	H	T	X	III	2	4	4	Xn,N	
16	amicarbazone	H	T			3	4	3		
17	amidosulfuran	H	SU	P		3	4	4		
18	amitraz	A, I		X	III	2	4	4	Xn	
19	amitrole	H	T	I	U	3	4	4	Xn,N	poss. carc.
20	ammonium sul-famate	H			U	3	4		Xi	
21	anilofos	H			II	2	4	2		
22	asulam	H	CA	P	U	3	4	4		
23	atrazine	H	T	P	U	2	4	4	Xn,N	long-term residual effect; poss. carc.
24	azaconazole	F	T	X	II	3	4		Xn	
25	azamethiphos	I	OP	X	III	1	1	2		
26	azimsulfuron	H	SU	I	U	3	4	4		
27	azinphos-ethyl	A,I	OP	X	Ib	2	1	1	T+,N	
28	azinphos(-methyl)	A,I	OP	P	Ib	1	2	1	T+,N	
29	azocyclotin	A		P	II	2	3	4	T+,Xi,N	
30	azoxystrobin	F	STRO	I	U	1	4	4	T,N	
31	beflubutamid	H	CO			2	4	4		
32	benalaxyl	F		I	U	3	4	4		
33	benazolin	H		X	U	3	4	4	Xi,N	
34	bendiocarb	I	CA	X	II	1	1	4	T,Xn,N	
35	benfluralin	H	DA	P	U	1	4	4	T,N	
36	benfuracarb	I	CA	P	II	2	3	2	T,N	
37	benfuresate	H		X	U	3	4			
38	benomyl	F	BEN		U	2	4	4		poss. carc.

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
39	bensulfuron-methyl	H	SU	P	U	3	4	4	N	
40	bensulide	H		X	II	2	4	1	Xn	
41	bensultap	I		X	III	3	3	3	Xn,N	phyt. to certain fruit
42	bentazone	H		I	III	3	4	4	Xi,N	
43	benthiavalicarb-isopropyl	F				2	4	4		
44	benzobicyclon	H				3	4	4		
45	benzofenab	H				3				
46	benzoximate	A		X	U	1		1		
47	bicarbonate	F								
48	bifenazate	A				1	4	4		
49	bifenox	H	DE	P	U	1	4	4		
50	bifenthrin	I, A	PY	P	II	1	4	1		
51	bioallethrin	I	PY	X	II	1	4		Xn,N	toxicity varies according to the concentration of isomers
52	bioresmethrin	I	PY	X	U	1	4	1	N	
53	biphenyl	F		X	U				Xi,N	
54	bispyribac-sodium	H			U	1	4	4		
	bistrifluron	I	BU			1	4	4		
55	bitertanol	F	T	P	U	2	4	4		phyt. to certain fruit
56	borax	H. F. I			U	3		4		not to be used near desired plants
57	bordeaux mixture	F	IC			1		4		phyt. to certain fruit
58	boscalid	F					4	4		
59	brodifacoum	R	AR	P	Ia	1	1		T+,N	
60	bromacil	H		X	U	3	4	4		
61	bromadiolone	R	AR		Ia	1	4	4		
62	bromethalin	R		X	Ia					
63	bromobutide	H			U	3				some phyt. to rice
64	bromopropylate	A		X	III	1	4	4		slight phyt. to fruit, ornamentals
65	bromoxynil	H		P	II	1	3	3	T	can poss. harm the unborn child
66	bromuconazole	F	T	P	II	2	4	4		
67	bronopol	B		X	II	3	4		Xn,Xi,N	
68	bupirimate	F		P	U	1	4	4	Xi,N	some phyt. observed
69	buprofezin	I, A		P	U	2	4	4		
70	butachlor	H	CHL	X	U	1	4	4		
71	butafenacil	H			III	3	4	4		

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard Fi	8 Bi	9 to: Be	10 risks	11 other remarks
72	butamifos	H			II	2				
73	butocarboxim	I	OCA	X	Ib	3	3	1	T,Xi,N	flammable
74	butoxycarboxim	I, A	OCA	X	Ib	3	3	4		
75	butralin	H	DA	P	U	2	4	4	Xn	can poss. harm the unborn child
76	butroxydim	H	CO		III	2	4	4	T,N	can poss. harm the unborn child
77	sec-butylamine	F			II	3	3		F,Xn,C, N	
78	butylate	H	TC	X	U	2	4	4		
79	cadusafos	N, I	OP	P	Ib	1	3			
80	cafenstrole	H				2	4	4		
81	calciumpolysulfide	F, I, A							Xi,N	poss. carc.; phyt. to sulphur-sensitive plants
82	captafol	F			Ia	1	4	4	N	poss. carc.; some phyt. to fruit
83	captan	F		P	U	1	4	4	Xi	poss. carc.; some phyt. to fruit
84	carbaryl	I	CA	P	II	1	3	1	Xn,N	poss. carc., some phyt. to fruit
85	carbendazim	F	BEN	P	U	1	4	4		poss. carc.
86	carbetamide	H	CA	P	U	3	4	4		
87	carbofuran	I, N	CA	P	IB	1	1	2	T+,N	
88	carbosulfan	I	CA	P	II	1	3	3	T,N	
89	carboxin	F	OX	P	U	2	4	4		do not eat treated seeds
90	carfentrazone-ethyl	H		I	III	2	4	4	N	
91	carpropamid	F			U	2	4			
92	cartap	I		X	II	1		2		some phyt. to cotton, tobacco, apples
93	cga 50 439	A			II	3	4			risk of impaired fertility
94	chinomethionat	F, A		X	III	1	3	4	Xn,Xi,N	poss. harm to the unborn child; some phyt. to fruit, ornamentals
95	chloralose	R		P	II		2		Xn	
96	chlordane	I	OC		II	1	3	3	Xn,N	accum. in body fat; persistent; poss. carc.
97	chlorethoxyfos	I	OP		Ia	1	2			
98	chlorfenapyr	I, A			II	2	2	2		
99	chlorfenvinphos	I,A	OP	X	Ia	1	1	2	T+,N	
100	chlorfluazuron	I	BU	X	U	3	4	4		
101	chlorflurenol-methyl	H			U	2	4	4		

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
102	chloridazon	H			III	3	4	4	N	some phyt. observed
103	chlorimuron-ethyl	H	SU		U	3	4	4		
104	chlormephos	I	OP	X	U	2	3	1	T+	phyt. to sorghum, soya
105	chloroacetic acid	H			III	3	1	1	T, C	
106	chlorondo	F			U	3	4			
107	chlorophacinone	R	AR	P	Ia	1	3	4	T+,N	
108	chloropicrin	F,I,N, H		P	Ia	1		4	Xn,T,Xi	to be used only by trained personnel; highly phyt.
109	chlorothalonil	F		P	U	1	4	4	Xn	phyt. to ornamentals
110	chlorotoluron	H	U		U	3	4	4		phyt. to wheat, barley
111	chlorpropham	H	CA	P	U	3	4	4		
112	chlorpyrifos(-ethyl)	I	OP	P	II	1	3	1	T,N	phyt. to ornamentals
113	chlorpyrifos-methyl	I	OP	P	U	1	4	1		
114	chlorsulfuron	H	SU	P	U	3	4	4	N	phyt. to broad-leaved crops
115	chlortal-dimethyl	H		P	U	2	4	3		phyt. to beet, spinach, flax
116	chlozolinate	F		P	U	3	4	4	N	
117	chromafenozide	I				3	4	4		
118	cinidon-ethyl	H		I		3	4	4		
119	cinmethylin	H			U	2	4		Xn,N	
120	cinosulfuron	H	SU		U	3	4	4		
121	clethodim	H	CO	P	III	3	4	4		
122	clodinafop-propargyl	H	ARP	P	III	1	4	4	Xn	
123	clofentezine	A		P	III	1	4	4		phyt. to roses
124	clomazone	H		P	II	3	4			phyt. to desired plants; poss. carc.
125	clomeprop	H	ARA		U	3				phyt. to rice
126	clopyralid	H		P	U	3	4	4	Xi,N	
127	cloransulam-methyl	H	TP		U	3	4	4		
128	clothianidin	I	NEO			3	4	1		
129	copper hydroxide	F, B	IC	P	III	1	4	4		
130	copper octanoate	F, B, A	IC	P		1		4		phyt. to roses
131	copper oxychloride	F	IC	P	III	2		4		
132	copper sulfate	F	IC	P	II	2	4	2	Xn,Xi,N	phyt. to most plants
133	coumaphos	R	OP		Ia	1	2		T+, Xn,N	
134	coumatetralyl	R	AR	X	Ib	3	3		T+,N	
135	cryolite	I			U		4		Xn,T,N	

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
136	cumyluron	H				3	4	4		
137	cuprous oxide	F	IC		II	3	4	4	Xn	phyt. to brassicas
138	cyanazine	H	T	X	II	2	3	4	Xn,N	
139	cyanophos	I	OP		II	2		1	Xn,N	
140	cyazofamid	F				1	4	4		
141	cyazofamid	F		I						
142	cycloate	H	TC	X	III	2	4	4		
143	cycloprotrin	I	PY		U	2	4	1		
144	cyclosulfamuron	H	SU		U	3	4	4		
145	cycloxydim	H	CO	P	U	3	4	4		phyt. to graminous crops
146	cyflufenamid	F				2	4	4		
147	cyfluthrin	I	PY	I	Ib	1	3	1	T+,N	phyt. citrus, greenhouse use
148	beta-cyfluthrin	I	PY		II	1	4		T+,N	
149	cyhalofop-butyl	H	ARP	I	U	1	4	4		
150	cyhalothrin	I	PY	X	II	1	4			
151	lambda-cyhalothrin (lindane)	I	PY	I	II	1	4	1	T+, Xn,N	
152	cyhexatin	A		P	III	1	4	4	Xn,N	
153	cymoxanil	F		P	III	3	4	4	Xn,N	
154	cypermethrin	I	PY	P	II	1	3	1	Xn,N	
155	cyphenothrin	I	PY		II	1	4			
156	cyproconazole	F	T	P	III	3	3	4	Xn,N	Poss. to unborn child
157	cyprodinil	F		P	III	2	4	4		
158	cyromazine	I		P	U	3	4	4		poss. carc.
159	2,4-D	H	ARA	I	II	2	3	4	Xn,Xi	avoid long-term exposure; phyt. to broadleaved plants
160	daimuron	H			U	3	4			
161	dalapon	H		X	U	3	4	4	Xn,Xi,N	
162	dazomet	N, F, H, I		P	III	2	3	4	Xn,Xi,N	phyt. to all green plants
163	2,4-DB	H	ARA	I	III	2		4	Xn,N	phyt. to soya
164	DCIP	N				3				
165	DDT	I	OC		II	2	2	3	T,N	accum. in body fat; persistent; poss. carc.; phyt. some crops
166	deltamethrin	I	PY	I	II	1	4	1	T,N	
167	demeton-s-methyl	I,A	OP	X	Ib	2	2	1	T,N	phyt. to ornamentals
168	desmedipham	H		P	U	2	4	4		
169	diafenthiuron	I, A		X	III	1	4	2	T,Xn	

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
170	diazinon	I,A,N	OP	P	II	2	1	1	Xn,N	
171	dicamba	H		P	III	3	4	4	Xn,Xi,N	phyt. to legumes
172	dichlobenil	H		P	U	2	3	4	Xn,N	phyt. to some fruit, ornamentals
173	dichlofluanid	F		X	U	1	4	4	Xn,Xi,N	flammable; phyt. to desired plants
174	dichlorophen	Al, F, B		P	III	1			Xn,Xi,N	poss. carc.
175	dichloropropene	N		X	Ib	2	4	2	T,Xn,Xi,N	poss. carc.
176	dichlorprop	H	ARA	X	III	3	3	4	Xn,Xi	poss. carc.
177	dichlorprop p	H		P						
178	dichlorvos	A,I	OP	P	Ib	2	2	1	T,N	volatile
179	diclofop-methyl	H	ARP	P	III	1	4	4	Xn,N	phyt. to maize, sorghum, rice, cotton
180	diclomezine	F			U	3	4	1		
181	dicloran	F		P	U	2	4	4		phyt. greenhouse use
182	diclosulam	H	TP		U	3	4	4		
183	dicofol	A	OC		III	1	3	4	Xn,Xi,N	phyt. aubergines, pear
184	dicrotophos	I,A	OP	X	Ib	2	1	1	T+,N	phyt. to certain fruit
185	dicyclanil	I			III	1	4			
186	diethofencarb	F		P	U	3	4	4		
187	difenacoum	R	AR	P	Ia	1	3		T+,N	
188	difenoconazole	F	T	P	III	1	4	4	Xn	
189	difenzoquat metilsul-fate	H, F		X	II	3	4	4	Xn,N	
190	difethialone	R	AR	X	Ia	1	1			
191	diflubenzuron	I	BU	P	U	3	4	4		
192	diflufenican	H		P	U	3	4	4	N	
193	diflufenzopyr	H				3	4	4		
194	diflumetorim	F				1	4	4		
195	dimefuron	H	U	X	U	3	4	4		
196	dimepiperate	H	TC	X	III	2	4		Xn,N	
197	dimethachlor	H	CHL	P	III	2	3	3	Xn,N	
198	dimethametryn	H	T		III	2	4	4		
199	dimethenamid	H	CHL	I		2	4	3		
200	dimethipin	H		P	III	2	4	4		
201	dimethirimol	F		X	U	3	4	4	Xn	
202	dimethoate	I,A	OP	P	II	2	2	1	Xn	phyt. to some crops
203	dimethomorph	F		P	U	3	4	4		
204	dimethylarsinic acid	H			III				T,N	

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard Fi	8 Bi	9 to: Be	10 risks	11 other remarks
205	dimethylvinphos	I	OP			1				
206	dimoxystrobin	F	STRO			1	4	4		
207	diniconazole	F	T	P	III	2	4	4	Xn,N	
208	dinitramine	H	DA	X	U	2	4			
209	dinobuton	A,F		X	II	2	3	2	T,N	persistent; phyt. to roses, tomatoes
210	dinocap	F,A		P	III	1	4	4	Xn,Xi	
211	dinotefuron	I	NEO			3	4			
212	dinoterb	H		X	Ib	1		1	T+,N	can poss. harm the unborn child; explosive
213	diphacinone	R	AR	X	Ia	2	4		T+	
214	diphenamid	H		X	III	2		4	Xn,N	
215	diphenylamine	F		P					T,N	
216	diquat dibromide	H	P	I	II	3	3	4	T+ Xn,Xi,N	
217	disulfoton	I,A	OP	X	Ia	1	2	2	T+,N	
218	dithianon	F		P	III	1	3	4	Xn,N	
219	dithiopyr	H	P		U	1	4	4		
220	diuron	H	U	P	U	2	4	4	Xn,N	poss. carc.
221	DNOC	I,A,H		X	Ib	1	4	1	T+,Xi,N	phyt.; explosive accum.; poss. carc.
222	dodemorph	F		P	U	3		4	Xi,N	phyt. to ornamentals
223	dodine	F		P	III	1	4	4	Xn,Xi,N	phyt. to fruit
224	edifenphos	F			Ib	1	4	4	T,Xn,N	
225	emamectin benzoate	I			II	1	2	1		
226	empenthrin	I	PY		III	1	4			
227	endosulfan	I,A	OC	P	II	1	3	3	T+,Xi,N	toxic to cattle; phyt. to ornamentals, legumes
228	endothal	H, Al		X	II	1	3	4	T,Xn,Xi	
229	EPN	A, I	OP		Ia	1	3	1	T+,N	
230	epoxiconazole	F	T	P		2	4	4	N	Poss. harm to unborn child & fertility
231	EPTC	H	TC	X	II	3	4	4	Xn	
232	ergocalciferol	R								
233	esfenvalerate	I	PY	I	II	1	4	2		phyt. to some crops
234	esprocarb	H	TC		III	2	4			
235	ethaboxam	F					4	4		
236	ethalfluralin	H	DA	P	U	1	3	4		
237	ethametsulfuron-methyl	H	SU		U	3	4	4		not registered in US

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
238	ethiofencarb	I	CA	X	Ib	2	2	3	Xn,N	phyt. to ornamentals
239	ethion	I,A	OP	X	II	1	1	2	T,Xn	
240	ethofumesate	H		I	U	3	4	4	N	
241	ethoprophos	N, I	OP	P	Ia	1	2	4	T+	
242	ethoxyquin	F		P					Xn	phyt. to some apples
243	ethoxysulfuron	H		I						
244	ethylene dibromide	I, N			Fum				T,Xi,N	phyt.; forbidden in many countries because of its carc.ity
245	etobenzanid	H				3	4	4		
246	etofenprox	I	PY	P	U	2	4	4		
247	etoxazole	A				1	4	4		
248	etridiazole	F		P	III	2	4	4	T,Xn,N	poss. carc.
249	famoxadone	F	STRO		III	1	4	4		
250	famphur	I	OP		Ib		2			
251	fenamidone	F		I						
252	fenamidone	F				1	4	3		
253	fenamiphos	N	OP	P	Ib	1	1	3	T+	
254	fenarimol	F		P	U	1	4	4	N	Poss. harm to unborn child & fertility
255	fenazaquin	A		P	II	2	4	3	T,Xn,N	
256	fenbuconazole	F	T	P		1	4	4		
257	fenbutatin oxide	A		P	U	1	4	4	T,Xi,N	phyt. to citrus
258	fenfuram	F		X	U	3		4		do not use treated seed as food
259	fenhexamid	F		I	U	2	4	4		
260	fenitrothion	I	OP	P	II	1	2	1	Xn,N	
261	fenobucarp	I	CA		II	3	3		Xn,N	
262	fenothiocarb	A		X	III	2	4	4		phyt. to some crops
263	fenoxanil	F				2	4			
264	fenoxaprop-p-ethyl	H	ARP	X		1	4	4		
265	fenoxycarb	I	CA	P	III	2	4	4	N	phyt. to fruit
266	fenpiclonil	F		X	U	1	4	4		
267	fenpropathrin	A, I	PY	X	II	1	4	1	T+, Xn,N	
268	fenpropidin	F		P	II	2	3	4	Xn,Xi	
269	fenpropimorph	F		P	U	2	4	4	Xn,Xi,N	
270	fenpyroximate	A		P	II	1	4	4		
271	fenthion	I	OP		II	1	2	1	T,Xn,N	poss. carc.; phyt. to fruit, cotton

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
272	fentin	F, AI, M		X	II	1	2	4	T+,Xi,N	phyt. to fruit
273	fentrazamide	H				2	4	4		
274	fenuron	H	U	X	U	3		4		poss. carc.
275	fenvalerate	I, A	PY	X	II	1	4	1		
276	ferbam	F	DC	X	U	2	4	4	Xi,N	
277	ferimzone	F			III	3	3	4		
278	ferric phosphate	M	IC	I			4			
279	fipronil	I		P	II	1	2	1		
280	flamprop-m	H		X	U	2	4	4		
281	flazasulfuron	H	SU			3	4	4	N	
282	flocoumafen	R	AR	X	Ia	3	3		T+,N	
283	florasulam	H	TP	I		3	4	4		
284	fluacrypyrim	A				1	4	2		
285	fluazifop-butyl	H	ARP	X	U	2	4	4	N	Poss. harm to unborn child
286	fluazinam	F		P		1	4	4		
287	flucarbazone-sodium	H				3	4	4		
288	fluchloralin	H			III	1	4	4		unavailable in many countries; phyt. to beet, spinach, sorghum
289	flucycloxuron	A, I	BU	X	U	3	4	4		
290	flucythrinate	I	PY	X	Ib	1	4	1		
291	fludioxonil	F		P	U	1	4	4		
292	flufenacet	H		I	III	2	4	4	Xn,N	
293	flufenoxuron	I, A	BU	P	U	3	4	4		
294	flumetsulam	H	TP		U	3	4	4		phyt. to some crops
295	flumiclorac-pentyl	H				2	4	4		
296	flumioxazin	H		I		2	4	4	N	Poss. harm to unborn child
297	fluometuron	H	U	P	U	3	4	4		poss. carc.
298	fluoroacetamide	R		X	Ib				T+	
299	fluoroglycofen-ethyl	H	DE	X	III	2	4	4		
300	fluoroimide	F			U	2	4			phyt. to pear
301	fluoxastrobin	F	STRO			1	4	3		
302	flupropanate	H			U	3	4			
303	flupyrsulfuron methyl	H	SU	I	U	3	4	2	N	
304	fluquinconazole	F	T	P		2	4		T,N, Xn, Xi	
305	flurenol	H			U	3		4	N	
306	fluridone	H		X	U	2	4	4		
307	flurochloridone	H		P	III	2	4	4		phyt., only cotton is tolerant

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
308	fluroxypyr	H		I	U	1	4	4	N	
309	flurtamone	H		I		2	4	4	N	
310	flusilazole	F	T	P	III	2	4	4	Xn,N	Poss. harm to unborn child
311	flusulfamide	F				2	2	4		
312	fluthiacet-methyl	H			U	1	4	4		
313	flutolanil	F	OX	P	U	2	4	4		
314	flutriafol	F	T	P	III	3	4	3	Xn,N	
315	tau-fluvalinate	I, A	PY	P	U	1	4	4	Xn,Xi,N	
316	folpet	F		P	U	1	4	4	Xn, Xi,N	poss. carc.; may be used after harvesting; phyt. in dry weather conditions
317	fomesafen	H	DE	X	III	3	4	4	Xn	
318	foramsulfuron	H		I		3	4	4		
319	formaldehyde	F			Fum	1			T, C	poss. carc.; apply 1-2 weeks before planting; extremely phyt.
320	formetanate	I, A	CA	P	Ib	1	3	3	T+,N	
321	fosamine	H		X	U	3	4	4		
322	fosetyl-alumimium	F		P	U	3	4	4		
323	fosthiazate	N, I	OP	I		3	2	1	T,Xn, Xi,N	
324	fuberidazole	F	BEN	P	II	1	3	4	Xn,N	do not use treated seed as food
325	furalaxyl	F		X	III	3	4	4	Xn,N	
326	furametpyr	F	OX							
327	furathiocarb	I	CA	X	Ib	1	1	1	T+, Xn,Xi,N	
328	gamma-HCH	I,R	OC	X	II	1	3	1	T,Xn	poss. carc.
329	glufosinate-ammonium	H		P	III	3	4	4	Xn	
330	glyphosate	H		I	U	3	4	4	Xi,N	do not use treated seed as food
331	guazatine	F		P	II	2	3	4		
332	GY-81	F, I, N				2	4	4		
333	halfenprox	A	PY	X		1	4	2		
334	halofenozide	I				2	4	4		
335	halosulfuron-methyl	H	SU		U	3	4	4		phyt. to some maize varieties
336	haloxyfop	H	ARP	X	II	1	4	4		
337	HC-252	H	DE							
338	heptenophos	I	OP	X	Ib	3	3	1	T	
339	hexachlorobenzene	F			Ia	1		4	T,N	poss. carc.; do not eat treated seed

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
340	hexaconazole	F	T	P	U	2	4	4	Xn,N	
341	hexaflumuron	I	BU		U	3	4	4		
342	hexazinone	H		X	III	3	4	4	Xn,Xi,N	
343	hexythiazox	A		P	U	3	4	4	N	
344	hydramethylnon	I		X	III	3	4	4		
345	hydrogen cyanide	I, R	IC		Fum	1	1	1	F+, T+,N	only to be applied by trained personnel
346	hydroprene	I			U	3		4		
347	8-hydroxyquinoline sulfate	F, B				3	4	4	Xn	
348	hymexazol	F		P	U	3	4	4	Xn,Xi,N	
349	imazalil	F	IMI	I	II	2	4	4	Xn,Xi,N	
350	imazamethabenz-methyl	H	IL	P	U	3	4	4		some crops cannot be planted for a long time
351	imazamox	H	IL	I		3	4	4		
352	imazapic	H	IL	III		3	4	4		
353	imazapyr	H	IL	X	U	3	4	4	Xi,N	
354	imazaquin	H	IL	P	U	3	4	4		
355	imazethapyr	H	IL		U	3	4	4		
356	imazosulfuron	H	SU			3	4	4		
357	imibenconazole	F			U	1	4	4		
358	imidacloprid	I	NEO	P	II	3	3	2		
359	iminoctadine	F		X	II	2	4	4	Xn,Xi,N	
360	imiprothrin	I	PY			1	4			
361	indanofan	H				1	4			
362	indoxacarb	I				1	3	3		
363	iodosulfuron-methyl-sodium	H	SU	I		3				
364	ioxynil	H		P	II	2	3	4	T,Xn,N	can poss. harm the unborn child
365	ipconazole	F				2				
366	iprobenfos	F			III	2	4		Xn	
367	iprodione	F		I	U	2	4	4	N	Poss. carc.
368	iprovalicarb	F		I	U	3	4	4		
369	isoprocarb	I	CA		II	2		3	Xn,N	
370	isopropyl-o-salicylate	I	OP							
371	isoprothiolane	F		X	III	2	4			phyt. to cucurbits
372	isoproturon	H	U	I	III	3	4	4	Xn,N	poss. carc.
373	isouron	H	U		III	3	4	4		
374	isoxaben	H		P	U	3	4	4	N	phyt. to follow-up crop
375	isoxaflutole	H		I		3	4	4	N	Poss. harm to unborn child

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
376	isoxathion	I	OP	X	Ib	2	2	1	T	
377	karbutilate	H	U		U	3		4		
378	kresoxim-methyl	F	STRO	I		1	4	4	N	Poss. carc.
379	lactofen	H	DE			1	4	4		
380	lenacil	H		P	U	2	4	4		
381	linuron	H	U	I	U	2	4	4	Xn,N	poss. carc.; residual activity 3-4 months
382	lufenuron	I, A	BU	P	III	3	4	4	N	
383	malathion	I, A	OP	P	III	1	4	3	Xn	do not store in humid surroundings; phyt. to some crops; poss. carc.
384	mancopper	F	DC	X						
385	mancozeb	F	DC	P	U	2	4	4	Xi	do not store in humid surroundings
386	maneb	F	DC	P	U	1	4	4	Xi	phyt. to fruit; poss. carc.
387	MCPA	H	ARA	P	III	3	3	4	Xn,Xi	poss. cargino-genic residual activity 3-4 months; toxic to cattle; phyt. to some crops
388	MCPA-thioethyl	H	ARA		III	2	4	4		
389	MCPB	H	ARA	P	III	3	4	4	Xn	poss. carc.
390	mecarbam	I, A	OP	X	Ib			4	T,N	persistent
391	mecoprop	H	ARA	I	III	3	4	4	Xn,Xi	poss. carc.
392	mefenacet	H		X	U	2	4		N	
393	mefluidide	H		P	III	3	4	4		
394	mepanipyrim	F			U	2	4	4		
395	mepronil	F	OX	X	U	2	4	4		
396	mercuric chloride	F	IC		Ia	1			T+, C, T,N	phyt.
397	mercuric oxide	F	IC		Ib	1			T+,N	
398	mercurous chloride	F, I	IC		II				Xn,Xi,N	
399	mesotrione	H		I						
400	mesosulfuron-methyl	H	SU			3	4	4		
401	mesotrione	H				3	4			
402	metalaxyl	F		X	III	3	4	4	Xn,N	
403	metalaxyl-m	F		I	II	3	4	4	Xn, Xi	
404	metaldehyde	M	IC	P	II	3	3	4	F, Xn	4g is fatal
405	metam	F, H, I, N		P	II	1	4	4	Xn,C,N	phyt.; do not plant within 4-10 weeks

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
406	metamifop	H				1		4		
407	metamitron	H		P	III	3	4	4	Xn,N	persistent
408	metazachlor	H	CHL	P	U	2	4	4		
409	metconazole	F	T	P	III	2	4	4		
410	methabenzthiazuron	H	U	P	U	3		3	N	
411	methamidophos	A,I	OP	P	Ib	3	2	1	T+,Xi,N	fatal if swallowed, inhaled or absorbed
412	methasulfocarb	F			II	2				
413	methidathion	I, A	OP	X	Ib	1	2	1	T,Xn,N	
414	methiocarb	M, I, A, B	CA	P	Ib	1	1	4	T,N	
415	methomyl	I, A	OCA	P	Ib	2	2	1	T+,N	
416	methoprene	I		X	U	2	4	4		
417	methothrin	I	PY							
418	methoxychlor	I	OC	X	U	1	4	3		
419	methoxyfenozide	I				2	4	4		
420	methylarsonic acid	H		X	III		4	4	T,N	
421	methyl bromide	I,A,N,F,H	IA	P	Fum	1	3	4	T,Xn,Xi,N	apply 7 days before planting; to be used by trained personnel only; phyt.
422	methyldymron	H			U	3				
423	methyliodide	I, A, R, F			Fum	1		2		
424	methylisothiocyanate	N,F,I, H		X	II	1	3	4	T, C,N	only to be used by trained personnel; phyt.
425	metiram	F	DC	P	U	2	3	4		
426	metobenzuron	H	U							
427	metobromuron	H	U	X	U	3	3	4		phyt. to tobacco, beans
428	metolachlor	H	CHL	X	III	2	4	4		
429	metolcarb	I	CA		II	2			Xn,N	
430	metominostrobin	F	STRO			3	4	3		
431	metosulam	H	TP	P	U		4	4		
432	metoxuron	H	U	X	U	3	4	4	N	phyt. to some graminaceous crops
433	metribuzin	H	T	P	II	2	3	4	Xn,N	phyt. to many crops
434	metsulfuron-methyl	H	SU	I	U	3	4	4	N	
435	mevinphos	I,A	OP	X	Ia	1	1	1	T+	Dangerous to cattle
436	MK-616	H				3	4			

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
437	molinate	H	TC	I	II	1	4		Xn	
438	monocrotophos	I,A	OP	X	Ib	2	1	1	T+,N	poss. Carc.; persistent
439	monolinuron	H	U	X	U	3	4	4	Xn,N	
440	myclobutanil	F	T	P	III	2	4	4	Xn,Xi,N	can poss. harm the unborn child
441	nabam	F, Al	DC	X	II	3		4	Xn,Xi,N	phyt., not when mixed with zinc sulphate
442	naled	I,A	OP	P	II	2		1	Xn,Xi	phyt. to many crops
443	naproanilide	H				2				phyt. to rice
444	napropamide	H		P	U	3	4	4		phyt. to wheat, barley
445	naptalam	H		X	U	3	4	4	Xn	phyt. to beet, spinach, tomatoes, lettuce
446	neburon	H	U	X	U	1		4		
447	niclosamide	M			U	1	4	4		
448	nicosulfuron	H	SU	P	U	3	4	4		
449	nicotine	I	BO		Ib	3	1	4	T+,N	greater risk for non-smokers
450	nitenpyram	I	NEO			3	4			
451	nitrapyrin	B			III	2	3		Xn,N	
452	nitrothal-isopropyl	F		X	U	1	4	4		
453	norflurazon	H		X	U	3	4	4		
454	novaluron	I	BU			2	4	4		
455	nuarimol	F		X	III	3	3	4		
456	octhilinone	F, B		X	III	1	4		T,Xn,C,N	
457	ofurace	F		X	U	3	4	4		
458	omethoate	I,A	OP	X	Ib	2	3	1	T,Xn,N	phyt. to peach
459	orbencarp	H	TC	X		2	4	4		
460	oryzalin	H	DA	P	U	2	4	4		
461	oxadiargyl	H		I		3	4	4		
462	oxadiazon	H		P	U	3	4	1	N	
463	oxadixyl	F		X	III	3	4	4	Xn	
464	oxamyl	I,A,N	OCA	P	Ib	2	1	2	T+, Xn,N	
465	oxasulfuron	H	SU	I	U	3	4	4		
466	oxaziclomefone	H				3				
467	oxine-copper	F	IC	X	U	1	4	4		poss. carc.
468	oxolinic acid	B				3				
469	oxpoconazole fumarate	F	IMI			2	4			

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
470	oxycarboxin	F	OX	X	U	3	4	4	Xn,N	in USA not allowed on food crops
471	oxydemeton-methyl	I	OP	P	Ib	1	1	1	T,N	phyt. to ornamentals
472	oxyfluorfen	H	DE	P	U	1	4	4		inflammable; phyt. to cotton, soya
473	paraquat dichloride	H	DP	P	II	3	3	4	T+,Xi,N	Dangerous if taken orally
474	parathion-ethyl	I,A	OP	X	Ia	1	1	1	T+,N	phyt. to some crops
475	parathion-methyl	I,A	OP	X	Ia	2	3	1	T+	
476	pebulate	H	TC	X	II	2	4	4	Xn,N	
477	pefurazoate	F	IMI			2	1	4		
478	penconazole	F	T	P	U	2	4	4		
479	pencycuron	F		P	U	2	4	4		
480	pendimethalin	H	DA	I	III	1	4	4	N	phyt. to maize
481	pentachlorophenol	I, F, H		X	Ib	1			T+,Xi,N	poss. carc.
482	pentanochlor	H		X	U			3		
483	pentoxazone	H				3	4	4		
484	permethrin	I	PY	X	II	1	4	1	Xn	poss. carc.
485	perthane	I	OC		III	1		3		
486	pethoxamid	H	CHL			1	4	4		
487	pertoleum oils	I, A, H			III	3		4		poss. carc.; phyt.
488	phenmedipham	H	C	P	U	3	4	4		
489	phenothrin	I	PY	X	U	1	4	1		
490	phenthoate	I,A	OP	X	II	1	3	1	Xn	phyt. to fruit
491	phenyl mercury acetate	F	IC		Ia	1	3	3	T, C,N	highly toxic to mammals
492	2-phenylphenol	F			U	1			Xi	phyt. to growing plants
493	phorate	I, A, N	OP	X	Ia	1	1	2	T+	phyt. to some crops
494	phosalone	I,A	OP	P	II	1	3	3	T+, Xn,N	
495	phosmet	A, I	OP	P	II	1	4	1	Xn	
496	phosphamidon	I,A	OP	X	Ia	2	1	1	T+,N	poss. carc.; phyt. to fruit, sorghum
497	phosphine	I,R	IC	P	Fum	1			F, T+	toxic when inhaled; only to be applied by trained personnel; inflammable; not to be applied to plants, fruit, vegetables
498	phosphonic acid	F			U				Xn, C	
499	phoxim	I	OP		II	1	2	1	Xn	phyt. to cotton

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
500	phthalide	F			U	3	4	4		phyt. to broad leaved plants
501	picloram	H		P	U	3	4	4		
502	picolinafen	H		I		1	4	4		
503	picoxustrobin	F		I						
504	picoxystrobin	F	STRO			1	4	4		
505	piperalin	F								
506	piperophos	H			II	2	4	4	Xn	
507	pirimicarb	I	CA	P	II	3	2	3	T,N	
508	pirimiphos-methyl	I	OP	P	III	1	2	1	Xn	phyt. to maize
509	prallethrin	I	PY		II	1	4			
510	pretilachlor	H	CHL		U	1	3	3	Xi	
511	primisulfuron-methyl	H	SU		U	3	4	4		
512	probenazole	F, B			U	2				
513	prochloraz	F	IMI	P	III	1	4	3	Xn,N	
514	procymidone	F		P	U	2		4		
515	prodiamine	H			U	2	4	4		
516	profenofos	I, A	OP	X	II	1	1	1	Xn	not to be used near desired plants
517	profoxydim	H	CO			1	4	4		
518	prometon	H	T		U	2	3	4		
519	prometryn	H	T	X	U	1	4	4		
520	propachlor	H	CHL	P	III	1	3	4	Xn,Xi,N	
521	propamocarb hydro-chloride	F		P	U	3	4	4	Xi	
522	propanil	H		P	III	2	3	4	Xn,N	phyt. in combination with insecticides
523	propaquizafop	H	ARP	P	U	1	4	4		not to be used on cucurbits
524	propargite	A		P	III	1	4	4	Xn,Xi,N	phyt. to citrus and cotton
525	propazine	H	T	X	U	3	4	4	N	poss. carc.; phyt. to many vegetables
526	propetamphos	I, A	OP	X	Ib	2	3		T	
527	propham	H	CA	X	U	3	4	4		poss. carc.
528	propiconazole	F	T	I	II	3	4	4	Xn,N	
529	propineb	F	DC	I	U	2	4	4		
530	propisochlor	H	CHL		III	1	4	4		
531	propoxur	I	CA	X	II	1	3	1	T,N	
532	propoxycarbazone-sodium	H				2	4	4		
533	propyzamide	H		I	U	3	4	4	N	

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
534	prosulfocarb	H	TC	P	II	1	4	4	Xn,N	phyt. to winter barley
535	prosulfuron	H	SU	I	III	3	4	4	Xn,N	
536	prothioconazole	F	TRI			1	4	4		
537	prothiofos	I	OP	X	II	1	2	4	Xn,Xi	
538	pymetrozine	I		I	III	3	4	4		
539	pyraclofos	I	OP	X	II	1	3	4		phyt. to fruit
540	pyraclostrobin	F	STRO			1	4	4		
541	pyraflufen-ethyl	H	SU	I		3	4	4		
542	pyrazolynate	H			U	3				
543	pyrazophos	F		X	II	1	3	4	Xn,N	
544	pyrazosulfuron-ethyl	H			U	3	4	4		
545	pyrazoxyfen	H		X	III	1				
546	pyrethrins (pyrethrum)	I	BO		II	1	4	1	Xn,N	
547	pyribenzoxim	H						4		
548	pyributicarb	H, F				3				
549	pyridaben	I, A		P	III	1	4	2	T,N	
550	pyridaphenthion	I, A	OP	X	III	3	3	1		
551	pyridate	H		I	III	3	4	4	Xi,N	should not be applied in mixtures
552	pyrifenox	F		X	III	2	4	4		
553	pyrimethanil	F		P	U	3	4	4		phyt. in humid conditions
554	pyrimidifen	A, I				1	3	1		
555	pyriminobac-methyl	H			U	3	4	4		
556	pyriproxyfen	I		P	U	1	4			
557	pyrothiobac-sodium	H			U	3	4	4		
558	pyroquilon	F		X	II	3	3	4	Xn,N	
559	quinalphos	I,A	OP	X	II	2	3	1	T,Xn	phyt. to fruit
560	quinclorac	H			U	3	4	4	Xi	
561	quinmerac	H		P	U	3	4	4		
562	quinoclamine	H, Al		P	III	1				
563	quinoxyfen	F			U	1	4	4	N	phyt. to cucurbits
564	quintozene	F		X	U	3	4	4	Xi	
565	quizalofop	H	ARP	X	III	2	4	4		
566	quizalofop-P	H	ARP	X	II	3	4	4	Xn,N	Poss. harm to unborn child & fertility
567	resmethrin	I	PY	X	III	1	4	1	Xn,N	
568	rimsulfuron	H	SU	P	U	3	4	4		
569	rotenone	I,A	BO		II	1		4	T,Xi,N	very toxic to pigs
570	RU 15525	I	PY			1		1		

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
571	sabadilla	I							Xi	
572	sethoxydim	H	CO	X	III	3	4	4		
573	siduron	H	U	X	U	3	4			phyt. to graminous crops
574	silafluofen	I	PY			3	4	2		
575	silthiofam	F		I						
576	silthiofam	F								
577	simazine	H	T	P	U	3	4	4	N	poss. carc.; phyt. to many crops
578	simeconazole	F	TRI							
579	simetryn	H	T		III	2		4	Xn,N	
580	sodium chlorate	H	IC		III	1		4	O, Xn	explosive; phyt.
581	sodium fluoroacetate	R	IC		Ia				T+,N	only to be used by trained personnel
582	spinosad	I			U	2	4	1		
583	spirodiclofen	A				3	4	4		
584	spiromesifen	I,A					4	4		
585	spiroxamine	F		I	II	3	2	4	Xn,Xi,N	
586	strychnine	R		X	Ib				T+,N	
587	sulcotrione	H		P		3	4	4		
588	sulfaquinoxaline	B, R								
589	sulfentrazone	H				3	4			
590	sulfluramid	I			III	2	2			
591	sulfometuron-methyl	H	SU		U	3	4	4		avoid desirable plants
592	sulfosulfuron	H	SU	I		3	4	4		phyt. to barley, oats
593	sulfotep	I, A	OP	X	Ia	1		4	T+	phyt. to ornamentals
594	sulfur	F,A	IC		U	3	4	4		sulphur can spontaneously ignite unless diluted with about 50% inert material; do not use on fruit that is to be processed
595	sulfuryl fluoride	I			Fum				T,Xi	Phyt.
596	SZI-121	A				3	4	4		
597	tar oils	I,H,F		X		1				poss. carc.; phyt.
598	2,3,6-TBA	H		X	III	3	4	4	Xn,N	
599	tca-sodium	H		X	U	3	4	4	Xi,N	
600	tebuconazole	F	T	P	III	2	4	4	Xn	
601	tebufenozide	I		P		2	4	4	N	
602	tebufenpyrad	A		P	III	1	4	3	Xn	
603	tebupirimifos	I	OP		Ia	3	2			
604	tebuthiuron	H	U	X	III	3	4	4	Xn,N	avoid desirable

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard Fi	8 Bi	9 to: Be	10 risks	11 other remarks
										plants
605	tecloftalam	B				3				
606	tecnazene	F		X	U	1		4	Xn,N	
607	teflubenzuron	I	BU	P	U	3	4	4		
608	tefluthrin	I	PY	P	Ib	1	4	1	T+,N	
609	temephos	I	OP	X	U	3	3	1		
610	terbacil	H		X	U	3	4	4		
611	terbufos	I,N	OP	X	Ia	1	2	3	T+	
612	terbumeton	H	T	X	II	3		4	Xn,N	
613	terbuthylazine	H	T	P	U	2	4	4	Xn	phyt. to many annuals
614	terbutryn	H	T	X	U	2	4	4		
615	tetrachlorvinphos	I,A	OP	X	U	1	4	2		poss. carc.
616	tetraconazole	F	T	P	II	2	3	4	Xn,N	
617	tetradifon	A		X	U	3	4	4		phyt. to ornamentals
618	tetramethrin	I	PY	X	U	1	4	1		
619	thenylchlor	H	CHL			1	4	4		
620	tetramethrin	I	PY			1				
621	thenylchlor	H	CHL			1	4	4		
622	thiabendazole	F	BEN	I	U	2	4	4	N	
623	thiacloprid	I	NEO		II	3	1	1		
624	thiamethoxam	I	NEO		III	3	4	1		
625	thiazopyr	H		X	III	2	4	4		
626	thifensulfuron-methyl	H	SU	I	U	3	4	4		
627	thifluzamide	F	OX			2	4	4		
628	thiobencarb	H	TC	P	II	1	4	4	Xn,N	
629	thiocyclam hydrogen oxalate	I			II	1	1	1	Xn,N	
630	thiodicarb	I, M	OCA	P	II	2	4	2	T+,N	
631	thiofanox	I,A	OCA	X	Ib	1	1	4	T+,N	
632	thiometon	I,A	OP	X	Ib	1	2	1	T,Xn	phyt. to ornamentals
634	thiophanate-methyl	F	BEN	X	U	2	4	4	Xn,N	poss. carc.
635	thiram	F	DC	I	III	1	3	4	Xn,Xi	poss. carc.
636	tiocarbazil	H	DC	X	U	3	4	4		
637	tolclofos-methyl	F		P	U	2	4			
638	tolyfluanid	F		P	U	1	4	4	T,Xi, Xn, ,N	
639	tralkoxydim	H	CO	P	III	2	4	4	Xn	
640	tralomethrin	I	PY	X	II	1	4	4		
641	transfluthrin	I	PY		U	1	4		Xi,N	

1	2 active ingredient	3 type	4 chem group	5 EU	6 WHO	7 hazard to: Fi	8 Bi	9 Be	10 risks	11 other remarks
642	triadimefon	F	T		III	3	4	4	Xn,N	
643	triadimenol	F	T	P	III	3	4	4	Xn	
644	tri-allate	H	TC	P	III	2	4	4	Xn,N	phyt. to oats
645	triasulfuron	H	SU	I	U	3	4	4	N	
646	triazamate	I		P	II	1	2	4	Xn	
647	triazophos	I,A,N	OP	X	Ib	1	1	1	T,Xn,N	
648	triazoxide	F		P	II	1	3	4		
649	tribenuron-methyl	H	SU	P	U	3	4	4		
650	trichlorfon	I	OP	P	II	1		2	Xn	poss. carc.
651	triclopyr	H		P	III	3	4	4		phyt. to some crops
652	tricyclazole	F		P	II	2	3		Xn	
653	tridemorph	F			II	1	4	3	Xn,Xi,N	poss. harm unborn child
654	trietazine	H	T	X	U	2	4	4	Xn	
655	trifloxystrobin	F	STRO	I	III	1	4	4		
656	trifloxy sulfuron-sodium	H	SU		III	3	4	2		
657	triflumizole	F	IMI	P	III	2	4	4		
658	triflumuron	I	BU	P	U	3	4	1		
659	trifluralin	H	DA	P	U	1	4	4	Xi,N	
660	triflusulfuron-methyl	H	SU	P	U	3	4	4		
661	triforine	F		X	U	3	4	4		phyt. to pear
662	trimethacarb	I, M	CA			1		1		phyt. to seed
663	triticonazole	F	T	P	U	3	4			
664	validamycin	F		X	U	2	4	4		
665	vamidothion	I,A	OP	X	Ib	3	2	1	T,Xn,N	persistent
666	vinclozolin	F		P	U	3	4	4	N	Poss. harm to unborn child
667	warfarin	R	AR	P	Ib			4	T,N	poss. harm unborn child
668	XMC	I			III	3	4	4	Xn	
669	xylylcarb	I			II	2			Xn,N	
670	zineb	F	DC	X	U	2		4	Xi	poss. carc.; phyt. to tobacco, cucurbits
671	ziram	F	DC	I	III	2	3	4	Xn,Xi	poss. carc.; phyt. to tobacco, cucurbits
672	zoxamide	F	BEN			3	4	4		

Appendix 3: Weights and measures

….	… equals ….	… equals ….	… equals ….
Length measures			
1 inch (in)		2.540 centimetres (cm)	
1 foot (ft)	12 in.	30.480 centimetres (cm)	
1 yard (yd)	3 ft	0.914 metre (m)	
1 mile	1760 yd	1.609 kilometres (km)	
1 millimetre (mm)		0.039 inch (in)	
1 centimetre (cm)	10 mm	0.394 inch (in)	
1 metre (m)	100 cm	1.094 yards (yd)	
1 kilometer (km)	1000 m	0.621 mile	
Area measures			
1 square inch (in^2)		6.452 cm^2	
1 square foot (ft^2)	144 in^2	0.093 m^2	
1 square yard (yd^2)	9 ft^2	0.836 m^2	
1 acre (a)	4840 yd^2	0.405 hectare (ha)	
1 square mile	640 acres	259 hectares (ha)	
1 square centimetre (cm^2)	100 mm^2	0.155 in^2	
1 square metre (m^2)	100 dm^2	1.196 yd^2	
1 hectare (ha)	10,000 m^2	2.471 acres (a)	
1 square kilometre (km^2)	100 ha	0.386 $mile^2$	
Volume measures (UK, metric)			
1 cubic inch		16.387 cm^3	
1 cubic foot (ft^3)	1.728 in^3	28.317 dm^3	
1 cubic yard (yd^3)	27 ft^3	0.765 m^3	
Volume measures (metric)			
1 cubic centimetre (cm^3)		0.061 cu. Inch (in^3)	
1 cubic metre (m^3)	1,000 dm^3	35.314 cu. feet (ft^3)	

Volume measures (UK and US)			
1 fluid ounce (fl.oz.)			29.573 milli-litres (ml)
1 pint (pt)	20 fl.oz.	4 gills	0.568 litre
1 gallon (UK)	8 pints	4 quarts	4.546 litres
1 gallon (US)	1.201 gallons (UK)		3.785 litres
1 bushel (UK)			36.28 litres
1 bushel (US)	0.969 bushel (UK)		35.24 litres
Measures of weight			
1 dram (dr)	27.343 grains	1.772 grams (g)	
1 ounce (oz)	16 dr	28.35 grams (g)	
1 pound (lb)	16 oz	0.454 kilogram (kg)	
1 hundredweight (cwt)	112 lb	50.80 kilogram (kg)	
1 long ton	20 cwt	1.016 tonnes	
1 short ton	2000 lb	0.907 tonne	
1 gram	0.035 oz		
1 kilogram (kg)	1000 g	2.205 pounds (lb)	
1 quintal (q)	100 kg	220.46 pounds (lb)	
1 tonne	1000 kg	0.984 long ton	1.102 short ton
Quantities/ area measures			
1 lb/acre	1.121 kg/ha		
1 bushel (60 lb/acre)	67.26 kg/ha		
1 long ton/acre	2.508 tonne/ha		
1 short ton/acre	2.242 tonne/ha		
1 kg/ha	0.892 lb/acre		
1 tonne/ha	0.398 long ton/acre	0.446 short ton/acre	
Temperature			
Freezing point of water	0ºC Celsius (0ºC)	32º Fahrenheit (32ºF)	
Boiling point of water	100ºC Celsius (100ºC)	212º Fahrenheit (212ºF)	
Conversion Celsius => Fahrenheit: (F x 9/5) + 32 C			
Conversion Fahrenheit => Celsius: (C – 32) x 5/9 F			

Further reading

Chapter 2 and Appendix 2:
Hartley, D. (ed.): **The Agrochemicals Handbook**. Royal Society of Chemistry, Nottingham, 2003. ISBN 0-85186-416-3.

C.D.S. Tomlin (ed.): **The Pesticide Manual**. A World Compendium. British Crop Protection Council (BCPC), London, UK, 2003. ISBN 1-901396-13-4. Also electronically available.

Copping, L. **The Biopesticide Manual**. 528 pp. British Crop Protection Council (BCPC), London, UK, 2001. ISBN 1-901396-29-0.

To view the content, sample entries from both manuals can be downloaded from **www.bcpc.org** in *.pdf* or *.doc*-format.

Chapter 3
Matthews, G.A. and E.W. Thornhill**: Pesticide application equipment for use in agriculture.** Vol. 1: Manually carried equipment. FAO Agricultural services bulletin 112/1.

Anon.: **Risks and consequences of the misuse of pesticides in the treatment of stored products.** GASGA (Group for Assistance on Systems relating to Grains After harvest) and CTA, Wageningen, 1996. 20 pp. No ISBN; also available in French.

Chapter 4
International Hazard Classification Systems for Crop Protection Products. CropLife International, Brussels, 1998, 7 pp. No ISBN.

AgroBrief no. 2: **Poisoning by agrochemicals - symptoms and first aid. Agromisa**, Wageningen, 2004.

Chapters 5 and 6

www.africastockpiles.org: African Stockpile Programme on obsolete pesticide stocks (ASP). International initiative aiming to clean-up stockpiles and waste in an environmentally sound manner, thus preventing further accumulation. Partners involved in ASP include governments and non-governmental organizations; the website shows a full list of partners.

www.fao.org/ag/AGP/AGPP/Pesticid/Disposal/: The FAO website on prevention and disposal of pesticides, including obsolete pesticide stocks.

General

Norris, R.F, E.P. Caswell-Chen, M. Kogan**: Concepts in Integrated Pest Management.** 2003. Ch. 11: Pesticides (p. 242-313) ISBN 0-13-087016-1

Oudejans, J.H.: **Agro-pesticides: Properties and Functions in Integrated Crop Protection.** United Nations Publications/ESCAP, Bangkok, 1994. 329 p. ISBN 974-88754-8-2.

Schwab, A. et al. **Pesticides in tropical agriculture – hazards and alternatives**. Tropical Agroecology vol. 3; also available in French. PAN-Europe, London, UK and CTA, Wageningen, Netherlands; 1995. 280 pp. ISBN 3-8235-1243-3

Pesticides & Alternatives (3 issues per year). Newsletter on pesticide news, alternatives to chemicals, Integrated Pest Management as well as sustainable agriculture. Editor: PAN Africa (see Useful addresses)

CropLife International: Guidelines (revised since 1997 – 1998), see following table.
'PDF' indicates: downloadable from www.croplife.org.

	Title (ISBN not available)	
1	Safe formulation and packaging of crop protection products	PDF
2	Emergency measures in cases of poisoning	PDF
3	Quality control of crop protection products	
4	The safe transport of crop protection products	PDF
5	The avoidance, limitation and disposal of pesticide waste on the farm	
6	The safe warehousing of crop protection products	PDF
7	Personal protection when using pesticides in hot climates	
8	Writing crop protection product labels and literature	
9	The safe and effective use of crop protection products	PDF
10	Disposal of unwanted pesticide stocks-guidance on practical options	

Useful addresses

Internet

General sources
www.fao.org/AG/AGP/AGPP/Pesticid, for:
* International Code of Conduct
* Maximum Pesticide Residue Levels (MRLs)
* Pesticide Specifications
* Prevention/Disposal of Obsolete Pesticides
* Prior Informed Consent – Rotterdam Convention (PIC)
* Management of Pesticides
* Codex Alimentarius (Ch. 4; also at www.codexalimentarius.net)

Chapter 1, Appendix 1
www.fao.org/pic/
Rotterdam Convention on the Prior Informed Consent (PIC). Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. FAO/UNEP, Rome/Geneva. 1998.

Chapter 2, Appendix 2
www.who.int/pcs/pcs_act.htm
WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification (fully revised 2000-2002).

www.biopesticide.org
Website of the International Biopesticide Consortium for Development. Includes a shortlist of bio-pesticides currently in use.

Chapters 2 and 4, Appendix 1
www.pan-uk.org/Internat/IPMinDC/ai~key.pdf
Guide to active ingredients hazards (5 pages).

www.pan-uk.org/Internat/IPMinDC/ai~dbase.pdf
Table of PAN-UK - full document (60 pages)

www.pan-uk.org/briefing/ListofL.pdf (14 pages)
The List of Lists, set up by PAN-UK. A catalogue of lists of pesticides identifying those associated with particularly harmful health or environmental impacts. Also contains the 2003 EU list of pesticides for voluntary withdrawal by their manufacturer between 2003 and (for some cases) the end of 2008.

www.fadinap.org/nib/nib2002_4/octdec02-6-pestcides.PDF
Full list of 320 active compounds in pesticides that will be banned in the EU at the latest by the end of 2008.

pesticides.coleacp.org/en/pesticides/ (also available in French)
Database of the ACP Group of States and the European Commission on the common Pesticides Initiative Program on ongoing restriction measures of active substances in Europe. Information on pesticide residues in imported agricultural commodities and fresh foodstuffs, that will not be tolerated in the future.

www.fao.org/docrep/X2244E/X2244E00.htm
Website especially devoted to Agricultural Pesticide Sprayers, edited as Volume 1 in the FAO Guidelines Series on Equipment Quality Control and Use, 1998. Rather theoretical; not illustrated.

Chapter 5
www.fadinap.org/safetyguide/guidecolor.pdf (or black-and-white: /guidegray.pdf)
Safety guide for pesticide retail distributors and shopkeepers. A small handbook (15 pages), dealing with almost the same subjects as Chapter 5 of this Agrodok, but more extensively and with abundant illustrations. Editors: Agricultural Requisites Scheme for Asia and the Pacific (ARSAP), of the United Nations ESCAP Rural Development Section, Bangkok, Thailand, 1984.

Harvest protection with insecticides
www.gtz.de/post_harvest/documents/gtzhtml/x0065e/X0065E02

Institutions

CropLife International
Avenue Louise 143, B-1050 Brussels, Belgium
T +32 2 542 04 10 F +32 2 542 04 19
E croplife@croplife.org W www.croplife.org

FAO: Secretariat of the FAO Code of Conduct on Pesticide Use
Plant Protection Service, Pesticide Management Unit, Food and Agriculture Organization
Viale delle Terme di Caracalla, I - 00100 Rome, Italy
T +39 06 5705 3441 F +39-06 5705 6347
E gerold.wyrwal@fao.org

Pesticide Action Network Africa
Regional Centre supporting sound ecological practices as alternatives to hazardous pesticide use
B.P. 15938, Dakar-Fann, Dakar, Senegal
T + 221 825 49 14 F + 221 825 14 43
E panafrica@pan-africa.sn W www.pan-africa.sn

Pesticide Action Network Asia and the Pacific
Regional Centre committed to protect safety and health of people and environment
P.O. Box 117, 10850 Penang, Malaysia
T + 60-4 656 0381 F + 60-4 657 7445
E panap@panap.net W www.panap.net/

Pesticide Action Network UK, Development House
56-64 Leonard Street, London EC2A 4JX, United Kingdom
T + 44 (0) 20 7065 0905 F + 44 (0) 20 7065 0907
E admin@pan-uk.org W www.pan-uk.org

www.intox.org/firstpage.htm
List of poison information centres in 70 countries. Webpage also available in French and Spanish.

Glossary

Term	Explained in section
Acute poisoning	4.3
Active ingredient	2.2
Band application	3.4
Bio(logical)-pesticide	2.2
Broad-spectrum pesticide	3.1
Chemical name	5.1
Chronic poisoning	4.3
Common name	2.1 5.1
Contact (action)	3.1
Dermal toxicity	4.2
Droplet spectrum	3.2
Drift (wind)	3.6
Droplet size	3.2
Good agricultural practice	App 1
Harvest interval	3.6
LD50	4.1
Maximum residue limit (MRL)	4.2
Natural enemies	4.4
Oral toxicity	4.2
Persistence	3.6 4.4
Recommended dose	3.5
Re-entry interval	3.6 5.1 5.6
Registration	4.2 5.1
Residue	2.2 3.6 4.2
Resistance (to pesticide effect)	4.4
Route of entry	4.2
Specificity	2.1
Systemic (action)	3.1
Toxicity	4.1 5.1 App. 2
Trade name	2.1. 2.2 5.1 App. 2
Water pollution	4.4