Desert Locust Guidelines

6. Safety and environmental precautions

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PREFACE

The Desert Locust plague of 1986-89 and the subsequent upsurges in the 1990s demonstrate the continuing potential of this historical pest to threaten agriculture and food security over large parts of Africa, the Near East and southwest Asia. They emphasize the need for a permanent system of well-organized surveys of areas that have recently received rains or been flooded, backed up by control capability to treat hoppers and adults efficiently in an environmentally safe and cost-effective manner.

The events of 1986-89 showed that, in many instances, the existing strategy of preventive control did not function well, for reasons including the inexperience of the field survey teams and campaign organizers, lack of understanding of ultra low volume spraying, insufficient or inappropriate resources and the inaccessibility of some important breeding areas. These reasons were compounded by the general tendency to allow survey and control capacity in locust-affected countries to deteriorate during locust recession periods. To address this, FAO has given high priority to a special programme, the Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES), that will strengthen national capacities.

Given the certainty that there will be future Desert Locust upsurges, FAO produced a series of guidelines primarily for use by national and international organizations and institutions involved in Desert Locust survey and control. The guidelines comprise:

1. Biology and behaviour
2. Survey
3. Information and forecasting
4. Control
5. Campaign organization and execution
6. Safety and environmental precautions

Appendixes (including an index) are provided for easy reference by readers.

These guidelines on safety and environmental precautions have not been produced before, and appear as a first edition. The overall guidelines revision and production process were carried out by K. Cressman of FAO and H.M. Dobson of the Natural Resources Institute, United Kingdom, with input from many locust and locust-related specialists around the world. This edition will be available in the three key languages of the locust-affected countries, English, French and Arabic.

I would like to extend my gratitude to all those who have been involved in this important contribution to improved Desert Locust management.

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24 September 2001

Contents

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INTRODUCTION

This guideline is primarily intended for use by decision-makers, field officers and monitoring staff involved in the organization and execution of Desert Locust control operations. Some parts will be important reference material for training new staff as well as providing background information for experienced locust officers. The guideline may also be useful for donor representatives assessing technical and financial needs of locust-affected countries.

Two subjects are addressed in this guideline. First, the reduction of environmental and human health risks from insecticide use during locust control is discussed. Practical recommendations are given on how to address risk reduction during the campaign preparation phase, how to implement it during the control operations, and how to evaluate it in post-campaign follow-up.

The second subject is environmental and human health monitoring during locust control operations. Monitoring of control operations is necessary to assess whether adverse effects occur and under what circumstances. Such information is essential for improving control techniques and approaches. The guideline will only address operational, short-term monitoring activities and will not discuss more in-depth or long-term monitoring and research.

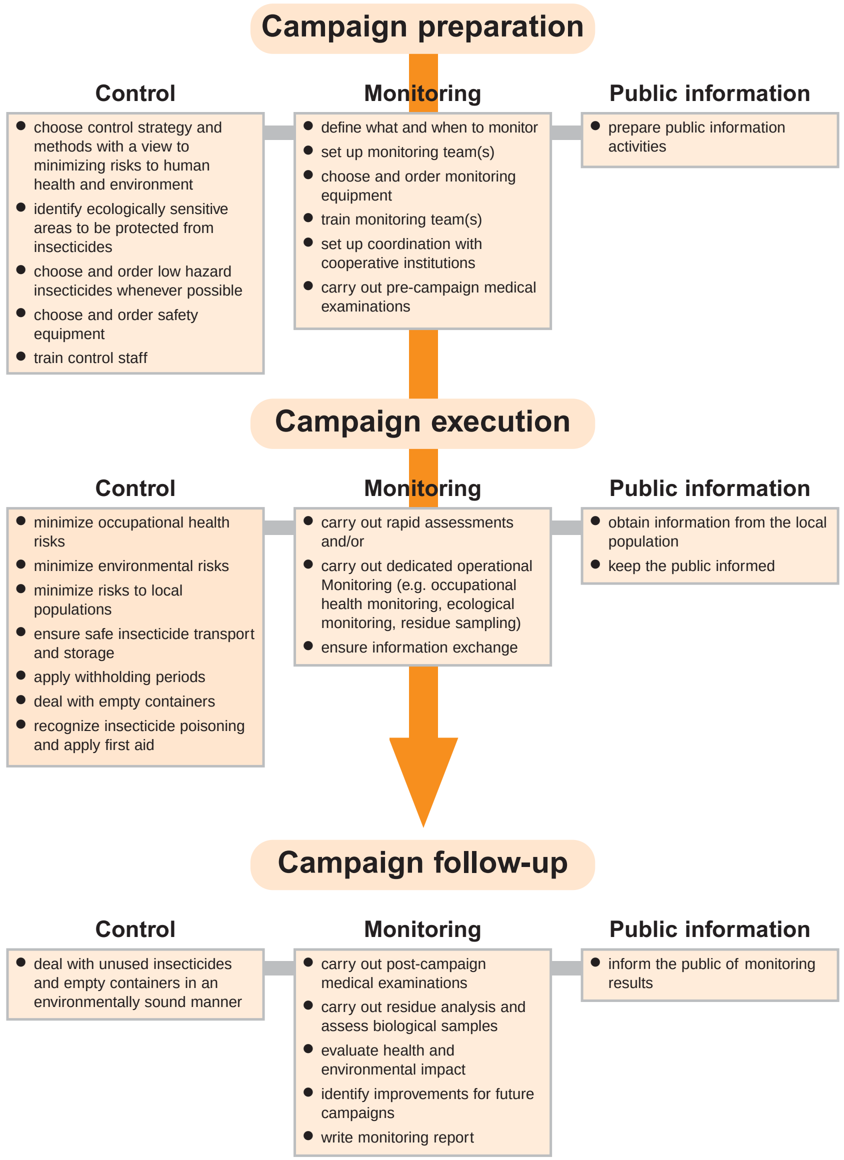
The guideline should be read in conjunction with the *Desert Locust Guidelines* on *Control* (No. 4) and on *Campaign organization and execution* (No. 5), as well as with the *Appendixes* (No. 7). Regular reference will be made to these documents.

Information, advice and explanations are given on the right-hand pages of the publication; illustrations and summaries are shown on the left-hand pages. When appropriate, tables, tips and warnings may appear on either side.

There is also a series of frequently asked questions (FAQs). These deal with some of the common problems encountered by locust control staff. Answers are given where available, but further research is needed in some areas, and FAO welcomes feedback on new information and solutions.

Much of the information given here is relevant to safety and environmental precautions when controlling other types of locusts and some grasshoppers, but techniques may have to be adapted to match the particular characteristics and habitat of the target species.

Figure 1. Elements of the risk reduction process during campaign preparation, execution and follow-up.



RISK REDUCTION PROCESS

The principal objective of all the recommendations and suggestions made in this guideline is to reduce the environmental and health risks of locust control to an acceptable minimum. Many, often interrelated, measures need to be taken to achieve this (see Fig. 1).

Crucial to successful risk reduction is a thorough preparation of the locust control campaign. It is absolutely essential to be well prepared since most control campaigns are a race against time. They rarely last more than eight to ten weeks from the first invasion of parent swarms to the formation of new swarms of the progeny (see *Desert Locust Guidelines* No. 5 *Campaign organization and execution*). This means that, as a control campaign gets off the ground, there will be no more time to start thinking about the best ways to reduce the risk of insecticide use or to plan monitoring activities. These have to be done in advance.

Many questions need to be answered during the preparation stage, such as: What control strategy and what insecticides will be used? What safety equipment should be available? Who should be trained and in which topics? How should medical staff be involved in cases of poisoning? Which areas in the country should not be sprayed, or which insecticides should be avoided? How many monitoring teams should be created, who should they consist of and what should they do? These preparations do not only involve the permanent staff of the locust control unit, but also temporary control staff, medical personnel, environmental scientists and public communication experts. The various pesticide risk reduction measures are best formalised in the contingency plan of the control campaign.

If campaign preparation has been done well, the actual risk reduction activities that need to be carried out during the control operations will be clear. This does not mean that they will be easy, but staff involved will know their tasks and will have been trained on how to carry them out correctly.

It is important to realize that being well prepared is not the same as executing a rigid programme. Everyone who has been involved in a Desert Locust control campaign knows that surprises and unexpected situations are the rule rather than the exception. Staff involved in monitoring safety and environmental precautions should thus be flexible and ready to change plans at short notice.

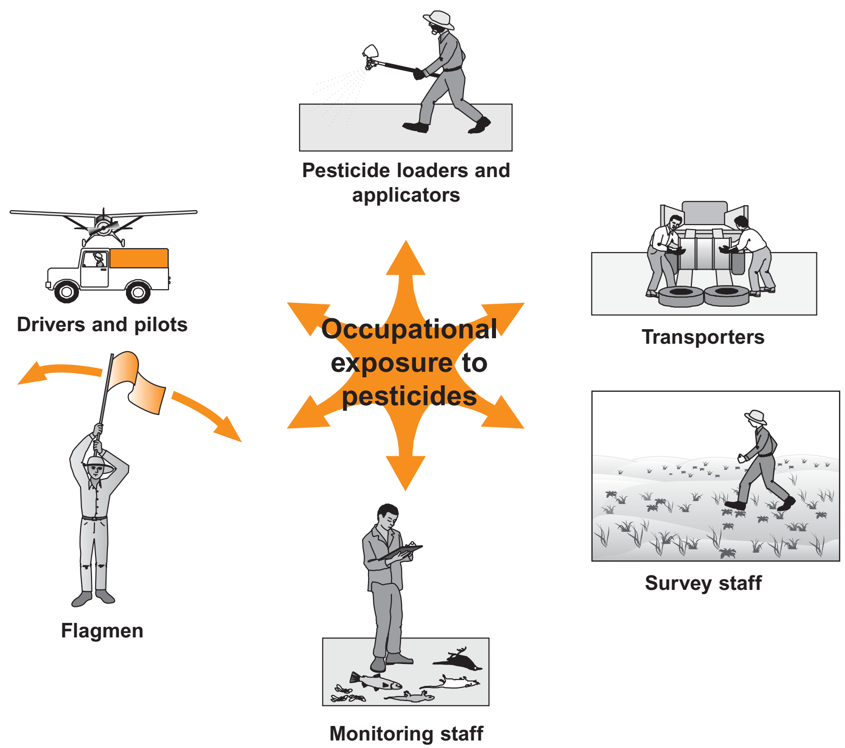
Health and environmental risk reduction activities are not over when the last locust has been killed. Campaign follow-up includes such diverse issues as managing the unused insecticides and empty containers; analysing residues and identifying biological samples; post-campaign health checks of control staff; evaluating the monitoring results and identifying improvements for future campaigns; and writing a detailed report of the risk reduction activities and conclusions.

In the rest of this guideline, all these issues will be discussed in more detail, problems specific to Desert Locust control operations will be addressed, and guidance will be given on how to implement practical risk reduction measures.

Summary of human risk:

- persons involved in locust control campaign (occupational risk)
- persons not involved (local populations)

Figure 2. Various locust control staff may be exposed to insecticides during their work.



Who is at risk?

All the insecticides that are used in locust control pose some risk to human health, although certain products are more dangerous than others. In this guideline a distinction is made between persons that may be exposed because they work in the locust control campaign (occupational exposure) and people that are not involved in locust control (the local populations).

Occupational risk

Field officers who are directly involved in spraying operations tend to be the most exposed to insecticides, and thus also run the highest risk of being poisoned. However, it is important to realize that almost all other field staff can be exposed, either accidentally or during the normal course of their work (see Fig. 2). How this may happen is summarized in the table below. Note that sometimes the same person may execute several of the listed tasks (e.g. an applicator who carries out the loading of the pesticide, and also does the efficacy verification after treatment).

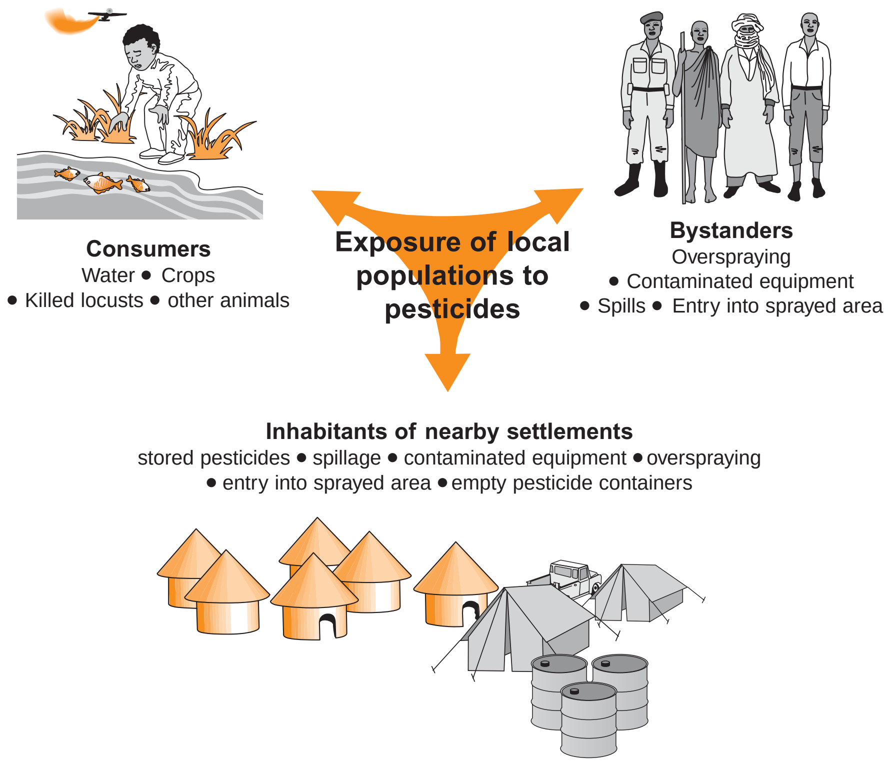
How locust control field staff may be exposed to pesticides

How?	When? *(this list is not exhaustive)*
Pesticide application (ground/vehicle applicators)	- re-entry into spray cloud (variable wind direction) - leaking or contaminated spray equipment and vehicle
Pesticide application (pilots of spray aircraft)	- entry of pesticide into cockpit (leak in hopper or tubing) - re-entry into drifting spray cloud (variable wind direction) - contaminated aircraft
Pesticide application (drivers of spray vehicles)	- re-entry into drifting spray cloud (variable wind direction) - contaminated vehicle
Pesticide loading	- splashes or leaking spray equipment - leaking or bursting loading equipment or tubing
Spray track marking (flagmen)	- direct overspraying (by aircraft or vehicle) - drift of spray cloud (variable wind direction) - entry in recently sprayed area
Storage	- leaking or contaminated containers, drums and bags - fire or explosion
Transport	- contaminated containers, drums and bags - leaking drums and containers (transport over rough terrain) - bursting drums or bags (unloading of vehicle)
Calibration	- splashes during collection of spray fluid - contaminated equipment, vehicle or aircraft
Monitoring	- overspraying or drift of spray cloud - entry into sprayed area - collection of sprayed soil, water, vegetation or animals
Survey and search	- contaminated vehicle (if the same vehicle is used for survey and control activities)

Summary of exposure to insecticides:

- during loading, storage and transport
- during calibration, marking and spraying
- by entering into sprayed areas
- by drinking contaminated water or by eating contaminated food

Figure 3. Local populations may be exposed to insecticides through various routes.



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FAQ number 1 **(see p. 88 for answers)**

If I happen to be accidentally oversprayed by a spray aircraft during locust control operations, should I see a doctor?

Local populations

Local populations are normally not directly involved in Desert Locust control (even though they may sometimes be asked to help localize spray targets). The only exceptions are farmer groups or brigades that, in some countries, may be called upon to assist in the control of hopper bands during an outbreak or plague.

But even if there is no direct involvement in control operations, the local population can still be exposed to insecticides. This is most likely in the areas in which spraying is carried out, but could also be through consumption of contaminated food grown in sprayed areas (see Fig. 3). The various possible routes of exposure are summarized in the table below.

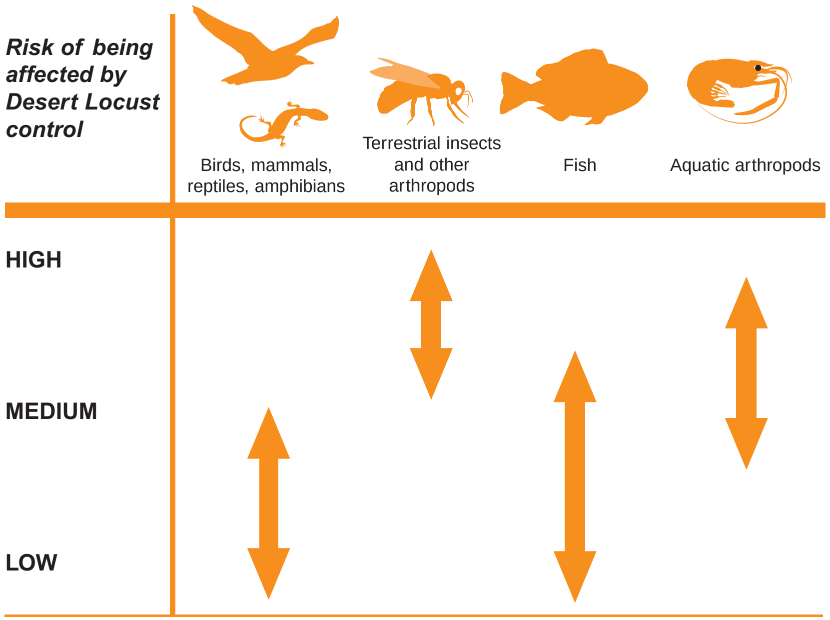
How local people may be exposed to pesticides during or after locust control operations

When?	**How?** *(this list is not exhaustive)*
Overspraying or drift of spray clouds	- people were not informed of treatment and advised to keep safe distance - error was made by pilot or spray operator
Entry into sprayed area	- people were not informed about re-entry period - population did not respect re-entry period
Contaminated equipment or vehicles	- locust control camp or base is close to habitations - people were not advised to keep safe distance - base or camp is not properly guarded
Pesticide spillage	- spillage or equipment cleaning site is not cleaned up - pesticide loading site is accessible to population - pesticide storage site is accessible to population
Sprayed crops	- people were not informed of pre-harvest interval - people did not respect pre-harvest interval
Contaminated drinking-water	- people were not told to close wells - error was made by pilot or spray operator - use of empty pesticide containers for storage of drinking water
Contaminated milk or meat	- people were not instructed to keep livestock away from treated areas - people did not respect livestock withholding period
Killed animals (e.g. fish or locusts)	- people were not instructed to avoid consuming animals killed by the treatments - people did not respect the above instructions

Some examples of the impact of insecticides on:

- Agriculture
  - mortality of natural enemies of pests
  - insecticide residues in crops
  - reduced pollination
- Fisheries
  - mortality of fish and shrimp
- Animal husbandry
  - insecticide residues in meat and milk
  - reduction of honey and wax production
- Surface and ground water
  - pollution, causing (temporary) reduced availability of drinking-water
- Biodiversity
  - reduction of important species for medicine, agriculture, fisheries or animal husbandry
  - reduction of tourism

Figure 4. Indicative risk of locust control insecticides to non-target organisms.



Note: Generalization of risk of insecticides that have been evaluated by the Pesticide Referee Group, at recommended application rates. The potential risk of adverse effects of individual locust control insecticides is given in Appendix 3.2.

What is at risk?

Almost all the insecticides that are at present used for Desert Locust control have broad-spectrum activity and are thus not entirely specific to locusts. As a result, they may adversely affect other organisms in the environment (see Fig. 4). Many organisms that could be affected by locust control insecticides, however, are important natural resources or perform ecological functions on which local populations depend.

For example, inland fisheries are a vital source of food but insecticides may directly kill fish or adversely affect the invertebrates on which they feed. Bees provide honey, wax and the essential pollination of many crops but they are also very susceptible to insecticides. Many wasps, flies, spiders and beetles prey on crop pests; if these natural enemies are killed by insecticides, pests may become a problem for farmers. Most rural people depend on wells or surface water to provide drinking-water; if these are polluted by insecticides, no alternative water supply may be available to them. Livestock will graze on green pastures just like locusts but no insecticide residues should end up in meat and milk after locust control operations. Many other examples can be given of environmental problems that may be caused by insecticides. Often these have a direct impact on the lives of local people in locust-affected countries.

It is therefore vitally important that the environmental impact of locust control is kept to an absolute minimum. This is not an easy task. Many different types of environment exist in the Desert Locust area, all with their own characteristics, animals and plants. An insecticide may pose a problem in one environment, but not in another. Environmental risk reduction therefore has to be done on a case-by-case basis. It involves choosing the right insecticide for a given situation or environment, using the appropriate control strategy and method, and strictly applying environmental protection measures where possible. All these topics will be discussed in more detail in the following sections.

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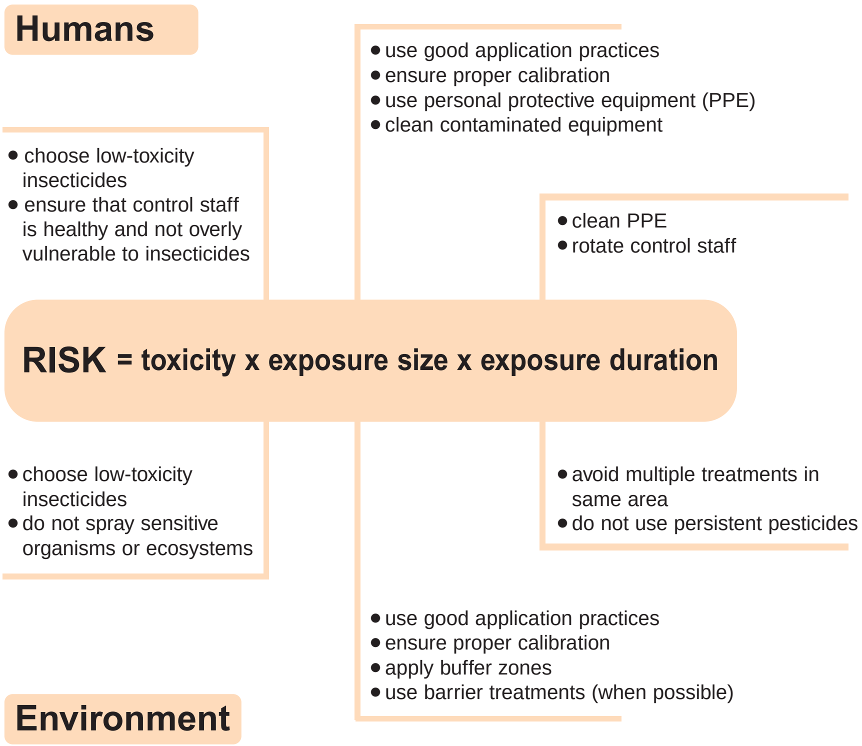
FAQ number 2 (see p. 88 for answers)

Mycopesticides, such as *Metarhizium anisopliae* var. *acridum*, are supposedly only killing locusts and no other non-target organisms. Is this true?

Summary of what determines risk:

- toxicity of the insecticide
- magnitude and duration of exposure

Figure 5. Factors that influence the risk of a pesticide for human beings and the environment, and examples on how to reduce this risk.



What determines risk?

Various factors determine the risk of an insecticide. These factors are very similar for both humans and other non-target organisms. Risk is a function of the toxicity of the insecticide, the magnitude of exposure and its duration (see Fig. 5). If any of these three factors increases, the risk that an insecticide will cause adverse effects increases as well.

Toxicity

Insecticides show both acute and chronic toxicity. Acute toxicity occurs after short-term exposure to the chemical. This is especially relevant for those locust control staff who may be exposed to relatively large doses of insecticides, such as applicators, pesticide loaders and workers who are cleaning equipment or storage sites. Symptoms of acute intoxication normally show soon after exposure.

Chronic toxicity shows much later after insecticide exposure. It may occur after acute exposure, but also following long-term exposure to relatively small amounts of insecticides. Locust control staff who have been working for many years with insecticides are most at risk of developing chronic effects. Symptoms of chronic intoxication to insecticides can be very diverse, and a causal link between the insecticide and its effects is often difficult to make.

The more toxic an insecticide is (either acutely or chronically), the higher the risk will be of adverse effects. In locust control, this risk factor can be influenced by choosing low-toxicity insecticides.

Magnitude of exposure

If an organism is exposed to larger amounts of an insecticide, there will also be a higher risk of adverse effects. This is why it is said that “the dose makes the poison”. In locust control, the magnitude of exposure of both humans and the environment is influenced by many factors. For instance, the dose rate of an insecticide, the number of treatments of the same area, the size of unsprayed buffer zones, the use of appropriate personal protective equipment (PPE), and the quality of equipment calibration will all affect the magnitude of exposure.

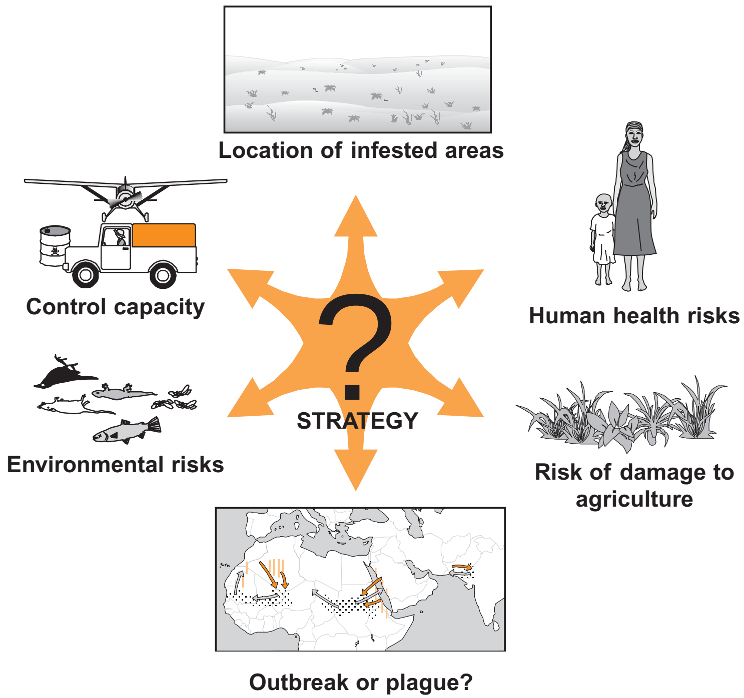
Duration of exposure

The longer an organism is exposed to an insecticide, the higher the risk will be of adverse effects. The duration of exposure is also influenced by many factors. For instance, the persistence of the insecticide and the number of treatments of the same area affect exposure of the environment; and the duration that an applicator works with insecticides or the time he wears contaminated protective clothing influences human exposure.

Summary of choosing a control strategy depends on:

- location of infestations
- outbreak, upsurge or plague situation
- available logistics and control capacity
- presence of ecologically sensitive areas
- potential for crop damage
- environmental and human health risks

Figure 6. The decision as to which control strategy to choose depends on many factors; environmental and health concerns are part of them.



Tip: just as thorough preparation is half the work needed for successful control, so it is with ensuring human and environmental safety. Start planning early, and involve relevant expertise in the preparation of the contingency plan (e.g. environmental scientists, doctors, residue chemists, public communication experts).

CAMPAIGN PREPARATION

As is the case for survey and control, the planning phase of risk reduction in locust control is very important. Without good preparation, the probability that accidents will happen is much greater and environmental and health monitoring will be less effective. Safety measures, environmental precautions and monitoring should therefore always be a standard part of the contingency plans for a control campaign (see *Desert Locust Guidelines* No. 5 *Campaign organization and execution*).

Experts on pesticide safety and environment, as well as senior medical staff, should be involved in campaign planning and organization from the start. This will ensure that they are aware of the specific problems and requirements of a Desert Locust control campaign. They may also be able at an early stage to incorporate human health and environmental concerns in the campaign plan. This will avoid surprises later on, when changes in the plan are difficult or impossible to make because insecticides and equipment have already been ordered and personnel has been trained.

Choosing a control strategy and methods

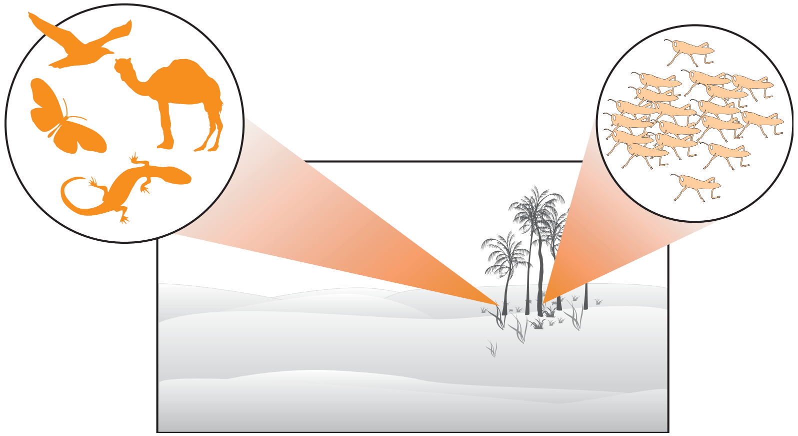
Desert Locust control strategies and methods are discussed in more detail in *Desert Locust Guidelines* No. 5 *Campaign organization and execution*. Which of these are finally chosen in any given situation will depend on many factors. These include the expected location of the Desert Locust infestations; the stage of the outbreak/upsurge; the available logistics and control capacity; the presence of ecologically sensitive areas; and the amount of agricultural and environmental risk a country is willing to take, and donors are prepared to accept in providing campaign funds (see Fig. 6). Environmental and human health concerns are just one factor in this evaluation, but are as important as any of the other factors under consideration. In the end, the expected (economic) benefits of a given control strategy will have to be weighed against the expected environmental and health costs. These will be different from country to country, and from one outbreak/upsurge to another. Some examples of environmental and health issues that need to be evaluated when choosing a control strategy are discussed below.

Recession and outbreak control

Ideally, upsurges are prevented by control of gregarizing populations during recession periods or early outbreaks. This is clearly advantageous from an environmental point of view because normally less insecticide will be needed than in the case of a fully fledged plague.

However, this does not mean that recession control is without environmental risk. Control of early gregarizing populations often takes place in relatively isolated, temporarily green, ecosystems such as wadis. Not only does the Desert Locust profit from these green environments, but many other organisms are dependent on them as well. Such environments tend to be hot spots of biological activity in an otherwise dry (and much less biologically active) desert. Recession control may thus have an environmental impact that is greater than expected if only based on the limited area treated.

Figure 7. The Desert Locust builds up its populations in green areas in deserts, which are also important for the survival of many other organisms.



Comparison of environmental and occupational health concerns between aerial and ground control

Environmental concerns

Aerial treatment

Increasing risk
- large areas sprayed
- higher probability of contaminating sensitive areas
- more uncontrolled drift

Reducing risk
- well-trained staff

Ground treatment

Increasing risk
- more temporary and inexperienced staff

Reducing risk
- small areas sprayed
- more precise applications
- less uncontrolled drift

Occupational health concerns

Aerial treatment

Increasing risk
- large quantities of pesticides handled

Reducing risk
- few staff involved
- well-trained staff
- protective equipment available
- fewer opportunities for exposure

Ground treatment

Increasing risk
- many staff involved
- more inexperienced staff
- more opportunities for exposure
- less protective equipment

Reducing risk
- smaller amounts of pesticides involved

Note that there are often more environmental concerns with aerial treatments but more occupational health concerns for ground control.

Because these green “islands” tend to be isolated in the desert, ecological recovery after insecticide impact may also be slower. Recession control therefore requires appropriate environmental precautions and monitoring, just like upsurge or plague control (see Fig. 7).

Another reason why early control may not always be better from an environmental point of view is that locust populations tend to become more gregarious over a number of generations during the development of an outbreak. As a result, locust numbers may increase dramatically, but the actual area that is infested will decline. In such cases, control may be more effective and less polluting if carried out later in the outbreak.

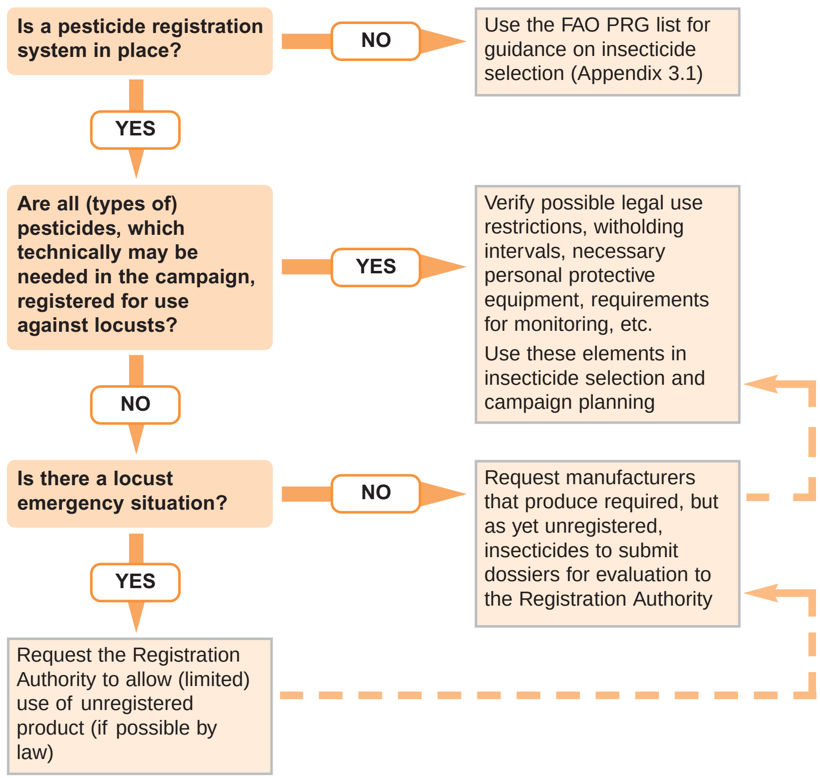
Upsurge and plague control

When upsurge or plague status is attained, control strategies tend to focus on reducing locust populations as much as possible, preferably in locations where the plague cycle may be most effectively broken. Direct crop protection is another major objective. Control methods change from mostly ground control during outbreaks to increasingly aerial control during upsurges and plagues. But this does not mean that strategic choices about control can no longer be made. The control methods that are chosen for the campaign may greatly influence environmental impact: aerial treatment versus ground applications; swarm control versus hopper control; individual band treatments versus block band treatments; and blanket spraying versus barrier treatments. These choices influence the amount of insecticides needed to control a given population, the surface area sprayed and the frequency of application in the same zone (see *Desert Locust Guidelines* No. 5 *Campaign organization and execution*).

In certain situations, entire locust targets may not need treatment, even during an upsurge or plague. This may be the case if it is unlikely that the locust population will contribute much to a new generation, and no direct threat to crops exists. Examples are the so-called “southern circuit” swarms in West Africa, which may infest the Sahel late in the rainy season. They often migrate southwards, towards the more tropical areas of West Africa where they tend to disperse and do not cause problems. Their capacity to generate new populations in the next season is also limited. Because these swarms have only limited potential to do damage, control may not be justified. Other situations exist where one can abstain from control, and thus reduce exposure of humans and the environment to insecticides.

Tip: work sheets are available from FAO that can be used to estimate total insecticide use and surface areas to be treated, depending on various control strategies and methods. These can be used in the pre-campaign environmental evaluation process.

Figure 8. Only registered insecticides should be used for Desert Locust control (where applicable). Use this decision scheme to check whether actions are needed for the registration of products in your campaign.



Tip: because pesticide registration authorities rarely receive the evaluation reports of the FAO Pesticide Referee Group, the locust unit should transmit a copy to them, so it can be used in the registration process of new insecticides for locust control.

Selecting insecticides

The selection of an insecticide for Desert Locust control is based on many criteria (*Desert Locust Guidelines* No. 4 *Control*, for more details), efficacy being a primary factor. The Pesticide Referee Group (PRG) advises FAO on insecticides that have been shown to be efficacious against the Desert Locust, on the correct dose rates to use, and on the environmental risks ofthe listed pesticides (see Appendix 3.1). The safety of the insecticide for humans and for the environment is another very important factor to take into account when choosing products for a control campaign. In the sections below, a number of simple methods will be discussed that may help in deciding which insecticide poses the lowest risk in a specific locust control situation.

Pesticide registration

Many countries affected by the Desert Locust have a regulatory system in place to authorize the use of pesticides. A national agency or committee will evaluate information on the efficacy, toxicity and environmental impact of a pesticide, and decide whether the product can be allowed for use on a given crop (or for public health use). This is referred to as pesticide registration. Pesticides that are not registered can normally not be used in a country (see Fig. 8).

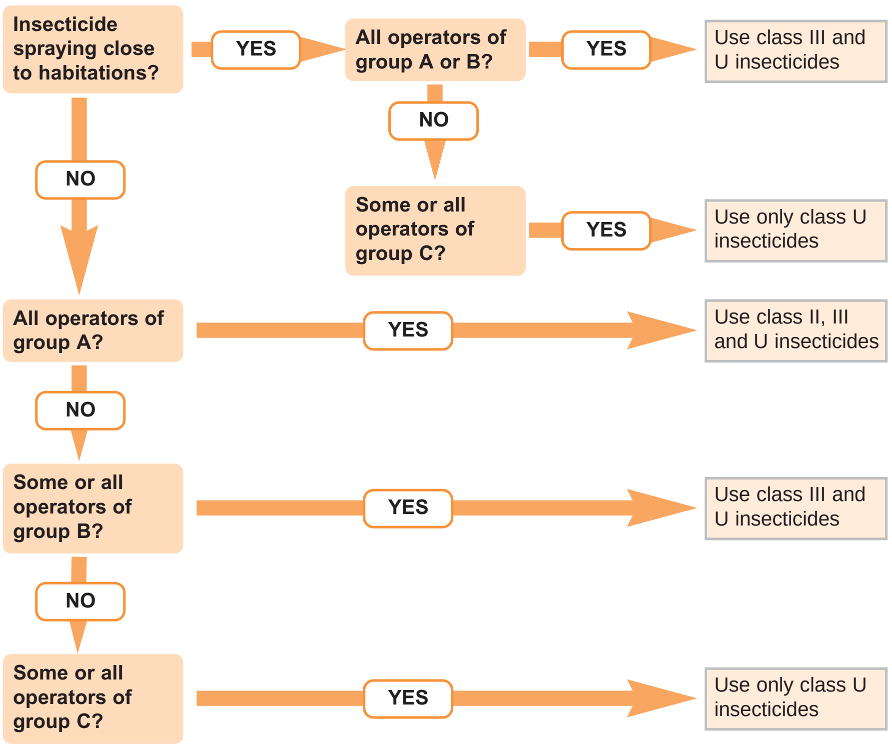
During campaign planning, contact should be sought with the Registration Authority to verify which insecticides have been registered for use against locusts. Additional safety information, such as pre-harvest intervals, witholding periods, required personal protective equipment and specific use restrictions should also be obtained from the Registration Authority.

Many countries will register individual commercial pesticide products and not pesticide active ingredients. This means, for instance, that one or several commercial products containing fenitrothion may be authorized for use against locusts, but not fenitrothion in general.

If a pesticide registration system exists in a country, then locust control units, but also bilateral or multilateral organizations and non-governmental organisations (NGOs), are legally obliged to buy, donate or use only insecticides that are registered for use against locusts. Sometimes, non-registered insecticides can be used in emergency situations (such as a locust invasion), but this is often limited in time and space.

! If pesticides are to be purchased with external funding, specific pesticide selection and tendering requirements by bilateral or multilateral donors may apply.

Figure 9. Indicative decision scheme for the selection of locust control insecticides, based on human health criteria.



Note: operator group codes as in table on opposite page

Tip: for insecticides or formulations that are not listed in Appendix 3.2, the WHO hazard classification can be determined using Appendix 3.3.

If the LD50 of the commercial formulation is known, use the table directly. If this is not the case, look up the LD50 of the active ingredient and then calculate the LD50 of the commercial formulation, using the formula provided .

LD50 values of active ingredients are listed in the most recent version of the WHO classification, which can be downloaded from the WHO Web site.

Pesticide selection: human health criteria

Occupational and bystander risk. The insecticides used for Desert Locust control have different toxicities, and thus do not pose the same risk to control staff or the local population. FAO uses the *WHO classification of pesticides by hazard* as a guideline on occupational and bystander risk. Pesticides are classified from extremely hazardous (class Ia), for the most toxic products, to unlikely to pose an acute hazard in normal use (class U), for the least toxic ones. The WHO classification is further explained in Appendix 3.3.

FAO recommends that class Ia and Ib products (extremely and highly hazardous) are not used for locust control. As a result, insecticides that have passed PRG evaluation are mostly class II (moderately hazardous) (see Appendix 3.2, for the complete list). Note that the hazard classes listed in Appendix 3.2 are based on the most concentrated formulation of each product that is being used for Desert Locust control.

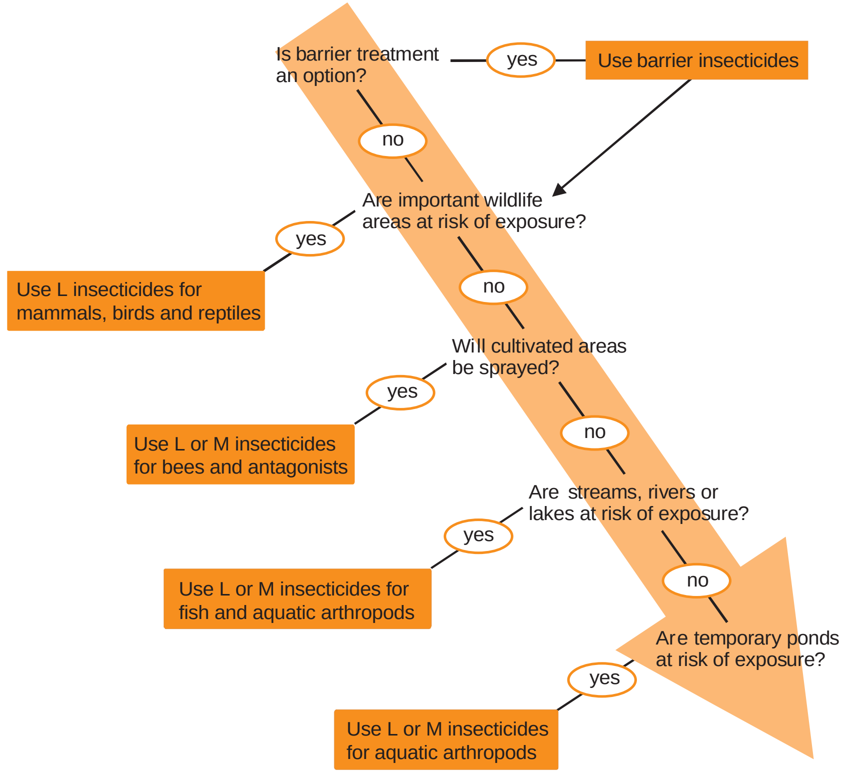
The hazard classification determines who should be allowed to use the insecticide. The more hazardous the insecticide, the better should control staff be trained and supervised. During campaign preparation, the locust control organization should assess whether all control staff are sufficiently trained to use the selected insecticides with minimum risk. If this is not the case, the necessary training should be organized before the start of the campaign. Obviously, if there is not sufficient time or capacity to provide the training, less hazardous insecticides need to be selected (see Fig. 9).

WHO recommended restrictions on the availability and use of pesticides

WHO hazard class		Availability and use restrictions	Operator code [1]
Ia	Extremely hazardous	Only individually licensed operators	--[2]
Ib	Highly hazardous	Well-trained, educated, strictly supervised operators	--[2]
II	Moderately hazardous	Trained and supervised operators who are known to observe precautionary measures strictly prescribed	A
III	Slightly hazardous	Trained operators who observe routine precautionary measures	B
U	Unlikely to pose an acute hazard in normal use	General public, respecting standard general hygienic measures and observing instructions for use given on the label	C

[1] *Locust control operator code used in Fig. 9.* [2] *Not recommended for locust control.*

Figure 10. Simplified decision scheme for the selection of locust control insecticides based on environmental criteria. Classification of insecticide use groups (low [L], medium [M] and high [H]) is shown in Appendix 3.2.



Tip: after every meeting of the PRG, the tables on insecticides for locust control are updated. Therefore, Appendixes 3.1 and 3.2 in Desert Locust Guidelines No. 7 may not be the most recent ones available. The most recent versions can be downloaded from the FAO Web site.

As stated earlier, ground treatments tend to expose control staff more to insecticides than aerial treatments. There is also a greater chance that less experienced staff are involved in ground treatments. Therefore, whenever possible, class III or class U insecticides should be selected for ground spraying. If control operations are to be carried out by farmer or village brigades, only class U insecticides should be used. An indicative decision scheme for insecticide selection based on human health risks is given in Fig. 9.

During upsurges and plagues, Desert Locust control may need to be carried out near inhabited areas. In such cases, the risk of accidental exposure of the local people (e.g. bystanders or farmers re-entering sprayed fields) is relatively high. When purchasing or prepositioning insecticides, this should be taken into account, for instance by favouring class U products for those areas.

Risk to consumers. In certain situations, Desert Locust control may take place in cultivated areas, where crops will be sprayed. To ensure that sprayed crops do not pose an unacceptable risk to consumers, pre-harvest intervals should be respected. More information on pre-harvest intervals is given in the campaign execution section of this guideline.

Pesticide selection: environmental criteria

Assessing the risk of locust control insecticides to the environment is not easy. This is because the environment is made up of many different organisms that do not necessarily have similar susceptibilities to a given insecticide. For instance, a product may pose a high risk to shrimp, but be relatively safe for birds and mammals, or it may be very toxic to bees and natural enemies of pests, but pose a low risk to reptiles.

Therefore, which insecticide is environmentally acceptable for locust control will depend very much on the type of environment to be sprayed and the organisms that need to be protected. No general environmental classification exists that is applicable to all locust control situations; it has to be evaluated on a case by case basis.

The FAO Pesticide Referee Group evaluates the potential environmental impact of the insecticides that pass their efficacy assessment. Insecticides are classified as posing low (L), medium (M) or high (H) risk to the main groups of organisms that may be exposed by locust control operations. The results of this evaluation are given in Appendix 3.2.

The national locust control unit and the national environmental authorities can use Appendix 3.2 when selecting insecticides. A simplified scheme to aid in such decisions is shown in Fig. 10.

Figure 11. Large national stocks of insecticides destined for Desert Locust control may become obsolete.

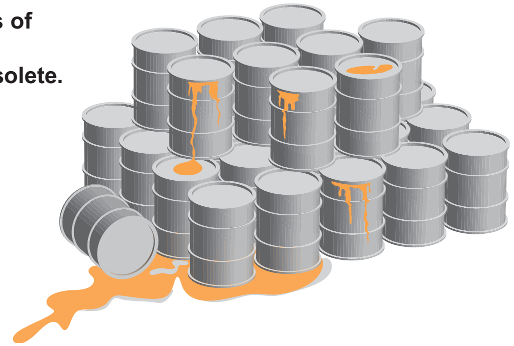


Figure 12. Good standards for packaging, labelling and quality control should be followed when ordering insecticides. (See the FAO Guidelines on tender procedures for the procurement of pesticides, for more information).

Basic international standards for insecticide packaging are provided by the *United Nations Recommendations on the Transport of Dangerous Goods*. More specific ones are provided by the international transport organizations (e.g. International Air Transport Association (IATA) for air transport and the International Maritime Organization (IMO) for maritime transport).

International guidelines on good labelling practice for insecticide containers have been published by FAO

Pesticide specifications for many individual pesticide formulations are available from FAO

Tip: ask the supplier of the insecticide to provide a reasonable amount of extra labels/technical leaflets and material safety data sheets. These can be distributed among the control teams and the medical authorities in the locust control areas. Also, if insecticides have to be repackaged for some reason, the spare labels can be attached to the new containers.

Ordering insecticides

What quantities to order?

A country that may face a Desert Locust outbreak will often want to have sufficient insecticides in stock. However, the size and timing of an outbreak is difficult to predict, and so is the quantity of insecticides needed to control it. Different options are available for insecticide provision, ranging from a large national stock to a more flexible pesticide bank system. *Desert Locust Guidelines* No. 5 *Campaign organization and execution*, provides more details about these systems, as well as advice on how to estimate insecticide needs.

From an environmental point of view, the less insecticide is stored in a country the better (see Fig. 11). Many of the obsolete pesticide stocks that at present exist in Africa and the Middle East were the result of overstocking of products expected to be needed for locust control, but were not. Setting up a flexible system of insecticide provision, such as a donor-supported pesticide bank, is therefore highly preferable.

Packaging

Insecticides for locust control often have to be transported over very rough terrain and stored under difficult environmental conditions. Therefore, packaging requirements have to be up to the highest standards. To avoid damage, and subsequent environmental contamination, containers must be durable and very robust. International standards for pesticide packaging have been set by the United Nations (see Fig. 12).

The size of insecticide containers may also affect the safety of their use. Large drums are heavy and difficult to manipulate. This may not be a problem for aerial control, as the insecticide will be transferred into the aircraft hopper using a pump. However, large drums are inappropriate if control is mostly on a small scale, using hand-held or vehicle-mounted sprayers. Pouring insecticides from large drums under such circumstances is a very hazardous practice. Therefore, container sizes should be based on the expected control techniques.

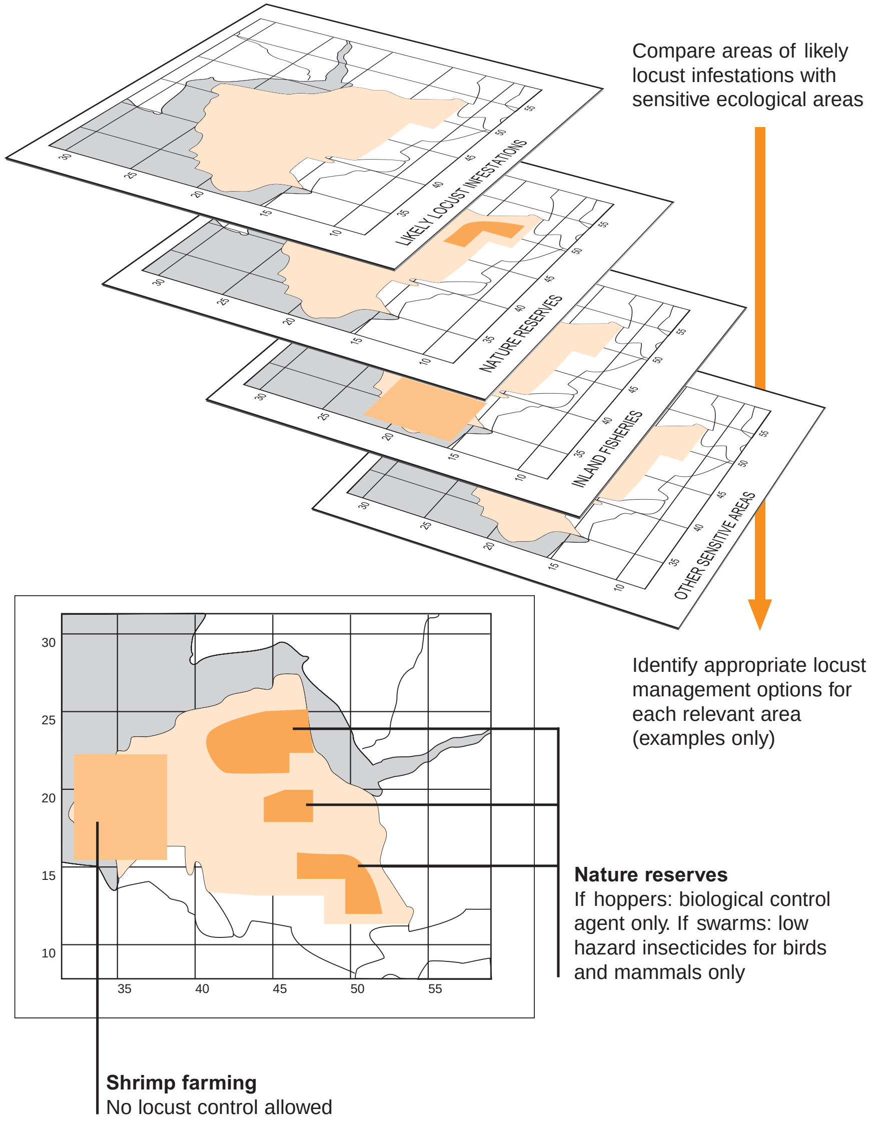
Labelling

All insecticide containers should be properly labelled. The label should conform to national or regional requirements. If these do not exist, they should follow the FAO labelling guidelines.

Quality control

The quality of any insecticide imported or locally formulated for locust control should be checked by an independent laboratory. This requirement should be part of the tendering procedure. If no national quality specifications exist, the FAO pesticide specifications can be followed. Apart from verifying the concentration of active ingredient(s), quality control should also assess levels of toxic metabolites, if these may be present.

Figure 13. Maps (either computerized or on paper) are powerful tools to identify ecologically sensitive areas and define appropriate locust management options.



Ecologically sensitive areas

During campaign planning all areas in the country should be identified that are ecologically and agronomically important or particularly sensitive to insecticides. In certain areas chemical locust control may also not be allowed by law (as in the case of national parks).

For each sensitive area, locust management options should be evaluated, based on the type of organisms at risk and the likely locust targets that may appear in the area. Subsequently, appropriate locust control techniques have to be identified for each area. These include the decision to allow chemical control or not, the choice of acceptable insecticides, periods when treatments are or are not allowed, appropriate control methods, etc.

It is important that all relevant national expertise is involved in this assessment, such as the national agencies dealing with environment, biological pest control, (inland) fisheries, bee-keeping, national parks, etc. Experience has shown that it is often most effective to try to map out the various sensitive areas, and make overlays with previous (or newly expected) locust infestations. This can be done using computerised geographic information systems, or directly on paper (see Fig. 13). In many locust-affected countries, electronic maps of important environmental areas are now available, and the locust unit should seek assistance from the relevant national agency to exploit them.

Examples of areas that may need special consideration

Ecologically and agronomically sensitive areas	Examples of management measures
• National parks; nature reserves; internationally protected areas	No insecticide applications; only biological control agents; only low hazard insecticides
• Important (inland) fisheries areas; mangrove forests	Only insecticides with very low hazard to fish and aquatic invertebrates
• Important fruit-growing areas; bee-keeping areas	No insecticide applications during flowering of fruit trees; only insecticides with very low hazard to bees; set up information system to warn bee-keepers of upcoming treatments
• Areas with important biological pest control programmes	No insecticide applications; only insecticides with very low hazard to natural enemies of pests
• Areas with export crop or livestock production	Only insecticides that do not pose problems with export maximum residue limits
• Areas with organic farming	No chemical insecticides

Figure 14. Personal protective equipment for insecticide applications against the Desert Locust. The number of pieces of each item that is minimally needed for a two-week control mission is indicated in parentheses.

Tip: always carry out a pre-campaign quality check of the PPE that is still in stock with the locust unit since the previous control campaign. For instance, gloves may become permeable after prolonged storage and respirator cartridges may have expired.

Personal protective equipment (PPE)

During the campaign planning phase, the necessary personal protective equipment has to be selected and ordered, for it to be available at the start of the control operation. The type of PPE that is needed depends on the toxicity of the insecticides that will be used. The table below lists the recommended PPE for locust control, presuming all insecticide formulations are WHO class II, III or U. In addition to PPE, other safety equipment also needs to be available for control teams. This includes eye wash kits, water and soap, and antidotes (in certain cases).

When ordering PPE, one has to take into account that all items have only a limited operational life. For instance, gloves get torn or impregnated by insecticides, and coveralls or canvas shoes will after a while become too contaminated for use, even if properly washed. Sufficient PPE has to be ordered and distributed to allow for such wear and tear. This is especially important since locust control teams may operate at long distances from places where replacement PPE can be obtained. Indicative numbers of PPE are given in Fig. 14, needed for a short control mission. A more complete assessment is provided on the next page.

More information on the use and maintenance of PPE is provided in the campaign execution section later in this guideline (see p. 51).

Recommended minimum personal protective equipment (PPE) for Desert Locust control (if all insecticide formulations are WHO class II, III or U)

Activity	Required PPE
• Moving and loading of ULV insecticides, equipment cleaning [*dustable powders*]	Boots; cotton coveralls or two-piece work suit; gloves; (hard)-hat; apron; face shield [*dust mask*]
• ULV spraying [*if dusting*]	Closed canvas shoes or boots; cotton coveralls or two-piece work suit; gloves; (hard)-hat; face shield [*dust mask*]
• Spray track marking (flagmen)	Closed shoes;cotton coveralls or two-piece work suit; hat
• Insecticide transport	Closed shoes or boots; cotton coveralls or two-piece work suit; gloves; apron; face shield; dust mask
• Medium and large-scale insecticide storage	Boots; cotton coveralls; chemical-proof coveralls; gloves; hat; apron; face shield; dust mask; hard hat; respiratory protective equipment

Approximate protective equipment needs for an eight-week locust control campaign, presuming spraying takes place every other day

Equipment	User group				Unit
	Loaders, sprayers, cleaners	Flag-men	Trans-porters	Store keeper	
Cotton coveralls	2	1	2	2	per person
Chemical-proof coveralls	-	-	-	1	per person
Gloves (heavy nitrile or PVC)	4-6	-	2-4	4-6	per person
Hard hat	1	-	1	1	per person
Cotton hat	1 [1]	1	-	-	per person
Impermeable boots	1	-	1	1	per person
Closed shoes (canvas)	(1 [2])	1	(1 [3])	-	per person
Impermeable apron (PVC)	1	-	-	1	per person
Face shield	1	-	1	1	per person
Dust mask (disposable)	30 [4]	-	10 [4]	30	per person
Full face respirator	-	-	-	1	per person
Spare respirator cartridges	-	-	-	2	per person
Eye wash set	1	-	1	1	per team
20 l jerry can for washing	2	1	1	- [5]	per team
Soap (bars)	8	2	2	8	per team
First aid kit	1	-	1	1	per team
Antidotes (units)	2	-	1	2	per team

[1] *If no hard hat is worn.* [2] *For sprayers, if no boots are worn.* [3] *If no boots are worn.*
[4] *If dustable powder applications.* [5] *Presumes running water is available at store.*

! **Of all PPE, gloves are probably the most exposed to insecticides. However, even good-quality gloves are not entirely impermeable to insecticides. ULV insecticide formulations in particular will slowly permeate gloves, even when the gloves are not used. Gloves therefore need to be replaced regularly, to ensure that the person wearing them is not continuously being exposed to the insecticide.**

The table opposite provides an indicative list of PPE and other safety equipment needed for an eight-week control campaign. This can be used to estimate actual needs, based on the number of personnel involved, the duration of the campaign and local experiences with the durability of protective equipment. Most PPE can be stored for several years, and it is therefore better to order too much of it than too little. The exact amount of material required will depend on the type of insecticide used (e.g. its corrosiveness), the type of treatments carried out and the general intensity of the campaign. It is therefore very important that the senior field officer keeps track of the use of PPE and orders new material in time. Obtaining good local statistics on the use of PPE in locust control operations will also help in planning the next campaign.

It is important not to economize on the amount and quality of PPE to be purchased. The cost of PPE is only very limited when compared to the cost of the insecticides and their application.

Indicative breakthrough times of ULV insecticides for different types of gloves.

The breakthrough time is the period between first exposure and first penetration of the glove by the insecticide, assuming that the glove is continuously immersed in the chemical.

Type of glove (with a minimum thickness of 0.4 mm)	**Breakthrough time for ULV formulations**
Natural rubber [1]	12 minutes or more
Neoprene	6 hours or more
Nitrile	6 hours or more
Butyl [1]	12 minutes or more
PVC supported (1 mm thick)	6 hours or more

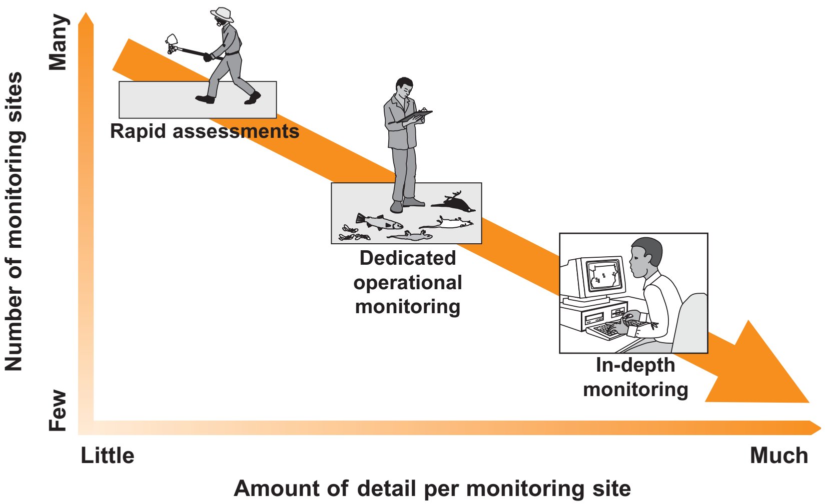
[1] *NOT recommended for locust control.*
Source: BCPC, 1999.

Various types of monitoring activities - when to carry them out?

Type of monitoring	When to be carried out?
Rapid assessments *(control teams)*	● Always. To be standard practice in all locust control operations
Dedicated operational monitoring *(monitoring teams)*	● If more than about 30 000 litres of insecticides are expected to be applied during a control campaign [1] ● If new insecticide or control method is introduced ● If rapid assessments suggest that certain problems exist
In-depth monitoring *(research teams)*	● If dedicated operational monitoring indicates that specific problems exist ● if new insecticide or control method is introduced on a large scale

[1] At this scale of control, the operations cost of a dedicated monitoring team are estimated to be less than five percent of the total pesticide and application costs (based on the situation in West Africa)

Figure 15. Different types of monitoring have different results.



Monitoring

What is monitoring?

The term *monitoring* is used here for the collection, analysis, interpretation and dissemination of data on the effects (both intentional and unintentional) of operational locust control. This includes control efficacy, effects on human health, impact on non-target organisms and the presence of insecticide residues. The objective of monitoring is to identify what goes right in operational locust control, and what can be improved. Monitoring is therefore an essential element of a locust control campaign. It aims to optimize control, improve cost efficacy and minimize adverse side-effects on human health and the environment.

In this guideline, three types of monitoring will be distinguished: *rapid assessments* (done by locust control teams), *dedicated operational monitoring* (carried out by special monitoring teams) and *in-depth monitoring* (executed by specialized research teams). These three types of monitoring differ by the activities that are carried out, the time span in which the work has to be done and the functional links to the control campaign organization. Rapid assessments focus on insecticide application quality, control efficacy and the reporting of incidents. Both dedicated operational monitoring and in-depth monitoring look in more detail into control efficacy, environmental impact, occupational health and insecticide residues. The main difference is that operational monitoring attempts to cover many control actions, in relatively limited detail, while in-depth monitoring looks at only a few control actions, but in much more detail. It could be said that the value of the former is in the numbers and of the latter in the details (see Fig. 15).

The first two types of monitoring will be discussed in more detail in these guidelines. In-depth monitoring, on the other hand, will only be briefly touched upon, as it is rather specialized and therefore not always part of a normal control campaign.

Different types of monitoring of locust control operations

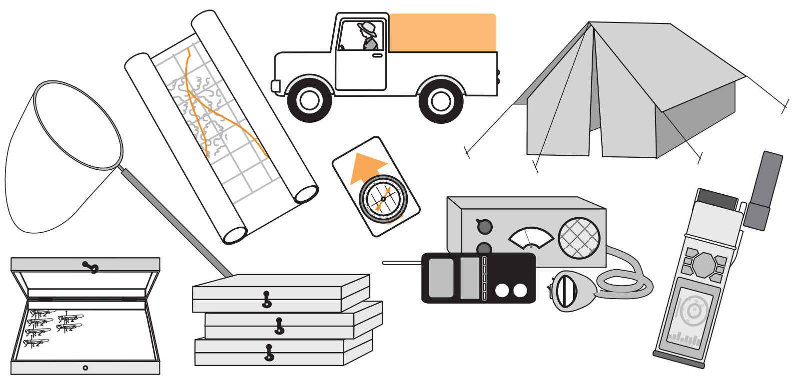
Type?	Who?	How long on site?	What?			
			Control efficacy	Human health	Non-target organisms	Insecticide residues
Rapid assessments	Control teams	Hours to 1 day	yes	yes	yes	no
Dedicated operational monitoring	Monitoring teams	1 day to 1 week	yes	yes	yes	yes
In-depth monitoring	Research teams	Weeks to months	(no)	yes	yes	yes

Rapid assessments by control teams – monitoring and reporting requirements and equipment needs

Topic	When required?	Equipment needs (per control team)
Application parameters	Always	PPE, clipboard, survey and control form (Appendix 4.1), spray monitoring form (Appendix 4.2), pen/pencil, marker pen, anemometer, tachometer, whirling hygrometer, measuring cylinder(s), bucket, funnel, stop watch, tape measure, compass, GPS, calculator, cages and insect net (optional), oil-sensitive paper (optional)
Efficacy [1]	As often as feasible	
Occupational poisoning incidents [1]	Always, if such cases occur	Poisoning incident form (see p. 84) clipboard, pen/pencil
Mortality of non-target organisms (e.g. fish, bees, birds) [1]	Always, if such cases occur	Notebook, pen/pencil, plastic bags, labels, marker pen
Poisoning incidents local people [1]	Always, if such cases occur	Notebook, pen/pencil
Complaints (e.g. by shepherds, beekeepers) [1]	Always	Notebook, pen/pencil
Residues [1]	Never	---

[1] *These tasks can also be carried out by the dedicated monitoring team, if one is on site.*

Figure 16. A dedicated operational monitoring team should be well equipped and able to operate independently to be efficacious.



Planning rapid assessments

Rapid assessments are carried out by the control teams themselves. During an upsurge or plague control staff is, as a rule, very busy searching targets, preparing equipment, spraying, cleaning up and moving on to the next spray target. Therefore, any monitoring that can be done by control teams has to be fast and to the point. However, the fact that they are busy does not exempt control staff from doing basic surveillance, e.g. of control parameters and efficacy. Incidents of occupational poisoning or environmental impact must also be registered by the control teams, because dedicated monitoring teams are not always present.

During the campaign planning phase, it has to be decided which monitoring tasks will be assigned to the control teams. Subsequently, appropriate equipment needs to be ordered. Most important, control teams have to be informed about and trained in the tasks that are required of them, so that they can carry them out rapidly and correctly.

More details about the various rapid assessment activities are provided in the campaign execution section of this guideline.

Planning dedicated operational monitoring

Most monitoring of control operations will have to be carried out by dedicated monitoring teams with specialized staff. The advantage of having one or more independent monitoring teams is that control staff can concentrate on searching and spraying locusts, while monitoring staff can remain in the treated area longer to assess impact. Also, because the quality of control is to be evaluated, having independent monitoring staff avoids being both "judge and judged".

To be able to do its job correctly, a monitoring team should be able to operate independently, have its own means of transport and be well equipped (see Fig. 16). A typical team will use two vehicles (e.g. one pick-up truck and one station wagon), to allow for sufficient transport capacity for equipment and personnel, but also for safety reasons in remote areas. The team's exact composition will depend on the required monitoring tasks, but it will consist of one or more of the following staff: a pesticide application expert, a chemist/insecticide residue expert, an ecologist or ecotoxicologist, a doctor or experienced nurse, and possibly an assistant to one or more of the above. The two vehicles referred to above will only accommodate four monitoring staff and two drivers, so choices will have to be made on each team's composition (note that a spare place may also be needed for a guide in some Desert Locust areas).

The exact equipment needs depend very much on the type of monitoring to be carried out. Therefore, team composition and monitoring topics must be determined well before the start of the locust control campaign, to allow for sufficient time for ordering.

Dedicated operational monitoring –
monitoring and reporting requirements and equipment needs

Topic	When required?	Equipment needs (per monitoring team)
Application parameters	If not done by control team	See table on rapid assessments
Efficacy		
Occupational exposure/poisoning incidents	Always, if such cases occur	Poisoning incident form (p. 84), cholinesterase test kit (if organophosphate or carbamate insecticides are used), UV tracer dye, UV lamp, absorption pads, storage facility for absorption pads (depends on type of insecticide)
Risk assessment for general population	Always	General monitoring checklist (p. 82)
Poisoning incidents in general population	Always, if such cases occur are presumed	Notebook, pen/pencil
Environmental risk assessment	Always	General monitoring checklist (p. 82)
Mortality of non-target organisms (e.g. fish, bees, birds)	Always, if such cases occur	Binoculars, traps (type depends on organisms to be monitored), scoop nets, sieves, funnels, biomonitoring cages (type depends on organisms to be monitored), glass and plastic vials and bottles of various sizes, forceps/scalpels/spoons, plastic (zip-lock) bags, aluminium foil, formaldehyde, ethyl-alcohol
Residues	If required	Coolbox and cooling elements, solvents, scissors/pincers/spoons, grinder, mixing trays, glass storage bottles, aluminium foil
(Additonal general monitoring equipment)		PPE, first aid kit, HF and UHF radio, walkie-talkies (2), camping material, GPS, camera, notebooks, marker pens, portable refrigerator (to work on car battery, mains electricity and gas), *Desert Locust Guidelines* No. 4 *Control*, No. 6 *Safety and environmental precautions* and No. 7 *Appendixes*, technical data sheets on insecticides being used

Even though monitoring staff may be experts in their respective fields, the importance of thorough pre-campaign planning and training cannot be overemphasized. Team members need to be entirely confident with the equipment and observation or sampling methods. They should also learn enough about each other's monitoring procedures so that they can provide mutual assistance if needed (which will very often be the case). The teams should collect data on the ecology of the areas that may be sprayed, in advance of any campaign, to identify the ecosystems involved and their susceptible species or processes. Contingency plans need to be prepared and tested in case major problems occur (e.g. large kills of non-target organisms, human insecticide intoxications and accidental overspraying of wells). Furthermore, if more than one monitoring team is active in the country, protocols should be standardized between teams.

Monitoring teams will often need external expertise for some of their tasks. Insecticide residues must be sent to and analysed by a specialized laboratory; biological samples may need to be sent to specialist taxonomists; staff of the national poisoning centre may need to be called up in case of poisoning incidents, etc. Such functional links must be discussed and set up before the campaign starts. This is especially important for actions that have to be carried out rapidly or at short notice.

The chain of command for monitoring also needs to be decided upon before the campaign starts. Who will the monitoring teams take orders from and report to? In some countries this may be the head of the locust unit, in others it may be a different ministry (e.g. of environment or public health). Linking monitoring teams directly to the locust unit has the advantage of good integration of their activities in campaign execution; making them accountable to a different agency may result in more independent operations. Related to these questions is the level of authority that monitoring teams obtain. Will they be authorized to review all spray records of a control team, issue stop spraying orders in case of observed problems, remove control staff from the job for health reasons, etc.? Or should they only report what they observe? This will vary from country to country and depend to a great deal on the administrative and locust control campaign organization.

Planning in-depth monitoring

In-depth monitoring differs from dedicated operational monitoring in the detail and the duration of the work. It is carried out by specialized and often quite large research teams. In-depth monitoring also assesses the impact of real-life locust control treatments. But after the insecticide application(s), the research team will generally no longer have much contact with the locust control campaign as they will continue to work on the treated plots for several weeks or months. In-depth monitoring has therefore different organizational requirements from dedicated operational monitoring.

The need for in-depth monitoring has to be assessed early in the campaign planning phase. Do any insecticides, control methods and non-target organisms require more detailed study? If so, a research team needs to be identified and contracted to carry out the work. Such a team must have the time to prepare the study, link up with relevant national and international institutions, possibly fly in equipment, arrange for

Summary of medical preparations:

- establish links with national poison centre and other medical institutes
- contact local hospitals and health centres
- provide data sheets on pesticide poisoning to hospitals and health centres
- locust control staff to undergo a medical exam before the campaign
- baseline AChE levels should be taken (for organophosphates and carbamates)

Figure 17. Pre-campaign medical examinations are required for all control staff.

FAQ number 3 (see p. 88 for answers)

It is often already difficult to obtain funds for a locust control campaign. Give me three good reasons why I should use part of my limited budget for one or more monitoring teams. They should preferably convince my Minister too.

semi-permanent camping facilities, etc. This entire process will often take several months.

Because of its complexity and high cost, in-depth monitoring of locust control operations will be relatively rare. No further details are given in this guideline on the organization and execution of in-depth monitoring of locust control. However, several useful sources and contacts are provided in the reference section of this guideline and in Appendix 5.7.

Pre-campaign medical examinations

During campaign planning, formal links should be established with the national poison control centre (if present) or other relevant national medical institutions. In those regions where locust control may be carried out, local hospitals and health centres should also be contacted. A practical system for the diagnosis and treatment of insecticide poisoning should be developed. Data sheets on poisoning symptoms, antidotes and treatments for all insecticides that may be used in the campaign should be made available to local hospitals.

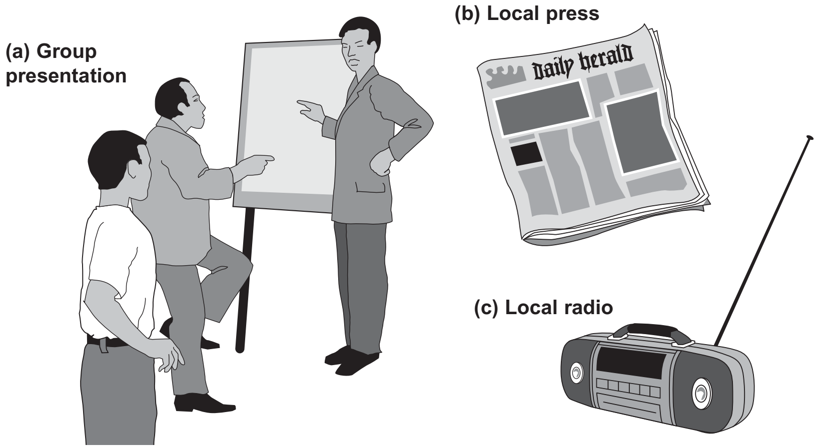
All control staff, and other persons who may come into contact with insecticides, should undergo a medical examination before the start of the campaign (see Fig. 17). This should be carried out by a physician who has knowledge about insecticide toxicology and is aware of the risks to which locust control staff may be exposed. Specific attention should be paid to medical conditions that may increase susceptibility to insecticides (e.g. skin lesions, liver disease, chronic alcoholism, haemolytic anaemia, malnutrition). Pre-campaign examination also establishes a baseline for future health monitoring.

If organophosphate (OP) or carbamate (CA) insecticides are to be used, blood cholinesterase (ChE) levels should be obtained for each control agent. These data can be used as a baseline for ChE monitoring during and after the campaign. Baseline ChE levels should be taken when the person has not been exposed to OPs or CAs for at least 30 days. Since there may be variability between laboratories or analysis methods, the same type of ChE test kit or blood analysis laboratory should be used throughout the control campaign.

Subjects to be covered by a pre-campaign training because they contribute to insecticide risk reduction

Target	Topics
Control teams	● Application techniques, equipment, maintenance ● Equipment calibration ● Safety measures, PPE, insecticide poisoning, first aid ● Environmental precautions ● Rapid assessments (efficacy, occupational health, environment)
Insecticide transport staff	● Proper handling and transport of drums and containers ● Safety measures, PPE, insecticide poisoning, first aid ● Environmental precautions, clean-up of spills
Storekeepers	● Pesticide storage manangement ● Safety measures, PPE, insecticide poisoning, first aid ● Environmental precautions, clean-up of spills
Flagmen	● Safety measures, PPE, insecticide poisoning, first aid
Monitoring teams	● Monitoring techniques ● All the above topics (monitoring staff should preferably participate in the training of all other campaign staff who they may need to evaluate)
Medical staff	● Recognition and treatment of insecticide poisoning

Figure 18. Different approaches can be used to inform the local population about safety precautions.



Training

Mastering the handling and application of insecticides is one of the most important ways to reduce health and environmental risks. Therefore, campaign staff should be well trained in these topics before control operations commence. Training should not only be limited to insecticide applicators, but also include transport personnel, storage staff, flagmen, monitoring teams and medical staff.

It is recommended that locust control staff be officially licensed or certified in the handling and application of insecticides, after having successfully completed the training. Only certified staff should then be allowed to carry out control. This will increase the incentive to follow the training and the probability that minimum technical standards are complied with. Good control practices are especially important since locust control is a government responsibility, and control staff will set an example to the general public.

Public awareness and information

It is important to keep the public informed about possible environmental and health effects of insecticides, before, during and after locust control operations (see Fig. 18). This is to ensure that precautionary measures are taken whenever needed but also to reduce any misunderstandngs that may exist about the risks of locust control. It is suggested that a specialized communication and information officer is assigned to this task, especially if the campaign is expected to be large.

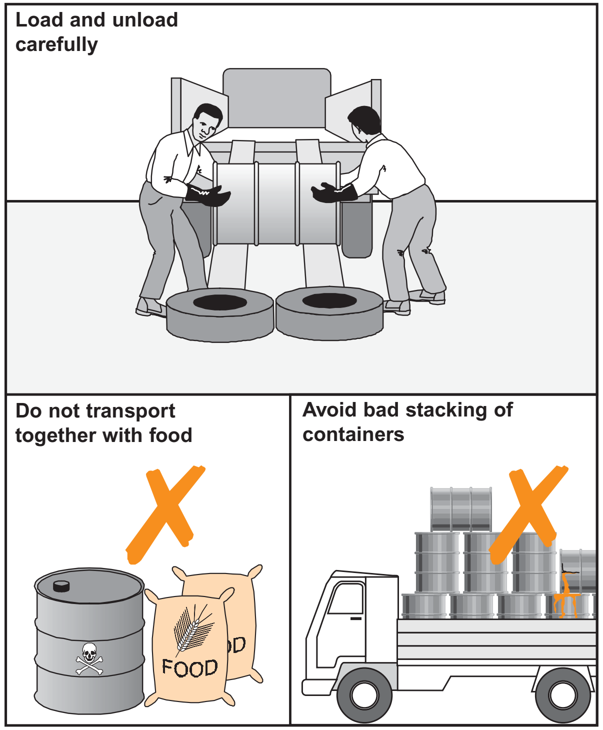
During the campaign planning phase, a communication strategy should be prepared in which the following issues are addressed:

- What should be the (technical) contents of the information? (e.g. location of treatments, general information on risks of pesticides, precautionary measures, re-entry intervals, pre-harvest intervals)
- Should there be “standard” answers to certain expected frequently asked questions on environmental and health issues? (e.g. by the public, politicians, the press)
- What is the appropriate type of communication method to reach the target groups effectively? (e.g. radio, television, newspapers, extension service, locust survey/control teams)
- How should the public be informed in case of emergencies? (e.g. insecticide spills, fish kills, human intoxications)
- How does one ensure that all control teams provide the same information to the local population? (e.g. to avoid that one team instructs villagers to close a well before spraying, and a second team operating in the same district tells another village this is not needed)
- What other information sources should be involved or kept on standby? (e.g. medical information sources in case of intoxications)

When transporting pesticides:

- load and unload containers carefully to avoid unstable stacking of drums
- do not allow persons on the back of the truck while driving
- avoid transport of insecticides with food, animal feed or other goods
- carry PPE, washing water, shovel, spill absorbents and decontaminants, and loading/unloading tools
- carry relevant Material Safety Data Sheet(s)
- clean vehicle after transport

Figure 19. Precautions for the transport of insecticides.



CAMPAIGN EXECUTION

In the following sections, environmental and health precautions to be taken during control operations are discussed. Details on monitoring activities are also provided.

Insecticide transport

Before a drum of insecticide reaches the location where it will be used to control locusts, it has often travelled hundreds of kilometres within the country.

Large-scale transport

Large amounts of insecticides may need to be transported between storage facilities in the country, or to primary field operations bases and airstrips. This often takes place over bad roads, or in areas where there are no roads at all.

Breakage of containers during transport over bad roads, or while unloading, is a major risk in locust control operations. This is especially the case for large drums. Appropriate tools for loading and unloading drums (e.g. planks, bands/ropes and old car tyres) should be available on each truck. Large drums (200 litres) should never be stacked in more than one layer on the truck bed. Because of their weight they can easily damage the drums in the layer below. Smaller drums and containers (e.g. 60 litres) can be stacked in two layers, but not higher. Drum layers should be separated by pallets and all drums should be securely fastened both to the pallets and to the truck bed. If this is not possible, stacking should be avoided.

It may be tempting to use the trucks that transport the insecticides to send other goods or equipment to the field bases, especially if transportation capacity is limited. However, this should be avoided at all times since the risk of contamination is too high. Every truck transporting insecticides should have the required set of safety equipment on board (see p. 28).

Small-scale transport

Typical for Desert Locust control is that individual control teams have to transport smaller amounts of insecticides during "search-and-destroy" missions. Since the number of vehicles in a control team tends to be small, such transport may pose problems. Insecticides should never be transported in the vehicle containing the camping equipment and the drinking-water or food. A separate vehicle is needed for transport of insecticides and spraying equipment. If treatments are done with a vehicle-mounted sprayer, the insecticide is often best transported in this vehicle. In such cases, proper fastening of the drums to the vehicle is crucial, since loose drums may seriously damage the sprayer (see Fig. 19).

Figure 20. Locate storage of insecticides and fuel away from habitations and the camp site.

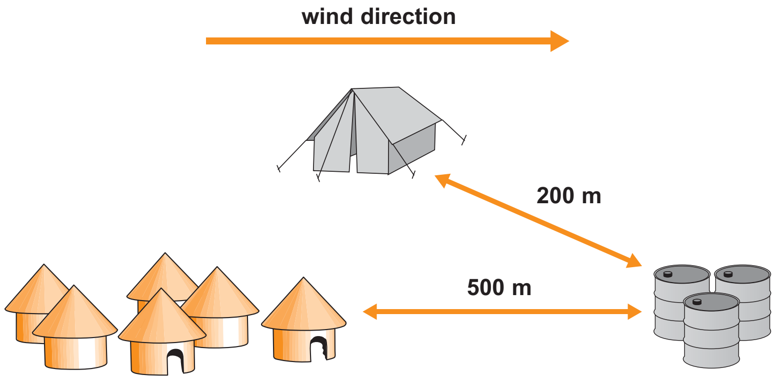
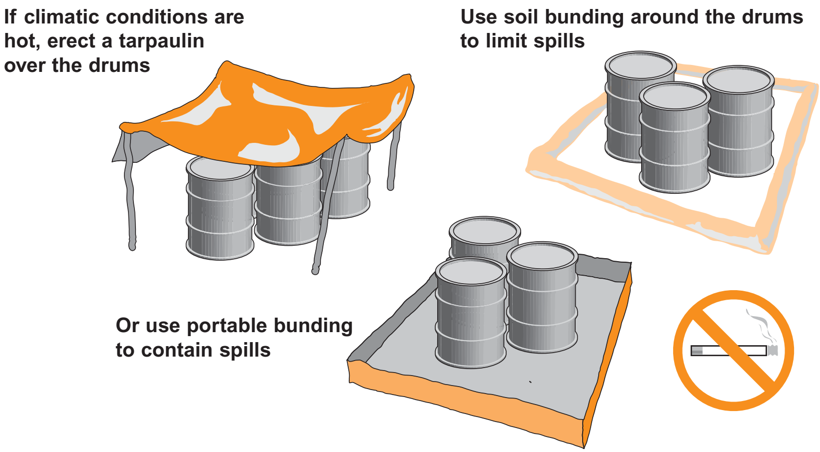


Figure 21. Temporary storage of insecticides.



!

Aircraft fuel is highly inflammable, and some insecticides may be as well. So strictly prohibit smoking:
- **around fuel and insecticide storage sites**
- **during refuelling of aircraft**
- **during loading of insecticides**

Insecticide and fuel storage

Large-scale storage

For a major control campaign, large amounts of insecticides may need to be stored temporarily at a limited number of locations, from where they are distributed to the various control sites. Large-scale pesticide stores should be custom-built. They must have all the necessary safety features to contain possible insecticide spillage, ensure sufficient ventilation and provide protection against rain and sunlight. FAO provides detailed guidelines on the design of pesticide stores (see p. 87).

Small-scale temporary storage

Typical for locust control is that relatively small amounts of insecticides need to be stored for a short period of time at the control site itself. This may be an airstrip or a temporary control camp. Safety issues are particularly important for temporary storage, because only rarely will custom-built pesticide stores be available. Insecticide storage should be set up well away from habitations and main traffic routes, and a good distance from, and preferably downwind of, the control camp (see Fig. 20). Storage sites should be guarded at all times, to avoid local people being exposed to the insecticides.

Care should be taken that insecticides are stored in the shade, whenever this is possible. Overheating may lead to buildup of pressure inside the insecticide drums, which may burst or forcefully eject the product when the bungs are opened. If control is carried out from the same site for several days, drums can be protected from direct sunlight by placing them under tarpaulins on poles (see Fig. 21). To contain any possible spills that may accidentally occur, temporary soil bunding should be constructed around the storage site. Special portable bunding also exists for temporary drum storage, which has the advantage that spilled insecticides will not penetrate into the soil (see Fig. 21).

Fuel storage

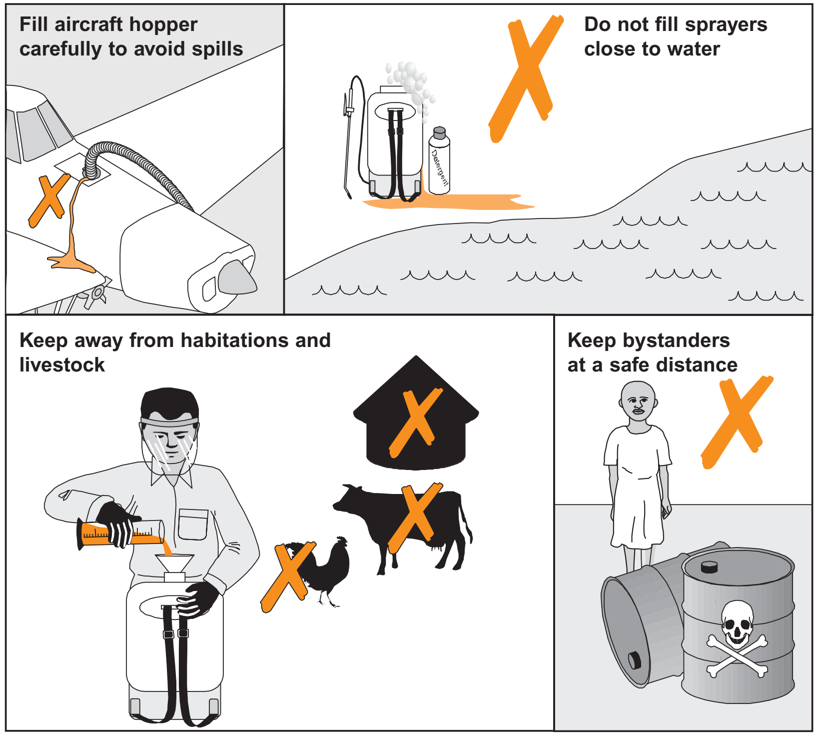
Fuel for the survey and control aircraft will need to be stored at (temporary) airstrips. As with insecticides, fuel storage must be well away from habitations and camp sites. In certain cases, both AvGas and Jet A1 fuel may have to be used at the same airstrip (e.g. when both helicopters and fixed-wing aircraft fly from the same location). In such cases, the two fuel types, and their respective pumps, need to be strictly separated to avoid "cross-fuelling", with potentially fatal consequences.

Fuel drums need to be stored in the shade to avoid overheating. They are best stored on their side, to reduce the risk of water entering the fuel during a rainstorm.

Fire risk

Certain insecticide formulations are inflammable, and aircraft fuel is very highly so. No smoking is therefore ever allowed around fuel and insecticide storage sites and during refuelling of aircraft. During refuelling any engine or apparatus that may give off sparks (e.g. cars) should be shut down or moved away.

Figure 22. Judicious loading of insecticides.



! **The main risks associated with pumping are bursting of hoses and loosening of the connections between the hose and the pump. Remember to check these regularly.**

Mixing insecticides

Most of the insecticides used in Desert Locust control are ULV formulations that are ready for use. Mixing is thus not a problem. However, in some countries, concentrated ULV formulations are diluted in the field. If this is the case, care should be taken that the staff carrying out the dilutions are not exposed to the concentrated insecticide. Appropriate PPE (especially gloves, face shield and impermeable apron) and pumping/mixing equipment should be available. Personnel should be well trained to carry out the mixing/diluting operations.

Loading insecticides

Filling aircraft hoppers

Aircraft hoppers are generally filled with insecticide using a motorized or hand-operated pump. This is potentially a hazardous operation, because if an accident occurs the operator may literally be drenched by the insecticide. The main risks associated with pumping are bursting of hoses and loosening of the connections between the hose and the pump. Both risks are more likely to occur with motor pumps.

It is therefore essential that pumping gear is of good quality and well maintained. ULV insecticides may be very corrosive and can destroy pump hoses relatively rapidly. Hoses should be checked daily for wear and tear and corrosion, and replaced as soon as needed. Similarly, connections between the hose and the pump may slowly loosen during operation, increasing the risk of operator exposure. They should be checked and fastened on a daily basis (see Fig. 22).

Directly pouring insecticides from drums into an aircraft hopper poses a high risk of operator contamination and may also damage the aircraft. This practice is therefore not recommended.

Filling vehicle-mounted and hand-held sprayers

Filling other types of sprayers may also be hazardous, since concentrated ULV formulation can splash on to the operator. Vehicle-mounted sprayers are best filled using a hand-operated drum pump. As with aircraft pumps, the hose may corrode relatively rapidly, and should be replaced immediately when this occurs. Smaller containers (up to 20 litres) can be poured directly into the sprayer. Hand-held sprayers are normally filled by pouring the insecticide directly from the container. A wide funnel should be used to facilitate pouring and avoid spillage.

For all insecticide loading operations, personnel should wear appropriate PPE, and water and soap for washing should be available. Sprayers should always be filled well away from habitations, bystanders, animals and water sources. Empty containers should be rinsed with a small amount of diesel or kerosene, and the rinsate added to the hopper or sprayer. Containers should be closed well after use (even if empty) and stored in a safe location (see Fig. 22).

Minimizing exposure to insecticides during spraying:

- Make sure to spray crosswind, because this minimizes exposure to spray droplets
- Avoid spraying at low wind speed and under still conditions since droplets will not move away from the operator or vehicle
- Start spraying at the downwind side of the plot, and move upwind, to avoid walking/driving/flying through the spray cloud or treated area
- Stop the sprayer when turning from one spray pass to the other
- Avoid spraying under convective conditions since hot air results in convection and unstable wind direction, making crosswind application impossible and increasing the chance of operator contamination

Figure 23. Control staff should follow several basic practices to minimize their exposure to pesticides

Do not eat, drink or smoke during spraying operations

Do not touch face or bare skin with contaminated gloves

Spraying

It is important to minimize the risk of exposure to the insecticide during spray operations against locusts, both of control staff and of bystanders or non-target organisms.

Minimizing exposure of control staff

The most important factor in reducing the risk of insecticide exposure during spraying is to ensure that all control staff are properly trained in good application practices. This holds true for the applicator or pilot as well as for support staff such as flagmen. Detailed advice on good spraying practice is provided in *Desert Locust Guidelines* No. 4 *Control*, and in No. 7 *Appendixes* 2.6 and 2.7.

Using good-quality application equipment, properly maintained, is another important risk reduction factor. Sprayers should not leak and must be regularly cleaned (see Fig. 23). Note that even a well-maintained sprayer, if not properly cleaned, forms a continuous source of exposure to insecticides. This is especially the case for ULV formulations. Certain vehicle-mounted sprayers require an operator to be present during application. This is hazardous since sudden wind direction changes may contaminate the operator. Vehicle-mounted sprayers that can be operated from within the cab of the vehicle are therefore recommended.

It is also important to use the necessary personal protective equipment or PPE (see p. 27). However, this is only the last line of defence against insecticide exposure. The degree of protection provided by PPE normally used in locust control is only limited. It will definitely not protect the applicator against careless insecticide application or faulty spray equipment.

Finally, basic occupational hygiene further reduces the risk of exposure (see Fig. 23).

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Basic occupational hygiene when working with pesticides:

- **do not eat, drink or smoke during or directly after treatment**
- **do not touch the face or skin with contaminated hands or gloves**
- **wash thoroughly after treatment**
- **always wash hands and face before eating or drinking**
- **wash PPE after treatment**

Suggested minimum buffer zones for the protection of aquatic habitats[1] to be respected during Desert Locust control operations

Emission height	Type of sprayer [2]	Minimum buffer distance[3]
1.0 - 1.5 m	Micro-ULVA	200 m
2.5 - 3 m	ULVA-Mast (X15)	400 m
10 m	Aircraft (Micronair AU5000)	1 500 m

[1] Buffer zones have been calculated for freshwater ecosystems. Pending verified buffer zones for terrestrial ecosystems, aquatic buffer zones may be used as indicative for terrestrial systems.

[2] Type of sprayer for which the buffer zone has been validated.

[3] Minimum distance to be left unsprayed between the last spray run and the area that has to be protected.

Figure 24. Before starting the spray operations, control staff should instruct the local population.

Minimizing exposure of bystanders, livestock and non-target areas

All people who have no direct role in the insecticide applications should be kept at a safe distance. Inhabitants of the zone in which the treatments take place must be informed of the operation beforehand, and warned not to come close to it (see Fig. 24). Since Desert Locust spray targets are often identified during late afternoon, to be treated the following morning, inhabitants can be warned the evening before spraying. But even if this is not the case, control teams should always make sure that nobody is present in the area to be sprayed. The same holds true for livestock. During spraying, control staff who are not directly involved in the application should verify that bystanders remain at a safe distance. If it is impossible to avoid spectators, ensure that they remain upwind from the treatment.

Certain areas or environments will be off limits for all insecticide treatments against locusts. This will normally be the case for villages or habitations, open water and nature reserves. The campaign organization should prepare a list of areas that cannot be sprayed and/or contaminated (see p. 25). If such areas lie downwind of the spray target, sufficient distance needs to be kept to ensure that insecticides do not drift into them. The size of these unsprayed buffer zones will depend on the type of application (air or ground), weather conditions (e.g. wind speed), topographical conditions (e.g. density and height of vegetation) and the sensitivity of the area to be protected (see table on the opposite page).

However, even when respecting these buffer zones, it is impossible to guarantee that all risk is excluded. The effectiveness of the buffer zones should therefore be monitored whenever possible. Even when buffer zones are respected, certain measures can be taken to minimize the risk of contamination further. Wells or water-holes that lie in the area in which treatments take place should be covered up (see Fig. 24). Beehives can also be covered up temporarily to protect them further from any unexpected spray drift (however, it is important to ensure that the hives do not overheat).

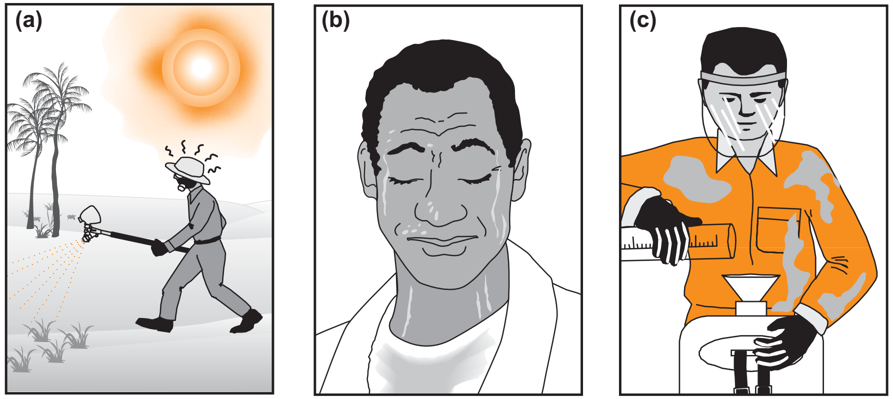
Pilots and spray operators should always be attentive to unforeseen circumstances. People or livestock may have wandered into the spray area inadvertently, ponds or water-holes may have been missed during survey of the spray area, a flagman may forget to move upwind in time, etc. In all such cases, application should be stopped temporarily, to avoid exposure of the non-target persons or organisms.

!

Disposal of water used for washing and cleaning

Great care should be taken that the water used for washing PPE or cleaning spray equipment does not contaminate wells or water-ways. Therefore, washing and cleaning should be done well away from open water or wells. Never clean spray equipment on a river bank or at a pond side, even though this may seem a practical choice.

Figure 25. Desert Locust control may pose an increased risk of exposure to insecticides, even when using appropriate PPE. This is because (a) heat stress may result in mistakes being made; (b) sweating increases insecticide absorption by the skin; (c) replacement PPE may be far away, forcing staff to continue working with contaminated material.



Maintenance of personal protective equipment used for ultra low volume insectides in locust control

Equipment	Maintenance	Equipment to be discarded if:
Cotton coveralls, cotton hat and canvas shoes	Wash regularly with water and (industrial strength) soap. Do not wash with domestic laundry	• smell of insecticide remains after washing • accidentally drenched by insecticide
Nitrile or PVC gloves	Wash with water and soap (inside/outside) after every treatment	• damaged or leaking • permanently stained with insecticide
Hard hat and face shield	Wash with water and soap (inside/outside) after every treatment	• damaged • face shield becomes opaque
Impermeable boots and apron	Wash with water and soap (outside) after every treatment	• damaged or leaking • permanently stained with insecticide
Disposable dust mask	None	• damaged
Respirator	Wash mask with water and soap (inside/outside) after every treatment	• damaged
Respirator cartridge	None	• effective use life of cartridge has expired (verify on label)

Using and maintaining personal protective equipment

As discussed in the previous section, personal protective equipment (PPE) is the last line of defence against exposure to insecticides. But PPE will never provide absolute protection on its own.

The recommended minimum PPE for Desert Locust control is listed on p. 27. It is based on the most hazardous type of insecticides used in locust control (WHO class II). However, it is recommended that this PPE is used as a standard, even if less hazardous insecticides are used. As government personnel, locust control staff should set an example for other pesticide users in the country. Demonstrating good pesticide application practice is therefore important.

PPE should be comfortable to wear. Using heavy or impermeable coveralls, under the hot conditions often encountered in Desert Locust control, will most probably result in overheating (see Fig. 25). This is dangerous as it may reduce the concentration of applicators and result in errors. It can also cause heatstroke. Lighter and more breathable coveralls tend to be more permeable and extra caution is needed during insecticide handling and spraying.

Gloves should be long, covering most of the forearm. When working with liquid insecticides, gloves should go on the outside of the coverall sleeves, and have the cuff turned over, providing a well to catch any insecticide that may run up the arm (see Fig. 14). If dustable powders are applied, gloves are best worn underneath the coverall sleeves.

Note that respirator cartridges may become unusable before the end of the effective use period mentioned on the label. This is because they may get clogged up with dust or become ineffective due to high humidity. Check cartridges therefore regularly and discard them immediately if one can smell the pesticide while wearing the respirator. It is of paramount importance that PPE is properly cleaned and maintained. Contaminated PPE worn directly on the body is a continuous source of exposure to insecticides. This may be more dangerous than wearing no PPE at all. Recommendions on PPE maintenance are given on the opposite page.

Ensure that sufficient spare PPE is available for each control team, to replace contaminated, worn or damaged items. PPE is relatively cheap when compared with the costs of insecticides or application. The regular replacement of PPE should therefore never be a problem.

!

- **Wash the outside of your gloves while they are still on your hands; wash the inside afterwards**
- **Whichever type of gloves you have used, always wash your hands after removing them**
- **ULV insecticides gradually permeate gloves, whether they are intact or not. Replace gloves regularly**

Figure 26. First aid measures to be taken in case of insecticide exposure and poisoning.

1. If insecticide in EYES – wash thoroughly (15 minutes) with clean water
2. If insecticide on SKIN – wash thoroughly with clean water and soap
3. If insecticide on CLOTHING – take off clothing and wash skin with water and soap
4. If insecticide INGESTED – do not induce vomiting – give active charcoal solution
5. If person is UNCONSCIOUS – check that breathing passages are clear – place person on the side with head down and tongue drawn forward
6. If person STOPS BREATHING – start artificial respiration (make sure you do not get contaminated yourself)
7. ALWAYS – keep person calm and cool
8. ALWAYS – take person to nearest medical facility
9. ALWAYS – take insecticide label or safety data sheet to medical facility

! **Antidotes should never be administered prophylactically. Using atropine or pralidoxime as “preventive medication” may mask early signs of organophosphate poisoning. This allows control staff to continue spraying when they should not, and can result in more severe poisoning.**

Insecticide poisoning

Signs and symptoms of poisoning

Even when all efforts have been made to reduce insecticide exposure, and appropriate personal protective equipment is used, insecticide poisoning cannot be excluded. Unfortunately, the signs and symptoms of insecticide poisoning are often not very specific, and may also be the result of other health problems. This means that field staff should be vigilant. If doubts exist as to whether symptoms are related to insecticide use or not, the affected person should stop handling the product. The most characteristic symptoms of poisoning by insecticides used in locust control are listed on p. 85.

First aid after insecticide exposure

First aid after insecticide exposure is of vital importance and may save lives. This is especially the case in Desert Locust control, where medical assistance may be very far away from the control sites. The most important aspects of first aid are to reduce or stop further exposure to the insecticide, and to stabilize the patient if needed. Advice on first aid is given in Fig. 26.

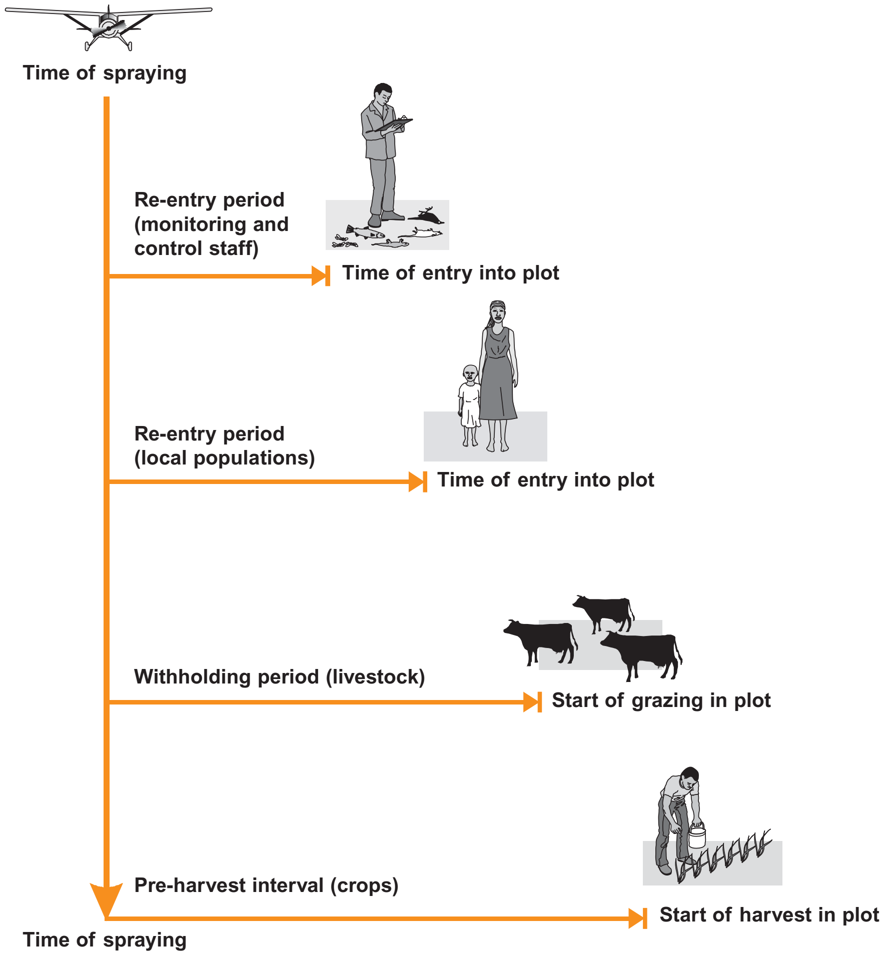
Treatment of insecticide poisoning

The treatment of severe insecticide poisoning is complicated, even in specialized well-equipped hospitals. In Desert Locust control, the distances between the control sites and hospitals further complicate fast treatment. Avoiding poisoning should therefore be the absolute priority. Insecticide poisoning should be treated by trained medical staff. However, in Desert Locust control, they may not always be nearby. Responsible field officers should therefore not only be trained in first aid measures, but also in basic treatment such as the application of atropine, using an automatic injector. More details on specific treatments are given in the table below.

Treatment of insecticide poisoning

Insecticide group	Treatment
All ULV insecticides	• If insecticide is ingested, gastric lavage may be needed • If insecticide has been inhaled, pulmonary oedema may develop; monitor respiration carefully, even after recovery from direct poisoning symptoms
Organophosphates	• If patient has difficulty breathing, apply pulmonary ventilation • Antidotes: atropine sulphate: 2-4 mg intravenously or intramuscularly, every 15 minutes, until atropinization (e.g. dry mouth, dilated pupils) and pralidoxime: 200 mg/min intravenously
Carbamates	• If patient has difficulty breathing, apply pulmonary ventilation • Antidotes: atropine sulphate: 2-4 mg intravenously or intramuscularly, every 15 minutes, until atropinization (e.g. dry mouth, dilated pupils). DO NOT USE pralidoxime
Pyrethroids	• No antidote exists; treat symptomatically • Skin numbness and burning can be treated with vitamin E oil/cream
Benzoyl ureas	• No antidote exists; treat symptomatically
Phenyl pyrazoles	• No antidote exists; treat symptomatically

Figure 27. Withholding periods should be respected after locust control treatments.



Tip: control or monitoring staff should explain the importance of respecting the livestock withholding period to shepherds and the pre-harvest interval to farmers.

Withholding periods

After insecticide treatment against locusts, a minimum time interval needs to be respected before humans or livestock re-enter the treated area, or before treated crops are harvested. This allows insecticide residues to diminish to acceptable levels and reduces the risk of exposure. Such minimum time intervals are generally called withholding periods. They are normally fixed by the regulatory agency responsible for pesticide registration, and are subsequently listed on the pesticide label. Locust control staff should inform the local population about these withholding periods and explain why it is important that they are respected. Clearly, control staff should set an example by strictly respecting these intervals (see Fig. 27).

Re-entry period – monitoring and control staff

Monitoring or control staff sometimes need to enter a sprayed plot shortly after treatment, for instance to check locust mortality or take residue samples. If appropriate protective clothing is worn, this should not pose an unacceptable risk to personnel. However, a minimum re-entry period should be respected to allow the spray cloud to settle, and avoid inhalation of small spray droplets. Overalls or work clothing of staff should be washed as soon as possible after work has ended.

Re-entry period – local populations

The local population does not have any protective clothing. Therefore, before bystanders and local inhabitants can re-enter a treated plot, the insecticide deposit on vegetation must have dried up completely, and the remaining residue should not pose a risk through dermal exposure (e.g. if people brush against the treated vegetation).

Withholding period – livestock

The withholding period for livestock is generally longer than the re-entry period for the general public. This is because livestock will feed on the treated vegetation. The risk of poisoning of livestock after locust control, at recommended dose rates of the Pesticide Referee Group evaluated insecticides, is extremely low. However, minimum withholding periods should be respected to avoid the risk of any insecticide residues in meat or milk. In certain countries, livestock is allowed in the sprayed area but then an extended withhold-from-slaughter period is imposed.

Pre-harvest interval – crops

The most strict withholding periods are generally those for the harvesting of crops for human consumption. At harvest, insecticide residues should not surpass the so-called maximum residue limits (MRLs). These are set by the national regulatory authorities, sometimes based on the international MRLs defined in the Codex Alimentarius.

Figure 28. Methods that should not be used to dispose of empty insecticide containers.

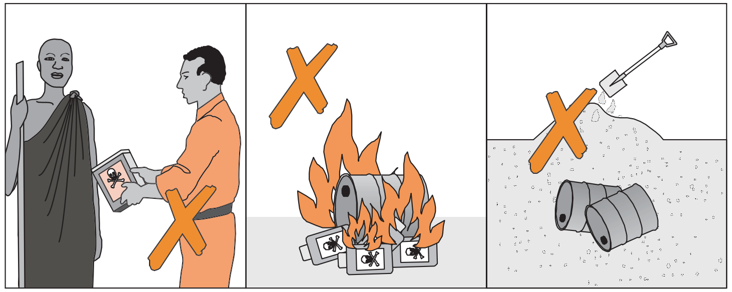


Figure 29. Actions to be taken in a small-scale insecticide spill.

Cleaning up

Empty containers

Empty insecticide drums, bags or other containers are a health risk to humans and the environment because small amounts of insecticide will always remain in the containers. This is the case particularly for ULV formulations, which are very difficult to clean out.

In several parts of the Desert Locust area, empty containers are in great demand. However, empty insecticide containers should never, under any circumstances, be reused for storage of drinking-water or food, not even after cleaning (see Fig. 28). Control staff should not respond positively to requests from the public for empty insecticide containers.

Empty paper bags, used for insecticide dust formulations, may be burned if this is done far away from habitations. Ensure that staff are kept upwind from the burning site. Empty drums or plastic containers are first rinsed with a small amount of diesel or kerosene, and the rinsate added to the sprayer. Subsequently, all empty containers must be returned to the locust control base. They should never be burned or buried on site, since this is dangerous to both humans and the environment. After the control campaign, the empty containers collected at the locust control base(s) can be dealt with in an appropriate manner (see p. 77).

Contaminated PPE

Contaminated or damaged personal protective equipment (PPE) should be treated as chemical waste. It should be packed in sturdy plastic bags and returned to the locust control base for appropriate disposal. It should never be discarded at the control site since passers-by (especially children) may collect it and become contaminated.

Spills

Accidentally spilled insecticides need to be cleaned up immediately to avoid further contamination (see Fig. 29). If spills occur:

- keep people and animals away from the contaminated site;
- remove damaged packages and place them on bare ground (or use portable bunding, if available), away from dwellings and water supplies;
- use soil or sawdust to absorb liquids, sweep up carefully and bury in a place where there is no possibility of contamination of wells and waterways;
- thoroughly wash down all contaminated parts of the vehicle, away from wells and waterways;
- wear protective clothing during clean-up operations.

Larger spills should be contained with a soil wall to limit the area affected and prevent contamination of waterways. Ensure that the contaminated site is closed off to people and livestock. Then immediately contact locust control headquarters so that a large-scale clean-up operation can be initiated.

Importance of spray monitoring -
example of the extra costs of a small upsurge campaign
if 20 percent of overdosing occurs.

Eight to ten week upsurge campaign

Quantity of insecticides to be sprayed	120 000 litres
Insecticide and application costs	US$ 15 per litre
Total campaign costs	US$ 1 800 000
Quantity of insecticides wasted if 20% overdosing	24 000 litres
Campaign funds wasted if 20% overdosing	US$ 360 000

Note: Based on previous monitoring exercises, it was found that over- and underdosing by 10-40 percent is relatively common in Desert Locust control.

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If insufficient mortality is encountered repeatedly, and cannot be explained from erroneous application, the officer-in-charge of the field base or the senior field officer should be contacted.

Any cases of occupational poisoning should be reported immediately by radio to the senior campaign officer or to the designated campaign medical officer.

Any pesticide spills or major leaks should be reported by radio to the senior campaign officer, as well as the measures that were taken to contain them

Monitoring – rapid assessments

A limited amount of monitoring must be carried out by the control teams themselves. These activities are referred to as rapid assessments and are partially described in the *Desert Locust Guidelines* No. 4 *Control*. The following activities are part of a rapid assessment.

Spray monitoring

Basic insecticide application parameters should be collected for each individual control operation. They include the exact control location, insecticide data, weather conditions during spraying and equipment settings. The *FAO Spray monitoring form* covers all these issues (see Appendix 4.2) and control teams should fill it out for each sprayed target. Since the application of insecticides is the most expensive part of a locust control campaign, incorrect spraying may be very costly. Spray monitoring is therefore essential, both from an economic and an environmental point of view.

Efficacy assessment

Efficacy assessments are made to verify whether the insecticide and the control technique are effective. They do not have to be done after each treatment, but it is recommended that efficacy is checked regularly, even for those insecticides with which one has experience. Further advice on locust mortality assessments is provided in *Desert Locust Guidelines* No. 4 *Control*.

Occupational poisoning incidents

All cases of (suspected) insecticide poisoning of control staff should be reported in as much detail as possible. Some space is reserved for this on the *FAO Spray monitoring form* (Appendix 4.2), but a more detailed form is provided on p. 84.

Mortality of non-target organisms

Mortality of non-target organisms (e.g. fish, bees, birds and shrimp) should be reported on the *FAO Spray monitoring form*. This will help the dedicated monitoring team(s) to investigate further unexpected or excessive adverse side-effects of the treatments.

Poisoning incidents in the general population and complaints

Control staff may receive information about presumed insecticide poisoning cases in the general population or may get complaints about the locust control operations. Such information should be noted down in as much detail as possible in the field notebook. However, control teams are generally not equipped, nor do they have time, to investigate such cases. They should report them to campaign headquarters, who can then take follow-up action (e.g. send a dedicated monitoring team).

Residues

Control teams do not have to take any samples for insecticide residue analysis. Because control staff continuously handle highly concentrated insecticides, the risk of contaminating such samples is too high. Residue sampling should be left to the dedicated monitoring team(s).

Figure 30. Dedicated operational monitoring may comprise one or all of the activities below. It will depend on the type of personnel involved, the funds available and the priorities set by the campaign organization.

Tip: if a dedicated monitoring team is on site, it can take over the spray monitoring and efficacy assessments from the control team(s). This will allow control teams to concentrate on finding and treating locusts and may speed up the control operation.

Dedicated operational monitoring

In many control campaigns, one or more dedicated operational monitoring teams will be active. In the sections below, various aspects of this type of monitoring are discussed. However, it is impossible, in this guideline, to provide detailed protocols on each and every aspect of environmental and human health monitoring. References to more detailed information on specific topics related to monitoring are provided on p. 86.

It will never be possible to monitor all treatments, or to assess all possible effects of an insecticide. Choices will therefore have to be made as to what exactly to monitor (see Fig. 30). This will generally be determined by the expertise and the funds available for the activity. Suggestions for priority setting have already been provided in the campaign preparation section of this guideline. As a rule, monitoring should at least address those issues that are considered to be a potential problem, either by the campaign staff or by the general public. It is better to limit monitoring to a few problems, and do it well, than to try to address many issues, and not provide a satisfactory answer to any of them.

Spray monitoring

Spray monitoring is the primary responsibility of the control teams (see p. 59). However, if a dedicated monitoring team is on site, it may take over this task. It will reduce the workload of the control team and may speed up the control operation. It also provides an independent verification of equipment calibration and the execution of the treatments. The *FAO Spray monitoring form* can be found in Appendix 4.2.

Efficacy assessments

For the same reasons, the dedicated monitoring team can also carry out efficacy assessments. This is especially useful for insecticides with moderate or slow speed of action. The control team can move on to new control targets, while the monitoring team stays behind to verify control efficacy. Further advice on locust mortality assessments is provided in *Desert Locust Guidelines* No. 4 *Control*.

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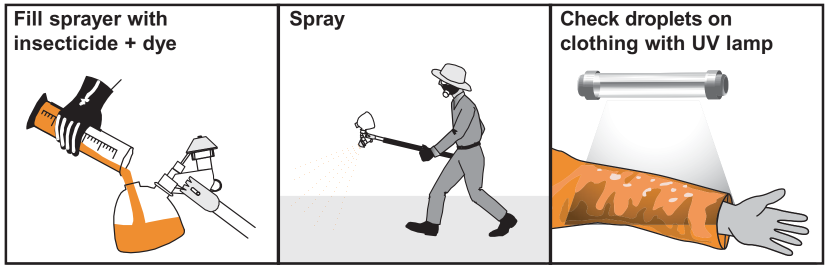
FAQ number 4 (see p. 88 for answers)

Is there any experience with operational environmental and human health monitoring of locust control campaigns, as described in this Guideline?

Advantages and disadvantages of various methods of assessing occupational exposure to insecticides during locust control

Method	Insecticides for which method can be used	Advantages	Disadvantages
Absorbent pads	Most	• quantitative measure of external exposure • efficacy of PPE can be assessed	• residue laboratory needed • transport of samples
(Fluorescent) tracer or dye	Most	• "on site" assessment of external exposure • easy to use	• qualitative measure only • efficacy of PPE cannot be assessed
Cholinesterase inhibition (laboratory assessment)	Organophosphates (carbamates)	• less training (only blood sampling to be done in the field)	• invasive sampling • transport of samples • time lag between assessment and corrective measures
Cholinesterase inhibition (field test kit)	Organophosphates (carbamates)	• immediate results allow rapid corrective action • no transport of samples	• invasive sampling • monitoring staff to be trained to use test kit
Metabolites in urine	Many	• non-invasive sampling	• no reliable field kits available

Figure 31. Adding a (fluorescent) dye to the insecticide can help to assess exposure of control staff.



Monitoring human health

Occupational exposure. Locust control staff run the highest risk of being exposed to, and possibly poisoned by, insecticides. It is therefore important that insecticide exposure is regularly monitored.

External exposure. External exposure to insecticides can be monitored using absorbent pads that are fixed, before insecticide spraying or handling, to certain parts of the body. The pads are stored after treatment in a refrigerator, transported to the laboratory, and analysed for insecticide residues. If the pads are also fixed inside the protective clothing, the level of protection provided can be assessed too.

A second method to assess external exposure is to mix a (fluorescent) tracer with the insecticide (see Fig. 31). Control staff subsequently carry out handling and spraying as usual. The tracer can be visualized after the control operation (for fluorescent tracers this can be done at night, back at the camp, using a battery-powered UV light). This method is only qualitative, but is an effective way of demonstrating potentially hazardous control practices.

Internal exposure. A commonly used indicator for organophosphate absorption is the depression of acetylcholinesterase (in red blood cells) and pseudocholinesterase (in blood plasma). This can be tested after taking a blood sample and subsequent analysis using a field test kit or in a specialized laboratory.

Indicative action thresholds based on cholinesterase inhibition levels

AChE levels (% below baseline[1])	Indication of:	Recommended action:
> 20%	exposure	(Senior) field officer should evaluate workplace and correct any unsafe practices
> 30%	possible health effects	Exposure must stop; staff should be temporarily taken off work with insecticides
> 50%	poisoning	Exposure must stop; staff should be temporarily taken off work with insecticides and medical attention sought
< 20%	(after any of the above)	Recovery; staff may resume work with insecticides

[1] *Action thresholds based on comparison with individual baseline levels.*

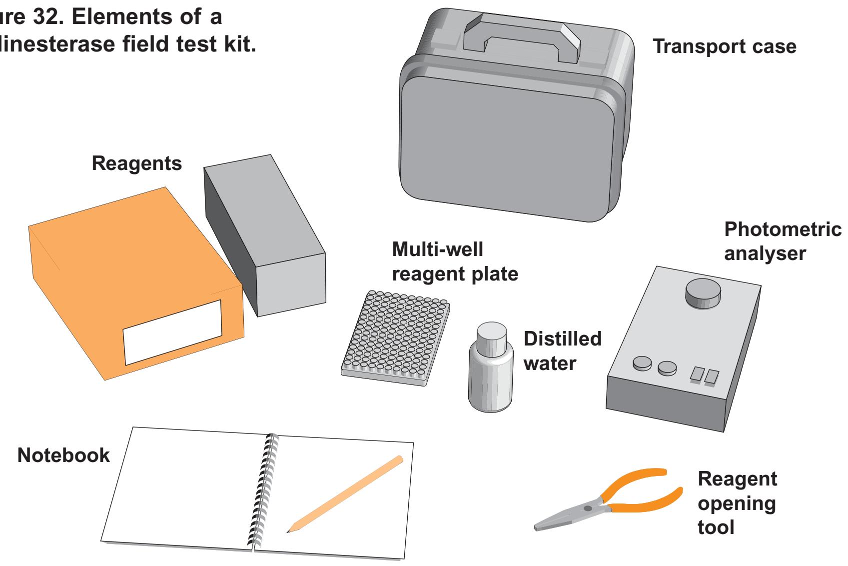


Figure 32. Elements of a cholinesterase field test kit.

Figure 33. Blood samples can be taken in the field, to assess exposure to organophosphate insecticides.

For Desert Locust control, cholinesterase field test kits are recommended because these avoid transport of samples to a laboratory (which may be far away from the control site) and allow immediate corrective action, if needed. Good, robust and easy to use field test kits are now available (see Fig. 32). Blood samples are best taken by medical or paramedical personnel (see Fig. 33). If cholinesterase levels are inhibited above what is considered acceptable, personnel should be (temporarily) removed from control operations until they have recovered.

Exposure to carbamates can also be assessed using a cholinesterase test. However, since carbamate-induced cholinesterase depression does not last very long, blood testing has to be done within an hour or so after exposure otherwise no effect will be found. No practical field kits are at present available for assessment of poisoning by pyrethroids, benzoyl ureas or phenyl pyrazoles.

Occupational poisoning. All cases of poisoning of control staff should be documented in as much detail as possible, so that measures can be taken to avoid them in the future. The *FAO Poisoning incident form* for locust control operations may be used for this (see p. 84).

Exposure of the local population. The risk of exposure of the local population to the insecticides used for locust control is generally evaluated through indirect assessments. These include the analysis of insecticide residues in food and water, verification of buffer zones and withholding periods, observation of the application practice of control teams and the behaviour of bystanders. Guidance on sampling for insecticide residue analysis is given in the next section. A checklist for the risk assessment of exposure of local populations to locust control insecticides is given on p. 82. It is recommended that this checklist be filled out regularly, especially if treatments take place close to human habitations.

Direct assessments (e.g. blood samples, medical evaluations, epidemiological studies) are only very rarely useful in locust control situations because exposure, if it occurs, is generally short-lived, single and by relatively non-persistent insecticides.

Minimum sample sizes for residue monitoring in emergency situations

Substrate	Minimum sample size [1,2]
Water (in case of drift or spillage)	1 litre
Soil (in case of spillage)	500 g
Grass, green forage	1 000 g
Crops (cereal grains, leafy crops)	1 000 g
Milk	500 ml
Arthropods (e.g. bees and shrimp)	100 - 200 g
Fish	500 g

[1] *Indicative figures only; the exact minimum sample size depends on the limit of detection for the individual insecticide and substrate*

[2] *If possible, the sample should be a composite of several subsamples*

Figure 34. Always take the exact sample size (fresh weight for solid samples and volume for liquid ones) directly after sampling.

Monitoring insecticide residues

It is sometimes useful to monitor insecticide residues after locust control treatments to evaluate whether the withholding periods recommended by the insecticide manufacturers are valid under local conditions or to confirm that no contamination of protected areas occurs when recommended buffer zones are respected. Moreover, if fish or wildlife mortality has been observed, residue analysis may help assess whether locust control caused such effects. However, insecticide residue analysis is expensive, and if sampling is not carried out correctly, the entire exercise may be worthless. Therefore, sampling for insecticide residues needs to be very well prepared.

Residue monitoring studies. There is no general sampling protocol for insecticide residues. It depends on the substrate that is being sampled (water, vegetation, etc.) and the type of insecticide concerned (see Fig. 34). Also, the exact question that needs to be answered determines to a large extent the nature and duration of the study. The checklist on the next page provides general guidance on the process of setting up a residue monitoring exercise. Further references for sampling methods for pesticide residues are given on p. 86.

Emergency sampling. Sometimes it may not be possible to develop a proper sampling plan. This is the case in emergency situations, e.g. if wildlife mortality has been observed, accidental spillage has occurred, beekeepers have claimed that locust control has caused them damage, etc. In these cases, the monitoring team may need to take samples immediately, for later residue analysis. It is important that sampling is carried out as soon as possible, otherwise residues may already have broken down. Indicative sample sizes that apply in such cases are given on the opposite page.

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FAQ number 5 (see p. 88 for answers)

Can you eat locusts that have been sprayed?

Issues to be addressed when setting up an insecticide residue monitoring study

Step	Issues to be addressed
1	Clarify the principal question to be answered
2	Define the substrate to be sampled (e.g. crop, grass, water, milk)
3	Identify which insecticide(s) (and possibly metabolites) have to be analysed; obtain physicochemical properties
4	Identify the laboratory that can analyse this insecticide (either in the country or abroad)
5	Obtain the analysis method for the insecticide in the selected substrate (either from the laboratory, the insecticide manufacturer or an analytical handbook)
6	Define sampling programme: sample size and frequency (depends on question to be answered [step 1], type of substrate [step 2], persistence of insecticide [step 3] and limit of detection [step 5])
7	Evaluate whether insecticide extraction will be done on site or in the laboratory (depends on type of insecticide [step 3] and available equipment)
8	Define method(s) and duration of sample transport, from field to laboratory (depends on stability of insectide [step 3], type of substrate [step 2], type of sample: entire or extracted [step 7] and distance to laboratory [step 4])
9	Select type of sample containers (depends on type substrate [step 2], type of insecticide [step 3] and type of sample: entire or extracted [step 7])
10	Define quality assurance measures (e.g. preparation of spiked samples, use of “double blind” labelling system, use of split samples for possible second opinion analysis, prevention of (cross-)contamination, etc.)

Note: Additional information on design and execution of residue monitoring can be found in the Reference section on p. 86.

Designing residue monitoring studies. Monitoring of pesticide residues in crops, soil, water or livestock may sometimes be required as part of an environmental monitoring exercise. Various questions need to be answered before such a study can be set up. The issues to be addressed to ensure that the monitoring study is properly designed are listed in the table on the opposite page.

Good sampling practices. Good sampling practices are essential for the success of monitoring for pesticide residues. The quantities of insecticides that need to be detected are extremely low. Contamination or inappropriate storage may cause the entire monitoring exercise to become invalid.

Insecticide residue monitoring should follow good laboratory and field practice whenever possible. Detailed sampling and sample handling protocols will then apply. But even in the case of emergency sampling, a number of basic sampling rules should be followed:

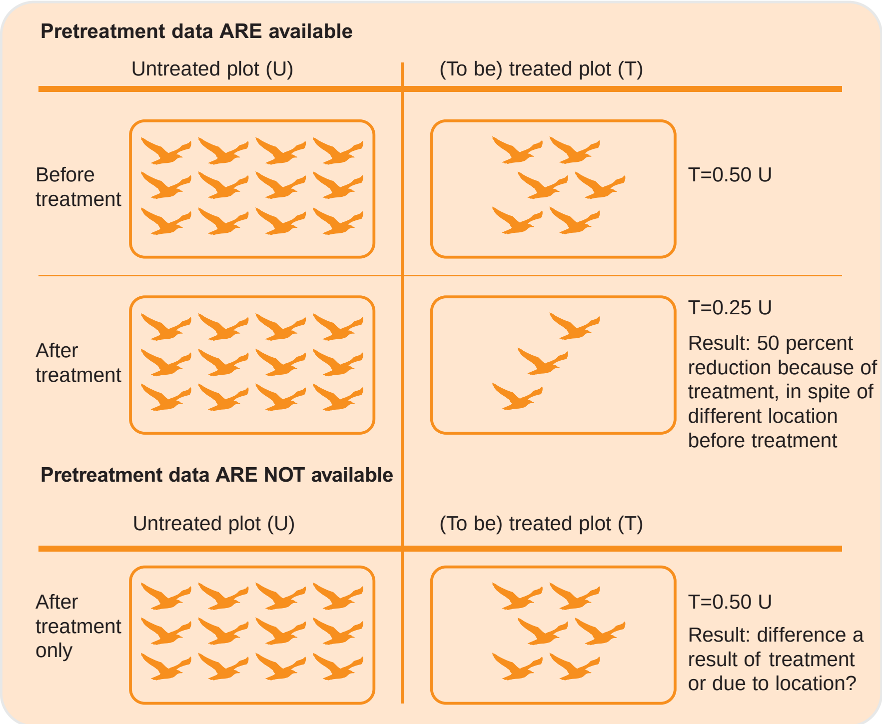
- Avoid contamination of the sample:
  - use clean sampling tools and storage containers;
  - wear clean, disposable laboratory gloves (no PVC) for each sample that is taken;
  - do not wear any protective clothing that has been used for pesticide application or otherwise contaminated by insecticides;
  - take control samples first at the unsprayed site, and only then the samples at the treated site.
- Ensure proper storage of samples:
  - store water samples in new (or very well cleaned) glass or teflon bottles. Do not use plastic containers;
  - wrap solid samples in aluminium foil and store subsequently in polyethylene or polypropylene bags or containers (do not use PVC materials);
  - store samples in a dark and cool place (a coolbox in the field and then a refrigerator at 4 - 8 °C) until reaching the residue analysis laboratory.
- Weigh (or measure) the sample in the field and note the fresh weight (or volume) in the field notebook or on the sampling form (see Fig. 34).
- Adequately label the sample containers with a unique code, both internally (on a piece of paper) and outside, using a pencil or a permanent marker.
- Write down all sampling details for each label in the field notebook or on the sampling form.

Figure 35. Observing mortality or abnormal behaviour in non-target organisms can provide valuable information on the environmental risk of the insecticide.

Monitoring staff should note:

- type (species) of organism affected
- approximate numbers (per unit area) killed
- time between spraying and effect or mortality
- knockdown and recovery (if occurring)
- time of day and weather conditions

Figure 36. Dilemma of monitoring abundances without pretreatment data: is the difference in bird density between the treated and the untreated plot as a result of the insecticide or only an effect of plot location?



Monitoring ecological side-effects

One of the main constraints for ecological monitoring of Desert Locust control is that the exact location of the insecticide treatments will often only be known very shortly before spraying. Many spray targets are identified the evening before treatment, and sometimes only on the day itself. This means that pre-spray observations or sampling are generally impossible. As a result, the scope of the ecological monitoring that can be carried out is relatively limited.

Three approaches to operational ecological monitoring can generally be used in Desert Locust control: observations, measurements and experiments.

Observations. Observations are (mostly) qualitative assessments of the direct impact of a treatment, e.g. fish kills, behavioural changes in birds, large bee mortality, etc (see Fig. 35). Even though ecological side-effects are not quantified, such observations are very important. Susceptible organisms can be identified for further study, and unexpected side-effects may indicate problems with the insecticide treatments.

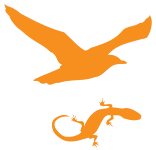
It is therefore always useful to take some time to walk through the treated plot and observe what happens. Most behavioural changes will occur fairly rapidly after spraying (i.e. 1 - 48 hours after treatment). Mortality, however, may take longer, depending on the type of organism and the insecticide applied. The observer should attempt to record the level of sampling effort to make this type of assessment (e.g. "Three out of five waterholes that were checked had dead fish"; or "15 dead reptiles were found in half an hour of searching").

Measurements. Measurements are all quantitative assessments of the impact of an insecticide treatment. Normally this will be the difference in a biological parameter between untreated and treated plots.

Blood cholinesterase (ChE) depression is an indicator of exposure to organophosphates and carbamates. It is a non-destructive technique, and useful for livestock. Brain ChE levels can only be measured in dead animals and may be used to confirm whether casualties were the result of spraying. Comparisons should be made with ChE levels in non-exposed organisms. This is no problem for blood sampling in livestock, but may be impossible if the species is rare or protected and should therefore not be caught and killed for brain extraction.

Ideally, the impact of an insecticide on the abundance of a non-target organism should be assessed. However, this can only be done in a meaningful way if pre-spray data have been collected. The abundance of many organisms in arid and semi-arid environments fluctuates greatly in time and space. As a result, if no pre-spray data have been collected, it is virtually impossible to prove that a difference in abundance observed between treated and untreated plots is a result of the insecticide unless mortality is observed (see Fig. 36).

Figure 37. What can be monitored after locust control treatments?

	Observations	Measurements	Experiments
 Birds, mammals, reptiles, amphibians	• killed animals in treated plots • unusual behaviour in treated plot • scavenging on killed locusts	• brain cholinesterase levels in dead or debilitated animals (if OPs[1] have been used) • blood cholinesterase levels in livestock (if OPs or CAs have been used) • insecticide residues	• none
 Fish	• fish kills in water downwind from treated plots • behavioural changes	• brain cholinesterase levels in dead or debilitated animals (if OPs have been used) • insecticide residues	• bioassays (floating cages)
 Terrestrial insects, other arthropods	• bee mortality (collection trays under hives) • large arthropod mortality • behavioural changes • scavenging on killed locusts	• insecticide residues • relative activity parameters (eg percentage of active ants nests, percentage of recent termite soil sheetings)	• bioassays exposing arthropods to treated vegetation/soil/ locusts, using arenas or cages
 Aquatic arthropods	• dead organisms (but note that certain crustaceans sink after death)	• increased drift (in rivers and streams only) • insecticide residues	• bioassays using floating cages or basins

[1]*OP: organophosphates, CA: carbamates*

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FAQ number 6 **(see p. 88 for answers)**

Do the insecticides used in locust control cause abortions in camels?

Pre-spray data can only be collected if the monitoring team knows exactly where treatments will take place. This may be the case during recession control, but will hardly ever be possible during outbreaks or plagues. Abundance assessments after treatment are therefore not recommended as a standard monitoring technique in emergency situations. An exception are barrier treatments. If there are consistent differences in the abundance of non-target organisms between sprayed barriers and the interbarrier spaces, they are unlikely to be a result of factors other than the insecticide treatment.

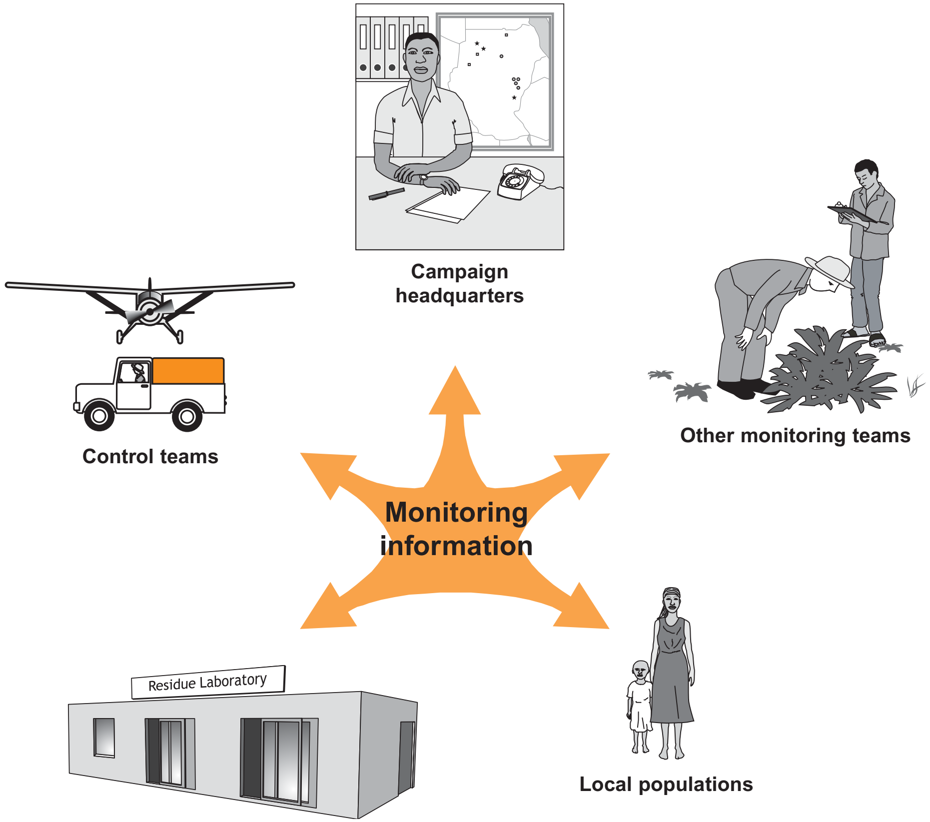
Other ecological parameters than abundance can often better be used in situations without pre-spray data; e.g. percentage activity at ant nest entrances or termite galleries, or repair rates of termite soil sheetings. These parameters are often relatively independent of the absolute abundance of the organism.

Experiments. The only experiments that can realistically be carried out in Desert Locust control situations are bioassays (see Fig. 37). Test organisms are exposed to the insecticide spray in the field, using cages or arenas, or treated substrate (vegetation, soil) is collected from the spray sites and organisms are subsequently exposed to it (either in the field or the laboratory). This works well for certain terrestrial arthropods and for various types of aquatic organisms. Such bioassays will show the toxicity of a substrate to the organism directly after treatment, but can also be used to evaluate the persistence of the insecticide under local environmental conditions. One of the main challenges with bioassays is to avoid large control mortality; mastering the handling and caging techniques is therefore a prerequisite for successful bioassays.

Timing. Timing of observations and measurements is very important, since certain biological parameters will show up rapidly after treatment, while others take a while to materialize. Behavioural changes in animals will often show up soon after treatment (a few hours to a day); mortality may take longer to occur (up to several days). If residue or ChE analysis is to be carried out in dead organisms, they need to be collected as soon as possible after death. Otherwise, residues may break down or the animals will start to putrefy.

Strength-of-evidence analysis. It is often not straightforward to make a causal link between an insecticide application and an effect. Some points deserve special attention. Evidence for a causal link is stronger if chemical and biological proof can be combined (e.g. finding lethal insecticide residue levels in animals found dead in a treated plot). Effects that are repeatedly observed after treatments with the same insecticide, and on different locations, also provide a strong indication of a causal link. Temporality is another important factor: a cause must always precede its effects. For instance, if miscarriages have already been observed in livestock before treatments were carried out, locust control insecticides are unlikely to be the cause.

Figure 38. Monitoring teams should ensure effective information exchange with all relevant parties in the control campaign.



Information exchange

An important element of environmental and health monitoring is the exchange of information, both within the campaign organization and with the local population (see Fig. 38).

Information exchange within the campaign

Monitoring teams will gather information that needs to be transmitted to other actors in the campaign. Good communications should, first of all, be ensured with the control teams. Since cooperation by the control teams is essential for effective monitoring, they need to be informed about the assessments that are being planned. The monitoring results should also be communicated directly to the control teams, so that corrective action can be taken, if needed. It is important that the monitoring team is not seen as the “policemen” of the control campaign, but as a way to improve control and provide technical assistance when needed.

Monitoring teams should communicate effectively with their technical cooperating agencies (residue laboratory, medical authorities, etc.), who need to be informed in a timely way about assistance they may need to provide to the monitoring teams, or any patients or samples that may be sent to them. Also, by being aware of the activities and problems in the field, the cooperating agencies can proactively suggest solutions.

Finally, campaign headquarters should at all times be informed about the location and immediate programme of the monitoring teams. This is to ensure that the most effective use is being made of often limited expertise. Campaign headquarters may also receive requests for information on health and environment from the press, other government institutions, or from politicians.

Information exchange with the local population

Local people will often show great interest in the possible environmental and health effects of the insecticides used in locust control. Monitoring teams will be in direct contact with these people and are the obvious source of information. Teams should therefore be well prepared to answer questions (see p. 39).

It is important to programme short information sessions in villages or settlements that are close to the control sites so that the local people are informed about the aims of the operation and the risks from pesticides. They should also be informed of precautionary measures they should take. Information sessions can be used to obtain feedback from local inhabitants on problems they have encountered. Furthermore, if dedicated operational monitoring is to take place, the teams should explain what monitoring techniques are used and obtain cooperation to avoid losses of equipment such as traps, etc.

Figure 39. Triangulation of remaining, but good-quality, insecticides for locust control.

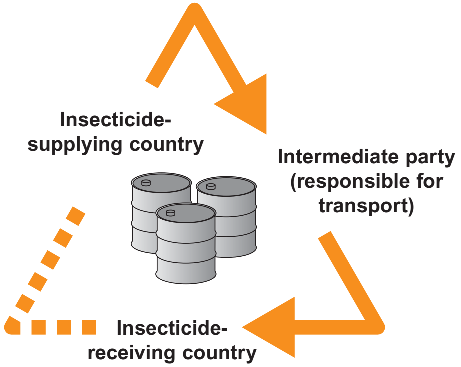
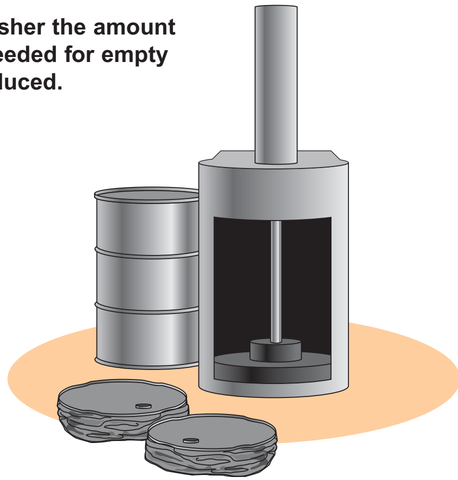


Figure 40. By using a drum crusher the amount of safe storage space that is needed for empty insecticide drums is greatly reduced.



FAQ number 7 **(see p. 88 for answers)**

Can empty pesticide containers be used for drinking-water or food?

CAMPAIGN FOLLOW-UP

Remaining insecticides and empty containers

Insecticides

Even if insecticide purchasing has been correctly planned, it is likely that some insecticide will remain after the locust control campaign. Most ULV insecticides, if properly stored, will remain usable for several years (pesticide manufacturers generally guarantee a shelf-life of two years, but many products will remain in good condition for longer).

If locust populations have to be controlled on a regular basis in the country, leftover pesticides can be stored for future use. They are best collected in only one, or a few, good pesticide storage facilities. Any containers that have been damaged during transport, and may therefore corrode or leak more rapidly, should be replaced. With insecticides coming from different sources, a good storage administration system should be kept.

If small amounts of insecticides remain, but will probably not be used for locust control in the near future, they may sometimes be used against other pests. Note that this should only be allowed if the insecticide has been registered for use against such pests.

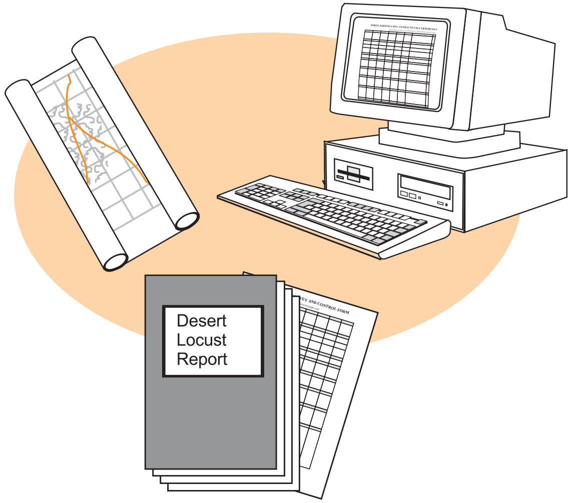
If large amounts of insecticides remain, and are unlikely to be used over the next few years, the sale or donation of these products to (neighbouring) countries that need them for locust control could be considered. This is highly preferable to the creation of obsolete stocks. If a third party is responsible for transport, this system is sometimes referred to as triangulation (see Fig. 39 and *Desert Locust Guidelines* No. 5 *Campaign organization and execution*)

Empty containers

If logistics have properly functioned during the campaign, the empty and rinsed insecticide drums will have been returned to a limited number of storage sites. After the campaign, they should be collected in one location, where appropriate arrangements can be made. In some cases, the purchasing contract will stipulate that the pesticide manufacturer will take back the drums for reconditioning. This is the best option from an environmental point of view.

If the drums are not taken back, a few empty drums of good quality should be kept for insecticide storage (e.g. in case of spills or container damage). The rest is best crushed using a custom-made drum crusher (see Fig. 40). This will greatly reduce the volume and thus facilitate safe (temporary) storage. Crushed drums can then be recycled in an industrial metal smelter or destroyed in a dedicated incineration plant.

Figure 41. A detailed analysis of the monitoring results and a good report will help improve future control campaigns.



Tip: if the post-campaign debriefing is organized soon after the last control operation, not all the results of (residue) sample analysis may be available. If this is the case, preliminary monitoring results should be discussed during the main debriefing session, while more detailed recommendations can be made at a later stage. It is important that for a second environmental and human health debriefing, all important participants in the control campaign are invited once again.

Finalizing monitoring activities

Various activities related to environmental and health monitoring will continue for some time after the control activities have stopped.

Post-campaign health examinations

All control staff should undergo, as soon as possible after the control campaign, a medical examination. If required, a final ChE analysis should also be carried out (e.g. if the staff member has shown ChE inhibition late in the campaign). The results of these checkups should be compared with the pre-campaign data. Any staff showing signs of (chronic) insecticide poisoning should continue to be monitored. Based on these results, staff may need to be assigned other tasks during the next control campaign.

Long-term monitoring

Sometimes residue or ecological monitoring needs to be continued after the last control operation. This may be the case if relatively persistent insecticides have been used, or if adverse ecological effects have been observed during the control operations and the time to recovery has to be assessed. Thus, not all monitoring teams can always be disbanded immediately after a campaign.

Sample treatments

Often, both residue and biological samples can only be analysed after the control operations (e.g. because relevant staff were involved in field monitoring). It is important that the campaign organization takes into account the time needed for such analysis, as the results may be important for the technical evaluation of the campaign.

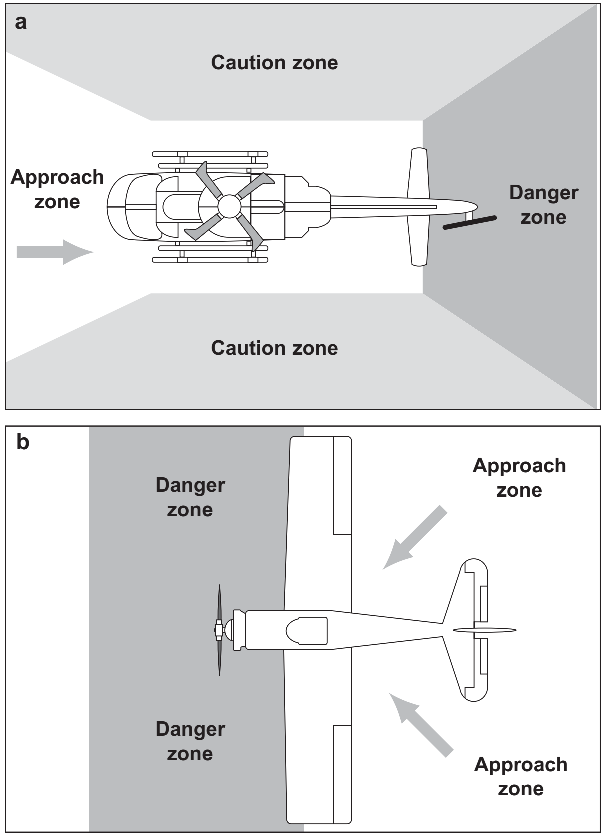
Reporting

The preparation of a detailed report of the results of the monitoring exercises is the final, but essential, task of the monitoring team. The report should contain all the results of the various studies and field evaluations. Furthermore, an analysis should be made of the (potential) environmental and health risks of the locust control campaign, based on these results, and concrete and practical recommendations made for improvements. Since the report may be an important source of information for monitoring exercises in other countries, the raw data should be added in annexes to the main report (see Fig. 41).

Post-campaign debriefing

At the end of a Desert Locust control campaign, a debriefing session is generally held to evaluate the results of the operations and identify possible improvements for the future (see *Desert Locust Guideline* No. 5 *Campaign organization and execution*). The results of environmental and health monitoring should also be discussed during this debriefing, and the lessons learned incorporated into the new contingency or campaign plan.

Figure 42. Approaching an aircraft
(a) helicopters
(b) fixed-wing aircraft



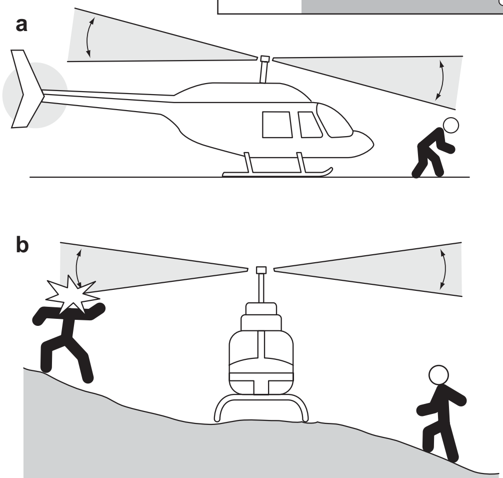


Figure 43. Approaching a helicopter:

(a) stay low or crouch when approaching

(b) if helicopter has landed on a hill, always approach from the downhill side

ADDITIONAL INFORMATION

Safety around aircraft

Desert locust survey and control operations often involve aircraft, both fixed-wing and helicopters. A number of basic safety rules apply for survey and control staff that need to come close to aircraft.

First and foremost, the pilot is responsible for his/her aircraft and any related safety issues. The pilot **always** has the final say with respect to aircraft safety.

Approaching helicopters

When approaching a helicopter, the following general safety rules apply:

- Do not approach a helicopter with its rotors turning; wait until the rotors have come to a complete standstill.
- Only approach when signalled to do so by a flight crew member.
- Always approach and depart the helicopter from the front; make sure that the pilot can see you (see Fig. 42a).
- Never approach from the rear and never walk around the tail rotor area since a turning tail rotor is practically invisible.
- Crouch low when approaching the helicopter; rotor blades are flexible and wind gusts can cause the blade tips to dip below their normal position (see Fig. 43a).
- When approaching the helicopter on a slope, never do so from the uphill side. Always approach from the downhill side because the clearance from the main rotor to the ground is much greater (see Fig. 43b).
- No objects should be carried above the head, and long objects should be carried parallel to the ground.
- Keep bystanders at a safe distance (at least 100 m) from the edge of the landing site.

Approaching fixed-wing aircraft

Most spray or survey planes used in locust control have either a central nose propeller or two wing propellers. When approaching a fixed-wing aircraft, the following general safety rules apply:

- Do not approach a fixed-wing aircraft with its propeller(s) turning; wait until both the aircraft and the propeller(s) have come to a complete standstill.
- Only approach when signalled to do so by a flight crew member.
- Do not approach the aircraft from the front (see Fig. 42b).
- Never pass underneath the wings of the aircraft; walk around them.
- Keep bystanders at a safe distance (at least 100 m) from the edge of the aircraft parking site.

FAO CHECK LIST FOR GENERAL MONITORING OF DESERT LOCUST CONTROL OPERATIONS

Fill out this check list for each monitoring excercise; use field notebook or specific forms for more detailed descriptions

1	**DATE & LOCATION OF MONITORING EXCERCISE**
1-1	date — 1-2 location (*name; latitute/longitude*):
2	**INSECTICIDE DATA (*of product involved in monitoring*)**
2-1	trade name: — 2-2 common name:
2-3	concentration (*g a.i./l or %*): — 2-4 formulation type:
3	**SPRAY MONITORING**
3-1	**spray monitoring form** filled in (*tick one box; if yes, write reference to relevant form/page number*): ☐ yes ☐ no — form/page reference:
3-2	same area sprayed for locust control before ☐ no, not recently ☐ yes, this campaign ☐ yes, last year
4	**EFFICACY MONITORING**
4-1	efficay monitoring carried out: ☐ yes ☐ no
4-2	mortality/survival how assessed: ☐ visual estimates ☐ cages ☐ pre- and post-spray counts
4-3	*provide details on methodology, replicates, results, etc. in field notebook* — notebook page reference:
5	**OCCUPATIONAL POISONING INCIDENTS**
5-1	case(s) of occupational poisoning observed: ☐ yes ☐ no
5-2	**occupational poisoning incident form** filled in (*tick one box; if yes, write reference to relevant form/page number*): ☐ yes ☐ no — form/page reference:
6	**RISK ASSESSMENT FOR GENERAL POPULATION**
6-1	human habitations nearby (*within 5 km of spray site, air strip or camp*): ☐ yes ☐ no
6-2	name(s) of nearest human habitations and distance(s) to spray sites; were they informed about control operations:

	habitation 1	habitation 2	habitation 3
name:			
distance (*km*):			
informed about spraying:	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no

6-3	open drinking water sources nearby (*e.g. wells, rivers, within 2 km of spray site*): ☐ yes ☐ no
6-4	buffer zones applied: i - between human habitations and spray site: ☐ yes ☐ no — buffer distance used (*m*): ii - between water sources and spray site: ☐ yes ☐ no — buffer distance used (*m*):
6-5	populations informed about re-entry interval into sprayed sites: ☐ yes ☐ no
6-6	any crops sprayed: ☐ yes ☐ no — if yes, specify which crops: if yes, farmers informed about pre-harvest interval: ☐ yes ☐ no
7	**ENVIRONMENTAL RISK ASSESSMENT**

7-1	ecologically sensitive areas nearby (*within 2 km of spray site*) (e.g. protected areas, biocontrol sites): ☐ yes ☐ no
	if yes, specify what type of areas:
	if yes, buffer zones applied between such areas and spray site: ☐ yes ☐ no — buffer distance used (*m*):

7-2	aquatic ecosystems nearby (e.g rivers, lakes, ponds) ☐ yes ☐ no if yes, buffer zones applied between aquatic ecosystems and spray site: ☐ yes ☐ no — buffer distance used (*m*):
7-3	beekeeping areas nearby (*within 5 km of spray site*) ☐ yes ☐ no if yes, what measures taken to reduce risk of bee kills:
7-4	any grazing land sprayed: ☐ yes ☐ no — if yes, herders informed about livestock witholding period: ☐ yes ☐ no
7-5	mortality or abnormal behaviour observed after treatment, in: i - terrestrial non-target arthropods: ☐ yes ☐ no ii - mammals: ☐ yes ☐ no iii - birds: ☐ yes ☐ no iv - fish: ☐ yes ☐ no v - aquatic arthropods: ☐ yes ☐ no — if yes, which groups (also note details of observations, e.g. mortality, behavioural changes, etc.):
7-6	experiments or more detailed observations carried out ☐ yes ☐ no if yes, which ones (describe): *provide details on methodology, results, etc. in field notebook* — notebook page reference:
8	**RESIDUE SAMPLING**
8-1	residue samples taken (*tick one box; if yes, write reference to relevant form/page number*): ☐ yes ☐ no *if yes, provide details on type, number, methodology, etc. in field notebook* — notebook page reference:
9	**REPORTING**
9-1	name of person who filled out this form:

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FAO general monitoring checklist

The FAO checklist for general monitoring of Desert Locust control operations is provided to help dedicated operational monitoring teams with their job. It provides an overview of the different activities that a monitoring team may need to cover.

The checklist is no more than that. In almost all cases, the monitoring team will have to collect more detailed information and report this on other forms (e.g. the *Poisoning incident form* or the *Spray monitoring form*), other locally developed forms (e.g. a residue sampling form provided by the laboratory), or the team's field notebook. Environmental and health monitoring therefore does not stop by filling in the checklist but it starts with it.

Tip: depending on the monitoring tasks that have to be carried out, standard operating procedures (SOPs) may need to be developed during the campaign planning phase. SOPs are detailed descriptions of how to carry out specific monitoring tasks, e.g. taking a vegetation sample, caging locusts for an efficacy assessment, carrying out a cholinesterase measurement with a field kit, etc.

SOPs ensure that these tasks are done in exactly the same way, during different times of the campaign and by different teams. This will mean that the quality of the work is consistent and it facilitates comparison of different cases as well as reporting.

Monitoring teams should develop SOPs for tasks that are regularly carried out, especially if it is relatively easy to make mistakes. Part of a SOP may be a standard form or table for data collection.

The latest versions of the *FAO Checklist for general monitoring* and the *FAO poisoning incident form* are available on the Internet at: **www.fao.org/news/global/locusts/pubs1.htm**

FAO POISONING INCIDENT FORM (Locust control)

Fill out this form for each (suspected) poisoning incident, and send it to the National Locust Unit in your country

1	**DATE & LOCATION OF POISONING INCIDENT**		
1-1	date of the incident:		
1-2	location of the incident (*name; latitute/longitude*):		
1-3	reference to Spray Monitoring Form (*if relevant; page number*):		
2	**INSECTICIDE DATA** (*of product involved in poisoning case*)		
2-1	trade name:	2-2	common name:
2-3	concentration (*g a.i./l or %*):	2-4	formulation type:
2-5	batch number:	2-6	production and/or expiry date:
2-7	solvent and mixing ratio (*if relevant*):		
3	**PERSONAL DETAILS** (*of suspected poisoned person*)		
3-1	name:		
3-2	sex: ❑ male ❑ female	3-3	age (*years*):
3-4	staff position (*e.g. applicator, flag man, driver*):		
4	**INCIDENT DETAILS**		
4-1	activity while exposed to insecticide (*e.g. spraying, filling aircraft hopper, etc*):		
4-2	personal protective equipment used (*tick one or more boxes*): ❑ boots ❑ hat ❑ apron ❑ coveralls ❑ face shield / goggles ❑ respirator ❑ gloves ❑ dust mask ❑ other (specify):		
4-3	way of exposure (*tick one or more boxes*): ❑ on skin ❑ by ingestion ❑ by inhalation		
4-4	estimate of quantity of exposure (*e.g. spray cloud droplets, coveralls entirely drenched, drank 1-litre bottle, etc.*):		
4-5	duration of exposure (*hours until decontamination / treatment*):		
4-6	other persons also exposed to insecticide: ❑ yes ❑ no		
4-7	other relevant details about the incident (*describe*):		
5	**SIGNS AND SYMPTOMS**		
5-1	observed signs and symptoms of poisoning (*tick one or more boxes*): ❑ skin irritation / rashes ❑ tingling or numbness of face or hands ❑ abdominal pain (stomach, belly) ❑ sweating ❑ headache ❑ nausea, vomiting ❑ tearing of eye(s) ❑ confusion, disorientation, incoordination ❑ diarrhea ❑ double vision ❑ muscle twitching, tremor ❑ respiratory failure, coma ❑ contraction of pupils ❑ runny nose ❑ seizures, convulsions ❑ salivation ❑ abnormal breathing ❑ death		
5-2	first onset of symptoms (*hours or days after last exposure*):		
5-3	cholinesterase measurement carried out: ❑ yes ❑ no		
5-4	type of cholinesterase measurement carried out (*tick one box*: ❑ plasma ❑ red blood cells ❑ whole blood		
6	**TREATMENT**		
6-1	treatment given: ❑ yes ❑ no		
6-2	type of treatment or antidote given (*provide details*):		
6-3	person taken to hospital or medical post: ❑ yes ❑ no		
6-4	period that person will be taken off insecticide application (*days*):		
7	**REPORTING**		
7-1	name of person who filled out this form:		
7-2	staff category (*tick one box*): ❑ medical ❑ paramedical ❑ non medical (specify)		

FAO poisoning incident form

The *Poisoning incident form* should be filled out as completely as possible after each (suspected) insecticide poisoning incident. If the incident is linked to an insecticide application, do not forget to provide a cross-reference to the *Spray monitoring form* on which the application details have been noted.

There are no specific signs or symptoms that are invariably present in poisonings by particular pesticides and many poisonings are characterized by unexpected manifestations. Therefore, this list below is indicative only, but it may help early recognition of insecticide poisoning cases.

Signs and symptoms of poisoning by insecticides used in Desert Locust control

Part of body	Characteristic signs and symptoms	Group of insecticides			
		OP	CA	PY	PP
General	Malaise, fatigue, dizziness	x	x	x	
Skin, face	Irritation, contact dermatitis			x	x
	Strong tingling, burning, numbness			x	
	(Profuse) sweating	x	x		
Eyes	Irritation			x	x
	Tearing	x	x		
	Double or blurred vision	x	x		
	Contraction of pupils	x	x		
Nervous system	Headache	x	x		
	Muscle twitching, tremor	x	x		x
	Lack of coordination, muscle weakness, paralysis	x	x		
	Depression, coma, respiratory failure	x	x		
Respiratory system	Runny nose	x	x	x	
	Abnormal breathing rate or pattern	x	x	x	
Stomach and intestines	Nausea, vomiting	x	x		
	Diarrhoea	x	x	x	
	Abdominal pain	x	x		
	Salivation	x	x		
Blood	Depressed red blood cell and plasma cholinesterase	x	x		

OP=organophosphates (chlorpyrifos, fenitrothion, malathion): CA=carbamates (bendiocarb): PY=pyrethroids (deltamethrin, lambdacyhalothrin): PP=phenyl pyrazoles (fipronil).
Note: there are no specific poisoning signs and symptoms for benzoyl ureas (diflubenzuron, teflubenzuron, triflumuron).

Selected references

Efficacy and environmental effects of Desert Locust control insecticides

FAO. 1999. Evaluation of field trials data on the efficacy and selectivity of insecticides on locusts and grasshoppers. Report to FAO by the Pesticide Referee Group. Eighth meeting, 11-14 October 1999. (Rome, Italy). 38 pp. The latest version of this report can be downloaded from: http://www.fao.org/news/global/locusts/reports1.htm

Technical data on individual insecticides (e.g. toxicology, environmental fate and effects)

IPCS (undated) INCHEM - Chemical safety information from intergovernmental organizations. WHO International Programme on Chemical Safety. Geneva, Switzerland. Database accessible on the Internet at: http://www.inchem.org, and on CD-ROM.

PANNA. undated. Pesticide Action Network Pesticide Database. PAN North America. Database accessible on the Internet at: http://www.pesticideinfo.org.

Tomlin, C.D.S. (ed.). 2000. The e-Pesticide Manual 2000-2001. Twelfth edition, version 2.0. British Crop Protection Council. Farnham, United Kingdom (exists both on CD-ROM or as a book).

WHO. 2001. The WHO recommended classification of pesticides by hazard, and guidelines to classification 2000-2002. World Health Organization. Geneva, Switzerland. The most recent version of the classification can be downloaded from: http://www.who.int/pcs/pcs_pubs.html

General ecotoxicology

Römbke, J. & Moltmann, J.R. 1996. Applied ecotoxicology. GTZ. Boca Raton, CRC Lewis Publishers. 282 pp.

Römbke, J. & Moltmann, J.R. 2000. Ecotoxicologie appliquée. GTZ & CERES/Locustox. Weikersheim, Margraf Verlag. 324 pp. [French version of English 1996 edition]

Environmental effects of locust control

A considerable body of publications is now available on the environmental impact of locust and grasshopper control. These publications provide much information on sampling methods, monitoring approaches and study set-up.

Given the large number of these publications, and since new studies are still being published on a regular basis, an annotated list is kept on the Web site of the FAO Migratory Pests Group. This list can be downloaded from: http://www.fao.org/news/global/locusts/pubs1.htm. It will be updated on a regular basis.

Occupational risk and pesticide poisoning

BCPC. 1999. Using pesticides - A complete guide to safe and effective spraying. British Crop Protection Council. Farnham, United Kingdom. 185 pp.

FAO. 1990. Guidelines for personal protection when working with pesticides in tropical climates. 17 pp. The document can be downloaded from: http://www.fao.org/waicent/faoinfo/agricult/agp/agpp/pesticid/

Osorio, A.M. 2002. Surveillance systems for pesticide intoxications. Int. J. Occup. Environ. Health, 8 (1): 1-13.

Plestina, R. 1984. Prevention, diagnosis and treatment of insecticide poisoning. Document No. WHO/VBC/84.889. World Health Organization. Geneva, Switzerland. 71pp.

Reigart, J.R & Roberts, J.R. 1999. Recognition and management of pesticide poisonings. Fifth edition. United States Environmental Protection Agency. Washington D.C., U.S.A. 236 pp. Book also available on the Internet at: http://www.epa.gov/oppfead1/safety/healthcare/handbook/handbook.htm

Biological and residue sampling, bioassays, ecological monitoring

Dent, D.R. & Walton, M.P. (eds.) Methods in ecological and agricultural entomology. CAB International. Wallingford, United Kingdom. 387 pp.

FAO. 1997. Manual on the submission and evaluation of pesticide residues data for the estimation of maximum residue levels in food and feed. Document can be downloaded from: http://www.fao.org/waicent/faoinfo/agricult/agp/agpp/pesticid/

Grant, I.F. & Tingle, C.C.D. (eds.). 2002. Handbook of ecological monitoring methods for the assessment of pesticide impact in the tropics. Natural Resources Institute. Chatham, United Kingdom. 266 pp. + method sheets.

Greaves, M.P., Smith, B.D. and Greig-Smith, P.W. (eds.). 1988. Field methods for the study of environmental effects of pesticides. British Crop Protection Council. Farnham, United Kingdom. 370 pp.

Mullié, W.C. & Touré, A. 2000. A validated field method for monitoring erythrocyte acteylcholinesterase inhibition in livestock after exposure to organophosphate and carbamate insecticides. Etudes et Recherches Sahéliennes / Sahelian Studies and Research 4-5: 50-61

Nagel, P. 1995. Environmental monitoring handbook for tsetse control operations. Margraf Verlag Weikersheim, Germany. 323 pp.

Southwood, T.E.R. & Henderson, P.A. 2000. Ecological methods. 3rd edition. Blackwell Science. Oxford, United Kingdom. 575 pp.

Sutherland, W.J. (ed.) 1996. Ecological census techniques. A handbook. Cambridge University Press. Cambridge, United Kingdom. 336 pp.

Pesticide purchasing, labelling and storage

FAO. 1995. Revised guidelines on good labelling practice for pesticides.

FAO. 1996. Pesticide storage and stock control manual. FAO Pesticide Disposal Series N°3.

Pesticide specifications

FAO. 1994. Provisional guidelines on tender procedures for the procurement of pesticides.

FAO. undated. FAO pesticide specifications and quality standards.

All these documents can be downloaded for individual pesticides from: http://www.fao.org/waicent/faoinfo/agricult/agp/agpp/pesticid/

FREQUENTLY ASKED QUESTIONS (FAQS)

1. If I happen to be accidentally oversprayed by a spray aircraft during locust control operations, should I see a doctor?

Answer: Only in exceptional cases. When the dosage is correct, the spray cloud is not acutely toxic to humans after a single overspraying. However, you should wash the exposed parts of your body as soon as possible with water and soap, and do the same with your clothes. Should any symptoms develop that could be the result of the insecticide (e.g. headache, nausea, blurred vision), you should consult a doctor.

2. Mycopesticides, such as *Metarhizium anisopliae* var. *acridum*, are supposedly only killing locusts and no other non-target organisms. Is this true?

Answer: The *acridum* variety of the entomopathogen *Metarhizium anisopliae* indeed appears to be very specific to locusts and grasshoppers. Very few other groups of insects have been found infected by this fungus, and then almost only in the laboratory and not under operational field conditions. No effects on fish, birds and mammals have been observed. It is without doubt the most specific of the available locust control insecticides. However, other entomopathogens, even within the species of *Metarhizium anisopliae*, may affect more groups of insects, so the high specificity is linked to the *acridum* variety of the fungus.

3. It is often already difficult to obtain funds for a locust control campaign. Give me three good reasons why I should use part of my limited budget for one or more monitoring teams.

Answer:

1) *Occupational health*
   Monitoring will reduce the risk of poisoning of control staff. Apart from the human suffering that occupational poisoning may cause, it also reduces labour productivity and thus the efficacy of the control campaign.
2) *Environmental health*
   Monitoring will minimize the environmental impact of locust control. Since the environment provides important natural resources and ecological services for humans, especially in rural areas, adverse environmental effects often result in direct or indirect economic costs.
3) *Cost*
   Monitoring will help to optimize locust control, e.g. by reducing the risk of overdosing or inefficacious treatments. In this way, monitoring will earn itself back very rapidly and minimizes wastage of control campaign funds.

4. Is there any experience with operational environmental and human health monitoring of locust control campaigns, as described in this Guideline?

Answer: Yes, although this experience is still quite limited. But operational monitoring of occupational health and/or environmental side-effects has been carried out in a number of locust-affected countries in the recent past. They include Kazakhstan, Madagascar, Mauritania, Morocco and Senegal. Unfortunately, this is not yet standard practice in all control campaigns.

5. Can you eat locusts that have been sprayed?

Answer: No. Locusts killed by insecticides should never be consumed, since they may still contain toxic levels of insecticides. Therefore, when locusts are sold on the market for human consumption, one should always be sure that they were caught alive (e.g. with nets) and not after insecticide treatments.

6. Do the insecticides used in locust control cause abortions in camels?

Answer: No. For none of the insecticides that appear on the list of the Pesticide Referee Group do we have toxicological indications that they will cause abortions in camels (or any other livestock, for that matter) at locust control application rates. However, camel abortions have in the past been linked to a number of other factors such as viruses and toxic plants.

7. Can empty pesticide containers be used for drinking-water or food?

Answer: No. It is impossible to clean insecticide containers completely, especially those that contained ULV formulations. Toxic residues will always remain. Certain methods that are used locally to reduce the smell of these containers (e.g. rinsing the containers with a strong instant coffee solution) do not decontaminate them. Empty insecticide containers should either be taken back by the pesticide manufacturer or destroyed in an appropriate manner.