# EVALUATION OF FIELD TRIAL DATA ON THE EFFECTIVENESS OF INSECTICIDES TO LOCUSTS AND GRASSHOPPERS

REPORT TO FAO BY PESTICIDE REFEREE GROUP

26-29 NOVEMBER 1990

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FAO set up a Pesticide Referee Group to provide an independent evaluation of insecticides and recommend which were suitable for the control of locusts and grasshoppers. This evaluation was needed as the use of dieldrin is no longer environmentally acceptable. Commercial companies and other organisations were invited to carry out trials and submit these reports for evaluation by the Pesticide Referee Group. Guidance notes for field trials were issued as Appendix V in the Report: Evaluation of Pesticides for Locust Control FAO; 2 February 1989. 32 reports were examined in September 1989 (see Appendix 1) and these have been considered again in relation to data obtained in 22 additional reports received up to 27 November 1990.

The decline in the populations of the Desert Locust, <u>Schistocerca gregaria,</u> has severely limited field trials, so most reports refer to the control of grasshoppers, principally <u>Oedaleus senegalensis</u>. Some reports were received concerning trials with the Brown Locust <u>Locustana pardalina</u>, while one report referred to the Migratory Locust <u>Locusta migratoria</u>.

In assessing the pesticides with diverse characteristics, attention had been given to their suitability for different control strategies. The control strategies considered were:

1. Rapid control in emergency situations (including spraying swarms in the air).
2. Protection of crops at risk.
3. Prevention of population development, for example in recession areas.
4. Barrier spraying to intercept marching hopper bands in breeding areas.
5. Combination of the above strategies.

Swarm spraying requires very effective, fast-acting insecticides with a relatively short persistence. Side effects on non-target organisms are acceptable to a certain extent where the application is localised and deposits persist for a short duration. Broad spectrum, contact insecticides may be used.

Local efforts within the field to protect crops from large Desert Locust swarms are futile. Crops can in theory be protected from hoppers by application of persistent insecticide on bait or on vegetation which kills hoppers as they move into the field. This is only acceptable if the insecticide is fast acting, selective and environmentally benign but such a pesticide does not exist at present. If a protective ring of vegetation is sprayed around the cropped area, the insecticide can be slow acting and still kill hoppers before they enter the crop.

Preventive control strategies do not need to be rapid, but the insecticides need to persist to reduce the population over a period of time. Under these conditions slower acting products can be used eg. stomach acting insecticides or biological insecticides preferably with greater selectivity. Side-effects need to be minimal due to their large scale use and longer persistence in the environment.

Barrier spraying can be used in breeding areas at the beginning of an upsurge and during a plague. A persistent, environmentally benign insecticide is required. The advantage is that the target comes to the insecticide so that exact location of the hopper band is not important and timing of application is less critical.

The main groups of insecticides for these strategies are outlined:

| Control strategy | Insecticide characteristics | | |
|---|---|---|---|
| | Rapid contact | Slow stomach | Slow contact |
| **Curative** | | | |
| Emergency operation | Organophosphates, pyrethroids, carbamates | Benzoyl ureas | - |
| **Preventive** | | | |
| Prevention of population increase eg barrier spraying | - | Benzoyl ureas, biological insecticides (eg. bacteria or Nosema)) | Biological insecticides (eg. fungi) |
| **Crop protection** | | | |
| a) by spraying around fields | - | Benzoyl ureas, | - |
| b) by baiting | OP, pyrethroids, carbamates | | - |

Relatively few of the reports contained all the data requested by FAO in the guidelines for evaluation of insecticides. Plot size was sometimes inadequate so changes in population may have been due to emigration or immigration. While replication on a particular day may have been impractical, few reports gave results of similar treatments within a short period. Unfortunately a reference product was often not used, limiting the extent of comparisons between treatments. Information on the methods of application, type of vegetation and meteorological conditions was often inadequate. Different application techniques and methods of sampling were used (see Appendix II) so direct comparison between trials was not possible.

Most trials referred to ultra-low volume application (ULV) and only insecticides appropriate to this technique have been selected. Dosages have been selected that provide effective control when optimally applied in one litre spray per hectare. Where lower volumes have been applied results are often less reliable due to insufficient droplets per unit area, especially where the vegetation is dense. Generally the minimum volume required is 1 litre per hectare with a maximum of 3 litres per hectare.

Preference should be given to formulations which can be used on crops against other pests so that agricultural departments do not need to keep stocks of insecticide solely for locust control. This is considered to be particularly important to avoid the problem of safe disposal of out-of-date stocks.

In some reports it was possible to compare different methods of application. In general, better control was achieved with a narrower droplet spectrum achieved with a sprayer using a spinning disc compared to the use of an exhaust nozzle sprayer (ENS). Apart from differences in the droplet size spectra, swath width may have been a factor, the ENS being used on much wider swaths so that the distribution of insecticide may have been less uniform.

## Table 1. Summary of data from trial reports listed by insecticide

| INSECTICIDE | CLASS | APP. RATE (g al/ha) | CONTROL 24 hrs (%) | SPECIES | SPRAYER | VOL RATE (l/ha) | PLOT SIZE (ha) | REPLICS | REPORT CODE |
|---|---|---|---|---|---|---|---|---|---|
| **alpha cypermethrin** | Py | 20 | 82 | OSE/CHA | Micro-Ulva | 0.5 | 0.6 | 1 | 89.4 |
| | | 9 - 13.6 | 47 - 70 | KRA | Ground | 0.225-0.34 | 0.2 - 4 | 4 | 89.5 |
| | | 22 - 24 | 55 - 86 | KRA | Ground | 0.55 - 0.6 | 0.2 - 4 | 3 | 89.5 |
| | | 38 | 93 | KRA | Ground | 0.95 | 0.2 - 4 | 1 | 89.5 |
| **bendiocarb** | Carb | 50 | 83 | OSE | Aerial Mcrnair | 0.25 | 12 | 4 | 87.9 |
| | | 75 | 80 | LPA | Ulva 8 | 2 | bands | 1 | 87.14 |
| | | 100 | 90 | LPA | Ulva 8 | 2 | bands | 1 | 87.14 |
| | | 150 | 70-98 | LPA | Ulva 8 | 2 | bands | 3 | 87.14 |
| | | 100 | 90/34 | OSE/CHA | ENS | 0.5 | 12.6 | 1 | 89.4 |
| | | 150 | 91/72 | OSE/CHA | Micro-Ulva | 0.75 | 1 | 1 | 89.4 |
| | | 200 | 93/85 | OSE/CHA | Micro-Ulva | 1 | 1 | 1 | 89.4 |
| | | 200 | 87/49 | OSE/CHA | Solo | 2 | 4 | 1 | 89.4 |
| **carbaryl** | Carb | 288 | 88 | OSE | Aerial Mcrnair | 0.6 | 12 | 4 | 87.9 |
| | | 288 | 91 | OSE | Aerial Mcrnair | 0.6 | 100 | 3 | 87.9 |
| **carbosulfan** | Carb | 365 | 100 | LPA | Solo | 3.65 | 0.16 | 2 | 86.10 |
| | | 1030 | 100 | LPA | Solo | 5.14 | 0.16 | 1 | 86.10 |
| | | 100 | 88 | G.hoppers? | ??? | 0.4 | ??? | 1 | 88.32 |
| **chlorpyrifos** | OP | 171 | 62 (cropland) 82 (pasture) | OSE | Aerial Mcrnair | 0.38 | 100 | 3 | 87.9 |
| | | 171 | 85 | OSE | Aerial Mcrnair | 0.38 | 12 | 4 | 87.9 |
| | | 170 | 82-92 | OSE | Ulvamast | 0.38 | 4 | 10 | 89.11 |
| | | 270 | | OSE | Aerial Mcrnair | 0.5 | 530 | 1 | 89.15 |
| | | 390 | | OSE | Aerial Mcrnair | 1 | 600 | 1 | 89.15 |
| **cyfluthrine** | Py | 20 | 84 | G.hoppers? | Ground | 3 | 0.25 | 1 | 88.25 |
| **deltamethrin** | Py | 5-20 | 100 (8 days) | LMI | Aerial Mcrnair | ??? | 30 | 1 | 84.1 |
| | | 7.3-10 | 87-97 | Ghopper? | Ground | 0.74 - 2.9 | 1 - 2 | 8 | 89.2 |
| | | 8 | 88/92 | OSE/CHA | Micro-Ulva | 0.63 | 1 | 1 | 89.4 |
| | | 10 | 92/79 | OSE/CHA | Micro-Ulva | 0.78 | 1 | 1 | 89.4 |
| | | 10 | 95/7 | OSE/CHA | ENS | 0.77 | 16 | 1 | 89.4 |
| | | 5-13 | 89/96 | OSE | Ulvamast | 1 - 3 | ??? | 3 | 90.1 |

**SPECIES KEY**

SGR = Schistocerca gregaria
LMI = Locusta migratoria
OSE = Oedaleus senegalensis
CHA = Cryptocatantops haemorhoidalis
LPA = Locusta pardalina
KRA = Krausella amabile
AME = Anacridium melanorhodon
SXA = Stenohippus xanthus
G.hoppers? = unstated species

**INSECTICIDE KEY**

OP = Organophosphate
Py = Pyrethroid
Carb = Carbamate
IGR = Insect growth regulator

**CONTROL KEY**

20 - 30 = range of mortality
20/30 = mortality of two species

**SPRAYER KEY**

Ground? = unstated ground sprayer

| INSECTICIDE | CLASS | APP. RATE (g ai/ha) | CONTROL 24 hrs (%) | SPECIES | SPRAYER | VOL RATE (l/ha) | PLOT SIZE (ha) | REPS | REPORT CODE |
|---|---|---|---|---|---|---|---|---|---|
| diazinon | OP | 450 | 90 | OSE | Aerial Mcrnair | 0.45 | 12 | 4 | 87.9 |
| | | 350 | 70-85 | KRA | Micro-Ulva | ??? | 1 | 10 | 90.2 |
| diflubenzuron | IGR | 22.5-45 | 0% (deformed) | SGR | Aerial Mcrnair | 1 | 150 | 1 | 89.6 |
| | | 45-90 | 0% (deformed) | Ghoppers? | Micro-Ulva | 0.44 - 1 | 1 | 19 | 89.14 |
| | | 45-90 | 60-97 | OSE/SXA | Aerial Mcrnair | 0.5 | 400 | 1 | 89.15 |
| | | 64 | 100 (9 days) | KRA | Ulvamast | 1 | 9 | 3 | 90.4 |
| esfenvalerate | Py | 7.5 | 57-67 | KRA | Ground | ??? | 0.2 - 4 | 2 | 89.5 |
| | | 10 | 37-87 | KRA | Ground | ??? | 0.2 - 4 | 3 | 89.5 |
| | | 12 | 68-74 | KRA | Ground | ??? | 0.2 - 4 | 3 | 89.5 |
| | | 21 | 80 | KRA | Ground | ??? | 0.2 - 4 | 1 | 89.5 |
| | | 25 | 94 | KRA | Ground | ??? | 0.2 - 4 | 1 | 89.5 |
| etofenprox | Py | 37.5 | 63 | KRA | Ground | ??? | 0.2 - 4 | 1 | 89.5 |
| | | 71 | 66-88 | KRA | Ground | ??? | 0.2 - 4 | 2 | 89.5 |
| | | 95 | 58-82 | KRA | Ground | ??? | 0.2 - 4 | 2 | 89.5 |
| | | 156 | 88 | KRA | Ground | ??? | 0.2 - 4 | 1 | 89.5 |
| fenitrothion | OP | 150 | 83 | OSE | Aerial Mcrnair | 0.3 | 12 | 4 | 87.9 |
| | | 50 | 60 | OSE | aerial | 1 | 12 | 1 | 87.13 |
| | | 150 | 65 | OSE | aerial | 0.4 | 12 | 1 | 87.13 |
| | | 50 | 54-71 | OSE | Aerial X15 | 1.3 | 12 | 2 | 89.7 |
| | | 165 | 83-86 | OSE | Aerial X15 | 2.6 | 12 | 2 | 89.7 |
| | | 330 | 76-84 | OSE | Aerial X15 | 1 | 12 | 2 | 89.7 |
| | | 190 | 80 | AME | Aerial Mcrnair | 0.6 | 220 | 1 | 90.3 |
| | | 190 | 90 | AME | Aerial Mcrnair | 0.8 | 220 | 1 | 90.3 |
| | | 250 | 85 | OSE | Ulvamast | 1 | 2.25 | 8 | 90.5 |
| l.lambdacyhalothrin | Py | 20 | 86 | OSE | Aerial Mcrnair | 0.5 | 12 | 4 | 87.9 |
| | | 20 | 98 | OSE | Aerial Mcrnair | 0.5 | 100 | 3 | 87.9 |
| | | 25 | 99.9 | SGR | mistblower | ??? | 8 | 1 | 88.16 |
| | | 28 | 9 | SGR | aerial ?? | ??? | 60 | 1 | 88.16 |
| | | 9.5 | 69 | AME | ??? | 0.57 | 225 | 1 | 90.3 |

| INSECTICIDE | CLASS | APP. RATE (g al/ha) | CONTROL 24 hrs (%) | SPECIES | SPRAYER | VOL RATE (l/ha) | PLOT SIZE (ha) | REPS | REPORT CODE |
|---|---|---|---|---|---|---|---|---|---|
| malathion | OP | 560 | 99 | OSE | Aerial Mcrnair | 0.58 | 12 | 4 | 87.9 |
| | | 560 | 89 pasture<br>69 cropland | OSE | Aerial Mcrnair | 0.58 | 100 | 3 | 87.9 |
| propoxur | Carb | 94-202 | 39-68 | KRA | Ulvamast | ??? | 4 | 6 | 89.5 |
| pyridafenthion | OP | 165 | 80/23 | OSE/CHA | Ulvamast | 0.33 | 4.2 | 1 | 89.4 |
| | | 165 | 59/64 | OSE/CHA | ENS | 0.33 | 16 | 1 | 89.4 |
| | | 215 | 79/79 | OSE/CHA | ENS | 0.43 | 12.7 | 1 | 89.4 |
| | | 250 | 88/77 | OSE/CHA | Ulvamast | 0.5 | 1 | 1 | 89.4 |
| | | 250 | 88 | OSE | Micro-Ulva | 1 | 2.25 | 8 | 90.5 |
| | | 87.5 | 59 | KRA | Ground | 0.175 | 0.2 - 4 | 1 | 89.5 |
| | | 221 - 269 | 38 - 96 | KRA | Ground | 0.5 | 0.2 - 4 | 5 | 89.5 |
| | | 285 - 395 | 67 - 90 | KRA | Ground | 0.57 - 0.79 | 0.2 - 4 | 2 | 89.5 |
| tralomethrin | Py | 10 | 80 | OSE | Aerial Mcrnair | 0.28 | 12 | 4 | 87.9 |
| | | 16.5 | 92 (4 day) | SGR | Aerial Mcrnair | 1 | 400 | 1 | 88.27 |
| esfenvalerate + fenitrothion | Py + OP | 4 + 196 | 76 - 86 | KRA | Ground | 0.2 | 0.2 - 4 | 3 | 89.5 |
| | | 5 + 245 | 68 - 93 | KRA | Ground | 0.25 | 0.2 - 4 | 3 | 89.5 |
| deltamethrin + pyridafenthion | Py + OP | 4 + 130 | 92 | OSE | Micro-Ulva | 1.5 | 8 | 2.25 | 90.5 |
| cypermethrin + profenophos | Py + OP | 30 + 300 | 82-100 | KRA | Ulvamast | 1 | 8 | 4 | 90.2 |
| pyridafenthion + etofenprox | OP + Py | 132 + 27 | 66 - 89 | KRA | Ground | 0.53 | 0.2 - 4 | 2 | 89.5 |
| | | 2.18 + 44 | 94 - 96 | KRA | Ground | 0.875 | 0.2 - 4 | 2 | 89.5 |
| | | 2.78 + 56 | 78 - 96 | KRA | Ground | 1.12 | 0.2 - 4 | 3 | 89.5 |
| Propoxur + pirimiphos methyl | Carb + OP | 54 + 364 | 40 - 81 | KRA | Ground | 0.45 | 0.2 - 4 | 5 | 89.5 |
| | | 42 + 1258 | 56 - 84 | KRA | Ground | 1 | 0.2 - 4 | 4 | 89.5 |

**Table 2. Pesticide trials reviewed by Pesticide Group in November 1990**

| | Title | Comments |
|---|---|---|
| 84.1 | Etude de l'activite du Decis ULV 0.5 sur Locust migratoria migratoroides (Acrididae) en essai de plein champ (application aerienne) Plant Protection Research Institute - Pretoria (Roussel Uclaf) | Caged insects, insufficient data. |
| 86.10 | Trials of two ULV formulations of Marshal (carbosulfan) against the brown locust, Locustana pardalina (A F Kock) | Inadequate data; plot size too small. |
| 87.9 | African grasshopper and locust pesticide testing project, Senegalese grasshopper - Mali (USAID, DYNAMAC) | Good data on equipment, calibration, meteorology, replicated data, analysis . Good sequence from small to large-scale trial. |
| 87.13 | The mortality of Oedaleus senegalensis and other invertebrates in Mali using reduced dosages of fenitrothion. | Preliminary trial on lower rates. |
| 87.14 | Trials with FICAM ULV against locust in South Africa. (Boase, Hurrell). | No data on plot size, not replicated, no reference product, data |
| 88.25 | Test d'efficaite de deux nouveaux insecticides sur le criquet pelerin (Centre National de lutte Antiacridienne d'ait-melloul). | Plot size too small, no replication. |
| 88.27 | Essai d'efficacite du Tracker 16.5 ULV en lutte anti-acridienne au Maroc Decembre 1988. | Inadequate data. |
| 88.28 | Compte rendus d'essais d'insecticides contre le Criquet Pelerin, Schistocerca gregaria - test du diflubenzuron contre les larves gregaires. | (To be obtained) |
| 88.32 | Essais d'estimation de l'efficacite de certains insecticides sur les sauteriaux. (FICAM). | Plot size too small, no replication or analysis. |
| 89.2 | Rapport, Essais de lutte chimique contre les sauteriaux, Deltamethrin - Fenitrothion. Mali SNPV/Roussel Uclaf | Supportive data, several dosages of same insecticide with fenitrothion as reference |
| 89.3 | Resultats du test d'efficacite du Sumicombi Alpha sur une population acridienne dans trois sites: Diass, Bandia et Kirene (DPV). | Small plots, no replication, dosages inconsistent. |
| 89.4 | Rapport de tests indicatifs d'efficacite "application insecticides ULV sur sauteriaux". (Agriculture Canada) | Supportive data but few replicates. Good comparison between grasshopper species and sprayers. |
| 89.5 | Essais d'insecticides sur les Acridiens (OCLALAV) | Small plots, variable results from different insecticides. Supportive of other data. |
| 89.6 | Field trials with Dimilin ODC 45 against the Desert Locust, Schistocerca gregaria in Sudan (Duphar PV). | Insufficient data, unreplicated, problems with application. |
| 89.7 | Reduced rate of fenitrothion: the effect on Oedaleus senegalensis and non target arthropods in Mali. (University of Oslo). | Investigated lower dosages, 2 replicates, 3 dosages, no reference product. |

| | | |
|---|---|---|
| 89.8 | Evaluation of a large scale application of Nosema locustae bait against grasshopper in the Malian Sahel. (Ciba Geigy, SNPV Mali, FAO). | Untimely application, negative result. |
| 89.11 | Consultants report on trials to evaluate the efficacy of Dursban and other ULV insecticides in controlling grasshoppers in Mali. J Clayton, FAO. | Good data, well reported replicated trial. |
| 89.13 | Efficacy trials with dust formulations against the Brown Locust, Locusta pardalina. (Plant Protection Research Institute, South Africa). | (To be obtained) |
| 89.15 | Efficacite comparee des traitements antiacridiens au Sahel effets sur les sauteriaux et la faune non cible (PRIFAS) | Includes initial environmental impact studies using double dosages |
| 90.1 | Qualite et efficacite d'applications d'insecticide contre sauteriaux avec CDA Ulvamast selon differentes largeurs d'andains, (DPV, Burkina Faso). | No replicates, used different swaths, no reference chemical. |
| 90.2 | Travel report - grasshopper trials - Mali August 1990 (Clayton, FAO) | Preliminary report, but used replicates, good data. |
| 90.3 | The impact of three pesticides, fenitrothion, deltamethrine and lambdacyhalothrine, in low dosages on the Sahelian tree locust Anacridium melanorhodon in Sudan, including evaluation of cost savings. ( Royal Norwegian Ministry of Foreign Affairs). | Study of oil carrier, no replicates, no reference treatment, but interesting data. |
| 90.4 | Trials of diflubenzuron (efficacy and persistence) on grasshopper populations in Mali, (Southampton University, FAO). | Preliminary report, good data on IGR. |
| 90.5 | Draft report of insecticide trials against grasshoppers in Niger, (Roussel Uclaf, DPV, FAO). | Preliminary report, good data with replicates. |

The importance of correct droplet size is clearly shown when it is realised that the volume of a 50 um diameter droplet is 65 picolitres whereas a 500 um diameter droplet (x10 increase in diameter) is 65,450 picolitres (x1000 increase in volume). The larger droplets not only fall out by gravity close to the sprayer, but waste a high proportion of the insecticide.

The insecticides considered are listed in Table 1 together with notes on their effectiveness (principally percentage mortality 24 hours after treatment), the main species sampled (usually Oedaleus senegalensis), the type of sprayer used, volume applied, plot size and replication. Comments on the individual reports are given in Table 2.

Table 2 lists the trials titles and the Group's comments on each report.

On the basis of these reports the following insecticides have been selected for use in operations against Desert Locusts. Most reports only referred to grasshopper control, but all these insecticides listed have been tested or used successfully in operations against the Desert Locust, Schistocerca gregaria, at the recommended dosages. A formulation should be chosen to allow an application rate of 1 litre/hectare.

**Table 3.**

**List of acceptable insecticides with a verified dose rate against Desert Locusts.**

| Insecticide | Dosage | Type |
|---|---|---|
| Bendiocarb | 100 g ai/ha | carbamate |
| Chlorpyrifos | 240 g ai/ha | organophosphate |
| Deltamethrin | 15 g ai/ha | pyrethroid |
| Fenitrothion | 400 - 500 g ai/ha | organophosphate |
| Lambdacyhalothrin | 20 g ai/ha | pyrethroid |
| Malathion | 925 g ai/ha | organophosphate |

The deltamethrin dose is greater than that on previous FAO lists due to the danger of knockdown and later recovery with lower doses. There is some circumstantial evidence for lower doses of fenitrothion in the University of Oslo trials on Anacridium m melanorhodon (trial 90.3) and on Oedaleus senegalensis (89.7), but further trials on Desert Locusts are required before lower doses can be recommended. Products on the FAO list which do not appear on this list are diazinon, phoxim + propoxur and fenitrothion + esfenvalerate. Diazinon is missing because the evidence available suggests that the previously recommended dose of 450 g/ha is too low, especially for hoppers which seem to be much more tolerant of it than adults. Phoxim + propoxur and fenitrothion + esfenvalerate are missing because there was insufficient evidence of effective doses in the reports to include them. There may be additional information in the form of laboratory reports or first hand field experience to include these and other products but the Group based its conclusions on the field trial reports presented to them.

The insecticides in Table 3 are principally fast-acting and suitable both for emergency operations and to protect farmers' crops. Lower dosages are not considered suitable, as mortality is often less then 90 per cent, especially where vegetation is dense. Low dosages of pyrethroids often cause "knock down" from which some recovery is possible.

At present there are no other pesticides proven for preventive control. This is a list of active ingredients and the rates at which they should be applied. They must of course be contained in a ULV formulation suitable for desert application e.g. low volatility.

A number of other insecticides have been evaluated, but trial data is generally insufficient or none of the trials were conducted on Desert Locusts and therefore they cannot be included in the above list. The benzoyl urea insect growth regulators have properties of selective activity and persistence which may make them appropriate for extensive use to prevent locust populations building-up. Further large scale trials with these products on Desert Locusts are recommended to determine appropriate dosages.

In addition to the insect growth regulators, further study of mixtures of insecticides is recommended to determine:

a) whether a lower dosage of each component will enable the total amount of insecticide applied to be less than if either component was applied on its own (eg. phoxim + propoxur).

b) whether knockdown achieved with a lower dosage of a pyrethroid can be complemented by mortality due to a low dosage of a second insecticide with a different mode of action (eg. deltamethrin + pyridafenthion).

An additional organophosphate (pyridafenthion) has been included in the list below as it has already given promising results in trials.

**Table 4**

**List of insecticides recommended for large-scale field trials on Desert Locusts**

| Insecticide | Type |
|---|---|
| Deltamethrin + Pyridafenthion | Pyrethroid + Organophosphate |
| Diflubenzuron | Insect growth regulator |
| Esfenvalerate + Fenitrothion | Pyrethroid + Organophosphate |
| Propoxur + Phoxim | Carbamate + Organophosphate |
| Pyridafenthion | Organophosphate |
| Teflubenzuron | Insect growth regulator |

All the insecticides in Table 3 have been evaluated against grasshoppers and in most cases similar dosages to those suggested for locust control were required to achieve greater that 90 per cent mortality. In sparse open grassland, lower dosages may be effective, but there are likely to be differences in susceptibility between species. Also their behaviour and the extent of spray coverage in their habitat could affect control. For example in several trials where mixed populations were sprayed greater control of Oedaleus senegalensis was achieved compared with Cryptocatantops haemorhoidalis.

At present it is not possible to produce a separate list of insecticides for grasshopper control although further study on the present field trial reports may yield some valuable conclusions. The Group advises further studies are needed to establish comparative field toxicities between grasshopper species.

The Insecticide Index (2nd Edition) has not been updated since it was compiled by R.D. MacCuaig in 1983. FAO should encourage companies to evaluate insecticides for toxicity to locusts under standard laboratory conditions. Field trials are very expensive so attention needs to be given to those insecticides which have already been shown to be very effective in the laboratory. This will allow more attention to be given to assessing dosage rates, the method of application and methods of assessment. One report referred to a field trial with an experimental insect growth regulator which had no apparent effects. Such failures could be avoided if more is known before embarking on a field trial programme.

**Table 5**

**Insecticides in the trial reports which cannot be recommended for Desert Locust control until further trials data were available.**

| | |
|---|---|
| Pyrethroids | Alphacypermethrin<br>Cypermethrin<br>Betacyfluthin<br>Fenvalerate<br>Esfenvalerate (but possibly in a mixture)<br>Fluvalinate<br>Tralomethrin |
| Carbamate | Propoxur (but possibly in a mixture)<br>Carbosulfan |
| Organophosphate | Diazinon (not for hoppers)<br>Fenthion<br>Phoxim (but possibly in a mixture) |

**Table 6**

**Insecticides in the trial reports which cannot be recommended for Desert Locust control (reasons given)**

| | |
|---|---|
| Carbamate | Carbaryl (operational problems with suspension in oil) |
| Organophosphate | Dichlorvos (too volatile)<br>Pirimiphos methyl (too volatile)<br>Methyl parathion (high mammalian toxicity) |
| Organochlorine | Lindane (environmental considerations) |

Laboratory dose mortality data can be calculated from topical application on individual insects and from simulated applications at field rates on vegetation. Difficulties in maintaining cultures of the different species of grasshopper in the laboratories (eg due to diapause stage) have confined laboratory data mostly to Schistocerca gregaria or Locusta migratoria migratorioides. If laboratory studies could be carried out, for example in West Africa, it might be possible to determine the relative dosages needed for each species. However, differences in their behaviour in the field are likely to affect the dosages actually required under field conditions. Laboratory studies cannot therefore replace field trials.

Insecticides that need to be evaluated in the laboratory include new products such as ethofenprox (already used in some field trials), mixtures of insecticides (to indicate optimal quantities of each component at reduced overall rates) and prospective new formulations to assess the effects of adjuvants, diluents or other constituents.

## Role of Pesticide Referee Group

The Pesticide Referee Group considered that despite the relatively low numbers of locusts at present, there was a continuing need to up-date information so that FAO would have additional recommendations to offer when another plague occurs, and it is to be hoped further study of locust control during recessions of the populations will reduce the likelihood of major plagues. However, having considered all the reports of trials from 1986 to 1990, there would be little need for the Group to meet in Rome until a further large number of trials had been completed. In the meantime, FAO could assess individual new reports and send a summary to the Group who would then give independent comment and advise FAO if any new data justified changes or additions to the list of suitable insecticides.

## Future of the FAO Pesticide Trials Support Programme

The Group urged FAO to maintain its support for trials during the present recession in locust populations, even though much of the data collected was more directly relevant to grasshopper control. In particular there needs to be continued research intended to develop efficient locust and grasshopper control strategies including optimal use of insecticides, and to develop environmentally safer and less expensive methods of control. FAO should continue to refine the guidelines and protocols for evaluation of new insecticides.

The insect growth regulator diflubenzuron has shown considerable promise in limiting grasshopper populations by affecting the moulting of nymphs. Initial trials have indicated persistence of spray deposits on vegetation for at least thirty days. This data is based on the effect of deposits on young nymphs of Kraussella amabile, so it is not known whether locusts populations would be similarly suppressed. The effect of rainfall, directly on spray deposits and indirectly by stimulating plant growth which dilutes the effect of deposits, is not yet known.

Some experiments investigated the use of reduced dosages of insecticide mixed with a vegetable oil carrier combined with an emulsifier. It is possible that the apparent improved effects due to the use of this adjuvant were obtained by reducing the volatility of the spray droplets, improving the penetration through the insect cuticle or some other factor. More trials are needed to establish whether it is possible to use lower dosages, especially for the young locust hoppers and for grasshopper control.

The use of appropriate IGR's selectively against low populations of grasshoppers and locusts in known recession areas might delay the upsurge of populations and prevent or delay future plagues. There is also the possibility of integrating the use of biological control techniques (eg. Nosema locustae and fungi, such as Metarhizium anisopliae and Beauveria bassiana) with selective insecticides. This research needs to be sustained in an appropriate region and coordinated by FAO.

Apart from selection of new pesticides, the field trials programme needs to support improvements in application technology. When dieldrin was recommended, it was possible to use a drift technique with wide swaths and a patchy deposition as locusts accumulated a toxic dosage while traversing areas of treated vegetation. Much less is known about the metabolism of the newer insecticides so a more even distribution of the spray deposits is required. Improvements in vehicle mounted equipment have been achieved, but more information is needed on the performance of hand-carried equipment and organisation of farmers to use it to protect their crops from both locusts and grasshoppers. Such information is essential to improve training programmes and ensure better utilisation of resources in control programmes.

During the last plague many insecticides were applied using aircraft against settled adults instead of spraying flying swarms, although the latter technique is known to be more efficient if aircraft are available at the appropriate time and place. As there are logistic difficulties in tracking swarms, the trials programme needs to define optimal track spacing, flying height and droplet spectra for controlling locusts and grasshoppers on vegetation.

## FAO Desert Locust Pesticide Data Sheet

There are many sources of information on pesticides, but those directly concerned with locust control need precise data on the limited number of insecticides recommended for locust and grasshopper control. This information is so different from general recommendations for crop protection that a specific series of data sheets is needed.

The draft introduction describes concisely the main factors such as toxicity, persistence, environmental hazards and safety precautions that the field user must know.

The sample data sheet for fenitrothion was examined and it was suggested that where several formulations of different concentrations are available, it would assist users if more detailed information was given relating formulation to specific types of equipment. Thus if the 20% ULV formulation were used, it should be applied at 2.5 l/ha and recommended for the hand-carried ULV sprayers (more dilute formulations are safer for the operator), but this is not specifically stated. Furthermore the 96% ULV formulation is recommended at 0.4 l/ha for aerial application, but thus volume rate is not always suitable if there is considerable vegetation. Further detailed information on application techniques should be included. A number of other suggestions were made for changes in the text.

As the recommended insecticides can be used for crop protection against other pests, the data sheets should indicate which crops can be treated (it mentions only crop tolerance) and where other sources of information can be obtained for these crops when required.

It might be argued that producing data sheets for Desert Locust is duplicating information in the other manuals, but most sources are not always readily available in field offices. The locust control staff need the relevant information in an easily accessible format.

__Recommendations by the Group__

1. FAO should update the list of products and their dosages considered suitable for Desert Locust control.

2. FAO should encourage laboratory toxicity studies on grasshopper species to compare their susceptibility. This data would assist in establishing field dosages for the different species of grasshopper.

3. FAO should encourage further field trials to establish specific field dosages for different grasshopper species. Existing trial reports may contain useful grasshopper information and time should be spent extracting as much as possible from the reports.

4. FAO should establish guidelines for methodology used in field trials to evaluate pesticides for grasshopper control, in addition to these available for Desert Locust trials.

5. FAO should seek finance to maintain its support for the pesticide trials programme on locusts and grasshoppers, with benzoyl urea insect growth regulators as a priority.

6. FAO should publish the Desert Locust Pesticide Data Sheets.

## LIST OF PESTICIDE TRIALS CONSIDERED IN SEPTEMBER 1989

| NUMBER | TITLE |
|---|---|
| 86-1 | Essai de lutte contre le criquet brun Locustana paradalina |
| 86-2 | Campagne de lutte contre les sauteriaux (1986). Essai des pesticides réalisé à Nara (Mali) du 8 au 18 octobre, 1986. |
| 86-3 | Evaluation of insecticides for grasshopper control. |
| 86-6 | Field evaluation of three insecticides against two grasshopper species in Mali, Africa. |
| 87-1 | Essais de traitements UBV aeriens contre les sauteriaux Oedaleus senegalensis, Niger-Campagne 1987. |
| 87-2 | Essais de lutte contre le criquet brun Locustana pardalina sur prairie naturelle, Afrique du sud. |
| 87-4 | Essais de traitements UBV terrestres contre les sauteriaux Oedaleus senegalensis, Niger-Campagne 1987. |
| 87-5 | Field trials on chemical control of the brown locust (Locustana pardalina Walker) in the Republic of Botswana. |
| 87-7 | Tests dynamiques d'insecticides sur les acridiens du Sahel en conditions naturelles, Niger-Tchad. |
| 87-8A | Report on FAO project to evaluate insecticidal dust treatments on grasshoppers in Mali 1987. |
| 87-10 | Antifeedant effect of Neem, Azadarichta indica A. Juss, kernel extracts on Kraussaria angulifera (Krauss) (Orthoptera: Acrididae), a Sahelian grasshopper. |
| 87-11 | Report on FAO project to evaluate Ultra Low Volume insecticides for grasshopper control in Mali 1987. |
| 87-12 | Essai d'insecticides contre sauteriaux au Senegal. |
| 88-1 | Compte rendu du 1er essai acridicide. |
| 88-3 | Essais Decis ULV sur larves criquets pèlerins. |
| 88-4 | Essais sur larves criquets. |
| 88-6 | Essai de lutte contre le criquet pèlerin. |
| 88-7 | An aerial application for the control of the African Migratory Locust (Locusta migratoria migratoriodes) with various ULV formulated products in the Republic of Botswana. |
| 88-8 | Controlling Desert Locust nymphs with bendiocarb applied by a spinning disc atomiser. |
| 88-9 | Essais d'insecticides sur les larves et de jeunes adultes de criquets pèlerins: Schistocerca gregaria au Mali. Campagne 1988. |
| 88-10 | Essais d'insecticides sur les larves et jeunes adultes de criquets pèlerins: Schistocerca gregaria à Gao Mali. |
| 88-11 | Tests dynamiques d'insecticides sur les acridiens du Sahel en conditions naturelles, Tchad 1988. |
| 88-12 | Compte rendu d'essai insecticides anti-acridien produit: Penncap M. |
| 88-13 | Essai au Tchad d'un inhibiteur de croissance pour la lutte contre le criquet pèlerin Schistocerca gregaria (Forskal, 1775). |
| 88-14 | Locust. |
| 88-15 | Comptes-rendus d'essais d'insecticides contre le criquet pèlerin Schistocerca gregaria (Forskal, 1775). Test du Teflubenzuron contre les larves gregaires. |
| 88-16 | Compte-rendu résumé des tests d'insecticides contre le criquet pèlerin Schistocerca gregaria (Forskal, 1775). |
| 88-17 | Essai au Senegal d'un dérégulateur de croissance pour la lutte contre le criquet pèlerin Schistocerca gregaria (Forskal, 1775). |
| 88-18 | Locust control trial with beta-cyfluthrin 1988 in Morocco. |
| 88-24 | Essai de lutte contre le criquet pèlerin. |
| 88-25 | Test d'efficacité de deux nouveaux insecticides sur le criquet pèlerin. |
| 89-1 | The efficacy and persistence of ULV and microencapsulated pesticides against Schistocerca gregaria in Saudi Arabia. |

APPENDIX I TABLE 2 BRIEF NOTES ON TRIAL REPORTS ASSESSED IN SEPTEMBER 1989

| | | | | | |
|---|---|---|---|---|---|
| 88/3 | ? | ? | MicroULVA | 1 l / ha | Deltamethrin at 5 and 7.5 g / ha were effective |
| 88/4 | ? | ? | Knapsack mistblower | 5 l / ha | Assess deltamethrin at 3.75, 5 and 6.25 g/ ha diluted in water |
| 88/6 | *Schistocerca* | ? | ? | ? | Lambdacyhalothrin gave 100 per cent control after 2 hours |
| 88/7 | *Locusta* | 4.8 - 10 ha | Pawnee AU 5000 | 0.5 - 2 l / ha | Phoxim + propoxur, cyfluthrin and fenitrothion all gave effective control |
| 88/8 | *Schistocerca* | 3.2 - 11.8 ha (1 test at 30 ha) | Micron ULVAMAST | 0.5 - 0.8 l/ha | Detailed series of trials with bendiocarb and fenitrothion |
| 88/9 | *Schistocerca* | ? | Micron ULVAMAST | ? | Several pyrethroids compared with fenitrothion |
| 88/10 | *Schistocerca* | ? | Micron ULVAMAST | ? | Comparison of chlorpyrifos, pyridafenthion, phoxim (alone or with propoxur) and carbosulphan |
| 88/11 | *Grasshoppers* | 0.25 ha | Technoma TI | most at 3 l/ha | Extensive range of trials including pyrethroids mixed with other insecticides |
| 88/12 | *Grasshoppers* | 400 ha | Cessna AU 5000 | ? | Fenitrothion was more effective than microcapsules of methyl parathion |
| 88/13 | *Schistocerca* | ? | Exhaust gas nozzle | ? | Teflubenzuron gave good control |
| 88/14 | *Schistocerca* | *25 ha* | Vehicle mounted Air-assisted ULV spinning disc (JACTO) | ? | Diflubenzuron prevented IV instar hoppers moulting 4-5 days after treatment |
| 88/15 | *Schistocerca* | 15 ha | As 88/14 | ? | Teflubenzuron - results not presented clearly |
| 88/16 | *Schistocerca* | 180 ha<br>Various<br>24m2 - 100 ha | also helicopter AU 7000<br>Various | 0.5 - 1 l/ha | Range of different insecticides - difficult to make valid comparisons |
| 88/17 | *Schistocerca* | 15 ha | As 88/14 | 1 l /ha | Teflubenzuron very effective against IV instar |
| 88/18 | *Schistocerca* | 30 ha | Aerial AU 7000 ? | ? | Betacyfluthrin knocked out swarm in 2 hours |
| 88/24 | *Schistocerca* | 640 ha | Helicopter Alouette 2 Micronair | ? | Phoxim + propoxur gave excellent control |
| 88/25 | *Schistocerca* | 0.25 ha | Knapsack mistblower? | ? | Cyflthin, propoxur + phoxim and dichlorvos effective |
| 89/1 | *Schistocerca* | 1-3 ha + unreplicated larger trial | Vehicle mounted Micronair AU 7000<br>Helicopter with boom and nozzle | 1-2 l / ha | Microencapsulated formulations of methyl parathion and fenitrothion compared with high dosage of fenitrothion mixed with fenvalerate. Malathion also used. |

APPENDIX I TABLE 2 BRIEF NOTES ON TRIAL REPORTS ASSESSED IN SEPTEMBER 1989

| Report Reference | Species | Plot size | Sprayer | Volume Application Rate | Principal Results |
|---|---|---|---|---|---|
| 86/1 | *Locustana pardalina* | 200 m 2 | Hand-held Micronair | 2.5 l/ha | Deltamethrin effective at 5-10 g/ha, poor result with diazinon + dichlorvos. |
| 86/2 | *Grasshoppers* | 0.5 ha | Helicopter, nozzles | 1-3 l/ha | Karate more effective than cyfluthin, propoxur or pirimiphos methyl; and in second test, compared with fenthion, propoxur, or fenitrothion: In 3rd test, chlorpyrifos was more effective than other OP's |
| 86/3 | *Grasshoppers* | 0.25 ha | Knapsack mistblower | | Similar results obtained with carbaryl in oil malathion and fenitrothion; carbaryl preferred due to greater persistence |
| 86/6 | *Grasshoppers* | 6.5 ha | Pawnee Micronair | 1.5 - 3 l/ha | Cypermethrin was more effective than carbaryl or fenitrothion: with no live insects seen 10h after application |
| 87/1 | *O. senegalensis* | 100-200 ha | Cessna Ag Truk AU 3000 | 0.5 - 1 l /ha | Lambdacyhalothrin (0.5 l / ha) was as effective as deltamethrin alone |
| 87/2 | *L. pardalina* | ? | ? | ? | Foliage treated with deltamethrin alone or with fenithrothion or with esfenvalerate and fenitrothion provided to caged insects |
| 87/4 | *Grasshoppers* | 0.25 ha | MicroULVA | 0.5 - 2.5 l / ha | Lambdacyhalothrin, cypermethrin, deltamethrin, fenitrothion and bendiocarb gave > 85 per cent mortality:dichlorvos only gave 42% |
| 87/5 | *L. pardalina* | 0.1 ha | Knapsack mistblower | | Unreplicated - plots far too small - irregular results |
| 87/7 | *Grasshoppers* | 0.2 ha | Technoma Tl | | Extensive report: trials using lambdacyhalothrin, carbaryl, lindane, fenitrothion and teflubenzuron |
| 87/8 | *Grasshoppers* | 0.25 ha | Dust formulations using bag and stick | | Reduction in population was less than when sprays applied with similar insecticides |
| 87/10 | *Kraussaria* | | | | Studies on antifeedant effect of neem |
| 87/11 | *O. senegalensis* | 4 ha - ground<br>10 ha - aerial | Vehicle with AU 7000 or C8<br>Helicopter with Beecomist 360 | ? | Range of products evaluated, including fenitrothion, bendiocarb, chlorpyrifos and pyridafenthion. Some microencapsulated formulations tested |
| 87/12 | *Grasshoppers* | 0.2 ha | Knapsack mistblower and motorised duster | ? | Tests included chlorpyrifos, bendiocarb, sumialpha and sumicombi. Several dosages assessed. |
| 88/1 | ? | 300 ha | Not stated | 0.35 - 1 l /ha | Comparison of chlorpyrifos, deltamethrin and fenitrothion: All effective |

## DIFFERENT METHODS OF APPLICATION USED IN TRIALS

Several different types of sprayer were used in the field trials. These were:

**Ground treatment**:

1. Hand-carried spinning disc sprayers
   e.g. Micron ULVA, micro-ULVA, Berthoud C8. Technoma TI

2. Motorised mistblowers
   e.g. Hudson Porta-Pak, Holder, Solo

3. Vehicle-mounted exhaust nozzle sprayer.

4. Vehicle-mounted rotary atomiser
   e.g. Micronair AU 7000, Micron Ulvamast

5. Vehicle-mounted ULV spray cannon (motorised mistblower with spinning discs).

**Aerial treatment**

Fixed wing eg. Pawnee, Agtruck
AU 5000, AU 7000, boom and nozzle.

Helicopter eg. Alouette 2, Bell 47
AU 7000. Beecomist 360

Volume rates have ranged from 0.5 - 3 l/ha with some exceptional treatments applied at much larger volumes.

**Sampling**: Different methods used in trials:

Walk across diagonal - count insects "flushed out"
Count living, dead and moribund insects in quadrats
Collect locusts and keep them in cages with fresh untreated foliage, assess mortality after given time.

**Plot size:** This varied considerably from 200 $m^2$ to over 100 ha. Ideally, small scale trials with hand-carried equipment should cover at least 1 hectare per plot; 4 hectares for vehicle mounted equipment and 100 hectares for aerial trials.

## MEMBERS OF THE PESTICIDE REFEREE PANEL

| | |
|---|---|
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## TERMS OF REFERENCE FOR PESTICIDE REFEREE PANEL

G. Matthews, P. Oomen, R. Sanderson, 26-29 November 1990

1. To evaluate pesticide trial reports with reference to the following:
    a) Satisfactory trial technique (eg. number of replicates, method of measuring mortality).
    b) Credibility of the report (methods and procedures fully described).
    c) Satisfactory kill at the dosages used.
2. On the basis above, compile a list of pesticides and dosages suitable for operations against locusts/grasshoppers.
3. Compile a list of pesticides that warrant further trials and specify what sort (laboratory, field, small scale, large scale, etc.).
4. Discuss the possibility and advisability of FAO preparing a list of pesticides and dosages suitable for control of grasshoppers in addition to the one for Desert Locust. There may have to be different recommended dosages for different grasshopper species. Can results from grasshopper trials be extrapolated to Desert Locust?
5. Comment on the role of the Pesticide Referee Committee. Should it continue next year?
6. Make recommendations for the future of the FAO pesticide trials support programme.
7. Comment on the example FAO Pesticide Data Sheet and the introduction to the series of data sheets.
8. Prepare a joint report covering the above points.

**FAO FIELD DOSE RATE RECOMMENDATIONS OF INSECTICIDES FOR DESERT LOCUST CONTROL**

(field dose rates for hopper and swarm control)
Version: 25 November 1990; overrules all previous versions

| | | | |
|---|---|---|---|
| 1 | **FENITROTHION** | | **400-500 g a.i./ha** |
| | | Formulation: | 20% ULV (200 g/l)(for micro-ULVA type) |
| | | Dose: | 2.5 l formulation/ha |
| | | Formulation: | 50% ULV (500 g/l) |
| | | Dose: | 1 l formulation/ha |
| | | Formulation: | 1000 g/l ULV |
| | | Dose: | 0.5 l formulation/ha |
| | | Formulation: | 96% ULV (technical)(w/w) (1275g/l) |
| | | Dose: | 0.4 l formulation/ha |
| 2 | **MALATHION** | | **900 g a.i./ha** |
| | | Formulation: | 925 g/l ULV/EC |
| | | Dose: | 1 l formulation/ha |
| | | Formulation: | 96% ULV(w/v)(960 g/l) |
| | | Dose: | 0.9 - 1 l formulation/ha |
| | | Formulation: | 96% ULV (technical)(w/w (1190 g/l) |
| | | Dose: | 0.75 l formulation/ha |
| 3 | **LAMBDA-CYHALOTHRIN** | | **20 g a.i./ha** |
| | | Formulation: | 40 g/l ULV |
| | | Dose: | 0.5 l formulation/ha |
| 4 | **FENITROTHION + ESFENVALERATE** | | **[245+5] g a.i./ha** |
| | | Formulation: | 250 g/l ULV |
| | | Dose: | 1 l formulation/ha |
| 5 | **CHLORPYRIFOS** | | **240 g a.i./ha** |
| | | Formulation: | 240 g/l ULV |
| | | Dose: | 1 formulation/ha |
| | | Formulation: | 450 g/l ULV |
| | | Dose: | 0.5 l formulation/ha |
| 6 | **DELTAMETHRIN** | | **15 g a.i./ha** |
| | | Formulation: | 12.5 g/l ULV |
| | | Dose: | 1.2 l formulation/ha |
| | | Formulation: | 25 g/l ULV |
| | | Dose: | 0.6 l formulation /ha |
| 7 | **BENDIOCARB** | | **100 g a.i.ha** |
| | | Formulation: | 20% ULV (200 g/l) |
| | | Dose: | 0.5 l formulation/ha |
| 8 | **PHOXIM + PROPOXUR** | | **[258 + 42] g a.i./ha** |
| | | Formulation: | 300 g/l ULV |
| | | Dose: | 1 l formulation/ha |
| 9 | **DIAZINON** | | **450-500 g a.i./ha (swarms only)** |
| | | Formulation: | 980 g/l ULV |
| | | Dose: | 0.5 l/ha |

Note: The ULV formulations given in this table are the most commonly used at present. ULV formulation at other concentrations can often be supplied by the manufacturer on specific request.