REPORT

PESTICIDE REFEREE GROUP

Rome,
Italy
2-6 March
1998

Evaluation of field trial data on the efficacy and selectivity of insecticides on locusts and grasshoppers

Seventh meeting

Food and Agriculture Organization of the United Nations

EVALUATION OF FIELD TRIALS DATA ON THE EFFICACY AND SELECTIVITYOF INSECTICIDES ON LOCUSTS AND GRASSHOPPERS

Report to FAO by the PESTICIDE REFEREE GROUP

Seventh meeting
Rome, 2 - 6 March 1998

TABLE OF CONTENTS

INTRODUCTION

1. The 7th meeting of the Pesticide Referee Group was opened by Mr. N. Van der Graaff, Chief Plant Protection Service. He welcomed Dr. Mohamed Y. Al-Ghashm of the General Department of Plant Protection, Republic of Yemen and Dr. Ralf Peveling, University of Basel, Switzerland, as observers. Since the last meeting, FAO had received comments on the previous report from certain agrochemical companies and these were invited to send representatives to present and discuss their views with the Group in a separate session prior to the main meeting. As the mycopesticide *Metarhizium* sp. was not yet commercially available, a representative of the LUBILOSA project was also invited to attend the meeting to update the Group on the progress being achieved.

2. The Pesticide Referee Group (members listed in Appendix I) received presentations by AgrEvo, CABI Bio-Sciences/LUBILOSA, Dow AgroSciences, Rh ne-Poulenc Agro and Uniroyal Chemical.

3. The representatives of Industry generally welcomed the changes introduced in the report of the 6th Meeting to reflect concern about the impact of insecticides on the environment when used in locust control. Information was provided to clarify the presentation of the ecotoxicological assessments and this is reflected in the way the present report has been compiled. New information was also provided on the effectiveness of insecticides listed in Tables 1 and 4 to reflect experience with different dosages from additional trials and work in more countries against other locust species.

4. The Pesticide Referee Group reviewed data provided on efficacy (31 reports listed in Appendix II and IV) and ecotoxicological reports (listed in Appendix III : Effective Insecticides).

5. The Group examined the data on the efficacy of insecticides together with an assessment of their impact on the environment when applied at the recommended dosage in locust affected areas.

6. Verified dose rates, speed and mode of action, and effect of different control agents for the Desert Locust are given in Table 1. This table has been expanded from the previous Pesticide Referee Group report in order to provide a more complete toxicology profile of the insecticides in common use against this locust. The speed of toxic action (e.g. knock-down, complete cessation of feeding) of the different compounds was reassessed and has now been set as: fast ("F" = 1-2 hours), moderate ("M" = 3-48 hours) and slow ("S" = >48 hours). Speed of action is generally determined by the class of the product, its dose rate and its inherent toxicity.

7. Among the faster compounds listed in Table 1 are the synthetic pyrethroids and bendiocarb which produce a rapid sublethal knockdown effect, followed by a protracted paralysis after which the insect may die or recover completely, depending on the dose received. Among the slower compounds listed in Table 1 are the mycoinsecticide *Metarhizium* and the Insect Growth Regulator (IGR) benzoylureas which take a week or more (up to 21 days) to kill. To ensure that sufficient product is ingested and accumulated the Group reaffirmed that the early and intermediate hopper instars should be optimally targeted when using the IGRs, which are more suitable when used in a proactive role as barrier treatments within a locust outbreak area. Between the two extremes lie most other insecticides listed in Table 1 which, depending on the dose applied, exhibit a moderate speed of kill, normally within 48 hours after treatment.

Table 1. Dose rates, speed and mode of action, and effect of different insecticides for which verified dose rates have been established for the Desert Locust. Speed of action was defined as: F = fast (1 - 2 hours), M = moderate (3 - 48 hours) and S = slow (>48 hours).

Insecticide	Class**	Dose (g a.i./ha)				Speed of action at the verified dose rate	Primary mode of action		Mechanism
		overall (blanket) treatment		barrier treatment (hoppers)			direct contact	stomach	
		hoppers	adults	treated area within barrier	protected area*				
bendiocarb	CA	100	100			F	+		AChE inhibition
chlorpyrifos	OP	225	225			M	+		AChE inhibition
deltamethrin	PY	12.5⁄	12.5			F	+		Na channel blocking
diflubenzuron	BU	60	n/a	100	5	S		+	chitin inhibition
fenitrothion	OP	450	450			M	+		AChE inhibition
fipronil	PP	5	5	12.5	0.63	M	+	+	GABA receptor blocking
lambda-cyhalothrin	PY	20⁄	20			F	+		Na channel blocking
malathion	OP	925	925			M	+		AChE inhibition
Metarhizium sp. (IMI 330 189)	fungus	100	100			S	+		mycosis
teflubenzuron	BU	30	n/a	not determined		S		+	chitin inhibition
triflumuron	BU	25	n/a	75	3.75	S		+	chitin inhibition

* calculated dose rate applied over the total protected area based on an average barrier width of 50m and a barrier spacing of 1000m (see ⁄ 12); ** BU: benzoylurea, CA: carbamate, OP: organophosphate, PY: pyrethroid, PP: phenyl pyrazole; ⁄ a higher rate may be required for the final instar hopper; n/a = not applicable; where the "lambda" isomer is not registered in a country, cyhalothrin is applied at 40 g a.i./ha.

8. The Group recommends that products should be used only at established dose rates, due to concern about efficacy, toxicity and the environment. The common name of listed insecticides, or in the case of biologicals, the appropriate isolate, should be given in FAO publications. Different formulations of the same active ingredient can often have very different properties, so increased reliability of locust and grasshopper control may be expected from established products obtained from manufacturers which have already provided products that meet the specifications required for ULV application.

APPLICATION CRITERIA

9. The Pesticide Referee Group continues to recommend ultra-low volume application as the standard technique to cope with the logistics of treating large areas with populations of locusts or grasshoppers, especially as these generally occur in remote areas without water. The application of one litre per hectare is preferred to ensure that sufficient droplets are applied for adequate coverage. However, when calibration is accurate and vegetation is not too dense, a lower rate of 0.5 litres per hectare is acceptable if aerially applied over large areas. Such low volumes necessitate a narrow droplet spectrum to reduce waste of insecticide in large droplets. A range of 50-100 m VMD (Volume Median Diameter) droplet spectrum using rotary atomisers is advocated to minimise environmental pollution.

10. In addition to overall blanket sprays, certain insecticides are also recommended as barrier treatments for control of locust hoppers. Precise application recommendations that are valid under all circumstances cannot be given since they depend on local conditions. A barrier consists of a treated strip interspersed with an untreated larger area arranged so that hoppers are expected to move across and feed on treated vegetation. The width of each barrier (one or more swath widths) and distance between barriers that have to be used will depend on:

a) mobility of the hoppers
b) insecticide used (dosage, persistence)
c) the terrain / vegetation (plant density)
d) wind direction during application

Highly mobile species may be controlled with a wide separation between barriers while a less mobile species will require closer intervals and in some cases the barriers will need to be arranged in a lattice (grid) pattern to allow for any changes in direction of hopper movement.

11. In assessing the width of the untreated area, due note must be taken of the height of release of droplets, wind speed and density of vegetation as these factors will influence the extent of drift of spray droplets downwind from the treated barrier. The pattern of spray deposition will vary significantly between different situations so care has to be exercised in interpreting trial data.

12. The standard dosage to be applied inside a barrier for Desert Locust control is calculated on the basis of a minimum cross wind barrier of 50m with a 1000m spacing between barriers. It is recognized that spray drift will deposit over a wider area. This arrangement will ensure that mobile Desert Locust hopper bands are still likely to pick up a lethal dose while crossing such a barrier. Further research is needed to provide information to optimise decisions on the implementation of barrier treatments under different environmental circumstances.

13. For ultra-low volume applications it is essential that the formulation meets the criteria for low volatility and low viscosity, so that the appropriate droplet spectrum is achieved at the flow rate required to apply the recommended dosage. UL formulations need to be selected so that corrosion to application equipment is avoided or minimised. Specifications for UL formulations are being established and approved by FAO.

14. While no new application equipment has been developed for locust control, some manufacturers have continued to update the specifications of their equipment, which must be sturdy to meet the rigours of the locust terrain. The importance of accurate application and

operator safety to minimize wastage and environmental pollution in conjunction with ease of operation of the equipment cannot be overemphasized. The Pesticide Referee Group once again stressed the importance of training to achieve more accurate application and urged continued provision of training courses under the EMPRES Programme.

15. Studies have revealed that some spray operators applying organophosphate insecticides for locust control had acetylcholinesterase levels depressed by more than 30%, the threshold for their temporary removal from exposure. It is advisable that further studies are initiated with different makes of equipment to determine under what circumstances operators become exposed (loading sprayers, during spraying, when cleaning equipment). Such information can assist development of improved design of equipment, protocols for method of use and devising better instruction manuals for training programmes to minimize operator exposure. A system for monitoring the health and improving safety standards of crop protection teams in remote areas is needed, especially where organophosphate and carbamate insecticides are used.

SPECIAL CONSIDERATIONS

16. The pesticides are divided into the following groups: organophosphates, pyrethroids, carbamates, insect growth regulators (IGRs), phenyl pyrazoles, biological insecticides (e.g. mycoinsecticides) and botanicals. Special consideration about their suitability for control purposes and conditions of use are given.

Organophosphates, carbamates and pyrethroids

17. Organophosphates, carbamates and pyrethroids have many aspects in common. They have a broad spectrum activity, exhibit moderate to fast action and are therefore suitable for use in emergency situations. They work mainly by contact action and are most effective during a short period, so need to be targeted directly on to the insect. Locusts exposed to treated vegetation are also affected by secondary pick-up for a limited period after spraying. The need to apply the spray directly on a target requires intensive efforts to identify and delimit suitable targets (hopper bands and swarms). These insecticides are particularly suitable for "crop protection", i.e. killing locusts menacing nearby crops directly. In view of the importance of minimizing environmental contamination, application accuracy is especially important with these compounds. Ongoing training of spray operators is therefore essential.

Insect growth regulators

18. Benzoylurea IGR insecticides have been shown to be very effective against locust hoppers, although their action is slow, which makes them unsuitable for immediate crop protection. They are persistent on foliage and their fairly narrow spectrum of activity makes them attractive from an environmental point of view, but, due to adverse effects on crustaceans, spraying of surface waters must be avoided.

19. Ideally these insecticides will be applied as barrier treatments, particularly where there are hoppers up to the 4th instar. Later instars may ingest insufficient insecticide to affect moulting before completing their development. There is some indication of toxic effects on adult locusts (e.g. reduced oviposition). Further investigations of the long-term effects of IGRs on locust populations is needed, especially in recession areas, where their use is expected to be particularly effective.

Phenyl pyrazoles

20. Additional reports confirmed the effectiveness of fipronil, which has a contact and stomach action, and have indicated that the minimum effective dose rate for blanket sprays can be reduced to 5 g a.i./ha. In some circumstances this dosage can be further reduced by increasing the track spacing between successive swaths. Downwind spray drift from individual

swaths will result in variable deposition, but this is offset by movement of locusts into the treated area. Where dosages lower than 5 g a.i./ha are applied, mortality will be delayed but observations indicate that affected locusts will cease feeding soon after initial contact with the insecticides. The persistence of fipronil may reduce reinfestation.

21. To minimize effects of fipronil on non-target arthropods, it can be applied as a barrier treatment, barriers separated by 1-2 km having been tested. This technique is suitable where hoppers move sufficiently to cross at least one treated barrier. In general barrier treatments are the preferred control option to minimize the area treated and reduce environmental impact.

Biological insecticides

22. Further information confirmed the effectiveness of the mycoinsecticide *Metarhizium* sp. (isolate IMI 330189) against acridids. The main route of dose transfer was secondary pickup from spray residues on the vegetation over the 24 hours following application. The technology has been further optimized by improving spore quality and developing an oil flowable formulation suitable for ultra low volume application which reduces the settling of spores.

23. Investigations are proceeding to commercialize the production of the spores and provide larger quantities of the UL formulations for use in environmentally sensitive areas. The Pesticide Referee Group expressed the hope that the research would continue to investigate the use of mycoinsecticides in recession areas to determine whether appropriately timed applications at the initiation of an upsurge would prevent swarms forming and migrating to other areas.

OTHER INSECTICIDES

24. Insecticides other than those listed in Table 1 have been used against locusts and grasshoppers but insufficient data are available to determine reliable effective dose rates. FAO should continue to encourage plant protection organisations, manufacturers, and any other institutions to submit for review information on new or existing products. This should include data from laboratory studies and field trials. In particular data from operational use of insecticides should be provided to FAO.

25. Further detailed information was provided on the effect of carbosulfan in trials carried out in the Sudan against different stages of the Desert Locust. However, previous data have indicated a nominal rate between 225-240 g a.i./ha and the doses now screened were much lower. In some treatments mortality was <80% and the number of replicates containing late instar Desert Locust nymphs was too few on which to base valid conclusions regarding the optimum dose. Recently moulted fledglings and young hopper instars are generally more susceptible to insecticides. The Pesticide Referee Group concluded that further testing was required and that a rate between 150-200 g a.i./ha may be a more appropriate benchmark dose for further evaluation. Carbosulfan is therefore not included in Table 1.

26. The Pesticide Referee Group previously indicated that a reduced dosage of a pyrethroid combined with an organophosphate might reduce environmental damage in sensitive areas. An EMPRES project in Mauritania has initiated laboratory studies and has suggested that a combination of 5 g deltamethrin + 60 g fenitrothion was sufficiently promising and warrants field trials. It was felt that a low dose product achieving rapid initial knockdown without subsequent recovery of locusts has definite operational advantages.

27. Progress on another *Metarhizium* isolate (SP-9) indigenous to Madagascar, and tested against the Malagasy Migratory Locust, was also reported. Development work on registration, adoption and operational use of this mycoinsecticide is well advanced.

28. Data on botanical insecticides derived from neem *Azadirachta indica* and from the related *Melia volkensii* were reviewed again. Some formulations based on neem are now commercially available. Where such a product is provided to meet the specifications in relation to quality and consistency of active ingredient, further research work is considered to be justified in areas where a slow rate of action is acceptable.

POSSIBLE USE PATTERNS

29. Locust control operations have to be carried out in a wide range of situations, varying from desert areas, environmentally sensitive nature reserves to intensive farming areas. In addition Desert Locust control could be in response to emergency situations or be an attempt to carry out preventive control. The choice of a particular insecticide and type of application (blanket *vs.* barrier) will depend on the particular circumstances and dominant features of the ecosystem. In some situations where rapid kill is not essential, lower dosages of some recommended insecticides may be effective.

30. Progress towards a commercial product of a mycoinsecticide is most encouraging as it will be particularly relevant to ecologically sensitive areas such as nature reserves or agricultural areas specializing in "organic" farming. In other areas where effects on non-target organisms or in grazing areas need to be minimised, preference will be for benzoylureas, provided the treatments avoid sensitive aquatic ecosystems.

31. The adoption of widely spaced barriers of IGRs or fipronil enables the dosage per protected hectare to be kept to a minimum to alleviate harmful effects to non-target organisms. Thus, for instance, fipronil applied at 12.5 g a.i./treated hectare in barriers 1 km apart is approximately equivalent to 1 g a.i./protected hectare. In agricultural areas with crops at risk, priority will be given to insecticides with a more rapid action, particularly pyrethroids and certain organophosphates. In some areas preference will be for pyrethroids to avoid the risk of organophosphate poisoning, especially where extensive ground control operations are undertaken.

ENVIRONMENTAL EVALUATION

32. With respect to the risk to non-target organisms, three main groups are distinguished, viz. aquatic organisms, terrestrial vertebrates including wildlife, and terrestrial non-target invertebrates. Aquatic fauna is divided into fish and invertebrates (crustaceans, insects, etc.); terrestrial vertebrates into mammals and birds and reptiles; terrestrial invertebrates into bees and others (including natural enemies of locusts and of other pests, ecologically important invertebrates, eg. soil fauna, and other non-target arthropods).

Table 2. Environmental risk to non-target organisms at verified dose rates of insecticides listed in Table 1 for control of Desert Locust.

Insecticide	Environmental risk						WHO toxicity class (human)
	Aquatic organisms		Terrestrial vertebrates		Terrestrial non-target invertebrates		
	fish	invertebrates	mammals	birds and reptiles	bees	others	
bendiocarb	M[2]	L[3]	M[1]	L[3]	H[1]	M[2]	II⁄
chlorpyrifos	M[3]	H[2]	L[3]	M[3]	H[1]	H[3]	II
deltamethrin	L[3]	H[3]	L[1]	L[3]	M[1]	M[3]	U
diflubenzuron (blanket)	L[3]	H[3]	L[1]	L[1]	L[1]	M[3]	U
diflubenzuron (barrier)	L	(H)*	L	L	L	(M)	U
fenitrothion	L[3]	M[3]	L[3]	M[3]	H[1]	M[3]	II
fipronil (blanket)	L[2]	L[2]	L[1]	L[1]	H[1]	H[3]	U
fipronil (barrier)	L	L	L	L	(H)	(H)	U
lambda-cyhalothrin	L[2]	H[2]	L[1]	L[1]	M[1]	M[3]	II
malathion	L[2]	M[2]	L[3]	L[3]	H[3]	M[3]	III
Metarhizium sp. (IMI 330189)	n.d.**	n.d.	L[1]	L[1]	L[3]	L[3]	not classified⁄⁄
teflubenzuron (blanket)	L[1]	H[2]	L[1]	L[1]	L[1]	M[1]	U
triflumuron (blanket)	L[1]	H[2]	L[1]	L[3]	L[1]	M[3]	U
triflumuron (barrier)	L	(H)	L	L	L	(M)	U

Risk is classified as low (L), medium (M) or high (H). The index next to the classification describes the level of availability of data: [1] classification based on laboratory and registration data with species outside the Desert Locust area; [2] classification based on laboratory data or small scale field trials with indigenous species from the Desert Locust area; [3] classification based on large scale field trials and operational data from the Desert Locust area. See Table 3 for the classification criteria applied. The WHO toxicity class was based on the LD_{50} of the active ingredient and the most concentrated formulation likely to be used in Desert Locust control (i.e. min. 0.5 l/ha). The actual toxicity of the formulated insecticide may differ slightly from the one given in this table due to the effect of the solvents, or when lower formulation concentrations are used.

* The risk of barrier treatments is extrapolated from blanket treatments and should be considered preliminary. Risk classes are therefore shown in brackets unless the blanket treatment was already considered to pose low risk; ** no data available; insect growth regulators are safe to adult worker bees but may cause serious damage to the honey bee brood of exposed colonies; ⁄ WHO class: II = moderately hazardous, III = slightly hazardous, U = unlikely to present acute hazard in normal use; ⁄⁄ would be classified as III or U if based on the presently available acute toxicity data.

33. The risk of each compound to the different groups of non-target organisms is presented in Table°2 using three classes: low, medium and high risk, as usual in environmental risk assessment in Europe. The assessment is based on exposure/toxicity ratios, unless more relevant field data were available. Low risk means that no serious effects are to be expected. Medium risk means that effects of short duration are expected on a limited number of groups. High risk means that effects of short duration are expected on many groups, or that effects of long duration are expected on a limited number of groups. Results obtained from situations most representative of the expected field conditions are given more weight than other studies. Field studies (indicated with index [3] in Table 2) are more relevant than laboratory or semi-field studies (index [1] and [2] in Table 2). Results obtained with indigenous species from the Desert Locust area are considered to be more relevant than results obtained with exotic species. The classifications are brought in line as much as possible with accepted international classifications.

34. The criteria for the risk assessment applied by the Pesticide Referee Group are given in Table 3. Existing classification criteria, e.g. widely used systems such as those agreed on by the European and Mediterranean Plant Protection Organization (EPPO) or the International Organization of Biological and Integrated Control (IOBC), are used as much as possible. Specific interpretations or modifications of certain of these schemes are discussed in the paragraphs below. Any assessments specifically designed and validated for locust areas (e.g. by the FAO Locustox Project) were given priority.

35. With respect to the risk to terrestrial vertebrates, the classifications based on laboratory data (with index [1]) are calculated as a result of direct exposure as a consequence of over-spraying. The results of this assessment were verified for some other possible routes of exposure whenever data were available. They included exposure of lizards to spray residues on the soil and exposure of mammals through ingestion of contaminated vegetation or invertebrate prey. This resulted in the same classification as given for risk of direct over-spraying as listed in Table 2.

36. For classification of risks to honey bees the widely accepted hazard ratio is used, which is defined as the recommended dose rate (gram of a.i. per ha) divided by the LD_{50} (microgram of a.i. per bee). Low risk to bees corresponds to a hazard ratio <50; medium risk to a hazard ratio between 50 and 500; high risk to a hazard ratio of >500. It is acknowledged that this classification deviates from the one used by EPPO, that does not define a medium risk class. The EPPO threshold for low risk includes a safety factor of about 10. This safety margin area is defined by the Pesticide Referee Group as a medium risk. The risk discussed here refers to risk to adult worker bees only. However, risk to brood may be caused by the insect growth regulators when transported by the worker bees into the hives and fed to the brood.

37. Risk to non-target arthropods other than bees has been classified according to IOBC criteria, including non-target organisms other than those covered by the IOBC.

38. In general, the risk of barrier treatments is expected to be less compared to blanket sprays because affected organisms may recover through recolonization from untreated between-barrier areas. Therefore, from an ecotoxicological point of view, barrier treatments are preferred over blanket treatments. Nevertheless, data confirming this assumption are lacking for specific vulnerable groups such as herbivorous insects and for secondary effects on insectivorous vertebrates. The Pesticide Referee Group welcomes further research in this field.

39. Information summarised in Table 2 does not cover all relevant environmental effects. Long term effects and the risk of residues in livestock in treated areas are not taken into account. The risk of bio-accumulation can be considered as limited since all the listed chemical pesticides are registered in OECD countries and have not been identified as posing a high risk of bio-accumulation.

40. Since most spraying is done on rangeland and pastures, a risk to livestock may exist. Withholding periods recommended by the manufacturer should be strictly adhered to.

Table 3. Criteria applied for the environmental risk classification used in Table 2. See text for further explanations.

A. Laboratory toxicity data

Group	Parameter	Risk class			Reference
		low (L)	medium (M)	high (H)	
Fish	risk ratio (PEC[1]/LC_{50}[2])	<1	1-10	>10	FAO/Locustox[4]
Aquatic invertebrates	risk ratio (PEC/LC_{50})	<1	1-10	>10	FAO/Locustox
Wildlife	risk ratio (PEC/LD_{50}[3])	<0.01	0.01-0.1	>0.1	EPPO[5]
Bees	risk ratio (recommended dose rate/LD_{50})	<50	50-500	>500	PRG[6]/EPPO
Other terrestrial invertebrates	acute toxicity (%) at recommended dose rate	<50%	50-99%	>99%	IOBC[7]

B. Field data (well conducted field trials and control operations)

Group	Parameter	Risk class			Reference
		low (L)	medium (M)	high (H)	
Fish	evidence of mortality	none	incidental	massive	PRG
Aquatic invertebrates	population reduction	<50%	50-90%	>90%	PRG
Wildlife	evidence of mortality	none	incidental	massive	PRG
Bees	evidence of mortality	not significant	incidental	massive	EPPO
Other terrestrial invertebrates	population reduction	<25%	25-75%	>75%	IOBC

[1] PEC: Predicted Environmental Concentration after treatment at the recommended dose rate; [2] LC_{50}: median lethal concentration; [3] LD_{50}: median lethal dose; [4] FAO/Locustox: FAO Locustox project in Senegal; [5] EPPO: European and Mediterranean Plant Protection Organization; [6] PRG: Pesticide Referee Group; [7] International Organization for Biological and Integrated Control of Noxious Animals and Plants

OTHER SPECIES

41. In response to FAO's request to include other locust species which migrate across national boundaries, and species for which information has been requested, the Group has examined data currently available for the Red Locust and the Migratory Locust, including *Locusta migratoria migratorioides* in Africa and *Locusta migratoria capito* in Madagascar (Table 4). In general similar dosages to those recommended for Desert Locust are effective against the Migratory Locust, although there is a possibility that lower dosages could be used. *Locusta* is generally reported to be more susceptible to insecticides and further trial work may indicate a reduction in the recommended dosage rates. In contrast, higher dosages are often required for the Red Locust but there is still a paucity of information on this species. Other than the testing of *Metarhizium* isolate IMI 330189 against the intermediate hopper instars of the Red Locust in Mozambique, little further trial data were received.

Table 4. List of insecticides known to have been field tested against Migratory Locust (*Locusta migratoria capito / migratorioides*) and Red Locust (*Nomadacris septemfasciata*).

Insecticide	Migratory Locust subspecies	Red Locust
chlorpyrifos	+	+
carbosulfan	+	-
cyfluthrin	+	+
deltamethrin	+	+
diflubenzuron	+	-
fenitrothion	+	+
fipronil	+	+
Metarhizium sp. (IMI 330189)	+	+
Metarhizium sp. (SP9)	+	-
propoxur+phoxim	+	+
triflumuron	+	-
Notes: +: data available, -: no data		

INSECTICIDE SELECTION

42. A major concern with locust control is that stocks of insecticides become obsolete if stored for too long. Every effort is needed to minimize the quantities of pesticides kept for emergency use and develop a system of rapid selection and delivery of the insecticides appropriate to a given situation. To assist the discussion, a flow chart is included that indicates factors which should be considered by decision makers when selecting insecticides (Figure 1). Where stocks of UL formulations are likely to exceed the recommended shelf life, they should where possible be reformulated for use, if appropriate, against other pests.

EVALUATION AND MONITORING

43. The Pesticide Referee Group was concerned that there was little further feed-back of information about operational use of insecticides. It was considered that a system should be developed for collection and collation of data on the type of insecticide, equipment used and efficacy achieved, in addition to the area treated that is generally the only item reported.

44. As pointed out previously, in view of the difficulty in quantifying the level of control achieved due to the mobility of locusts, attention should be given to appoint specially designated operational research teams whose task it would be to monitor control efficiency. In addition to evaluating the level of control achieved, the teams would provide data on any environmental effects observed in the locality treated. This is considered to be especially important where several sprays may be applied, for example when a series of barrier treatments is aimed at control of hopper bands. The position of treated areas can be demarcated by using global positioning systems (GPS) and the information should be stored in a geographical information system. This will be particularly relevant to application of residual deposits, such as benzoylurea insecticides in areas with temporary aquatic ecosystems, to monitor any long term effects.

45. The increased availability of GPS linked to GIS now provides better means of maintaining exact records of areas treated so that the long-term impact of insecticides on locusts and non-target organisms could be evaluated. FAO should be encouraged to extend their "SWARMS" database (Schistocerca Warning Management System) to include information on the use of insecticides. Similar data will be required on the impact of mycopesticides in areas treated repeatedly to assess whether the intensity of outbreaks in breeding areas can be reduced.

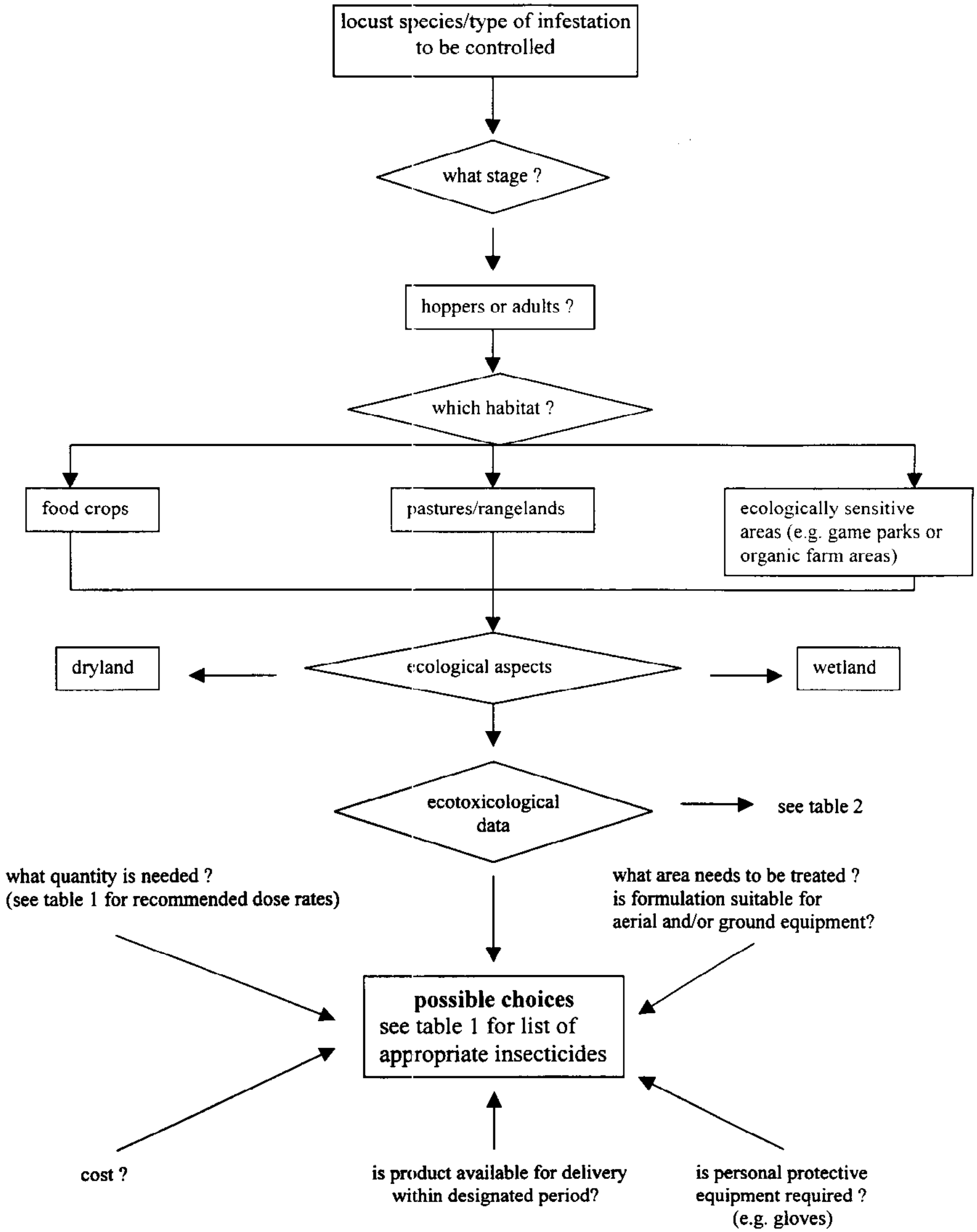

Figure 1. Factors that should be considered by decision makers when selecting insecticides for locust control.

IMPLEMENTATION OF PREVIOUS RECOMMENDATIONS

46. Significant progress has been made since the last meeting in following up some of the recommendations made to FAO.

Under the EMPRES programme, a training course was held in Saudi Arabia and another is planned to be held in the Sudan. A "train the trainer" course was held in the UK, with participation of locust affected countries, to improve the accuracy of pesticide application. Training will continue to be a requirement to ensure that more locust control staff are able to minimize environmental contamination and overall cost of locust control.

FAO has encouraged the development of a model to optimize the use of barrier treatments.

An updated guideline on locust control has been prepared for circulation and final comments prior to publication.

Monitoring of control operations is now being promoted under the EMPRES Programme.

FAO has initiated a mission to assess the development and use of mycopesticides in the Central Region.

FAO has encouraged the further collection of data on residues and the provision of more information for the ecotoxicological database specific to the locust situation.

FAO has initiated preparation of specifications for formulations used in locust control and is consulting WHO with respect to these specifications.

Pesticide data sheets for locust control insecticides are in preparation

RECOMMENDATIONS

47. The following recommendations were made by the meeting:

FAO should continue to support ecotoxicological studies relevant to the locust situation. In particular data are needed on the potential environmental advantage of barrier treatments.

FAO should collect operational data on the area treated, the type and amount of insecticide used and the efficacy achieved during Desert Locust control operations so as to build up a centralized database.

FAO should encourage submission of pesticide efficacy and environmental data on other migratory locust species.

FAO should continue to make the work of the Pesticide Referee Group more widely known in the context of general crop protection.

APPENDIX I

PARTICIPANTS IN THE MEETING OF THE PESTICIDE REFEREE GROUP.
2 - 6 March 1998

MEMBERS OF THE PESTICIDE REFEREE GROUP

G.A. Matthews
Chairman

Professor of Pest Management,
IPARC/Imperial College
Silwood Park, Sunningdale
Ascot, Berks. SL5 7PY
United Kingdom
Fax: ++ (44) 1 344 294450
E-mail: g.matthews@ic.ac.uk

D. Brown

Locust Research and Control Specialist
Plant Protection Research Institute
Agricultural Research Council
Locust and Termite Research Division
Private Bag X 134
Pretoria, 0001
Republic of South Africa
Fax: ++ (12) 3293278
E-mail: rietdb@plant2.agric.za

P.A. Oomen

Senior Entomologist / Phytopharmacist
Ministry of Agriculture, Nature Management and Fisheries
Plant Protection Service
15, Mansholtlaan. P.O. Box 9102
6700 HC Wageningen
The Netherlands
Fax: ++ (31) 317421701
E-mail: p.a.oomen@pd.agro.nl

R. Sanderson

Application Specialist
Entomology Department
New Mexico State University
PO Box 30003, Campus Box 3AG
Las Cruces, New Mexico, USA 88003
Fax: ++ (1) 505 646 8087
E-mail: bobsand@taipan.nmsu.edu

INVITED OBSERVERS

M. Y. Al-Ghashm

Director General
General Department of Plant Protection
PO Box 26
Sana'a
Republic of Yemen
Fax: ++ 967 1 228064

R. Peveling

Tropical Ecologist
University of Basel
Institute of Environmental Sciences (NLU) - Biogeography
St.-Johanns-Vorstadt 10
4056 Basel
Switzerland
Fax: ++ 41 61 2676434
E-mail: peveling@ubaclu.unibas.ch

INVITED REPRESENTATIVES FROM INDUSTRY

P. Pastre Hoechst Schering AgrEvo

H. Stier France

R. Bateman CABI Biosciences / LUBILOSA Project
United Kingdom

D. Kelili Dow AgroSciences
France

E. Planchon
C. Meniaud
G. Bruge
K. Romijn
Rh ne Poulenc Agro
France

J. Fongers
T. Pels
Uniroyal Chemical
The Netherlands

F.A.O.

N. Van der Graaff
Chief
Plant Protection Service (AGPP)
Plant Production and Protection Division (AGP)
Rome
Italy

A. Hafraoui
Senior Officer i/c
Locusts and Other Migratory Pests Group
Plant Protection Service (AGPP)
Plant Production and Protection Division (AGP)
Rome
Italy
Fax: ++ (39) 6 522 55271
E-mail: Abderrhahmane.Hafraoui@fao.org

C. Elliott
Senior Officer : Migratory Pests
Locusts and Other Migratory Pests Group
E-mail: Clive.Elliott@fao.org

A. Monard
Locust Information Officer
Locusts and Other Migratory Pests Group
E-mail: Annie.Monard@fao.org

J.W. Everts
Chief Technical Adviser
FAO / Locustox Project
BP 3300, Dakar
Senegal
Fax: ++ (221) 8 344290
E-mail: locustox@metissacana.sn

H. van der Valk
Secretary
Ecotoxicologist
Burg. Jansenstraat 50
5038 DE Tilburg
The Netherlands
Fax: ++ (31) 13 4633908
E-mail: harold.vandervalk@wxs.nl

APPENDIX II

1998 Pesticide Referee Group Meeting - Efficacy reports by individual submission

Controlagent	***Efficacy report*** Submission title	*Author*	Country	Target species	Report code
diflubenzuron	***1 - Recommendations for use of Dimilin OF-6 in a barrier spray programme for control of migratory locust (Locusta migratoria) in Madagascar***	--	Madagascar	*Locusta migratoria capito*	-- (no new data)
	2 - Biocontrol of locusts in Madagascar, phase III: implementation of biocontrol with indigenous pathogens	Montana State University *c.s.*			
Metarhizium flavoviride SP9	Appendix A: Large scale field evaluation of *Metarhizium flavoviride* Gams and Rozsypal against *Locusta migratoria capito* Sauss (Orthoptera) in Madagascar, 1996	Montana State University *c.s.*	Madagascar	*Locusta migratoria capito*	98-1
Metarhizium flavoviride SP3 and SP9; *Beauveria bassiana* SP16	Appendix E: Field and laboratory evaluations of leading entomopathogenic fungi isolated from *Locusta migratoria capito* Sauss in Madagascar. *Memoirs of the Entomological Society of Canada 171:000-000*	Delgado *et al.*	Madagascar Cape Verde	*Locusta migratoria capito* *Oedaleus senegalensis*	98-2
	3 - Biocontrol of locusts in Eritrea: identification and development of indigenous pathogens	Montana State University *c.s.*			
Metarhizium flavoviride ER1, ER36 and ER61	Appendix C: Evaluation of the Eritrean fungal isolates against Deserts Locusts under simulated field conditions and in semi-field trials	Montana State University *c.s.*	Eritrea	*Schistocerca gregaria*	98-3 (cage trials)
triflumuron	***4 - Alsystine 050 UL pour la lutte antiacridienne. Dossier biologique***	Bayer			
triflumuron cyhalothrin lambda-cyhalothrin beta-cyfluthrin lambda-cyhalothrin + pirimiphos-methyl fenitrothion	Appendix 5.1 Essai de contr le du criquet s n galais *Oedaleus senegalensis* avec des r gulateurs de croissance l aide du Micro-ULVA et les aspects de techniques d application pour les brigades villageoises.	Dorow	Niger	*Oedaleus senegalensis*	91.12
triflumuron	Appendix 5.2 Alternative bek mpfung von Heuschrecken. Versuchsspr hungen mit Alsystin 250 OF (triflumuron) gegen *Locusta migratoria capito* in Madagaskar und *Oedaleus senegalensis* im Niger 1991	Dorow	Niger Madagascar	*Oedaleus senegalensis* *Locusta migratoria capito*	91.11
triflumuron	Appendix 5.3 Lutte alternative contre les criquets avec les inhibiteurs de croissance. Etudes de terrain sur l utilisation d Alsystin 050 UL (triflumuron) dans la lutte contre les populations de larves de *Locusta migratoria capito*. mars/avril 1992 Madagascar.	Dorow	Madagascar	*Locusta migratoria capito*	98.4
triflumuron	Appendix 5.4 Barrier treatment with a benzoyl urea insect growth regulator against *Locusta migratoria capito* (Sauss) hopper bands in Madagascar. *Int. J. Pest Manag. 39(4):411-417*	Scherer & Rakotonandra-sana	Madagascar	*Locusta migratoria capito*	93.2
triflumuron	Appendix 5.5 Alternative Bek mpfung von Wanderheuschrecken mit Chitinsynthesehemmern. Felduntersuchungen zur Barrierebehandlung von Larvenpopulationen von *Locusta migratoria capito* mit IGR s (insect growth regulators - d r gulateurs de croissance) und applikationstechnische Gesichtspunkte. M rz/April 1993 in Madagaskar.	Dorow	Madagascar	*Locusta migratoria capito*	98.5

triflumuron	Appendix 5.6 Alternative Bek mpfung der W stenheuschrecke *Schistocerca gregaria* - Versuche mit Alsystin, Melia- und Neem-Produkten. November/Dezember 1994	Dorow	Mauritania	*Schistocerca gregaria*	98.6
triflumuron	Appendix 5.7 The effects of the insect growth regulator triflumuron (Alsystin) on hopper bands of *Schistocerca gregaria. Int. J. Pest M 43(1):19-25*	Wilps & Diop	Mauritania	*Schistocerca gregaria*	98.7 (=96.2)
triflumuron	Appendix 5.8 Grossversuch Barrierebehandlung mit Alsystin 050 UL (SIR 8514 0050 UL 0133) gegen Larvenb nder der W stenheuschrecke *Schistocerca gregaria*. Mauretanien M rz-April 1995	Dorow	Mauritania	*Schistocerca gregaria*	98.8
diflubenzuron	***5 - Traitement en barri re avec le diflubenzuron (Dimilin 450) contre les bandes larvaires de* Locusta migratoria**	Randriama-nantsoa	Madagascar	*Locusta migratoria capito*	98.9
diflubenzuron deltamethrin beta-cypermethrin	***6 - Results of trials in 1997 for control of locusts and grasshoppers with Dimilin OF-6, using a new application technology, in the Pavlodar Region, Kazakhstan***	Kazakh Plant Protection Stations	Kazakhstan	*Dociostaurus brevicollis, Calliptamus italicus*, + others	98.10
	7 - Update on the use of Metarhizium* sp. *for the biological control of locusts and grasshoppers	Lubilosa (Bateman)			
Metarhizium flavoviride fenitrothion	Appendix II 2.1 Comparison of a synthetic insecticide with a mycoinsecticide for the control of *Oedaleus senegalensis* Krauss (Orthoptera: Acrididae) in the field at operational scale: the importance of the spray residue.	Langewald *et al.*	Niger	*Oedaleus senegalensis*	96.18
Metarhizium flavoviride fenitrothion	Appendix II 2.2 A large scale field trial in Niger to assess operational aerial control of *Oedaleus senegalensis* with *Metarhizium* and an organophosphorous insecticide	Lubilosa	Niger	*Oedaleus senegalensis*	98.11
Metarhizium flavoviride	Appendix II 2.3 First use of a *Metarhizium flavoviride* myco-insecticide for the control of the red locust in a recognized outbreak area	Price *et al.*	Mozambique	*Nomadacris septemfasciata*	98.12
Metarhizium flavoviride	Appendix III Field treatment of Desert Locust (*Schistocerca gregaria* Forskal) hoppers in Mauritania using an oil formulation of the entomopathogenic fungus *Metarhizium flavoviride. Biocontrol Science and Technology* 7, 603-611	Langewald *et al.*	Mauritania	Schistocerca gregaria	95.12
Carbosulfan Malathion	***8 - Report on field trials to assess the efficacy of carbosulfan against hoppers of the Desert Locust in Sudan; 27 November - 16 December 1997***	King *et al.*	Sudan	*Schistocerca gregaria*	98.13
	9 - ADONIS (fipronil) Compte rendu des travaux de d veloppement en lutte antiacridienne (p riode 1996 - 1997)	Rh ne Poulenc			
fipronil	Appendix 1 Rapport de tourn e - contr le de l'efficacit d'ADONIS 7,5 UL lors d'un traitement antiacridien.	Randriama-nantsoa	Madagascar	*Locusta migratoria capito*	98.14
fipronil deltamethrin fenitrothion + esfenvalerate	Appendix 2 and 3 Report of the results of research of the insecticide "ADONIS, 4% EC" of the firm Rh ne Poulenc (France) against harmful locusts in Kazakhstan	Nurmuratov *et al.*	Kazakhstan	*Locusta migratoria, Calliptamus italicus,* others	98.15
fipronil	Appendix 4 and 5 Rapport des essais d'ADONIS 40 EC. Volgograd R gion, de 1996	Naoumovitch	Russia	*Calliptamus italicus*	98.16
fipronil chlorpyrifos	Appendix 6 and 7 Rapport des essais d'ADONIS 40 EC, Russie (Sib rie), 1997	Latchininsky & Duranton	Russia	various grasshoppers	98.17
fipronil deltamethrin	Appendix 8 Rapport des essais d'ADONIS 40 EC, Russie (Stavropol), 1997	Nikouline	Russia	*Calliptamus italicus*	98.18
fipronil deltamethrin	Appendix 9 Rapport des essais d'ADONIS 40 EC, G orgie, 1997	Abashidze	Georgia	*Calliptamus italicus*	98.19

fipronil deltamethrin	Appendix 10 Rapport des essais d'ADONIS 40 EC	Plant Protection Institute	Ouzbekistan	*Dociostaurus maroccanus, Calliptamus turanicus*	98.20
fipronil RPA 107382 malathion carbaryl	Appendix 11 Large scale evaluations of fipronil and small scale evaluations of RPA 107382	Lockwood *et al.*	USA/Wyoming	various grasshoppers	98.21
fipronil	Appendix 12 Exp rimentation du fipronil (ADONIS 4 UL) contre les bandes larvaires du criquet du Mato Grosso, *Rhammatocerus schistocercoides* (Rehn, 1906). Br sil, mars-avril 1997	Lecoq & Balan a	Brasil	*Rhammatocerus schistocercoides*	98.22
fipronil	Appendix 13 Trials of Adonis 6.25 g/l against hoppers in Saudi Arabia	Halawani	Saudi Arabia	*Schistocerca gregaria*	98.23
fipronil	Appendix 14 Attestation des essais d'ADONIS 6,25 UL	Sayyar Siddiqi	Pakistan	*Schistocerca gregaria*	98.24
fipronil fenitrothion	Appendix 15 Lutte contre le criquet nomade (*Nomadacris septemfasciata*). Test mise en place de m thode de lutte.	Pastou & Rococo	Reunion	*Nomadacris septemfasciata*	98.25
fipronil	Appendix 16 Etude de la bio-efficacit du fipronil l' gard des ravageurs de caf ier: *Hypothenemus hampei* (Coleoptera, Scolytidae) and *Zonocerus variegatus* (Orthoptera, Pyrgomorphidae)	Mbondji & Mpe	Cameroun	*Zonocerus variegatus*	98.26
fipronil endosulfan	Appendix 17 Recherche sur la bio-efficacit de l'insecticide ADONIS l' gard de *Zonocerus variegatus* (Orthoptera, Pyrgomorphidae)	Mbondji & Mpe	Cameroun	*Zonocerus variegatus*	98.27
fipronil	Appendix 18 Evaluation de la toxicit et de la r manence du fipronil appliqu faibles doses contre le criquet marocain et saut riaux dans le massif de Siroua (Maroc)	Mouhime & Chihrane	Morocco	*Dociostaurus maroccanus*	98.28
fipronil fenitrothion	Appendix 19 Essais de l'efficacit et de la r manence de "Adonis" en lutte antiacridienne au Mali	PlantProduct. and Prot.Div.	Mali	grasshoppers	98.29
chlorpyrifos	***10 - Spray trials applying chlorpyrifos (Dursban ULV) to control Moroccan Locusts (Dociostaurus maroccanus) in Kazakhstan***	Clayton & Rilakovic	Kazakhstan	*Dociostaurus maroccanus*	98.30
chlorpyrifos	11 - Aerial survey and control of adult red locusts in the Buzi flood plains, Sofala Province, Mozambique.	Chambers & D'Uamba	Mozambique	*Nomadacris septemfasciata*	98.31
Neem *Melia*	***12 - Neem (Azadirachta indica) and melia (Melia volkensii) seed extracts: their potential in locust control. Summary of research Niger and Mauritania 1990-1996***	GTZ	Niger Mauritania	various	as yet uncoded

APPENDIX III

1998 Pesticide Referee Group Meeting - (Eco)toxicological reports by individual submission

Control agent	***Submission title*** (Eco)toxicology report title	Author	Country
	1 - Biocontrol of locusts in Madagascar, phase III: implementation of biocontrol with indigenous pathogens	Montana State University	
Metarhizium flavoviride SP9 *Metarhizium flavoviride* SP3 *Beauveria bassiana* SP16 fenitrothion+esfenvalerate	Appendix D: Effects of anti-locust fungal biopesticides on non-target coleopteran biodiversity in Madagascar	Montana State University *c.s.*	Madagascar
	2 - Biocontrol of locusts in Eritrea: identification and development of indigenous pathogens	Montana State University	
Metarhizium flavoviride ER1	Appendix A: Screening of pathogenic fungi (mammalian toxicity)	Illinios Institute of Technology Research Institute	USA
	3 - Alsystin 050 UL. Dossier cotoxicologique	Bayer	
triflumuron beta-cyfluthrin propoxur + phoxim teflubenzuron deltamethrin lambda-cyhalothrin fenitrothion *Metarhizium* flavoviride	Acute toxicity tests with two aquatic invertebrates from the Sahel: *Streptocephalus sudanicus* (Branchiopoda, Anostraca) and *Anisops sardeus* (Hemiptera, Notonectidae) - Effects of chemical insecticides and observations on test methods	Marquenie & Schuiling	Senegal
triflumuron fenitrothion fenitrothion + esfenvalerate	The impact of locust control agents on springtails in Madagascar	Peveling, Osterman *et al.*	Madagascar
triflumuron	Side effects of the insect growth regulator triflumuron on spiders.	Peveling, Hartl *et al.*	Madagascar, Mauritania, Germany
triflumuron diflubenzuron teflubenzuron *Beauveria bassiana* *Metarhizium flavoviride* *Melia volkensii* profenofos + cypermethrin fenitrothion + esfenvalerate	Lutte biologique et int gr e contre les acridiens	Wilps *et al.*	Mauritania
triflumuron	Wirkungstests mit triflumuron (Alsystin) an Araneae	K hne	Germany
triflumuron	Untersuchungen zur Wirkung von Alsystin (WP25) und Dimilin (WP25) auf Mortalit t und Reproduktionsleistung von *Folsomia candida* (Collembola).	Wefringhaus	Germany
triflumuron diflubenzuron	kotoxikologische Nebenwirkungen von Triflumuron (Alsystin) auf Honigbienen (Apis mellifera L., Apidae:Hymenoptera) und Schwarz-Braune Wegameisen (Lasius niger L., Fomicidae:Hymenoptera).	Osman Gedow	Germany
triflumuron fenitrothion	Comparaison des effets d un insecticide organophosphor et d un insecticide d r gulateur de croissance utilis s dans la lutte antiacridienne sur les arthropodes non-cibles dans le Sud-Ouest de Madagascar - r sultats de la saison 1994	Osterman	Madagascar
triflumuron	Side-effects of botanicals, insect growth regulators and entomopathogenic fungi on epigeal non-target	Peveling, Weyrich *et al.*	various

teflubenzuron fenoxycarb Neem *Melia* *Beauveria bassiana* dieldrin profenofos + cypermethrin	arthropods in locust control		
triflumuron	kotoxikologische Freiland- und Halbfreilandversuche mit triflumuron in Akjoujt / Mauretanien	Hartl	Mauritania
various	Preliminary report	Peveling	Mauritania
	4 - Set of reports from the FAO/Locustox project		
fenitrothion chlorpyrifos	No. 97/11: Blood cholinesterase levels in crop protection wokers after routine spraying operations with organophosphate insecticides in Senegal. Locustox Project, FAO.	Mulli *et al.* (1997)	Senegal
fenitrothion chlorpyrifos	No. 96/7: Toxicit aigu de deux organophosphor s (fenitrothion & chlorpyrifos) vis vis 'une esp ce de poisson *Oreochromis niloticus* (L) (Pisces, Cichlidae) dans le Nord du S n gal. FAO, Projet Locustox, Dakar.	Diallo & Lahr (1996)	Senegal
phoxim/propoxur teflubenzuron triflumuron beta-cyfluthrin *Metarhizium flavoviride*	No. 97/1: Acute toxicity of five insecticides used in Desert Locust control to *Streptocephalus sudanicus* (Branchiopoda , Anostraca) and *Anisops sardeus* (Hemiptera , Notonectidae). FAO, Projet Locustox, Dakar. *Note: partly overlaps the 1st report in submission 3*	Marquenie *et al.* (1997)	Senegal
beta-cyfluthrin deltamethrin lambda-cyhalothrin fenitrothion	No. 97/2: Acute toxicity tests with *Streptocephalus sudanicus* (Branchiopoda , Anstraca) and *Anisops sardeus* (Hemiptera, Notonectidae): effectsof synthetic pyrethroids and methodological aspects. FAO, Locustox Project, Dakar	Schuiling *et al.* (1997)	Senegal
bendiocarb chlorpyrifos fenitrothion malathion deltamethrin lambda-cyhalothrin diflubenzuron fipronil	No. 97/3: An ecological assessment of the hazard and risk of eight insecticides used in Desrt Locust control, to invertebrates in temporary ponds in the Sahel. FAO, Locustox Project, Dakar.	Lahr (1997)	Senegal
various	No. 97/7: Tests de toxicit au laboratoire de huit acridicides vis vis de *Oreochromis niloticus* (Pisces, Cichlidae). FAO, Projet Locustox, Dakar.	Diallo *et al.* (1997)	Senegal
fenitrothion	No. 94/1: A laboratory toxicity test with *Bracon hebetor* (SAY) (Hymenoptera, Braconidae). First evaluation of rearing and testing methods. FAO, Locustox Project, Dakar.	Van der Valk *et al.* (1994)	Senegal
Metarhizium flavoviride	No. 94/2: Toxicity tests with *Metarhizium flavoviride* (Deuteromycetes-Moniliales) on *Bracon hebetor* (Hymenoptera, Braconidae), *Pimelia senegalensis* and *Trachyderma hispida* (Coleoptera: Tenebrionidae). FAO, Locustox Project, Dakar.	Danfa (1994)	Senegal
Metarhizium flavoviride	No. 96/1: Effets des entomopathog nes *Metarhizium spp.* et *Beauveria bassiana* sur *Bracon hebetor* et *Epidinocarsis lopezi*. FAO, Projet Locustox, Dakar.	Danfa (1996)	Senegal
---	No. 96/2: Impact potentiel des insecticides sur la mortalit naturelle de la chenille mineuse de l' pi de mil (*Heliocheilus albipunctella*) : une tude de la table de survie. FAO, Projet Locustox, Dakar. *Note: ecological study; no insecticides included*	Thiam & Van der Valk (1996)	Senegal
---	No. 97/4: D termination de l impact potentiel des pesticides sur *Heliocheilus albipunctella* (mineuse de l pi de mil) partir d une m thode indirecte: l tude de la table de survie. FAO, Projet Locustox, Dakar *Note: ecological study; no insecticides included*	Sarr (1997)	Senegal
bendiocarb chlorpyrifos deltamethrin fipronil	No. 97/5: Test de toxicit aigu sur un parasito de, *Bracon hebetor* Say (Hymenoptera: Braconidae), avec diff rents insecticides utilis s en lutte antiacridienne. FAO, Projet Locustox, Dakar.	Danfa *et al.* (1997)	Senegal

lambda-cyhalothrin malathion			
fenitrothion	No. 97/7: Effets du f nitrothion sur les col opt res pig s de l agro cosyst me mil au S n gal. FAO, Projet Locustox, Dakar.	B ye *et al.* (1997)	Senegal
various	No. 97/10: Test de toxicit aigu sur les termites *Psammotermes hybostoma*. FAO, Projet Locustox, Dakar.	Danfa *et al.* (1997)	Senegal
fenitrothion malathion	No. 97/8: D position disparition du Fenitrothion et du Malathion sur v g tation de mil et du Chlorpyrifos sur herbe au S n gal (campagne 1994 et campagne 1996). FAO, Projet Locustox, Dakar.	Gadji (1997)	Senegal
various	No. 97/13: Etude r trospective des effets long terme des pesticides chez les manipulateurs de la Direction de la Protection des V g taux (DPV) du S n gal. Phase I : Inventaire de l exposition individuelle dans quatre r gions. 1988-1995. FAO, Projet Locustox Dakar.	Dossou & Mulli (1997)	Senegal
	5 - Update on the use of Metarhizium* sp. *for the biological control of locusts and grasshoppers	Lubilosa (Bateman)	
Metarhizium flavoviride	Chapter 4 Current status of evaluations for environmental impact		various
	Appendix I 1.3 Mammalian toxicology profile (summary)		various
	Appendix I 1.4 Ecotoxicological summaries		various
carbosulfan	***6 - Report on field trials to assess the efficacy of carbosulfan against hoppers of the Desert Locust in Sudan; 27 November - 16 December 1997***	King *et al.* (1998)	review summary
	7 - ADONIS (fipronil) Compte rendu des travaux de d veloppement en lutte antiacridienne (p riode 1996 - 1997)	Rh ne Poulenc	
fipronil RPA 107382 carbaryl malathion	Appendix 11 Large scale evaluations of fipronil and small scale evaluations of RPA 107382	Lockwood *et al.* 1997	USA / Wyoming
fipronil	Appendix 20 Etudes de toxicit aigu d'ADONIS 40 EC	de Jouffrey	laboratory
silafluofen	***8 - Environmental impact of silafluofen locust bait on non-target organisms in the Karoo, South Africa***	Chambers *et al.* 1997	South Africa

[1]: Evaluation of ecotoxicological data from affected zones of insecticides against locusts and grasshoppers. Report to the PRG. FAO/Locustox, November 1996.

APPENDIX IV

Summary of data from efficacy trial reports listed by insecticide as discussed in the 1998 Pesticide Referee Group meeting

Insecticide	Application rate (g a.i./ha)	Control % @ hours/days after treatment	Species	Sprayer	Volume application rate (l/ha)	Plot size (ha)	Replicates	Report code	Comments
carbosulfan	100 125	62% @ 6 hrs 71 - 90 % @ 6hrs	SGR	Ground: UlvaMast	1	3.7 - 10.9	4 8	98.13	
chlorpyrifos	144 to 225	84 - 100% @ 24 hrs	DMA	Ground: MicroUlva, UlvaMast	0.25 - 0.6	1 - 4	6	98.30	range finding test
chlorpyrifos	450	63% @ 24 hrs 100% @ 72 hrs	NSE	Aerial: AU3000	1	560	1	98.31	
diflubenzuron	100 (in barrier)	>90% @ 10 d	LMI	Aerial: AU3000	1 (in barrier)	10000	1	98.9	100m barrier width, 500m barrier spacing
diflubenzuron	40 (in barrier), 60 (in barrier)	>95% @ 10d	CIT, DMA	Ground: AU8000, AU8110	1	14.7 100	2	98.10	40m barrier width, 100m barrier spacing
fipronil	6 (in barrier)	>99 @ 5d	LMI	Aerial	0.8 (in barrier)	1000	6	98.14	barrier width 1 aircraft track, 700m barrier spacing
fipronil	4 (in barrier)	63% @ 24 hrs	LMI, CIT	Ground	210	0.5	2	98.15	20m barrier width, 20 m barrier spacing; EC formulation; not real barrier treatment
fipronil	4	100% @ 24 hrs	LMI, CIT	Ground	210	0.5	2	98.15	blanket treatments
fipronil	4	>96% @ 7d	CIT	Ground	400	2		98.16	EC formulation
fipronil	2 - 4	>95% @ 2d	various grasshoppers	Ground	25 - 150	44		98.17	EC formulation
fipronil	4	>95% @ 2d	CIT	Ground	?	?	2	98.18	EC formulation; summary report
fipronil	3 4 5	55%@6d, 80%@12d 90%@6d, 92%@10d 94%@6d	CIT	Ground	400	1	2	98.19	EC formulation
fipronil	3.2 4 4.8	83% @ 14d >90% @ 7d >90% @ 7d	DMA, CIT	Ground	200	5	2	98.20	EC formulation
fipronil	4	96% @ 3d	various US grasshoppers	Aerial	1	260	1	98.21	large scale trial
fipronil	1.3 (RAAT)	85-99% @ 3 d 86-99% @ 7d	various US grasshoppers	Aerial	1	260	2	98.21	RAAT: reduced area treatment: 30m wide barriers, 60m barrier spacing
fipronil	2 - 12	>99% @ 5d	various Brazilian grasshoppers	Ground: MicroUlva	0.5 - 1	<1		98.22	tests on small plots
fipronil	12.5 (in barrier)	100% (in barrier)	SGR	Aerial: AU7000	1			98.23	single barrier? control 100% in barrier, 95% at 200m and 20% at 500m from barrier
fipronil	6.25	100% @ 24hrs	SGR	Aerial: AU7000	1			98.23	blanket treatment
fipronil	6.25	90% @ 24hrs	SGR	Ground: MicroUlva	1	bands	3	98.24	summary only

fipronil	2.6 6	>96% @ 7d 100% @ 3d	NSE	Ground: Berthoud	3			98.25	summary only
fipronil	4	>90%	ZVA	Ground: MicroUlva	1	cages		98.26	
fipronil	4	>95%	ZVA	Ground: Solo, MicroUlva	0.5 (EC) 2 (ULV)	0.75 (EC) $750m^2$ (ULV)	4	98.27	summary only; EC and ULV formulations
fipronil	2 - 3	99% @ 4d	DMA	Ground: MicroUlva	1	<1	6	98.28	small plots and cage persistence tests
fipronil	4	>90 @ 8d	OSE and other grasshoppers		0.5	1	3	98.29	
Metarhizium sp. (isolate SP9)	4×10^{12} 1.6×10^{13} (spores/ha)	63% @ 20d 84% @ 20d	LMI	Ground: MicroUlva	2	10	3	98.1	
Metarhizium sp. (isolates SP9/SP3)	2.5×10^{13} (spores/ha)	100% @ 8d 100% @ 8d	OSE LMI	Ground: MicroUlva	5	$50m^2$, 0.5 ha	4	98.2	small plots, enclosures bioassay
Metarhizium sp. (isolates ER1, ER36, ER61)	2.5×10^{13} (spores/ha)	98% @ 11d (ER1) <50% @ 11d (ER36, ER61)	SGR	Brush	6	cages	4	98.3	indigenous pathogen in Eritrea; cage tests
Metarhizium sp. (isolate IMI 330189)	1×10^{12} (spores/ha)	>80% @ 21d	OSE	Aerial: AU5000	0.5	800	1	98.11	large scale trial of OF formulation
Metarhizium sp. (isolate IMI 330189)	1×10^{12} (spores/ha)	>90% @ 21d	NSE	Ground: Solo	2.5	1	3 bands	98.12	
triflumuron	25 - 50	50 - 80% @ 3d	LMI	Ground: Solo	0.5 - 1		7 bands	98.4	concludes that efficacy depends on time in treated area and not on dose
triflumuron	50 (in barrier)	>90% @ 5d	LMI	Ground: MicroUlva	1 (in barrier)	460	14 bands	98.5	50m barrier width; barrier spacing irregular
triflumuron	50 (in barrier)	>90% @ 21d	SGR	Ground: MicroUlva, Solo	1 (in barrier)	15 - 50	3	98.6	10m barrier width; 100m barrier spacing
triflumuron	80 (in barrier)	80 - 90% @ 25d	SGR	Aerial: AU5000	1.6 (in barrier)	4100	1	98.8	4 barriers: 100-300m barrier width, 550-2750m barrier spacing

Species codes:

CIT: *Calliptamus italicus*
DMA: *Dociostaurus maroccanus*
LMI: *Locusta migratoria*
NSE: *Nomadacris septemfasciata*
OSE: *Oedaleus senegalensis*
SGR: *Schistocerca gregaria*

APPENDIX V

TERMS OR REFERENCE

1. To evaluate, at least once a year, pesticide trial reports on Desert Locusts and other migratory locusts, with reference to the following:

   a) satisfactory trial technique (eg. number of replicates, method of measuring mortality, application technique).

   b) validity of the report (methods and procedures fully described).

   c) effective kill at the dosages used.

   d) health and environmental implications.

2. On the basis of the above, and relevant information on large scale control operations, prepare a list of pesticides and dosages efficacious for operations against Desert Locusts and other migratory locusts, and appraise them according to their health and environmental risk.

3. Compile a list of pesticides that warrant further evaluation either from the point of view of efficacy or environmental side-effects, and specify the trials required (laboratory, field, small scale, large scale).

4. Provide FAO with advice on pesticides, when required between meetings.

5. Prepare a report covering the above points.

Members (not more than 5), appointed on a personal basis, should be impartial and objective in their assessments and should have at least one of the following qualifications:

- should have experience of locust field work.
- should be actively involved in locust control in a locust-affected country.
- should have experience in pesticide application and evaluation.
- should have environmental/ecotoxicological experience.