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

Report to FAO by the PESTICIDE REFEREE GROUP

Ninth meeting
Rome, 18 - 21 October 2004

December 2004

Food and Agriculture Organization of the United Nations

TABLE OF CONTENTS

Tables

Appendices

INTRODUCTION

1. The 9th meeting of the Pesticide Referee Group (PRG)(members listed in Appendix 1) was opened by Mr. N. Van der Graaff, Chief of the FAO Plant Protection Service. He welcomed Dr. M. Jamal Hajjar, Director of the Plant Protection Directorate in Syria, as a new participant in the PRG meeting. Mr. Van der Graaff noted that this was the first meeting of the PRG during the present Desert Locust upsurge. Advice was needed on the use of pesticides, including the role of fipronil versus IGRs, and how to apply them. The PRG was to have the opportunity to question Industry on the products available for locust control.

2. Mr. C. Elliott, Senior Officer, Locust and Other Migratory Pests Group, expressed concern that FAO had been using mainly organophosphates (OPs) in the current upsurge due to the alleged recovery of locusts after knockdown with pyrethroid insecticides. It was also pointed out that FAO now only purchases insecticides that are both listed by the PRG in its Table 1, and are registered in locust-affected countries.

3. The PRG felt sorry that Dr. R Sanderson was unable to attend the meeting and wished him a speedy recovery.

4. During the second day of the meeting, representatives from BASF, Bayer Environmental Science, BCP Biological Control Products, Crompton/Uniroyal Chemical, Dow AgroSciences and Syngenta Agro gave short presentations and responded to questions from the PRG.

5. The interval of five years since the last PRG meeting was primarily due to the lack of new trials data submitted by Industry. The present meeting was able to review more than 40 reports (listed in Appendix III) and considered a number of problems that had been raised by the ongoing control programme. Adjustments to the Tables given in the previous report were made on the basis of new data and a re-examination of previous data. No new insecticide has been added to Table 1 due to the lack of data relevant to Desert Locust control. Dose rates are based on reported efficacy data and do not imply registration in specific countries.

6. At request of the DLCC, reports and data from earlier PRG meetings have been compiled on a user-friendly, interactive *Insecticide Trials Database* on CD-ROM. The database proved invaluable at this meeting by allowing rapid re-examination of trials data of specific insecticides. Additional data can be easily added to the database and a new CD-ROM can be produced. Access to confidential information can be denied in a version that could be made more widely available, but the main purpose will be to assist registration authorities in locust affected countries. The PRG thanked FAO and the developers of the database for this excellent work.

7. In using the common names, the Group referred specifically to the ultra-low volume (ULV) formulations considered efficacious for locust control. It was recognized that Industry markets its products using specific trade names and different formulations. The PRG welcomed the recognition by FAO of the need to purchase insecticides based on products evaluated by the Group.

8. It was reaffirmed that the Pesticide Referee Group is an independent body of experts that advises FAO on the efficacy and environmental impact of different pesticides for locust control. This advice is based on a critical review of reports submitted by industry, research

institutes, plant protection departments, of other available literature, and on the experience of its members and of FAO experts. The resulting advice systematically lists pesticides suitable for locust control from the scientific point of view. The PRG has no legal status. All uses of pesticides discussed in this report are fully subject to national legislation, regulation and registration.

DESERT LOCUST

9. Verified dose rates, speed of action, and primary route of exposure of different control agents for the Desert Locust are given in Table 1. Dose rates were modified for three agents, chlorpyrifos, deltamethrin and diflubenzuron. The dosage of chlorpyrifos was slightly increased to correspond with the most commonly used UL formulation applied at 1 litre/ha. The dosage set for deltamethrin had been 12.5 g a.i./ha at an earlier meeting as reports had indicated good efficacy at this rate, although it was indicated that a higher dosage would be needed for fully grown hoppers. In view of concerns about alleged recovery after knock-down, a further trial at 17.5 g a.i./ha had been carried out. This confirmed that at the higher dose, the locusts failed to recover. It was also noted that due to a negative temperature coefficient the higher dosage would be better if ambient temperatures were high. It was decided that both dosages should be listed and a choice made in relation to the stages of the locusts being treated and temperature conditions. The dose rate of diflubenzuron as a blanket spray was reduced to 30 g a.i./ha which proved equally effective against Desert Locust hoppers as the dose previously recommended (60 g a.i./ha).

10. Fipronil should be used only for barrier treatments in non-crop areas. This new use pattern is supported by the producer. Barrier treatments with fipronil must comply with the requirements for environmentally friendly barrier treatments outlined in § 62.

11. The speed of toxic action (e.g. knock-down, complete cessation of feeding) of the different compounds was confirmed 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, its inherent toxicity and its primary route of exposure. The synthetic pyrethroids produce a rapid sublethal knockdown effect, followed by a protracted paralysis after which the insect may die or partially recover depending on the dose received. Locusts that may partially recover usually die later without feeding. Some insecticides may not have such a rapid toxic effect, but still adversely affect the behaviour of the locusts. Cessation of feeding can occur very quickly even though death occurs later within the first day following treatment. Among the slower compounds listed in Table 1 are the mycoinsecticide *Metarhizium anisopliae* var. *acridum* and the benzoylureas (IGRs) which take a week or more to kill. To ensure that sufficient product is ingested and accumulated, the Group reaffirmed that when using the benzoylureas the early and intermediate hopper instars should be optimally targeted although later instars are also affected. Reports indicate that IGRs can adversely affect adult locusts by reducing fecundity and fertility. Such products are particularly suitable for a proactive role within the confines of a locust outbreak area where barrier treatments are advisable.

12. The Group reaffirmed the recommendations that only products with established dose rates should be used because of efficacy, toxicity and environmental concerns. The common names 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 have very different properties, so for optimal reliability for locust and grasshopper control, established products that meet the FAO specifications for ULV application should be used.

Table 1. Dose rates and speed of action of different insecticides for which verified dose rates have been established for the Desert Locust. Speed of toxic action (see text) 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 verified dose rate	Primary mechanism
		overall (blanket) treatment †		barrier treatment (hoppers)*			
		hoppers	adults	intra-barrier	overall		
Bendiocarb	CA	100	100			F	AChE inhibition
Chlorpyrifos	OP	240	240			M	AChE inhibition
Deltamethrin §	PY	12.5 or 17.5	12.5 or 17.5			F	Na channel blocking
Diflubenzuron ϕ	BU	30	n.a.	100	14.3	S	chitin synthesis inhibition
Fenitrothion	OP	400	400			M	AChE inhibition
Fipronil	PP			4.2	0.6	M	GABA receptor blocking
Lambda-cyhalothrin ‡	PY	20	20			F	Na channel blocking
Malathion	OP	925	925			M	AChE inhibition
Metarhizium anisopliae (IMI 330189)	fungus	50	50			S	mycosis
Teflubenzuron	BU	30	n.a.	n.d.		S	chitin synthesis inhibition
Triflumuron ϕ	BU	25	n.a.	75	10.7	S	chitin synthesis inhibition

Abbreviations: BU: benzoylurea, CA: carbamate, OP: organophosphate, PY: pyrethroid, PP: phenyl pyrazole; n.a. = not applicable; n.d. = not determined; *Notes*: * calculated dose rate applied over the total target area based on an average barrier width of 100 m and a track spacing of 700 m (see §§ 18-19); § The higher dose rate may be required if there is a risk of recovery of late instars or at high temperatures; ϕ Blanket spray data and observations for other locusts suggest that effective dose rates for Desert Locust barrier treatments may be further reduced; ‡ Where the "lambda" isomer is not registered in a country, cyhalothrin is applied at 40 g a.i./ha; † Application volumes for the recommended dose rates differ depending on the formulation available. See the conversion table in Appendix II for appropriate volumes of common formulations.

APPLICATION CRITERIA

13. The PRG noted that *Guidelines for Minimum Requirements for Pesticide Application Equipment used in Locust Control* are in preparation. These new guidelines are expected to help to reduce incidences of insufficient control caused by the use of inadequate spraying equipment.

14. The PRG continued to recommend ULV application as the standard technique to cope with the logistics of treating large areas with populations of locusts or grasshoppers, especially as these generally occurred in remote areas without water. The application of about one litre per hectare was preferred to ensure that sufficient droplets were applied for adequate coverage. However, depending on what formulation was available and when calibration was accurate and vegetation was not too dense, a lower rate of down to 0.5 litres per hectare (0.2 litres per hectare for barrier treatments) was acceptable if aerially applied over large areas. Such low volumes necessitated a narrow droplet spectrum to reduce waste of insecticide in large droplets, and a range of 50-100 µm VMD (Volume Median Diameter) droplet spectrum using rotary atomisers was advocated. Spray aircraft should be equipped with GPS-track guidance systems to assure correct application and to record spraying operations. GPS should also be used in ground treatments.

15. For ULV application it was essential that the formulation met the criteria for low volatility and low viscosity so that the appropriate droplet spectrum was achieved at the flow rate required to apply the recommended dosage. UL formulations must meet the FAO/WHO specifications to avoid corrosion of the application equipment and other technical problems encountered with unspecified formulations.

16. Emulsifiable concentrate formulations were not recommended for ULV application, as the volatility was too high. They should be used only if the targets were too small for drift spraying, for example when treating small and discrete patches of locusts, using manually operated knapsack sprayers. Dust formulations were used by farmers as a last resort to protect their crops. As small dust particles could be inhaled and many of the formulations were based on OPs and carbamates, dusts were not recommended for ground application.

17. In certain areas (e.g. Central Asia) that did not have the equipment needed for ULV application, the use of suspension concentrate formulations diluted in water had been advocated, especially to protect cereal crops. The use of 200 litres of water per hectare in ground equipment was a severe constraint on the area that could be treated, so wherever possible preference should be given to ULV application.

18. In addition to overall blanket sprays, certain insecticides were also considered efficacious for barrier treatments for control of locust hoppers. The aim is that while crossing a treated strip, the hoppers will collect a lethal dose. Precise application recommendations that were valid under all circumstances could not be given since they depended 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 a barrier (one or more swath widths) and distance between barriers that had to be used would depend on:

a) mobility of the hoppers
b) insecticide used (persistence)

c) the terrain/vegetation (plant density)
d) wind speed and direction during application
e) height of application

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

19. In assessing the width of the sprayed barrier, due note must be taken of the height of release of droplets, wind speed and density of vegetation as these factors would influence the extent that spray droplets moved downwind. The pattern of spray deposition would vary significantly between different situations, so care had to be exercised in interpreting data from trials. The width between treated barriers should be at least twice the width of the treated swath. Based on presently available efficacy data, the widest untreated strip was likely to be six times the sprayed swath width. This meant that for an effective single swath width of 100 m, a track spacing of 700 m was recommended. Further studies were needed to determine if wider gaps between swaths would remain effective as little was known about the rate at which the hoppers could detoxify and excrete insecticides recommended for barrier treatment.

20. Application techniques where spray drift from one barrier reached to or overlapped with the subsequent one were considered as irregular blanket rather than barrier treatments.

21. In the present upsurge, reports indicated that a wide range of aircraft and spray gear were being deployed. Rotary atomisers were now widely used and some aircraft were fitted with DGPS or GPS-track guiding systems. The PRG again stressed the need for training all those involved in operational application. It urged the continuation of training courses under the EMPRES Programme.

22. Reports on operator exposure during the application of insecticides indicated that in the present campaign no fatal casualties had occurred. In a number of cases, spray operators had to be temporarily relieved. Efforts to monitor safety of operators had to be increased, in an integral system for the control of the quality of spray operations. This included handling of pesticides, proper spray practice, the efficacy of the treatments as well as human and environmental safety, and the disposal of empty and contaminated material and pesticide remainders. FAO would train and equip specialized field teams for control of the quality of the operations, as of December 2004.

SPECIAL CONSIDERATIONS

23. The pesticides were divided into the following groups: organophosphates, pyrethroids, carbamates, benzoylureas, phenyl pyrazoles, neonicotinyls and biological insecticides (e.g. mycoinsecticides). Special consideration about their suitability for control purposes and conditions of use were given.

Organophosphates, carbamates and pyrethroids

24. Organophosphates, carbamates and pyrethroids had many aspects in common. They had a broad-spectrum activity, exhibited moderate (OPs) to fast (carbamates, pyrethroids) action and were therefore suitable for use in emergency situations. They worked mainly by contact action and were most effective during a short period of time, so needed to be targeted directly to the insect. Locusts exposed to treated vegetation were also affected for a limited pe-

riod of time after spraying, by contact and ingestion. The need to apply the spray directly on a target, required intensive efforts to identify and delimit appropriate targets (hopper bands and swarms). These insecticides were particularly suitable for swarm control and direct crop protection. The pesticides constituted a medium to high risk to aquatic invertebrates, especially crustaceans when pyrethroids were used, and to terrestrial non-target arthropods. Moreover, OPs may affect birds and reptiles.

25. The PRG discussed in detail the use of organophosphate insecticides and reviewed human toxicity data regarding their application against other pests. Apart from acute toxicity, it was now established that there could be chronic effects after recovery of an acute intoxication. Spray operators could be exposed to organophosphate insecticides, especially when filling sprayers with the formulated product. Their exposure could reduce seriously the acetylcholinesterase (AChE) level, so operator protection with coveralls, gloves, boots and face shields was required. Operators must be trained and subject to mandatory health monitoring. If the AChE level fell significantly, they must be given rest or alternative tasks until they were fully recovered. The toxicity varied strongly between the OP insecticides, with particular care needed when using chlorpyrifos and fenitrothion. Chemical transfer by pumps with closed coupling to the container was essential to minimize exposure.

Benzoylurea insect growth regulators

26. Benzoylurea IGR insecticides have been shown to be very effective against locust hoppers. Their action was slow, which made them unsuitable for immediate crop protection. They were persistent on foliage and their fairly narrow spectrum of activity made them attractive from an environmental point of view, but, due to adverse effects on crustaceans, spraying of surface waters must be avoided. They were most effective when applied against hoppers up to the 4^{th} instar, but later instars could be affected. Fecundity and fertility may be influenced by treatment of adults and hatching of eggs be reduced. A reduction in the initial locust population in areas treated with a benzoylurea during the previous year was confirmed in Central Asia. Moreover, dose rates could be reduced considerably for a range of species, including the Migratory Locust, suggesting that lower doses could also be effective against the Desert Locust.

27. Benzoylureas should be used primarily as barrier treatments. However, blanket treatments at a lower dose could also be effective.

Phenyl pyrazoles

28. The effectiveness of fipronil by contact and stomach action was confirmed in large-scale applications against the Australian Plague Locust using barrier treatments. Dosages of 0.6 g a.i. per protected hectare with swaths up to 500 m apart were used. Movements of Desert Locust hopper bands could allow wider track spacing (700 m). The width of the untreated area would also depend on whether the insects were able to degrade the insecticide. Good efficacy at high temperatures could also be due to toxic metabolites. The toxic effect was not so immediate as with certain other insecticides, but affected locusts ceased feeding rapidly.

29. The persistence of fipronil was comparable to that of benzoylureas. However, due to its broad-spectrum activity and the high risk of long term effects in soil insects such as termites, fipronil should only be applied as a barrier treatment. Spray drift on to the inter-barrier area must be minimised to reduce environmental impact (see §§ 48 & 62).

Biological insecticides

30. Limited new data on the efficacy and environmental impact of the biopesticide *Metarhizium anisopliae* var. *acridum* isolate 330189 was provided. Large-scale field trials indicated no adverse effects on non-target organisms. Based on the current ecotoxicological profile, the use of *Metarhizium* in ecologically and otherwise sensitive areas should be encouraged. Nonetheless, further research on possible side-effects on non-target grasshoppers was strongly recommended.

31. Concern was expressed about reduced speed of kill with *Metarhizium* when hot days were followed by cold nights, thus in using the mycoinsecticide attention should be given to meteorological conditions and further research into the optimal conditions for application was recommended. Problems reported with this insecticide in trials in West Africa were due to problems of formulation and they have been reported to be overcome.

32. The PRG noted that one manufacturer was now able to supply *Metarhizium* in Africa and that it was being used operationally in Australia in ecologically sensitive areas such as pastures for organic beef production. The price of the product could be reduced if the size of production was increased. A shelf life of 4 years was reported for dry spores held at low temperature. These spores could then be formulated just prior to use and special equipment for pumping the formulation is available.

33. Since the use of *Metarhizium* presently seems to be limited to Australia and East and Southern Africa, FAO should attempt to facilitate the availability and use of this mycoinsecticide in other regions affected by the Desert Locust.

OTHER INSECTICIDES

34. Insecticides other than those listed in Table 1 had been used against locusts and grasshoppers but insufficient data were available to determine reliable effective dose rates for the Desert Locust. FAO should continue to encourage plant protection organisations, manufacturers, and any other institutions to submit Desert Locust data on new or existing products for review. This should include data from laboratory studies and field trials. In particular data from operational use of insecticides should be provided to FAO. In addition to efficacy data, it was important to include as much information as possible on environmental impact studies.

Neonicotinyl insecticides

35. No new data were provided for imidacloprid, so it was not included in Table 1. This insecticide had a different mode of action (blockage of postsynaptic nicotinergic acetylcholine receptors) than previously listed insecticides and was fast-acting. Another nicotinyl insecticide, thiamethoxam, was reported, and a mixture with the pyrethroid lambda-cyhalothrin had been proposed, but until trails against the Desert Locust were carried out a verified dose rate could not be recommended.

Pheromones

36. It was reported that ICIPE had continued work on pheromones of the Desert Locust (specifically phenyl acetonitrile) and that there might be a possibility of combining the pheromone with an insecticide ("attract and kill"), but so far no data had been forwarded to the PRG.

Possible new insecticides

37. Manufacturers reported that there was a potential to introduce certain new insecticides if FAO felt that further development and field trials were justified. It concerned in particular one product, spinosad, with a uniquely different mode of action. This product had a good ecotoxicological profile and would make a good substitute for some existing insecticides.

POSSIBLE USE PATTERNS

38. Locust control operations had to be carried out in a wide range of situations, varying from desert zones, ecologically sensitive areas to intensive farmland. In addition, 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) would depend on the particular circumstances and dominant features of the ecosystem. In some situations where rapid kill was not essential, lower dosages of some listed insecticides might be effective.

39. In agricultural areas with crops at risk, priority would be given to insecticides with a more rapid action, particularly pyrethroids.

40. One comment from the Desert Locust Control Committee in response to an earlier PRG report was concern about residues in meat and milk when animals grazing in treated grasslands. It was felt that Industry should recommend withholding periods for the UL formulations at Desert Locust control rates. However, there was no evidence at the moment that locust control lead to unacceptable residues in milk or meat.

WHO HAZARD CLASSIFICATION

41. Table 2 provides the WHO hazard classification of the insecticides listed in Table 1. It was stressed that the final classification of any insecticide is intended to be by formulation. Therefore, the WHO hazard class was presented of the UL formulation with the highest concentration of active ingredient likely to be used for Desert Locust control. This hazard class had been calculated based on the WHO reported LD50 value of the active ingredients. Note that LD50 values of the actual commercial formulation could be slightly different from the ones used below, due to the effect of solvents and formulation products on toxicity.

42. The WHO hazard class could be used as an indicator to decide on the type of spray operator that could be allowed to handle the insecticide, with better trained, equipped and supervised operators generally being able to use more hazardous formulations. The FAO Guide-

line on *Safety and Environmental Precautions* (FAO, 2003) provided further guidance on this aspect, which could be used in the absence of appropriate operator exposure risk assessments done by national registration authorities.

Table 2. Hazard classification of the insecticide formulations listed by the Pesticide Referee Group as having verified dose rates against the Desert Locust (as listed in Table 1)

Insecticide	Active ingredient	Formulation	
	WHO class ‡	Highest likely concentration [g a.i./L]	WHO class †
Bendiocarb	II	200	II
Chlorpyrifos	II	450	II
Deltamethrin	II	25	U
Diflubenzuron	U	60	U
Fenitrothion	II	1000	II
Fipronil	II	7.5	U
Lambda-cyhalothrin	II	40	II
Malathion	III	960	III
Teflubenzuron	U	50	U
Triflumuron	U	50	U
Metarhizium anisopliae (IMI 330189)	– ϕ	100	[III] §

‡ according to WHO (2001): II = moderately hazardous, III = slightly hazardous, U = unlikely to present acute hazard in normal use; † extrapolated from the WHO active ingredient LD_{50}; ϕ mycopesticides are not included in the WHO classification; § based on Lubilosa toxicity data of the 189MSU formulation.

ENVIRONMENTAL EVALUATION

43. The Group emphasised the importance of the Agenda 21 (Declaration on Environment and Development) as a general framework for environmental evaluation (UNCED, 1992). The Agenda advocated the use of target-specific and readily degradable pesticides as well as the use of biocontrol agents as alternatives to chemical pesticides to reduce environmental risks. It also called for appropriate environmental impact assessment procedures for projects likely to have significant impacts upon biological diversity and stressed the need of national capacities in toxicity testing, exposure analysis and risk assessment. Furthermore, in ratifying the Convention on Biological Diversity (UNEP, 1992), locust-affected countries had committed themselves to incorporating these principles in their national environmental policies.

44. Data on environmental hazard provided by the manufacturer must be valid for the area of application. Data on ecological key taxa (see Table 3) in locust areas were important for a proper risk assessment. The quality standards for the studies needed to be the same as for efficacy tests.

45. With respect to the risk of single pesticide treatments to non-target organisms, three main groups were distinguished, *viz.* aquatic organisms, terrestrial vertebrates including wildlife, and terrestrial non-target arthropods. The aquatic fauna considered here were divided into fish and arthropods (crustaceans and insects). Terrestrial vertebrates included mammals, birds and reptiles, and terrestrial arthropods covered bees, natural enemies (antagonists) of locusts and other pests as well as ecologically important soil insects (e.g., ants and termites). The Group considered the classified non-target organisms as reasonably representative of the fauna exposed to pesticides in locust habitats. In some cases, however, other non-target taxa such as amphibians or butterflies might be of concern and required a specific risk assessment, as did multiple treatments within the same area and season.

46. The risk of each compound to the different groups of non-target organisms was presented in Table 3, using three classes: low, medium and high risk. The assessment was based mainly on field data. If relevant field data were not available, assessments were based on exposure/toxicity ratios. Low risk meant that no serious effects were to be expected. Medium risk meant that effects of short duration were expected on a limited number of taxa. High risk meant that effects of short duration were expected on many taxa, or that effects of long duration were expected on a limited number of groups. Results obtained from situations most representative of the expected field conditions were given more weight than other studies. Field studies (indicated with index [3] in Table 3) were more relevant than laboratory or semi-field studies (index [1] and [2] in Table 3). The classifications were brought in line as much as possible with accepted international classifications. Results obtained with indigenous species from locust areas in the field or in the laboratory were considered to be more relevant than results obtained with species from elsewhere. Considerable progress had been made in this respect, in particular with regard to terrestrial and aquatic non-target arthropods.

47. The PRG revised its previous risk classification on the basis of new field data. In most cases, this lead to a shift from laboratory to field evidence (index 1 to index 3). For some insecticides, risk classifications had been done for groups that had not been studied previously (reptiles). The changes were explained in the following paragraphs.

48. New field evidence from locust areas lead to a different risk classification for fipronil. Fipronil as a barrier spray was now considered to pose a medium risk to aquatic arthropods, due to its high toxicity to shrimp and other decapod crustaceans. A medium risk was also assumed for insectivorous mammals and reptiles. However, this was not related to direct toxic effects but to the indirect effect of food shortages. Fipronil for blanket treatment was not listed in Table 3 because its use as blanket spray against the Desert Locust was no longer recommended by the PRG. New field data were provided for triflumuron, confirming the previous risk assessment based on laboratory and small-scale field data.

49. A risk assessment based on new environmental impact field data for deltamethrin sprayed at 15 g a.i./ha lead to the same risk classification as the assessment based on 12.5 g a.i./ha, the dose previously considered efficacious for Desert Locust control. However, further environmental impact studies were recommended when applying a field dose of 17.5 g a.i./ha.

Table 3. Risk to non-target organisms at verified dose rates against the Desert Locust (Table 1). Risk is classified as low (L), medium (M) or high (H). See Table 4 for the classification criteria.

	Environmental risk							
	Aquatic organisms		Terrestrial vertebrates			Terrestrial non-target arthropods		
Insecticide	fish	arthropods	mammals	birds	reptiles	Bees	antagonists	soil insects
Bendiocarb	M[2]	L[3]	M[1]	L[3]	–	H[1]	H[3]	M[3]
Chlorpyrifos	M[3]	H[2]	L[3]	M[3]	M[3]	H[1]	H[3]	–
Deltamethrin	L[3]	H[3]	L[3]	L[3]	L[3]	M[1]	M[3]	M[3]
Diflubenzuron (blanket)	L[3]	H[3]	L[1]	L[1]	–	L[1 ϕ]	M[2]	M[3]
Diflubenzuron (barrier) *	L	(H)	L	L	–	L[ϕ]	L[3]	(M)
Fenitrothion	L[3]	M[3]	L[3]	M[3]	M[3]	H[1]	H[3]	H[3]
Fipronil (barrier) *	L	M[3]	M[3]	L[3]	M[3]	(H)	H[3]	H[3]
Lambda-cyhalothrin	L[2]	H[2]	L[1]	L[1]	–	M[1]	M[3]	H[3]
Malathion	L[2]	M[2]	L[3]	L[3]	–	H[3]	H[3]	H[3]
Metarhizium anisopliae (IMI 330189)	L[2]	L[2]	L[1]	L[1]	L[2]	L[3]	L[3]	L[3]
Teflubenzuron (blanket)	L[1]	H[2]	L[1]	L[1]	–	L[1 ‡]	M[1]	–
Triflumuron (blanket)	L[1]	H[2]	L[1]	L[1]	L[3]	L[1 ‡]	L[3]	L[3]
Triflumuron (barrier) *	L	(H)	L[3]	L[3]	L[3]	L[1 ‡]	L[3]	L[3]

The index next to the classification describes the level of availability of data: [1] classification based on laboratory and registration data with species which do not occur in locust areas; [2] classification based on laboratory data or small scale field trials with indigenous species from locust areas; [3] classification based on medium to large scale field trials and operational data from locust areas (mainly Desert Locust, but also Migratory and Brown Locust).

* If no field data are available, the risk of barrier treatments is extrapolated from blanket treatments. However, it is expected to be considerably lower if at least 50% of the area remains uncontaminated for a period long enough to allow recovery of affected fauna, and if barriers are not sprayed over surface water. Risk classes are therefore shown in brackets unless the blanket treatment was already considered to pose low risk, and no reference is made to the level of data availability. More field data are needed to confirm that products posing a medium or high risk as blanket sprays can be downgraded to "L" when applied as barrier sprays; [ϕ] At normal use, diflubenzuron is not harmful to the brood of honey bee. [‡] Benzoylureas are safe to adult worker bees but some may cause damage to the brood of exposed colonies; (–) insufficient data.

50. The risk classification of chlorpyrifos sprayed at the slightly higher dose of 240 g a.i./ha was similar to the one for the previous dose (225 g a.i./ha).

51. The risk classifications applied by the PRG were brought in line as much as possible with accepted international classifications. The criteria for the risk assessment were given in Table 4. Widely used classification schemes such as those agreed on by the European and Mediterranean Plant Protection Organization (EPPO) or the International Organization of Biological and Integrated Control (IOBC) were used as much as possible. Specific interpretations or modifications of certain of these schemes were discussed in the paragraphs below. Any assessments specifically designed and validated for locust areas were given priority.

52. With respect to the risk to terrestrial vertebrates, the classifications based on laboratory data (with index [1]) were considered as resulting from 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 3.

53. For classification of risks to honey bees, the widely accepted "hazard ratio" was used, which was defined as the recommended dose rate (g a.i. per ha) divided by the LD50 (µg a.i. per bee). Low risk to bees corresponded to a hazard ratio <50; medium risk to a hazard ratio between 50 and 500; high risk to a hazard ratio of >500. It was acknowledged that this classification deviated from the one used by EPPO, that did not define a medium risk class. The EPPO threshold for low risk included a safety factor of 10. This safety margin area was defined by the PRG as a medium risk. The risk discussed here referred to risk to adult worker bees only. However, risk to brood might be caused by benzoylurea IGRs when transported by the worker bees into the hives and fed to the brood.

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

55. In the majority of non-target arthropods, the risk of barrier treatments was lower than of blanket sprays because affected populations might recover through recolonisation from untreated inter-barrier areas. Therefore, from an ecotoxicological point of view, barrier treatments were preferred over blanket treatments. This implied that at least half of the inter-barrier areas should be completely uncontaminated during a control campaign if they are to function as true refugia (see § 62 for details).

56. Information summarised in Table 3 did not cover all relevant environmental effects. Long-term effects and the risk of residues in livestock in treated areas were not taken into account. However, since most spraying was done on rangeland and pastures, a risk to livestock might exist. The PRG recommended that industry should provide data on withholding periods for pastures and pre-harvest periods for crops, in particular cereals, for inclusion in the PRG review (see § 74).

57. The risk of bio-accumulation was considered to be low since all chemical pesticides listed were registered in OECD countries and had been classified by registration authorities as not posing a high risk of bio-accumulation. Therefore, the group did not specifically address this question.

Table 4. Criteria applied for the environmental risk classification used in Table 3. 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 arthropods	risk ratio (PEC/LC_{50})	<1	1-10	>10	FAO/Locustox
Reptiles, birds, mammals	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[7]
Other terrestrial arthropods	acute toxicity (%) at recommended dose rate	<50%	50-99%	>99%	IOBC[8]

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 arthropods	population reduction	<50%	50-90%	>90%	PRG
Reptiles, birds, mammals	evidence of mortality	none	incidental	massive	PRG
Bees	evidence of mortality	not significant	incidental	massive	EPPO
Other terrestrial arthropods	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 (Everts et al., 1997, 1998); [5] EPPO: European and Mediterranean Plant Protection Organization (EPPO, 2003a); [6] PRG: Pesticide Referee Group; [7] EPPO (2003b); [8] International Organization for Biological and Integrated Control of Noxious Animals and Plants (Hassan, 1994). Note: As a result of a greater error associated with population estimates of terrestrial arthropods, the lower limits of the different risk classes are lower than for aquatic arthropods.

58. New data had been presented on the efficacy of insecticide mixtures. However, the PRG considered the database on side-effects as insufficient for a full environmental assessment. This had to be considerably improved if mixtures were to play a role in future locust control.

59. The Group was concerned that among the many reports received from Central Asia there were none on the environmental impact. Thus the particular situation in this region could not be taken into consideration. New information from the Desert Locust area was also scarce and the Group reiterated the need to collect more environmental impact field data.

60. In 2003, FAO published the 6th Desert Locust Guideline *Safety and Environmental Precautions*. The guideline addressed major environmental and human health risks related to locust control and gave guidance on safety procedures and operational monitoring techniques that might contribute to reducing these risks. The PRG considers the new guideline as an important step towards improving human and environmental health standards in locust as well as grasshopper control. The Group recommended that monitoring programmes be launched to assure that the new Guidelines would be implemented during the current Desert Locust control campaign. The Group stressed that compliance with and use of the 4th and 5th Desert Locust Guidelines on Control and Campaign organization and execution were equally important in reducing environmental and human health risks.

61. The PRG acknowledged concerns of CropLife with respect to the current risk assessment as based on either theoretical risk assessment or field evidence. Information to base the assessment entirely on field evidence was as yet incomplete. Therefore, the PRG welcomed all new information that might complete the field-based classification.

62. FAO had funded a review on the environmental effects of barrier treatments of two IGRs and fipronil (Appendix III, report 2004-G). The results of this review, which covered 25 separate environmental monitoring studies from different locust areas, were evaluated by the PRG. The study confirmed that barrier treatments were an environmentally benign technique, and the PRG considered that it should be adopted where possible. The PRG stipulated that inter-barrier spaces needed to be sufficiently wide to include an untreated area of at least 50% of the treatment area. It also concluded that environmental side-effects were generally lower with IGRs than with fipronil, and that precautions must be taken in case of persistent effects and if the same area was treated repeatedly. This was particularly important when using a barrier spacing of 700 m which was lower than previously recommended. Replicate treatments might lead to an accumulation of adverse effects and put the environmental premium of the barrier technique at stake. To manage this risk, the coordinates of all spray blocs should be recorded, and spatio-temporal spray histories of locust-infested areas be derived. These histories should be consulted to avoid replicate treatments in areas where adverse effects were known to persist for a longer period of time. Another important outcome of the review was that the design and data analysis of barrier studies needed to be improved, and that some of the available data were not analysed optimally. The PRG recommended to re-analyse these data in order to complete the data base. The PRG further recommended that the conditions for barrier treatments be clearly defined and respected in operational control, and that the barrier technique should not be confounded with irregular blanket treatment, a technique also known as RAAT (reduced area-agent treatment *sensu* Lockwood & Schell, 1997). Many of the so-called barrier treatments in Central Asia used a treated/untreated surface ratio of 1:1 and were therefore considered as irregular blanket treatments (see § 20).

63. The PRG was concerned that the current Desert Locust control campaign relied nearly exclusively on OPs which were considered among the more dangerous products according the environmental and human health risk assessment (c.f., Tables 2 & 3). The Group recommended to widen the scope of pesticides used in order to assure that less hazardous insecticides be included in the Desert Locust control programme.

OTHER SPECIES

64. Apart from data relevant to Central Asia, little information was provided on other locust species. Further analysis of the *Field Trials Database* should be undertaken, in particular with respect to other locust species.

65. FAO had been involved in the control of locusts in Central Asia and in Madagascar. Although dosages recommended for Desert Locust given in Table 1 might provide similar control of other locust species, reviews of trials in these regions had been made so that as much information as possible could be tabulated in a similar format. Table 5 provides a summary of the recommendations for *Calliptamus italicus, Dociostaurus maroccanus*, *Locusta migratoria capito* and *Locusta migratoria migratoria*. This information was primarily limited to those reports which were submitted to FAO during 1999 and 2004, but also included reference to relevant earlier reports. There were still insufficient data to include the Red Locust *Nomadacris septemfasciata*.

66. The efficacy of the benzoylurea teflubenzuron against *Locusta migratoria capito* at 50 g a.i./ha and 1 L/ha (within barriers) applied in barriers 50 m wide spaced 1000 m apart or 20 m wide and 200 m apart had been previously reported.

Table 5 List of insecticides for which dosages can be suggested for the control of species other than the Desert Locust

Insecticide	Species	Dose (g a.i./ha)	treatment	Comments
Chlorpyrifos	LMC	240	blanket	
Chlorpyrifos + cypermethrin	LMC	120 + 14	blanket	
Profenofos + cypermethrin	LMC	200 + 20	blanket	
Deltamethrin	LMC	15	blanket	
α-Cypermethrin	LMM, CIT, DMA	15	blanket	
Thiamethoxam + λ-cyhalothrin	LMM, CIT, DMA	14.1 + 10.6	blanket	
Fipronil	LMC	7.5	within barrier	barrier spacing 700-1000 m
Triflumuron	LMC	50	within barrier	barrier spacing 500-700 m
Diflubenzuron †	CIT, DMA	12	blanket	
	CIT, DMA	24	within barrier	ratio treated/untreated 1:1
	LMC	60	within barrier ‡	
Teflubenzuron	LMC	50	within barrier	barrier spacing 500-700 m
	LMM, CIT, DMA	9	blanket	
	LMM, CIT, DMA	18	within barrier ‡	ratio treated/untreated 1:1
α-Cypermethrin + teflubenzuron	LMM, CIT, DMA	2.4 + 7.2	blanket	
	LMM, CIT, DMA	4.8 + 14.4	within barrier ‡	ratio treated/untreated 1:1

† verified dose rates are for OF formulations, higher dose rates may be needed when using SC formulations (see Appendix IV); ‡ tests done with irregular blanket spraying (no true barriers); CIT = *Calliptamus italicus*, DMA = *Dociostaurus maroccanus*, LMC = *Locusta migratoria capito*; LMM = *Locusta migratoria migratoria*

INSECTICIDE SELECTION

67. The flow chart was repeated in the report to provide a guide for decision makers when selecting insecticides (Figure 1).

68. In the current upsurge, most of the insecticides supplied had been organophosphates, which had been available in sufficient quantities at short notice. Unfortunately, there had been reluctance to purchase pyrethroids after observations that many locusts seemed to recover after initial knockdown. However, the recommended pyrethroid insecticides had been successfully applied at the recommended dosages elsewhere in Africa. As described earlier (§ 9), a higher dose of deltamethrin may be applied to overcome any risk of recovery, although where possible the lower dosage is preferred in relation to environmental considerations.

69. Where stocks of UL formulations were likely to exceed the recommended shelf life, they should where possible be reformulated for use, if appropriate, against other pests.

70. One concern related to the application of an insecticide to settled swarms. As a rapid effect was required over a short period, there was no need for a persistent insecticide under these circumstances. An exception to this could occur when copulating swarms – especially the Malagasy Migratory Locust – stayed in a particular area for a longer period of time and gave rise to overlapping generations. However, the benefits of using persistent insecticides always had to be weighed against the increased environmental risk to non-target fauna.

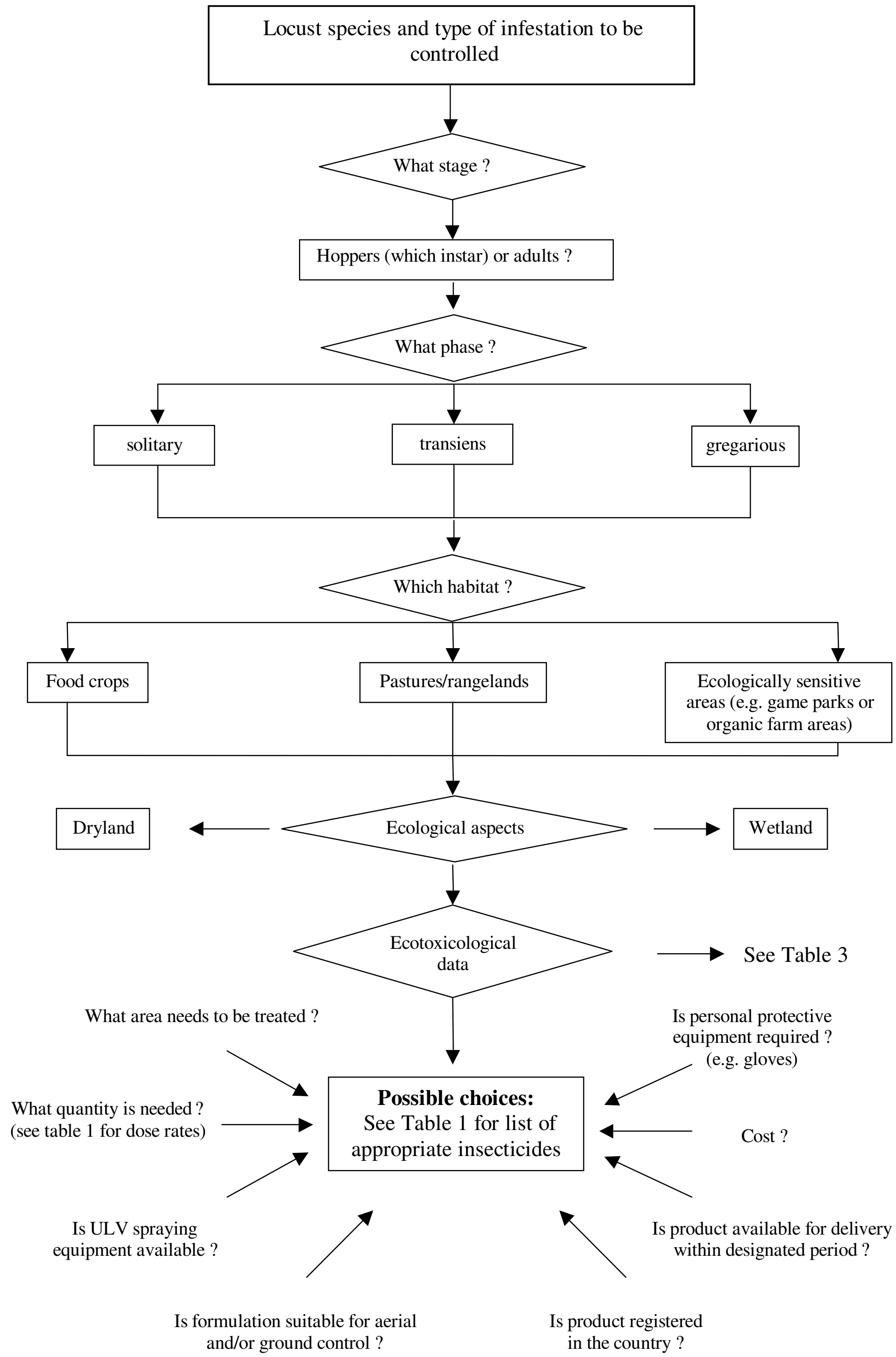

Figure 1. Factors that should be considered by decision makers when selecting insecticides for locust control.

EVALUATION AND MONITORING

71. The PRG was particularly concerned about the feedback on the operational use of insecticides against the Desert Locust. Reports of area treated need to be combined with information on which insecticides were used, dosage applied and equipment used, with a comment on effectiveness. Any reports that were received referred generally to problems which in some cases were the result of using insecticide products that did not meet the FAO/WHO specifications. Similarly, causes of corrosion to aircraft were considered to be due to the use of a formulation that did not meet the FAO/WHO specifications.

72. 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 was considered to be especially important where several sprays might be applied to the same area. The position of treated areas could be demarcated by using global positioning systems (GPS) and the information should be stored in a geographical information system. This would be particularly relevant to application of persistent pesticides, such as benzoylurea insecticides in areas with temporary aquatic ecosystems, to monitor any long term effects.

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

IMPLEMENTATION OF PREVIOUS RECOMMENDATIONS

74. Since the 8th meeting of the PRG held in 1999, the following progress has been made:

- FAO had continued to support ecotoxicological studies relevant to the locust situation, at a limited scale, in particular to quantify further the environmental advantages of barrier treatment. Further studies were planned to be carried out in 2005. A literature review on the environmental impact of barrier treatments had been presented at the 9th meeting.

- FAO was collecting data on the present campaign with respect to the area treated, the type and amount of insecticide used and the efficacy achieved.

- FAO encouraged submission of pesticides efficacy and environmental data on other species that Desert Locust. Data on six other species had been received.

- FAO had further made known the work of the Pesticides Referee Group, through among others the widely distributed Desert Locust Control Guidelines, and the Internet Site of the Locust Group.

RECOMMENDATIONS

75. The PRG agreed on the following recommendations:

⇒ PRG recommended that the operational *Desert Locust Control Guidelines* should be fully implemented.

⇒ FAO should adopt barrier treatment as the preferred technique for Desert Locust hopper control.

⇒ FAO should use the full list of recommended insecticides in order to make the best choice for purchases, taking into account not only efficacy but also human health and environmental risks.

⇒ The PRG emphasized that the volumes of spray in the report were recommendations and need to be adjusted in relation to the formulations available and the field conditions (vegetation density, infestation density, etc.)

⇒ The PRG highly commended the production of the Field Trials Database and requested FAO to assure regular updating. It further recommended that it should be made available to registration authorities, provided that the confidentiality of the data were endorsed by users.

⇒ PRG encouraged industry to register appropriate formulations of the listed insecticides in locust-affected countries. In countries without registration, FAO should only purchase pesticides recommended by PRG and registered in at least one OECD country.

⇒ FAO should urge Industry to follow the FAO Guidelines for pesticide trials for locust control (http://www.fao.org/NEWS/GLOBAL/LOCUSTS/Pubs1.htm#Trials). The PRG recommended that the guidelines for trials of barrier treatments be updated.

⇒ Industry was urged to test new insecticides and mixtures while populations of Desert Locust were present.

⇒ Industry was requested to provide recommendations on withholding periods of livestock and pre-harvest intervals for relevant crops, after treatments against locusts.

⇒ Industry was also requested to provide data on the fate and behaviour of insecticides used in or tested for locust control, specifically under tropical conditions.

⇒ Industry should provide draft specifications of UL formulations, including data on volatility and viscosity, in addition to standard data requirements, to the FAO/WHO Joint Meeting on Pesticide Specifications (JMPS).

⇒ FAO should continue to support ecotoxicological studies relevant to the locust situation.

⇒ 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 to build up a centralised database.

⇒ FAO should convene the PRG as required in relation to the number of reports submitted by Industry and information received from locust affected countries concerning the efficacy of control operations.

⇒ The PRG recommended FAO to translate this report into at least Arabic and French.

⇒ Important contributions had come from representatives of locust affected countries, so it was suggested that FAO considered the possibility of convening one of the Group's meetings in one of these countries. This would enable the Group to discuss the latest reports with more persons directly involved in the practical aspects of locust control. Such discussions would undoubtedly benefit the host country.

REFERENCES

EPPO/Council of Europe (2003a) Environmental risk assessment scheme of plant protection products – Chapter 10: Honeybees. OEPP/EPPO Bulletin 33, 141–145.

EPPO/Council of Europe (2003b) Environmental risk assessment scheme of plant protection products – Chapter 11: Terrestrial vertebrates. OEPP/EPPO Bulletin 33, 211-238.

Everts, J. W., Mbaye, D., Barry, O. (Eds.) (1997) Environmental side-effects of locust and grasshopper control. Vol 1. FAO: GCP/SEN/053/NET. Rome, Dakar

Everts, J. W., Mbaye, D., Barry, O., Mullié, W. (Eds.) (1998) Environmental side-effects of locust and grasshopper control. Vols 2 & 3. FAO: GCP/SEN/053/NET. Rome, Dakar

FAO (2003) Safety and environmental precautions. The Desert Locust guidelines – Volume 6. Food and Agriculture Organization of the United Nations, Rome.

Lockwood, J.A., Schell, S.P. (1997) Decreasing economic and environmental costs through reduced area and agent insecticide treatments (RAATs) for the control of rangeland grasshoppers: empirical results and their implications for pest management. J. Orthoptera Res. 6, 19–32.

Hassan, S. A. (1994) Activities of the IOBC/WPRS working group "Pesticides and Beneficial Organisms". IOBC/WPRS Bulletin 17 (10), 1–5.

UNCED (1992) United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992. Section II. Conservation and management of resources for development. United Nations, New York

UNEP (1992) Convention on Biological Diversity. United Nations Environment Programme. Nairobi, Kenya.

WHO (2001) The WHO recommended classification of pesticides by hazard and Guidelines to classification 2000-2002. Document WHO/PCS/01.5. International Programme on Chemical Safety, World Health Organization, Geneva.

APPENDIX I

PARTICIPANTS IN THE MEETING OF THE PESTICIDE REFEREE GROUP

18-21 October 2004

MEMBERS OF THE PESTICIDE REFEREE GROUP

G. A. Matthews
Chairman

Emeritus Professor of Pest Management,
IPARC
Imperial College London
Silwood Park
Buckhurst Road
Ascot
SL5 7PY
United Kingdom
Fax: ++ 44 (0) 20 594 2450
E-mail: g.matthews@imperial.ac.uk

C. Coste

Chimie Environnementale - Pesticides
Université de Perpignan
Centre de Phytopharmacie UMR 461
52 Avenue Paul Alduy
66 860 Perpignan Cedex
France
Tel/Fax : ++33 4 68 870687
E-mail: c-m.coste@wanadoo.fr

M. J. Hajjar

Director of Plant Protection Directorate / Toxicologist –
Pesticide Science
Associate Professor
Faculty of Agriculture
Damascus University
Damascus
Syria
Tel: ++ 22 20 187
Fax: ++ 22 47 913
E-mail: hajjar-j@scs-net.org

P. A. Oomen

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

APPENDIX I

R. Peveling
Secretary

Tropical Ecologist
University of Basel
Institute of Environmental Sciences (NLU) – Biogeography
St-Johanns-Vorstadt 10
4056 Basel
Switzerland
Tel: ++41-61-267-0800 (Secretariat)
Fax: ++41-61-267-0801
E- mail: ralf.peveling@unibas.ch

INVITED OBSERVER

H. van der Valk

Environmental Toxicologist
Dorpsstraat 23
5261 CJ Vught
The Netherlands
Tel/Fax: ++31 73 657 8680
E-mail: harold.vandervalk@wxs.nl

INVITED REPRESENTATIVES FROM INDUSTRY

S. Bothe **A. Brejc** **H. Elamri** **J.-P. Vialaneix**	BASF, Germany
P. Day **M. Rampaud**	Bayer Environmental Science, Germany
D. Neethling	BCP, South Africa
N. Locher **E. Puri**	Syngenta Crop Protection, Switzerland
L. Avella **A. de Jong** **O. Raucci**	Crompton – Uniroyal Chemical (Europe), The Netherlands
D. Kelili	Dow AgroSciences, France

APPENDIX I

F.A.O.

N. Van der Graaff Chief
Plant Protection Service (AGPP)
Plant Production and Protection Division (AGP)
Rome
Italy
E-mail: Niek.VanDerGraaff@fao.org

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

J. W. Everts Environment Officer
Locusts and Other Migratory Pests Group ct
E-mail: James.Everts@fao.org

M. Ammati Environment Consultant
Locusts and Other Migratory Pests Group
E-mail: Mohamed.Ammati@fao.org

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

APPENDIX II

Conversion table for different formulations of insecticides with verified dose rates for the Desert Locust

Insecticide	Dose (g a.i./ha)	Common formulation (g a.i./L) ‡	L / ha of formulation
Bendiocarb	100.0	200	0.50
Chlorpyrifos	240.0	450	0.50
"	"	240	1.00
Deltamethrin	12.5	25	0.50
"	17.5	17.5	1.00
Diflubenzuron	30.0	60	0.50
Fenitrothion	400.0	1000	0.40
"	"	500	0.80
"	"	200	2.00
Fipronil (overall dose) †	0.6	7.5	0.56
"	"	12.5	0.33
Lambda-cyhalothrin	20.0	40	0.50
Malathion	925.0	960	1.00
Metarhizium anisopliae (IMI 330189)	50.0	–	–
Teflubenzuron	30.0	50	0.60
Triflumuron	25.0	50	0.50

† In the present upsurge, the current recommendation for Desert Locust would be 0.6 g a.i. per protected ha applied as a single swath at 700 m track. Such treatments will need to be carefully supervised and an environmental assessment be made. Trials for Desert Locust at a wider track spacing should continue.

‡ These are examples of the most common formulation concentrations; other formulations may be marketed by the pesticide industry.

Appendix III

2004 Pesticide Referee Group Meeting – submitted efficacy and environmental impact reports

Report	Comp./Org.	Code	Author	Year	Title / Remarks
A. Efficacy data					
2004-1	BASF	1	Tuelenberginov Z	2001	Report of the Phytosanitation (RSE) Republican State Enterprise Branch Office in the Southern Kazakhstan Oblast (SKO) on field tests of the preparations for Moroccan locust larvae such as Fastac 10% OESC, Nomolt 15% SC, Nomolt 5% ULV and Bonus 40/120 of the BASF Company as carried out at the pastures in the Saryagashsky Region of the Southern Kazakhstan Oblast. Shymkent, Kazakhstan.
2004-2	BASF	2	Anonymous	2001	Report of the Phytosanitation (RSE) Republican State Enterprise Branch "Test & Information Centre" on field tests of the preparations for Italian locust such as Fastac 10% OESC, Nomolt 15% SC, Nomolt 5% ULV and Bonus 40/120 of the BASF Company as carried out at the natural vegetation in the Maisky Region of the Pavlodarskaya Oblast. Astana - Pavlodar, Kazakhstan.
2004-3	BASF	3	Migmanov AM, Mamyshev A, Ilaubekov S	2001	Report of the Phytosanitation (RSE) Republican State Enterprise Almaty Branch on field tests of the preparations for Asian locust such as Fastac 10% OESC, Nomolt 15% SC, Nomolt 5% ULV and Bonus 40/120 of the BASF Company as carried out at the natural vegetation (common reed) in the Balkhashsky Region of the Almaty Oblast. Almaty, Kazakhstan.
(1988-36)	BASF	5			Resubmission of report 88-36
2004-4	BASF	6	Chambers BQ, de Klerk JC	1997	Evaluation of alpha-cypermethrin for the control of the Brown locusts in the Karoo, South Africa. Agricultural Research Council - Plant Protection Research Institute, Pretoria.
2004-5	BASF	7	Latigo AAR	1986	Spray trials in Botswana using alpha-cypermethrin against brown locust. FAO/TCP/BOT/6651.
2004-6	BASF	8	Kriel CF, Butler ET	1992	Determination of the LD50 and LD90 values for alphamethrin in the laboratory against fifth instar brown locust hoppers, Locustana pardalina (Walker). Agricultural Research Council - Plant Protection Research Institute, Pretoria.
2004-7/A	BASF	10	Mouhim A, Chihrane J, Said C	1997	Evaluation de la toxicité et de la rémanence du Nomolt ® 50 ULV (Teflubenzuron) contre les larves du criquet marocain et sauteriaux au maroc. Centre National de Lutte Antiacridienne, Inezgane, Maroc. (Note: This study includes an environmental impact substudy 2004-A)
2004-8	Syngenta		Anonymous	2003	Report written in Russian
2004-9	Syngenta		Anonymous	2003	Report written in Russian
2004-10	Syngenta		Anonymous	2003	Report written in Russian
2004-11/B	Dow		Peterson RKD	1996	Spinosad - Locust/grasshoppers - beneficials Alfalfa (Note: This study includes an environmental impact substudy 2004-B)

Appendix III

Report	Comp./Org.	Code	Author	Year	Title / Remarks
	Crompton			2000-2004	28 separate reports listed in Appendix 3 of the Dimilin dossier. The reports summarize results from field trials and large scale operational control. The results are compiled in Appendix 3. However, original efficacy data are not provided for all trials. Only those reports are included in the PRG overview table that contain original data.
2004-12	Crompton	066-067	Georgiev I	2000	Report on field biological tests of insecticides and acaricides
2004-13	Crompton	070-071	Georgiev I	2000	Report on field biological tests of insecticides and acaricides
2004-14	Crompton	068-069	Georgiev I	2000	Report on field biological tests of insecticides and acaricides
2004-15	Crompton	061-065	Childibaev M, Pchelnikova T, Amerghuzin R, Yussupova G	2000	Report on the outcome of Dimilin 48% SC insecticide (Uniroyal Chemical firm, USA) trials against adult locusts in the Akmola Oblast in 2000. Kazakhstan.
2004-16	Crompton	060-060	CUPPAC	2000	Untitled - contains summary of field trials
2004-17	Crompton	058-059	Khudanov S et al.	2000	Untitled - contains summary of field trials
2004-18	Crompton	014-018	Mamanandro T, Falimanana, Ravolasahondra MF, Rajerison F	2000	Trial report of the product Dimilin OF6 for locust control. Ministry of Agriculture, Direction of Crop Protection, Department of Phytopharmacy and Pesticides Control, Antananarivo, Madagascar.
2004-19	Crompton	001-013	Kirillova MN	2000	Report on the result of experimental spraying with insecticide Dimilin OF-6 OS (60 g/L), by Uniroyal Chemical Co., USA, on pastures. Saint-Petersburg.
2004-20	Crompton	051-057	Khudanov S	2000	Untitled - contains summary of field trials
2004-21	Crompton	091-097	Dolzhenko et al.	2001	Report on the results of biological evaluation of insecticide Dimilin OF-6 OS (60 g/L), by Crompton Europe Limited, used on pastures. Saint-Petersburg.
2004-22	Crompton	132-141	Nevenkova Z et al.	2002	Official report on a series of trials - Dimilin 480 SC - UNIROYAL CHEMICAL.
2004-23/C	Crompton	145-175	Taleb MH, Hadj A	2004	Comparison of three doses of diflubenzuron (ULV) in total cover treatment against larvae of the Desert Locust (Schistocerca gregaria: Orthoptera: Acrididae) in Mauritania. Nouakchott, Mauritania. (Note: This study includes an environmental impact substudy 2004-C)
2004-24	Crompton		Bouaïchi A, Oozane M	2004	Evaluation of the effectiveness of Dimilin OF6 ® (Diflubenzuron) used as a total cover treatment on larvae of the Desert Locust Schistocerca gregaria. Iezgane, Rabat, Morocco.
2004-25	BCP		Kooyman C, Bahana J, Katheru J, Mutahiwa S, Spurgin P	2003	Operational trial of Green Muscle ® against Red Locust adults in the Iku Plains, Tanzania. Nairobi, Dar Es Salaam.
2004-26	BCP		Bashir M O	2004	Use of the fungus *Metarhizium anisopliae* var. *acridum* in the control of locusts with reference to *Schistocerca gregaria* (Forskal) and *Locusta migratoria migratorioides* (R. & F.).

Appendix III

Report	Comp./Org.	Code	Author	Year	Title / Remarks
B. Campaign reports (summaries and assessments of control campaigns)					
2004-27	Crompton	073-074	Ahmetov K, Kitichuk L, Griaznova A	2001	Report on using of product Dimilin company Uniroyal Chemical) for Italian locust control in Kostanaiskaya oblast in 2001. Kazakhstan. - Campaign summary.
2004-28	Crompton	072-072	Turbekov. S.	2001	Report about insecticide Dimilin OF-6 using for control of hoppers of Moroccan locust in South Kazakhstan region in 2001. Saint-Petersburg.
2004-29	Crompton	088-090	Mullov VD, Ageyev AA, Alekseyeva VI	2001	Report on the results of experimental spraying with the insecticide Dimilin 25% WP for the control of locust pests in KFU "Pcholka" located in Provolhasky district of the Saratov region in 2001. Russia. - Data reporting insufficient.
2004-30	Crompton	083-087	Anisimov IV, Manokhin M, Alekseyeva VI	2001	Report on the results of experimental spraying with Dimilin 25% WP for control of harmful locust species in the Samara region in 2000. Russia. Original data and efficacy assessment method not given. - Data reporting insufficient.
2004-31	Crompton	098-105	Kuzmina TN, Strizhak VI	2001	Report on the results of the trials of UNIROYAL CHEMICAL products in the Novosibirsk region in 2001. Novosibirsk. - Data reporting insufficient.
2004-32	Crompton	142-144	Ahanov SK, Denisenko YC	2003	Report on the results of demonstration experiments of insecticide Dimilin, 48% SC for locust control in the conditions of South-East of Kazakhstan in 2003. Almaty, Kazakhstan. - Campaign Summary.
2004-33	Crompton	142-144	Khodjaev ST, Rashidov MI, Gaparov FA, Khudanov S, Khodjaev JSh, Turamuradov Kh, Jamalov A, Bobobekov K	2003	Guidelines on use of Dimilin against pests of agricultural crops. Tashkent, Uzbekistan. - Guidelines and trial summaries.
C. Review on the efficacy of barrier treatments					
2004-34	GTZ		Wilps H	2004	Study on barrier treatments as a means of controlling migratory locusts - A review. GTZ, Eschborn, Germany.
D. Environmental impact reports (reports A - C are part of efficacy reports 2004-7, 11 and 23, respectively; see above)					
2004-D	GTZ, DPV		Zehrer W (ed.)	2001	Lutte antiacridienne à Madagascar - Tome III: Ecotoxicologie. Ministère de l'Agriculture, Direction de la protection des végétaux & GTZ, Antananarivo, Madagascar.

Appendix III

Report	Comp./Org.	Code	Author	Year	Title / Remarks
2004-E			Peveling R, McWilliam AN, Nagel P, Rasolomanana H, Ra-holijaona, Rakotomianina L, Ravonin-jatovo A, Dewhurst CF, Gibson G, Rafonomezana S & Tingle CCD	2003	Impact of locust control on harvester termites and endemic vertebrate predators in Madagascar. *Journal of Applied Ecology* **40**, 729-741.
2004-F	CERES/Locustox		Everts JW, Mbaye D, Barry O & Mullié WC	2002	Environmental side effects of locust and grasshopper control. Volume 4. Centre for Ecological Research in the Sahel (CERES/Locustox) & Food and Agriculture Organization of the United Nations, Dakar, Senegal.
2004-G	FAO		Van der Valk H	2004	Environmental impact of barrier treatments against migratory locusts – a review of field studies.) Discus-sion paper for the 9th meeting of the FAO Pesticide Referee Group. Draft, July 24th, 2004. Food and Agriculture Organization of the United Nations.
2004-H	FAO			2004	Chronic neurotoxic effects of organophosphate exposure - A short review. Discussion paper for the 9th meeting of the FAO Pesticide Referee Group. Draft, July 20th, 2004. Food and Agriculture Organization of the United Nations.
2004-I			Peveling R	2001	Environmental conservation and locust control - Possible conflicts and solutions. Journal of Orthoptera Research **10**, 171–187.

Appendix IV

Summary of data from efficacy trial reports

Report	Country	a.i.	Formul.	Target & dominant stages	Treat.	Sprayer	No.	# of repl.	Size [ha]	Dosage [g a.i./ha] or vol. of formulation [L/ha]: Overall Dosage	Overall Volume	Intra-barrier Dosage	Intra-barrier Volume	Barrier / inter-barrier [m]	Effect [% @ DAT] (other units or parameters in italics): earliest > 90%	highest observed	Remarks
2004-1	Kazakhst.	α-cypermethrin	10% OC	DMA, L1-3	Blanket	not clear	1	2	5.0	7.0	0.070				99 @ 3	99 @ 3	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	α-cypermethrin	10% OC	DMA, L1-3	Blanket	not clear	2	2	5.0	10.0	0.100				99 @ 3	99 @ 7	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	teflubenzuron	15% SC	DMA, L1-3	Blanket	not clear	3	2	8.0	7.5	0.050				95 @ 7	95 @ 15	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	teflubenzuron	5% ULV	DMA, L1-3	Blanket	not clear	4	2	8.0	8.8	0.175				94 @ 7	99 @ 21	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	α-cyp/teflubenz	40/120SC	DMA, L1-3	Blanket	not clear	5	2	6.0	2.4/7.2	0.060				97 @ 7	99 @ 15	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	teflubenzuron	15% SC	DMA, L1-3	Barrier	not clear	6	2	8.0	7.5	0.050	15.0	0.100	1:1	95 @ 7	99 @ 15	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	teflubenzuron	5% ULV	DMA, L1-3	Barrier	not clear	7	2	8.0	8.8	0.175	17.5	0.350	1:1	93 @ 7	99 @ 21	No contr. plot; effic. relative to pre-spray
2004-1	Kazakhst.	α-cyp/teflubenz	40/120SC	DMA, L1-3	Barrier	not clear	8	2	6.0	2.4/7.2	0.060	4.8/14.4	0.120	1:1	96 @ 7	99 @ 21	No contr. plot; effic. relative to pre-spray
2004-2	Kazakhst.	α-cypermethrin	10% OC	CIT, L4-5	Blanket	PSO 2000	1	2	5.0	7.0	0.070				97 @ 5	97 @ 5	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	α-cypermethrin	10% OC	CIT, L4-5	Blanket	PSO 2000	2	2	5.0	10.0	0.100				91 @ 3	98 @ 5	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	teflubenzuron	15% SC	CIT, L4-5	Blanket	PSO 2000	3	2	5.0	7.5	0.050				94 @ 14	97 @ 21	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	teflubenzuron	15% SC	CIT, L4-5	Barrier	PSO 2000	4	2	12.5	7.5	0.050	15.0	0.100	1:1	93 @ 14	96 @ 21	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	teflubenzuron	5% ULV	CIT, L4-5	Blanket	PSO 2000	5	2	5.0	8.8	0.175				98 @ 21	98 @ 21	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	teflubenzuron	5% ULV	CIT, L4-5	Barrier	PSO 2000	6	2	12.5	8.8	0.175	17.5	0.350	1:1	96 @ 21	96 @ 21	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	α-cyp/teflubenz	40/120SC	CIT, L4-5	Blanket	PSO 2000	7	2	5.0	2.4/7.2	0.060				91 @ 5	98 @ 14	Efficacy: Henderson & Tilton
2004-2	Kazakhst.	α-cyp/teflubenz	40/120SC	CIT, L4-5	Barrier	PSO 2000	8	2	12.5	2.4/7.2	0.060	4.8/14.4	0.120	1:1	92 @ 14	96 @ 21	Efficacy: Henderson & Tilton
2004-3	Kazakhst.	teflubenzuron	15% SC	LMI, L1-3	Blanket	Micronair	1	2	4.5	7.5	0.050				90 @ 7	97 @ 21	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	teflubenzuron	15% SC	LMI, L1-3	Barrier	Micronair	2	2	5.0	7.5	0.050	15.0	0.100	1:1	91 @ 7	96 @ 21	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	teflubenzuron	5% ULV	LMI, L1-3	Blanket	Micronair	3	2	4.0	8.8	0.175				92 @ 7	96 @ 21	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	teflubenzuron	5% ULV	LMI, L1-3	Barrier	Micronair	4	2	2.0	8.8	0.175	17.5	0.350	1:1	91 @ 7	96 @ 21	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	α-cyp/teflubenz	40/120SC	LMI, L1-3	Blanket	Micronair	5	2	3.0	2.4/7.2	0.060				94 @ 7	98 @ 21	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	α-cyp/teflubenz	40/120SC	LMI, L1-3	Barrier	Micronair	6	2	3.0	2.4/7.2	0.060	4.8/14.4	0.120	1:1	92 @ 7	97 @ 21	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	α-cypermethrin	10% OC	LMI, L1-3	Blanket	Micronair	7	2	5.0	7.0	0.070				98 @ 3	99 @ 7	No control; efficacy: propor. dead loc./quadrat
2004-3	Kazakhst.	α-cypermethrin	10% OC	LMI, L1-3	Blanket	Micronair	8	2	7.5	10.0	0.100				99 @ 3	99 @ 3	No control; efficacy: propor. dead loc./quadrat

CAL = *Chorthippus albomarginatus*
CIT = *Calliptamus italicus*
DBR= *Dociostaurus brevicollis*
DKR = *Dociostaurus krauss*
DMA = *Dociostaurus maroccanus*
LMI = *Locusta migratoria*
LMC = *Locusta migratoria capito*
LMM = *Locusta migratoria migratoria*
NSE = *Nomadacris septemfasciata*
OSE = *Oedaleus senegalensis*
PMI = *Paracyptera microptera*
SGR = *Schistocerca gregaria*

Appendix IV

										Dosage [g a.i./ha] or vol. of formulation [L/ha]					Effect [% @ DAT] (other units or parameters in italics)		
				Target & domi-				# of	Size	Overall		Intra-barrier		Barrier / inter-	earliest	highest	
Report	Country	a.i.	Formul.	nant stages	Treat.	Sprayer	No.	repl.	[ha]	Dosage	Volume	Dosage	Volume	barrier [m]	> 90%	observed	Remarks
2004-4	RSA	α-cypermethrin	15 UL	LPA, L4-5	Blanket	Micro-Ulva	1	5	< 0.3	20.0	1.300				none	77 @ 3	Spot appl. hopper bands; cage assess. Mort.
2004-4	RSA	α-cypermethrin	15 UL	LPA, L4-5	Blanket	Micro-Ulva	2	5	< 0.3	25.0	1.700				none	81 @ 3	Spot appl. hopper bands; cage assess. Mort.
2004-4	RSA	α-cypermethrin	15 UL	LPA, L4-5	Blanket	Micro-Ulva	3	5	< 0.3	30.0	2.000				92 @ 3	92 @ 3	Spot appl. hopper bands; cage assess. Mort.
2004-4	RSA	deltamethrin	17.5 UL ?	LPA, L4-5	Blanket	Micro-Ulva	4	5	< 0.3	17.5					93 @ 3	93 @ 3	Spot appl. hopper bands; cage assess. Mort.
2004-5	Botswana	α-cypermethrin	6% ULV	LPA, L3-4	Blanket	AU 7000	1	1	2	20.0	0.300				*none*	*89 @ 3 h*	KD only; efficacy: proport. Morib. Loc./quadrat
2004-5	Botswana	α-cypermethrin	6% ULV	LPA, L3-4	Blanket	AU 7000	2	1	3	30.0	0.400				*none*	*92 @ 3 h*	KD only; efficacy: proport. Morib. Loc./quadrat
2004-6	RSA	α-cypermethrin	technical	LPA, L5	Lab.	Topical	1	3							*LD50 (3 d):*	*0.19 mic.-g/g*	Test substance
2004-6	RSA	deltamethrin	technical	LPA, L5	Lab.	Topical	1	3							*LD50 (3 d):*	*0.07 mic.-g/g*	Toxic standard
2004-7	Morocco	teflubenzuron	50 ULV	mix. grassh.	Blanket	Micro-Ulva	1	3	1	5.0	0.100				none	60 @ 15	persistent effect; efficacy: Hend. & Tilt.
2004-7	Morocco	teflubenzuron	50 ULV	mix. grassh.	Blanket	Micro-Ulva	2	3	1	20.0	0.200				none	79 @ 15	persistent effect; efficacy: Henderson & Tilton
2004-7	Morocco	teflubenzuron	50 ULV	mix. grassh.	Blanket	Micro-Ulva	3	3	1	30.0	0.300				none	77 @ 15	persistent effect; efficacy: Henderson & Tilton
2004-7	Morocco	malathion	950 ULV	mix. grassh.	Blanket	Micro-Ulva	4	3	1	547.0					92 @ 1	96 @ 4	rapid recolonisation; efficacy: Hend. & Tilt.
2000-8	Kazakhst.	thiameth/λ-cyh	247 SC	CIT, L2-4	Blanket	AU 8000	1	4	5	1.06/0.8	0.075				none	88 @ 3	in Russian; efficacy: Henderson & Tilton
2000-8	Kazakhst.	thiameth/λ-cyh	247 SC	CIT, L2-4	Blanket	AU 8000	2	4	5	1.41/1.02	0.100				none	97 @ 3	in Russian; efficacy: Henderson & Tilton
2000-8	Kazakhst.	thiameth/λ-cyh	247 SC	CIT, L2-4	Blanket	AU 8000	3	4	5	2.11/1.53	0.150				92 @ 1	98 @ 3	in Russian; efficacy: Henderson & Tilton
2000-8	Kazakhst.	deltamethrin	050 SC	CIT, L2-4	Blanket	AU 8000	4	4	5	6.25	0.125				92 @ 1	97 @ 3	in Russian; tox.stand.; effic.: Henders. & Tilton
2000-9	Kazakhst.	thiameth/λ-cyh	247 SC	DMA, L1-2	Blanket	AU 8000	1	4	5	1.06/0.8	0.075				none	76 @ 3	in Russian; efficacy: Henderson & Tilton
2000-9	Kazakhst.	thiameth/λ-cyh	247 SC	DMA, L1-2	Blanket	AU 8000	2	4	5	1.41/1.02	0.100				93 @ 3	93 @ 3	in Russian; efficacy: Henderson & Tilton
2000-9	Kazakhst.	thiameth/λ-cyh	247 SC	DMA, L1-2	Blanket	AU 8000	3	4	5	2.11/1.53	0.150				96 @ 3	96 @ 3	in Russian; efficacy: Henderson & Tilton
2000-9	Kazakhst.	deltamethrin	050 SC	DMA, L1-2	Blanket	AU 8000	4	4	5	6.25	0.125				93 @ 3	93 @ 3	in Russian; tox.stand.; effic.: Henders. & Tilton
2000-10	Kazakhst.	thiameth/λ-cyh	247 SC	LMM, L1-4	Blanket	Ulvamast V3M	1	4	5	1.06/0.8	0.075				94 @ 10	94 @ 22	in Russian; efficacy: Henderson & Tilton
2000-10	Kazakhst.	thiameth/λ-cyh	247 SC	LMM, L1-4	Blanket	Ulvamast V3M	2	4	5	1.41/1.02	0.100				99 @ 3	100 @ 10	in Russian; efficacy: Henderson & Tilton
2000-10	Kazakhst.	thiameth/λ-cyh	247 SC	LMM, L1-4	Blanket	Ulvamast V3M	3	4	5	2.11/1.53	0.150				99 @ 3	100 @ 10	in Russian; efficacy: Henderson & Tilton
2000-10	Kazakhst.	deltamethrin	050 SC	LMM, L1-4	Blanket	Ulvamast V3M	4	4	5	6.25	0.125				100 @ 3	100 @ 3	in Russian; tox.stand.; effic.: Henders. & Tilton

CAL = *Chorthippus albomarginatus*
CIT = *Calliptamus italicus*
DBR= *Dociostaurus brevicollis*
DKR = *Dociostaurus krauss*
DMA = *Dociostaurus maroccanus*
LMI = *Locusta migratoria*
LMC = *Locusta migratoria capito*
LMM = *Locusta migratoria migratoria*
NSE = *Nomadacris septemfasciata*
OSE = *Oedaleus senegalensis*
PMI = *Paracyptera microptera*
SGR = *Schistocerca gregaria*

Appendix IV

Report	Country	a.i.	Formul.	Target & dominant stages	Treat.	Sprayer	No.	# of repl.	Size [ha]	Dosage [g a.i./ha] or vol. of formulation [L/ha]: Overall Dosage	Overall Volume	Intra-barrier Dosage	Intra-barrier Volume	Barrier / inter-barrier [m]	Effect [% @ DAT] (other units or parameters in italics): earliest > 90%	highest observed	Remarks
2004-11	USA	spinosad	2 SC	mix. grassh.	Blanket	?	1	4	<0.1	50.0					92 @ 1	92 @ 1	effic. Simil to cyflu, cyflu-imid, zet-cyp, bifenthrin
2004-11	USA	spinosad	2 SC	mix. grassh.	Blanket	?	2	4	<0.1	100.0					>92 @ 1	>92 @ 1	effic. Simil to cyflu, cyflu-imid, zet-cyp, bifenthrin
2004-12	Bulgaria	dimilin	48 SC	DMA, L2-5, ad.	Blanket	Micro-ULVA	1	1	0.1	4.8	0.010				none	49 @ 10	small plots ; efficacy: Henderson & Tilton
2004-12	Bulgaria	λ-cyhalothrin	2.5 EC	DMA, L2-5, ad.	Blanket	Micro-ULVA	2	1	0.1	15.0	0.060				none	32 @ 10	small plots ; efficacy: Henderson & Tilton
2000-13	Bulgaria	dimilin	48 SC	DMA, L2-5, ad.	Blanket	Micro-ULVA	1	1	0.1	4.8	0.010				none	67 @ 10	small plots ; efficacy: Henderson & Tilton
2000-13	Bulgaria	λ-cyhalothrin	2.5 EC	DMA, L2-5, ad.	Blanket	Micro-ULVA	2	1	0.1	15.0	0.060				none	28 @ 10	small plots ; efficacy: Henderson & Tilton
2000-14	Bulgaria	dimilin	48 SC	DMA, L2-5, ad.	Blanket	Micro-ULVA	1	1	0.1	4.8	0.010				none	54 @ 10	small plots ; efficacy: Henderson & Tilton
2000-14	Bulgaria	λ-cyhalothrin	2.5 EC	DMA, L2-5, ad.	Blanket	Micro-ULVA	2	1	0.1	15.0	0.060				none	21 @ 10	small plots ; efficacy: Henderson & Tilton
2004-15	Kazakhst.	dimilin	48 SC	CIT, L5	Blanket	GRD-10	1	1	250	9.6	0.020				96 @ 10	96 @ 10	narrow plots; effic: ref. To nat. standard meth.
2004-15	Kazakhst.	dimilin	48 SC	CIT, L2-?	Blanket	Ulvamast	2	?	5	9.6	0.020				99 @ 10	99 @ 10	narrow plots; effic: ref. To nat. standard meth.
2004-15	Kazakhst.	dimilin	6 OF	CIT, L2-?	Blanket	Ulvamast	2	?	5	9.0	0.150				100 @ 10	100 @ 10	narrow plots; effic: ref. To nat. standard meth.
2004-16	Kazakhst.	dimilin	48 SC	CIT, DCR, L1-2	Blanket	OVKH-28	1	1	2	9.6	0.020				none	71 @ 18	migration of grasshoppers among plots
2004-16	Kazakhst.	dimilin	48 SC	CIT, DCR, L1-3	Blanket	OVKH-28	2	1	2	14.4	0.030				none	75 @ 18	migration of grasshoppers among plots
2004-16	Kazakhst.	dimilin	48 SC	CIT, DCR, L1-4	Blanket	OVKH-28	3	1	2	19.2	0.040				none	76 @ 18	migration of grasshoppers among plots
2004-16	Kazakhst.	dimilin	48 SC	CIT, DCR, L1-5	Blanket	OVKH-28	4	1	2	21.6	0.045				none	86 @ 25	migration of grasshoppers among plots
2004-16	Kazakhst.	fipronil	4 EC	CIT, DCR, L1-6	Blanket	OVKH-28	5	1	2	4.0	0.100				none	87 @ 3	migration of grasshoppers among plots
2004-16	Kazakhst.	zeta-cypermerm	4 EC	CIT, DCR, L1-6	Blanket	OVKH-28	5	1	2	10.0	0.100				none	71 @ 3	migration of grasshoppers among plots
2004-17	Kazakhst.	dimilin	48 SC	DMA L2-3	Blanket	OVKH-28	1	1	10	14.4	0.030				not calc.	91 @ 30	only raw data; effic.: proport. Dead loc./quadrat
2004-17	Kazakhst.	dimilin	48 SC	DMA L2-3	Blanket	OVKH-28	2	1	10	21.6	0.045				not calc.	94 @ 30	only raw data; effic.: proport. Dead loc./quadrat
2004-17	Kazakhst.	dimilin	48 SC	DMA L2-3	Barrier	OVKH-28	3	1	10	16.0	0.030	28.8	0.060	100/80	not calc.	97 @ 30	only raw data; effic.: proport. Dead loc./quadrat
2004-17	Kazakhst.	dimilin	48 SC	DMA L2-3	Barrier	OVKH-28	4	1	10	24.0	0.045	43.2	0.090	100/80	not calc.	97 @ 30	only raw data; effic.: proport. Dead loc./quadrat
2004-17	Kazakhst.	cypermethrin	25 EC	DMA L2-3	Blanket	OVKH-28	5	1	10	62.5	0.250				not calc.	0 @ 30	only raw data; effic.: proport. Dead loc./quadrat
2004-18	Madagas.	dimilin	6 OF	NSE L3-4	Blanket	Soloport 423	1	1	10	58.2	0.970				93 @ 5	93 @ 5	subleth. Eff. Assessed.; effic. Rel. to pre-spray

CAL = *Chorthippus albomarginatus*
CIT = *Calliptamus italicus*
DBR= *Dociostaurus brevicollis*

DKR = *Dociostaurus krauss*
DMA = *Dociostaurus maroccanus*
LMI = *Locusta migratoria*

LMC = *Locusta migratoria capito*
LMM = *Locusta migratoria migratoria*
NSE = *Nomadacris septemfasciata*

OSE = *Oedaleus senegalensis*
PMI = *Paracyptera microptera*
SGR = *Schistocerca gregaria*

Appendix IV

										Dosage [g a.i./ha] or vol. of formulation [L/ha]					Effect [% @ DAT] (other units or parameters in italics)		
										Overall		Intra-barrier					
Report	Country	a.i.	Formul.	Target & dominant stages	Treat.	Sprayer	No.	# of repl.	Size [ha]	Dosage	Volume	Dosage	Volume	Barrier / inter-barrier [m]	earliest > 90%	highest observed	Remarks
2004-19	Russia	dimilin	6 OF	CIT L1-3	Blanket	AI-8000	1	2	10	9.0	0.150				-	95 @ 12	Hend. & Tilt. Calcul. For d 12 by PRG
2004-19	Russia	dimilin	6 OF	CIT L1-3	Blanket	AI-8000	2	2	10	12.0	0.200				-	96 @ 12	Hend. & Tilt. Calcul. For d 12 by PRG
2004-19	Russia	dimilin	6 OF	CIT L1-3	Blanket	AI-8000	3	2	10	15.0	0.250				-	97 @ 12	Hend. & Tilt. Calcul. For d 12 by PRG
2004-19	Russia	dimilin	6 OF	CIT L1-3	Barrier	AI-8000	4	2	15	12.0	0.200	36.0	0.600	20/40	-	96 @ 12	Hend. & Tilt. Calcul. For d 12 by PRG
2004-19	Russia	deltamethrin	EC (25)	CIT L1-3	Blanket	AI-8000	5	2	10	10.0	0.400				-	65 @ 12	Reimmigration; … calcul. For d 12 by PRG
2004-19	Russia	dimilin	6 OF	CIT L2-3	Blanket	AI-8000	8	2	2	9.0	0.150				none	90 @ 3	No control plot; effic. Relative to pre-spray
2004-19	Russia	dimilin	6 OF	CIT L2-3	Blanket	AI-8000	9	2	2	12.0	0.200				94 @ 3	94 @ 3	No control plot; effic. Relative to pre-spray
2004-19	Russia	dimilin	6 OF	CIT L2-3	Blanket	AI-8000	10	2	2	15.0	0.250				97 @ 3	97 @ 3	No control plot; effic. Relative to pre-spray
2004-19	Russia	dimilin	6 OF	CIT L2-3	Barrier	AI-8000	11	2	2	8.0	0.133	24.0	0.400		none	90 @ 6	No control plot; effic. Relative to pre-spray
2004-19	Russia	deltamethrin	EC (25)	CIT L2-3	Blanket	AI-8000	12	2	2	10.0	0.400				97 @ 3	97 @ 3	No control plot; effic. Relative to pre-spray
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Blanket	AN2 (aerial)	1	1	24	9.6	0.020				none	73 @ 23	
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Blanket	AN2 (aerial)	2	1	24	14.4	0.030				94 @ 12	97 @ 15	
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Blanket	AN2 (aerial)	3	1	24	21.6	0.045				96 @ 12	97 @ 15	
2004-20	Uzbekist.	dimilin	6 OF	CIT L1-3	Blanket	AN2 (aerial)	4	1	24	30.0	0.500				91 @ 15	91 @ 23	OF appl. data missing;
2004-20	Uzbekist.	fipronil	4 EC	CIT L1-3	Blanket	AN2 (aerial)	5	1	24	4.0	0.100				91 @ 8	94 @ 10	
2004-20	Uzbekist.	zeta-cypermerm	10 WC	CIT L1-3	Blanket	AN2 (aerial)	6	1	24	10.0	0.100				93 @ 2	93 @ 2	
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Barrier	OPSH-2000	6	1	6	4.8	0.010	9.6	0.02	100/100	none	61 @ 23	mean of efficacy within and between barriers
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Barrier	OPSH-2000	7	1	6	7.2	0.015	14.4	0.03	100/100	none	78 @ 23	mean of efficacy within and between barriers
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Barrier	OPSH-2000	8	1	6	14.4	0.030	28.8	0.06	100/100	92 @ 15	92 @ 15	mean of efficacy within and between barriers
2004-20	Uzbekist.	dimilin	48 SC	CIT L1-3	Barrier	OPSH-2000	9	1	6	21.6	0.045	43.2	0.09	100/100	90 @ 12	96 @ 15	mean of efficacy within and between barriers
2004-20	Uzbekist.	dimilin	6 OF	CIT L1-3	Barrier	OPSH-2000	9	1	6	30.0	0.500	60.0	1.00	100/100	92 @ 15	92 @ 15	OF appl. data missing; efficacy as above
2004-20	Uzbekist.	fipronil	4 EC	CIT L1-3	Barrier?	OPSH-2000	10	1	6	2.0	0.050	4.0	0.10	100/100	none	75 @ 15	sprayed as barriers? Not clear; effic. As above
2004-20	Uzbekist.	zeta-cypermerm	10 WC	CIT L1-3	Barrier?	OPSH-2000	11	1	6	5.0	0.050	10.0	0.10	100/100	49 @ 2	49 @ 2	sprayed as barriers? Not clear; effic. As above
2004-21	Russia	dimilin	6 OF	CIT L1-3	Blanket	Ulvamast V3M	1	2	24	12.0	0.2				96 @ 9	99 @ 15	efficacy: Henderson & Tilton
2004-21	Russia	zeta-cypermerm	10 WC	CIT L1-3	Blanket	Ulvamast V3M	2	2	24	10.0	0.10				97 @ 3	97 @ 3	re-infestation; efficacy: Henderson & Tilton

CAL = *Chorthippus albomarginatus*
CIT = *Calliptamus italicus*
DBR= *Dociostaurus brevicollis*
DKR = *Dociostaurus krauss*
DMA = *Dociostaurus maroccanus*
LMI = *Locusta migratoria*
LMC = *Locusta migratoria capito*
LMM = *Locusta migratoria migratoria*
NSE = *Nomadacris septemfasciata*
OSE = *Oedaleus senegalensis*
PMI = *Paracyptera microptera*
SGR = *Schistocerca gregaria*

Appendix IV

Report	Country	a.i.	Formul.	Target & dominant stages	Treat.	Sprayer	No.	# of repl.	Size [ha]	Dosage [g a.i./ha] or vol. of formulation [L/ha]: Overall Dosage	Overall Volume	Intra-barrier Dosage	Intra-barrier Volume	Barrier / inter-barrier [m]	Effect [% @ DAT] (other units or parameters in italics): earliest > 90%	highest observed	Remarks
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	1	1	<0.01	24.0	0.05				100 @ 7	100 @ 7	very small plots; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	2	1	<0.01	24.0	0.05				100 @ 7	100 @ 7	very small plots; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	3	1	<0.01	24.0	0.05				91 @ 7	99 @ 14	very small plots; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	4	1	<0.01	48.0	0.10				100 @ 7	100 @ 7	very small plots; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	5	1	<0.01	48.0	0.10				100 @ 7	100 @ 7	very small plots; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	6	1	<0.01	48.0	0.10				92 @ 7	99 @ 14	very small plots; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	7	1	<0.001	24.0	0.05				90 @ 3	98 @ 14	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	8	1	<0.001	24.0	0.05				100 @ 7	100 @ 7	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	9	1	<0.001	24.0	0.05				100 @ 7	100 @ 7	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	10	1	<0.001	24.0	0.05				91 @ 7	99 @ 14	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	11	1	<0.001	24.0	0.05				92 @ 7	98 @ 14	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	12	1	<0.001	48.0	0.10				97 @ 3	100 @ 14	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	13	1	<0.001	48.0	0.10				100 @ 7	100 @ 7	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	14	1	<0.001	48.0	0.10				100 @ 7	100 @ 7	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	15	1	<0.001	48.0	0.10				94 @ 7	99 @ 14	field cage trials; efficacy: Henderson & Tilton
2004-22	Bulgaria	dimilin	48 SC	DMA, CIT L1-3	Blanket	Knapsack	16	1	<0.001	48.0	0.10				93 @ 7	99 @ 14	field cage trials; efficacy: Henderson & Tilton
2000-23	Mauritania	dimilin	6 OF	SGR L1-5	Blanket	ULVA+	1	1	7	15.0	1.001				none	74 @ 11	re-infest. But 4-w resid. Activity; effic.: Abbott
2000-23	Mauritania	dimilin	6 OF	SGR L1-5	Blanket	ULVA+	2	1	7	30.0	1.000				none	88 @ 21	re-infest. But 4-w resid. Activity; effic.: Abbott
2000-23	Mauritania	dimilin	6 OF	SGR L1-5	Blanket	ULVA+	3	1	9	57.5	0.958				92 @ 11	92 @ 11	re-infest. But 4-w resid. Activity; effic.: Abbott
2000-24	Morocco	dimilin	6 OF	SGR L3	Blanket	Ulvamast V3	1	2	30	24.0	0.400				none	97 @ 11	repl. Are hopp. Bands; effic. Rel. to pre-spray
2000-24	Morocco	dimilin	6 OF	SGR L3	Blanket	Ulvamast V3	2	2	35	32.0	1.060				95 @ 8	100 @ 11	repl. Are hopp. Bands; effic. Rel. to pre-spray
2000-24	Morocco	dimilin	6 OF	SGR L3	Blanket	Ulvamast V3	3	3	32	65.0	1.090				92 @ 5	100 @ 8	repl. Are hopp. Bands; effic. Rel. to pre-spray

CAL = *Chorthippus albomarginatus*
CIT = *Calliptamus italicus*
DBR= *Dociostaurus brevicollis*
DKR = *Dociostaurus krauss*
DMA = *Dociostaurus maroccanus*
LMI = *Locusta migratoria*
LMC = *Locusta migratoria capito*
LMM = *Locusta migratoria migratoria*
NSE = *Nomadacris septemfasciata*
OSE = *Oedaleus senegalensis*
PMI = *Paracyptera microptera*
SGR = *Schistocerca gregaria*

Appendix IV

										Dosage [g a.i./ha] or number of spores per hectare					Effect [% @ DAT] (other units or parameters in italics)		
				Target & domi-				# of	Size	Overall		Intra-barrier		Barrier / inter-	earliest	highest	
Report	Country	a.i.	Formul.	nant stages	Treat.	Sprayer	No.	repl.	[ha]	Dosage	Volume	Dosage	Volume	barrier [m]	> 90%	observed	Remarks
2000-25	Tanzania	*M. anisopliae*	OF	NSE imagoes	blanket	AU 4000	1	1	400	1.25×10^{12} spores/ha					> 70 @ 27	> 70 @ 27	
2000-25	Tanzania.	*M. anisopliae*	OF	NSE imagoes	blanket	AU 4000	2	1	800	1.25×10^{12} spores/ha					> 70 @ 27	> 70 @ 27	caged locusts; highly variable efficacy due to variable spray deposit in tall vegetation
2000-25	Tanzania.	*M. anisopliae*	OF	NSE imagoes	blanket	AU 4000	3	1	1400	2.50×10^{12} spores/ha					> 50 @ 32	> 50 @ 32	
2000-25	Tanzania.	Fenitrothion	96%	NSE imagoes	blanket	AU 4000	4	1	600	480.0	0.500				> 90 @ 1		
2000-26	Sudan	*M. anisopliae*	OF	SGR L3-4	Blanket	ULVA+	1	3	<0.001	1.25×10^{12} spores/ha					62 @ 27	62 @ 27	field enclosures; effic. calcul. not given
															77 @ 22	77 @ 22	same trial: caged locusts; effic. presum. Abbott
2000-26	Sudan	*M. anisopliae*	OF	SGR L3-4	Blanket	ULVA+	2	3	<0.001	2.50×10^{12} spores/ha					73 @ 27	73 @ 27	field enclosures; effic. calcul. not given
															95 @ 15	98 @18	same trial: caged locusts; effic. presum. Abbott
2000-26	Sudan	*M. anisopliae*	OF	SGR L3-4	Blanket	ULVA+	3	3	<0.001	3.75×10^{12} spores/ha					90 @ 21	92 @ 27	field enclosures; effic. calculation not given
															92 @ 12	96 @ 21	same trial: caged locusts; effic. presum. Abbott
2000-26	Sudan	*M. anisopliae*	OF	SGR L3-5	Blanket	Mist Blower	4	3	1	1.25×10^{12} spores/ha					95 @ 15	100 @ 21	caged locusts; control data not given
2000-26	Sudan	*M. anisopliae*	OF	SGR L3-5	Blanket	Mist Blower	5	3	1	2.50×10^{12} spores/ha					100 @ 12	100 @ 12	caged locusts; control data not given
2000-26	Sudan	*M. anisopliae*	OF	SGR L3-5	Blanket	Mist Blower	6	3	1	3.75×10^{12} spores/ha					100 @ 12	100 @ 12	caged locusts; control data not given
2000-26	Sudan	*M. anisopliae*	OF	SGR L4-5	Blanket	Mist Blower	7	3	1	1.25×10^{12} spores/ha					88 @ 15	88 @ 15	field counts; effic. rel. to pre-spray
2000-26	Sudan	*M. anisopliae*	OF	SGR L4-5	Blanket	Mist Blower	8	3	1	2.50×10^{12} spores/ha					98 @ 12	99 @ 15	field counts; effic. rel. to pre-spray
2000-26	Sudan	*M. anisopliae*	OF	SGR L4-5	Blanket	Mist Blower	9	3	1	3.75×10^{12} spores/ha					97 @ 9	99 @ 12	field counts; effic. rel. to pre-spray
2000-26	Sudan	*M. anisopliae*	OF	LMI nymphs	Blanket	ULVA+	10	3	<0.001	1.25×10^{12} spores/ha					93 @ 15	94 @ 18	caged locusts; efficacy: Abbott (PRG)
2000-26	Sudan	*M. anisopliae*	OF	LMI nymphs	Blanket	ULVA+	11	3	<0.001	2.50×10^{12} spores/ha					99 @ 9	99 @ 9	caged locusts; efficacy: Abbott (PRG)
2000-26	Sudan	*M. anisopliae*	OF	LMI nymphs	Blanket	ULVA+	12	3	<0.001	3.75×10^{12} spores/ha					99 @ 9	99 @ 9	caged locusts; efficacy: Abbott (PRG)

CAL = *Chorthippus albomarginatus*
CIT = *Calliptamus italicus*
DBR= *Dociostaurus brevicollis*
DKR = *Dociostaurus krauss*
DMA = *Dociostaurus maroccanus*
LMI = *Locusta migratoria*
LMC = *Locusta migratoria capito*
LMM = *Locusta migratoria migratoria*
NSE = *Nomadacris septemfasciata*
OSE = *Oedaleus senegalensis*
PMI = *Paracyptera microptera*
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 (e.g. 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.