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The Pesticide Referee Group of FAO and its contribution to locust control

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Abstract

At the time of the major outbreak of desert locust in the late 1980s, FAO convened a meeting to discuss control operations in view of the worldwide ban on the use of dieldrin, hitherto regarded as the most important insecticide to control locusts. An outcome of the meeting was to set up an independent advisory body, the Pesticide Referee Group (PRG), to examine the scientific data obtained from laboratory and field trials submitted to FAO. The PRG was expected to make recommendations on which insecticides were effective and the dosage that should be used, either as a barrier treatment or for full-cover applications. The remit of the PRG was subsequently extended to consider environmental data and indicate the possible risk that the effective insecticides pose to various categories of nontarget fauna.

The aim of the recommendations has been to give locust-affected countries a choice of suitable insecticides, to avoid the previous problems of maintaining stocks of only one insecticide, and to allow flexibility in relation to possible environmental impact. The need for ULV formulations, with specifications that include appropriate volatility and viscosity requirements, is stressed for operational reasons. Stocks of these formulations can be reformulated for use against other pests to avoid long-term storage or obsolesence. Attention has been given to new alternatives, including insect growth regulators and the biopesticide *Metarhizium anisopliae* var. *acridum*. The PRG has requested feedback on operational use of insecticides, including these new products, so that the list can be refined and extended.

Introduction

The last major plague (1987 to 1989) which originated in western Sudan, affected countries from West Africa to India. Control operations, migration from West Africa to the Caribbean, and a failure of the rains, ended this particular plague. Prior to this plague, many tests had been carried out to determine which insecticides were effective on locusts, and McCuaig (1983) compiled an Insecticide Index (2nd edition) that provides a summary of each insecticide. Studies had shown that dieldrin was extremely effective and its persistence enabled it to be used as a barrier treatment against hoppers (Gunn 1979). FAO and others agreed to hold stocks of this insecticide in Africa to permit a rapid response to upsurges in locust populations, but when FAO sought donor funding to combat locusts in 1987 (FAO 1988), there was an immediate outcry from environmentalists that dieldrin should no longer be used. Donors responded by confirming that funding would not be provided if dieldrin was used. The legacy of this was the continuing problem of disposal of obsolete stocks of pesticides from many locust-affected countries, as containers had to be replaced and the chemical shipped for incineration.

At that time the main alternative to dieldrin was fenitrothion for aerial application against adults, mainly when swarms had settled. As this approach had clear limitations, the meeting convened by FAO agreed that a Pesticide Referee Group should be established to examine trials data and advise FAO on which insecticides should be used primarily for desert locust control, but also to consider other locust species.

The Pesticide Referee Group

This small group of independent advisers has met on 9 occasions, although some changes in those attending have occurred. At each meeting the aim is to have at least one representative from a locust-affected country. Since the 7th meeting, representatives of the agrochemical companies who had carried out trials were invited to make short presentations on their data on the first day of the meetings. Data considered by the Group are almost entirely based on trials reported (or supported) by the agrochemical industry; but independent data, data from trials established by FAO, and data published in peer-reviewed journals, are also considered. High levels of efficacy are needed, but mortality can occur over a period of days, recognising that some products, more acceptable from an environmental aspect, may take longer to attain acceptable levels.

At the first meeting in 1989, 32 reports on trials from 1986 onwards, involving 27 different insecticides, some as mixtures, were assessed to determine their efficacy, assuming a maximum volume application rate of 1 liter per hectare, *i.e.*, at ultra-low volume. On this occasion 6 insecticides were selected as suitable for emergency operations, although more detailed large-scale trials were considered to be needed, as most of the data available at that time related to trials with other species of grasshoppers. Two organophosphate (OP) insecticides–chlorpyrifos and fenitrothion–were included with 2 pyrethroids–deltamethrin and lambda-cyhalothrin– a carbamate, bendiocarb and an insect growth regulator, teflubenzuron.

At the 2nd meeting in 1990, the need for different control strategies was examined and 5 strategies considered in respect of making recommendations and allowing those in the field to select the most appropriate insecticide. The strategies were:

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

Apart from teflubenzuron, for which more data were sought, the initially recommended insecticides were confirmed with a verified dose. Malathion was added as an alternative OP. This list remained unchanged at the 3rd meeting in 1992. In 1994, the dose for deltamethrin was reduced from 15 to 12.5 g ai ha^{-1}, although it was recognised at the following meeting in 1995, that a higher dose may be required for late instars to prevent them recovering from knock-down. The deltamethrin dose was re-examined at the 9th meeting in 2004, as preference had been given by purchasers during the upsurge in West Africa to organophosphates, due to the perception that locusts recovered after pyrethroid sprays. It was recognised that in some circumstances a dose of 17.5 g ai ha^{-1} would be more effective, although there was still the choice of the lower 12.5 g ai ha^{-1}, where timely control could be carried out.

The main changes in 1995 were the addition of diflubenzuron for hopper control and fipronil, which had been extensively tested as band treatments. Control of hoppers remains a crucial technique where surveillance can detect hopper bands early enough to deploy sprayers. Subsequently there has been concern about the effect of fipronil on nontarget species, but where the lowest effective dose is applied in bands with a wide separation between, fipronil is very effective against locusts.

Then in 1996, it was possible to add alternatives to diflubenzuron, namely teflubenzuron and triflumuron, but the key change was the addition of *Metarhizium anisopliae* var. *acridum*, a mycoinsecticide that had been developed as the first biopesticide for locust control. Studies on this fungus had been initiated at the same meeting in Rome that established the pesticide referee group, as donors wanted to move away from chemicals to a biological control strategy. The new mycoinsecticide had been field tested and shown to be effective, while at the same time it had no adverse effects on other insects, apart from other grasshopper species. It was therefore ideal for use in ecologically sensitive areas, despite a slower speed of action.

Recognizing the need for a more ecological approach to locust control, the 7th meeting developed criteria for environmental risk assessments. Using data from a number of sources, including the FAO Locustox project in Senegal, the insecticides recommended for locust control were classified as low, medium or a high-risk to fish, aquatic invertebrates, mammals, birds and reptiles, bees and other nontarget invertebrates, as well as humans, the latter using the WHO classification. The 8th report, following the Agenda 21 Declaration on Environment and Development, provided more detailed risk assessments for nontarget arthropods.

The main concern during the last meeting in 2004 was how the recommendations stood up to the needs of an on-going campaign to control the upsurge in West Africa.

Inevitably the emergency situation had throw up a number of problems, many of which had been already dealt with by FAO. Apart from the preference given to OP insecticides, as these had been more readily available in sufficient quantities at short notice, a major cause of concern to companies that had done trials specifically for locust control, was that some products that had not been assessed were being used. This involved generic copies of recommended insecticides which were less expensive, but frequently gave rise to problems as the formulation was not suitable for ULV application. FAO had responded that purchases would be limited to products with specific Trade names registered in a locust-affected country and that had been evaluated by the PRG.

During the 2003-2005 upsurge in West Africa, an estimated 12.8 million ha were treated. At this time data on which insecticides had been used, the equipment involved and how effective each treatment had been, are not available. However, the PRG hopes that there will be more feedback, so that the impact of each insecticide can be refined.

Discussion

The post-dieldrin situation is that locust-affected countries now have an array of insecticides from which to choose products most suited to the locust situation at any one time. This obviates the need to stockpile large quantities of one chemical. However, as a UL formulation is needed for locust control, there is a problem of reformulation of any excess quantities of insecticides after a locust upsurge, so that the active ingredient can be utilised in some other form of plant protection against other insect pests. The risk assessment for each active ingredient allows users to determine which of the recommended insecticides is likely to be most appropriate for a given situation. The development of a biopesticide now permits control operations at the onset of an upsurge, even in ecologically sensitive areas, and may allow control to be achieved during periods of a recession once an increase in locust populations is detected. However, the key problem will remain the early detection of locusts, necessitating vigilance even during a recession.

The PRG has been able to evaluate a large number of trial reports, summaries of which have been compiled into a Field Trials Database, which was invaluable in allowing rapid access to earlier data. It has been recommended that these data be made more widely available to those involved in locust control, provided confidentiality of data is endorsed by users.

The PRG has continued to support the use of ultra-low volume application, which is logistically most suitable for treating large areas rapidly. It has however, stressed the absolute need for formulations suitable for this specialised application technique, especially the need for low volatility and viscosity when applying such small volumes of spray. The use of rotary atomisers, *eg.*, the Micron Ulvamast and Micronair equipment on aircraft, together with the use of Global Positioning Systems, has enabled more accurate application of the insecticides.

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Table 1. The latest recommendations extracted from the 9th Report of the Pesticide Referee Group.
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 was defined as: F = fast (1 to 2 h), M = moderate (3 to 48 h) and S = slow (> 48 h).

		Dose (g a.i./ha) [†]					
		overall (blanket) treatment †		barrier treatment (hoppers)*		Speed of action at verified dose rate	Primary mechanism
Insecticide	Class	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	450	450			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; [§] 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^{-1}; [†] Application volumes for recommended dose rates differ depending on the formulation available.

Table 2. Extracted from 9th report to show risk to nontarget organisms at verified dose rates against the desert locust (Table 1). Risk is classified as low (L), medium (M) or high (H). See following Table 3 for the classification criteria.

	Environmental risk							
	Aquatic organisms		Terrestrial vertebrates			Terrestrial nontarget 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 [1ϕ]	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 bees. [‡] Benzoylureas are safe to adult worker bees, but some may cause damage to the brood of exposed colonies; (–) insufficient data.

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Table 3. Criteria applied for the environmental risk classification used in Table 2.

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.