Migratory Pests Group

Guideline

Operational-scale field trial of barrier treatments with benzoyl-urea insect growth regulators

Version 2 – March 31, 2005

1. INTRODUCTION

The Pesticide Referee Group (PRG) in its 9th Meeting in 2004 lists two benzoyl-urea insect growth regulators (IGRs) for use in barrier treatments against the Desert Locust. They are diflubenzuron and triflumuron, with recommended dose rates (within the barrier) of 100 and 75 g a.i./ha respectively (FAO, 2004). In addition, teflubenzuron has been listed for blanket sprays, but could also be used in barrier treatments as soon as a dose rate has been set. The PRG states that a track spacing of 700 m will give good efficacy, but also suggests that wider track spacing may be possible after appropriate trials are carried out.

The present recommendations of dose rates and barrier spacing are based on relatively limited field trial data obtained on the Desert Locust and no additional large scale operational barrier treatments against this species have been reported so far. A reasonable amount of relevant data on the African migratory locust is available, however. Further information on barrier treatments against the Desert Locust is necessary to confirm the efficacy of this control approach on a large scale and in varying environmental conditions.

The objective of this guideline is to give advice on the design of an operational-scale field efficacy trial of barrier treatments benzoyl-urea IGRs on the Desert Locust (*Schistocerca gregaria*). Furthermore, logistical needs, a budget and some advice on planning are provided.

The guideline does not include environmental impact assessment of the insecticide.

2. PRINCIPLES OF THE TRIAL

The trial concerns one or more aerial barrier treatments of a benzoyl-urea insecticide against hopper bands of the Desert Locust. The size of the trial plots needs to be representative of what will likely be operational barrier treatments against hopper band targets.

Only the PRG recommended dose rate within the barrier will be tested, but barrier spacing may be varied.

In principle, the trial will be an integral part of the ongoing Desert Locust control campaign in the country, and be coordinated by the national locust control unit or plant protection department.

3. TRIAL DESIGN

Target type

The spray targets are blocks of land containing several hopper bands of the Desert Locust. The actual target for the spray droplets is the vegetation on which the hoppers feed, since the insecticide acts after ingestion. Application of the insecticide on bare ground, even if occupied by hopper bands, is thus not effective.

Target stage

Hopper stages should ideally range from 2nd to 4th instar. First instar hoppers are also susceptible to the IGRs but are relatively immobile. As a result, by the time they have moulted into more mobile 2nd or 3rd instars, the insecticide on the vegetation will have partly degraded and may be less effective. Similarly, if barrier spacing is wide, some 5th instar bands may not reach a treated barrier before they moult to fledge.

Trial area

Areas with sparse and clumpy vegetation are suitable. The vegetation should neither be too dense (where hopper bands are difficult to trace and the insecticide is too much diluted) nor too light (where hopper bands may move too fast out of the spray block and much pesticide is lost on the soil). Area and vegetation type should in principle be representative of Desert Locust habitat conditions, but a relatively uniform habitat tends to make evaluation easier.

Type of treatment

For operational-scale trials, aerial treatments are recommended.

Barrier width

The width of a barrier cannot be defined in an exact manner since with ULV drift spraying there is no distinct downwind edge of a spray swath.

The PRG presently recommends a barrier width of a single aircraft spray run, applied from about 10 m flying height. This would result in most of the insecticide depositing in a strip of about 100 – 200 m wide (so a nominal effective barrier width of about 100 – 200 m). Also from an operational point of view, the barrier width should ideally be a single aircraft spray run as this will allow rapid treatment of large areas.

Barrier spacing

The Pesticide Referee Group states that a barrier spacing of 700 m will provide control in most situations. They suggest, however, that wider spacing may well be effective, but that this needs to be tested.

Various other assessments (e.g. Coppen, 1999; or Wilps, 2004) tend to suggest wider spacing of IGR-treated barriers, but the biological and toxicological basis for these recommendations is insufficient to set reliable barrier spacing at this stage.

This means that barrier spacing will need to be set on a pragmatic basis. Since a spacing of 700 m is presently considered to have proven effectiveness, it is suggested to test a barrier spacing of about 1000 m for this operational-scale trial.

Plot size

The minimum plots size should be large enough to ensure that hoppers bands do not march out of the sprayed plot before the insects have the possibility to encounter a minimum of two barriers. This is because a hopper band may traverse a barrier at a time that the insects are less susceptible to the IGR (i.e. the first one or two days after moulting) (Coppen & Jepson, 1999b). This means that a minimum of 3 barriers, but likely more, should be sprayed in each plot to ensure that enough individual bands can be monitored.

The minimum plot size is also determined by the need to avoid as much as possible that bands move from untreated zones into the treated plot, as this will complicate assessment of efficacy. With mid-instar hopper bands being able to move several hundreds of meters per day, the minimum plot size is likely to be at least 4 x 4 km (1600 ha), and preferably more. To minimize immigration into a treated plot, it is recommended to treat an entire hopper band population in a given location, or at least the most densely populated area, if this is possible.

Little experience has as yet been gained in spraying barriers of IGRs against Desert Locust hopper bands, and typical "operational spray block sizes" do not yet exist.

Most likely, the maximum spray block size will be determined by the pesticide hopper capacity of the spray aircraft. If possible, the trial plot should be sprayed on one day, and depending on the distance between spray plot and air strip, this may mean that only one sortie is possible.

As an indication, a 1000 L load of insecticide sprayed at 1.7 L/ha would treat 590 ha, which, at a nominal barrier width of 100 m, corresponds to 59 km of barrier. With a barrier spacing of 1000 m, this is enough to treat a block of 5900 ha (or about 10 x 6 km).

Plot number (replicates)

Since the objective of the operational-scale trial is to confirm the field dose rate rather than to set a new rate, there is less of need to treat several replicates with similar hopper populations and similar environmental conditions. However, different plots need to be treated, preferably under different environmental and meteorological conditions that can be encountered in Desert Locust control, to assess the robustness of the recommended dose rate.

Therefore, it is strongly recommended that at least 2 and preferably more plots are treated independently one from the other. Treatments need to be independently carried out to ensure that potential errors made in the execution of one treatment are not "carried over" to the next one. For all practical purposes for this type of trial, treatments can be considered independent if:

(i.) plots are treated during different aircraft sorties, and
(ii.) sprayer/atomiser settings are (re-)calibrated before each treatment[1].

Unsprayed control plots

One unsprayed control plot should be included in the trial. For slow acting insecticides, like the benzoyl-urea IGRs, an untreated control plot gives an indication, although not a completely certain one, of what would have happened to the locust population within the sprayed plots had they not been sprayed. Untreated control plots are particularly useful to check on major changes in background population, such as mass exodus after fledging, or mass hatching if several events of egg laying occurred in the same area.

Since the function of the control plot is primarily to assess general changes in untreated hopper populations, it is more important that the age of the hoppers is similar between treated and control plots, rather then that the vegetation is homogeneous among plots.

The national locust control organization may want to ensure that no locusts will fledge from the control plot. But since there is no real need to monitor the control plot anymore when fledging starts, an agreement can be made that the control plot will be

[1] Ideally, hopper populations in each plot should also be genetically/ecologically distinct, but this can with the highly mobile Desert Locust hardly ever be ensured.

sprayed with a conventional contact insecticide at that moment. No budgetary reservation is made for this in the trial protocol, as it is assumed that spraying of such a plot would have occurred anyway using the available national capacity. Clear arrangements need to be made with the locust control unit about this, however.

Plot layout

Trial plots should be well separated to prevent spray drift from one to another. Furthermore, hopper bands should not be able to move from one trial (or control) plot into another. Distances between plots should therefore be at least 3 km. Untreated control plots are preferably positioned upwind from the treated plot.

Test Product

The following insecticides may be tested:

- Diflubenzuron, as Dimilin OF6® (60 g a.i./L)
- Triflumuron, as Alsystin 050 UL (50 g a.i./L)
- Teflubenzuron, as Nomolt 50 ULV (50 g a.i./L)

Area dosage

The above insecticides are to be applied at the following area dosages and volume application rates (within-barrier rates are based on a nominal barrier width of 100 m)

- Diflubenzuron: dose rate of 100 g a.i./ha within the barrier, or 1.67 L/ha of Dimilin OF6
- Triflumuron: dose rate of 75 g a.i./ha within the barriers, or 1.5 L/ha of Alsystin 050 UL
- Teflubenzuron: no PRG barrier treatment rate has as yet been set. A within barrier rate of 75 g a.i./ha is suggested, or 1.5 L/ha of Nomolt 50 ULV

Product quality assessment

Any insecticide that has been stored for a prolonged period in the country of testing (i.e. more than 1 year) should be sampled and sent to a reputed laboratory for a formulation quality test. The same holds for newer insecticides for which no formulation quality certificate is available.

Reference product

No reference product is required[2].

Aircraft

Due to the plot size required (a minimum of 1600 ha, but preferably larger) the spray aircraft should have sufficient hopper capacity to allow the plot to be sprayed in one day. Assuming some ferry time between airstrip and trial plot, often only one sortie will be feasible.

The minimum plot size of 1600 ha would require, at 1000 m barrier spacing and a volume application rate of 1.7 L/ha, about 280 L of insecticide. Such a load can still be sprayed in one sortie by relatively small spray planes, such as the Cessna Ag Truck 188 or the Piper PA-25 Pawnee.

However, larger trial plots will require spray aircraft with a bigger hopper volume, for example the Turbo Thrush 510 or the Air Tractor AT-401 or AT-402, or similar/larger aircraft.

2 A reference product is often included in the trial to detect if there are any general problems with the trial, such as a defective atomiser or unfavourable meteorological conditions. Its mode of action should ideally be similar to the test product. However, no reference product exists yet for barrier treatments. The requirement for independency of treatments should reduce the risk of a general problem going undetected.

Sprayer

Rotary atomisers give the narrowest drop spectra and should always be used in trial work.

The pesticide pump system should preferably be electrical (or otherwise independent) rather than propeller-driven, to allow calibration on the ground. However, since this may often not be available, the aircraft should always be equipped with an onboard automatic flow control linked to the track guidance system.

Before treatment, the aircraft pesticide hopper, tubing system and atomisers should be rinsed well with diesel or kerosene, to wash out as much of leftover previously used (contact) insecticides as possible. This is best done by having the aircraft fly and spray out (at least) 200 L of diesel or kerosene 2-3 times.

Aircraft navigation equipment

The aircraft should be equipped with GPS-based agricultural navigation equipment, permitting spray track guidance for the pilot, and an output showing exact location of the treatment, delimitation of spray blocks and plotting of spray tracks.

An automatic flow control unit should also be fitted. This should be linked to the track guidance system to give an output of the total volume of pesticide been applied (e.g. systems such as Satloc® or Ag-Nav® will give a detailed treatment map showing the volume of liquid applied per hectare.

4. TRIAL PROCEDURES

Calibration of equipment

Before the trials start, the spray equipment should be calibrated to apply the required area dosage. The spray equipment should be recalibrated, or calibration checked, before each individual treatment. Note that atomiser flow rates may vary from day to day, or even during the day, but this will be controlled by the onboard flow control system. The latter needs to be carefully calibrated to ensure precise flow measurements.

If the aircraft is equipped with well-know rotary atomisers, there is no need to carry out a swath width estimate before the trial. The blade angle of the atomisers should be set to achieve a VMD of 75 µm based on the operating handbook.

Laying out of the plot

Spraying must be carried out as close to crosswind as possible. A rough plot layout can be delimitated the day(s) before treatment, based on prevailing wind direction in the area. This will allow pre-spray sampling of the hopper bands in the central area of the plot, with a reasonable certainty that these populations will indeed be sprayed. The actual spray plot will be delimitated on the day of the treatment, by ground crews marking the four plot corners with GPS. These are the co-ordinates passed to the pilot for use in the aircraft track guidance system.

Application conditions

Spraying should start early in the morning and finish before the onset of heat convective turbulence, characterised by the wind beginning to vary considerably in strength and direction. The time that this occurs will depend on factors such as cloud cover and temperature, so no absolute time can be given. Further spraying can be carried out in the hour or so before sunset. It is by far the best to spray the entire plot on one day.

Wind speed should preferably range from 2 – 4 m/s, to ensure that the spray is carried over a reasonable but discrete swath. Such winds will carry spray droplets horizontally, increasing their likelihood of impaction on vegetation (the intended target) and reducing wastage on the bare ground.

Wind speed and direction (measured at 2 m above ground level), temperature, relative humidity, estimated cloud cover (in octas), possible (temporary) onset of convection and rainfall must all be measured at the start, during (at about half-hour intervals) and at the end of the application.

Spray technique

Applications should be made on tracks at right angles to the wind, and a flying height used of 5 – 10 m. This corresponds to operational aerial spray practice against the Desert Locust.

Area dosage measurement

The exact volume of pesticide actually applied per unit area of plot will never be precisely what is intended, so every effort should be made to accurately determine it. The use of a spray aircraft equipped with a GPS-based agricultural navigation system, coupled to an onboard (computerised) flow meter, will allow easy calculation of the area dosage. GPS data for the application should be downloaded to a computer for calculation of the actual spray block. The flow meter should provide total volume of pesticide applied. If the latter is not available, the volume of pesticide loaded before and left over after treatment should be measured, taking into account the "dead volume" of the sprayer plumbing system.

Droplet deposition assessment

An assessment of droplet deposition on vegetation or on droplet samplers after treatment can give a useful indication of application quality as well as of effective barrier width (though it is indicative only).

Narrow, oil-sensitive paper cards should be used to verify droplet deposition mimicking to a certain extent deposition on vegetation. Two lines droplet collection cards can be set out perpendicular to the flight direction before treatment in the centre of each plot. Cards are positioned vertically on a stick at the height of the grassy vegetation and facing the wind. Sticks can be placed at 50 m intervals and the length of the sampling line should traverse at least 2 barriers (so would be at least 2000 m long).

The formulation needs to be tested on the oil sensitive paper beforehand, to ensure that it stains clearly and that that the droplet marks do not disappear within a few minutes after deposition (as can be the case with certain insecticides).

5. ASSESSMENT OF MORTALITY & ENVIRONMENTAL CONDITIONS

Methods

Benzoyl-urea IGRs are slow acting agents, with mortality occurring during or just after the next moult of the insect. This would typically occur between 5 and 12 days after treatment, depending mainly on hopper stage and ambient temperature. This means that hopper bands can move considerable distances before the last hoppers die. Both emigrations of treated hopper bands out of the plot, and immigration of untreated bands into the plot, may perturb the efficacy assessment.

Three assessment methods can be used to assess mortality under such circumstances:

1. Monitoring of individual hopper bands
2. Presence / absence sampling along transects
3. Caging

Each of the three methods has advantages and inconveniences, and none is likely on its own to provide the answers needed to assess efficacy in a sufficient manner. If possible, all three methods should be applied.

Monitoring of individual hopper bands

Individual hopper bands can be monitored to assess the impact of the insecticide on the insects. This method is relatively precise but also very labour intensive. It is particularly useful if the spray plot is relatively small when compared to hopper band movement, and it is likely that sprayed hopper bands may move out of the plot. Monitoring individual bands will then ensure that such bands are not lost for the efficacy evaluation.

Because individual hopper bands may be very difficult to find again if not continuously observed (especially in denser vegetation or in dense band infestations), a scouting system is often used. A number of scouts are recruited to physically follow one (or sometimes two) hopper band(s) each during the entire day, till the band stops to roost. The band location is marked once or twice during the day with a flag, but always at the end of the day. An assessment team takes GPS readings of the marked locations. The scout returns to the spot to continue his/her work the following morning, before the band starts to march again. Shepherds or other local people with good knowledge of the surroundings have been used for this task, or possibly students from an agricultural school (who may be trained to use the GPS). If we assume that 4 – 7 hopper bands need to be followed in each plot, and 2 sprayed plots plus one control plot may need to be monitored for one trial, then 16 – 28 scouts are needed for such a task.

An assessment team will visit each hopper band several times during the trial period and estimate hopper populations. Insects can also be sampled for caging (see below). Precise estimates of hopper population sizes in bands are notoriously difficult to make. During each visit the following information should be collected: size estimate of the hopper band (m^2), hopper density estimate (number/m^2), hopper stage(s), band location (GPS reading), type of hopper activity (marching, roosting), abnormalities in behaviour or development of the hoppers.

Langewald *et al.* (1997) describe a more precise method, based on digital photography, but it is quite labour intensive and may not be feasible for operational-scale dose confirmation trials.

Presence/absence sampling along transects

A method to determine the efficacy of slow acting pesticides in large plots with a large number of hopper bands is to compare the "percentage band infestation" before and at intervals after spraying. This is done by driving parallel transects through the plot and noting at regular intervals whether one is in a band or not.

The proportion of points in a band is a valid measure of the proportion of the area covered by bands. The change in percentage band infestation can then be used as a measure of efficacy, as long as there is only limited immigration of bands into the plot or emigration out of it.

Density estimates can be improved by assigning density categories to each point and calculating the percentage of points in each density category before and at intervals after spraying (see FAO, 1991, for indicative categories).

Fledging assessment

If, at the time of treatment, the hopper bands consist mostly in 4^{th} or 5^{th} instars, a qualitative assessment of fledging rates can be carried out as a measure of success of the treatment (if hopper bands are younger, the absence/presence transect observations of hopper bands will provide sufficient indication of efficacy).

If the IGR performs well, no, or very few, groups of fledgelings should be formed in the overall treated area. Only groups or swarms that immigrate into the plot might possibly be observed.

Therefore, when hopper bands are in their last stage, and fledgelings would normally start to appear, the absence of fledgelings would indicate efficacy of the treatment. If groups of fledgelings are observed, however, either the efficacy may have been insufficient or groups of locusts have moved into the plot.

Caging

Collecting samples of hoppers in the field after treatment and caging them can provide useful supplementary information to the field assessments. However, various factors may complicate interpretation of such data, such as increased mortality due to stress.

There are two types of cage assessment that may be useful to help interpret the field observations: (i) caging of insects that have just passed through a barrier and (ii) caging to verify persistence of the insecticide.

(i) Hoppers can be collected just after they have passed through a sprayed barrier, to asses if they have consumed a lethal dose of the IGR. The sampled insects are caged on untreated vegetation, and mortality monitored. If mortality is low, this may mean that the barrier was too narrow, the dose rate in the barrier too low or the insects were not very susceptible to IGRs when traversing the barrier.

This type of caging is only informative for a limited period after treatment, for approximately 6 days, when insecticide degradation is still limited. It should preferably be done for at least 3 bands in each plot, if possible.

(ii) Caging hoppers on sprayed vegetation at various periods after treatment will show how long the insecticide remains active on the vegetation. Since IGRs are likely to have a half-life of 5-10 days on vegetation under desert conditions, caging insects at 5 to 7-day intervals, up to about 4 weeks after treatment, should be sufficient. This type of caging is best done *in situ*, in the sprayed barrier. Preferably, 3 cages are placed in 2 or 3 barriers in the plot each time. Insects are caged for 24 hours on the sprayed vegetation, and are then transferred to cages with unsprayed vegetation, and further monitored. This is because moving hopper bands are unlikely to remain in any given barrier for longer than 24 hours.

No less than 15 to 20 insects should be kept in each cage. Cages should be large enough to contain this number of hoppers for a prolonged period. They should be absolutely uncontaminated by (any) insecticide, and are therefore best made new for the trial. Cages should be placed in the shade, and set up in such a way that access by ants and other predators is excluded.

Cadaver counts

Counts of dead locusts in the field are not necessary since they cannot be linked quantitatively to efficacy. Furthermore, they tend to disappear rapidly due to scavengers. Observations of many malformed nymphs will confirm, however, that mortality was due to the IGR.

Place

Population assessments are best started in a central area in the upwind part of the block. Since hopper bands will likely move downwind, this will result in the highest likelihood of hopper bands remaining in the sprayed plot as long as possible. However, marching direction is also strongly affected by topography, and this should be taken into account.

Note that sampling should not be done within roughly one swath width of the upwind plot boundary, since this area will be underdosed.

Environmental conditions

A number of meteorological measurements should be carried out on a regular basis during the entire trial, because such information may be linked to hopper band displacement, hopper development and to the persistence of the insecticide on vegetation.

They include ambient temperature and relative humidity at "locust heights". These are best taken on a regular basis using a simple data logger. Furthermore, rainfall and an indication of cloud cover should be noted daily. Wind speed and direction are particularly important during the treatments. However, if measured on daily basis, it may provide useful information with respect to its influence on the direction of hopper band movement (important for future trials).

6. REPORTING

The report should be concise, but should contain all information necessary to understand and independently evaluate the quality of the treatment, the quality and results of the biological monitoring exercises and the environmental and meteorological conditions during the trial. The original, not analysed or otherwise transformed data should be annexed to the report. Statistical analyses should be used, where appropriate, by clearly explained and referenced methods.

7. LOGISTICS & PERSONNEL

Organization

The trial will be part of the ongoing control campaign. The national coordinator of the trial will be a staff member of the locust control unit or plant protection department, but will be specifically assigned to the trial during its preparation and execution (a budget line for possible reimbursement of his time as a national consultant is included in the budget). In principle, the national coordinator will participate as efficacy monitoring staff during the entire trial. In addition, a specialist (international) consultant with intimate knowledge of all aspects of trials with Desert Locust with slow-acting insecticides needs to monitor the entire trial.

The amount of flight hours that has been reserved for the trial presumes that an aircraft company is carrying out locust control in the country, and that extra flying hours can be purchased, or reserved, on a local basis. No aircraft positioning costs have been included for planes to be flown in from outside the trial country.

Aerial spraying

Below are a number of scenarios regarding the required flying hours for aerial application. They are indicative only since the aircraft type is not yet known. For details on the calculations, see Annex 1.

Plot size	# Replicates	Total flying hours	
		large spray plane e.g. Turbo Thrush/Air Tractor	**small spray plane** e.g. Ag Truck
1600 ha	3	4.8	4.8
3600 ha	3	5.4	13.2
6400 ha	3	6.0	17.7

Ground support for spraying

Ground support for spraying consists of:

- team at the airstrip for mixing loading (presumed to be arranged by the company that carries out the treatment, as part of the contract)
- transport of pesticides to the airstrip
- 1 project staff to supervise mixing and loading of the insecticide (2 – 4 days at the airstrip) and check on calibration. This staff will also compile AgNav data and check leftover pesticide after each treatment.
- 1 project staff on the ground to ensure ground to air communication at the plot sites (2 – 4 days on plots), and carry out droplet sampling, independent from the efficacy monitoring staff.

Mortality assessments

Various mortality assessments have to be carried out. Staff and vehicle requirements (for 2 or 3 treated plots) are listed below, based on the tentative sampling schemes provided in Annex 2

Activity	Needs	Number of plots	
		2 treated & 1 control	**3 treated & 1 control**
hopper band observations	scouts	21	28
	monitoring staff	1 (+1 during treatments)	2
	vehicles (4x4)	1 (+1 during treatments)	2
Hopper band transects	monitoring staff	1 (+1 during treatments)	2
	vehicles (4x4)	1 (+1 during treatments)	2
Sampling for mortality in cages & Caging for persistence	staff	1	1
	vehicles	1	1
	camp staff (supervision of cages)	1	1

9. BUDGET

All estimates in this indicative budget are based on treatment and monitoring of three 6400 ha plots and 1 control plot.

Cost reductions could be obtained by spraying only 2 plots instead of 3 (amounting to a total of 102 000 US$ instead of 139 000 US$).

Item	Number / quantity	Number of days	Cost per unit ($US)	Total cost ($US)		Comments / assumptions
				intern'l	local	
Local trial preparation						
international consultant	1	7	350	2450		salary & field per diem ($300+$50)
national consultant/staff	1	10	100		1000	salary & field per diem ($70+$30)
4x4 vehicle	1	6	100		600	
fuel (litres)	200		0.5		100	
Pesticide application						
Flying hours - (incl. fuel & logistics)	6		2500	15000		large spray aircraft
Ground support (transport of fuel & insecticide loading)	--		--			part of aircraft contract
insecticide (litres) (incl. transport)	3300		12	39600		on site or to be covered by company
Small truck for transport of pesticides	1	3	200		600	rent & fuel & driver
Extra ground support staff at airstrip	1	7	100		700	salary & field per diem ($70+$30)
Extra ground support staff at spray plots	1	7	100		700	salary & field per diem ($70+$30)
droplet deposition equipment	1			200	100	cards, sticks, etc.
anemometer	1			100		
formulation quality control analysis	1			300		
Efficacy monitoring						
scouts (local)	28	21	10		5880	salary ($10)
international consultant	1	23	350	8050		salary & field per diem ($300+$50)
national consultants/staff	6	23	100		13800	salary & field per diem ($70+$30)
4x4 vehicles	6	23	100		13800	all commercially rented
HF/UHF radios (in vehicles)	6		--			available nationally?
walkie talkies (possibly integrated with GPS)	4		--			available from FAO
drivers	6	23	50		6900	salary & field per diem ($35+$15)
fuel for 4 vehicles (litres)	5500		0.5		2750	40 L/vehicle/day
cages	300		10		3000	60 cages for mortality & 240 cages for persistence (local production)
insect nets	20		25	500		

Item	Number / quantity	Number of days	Cost per unit ($US)	Total cost ($US) intern'l	Total cost ($US) local	Comments / assumptions
General equipment						
GPS	6		--			available from FAO.
portable computer, printer & mapping software	1		--			available from FAO or intern. consultant?
electronic data logger (temperature/RH)	2		150	300		
digital camera	1		--			available from FAO or intern. consultant?
small portable generator	1				250	available nationally or rent?
Satellite telephone calling costs				400		telephone available from FAO
various small equipment				500	500	
Camping equipment						
large tents	4		1000		4000	available nationally?
camping beds	15		100		1500	available nationally?
cooking material					500	available nationally?
water jerrycans/drums	10		25		250	available nationally?
gas lamps + bottles	4		50		200	available nationally?
folding tables & chairs	15		25		375	available nationally?
various camping equipment					1000	
General personnel						
Cook	1	23	50		1150	salary & field per diem ($35+$15)
Guard (camp)	1	23	20		460	salary ($20)
Report writing						
international consultant	1	5	300	1500		work at home
national consultant	1	5	70		350	work at home
International travel						
international consultant	1			3000		

	intern'l	local
Subtotals	**71900**	**60465**
Unforeseen (5%)	3595	3023

Grand total	**138983**
Grand total without insecticides	**99383**

10. TIMELINE

Below is an indicative timeline for the various actions that have to be taken before the trial. This timeline will certainly be modified as the trial is being organized. Rather than a fixed planning, it should be seen as a checklist of actions to be dealt with before the trial.

When?	What?	Who?
D – 3 months	Preparatory meeting with national locust control organization or PPD – to be done in all countries where trials may likely be carried out	FAO HQ
D – 3 months	Purchase of IGR (keep at supplier until potential targets and thus country of trial has been confirmed)	FAO HQ
D – 3 months	Establishment of short-list of possible international / national consultants and their periods of availability	FAO HQ
D – 3 months	Purchase of equipment (as far as it is unlikely to be available in the country) and store at FAO HQ, or Discuss the purchase/supply of equipment by the consultants/groups that may carry out the trial.	FAO HQ Consultants
D – 1 month	**Decision on trial country**	FAO HQ
D – 1 month	Obtain experimental permit (if needed)	National PPD
D – 1 month	Raise Field Authorisation for FAOR	FAO HQ
D – 1 month	Dispatch of IGR from supplier to country	FAO HQ
D – 1 month	Establish aircraft contract or reserve flying hours	FAO HQ
D – 1 month	Dispatch of equipment to country	FAO HQ
D – 1 month	Recruitment of national coordinator	Government & FAOR
D – 1 month	Recruitment international consultant	FAO HQ
D – 1 month	Arrange appropriate storage of IGR	National coordinator
D – 1 month	Initiate customs clearance IGR & equipment	FAO HQ & FAOR
D – 20 days	Recruitment other national staff	National coordinator & FAOR
D – 20 days	Rent of vehicles	National coordinator & FAOR
D – 16 days	Arrival insecticides and other equipment in country	--
D – 15 days	Insecticides and other equipment out of customs	National coordinator & FAOR
D – 15 days	Reception of experimental permit	National coordinator
D – 15 days	Initiate local purchase of equipment	National coordinator
D – 10	Identification of potential treatment locations	National coordinator
D – 7	Arrival international consultant	--
D – 7	Organize logistics discussions with PPD and aircraft company	National coordinator & international consultant
D – 6 to 4	Filed visits / identification definitive plot locations	National coordinator & international consultant
D – 4	Travel team and equipment to trial location	all technical staff involved
D – 3	Methodology session with entire team	all technical staff involved
D – 2	Work session with pilot / calibration aircraft (if needed)	National coordinator & international consultant & national application expert
D – 1	Collection pre-spray data	all field monitoring staff
D	Treatments	all staff
D + 28	Monitoring of plots	all field monitoring staff

The preparatory meeting with national locust control organization or PPD and with FAOR should deal with the following issues:

- Agreement on trial
- Legal requirements (experimental permit; customs formalities)
- Aerial contract possibilities
- Identification national coordinator
- Short list for national staff (recruitment/reimbursement modalities)
- Needs for outside recruitment
- Discussion equipment list (available for use; local purchase; international purchase)
- Vehicle rent possibilities
- Communication links between FAO HQ and the national coordination/PPD

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Annex 1 – Indicative calculations for flying hours

Plot size (ha)	**Number of barriers** (at 1000 m barrier spacing)	**Total barrier length to be sprayed** (at 1000 m barrier spacing)	**Total barrier surface to be sprayed** (at 100 m barrier width)	**Amount of insecticide needed** (at 1.7 L/ha)	
1600 (4x4 km)	4	16 km	160 ha	275 L	
Indicative flying hours per plot *[airstrip 100 km from plot; treatment and ferry speed 160 km/h]*					
Aircraft type	**max. hopper capacity***	**# sorties**	**spray time of plot** (hours)	**ferry time** (hours)	**total flying hours** (hours)
Turbo Thrush 510	1900	1	0.3	1.3	1.6
Air Tractor 401B	1500	1	0.3	1.3	1.6
Ag Truck 188	280	1	0.3	1.3	1.6

Plot size (ha)	**Number of barriers** (at 1000 m barrier spacing)	**Total barrier length to be sprayed** (at 1000 m barrier spacing)	**Total barrier surface to be sprayed** (at 100 m barrier width)	**Amount of insecticide needed** (at 1.7 L/ha)	
3600 (6x6 km)	6	36 km	360 ha	615 L	
Indicative flying hours per plot *[airstrip 100 km from plot; treatment and ferry speed 160 km/h]*					
Aircraft type	**max. hopper capacity***	**# sorties**	**spray time of plot** (hours)	**ferry time** (hours)	**total flying hours** (hours)
Turbo Thrush 510	1900	1	0.5	1.3	1.8
Air Tractor 401B	1500	1	0.5	1.3	1.8
Ag Truck 188	280	3	0.5	3.9	4.4

Plot size (ha)	**Number of barriers** (at 1000 m barrier spacing)	**Total barrier length to be sprayed** (at 1000 m barrier spacing)	**Total barrier surface to be sprayed** (at 100 m barrier width)	**Amount of insecticide needed** (at 1.7 L/ha)	
6400 (8x8 km)	8	64 km	640 ha	1090 L	
Indicative flying hours per plot *[airstrip 100 km from plot; treatment and ferry speed 160 km/h]*					
Aircraft type	**max. hopper capacity***	**# sorties**	**spray time of plot** (hours)	**ferry time** (hours)	**total flying hours** (hours)
Turbo Thrush 510	1900	1	0.7	1.3	2.0
Air Tractor 401B	1500	1	0.7	1.3	2.0
Ag Truck 188	280	4	0.7	5.2	5.9

* actual pesticide loads are generally lower, depending on the needed ferry time between airstrip and plot, and the length and condition of the airstrip.

Annex 2 – Indicative sampling regime

Presuming 3 replicate plots; underlined plots are pre-spray samples; unsprayed control plot is D

Type of sampling											**Day**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Treatment (plots A, B & C)		**A**	**B**	**C**																	
Hopper band observations	A	B D	C A	B D	C	A	B D	C	A	B D	C	A	B D	C	A	B D	C	A	B D	C	
Hopper band transects	A	B D	C A	B D	C	A	B D	C	A	B D	C	A	B D	C	A	B D	C	A	B D	C	
Mortality in cages (sampling after crossing of barrier)			A	B D	C	A	B D	C													
Caging for persistence			A	B D	C	A	B D	C	A	B D	C				A	B D	C				
Number of vehicles in the field	2	4	5	5	3	3	5	3	3	5	3	2	4	2	3	5	3	2	4	2	
Number of monitoring staff in the field	2	4	5	5	3	3	5	3	3	5	3	2	4	2	3	5	3	2	4	2	
Number of spray staff in field/airstrip	2	2	2	2																	
Number of staff at camp (cages)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

Presuming 2 replicate plots; underlined plots are pre-spray samples; unsprayed control plot is D

Type of sampling	**Day**																				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Treatment (plots A, B & C)		**A**	**B**																		
Hopper band observations	A	B D	A	B	D	A	B	D	A	B	D	A	B	D	A	B	D	A	B	D	
Hopper band transects	A	B D	A	B	D	A	B	D	A	B	D	A	B	D	A	B	D	A	B	D	
Mortality in cages (sampling after crossing of barrier)			A	B D		A	B D														
Caging for persistence			A	B D		A	B D		A	B D					A	B D					
Number of vehicles in the field	2	4	3	3	2	3	3	2	3	3	2	2	2	2	3	3	2	2	2	2	
Number of monitoring staff in the field	2	4	3	3	2	3	3	2	3	3	2	2	2	2	3	3	2	2	2	2	
Number of spray staff in field/airstrip	2	2	2	2																	
Number of staff at camp (cages)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	