Field evaluation of a test kit for monitoring insecticide resistance in stored-grain pests

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Abstract

A world survey of insecticide resistance of stored-grain pests, carried out by IRAC (Insect Resistance Action Committee of GIFAP) was published in 1990. One of the main factors governing good management practice of pesticides is the requirement for sound baseline data on the susceptibility of target pests to individual products. IRAC subsequently concentrated on developing practical methods for monitoring field resistance and details of the full series of tests were published in OEPP/EPPO Bulletin. Pioneering studies at Natural Resources Institute, U.K. led to the development of a modified FAO test for stored-grain insects, ideal for use in a monitoring kit.

The next stage was to test the reliability of the prototype test kit under practical field conditions. An IRAC-funded project was, therefore, undertaken by NRI to investigate the patterns of organophosphate resistance in grain beetles in three African countries using the test equipment. The results of this survey will be presented at the meeting. Progress in developing a related technique for monitoring resistance to pyrethroids is well-advanced.

Introduction

The development of a portable field test kit by the Natural Resources Institute (NRI, formerly ODNRI) now enables evaluation of major grain beetle pests for resistance to several organophosphorous insecticides without the need for laboratory facilities. This is achieved using the standard FAO technique (Anon. 1974), but with filter papers that have been pretreated with discriminating doses of insecticide. Treated papers have been shown to remain effective for six months when foil-wrapped and refrigerated. The reliability of the prototype test kit was tested under practical field conditions and this paper summarises the results of this survey. On the other hand, a program for developing a technique for monitoring resistance to pyrethroids is well advanced. The second half of this paper reports the evaluation of sensibility to deltamethrin of grain insect pests, using a specific treated paper disc.

Survey of the Field Testing of the Prototype Kit in Africa (Organophosphorous Insecticides)

Need for resistance tests programs

Few contact insecticides are cleared for use in postharvest storage. The increasing cost to chemical manufacturers of obtaining clearance suggests that new insecticides are unlikely to become readily available. Continued effectiveness of insecticides in present use is, therefore, highly desirable, and data on the resistance status of insect pests is of great importance in the maintenance of good pest management strategies. Early detection of resistance might permit avoiding or delaying action to prolong the effective life of an insecticide. Field testing in several African countries and in Southeast Asia has indicated that potential users having access to the test kit are much more likely to adopt resistance test programs than hitherto. Great interest has been expressed in the test kits by the IRAC Stored Products subcommittee, and close liaison with the committee has been maintained by NRI during the latter phases of the test kit development. An IRAC-funded project was, therefore undertaken by NRI to investigate the patterns of OP resistance in grain beetles in three African countries using the test equipment.

Description of the test kit

A standard technique recognised by FAO for detecting insecticide resistance in stored-product beetle pests has been available for many years, but little used, particularly in developing countries. A major constraining factor has been the preparation of standardised insecticide solution for application to filter papers on which insects are exposed.

An investigational program at NRI has demonstrated that the problems associated with local preparation of insecticide-treated filter papers may be overcome by supplying potential users with pre-treated papers. Papers in foil/plastic wrappers remain effective for six months when refrigerated. Thus, the kit is designed to permit detection of resistance without the need for laboratory facilities, but adopting much of the original FAO methodology.

Components of the test kit include:

- Foil/plastic packs containing: filter papers treated with discriminating doses of insecticide and filter papers treated with solvents only for control use.
- Plastic rings for containing insects on filter papers. These can be conveniently mailed without breakage, and re-used provided they are well washed and water-soaked overnight to remove adsorbed insecticide.
- Perforated plastic lids and fluon to restrain insects which may escape by flying or crawling vertical surfaces.
- Small brush or forceps for transferring insects.

Description of the field tests

The tests were run in 3 countries by the following organisations:

Ghana—Crops Research Institute Substations, Pokoase
Mali— OPAM Protection des Stocks, Bamamko
Zimbabwe—Grain Marketing Board , Harare.

Table 1 gives the details of insect species and insecticides used, and Table 2 the discriminating doses of each insecticide for each insect species.

Results and discussion

Tables 3, 4 and 5 give the results of the tests in each country. By far the most comprehensive test program has been under-

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taken by the Grain Marketing Board in Zimbabwe. Samples of *Tribolium castaneum* (Herbst) tested were from 9 separate locations and *Sitophilus zeamais* (Motschulsky) were sampled from 7 locations. Insects were collected in October–November 1991 and the resistance tests, which were replicated 3 times, undertaken in January 1992.

The origin of maize from which the insects were collected was varied. Some had been in central storage for up to 3 years, and treated with pirimiphos-methyl. Other maize had been recently received by the marketing board from communal areas and not necessarily treated with insecticides, although it is assumed that farmers in Zimbabwe do not treat maize with grain protectants.

S. zeamais from maize collected from communal areas were in some instances resistant to pirimiphos-methyl. Resistance of *Tribolium castaneum* to malathion is obvious in all tests.

The results from Mali at present are for 6 samples only of *T. castaneum*, collected from 6 different localities, and all infesting sorghum. The sample in which 29% mortality occurred in a test against fenitrothion was indicated to have come from a store where that chemical is regularly applied.

Interestingly, 99% mortality was obtained with pirimiphos-methyl on insects from this same store. Most *Tribolium* spp. samples have shown a high level of resistance to malathion.

The insects tested for resistance in Ghana were from five locations and there is some evidence of resistance of *Sitophilus* spp. to pirimiphos-methyl.

Progress in the Evaluation of a Resistance Testing Kit for Pyrethroids

Filter papers used for organophosphorous insecticides testing kits have proved to be unsuitable for pyrethroids, due mainly to the absorption of the active ingredients applied at very low rates, in the depth of the paper. Thus, specific paper discs, lined with an aluminium foil, were used. The tests were carried out by Roussel Uclaf's Cebat laboratory in Marseille

Table 1. Test program for resistance kits in Africa

Country	Species	Products		
		Malathion	Fenitrothion	Pirimiphos-methyl
Ghana	*Sitophilus zeamais*		x	x
	Tribolium castaneum		x	x
Mali	*Tribolium castaneum*	x	x	x
Zimbabwe	*Sitophilus zeamais*		x	x
	Tribolium castaneum	x	x	x

Table 2. Discriminating doses tested (in mg a.i. per m^2 of filter paper)

Insecticides	Insect species	
	Sitophilus zeamais	*Tribolium castaneum*
Malathion	–	130
Fenitrothion	208	130
Pirimiphos-methyl	520	182

Table 3. Tests carried out in Zimbabwe

	Insect sample no.	Mortalities in % (corrected Abbott)		
		Malathion	Fenitrothion	Pirimiphos-methyl
Sitophilus zeamais	1	-	100	45
	2	-	66	2
	3	-	97	9
	4	-	100	18
	5	-	96	21
	6	-	89	13
	7	-	100	41
Tribolium castaneum	1	17	100	100
	2	3	100	100
	3	26	100	99
	4	0	98	92
	5	3	97	98
	6	0	99	99
	7	3	100	100
	8	11	96	96
	9	6	97	96

Table 4. Tests carried out in Mali

	Insect sample no.	Mortalities in % (corrected Abbott)		
		Malathion	Fenitrothion	Pirimiphos-methyl
Tribolium castaneum	1	93	100	100
	2	41	100	100
	3	49	100	100
	4	1	100	100
	5	3	29	99
	3	-	-	78

Table 5. Tests carried out in Ghana

	Insect sample no.	Mortalities in % (corrected Abbott)		
		Malathion	Fenitrothion	Pirimiphos-methyl
Sitophilus zeamais	1	-	100	100
	2	-	100	100
	3	-	83	68
	4	-	98	99
	5	-	98	95
Tribolium castaneum	1	100	100	100
	2	-	100	50

Table 6. Percent efficacy after 1 hour exposure to Deltamethrin: observation at the end of exposure

Dose mg/m^2	*Oryzaephilus surinamensis*	*Sitophilus granarius*	*Tribolium confusm*
10	100	100	100
5	100	100	100
1	100	100	100
0.5	100	98	100
0.1	100	64	48
0.05	100	30	12
0.01	86	12	0
0.00	0	0	0

by M. Gohar, J.P. Trijau and J. Nicolas (Internal Roussel Uclaf report).

The discs were treated on the foiled side with acetonic solutions of deltamethrin and then dried.

Fifty adults of each insect species: *Oryzaephilus surinamensis* (L.), *Sitophilus granarius* (L.) and *Tribolium confusum* (Jacquelin du Val) were exposed to the treated surface for 1 hour. The insects were then transferred into clean chambers with untreated grain. Knocked-down and killed insects were counted at the end of the forced contacts and 24 hours and 14 days later. The results are summarised in Table 6. The evolution of the response to the contact test over the period of 14 days is different according to the species. *O. surinamensis* and *S. granarius* show a progressive increase of the lethal effect, up to 14 days. On the other hand, for *T. confusum*, the maximum effect is seen immediately after the contact, and is followed by a progressive recovery.

In every case, the response should be read after 14 days. The conclusion is that *O. surinamensis* is the most susceptible to deltamethrin followed by *S. granarius*, *T. confusum* being the least susceptible. Further studies on the device should be undertaken, aiming at a more accurate determination of discriminating doses, optimal exposure time and product stability on the disc surface.

Conclusions

The portable field test kit is perfectly suitable for the field evaluations of resistance to organophosphorous insecticides in developing countries with poor laboratory facilities. It is a very helpful tool to prevent the occurrence of resistance and implement in due time good pest management strategies.

Additional studies are required to develop a suitable kit for testing resistance to pyrethroids, adapted to the specific mode of action of this insecticide family.

Reference

Anon. 1974. Recommended methods for the detection and measurement of resistance of agricultural pests to pesticides. FAO Method No. 15. FAO Plant Protection Bulletin, 22, 127–137