HGCA

PROJECT REPORT No. 30

IMPROVING THE EFFECTIVENESS OF PITFALL TRAPS FOR THE DETECTION OF INSECT PESTS IN GRAIN

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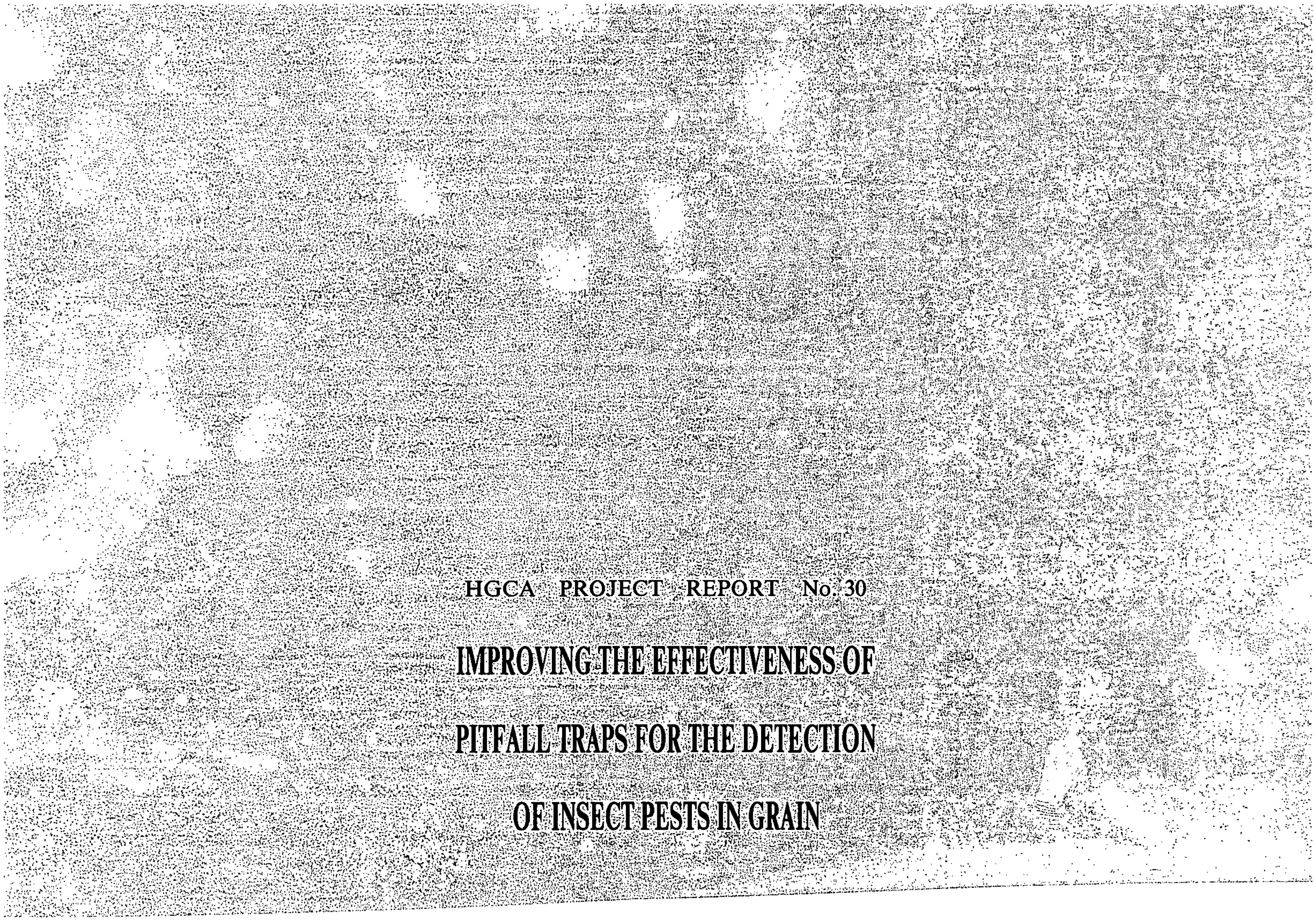

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Final report of a one year project which commenced in January 1988. The studies were carried out at the ADAS Central Science Laboratory, Slough and were supported by a grant of £5,340 from the Home-Grown Cereals Authority (Project No: 0102/2/87).

IMPROVING THE EFFECTIVENESS OF PITFALL TRAPS FOR THE DETECTION OF INSECT PESTS IN GRAIN

D.B. PINNIGER, P.M. COGAN, J. CHAMBERS, D.E. FINNEGAN AND C.P. MORGAN
ADAS Central Science Laboratory, London Road, Slough
Berks, SL3 7HJ

Abstract

The use of insect probe and pitfall cup traps for the detection of insects in grain bulks has been shown to be more efficient than 'traditional' methods of examination of spear or vacuum samples for insects. However, these traps have some limitations due to their cost and difficulties in use. A simple trap design of a perforated, covered pitfall cone trap was developed to replace both the probe and pitfall cup. Following pilot laboratory and practical trials a production design 'PC' trap was produced. Initial trials indicate that 'PC' traps are as good, if not better for the detection of the major pest species of grain insects than probe or pitfall cup traps.

A method to produce carob-derived volatiles for use in traps as a multi-species attractant has been refined and scaled up by a factor of 10, to provide sufficient material for testing in traps. Attention has now been directed to work on formulation development in order to increase lure life.

Objectives

1. To develop a covered pitfall trap for detecting insects in grain bulks and to test the performance of prototype designs. To produce sufficient numbers of the most effective design and evaluate this trap in pilot laboratory and practical trials.

2. To obtain sufficient food attractant to enable lures to be produced which can then be evaluated in the new traps.

Introduction

Early warning of insect presence in grain bulks is an essential component of effective storage strategies. It has been shown that the use of pitfall cup traps and probe traps can result in much more efficient detection of the major beetle pest species when compared to 'traditional' methods of examination of spear or vacuum samples (Cogan and Wakefield 1987, Pinniger *et al.* 1986).

Although the traps are effective, they have limitations because differences in behaviour and distribution in grain between beetle species means that both types are needed to ensure that infestation of saw-toothed grain beetle (*Oryzaephilus surinamensis*), grain weevil (*Sitophilus granarius*) and the flat grain beetle (*Cryptolestes ferrugineus*) are detected at an early stage.

Probe traps are expensive (£10-12 each) compared to pitfall cup traps but the latter are extremely difficult to use in sloping grain bulks where they tend to fill up with grain and are rendered ineffective or lost altogether. Our objective was to design a trap to combine the best features of probe and pitfall traps and at the same time remove the problems of use and lower the cost per trap. The basic premise was therefore a perforated cover on a pitfall cup.

Experience with other trap types in food processing environments has shown that the presence of food or pheromone lures can greatly enhance the effectiveness of trap catch (Cogan and Wakefield 1987, Chambers 1991, Pinniger 1991). Since grain infestations may consist of several species, each of which uses a mixture of pheromone components, (Pinniger and Chambers 1988) it is very unlikely that grain beetle pheromones will be cost-effective for use in traps in grain bulks. However, the multi-species attraction which has been shown by carobs and carob-derived volatiles gives some encouragement to the potential of food based lures in grain traps (Pinniger and Wildey 1975, Pinniger 1991). Earlier work on the capture of food volatiles from carobs (Chambers 1987) showed that it was possible to obtain usable material but that the process would need to be refined and scaled up to provide sufficient material for testing in traps. It was also clear that some form of formulation development would be necessary to provide a practical lure for use in traps.

<u>Materials and methods</u>

Trap development

To establish the validity of the principle of a covered pitfall, existing 'beer glass' pitfall traps were fitted with a lid made of perforated wire mesh with 2mm apertures which allowed entry of insects but prevented grain filling the trap. A list of basic requirements was then drawn up to provide the parameters for trap designs.

1. Effectiveness in trapping insects.
2. Effectiveness in excluding grain

3. Ease of insertion and withdrawal from bulks.
4. Ease of removal and replacement of lid.
5. Robustness of trap construction.
6. Cost of trap materials.
7. Cost of trap tooling.
8. Ability to incorporate a lure in the future.
9. Portability in respect of weight and size.

In order to meet requirements 5 to 9 it was decided to hold discussions with plastic moulding engineering firms to obtain expert advice on the choice of materials and moulding methods. It then became clear that the requirements for manufacture of production traps involved expensive tooling costs for injection moulding and it would be difficult to change the design substantially without having to retool the moulds. Preliminary designs of traps would therefore have to be evaluated on the basis of traps produced using a pilot process of vacuum forming with different plastic for the both trap body and lid.
Following consideration of a number of candidate designs the pitfall cone (PC) format was chosen for pilot studies and traps were produced by F & B Engineering Ltd as shown in figure 1. White vacuum formed polystyrene was used for PCI traps (Fig 1.1). The lids were drilled with 184 holes (2.5 - 2.9 mm diameter) in 7 concentric rings with a 15mm diameter central area devoid of holes.

A further series of traps designated PCII were produced using the same process but with 308 holes in 8 concentric rings in the lid (Fig 1.2). The hole size was more variable ranging from 1.9 to 2.5mm diameter. Evaluation of this trap confirmed that the actual trapping area represented by the number of holes and their total cross sectional area was insufficient. A decision was therefore taken to increase the overall trap size to 90mm diameter with 430 holes 2.1 - 2.5 mm diameter in 9 offset concentric rings achieved by use of a continuous numerical control machine. This trap is designated PCIII (Fig 1.3). Although the top of this trap presented a larger trapping area to the insects, the underside of the trap top was noticeably rougher than PCI and PCII. Knowing the limitations of pre-production trap materials the experience of this trap in the laboratory and field tests was sufficient to encourage us to make the decision to adopt this design for the first production run designated PCIV, trap materials being clear polystyrene for the cone and red polypropylene for the lid (Figure 1.4).

Evaluation of this production PC trap is still proceeding in the laboratory and commercial grain stores.

Lure development

Two complete sets of the large scale apparatus have been constructed to scale up the process of collection of volatiles from kibbled carobs and provide greater quantities of material for testing in lures.

Results

Trap Development

1 Laboratory Tests

The test method was as described by Cogan and Wakefield (1987) using 230 litre plastic bins each containing 150kg of wheat and four species of insects, saw-toothed grain beetle (*Oryzaephilus surinamensis*), grain weevil (*Sitophilus granarius*) flat grain beetle (*Cryptolestes ferrugineus)* and foreign grain beetle (*Ahasverus advena*). Insects were introduced at a rate of 3 adults/kg 3 days before placement of trap either level with the surface of the grain or buried 100mm or 200mm below the surface. After 3 days the traps were removed and the insects counted. The PC traps were compared to commercially obtained pitfall 'beer glass' traps and probe traps. All traps were treated with a coating of non-stick PTFE emulsion (Fluon Tm) to prevent insects escaping.

Table 1 shows the trapping results from production PCIV traps at the surface and at 100 mm depth compared to pitfall and probe traps.

Tests were conducted in an experimental room at 50-60% humidity with some control over temperature. Temperatures recorded during the tests covered a range of 21°-25°C.

TABLE I

Mean ± SE n= 3

	PCIV (Surface)	PCIV (100mm)	Pitfall (200mm)	Probe
Oryzaephilus surinamensis	32.67±8.84	13.00±3.06	10.00±4.62	11.67±2.4
Sitophilus granarius	20.00±3.79	15.00±6.43	50.3±14.0	26.00±9.85
Cryptolestes ferrugineus	2.00±2.00	13.67±0.88	0.67±0.67	2.67±2.19
Ahasverus advena	93.7±26.1	40.0±11.3	64.70±27.20	33.00±13.00

2. Field Tests

Two sites were chosen for field evaluation of the prototype PCIII trap and one for the commercial PCIV version.

Sites 1 and 2 were ex aircraft hangars containing bulk floor-stored barley in which low level infestations of *Sitophilus granarius* had previously been detected using probe and pitfall traps.

At each site 5 trapping positions were set up 1 metre apart. At each position traps were tied to a central cane. Traps were placed 180^0 apart 0.25m from the marker cane and consisted of either pitfall and probe or 2 PC traps (one at surface, one buried 150mm). At each trap inspection the positions of the pairs of traps were exchanged.

Site 3 contained 10,000 tonnes of barley which had been recently been discovered to be infested with lesser grain borer (*Rhyzopertha dominica)* and heating to over 35°C. Production PCIV traps on the surface and buried at 100 mm depth were compared to probe traps.

Lure development

With the newly constructed apparatus it has been possible to isolate carob volatiles on a scale ten times larger than previously. The extract from the large-scale apparatus was compared with an extract at the same concentration obtained earlier from the small-scale apparatus. The two extracts were found to be qualitatively similar to each other. There are however some quantitative differences but the significance of these has yet to be assessed.

Evaluation of carob volatiles by bioassay using *Oryzaephilus surinamensis* has shown that material placed on rubber septa is attractive to the beetles but has a short life (Table V). Further bioassays will be conducted subsequent to progress on formulation development to increase lure life.

<u>TABLE II</u> **Field evaluation of PCIII**

Site 1: 6800T Barley from the 1987 harvest put in store May 1988 with a mean depth of 7m.

Total *S. granarius* trapped

Week	Pitfall	Probe	PC III surface	PC III buried
1	1	0	0	0
2	1	0	0	0
3	14	6	2	1
4	12	0	1	2
5	4	20	6	0
6	4	0	8	3
7	9	5	6	0
8	4	0	3	3
9	16	12	6	0
10	2	0	0	0
TOTAL	67	43	32	9

<u>TABLE III</u> **Field evaluation of PC III**

Site 2: 9000T of Barley from the 1986 harvest and put in store May 1987 with a mean depth of 7m.

Total *S. granarius* trapped

Week	Pitfall	Probe	PC III Surface	PC III Buried
1	3	0	0	0
2	2	0	1	0
3	5	0	3	0
4	2	0	0	0
5	1	0	0	0
6	1	0	1	0
7	0	0	0	0
8	0	0	0	0
9	0	0	1	0
TOTAL	14	0	6	0

<u>TABLE IV</u>

Site 3. Field evaluation of the PC IV trap
10677T of Barley from the 1987 Harvest and put in store late 1988

Traps left for 1 week

Ambient temp 12° Max

Position	Number of *R. dominica* PC IV Trap Surface	PC IV Trap Buried	Probe Trap
A	0	16	6
B	1	104	20
C	-	7	4
D	-	0	0
E	-	9	2
F	0	1	0
	1	137	32
Positions where *Rd* located	1	5	4

Max temp in bulk between A & B 39°C.

Temp probe recorded 24°C near position A when the traps were examined.

TABLE V

RESPONSE OF *ORYZAEPHILUS SURINAMENSIS* TO RUBBER SEPTA TREATED WITH CAROB VOLATILES

Summary of single pitfall assay results, each figure is a mean of five replicates of 20 *O.surinamensis*. Placement of replicates randomised. 5 μl of carob material per treatment.

Bioassay time (hrs)	% response		
	Pentane control	Carob (Nxl)	
0	28	78	*** 0.001.P
8	32	76	*** 0.001.P
24	28	61	** 0.01.P
72	37	44	NS P. 0.05

Discussion

The major objectives have been achieved in both areas of the project. It is clear that we had underestimated the importance of the number of apertures in the trap tops. With the benefit of hindsight, a clear relationship between trap efficiency and total cross sectional area of aperture available for trapping insects should have been established at the beginning of the project. However, our approach of pilot trap designs which were produced using techniques which could easily be modified in the light of results meant that we were not faced with expensive tooling costs when changes were needed. The results obtained with the initial trap designs were very variable in part because of variation between individual and prototype traps, but the work showed that overall the PC traps had a similar performance to existing traps.

Because of limitation of time and resources for this project, rather than obtain further data on pilot designs made from pre-production materials, a decision was taken to proceed with a production design (PCIV) based on the experiences of using the PCI, II and III in laboratory and field experiments. Although the full results from the evaluation of the PCIV trap are not yet available, the initial indications are that the trap can be used to replace both pitfall and probe traps for the detection of the four major species of grain beetle pest found in the UK. An additional bonus is that the results from the field trial at the site infested with *Rhyzopertha dominica* shows that the PCIV trap performed much better than probe traps against this species. This result has important implications for the use of PC traps in countries where this insect species is a serious pest.

It seems likely that the results from further tests will confirm that the PC is as good if not better than probe or pitfall traps and this will simplify the recommendations for trap use in UK grain stores as one trap type can be used with confidence of trapping the major pest species. The PC trap is now commercially available from CSL, Slough.

We now have the facility to produce sufficient quantities of food-derived volatiles for large-scale tests.

At the start of this work, the only bioassay results were from the preliminary tests to establish the need for a long-life lure. Collaboration with AgriSense-BCS and access to technical expertise in formulation chemistry from Dow Corning has resulted in encouraging developments in recent months. Considerably more input must be invested to develop this formulation into a lure which can be incorporated into traps on a commercial basis.

The benefits to the UK grain industry by the adoption of PC traps will result from the simpler strategy of a single type of trap which is easy to use in practice for monitoring all grain bulks. These features should encourage greater adoption of the trap by commercial grain stores and farms and this should improve early detection of pests. It should then be possible to increase the quality of grain stored in the UK without increasing pesticide use on grain.

Development of an attractant lure for use in these traps will increase their ability to detect pests and if this development is accompanied by guidance on storage strategies related to trap catch then a further increase in grain quality could be achieved with less pesticide use.

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FIGURE 1. DEVELOPMENT OF PC TRAPS

1 - PC 1 2 - PC II 3 - PC III 4 - PC IV