PC, A NOVEL AND INEXPENSIVE TRAP FOR THE DETECTION OF BEETLE PESTS AT LOW DENSITIES IN BULK GRAIN.

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ABSTRACT

There is an established need to use two trap types, surface pitfall and insect probe trap, for the effective monitoring of beetle pests in grain bulks, but for a number of reasons the use of both traps has not been adopted by the grain trade. To overcome these problems, a PC trap has been developed to replace both of the previously recommended traps. Evaluated in the laboratory and in 20 tonne bins, the PC trap buried to a 5cm depth in grain was as effective as the insect probe trap for the detection of *Oryzaephilus surinamensis* and *Cryptolestes ferrugineus* and in the field for *Rhyzopertha dominica*, although not as effective as the surface pitfall trap for trapping *Sitophilus granarius*. It is recommended that at least 2 surface PC traps and one buried PC trap are used to replace the surface pitfall and insect probe traps. Use of PC traps should result in a saving of 50 percent on the current cost of monitoring U.K. grain bulks compared with using both of the previous types of trap.

INTRODUCTION

The use of traps for the detection of insect pests in bulk grain has been shown to be superior to conventional methods which involve either grain spears or vacuum samplers to obtain grain samples which are then sieved and inspected for insects (Wright and Mills, 1984, Cogan and Wakefield, 1987). Cogan *et al*, (1985) using a combination of surface pitfall trap and insect probe trap (Burkholder, 1984) found that these traps were at least ten times as sensitive as conventional methods, for the detection of beetle pests in U.K. bulk floor-stored grain.

Cogan *et al* (1985) and Cogan and Wakefield (1987) found that the surface pitfall most effectively trapped *Sitophilus granarius* while the insect probe trap was most effective for trapping

Cryptolestes ferrugineus. As grain bulks are likely to be infested by any of a number of beetle species (Chambers, 1987) including the above, both trap types are recommended to be used for detection of storage beetles.

Insect probe traps are widely used in N. America (Barak and Harein, 1982, Fargo *et al*, 1989) and in the UK (Muggleton and Prickett, 1990) but surface pitfalls are regularly used only in the U.K., Germany and most recently in Australia (Jane Wright, personal communication).

A recent survey of commercial stores (Muggleton and Prickett, 1990) established the dominance of insect probe traps in the U.K. market, despite the second major grain beetle pest (*S.granarius*) being more effectively trapped by pitfall traps.

The reluctance of the grain trade to use pitfall traps and to use both trap types stems from a number of factors:

a) Companies sell only one trap type or heavily promote the more expensive insect probe trap.
b) The insect probe trap is more marketable as a trap because the surface pitfall is perceived as a 'drinks container', i.e. it has a poor perceived value (Jones, 1987).
c) Storekeepers are reluctant to use, or reluctant to buy, more than one trap type.
d) The pitfall trap can only reliably be used on flat grain surfaces. Sloping grain may fill the trap rendering it useless.

As both surface pitfall and insect probe traps provide, in combination, the most effective means for detecting storage beetles in bulk grain, and for reasons stated above they are not being used, there appears a need for a single trap which combines the qualities of both traps. We therefore aimed to produce a suitable replacement trap and evaluate it in both the laboratory and field.

MATERIALS AND METHODS

A list of basic requirements were drawn up to provide the parameters for trap design.

1) Effectiveness in trapping insects.
2) Effectiveness in excluding grain.
3) Ease of insertion and withdrawal from grain 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 into the trap.
9) Portability in respect of weight and size.
10) Customer appeal (good perceived value).

In order to meet the requirements 5 to 9, discussions were held with plastic moulding engineering firms to obtain advice on the choice of materials and moulding methods. Following consideration of a number of designs, a pitfall cone (PC) format (Figure 1.) was chosen for pilot studies. The final design, which has been filed for patent (Cogan and Pinniger, 1989), consisted of a 90mm diameter lid, constructed of vacuum-formed red polypropylene and a base made from clear polystyrene. The lid was drilled with 430 holes, 2.1-2.5mm diameter in 9 offset concentric rings achieved by the use of a continuous numerical control machine. A central area 22mm in diameter was left without holes, so as to provide a location for a future lure.

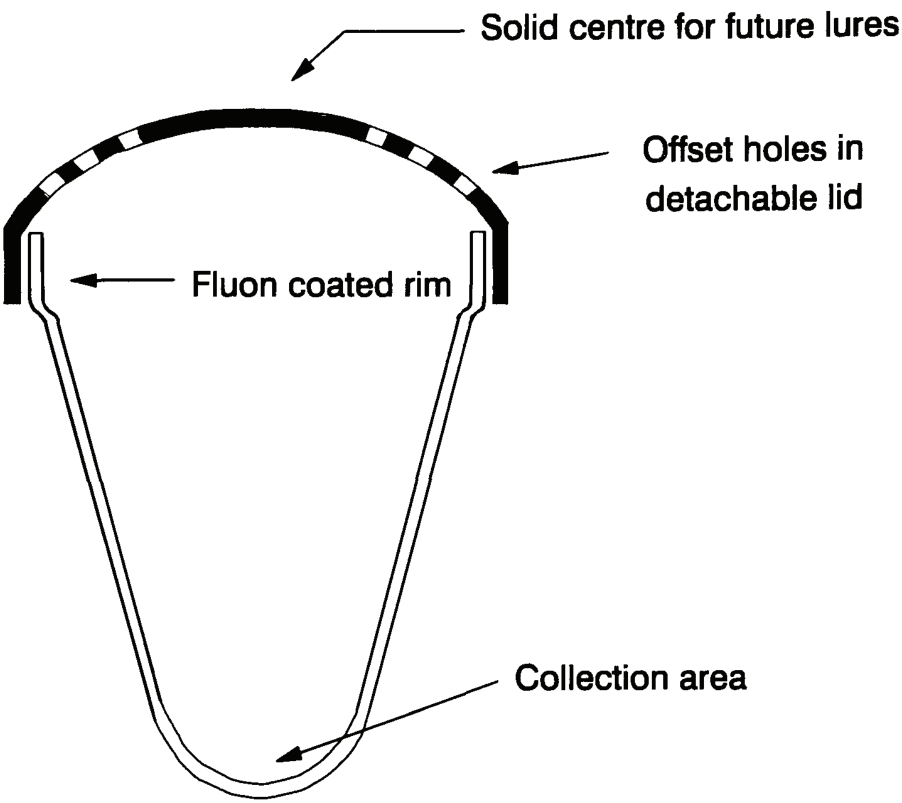

FIGURE 1. CROSS SECTION OF A PC TRAP.

The PC trap design was tested in the laboratory following the method described by Cogan and Wakefield (1987) using 230 litre plastic bins, each containing 150kg of wheat and one of 3 species of beetle; *Oryzaephilus surinamensis*, *S.granarius* and *C.ferrugineus*. Insects were introduced at a rate of 3/kg, 3 days before placement of the traps. Insect probe traps and surface pitfall traps were compared with PC traps placed approximately 5cm beneath and also upon the grain surface. Traps were tested individually, that is one trap type per bin, not in competition with each other. Trap catches were recorded after 3 days. All traps were treated with a coating of non-stick PTFE emulsion (Fluon Tm) to prevent trapped insects escaping.

A second series of tests was carried out in three 3 x 3 x 3.5 metre 20 tonne bins filled with barley. Each bin had been seeded with *O.surinamensis* and *S.granarius* at 1/kg plus *C.ferrugineus* at 0.5/kg as part of work on integrated control of insect pests in stored bulk cereals (Cogan *et al*, 1990). Each bin was trapped using a 4 x 4 grid (16 positions) across the surface at approximately 0.75 metre intervals with traps no closer than 0.25 metres from the edges of each bin. At each trap position a pitfall, insect probe and two PC traps were placed in the grain at the four cardinal points, approximately 0.33 metres from the marker cane. One PC trap was buried about 5cm below the grain surface while the other was placed level with the surface. Traps were sited so that at adjacent trapping positions the same trap type was moved through 90 degrees (from north to east, east to south etc), thus giving in each bin, 4 replicates of each trap in a north, east, west and south position. Traps were inspected after one week and numbers of insects trapped were recorded.

Finally, the performance of the PC traps was evaluated in two bulk floor stores. In one store, 1000 tonnes of barley was found to be infested with *Rhyzopertha dominica*. Eight PC traps and 8 insect probe traps were positioned on the sloping grain surface. The PC traps were buried at approximately 10cm depth as the surface temperature of the grain was below 10^{o}C whereas the temperature of the grain at approximately 1 metre was in excess of 35^{o}C. The traps were examined for insects after one week and then at approximately monthly intervals. The second evaluation was undertaken in a store containing 1600 tonnes of wheat infested with *S.granarius*. Five PC and 5 pitfall traps were placed in the surface of the grain, each pair tied to a marker cane 180 degrees apart, and examined weekly for 10 weeks. At each inspection, the position of each pair of traps was exchanged.

RESULTS

Table I. Laboratory evaluation of the PC trap. Bins filled with 150kg wheat and seeded with insects at 3/kg. Traps inspected after 3 days. Means and standard errors of 10 replicates.

Species trapped	MEAN CATCH PER TRAP +/- S.E.			
	PC buried	Insect probe trap	PC surface	Pitfall
O.surinamensis	22.1+/-3.0^{a}	14.5+/-2.2^{b}	9.6+/-2.0^{bc}	5.8+/-1.7^{c}
S.granarius	8.0+/-1.2^{a}	8.1+/-0.8^{a}	7.7+/-1.8^{a}	26.8+/-2.9^{b}
C.ferrugineus	10.3+/-2.0^{a}	3.8+/-0.6^{b}	1.4+/-0.8^{c}	1.8+/-0.4^{c}

Means followed by the same letter in each row do not differ significantly, P = > 0.05 (t-test).

Results of the laboratory trial are presented in Table I. The buried PC trap caught significantly more *O.surinamensis* and *C.ferrugineus* than the other traps (P = > 0.05, using two sample t-test). The surface pitfall trap was most effective for trapping *S.granarius* (P = > 0.05, two sample t-test) while the other traps were equally as effective as each other.

The bin trial results (Table II) show that the buried PC trap performed as well as the insect probe trap for trapping *O.surinamensis* and as well as the pitfall trap for *S.granarius*. There was no significant difference in mean trap catch for *C.ferrugineus* for all the traps except the surface pitfall which failed to trap any of this species.

Table II. Bin evaluation of PC trap. Three 20 tonne bins filled with barley. Each bin seeded with *O.surinamensis* and *S.granarius* at 1/kg plus *C.ferrugineus* at 0.5/kg. Mean trap catch per bin +/- SE for PC, surface pitfall and insect probe traps (n=48) examined after one week.

Species trapped	MEAN CATCH PER BIN +/- S.E.			
	PC buried	Insect probe trap	PC surface	Pitfall
O.surinamensis	66.0+/-19.9^{a}	55.7+/-33.2^{ab}	15.3+/-3.7^{b}	7.3+/-2.0^{c}
S.granarius	9.3+/-2.9^{a}	4.0+/-1.0^{b}	2.3+/-0.9^{b}	10.0+/-2.0^{a}
C.ferrugineus	4.3+/-3.0^{a}	1.7+/-0.7^{a}	1.7+/-1.2^{a}	0^{b}

Means followed by the same letter in each row do not differ significantly, P = > 0.05 (t-test).

Table III. PC trap evaluation in bulk floor stores. a) 1000 tonnes of barley infested with *R.dominica*. Eight PC buried and insect probe traps monitored 4 times during a 5 month period. b) 1600 tonnes of wheat infested with *S.granarius*. Five PC and surface pitfall traps monitored weekly for 10 weeks.

Species trapped	TOTAL TRAP CATCH.			
	PC buried	Insect probe trap	PC surface	Pitfall
a) *R.dominica*	161	55	NT	NT
b) *S.granarius*	NT	NT	32	67

NT = Traps not tested.

When evaluated in commercial grain stores, the buried traps were easy to insert and remove from the grain and little material and no grain entered the traps. The PC traps were easy to transport across the grain surface as both the basal cone and trap tops were easily stacked within each other. Table III shows the results from the two field evaluations. Few insects were trapped, so total trap catch is presented. It can be seen that almost three times as many *R.dominica* were trapped in the buried PC traps compared with the insect probe trap whilst twice as many *S.granarius* were trapped in the surface pitfall trap compared with the PC trap.

DISCUSSION

The PC trap has proved to be an effective means for the detection of storage beetles in grain. The requirements for a trap to replace both the insect probe trap and surface pitfall trap were that it should perform as well, but not that it should necessarily out-perform both traps. In each of the three evaluations (laboratory, bin and field) the buried PC trap performed as well as the insect probe trap and significantly better in the laboratory 150kg bin tests for *O.surinamensis* and *C.ferrugineus*, whilst 3 times as many *R.dominica* were trapped in the field evaluation. The buried PC trap was more effective trapping *C.ferrugineus* than the insect probe trap in the laboratory experiments which is surprising, as the original design of the insect probe trap was specifically for the detection of this species (Loschiavo 1974). The surface PC trap was not as effective as the surface pitfall trap for detecting *S.granarius* but was as effective as the insect probe trap for this species. It must be remembered that the PC surface trap may be positioned on sloping grain surfaces and is therefore more versatile than the surface pitfall. The ability to place the surface PC trap on sloping grain enables more grain surfaces, particularly small grain heaps to be monitored. The sloping surfaces of grain surcharged above grain walling, amounting to 85 percent of commercially stored grain in the U.K. (Muggleton and Prickett, 1990), will also be able to be monitored more effectively using the PC trap. The benefit of trapping more of the surfaces of grain bulks was shown in the trapping results in a recent survey of commercial grain stores in the U.K. (Cogan, 1990). In stores where both surface pitfall and insect probe traps were used 52 percent of *S.granarius* and 6 percent of *C.ferrugineus* populations (one or more insects) were detected by the surface traps alone. These figures indicate that PC traps on the surface of grain should be increased in number to compensate for their poorer performance against *S.granarius* than surface pitfalls, but a positive benefit may be that they detect *C.ferrugineus* populations which might remain undetected by insect probe traps. The PC trap has proved to be a suitable candidate for replacing the use of two trap types in bulk grain monitoring. The trap satisfies conditions 1 to 10 outlined in the Materials and Methods section of this paper. The relatively poor trapping results for *S.granarius* may be offset by increasing PC trap numbers on the surface possibly using two surface PC traps where currently one surface pitfall would be employed. As the cost of the PC trap is envisaged to be similar to the cost of surface pitfalls this would mean an additional expenditure for the effective monitoring of grain surfaces. Offsetting this additional cost is the saving to be made by replacing the insect probe traps with buried PC traps. Currently the insect probe trap is approximately 5 times the proposed cost of the PC trap, which would result in a considerable net saving, probably 50 percent, in the overall cost of monitoring a grain bulk in the UK.

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LE "PC", UN NOUVEAU PIEGE BON MARCHE SERVANT A LA DETECTION DES FAIBLES DENSITES DE COLEOPTERES RAVAGEURS DANS LE GRAIN EN VRAC.

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RESUME

L'emploi des pièges statiques ne cesse d'augmenter pour remplacer les échantillonneurs de grain et les échantillonneurs aspirants dans la détection des insectes dans les stocks de grains en vrac immobiles. Afin de piéger les principales espèces de déprédateurs du Royaume-Uni, on recommande habituellement deux sortes de pièges (du type sonde perforée et entonnoir). On décrit un nouveau piège "PC" bon marché testé à la fois en laboratoire et sur le terrain, pour remplacer les deux autres. On a trouvé qu'un piège PC placé au niveau de la surface du grain et un autre enfoui à 30 cm de profondeur à l'intérieur de ce grain en formant un réseau idéal de pièges, à 4 mètres d'intervalle les uns des autres dans tous les sens, étaient aussi efficaces que les 2 pièges conventionnels utilisés dans les même conditions. Pour les stocks de grain en vrac plus petits, ou les cellules d'accès difficile, on peut utiliser un seul PC de surface et un seul PC enfoui.

Ces pièges sont faciles à transporter, simples à employer et sont des outils utiles pour la détection précoce des insectes ravageurs dans les stocks de grains en vrac. Des emplacements ont été prévus afin d'y placer plus tard de la nourriture et des leurres à phéromones.