NON-UNIFORM APPLICATION OF GRAIN PROTECTANTS IN COMMERCIAL STORAGES

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INTRODUCTION: Distribution of insecticide amongst grains has an important bearing on the efficacy and persistence of the insecticide applied to stored grain (1-4). Laboratory experiments and field trials have demonstrated that controlled non-uniform treatment of wheat with malathion and conventional spraying aimed at treating all grain uniformly, were initially equally effective against insects but that greater persistence of the non-uniform treatment had the advantage of extending the period of protection during storage (5, 6).

In a successful field trial (6) the method used for applying the malathion non-uniformly to the grain was cumbersome. A trial was therefore undertaken to assess whether a gravity feed technique for applying the insecticide non-uniformly to the grain would be commercially acceptable. The insecticide used consisted of a mixture of fenitrothion and bioresmethrin, which has replaced malathion as a standard grain treatment in Australia.

MATERIAL AND METHODS: The trial was carried out in North East Victoria, Australia, using vertical steel bins with conical roofs and flat concrete floors, each with a capacity of 1,700-1,800 t.

An insecticide mixture of fenitrothion (100% $^{W}/v$) and bioresmethrin (5% $^{W}/v$) with piperonyl butoxide (40% $^{W}/v$) was applied to Australian Standard White wheat at a rate of approximately 12 mg/kg of fenitrothion, 1 mg/kg of bioresmethrin, and 10 mg/kg of piperonyl butoxide (a synergist for bioresmethrin). Two methods of application were used; a conventional spray treatment, using a water emulsion of the insecticides in a pressurized spray system, and an experimental non-uniform treatment using the insecticide mix in concentrated form applied by gravity feed from a 100 l tank fitted with a constant head device (Fig. 1). Insecticide flowed from the tank through a short tube to the application nozzle. The flow rate at the nozzle was adjusted by a clamp, usually set to deliver 64.0 ml/min to match an estimated grain flow rate of 120 t/h. The insecticide flow was switched on and off by a solenoid valve operated by a microswitch linked to a control bar resting on a rubber flap which in turn rested on a conveyor belt. When wheat flowed along the belt, the flap and control bar were raised, thereby activating the microswitch and the insecticide mixture was released as a continuous flow. This equipment cost (1977) approximately A$580.00, and installation estimated at A$120.00, making a total cost of A$700.00

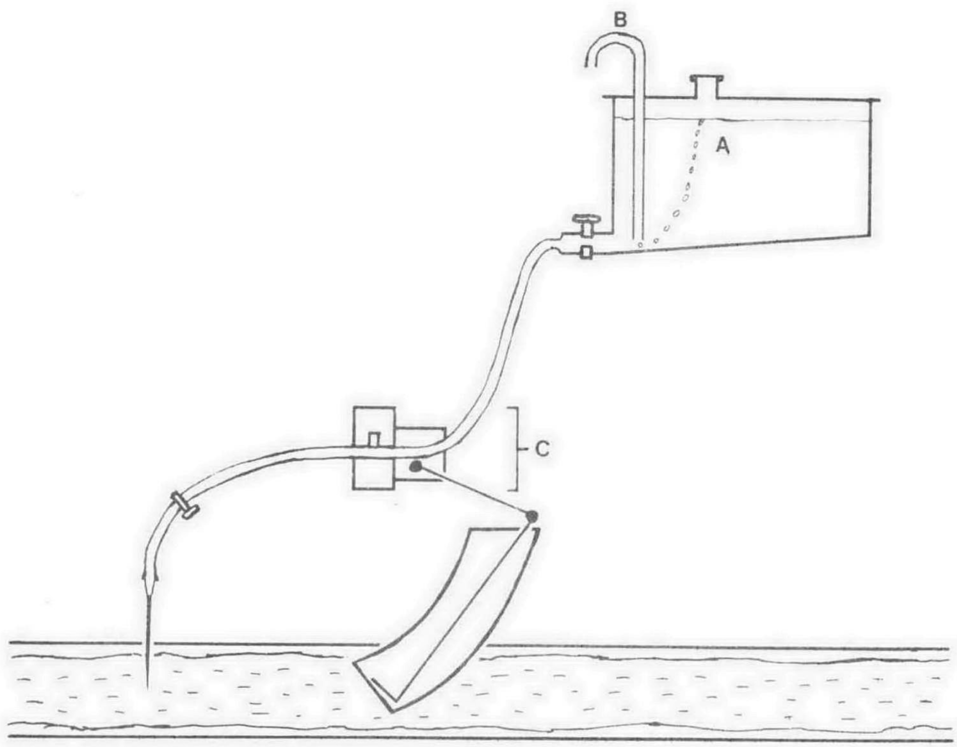

Figure 1. Plan of equipment used to apply a controlled non-uniform treatment of concentrated insecticide to wheat

Treatments were applied to the grain on the conveyor belt at the base of the silos, the treated grain being carried up an elevator to a conveyor belt above the silos and thence through chutes into the silos.

Wheat samples (4 kg each) for biological and chemical assay were taken from the bins immediately after treatment and approximately 6 months later. The samples were collected with a Probe-a-vac suction probe at a depth of 3 m below the surface at the centre, northern and southern sides of the bin.

Chemical analyses for insecticide residues were carried out using a G.L.C. Grain temperatures were measured with a thermocouple probe and moisture content of wheat samples was determined by loss of weight on drying 2 g of ground wheat for 1 hour in an oven at 130°C.

For each treatment bioassays were carried out on three replicate groups of 100 adults of *Rhyzopertha dominica* F., *Sitophilus oryzae* (L.), and *Tribolium castaneum* (Herbst) exposed in grain samples for seven days. Malathion resistant strains of the three species and malathion susceptible strains of *R. dominica* and *S. oryzae* were used in the bioassays.

RESULTS AND DISCUSSION: During the trial, grain temperatures ranged from 5°-35°C at the surface and from 30°-32°C within the bulk (3 m below surface) in both bins.

Results of the chemical analyses carried out on 100 g wheat samples are shown in Table I. The initial levels of fenitrothion on the wheat were similar in both treatments, but after 6 months' storage there was an indication of greater persistence of fenitrothion resulting from the experimental treatment. To determine insecticide distribution on the wheat more precisely than could be achieved from the 100 g samples, 30 sub-samples, each of 10 g, were taken from each treatment and assayed for fenitrothion. Mean levels of 9.2 and 9.0 mg/kg were obtained for the conventional and experimental treatments, respectively. Variation in residue levels was, as expected, significantly greater in the experimental treatment ($P = 0.002$), and was believed to be responsible for the greater persistence of the fenitrothion in the experimental treatment after 6 months' storage (Table I).

Both the conventional and experimental treatments were very effective against insecticide resistant and susceptible strains of *R. dominica* and *S. oryzae* throughout the 6 month storage period (Table II). Although the levels of bioresmethrin in the samples taken from the conventional treatment were lower than expected, the treatment was still effective against *R. dominica* (bioresmethrin being incorporated into the insecticide mixture specifically to control this species). There was no sign of the effectiveness of the conventional treatment decreasing during the storage period as can occur with malathion when used against susceptible insects (6).

Both conventional and experimental treatments were not effective against *T. castaneum* as revealed by bioassays (Table II). However, it is worth noting that the strain of *T. castaneum* used was known to be resistant to a wide range of different insecticides, including organophosphates and chlorinated hydrocarbons (7). This strain did not originate, and no such strain has yet been found, in Victoria where the vast majority of resistant *T. castaneum* possess the malathion specific type of resistance.

Although both conventional and experimental treatments were equally effective against *R. dominica* and *S. oryzae*, there are considerable advantages inherent in the technique for applying the insecticide concentrates non-uniformly to the grain. The apparatus required is simple, requires no pumps and can be easily installed. Moreover, there is no need of water for mixing the insecticide emulsions as concentrates are used, and therefore water storage tanks, pumps, and other accessories, are not required. Thus, maintenance and running costs can be expected to be considerably lower than those for equipment used for

TABLE I. Chemical analyses of grain samples from 3 m below grain surface in bins of wheat subjected to conventional and experimental non-uniform treatments with an insecticide mixture of fenitrothion and bioresmethrin

		Moisture content (wet basis) %	Bioresmethrin (mg/kg)	Fenitrothion (mg/kg)
Initial assay after treatment	Conventional	10.2	0.23	10.6
	Experimental	9.3	1.4	10.8
Assay after 6 months storage	Conventional	10.2	*	5.6
	Experimental	11.1	*	9.4

*Results of analyses not yet available.

TABLE II. Percentage mortality of malathion resistant (*) and susceptible strains of stored product beetles exposed for 7 days in wheat samples taken from conventional and experimental non-uniform treatments with an insecticide mixture of fenitrothion and bioresmethrin

		R. dominica		*S. oryzae*		*T. castaneum*
		CRD 118*	VRD 15	CSO 231*	VSO 11	CTC 12*
Initial assay after treatment	Conventional	100.0	100.0	100.0	100.0	42.6
	Experimental	100.0	100.0	100.0	100.0	02.0
Assay after 6 months storage	Conventional	100.0	100.0	100.0	100.0	3.6
	Experimental	100.0	99.9	100.0	100.0	6.4

conventional treatment of grain. Another advantage is that greater persistence of the insecticide is likely to result from non-uniform treatment. This will provide protection from insect attack during extended storage periods, and thereby reduce the need for costly retreatment of the grain.

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