Use of methoprene without adulticide as a grain protectant

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Abstract

The feasibility of storing grain treated with methoprene rather than an organophosphate plus pyrethroid was assessed in silo trials in New South Wales, Australia. Wheat which had been received at harvest was treated with methoprene at 1 mg/kg within 8 weeks and was stored in vertical silos at initial conditions of about 28°Cand 11% moisture content. Insect infestations in treated and untreated static bulks were monitored at intervals by traps at 0 and 1.5 m depth, and by sieving the grain during turning with a large capacity inclined mesh. An initial infestation of *Cryptolestes* sp. before treatment had declined to low levels in the methoprene-treated bulk after 13 weeks but *Sitophilus oryzae* became dominant after this time. Psocids and parasitic wasps were also detected. The infestation in the untreated bulk consisted mainly of *Cryptolestes* sp., *Tribolium castaneum* and *Oryzaephilus surinamensis*, and increased during storage to high levels in the top grain layer. *S. oryzae, Typhaea stercorea* and *Ahasverus advena* were also present. Treated wheat prevented progeny of *Rhyzopertha dominica* and *O. surinamensis* from developing in bioassays during storage. The potential and limitations of using methoprene to supply grain to organophosphate-sensitive markets, and for resistance management within the bulk handling system, are discussed.

Introduction

Tandem applications of grain protectants have been recommended for storage of wheat in eastern Australia since the detection of resistance to organophosphates (OPs) in *Rhyzopertha dominica* in the mid-1970s (Greening et al. 1974). Mixtures of fenitrothion with synergised bioresmethrin were effective in most cases against the range of grain insects encountered (Bengston et al. 1990a). Recently, the insect growth regulator methoprene was introduced as an alternative for the bioresmethrin component to combat OP resistance in *Oryzaephilus surinamensis* and isolated pyrethroid resistance in *R. dominica*. Methoprene at economic rates prevented emergence of adult progeny of most grain insects except *Sitophilus* spp. but had no immediate effect on adults of target or other species (Bengston et al. 1990b). The OP component readily controlled local strains of *Sitophilus* spp. as well as a proportion of adults of other insects, particularly *Tribolium castaneum*.

Infestations of *Sitophilus* spp. are uncommon in bulk wheat in eastern Australia unless harvests are affected by rain. This is due in part to these species favouring grain with moisture contents above 11% (wet basis) (Birch 1953; Longstaff 1981). A strategy of treating dry grain with methoprene only, without a companion OP, would have several advantages in resistance management and minimising insecticide residues on suitable grain. Natural infestations of freshly harvested grain at silo-receival are likely to be very low, so the lack of adulticide effect need not jeopardise the treatment.

The aim of this silo trial was to test the effectiveness of methoprene-treated grain in suppressing natural infestations of grain insects in practical conditions, and to determine operational limitations, including length of time in storage.

Materials and Methods

Grain treatment

Australian Hard 1 wheat was received untreated to a vertical silo complex at Maimuru, New South Wales during early December 1992. Wheat (636 t) was treated 2 months later by standard spray equipment with a commercial formulation of methoprene (50 g active compound/L) at a target rate of 1 mg/kg during transfer to an empty silo cell. The application rate was calculated post-treatment as 0.84 mg/kg. Untreated wheat (813 t) in an identical cell was retained as a comparison. The moisture content of both bulks ranged from 10.8 to 11.6% but surface samples within 1 m of the grain peak ranged from 11.5 to 12.0%.

Infestation assessment

Both bulks were assessed for infestation by sieving 2–5 t of the bulk with an inclined mesh (after White, 1983). The sample comprised at least 10 batches of 200–400 kg grain diverted to a holding cell during grain operations. The grain was returned to the bulk surface after assessment. Between assessments the static bulks were monitored for insect activity by inserting acrylic insect traps (AgriSense-BCS Ltd) at 0.25 m and 1.5 m depth for periods ranging from 2 to 13 weeks.

Bioassays

Grain for challenge in bioassay was collected from the grain stream during turning of both bulks after 13 weeks storage. Samples of 100 g or 500 g were infested with 50 adults of *R. dominica* or *O. surinamensis* respectively and stored at 25°C. Two strains of each species, representing a range of resistant populations in New South Wales (Table 3), were used in treated and untreated samples, and each bioassay was replicated three times. Adults were checked for mortality after 3 weeks storage and then returned to the samples to allow the development of the infestation to continue. Progeny numbers were deduced from total adults present after 15 weeks development after allowing for parent numbers.

Results

Sitophilus oryzae was detected at low levels in the bulk treated with methoprene about 8 weeks after application and became

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Table 1. Insects detected by inclined mesh during silo storage of untreated wheat or wheat treated with methoprene 1 mg/kg at Maimuru, NSW, Australia.

Storage (weeks)	Sample (approx kg)	Insects[a] detected (number) Rd	So	Os	Tc	Cr	Infestation (estimate)
Before treatment							
0	200	0	0	0	0	25	150/t
Methoprene-treated bulk							
3	2000	0	0	0	0	0	negligible
13	2000	0	10	13	0	0	15/t
26	5000	–	3200	few	few	–	600/t
Untreated bulk							
3	2000	0	0	0	0	5	<10/t
13	2000	110	0	270	200	4	300/t

[a]Rd, *Rhyzopertha dominica*; So, *Sitophilus oryzae*; Os, *Oryzaephilus surinamensis*; Tc, *Tribolium castaneum*; Cr, *Cryptolestes* sp.; Numbers rounded to two significant figures.

Table 2. Insects detected in probe traps during silo storage of untreated wheat or wheat treated with methoprene 1 mg/kg at Maimuru,NSW, Australia

Storage (weeks)	Insects[a] in traps(number) Rd	So	Os	Tc	Cr	Aa/Ts	Ps[b]	Hym[b]
Methoprene bulk								
1-3	1	0	2	8	270	1	-	-
3-6	0	0	0	12	160	1	-	-
6-8	0	0	0	1	6	3	-	-
8-13	0	1	0	0	6	0	+	+
13-26	1	18	0	0	0	0	+++	+++
Untreated bulk								
1-3	0	0	100	32	210	0	-	-
3-6	0	1	850	310	1700	150	++	(+)
6-8	1	3	18	630	3500	0	+++	+

[a] Rd, *Rhyzopertha dominica*; So, *Sitophilus oryzae*; Os, *Oryzaephilus surinamensis*; Tc, *Tribolium castaneum*; Cr, *Cryptolestes* spp.; Ps, psocids; Hym, parasitic wasps (Hymenoptera); Aa, *Ahasverus advena*; Ts, *Typhaea stercorea*; Numbers rounded to two significant figures.
[b] - none; (+) <10; + 10-100; ++ 100-1000; +++ >1000

the dominant insect between 13 and 26 weeks (Table 1). *Cryptolestes* sp. had been present in the grain before treatment and remained detectable in the surface layers for 13 weeks (Table 2). Low numbers of *T. castaneum, O. surinamensis* and *R. dominica* were also found. A large infestation of psocids and parasitic wasps developed near the grain surface after about 13 weeks, in pockets where grain moisture content exceeded 11.5%.

The untreated bulk became heavily infested with *Cryptolestes* sp., *T. castaneum, O. surinamensis, R. dominica* and psocids after 13 weeks and required fumigation. Only a few *S. oryzae* were detected in traps in the grain surface, and none was detected during turning. *Ahasverus advena, Typhaea stercorea,* psocids and parasitic wasps were also detected in traps.

Grain from the methoprene-treated bulk completely suppressed adult progeny of both strains of *R. dominica* in bioassays, whereas untreated wheat allowed large infestations to develop (Table 3). Both strains of *O. surinamensis* were suppressed by methoprene treated wheat, and parent adults also died out after several weeks.

Discussion

The infestation of *Cryptolestes* sp. in the bulk treated with methoprene was virtually undetectable 3 months after treatment, indicating that practical control of this species had been achieved. Similarly, infestations of *R. dominica, T. castaneum* and *O. surinamensis* in the untreated bulk were either not detected or present only at low levels in the treated bulk after the same storage period. These species as well as *A. advena* and *T. stercorea* found in the probe traps would have become established in the 2 months before treatment since moisture content and grain quality were suitable. Even in these adverse conditions methoprene without a supplementary adulticide was effective as a grain protectant against target species for 5 months after receival. The estimated infestation of 15 insects/t after this time was undetectable by normal methods and would fulfil outloading specifications. Normal procedures would ensure that grain was treated on intake, thus reducing further the opportunity for latent infestations to become established.

The major limitation to medium-term storage was the susceptibility of treated grain to attack from *S. oryzae* and psocids. Neither insect has been of major importance in the past because of wheat receival standards which specify a maximum of 12% moisture content. Lower moisture contents may be required where wheat treated with methoprene is to be stored for longer than 3 months. Bulk handling authorities and others capable of risk management may choose to treat a proportion of receivals with methoprene and be prepared to adopt other measures if grain moisture contents approached levels that favoured the development of *Sitophilus* spp. If moisture contents remained low during the receival period, bulks could

Table 3. Bioassay challenge of strains of *Oryzaephilus surinamensis* and *Rhyzopertha dominica* on stored wheat 3 months after treatment with methoprene 1 mg/kg.

Strain	Frequency	Resistance[a] (major)	Mortality in treated grain (%)		Deduced progeny (mean no.)	
			3 weeks	5 weeks	Treated	Untreated
O. surinamensis						
NOS836	Common	FEN	8.3	93.1	0	11.0
NOS144	Rare	FEN, CHL	2.0	99.1	0	64.7
R. dominica						
NRD990	Common	OP	1.3	50.3	0	730
NRD803	Rare	OP, PYR	2.7	23.1	0	1080

[a] FEN, fenitrothion; CHL, chlorpyrifos-methyl; OP, general organophosphate; PYR, pyrethroid.

be retained for longer periods under increased monitoring for infestation. The results achieved to date were sufficiently promising to warrant wider pilot evaluation.

Methoprene without adulticide may be especially suited to short-term facilities such as export terminals, or where grain will be moved soon after receival to make space for other grains. It may also be utilised for retreatments of uninfested grain provided the moisture content is not favourable to the development of *Sitophilus* spp. A major advantage of grain treated only with methoprene would be to supply markets sensitive to OP residues. At present untreated grain from sealed storages or grain which has been fumigated with phosphine would be used. In both cases no residual protection would be retained by the grain after removal from storage, whereas grain treated with methoprene at the rate used may remain protected from target species such as *R. dominica* for 12 months or more after treatment (Mian and Mulla 1982). Grain treated with methoprene could be suitable for these markets and be supplied in small tonnages without jeopardising the remainder of the grain in sealed storage.

The treatment could also be a useful component in resistance management strategies aimed at removing selection pressure of OPs. This would be of particular relevance in regions such as eastern Australia where OP resistance to *O. surinamensis* and *R. dominica* is widespread.

Insect traps in the upper layers of grain provided complementary data to sieving. In the untreated bulk, *T. castaneum* and *O. surinamensis* were consistently found by either method. *R. dominica* was more readily detected by the inclined mesh than by trapping whereas large numbers of *Cryptolestes* sp. were trapped in the probes in untreated grain, even after grain had been turned and few *Cryptolestes* sp. had been found in the sievings. This may indicate different distributions of species in the bulks as well as different affinities of the methods for detection. *Cryptolestes* sp. was localised at the grain peak in the treated bulk but became more widely distributed when numbers were greater in the untreated bulk. The probes also detected psocids and wasps in both bulks, sometimes in very large numbers, whereas none was found by sieving.

Grain bulks would not normally be assessed so intensively for infestation during storage. The ability to detect infestations in grain samples was increased greatly over hand sieving by the capacity and continuous operation of the inclined mesh. The low infestation in the methoprene-treated bulk at 3 months was undetected by hand sieving, and even the infestation of about 300 insects/t of four species in the untreated bulk after the same period was barely detected by hand sieving. The limit of reliable detection using the inclined mesh and a holding cell to accumulate batches was of the order of 5 insects/t but depended on the amount of grain sampled and the amount of dust to separate. The absence of insects from 2000 kg grain sampled after 3 weeks storage gave far greater confidence of control at that time than if the samples had been sieved by hand.

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