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An update on development of bifenthrin as a grain protectant

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Abstract. Large-scale field trials by researchers in collaboration with grain handling and marketing companies in four states have provided extensive data to support the registration of the pyrethroid bifenthrin, as a grain protectant. Trials were conducted on wheat, barley, sorghum and oats, under a range of storage conditions. Bifenthrin is seen primarily as a protectant for control of the lesser grain borer, *Rhyzopertha dominica*, but would be applied as part of a combined treatment to maximise the number of species controlled. These trials show that bifenthrin (0.5 mg/kg) + piperonyl butoxide (7 mg/kg) in combination with either chlorpyrifos-methyl or fenitrothion is effective in controlling *R. dominica*, except for bioresmethrin-resistant strains which occur in parts of eastern Australia. Treatments combining bifenthrin + piperonyl butoxide with either chlorpyrifos-methyl (10 mg/kg) or fenitrothion (12 mg/kg) produce complete, or almost complete, control of a range of other beetle pests. If registered, bifenthrin is likely to play a significant role in protecting of stored cereals from insects.

Introduction

Bifenthrin is a pyrethroid that has been investigated since the early 1990s as a potential grain protectant for stored grain in Europe (Wilkin et al. 1994, 1999). It is registered in several European countries. As bifenthrin showed promise against a range of stored grain beetles, research was commenced in Australia in 1994 to evaluate its potential to protect grain from prevalent resistant strains under Australian storage conditions. Much of this research was conducted with the support of the National Working Party on Grain Protection—comprising principally representatives of the grain industry, regulatory authorities and researchers. At the time that this research began, complete control of grain beetles could be expected in most parts of the country using protectants then registered. However, the National Working Party on Grain Protection has followed a tradition of trying to ensure that a range of protectants is available to deal with unexpected events, such as resistance development in insects, or withdrawal of protectants by companies for commercial reasons or following review by the regulatory bodies (e.g. Codex Alimentarius Commission). This paper summarises the research undertaken in Australia, the results achieved and the role bifenthrin would play in Australia should it be registered.

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Laboratory experiments

Early laboratory experiments on bifenthrin by the Queensland Department of Primary Industries were conducted with the aim of identifying effective application rates of bifenthrin for control of two species: the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.); and the lesser grain borer, *Rhyzopertha dominica* (F.) (M. Bengston, unpublished data). *O. surinamensis* was chosen because resistance to the organophosphates fenitrothion, primiphos-methyl and chlorpyrifos-methyl were becoming common (Collins et al. 1993; Kotze and Wallbank 1996). *R. dominica* was chosen because some populations had appeared in Queensland that were resistant to the pyrethroid bioresmethrin (Collins et al. 1993).

An application rate of 0.5 mg/kg of bifenthrin gave complete control of susceptible and resistant *O. surinamensis* in freshly-treated wheat. This rate also gave complete control of susceptible and malathion-resistant *R. dominica*, but not *R. dominica* that was resistant to both malathion and bioresmethrin. Even addition of a synergist, piperonyl butoxide, did not improve bifenthrin efficacy against the bioresmethrin-resistant *R. dominica*.

Field trials

Seventeen field trials were conducted to generate efficacy and residue data to support registration of bifenthrin

(Table 1). All of these trials were conducted in grain storages owned by the major bulk handling companies in Queensland, NSW, Victoria and SA. The Queensland Department of Primary Industries, NSW Agriculture and CSIRO determined efficacy against relevant resistant strains. The Queensland Department of Natural Resources and Mines, and AWB Ltd determined residue levels. The National Working Party on Grain Protection endorsed trials before they commenced, and the results of completed and ongoing trials were reported at its annual meetings. This provided opportunities for feedback and debate from representatives of the grain industry, regulatory authorities and other researchers. A paper based on the two sorghum trials was submitted for peer review to ensure scientific rigour in the methodology and interpretation of results (Daglish et al. 2002).

Initially the trials involved wheat but later trials were conducted on other cereals to confirm that efficacy and residue results were similar across grain types. Except for the malting and brewing trial started in 2002, the efficacy and residue trials were conducted along similar lines. Large quantities (200–500 t) of grain were treated by normal commercial methods with bifenthrin + piperonyl butoxide and either chlorpyrifos-methyl or fenitrothion. The bulks were stored for up to 9 months, and sampled at intervals during storage to determine residual efficacy and residue levels. Grain temperature and moisture were also measured. Laboratory bioassays were conducted with the aim of mimicking what happens when adults colonise treated but insect-free grain. While complete control of progeny was preferred, a lesser degree of control in which fewer progeny were produced than parents was also acceptable because this indicated that the population was in decline. Residue analyses were conducted according to accepted protocols with each chemical laboratory.

Generally, the field trials yielded similar results, both in terms of efficacy against insects and residues in grain. The trials described by Daglish et al. (2002) serve to illustrate the general results. Despite the range of grain temperatures and moistures recorded during the trials, bifenthrin residues were very stable (Table 2). Treatments containing bifenthrin were very effective against almost all of the strains of beetles tested for the duration of each trial (Table 3). The exception was a pyrethroid-resistant strain of *R. dominica*, for which control was negligible. Psocids were also tested in the sorghum trials (Table 4). Bifenthrin plus piperonyl butoxide plus chlorpyrifos-methyl was very effective against *Liposcelis bostrychophila*, *L. decolor* and *L. paeta* but control of *L. entomophila* was generally poor.

Discussion

Following laboratory experiments in 1994 that showed the potential for the pyrethroid bifenthrin as a grain protectant, particularly against *R. dominica* and *O. surinamensis*, 17 large-scale field trials have generated efficacy and residue data to support registration of bifenthrin as a

Table 1. Bifenthrin field trials undertaken to generate efficacy and residue data.

Treatment	Grain	Site	Initiated
Bifenthrin + piperonyl butoxide + chlorpyrifos-methyl	Wheat	Rand, NSW	1995
		Sutherland, Victoria	1995
		The Rock, NSW	1996
		Millmerran, Queensland	1997
		The Rock, NSW	1997
		Sutherland, Victoria	1997
		Millmerran, Queensland	1998
		The Rock, NSW	1998
		Wychitella, Victoria	1998
		Wirrabara, SA	1998
	Sorghum	Baigin, Queensland	1999
		Baigin, Queensland	2000
	Oats	Stawell, Victoria	1999
Bifenthrin + piperonyl butoxide + fenitrothion	Barley	Pira, Victoria	1999
		Batchica, Victoria	2000
		Litchfield, Victoria	2002
		Baan Baa, NSW	2002

Table 2. Details of trials of bifenthrin (0.5 mg/kg) + piperonyl butoxide (7 mg/kg) + chlorpyrifos-methyl (10 mg/kg) on sorghum (data from Daglish et al. 2002).

Trial	Storage period (months)	Grain temperature (°C)	Grain moisture (%)	Bifenthrin residue (mg/kg)
1999	7	19–26	12.0–12.1	0.35–0.47
2000	6.5	21–29	12.7–13.0	0.31–0.48

grain protectant. These trials have shown that synergised bifenthrin combined with an organophosphate protectant (fenitrothion or chlorpyrifos-methyl) is very effective against a range of grain insects. The major exception was pyrethroid-resistant *R. dominica* which is found in parts of eastern Australia.

FMC Ltd, which owns bifenthrin, has submitted a proposal to have bifenthrin registered in Australia for use on wheat, with the possibility of seeking an extension of the label to include all cereals at a later date. If registered, bifenthrin could play a valuable role in combination with either fenitrothion or chlorpyrifos-methyl in much of the eastern grain-growing states. Recently the pyrethroid bioresmethrin was withdrawn from the market after many years of use in Australia. This severely limits the protectant options available to growers and bulk handling companies, and bifenthrin could be a useful replacement.

Table 3. Periods of protection against beetles in sorghum treated with bifenthrin (0.5 mg/kg) + piperonyl butoxide (7 mg/kg) + chlorpyrifos-methyl (10 mg/kg) on sorghum (OP = organophosphate) (data from Daglish et al. 2002).

Species	Strain	Resistance status	Period of protection (months)	
			No live progeny	Fewer progeny than parents
Trial 1 (7 months duration)				
Rhyzopertha dominica	QRD63 NRD815 QRD318	OP OP OP/bioresmethrin	7 7 nil	7 7 nil
Oryzaephilus surinamensis	QOS302 NOS144	OP OP	7 3	7 7
Tribolium castaneum	QTC279	Malathion/pyrethroid	7	7
Cryptolestes ferrugineus	QCF31	Susceptible	7	7
Trial 2 (6.5 months duration)				
Rhyzopertha dominica	QRD788 NRD815 QRD318	OP OP OP/bioresmethrin	6.5 6.5 nil	6.5 6.5 nil
Oryzaephilus surinamensis	QOS302 NOS144	OP[a] OP[a]	nil 3	6.5 6.5
Tribolium castaneum	QTC279	OP/pyrethroid	6.5	6.5
Cryptolestes ferrugineus	QCF31	Susceptible	6.5	6.5

[a] Malathion-resistant strains with a degree of tolerance to other organophosphates.

Table 4. Periods of protection against *Liposcelis* species psocids (resistance status = unselected) treated with bifenthrin (0.5 mg/kg) + piperonyl butoxide (7 mg/kg) + chlorpyrifos-methyl (10 mg/kg) on sorghum (data from Daglish et al. 2002).

Species	Strain	Period of protection (months)
Trial 1 (7 months duration)		
L. bostrychophila *L. entomophila* *L. decolor*	LQLB LQLE SLD QLD NLD	7 nil 7 7 7
L. paeta	LQLP	7
Trial 2 (6.5 months duration)		
L. bostrichophila *L. entomophila* *L. decolor*	LQLB LQLE SLD QLD NLD	6.5 nil 6.5 6.5 6.5
L. paeta	LQLP	6.5

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