Cyfluthrin plus piperonyl butoxide — a promising new stored product protectant

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Abstract

Cyfluthrin is an alpha-cyano pyrethroid developed by Bayer AG which shows good activity against a broad range of pests. The results of several studies in wheat, maize, and rice are summarised. They showed that cyfluthrin applied in combination with piperonyl butoxide will control a broad range of stored product pests including the beetles *Sitophilus granarius, S. oryzae, S. zeamais, Rhyzopertha dominica, Tribolium confusum, T. castaneum, Tenebroides mauritanicus, Niptus hololeucus, Gibbium psylloides, Dermestes peruvianus, Prostephanus truncatus* and the moths *Plodia interpunctella, Sitotroga cerealella* and *Ephestia cautella*. The recommended dose for the control of all pests is 2 g/t cyfluthrin plus 10 g/t piperonyl butoxide. A water-based EW formulation is recommended because of lower irritancy.

Under the relatively dry and dark conditions of silos, the concentration of cyfluthrin declines slowly. Residues generally remain on the bran and germ and do not penetrate into the flour. Baking does not significantly reduce the residue levels. The rates required for control, the fate of the residues and the toxicological data for the active ingredient are consistent with a legal residue tolerance level of 2 mg/kg grain.

The complementary efficacy spectrum of cyfluthrin and organophosphates is also discussed, as is the possibility of reduced rates of both active ingredients, with both cost and residue advantages.

Introduction

Cyfluthrin is an alpha-cyano pyrethroid discovered by Bayer AG in 1976. It has been developed and is sold for use in agricultural, veterinary and public health applications. It is registered in most countries and sold under the trade names of Baythroid®, Solfac® and Tempo®.

Cyfluthrin is composed of a mixture of roughly equal ratios of four enantiomer pairs. With respect to insecticidal activity it is approximately half as active as deltamethrin but twice as active as cypermethrin. It shows a strong negative temperature coefficient with respect to insecticidal activity.

Cyfluthrin has relatively favourable toxicological characteristics with an oral LD_{50} in the rat for the active ingredient (in Lutrol) of 500–800 mg/kg body weight and a dermal LD_{50} in the rat of >5000 mg/kg. A summary of toxicological data can be found in Behrenz et al. (1983). The ADI has been determined by FAO at 0–0.2 mg/kg body weight/day.

Initial screening tests by Dr J. Desmarchelier (CSIRO, Australia) and Dr. M. Bengston (Qld DPI) in 1980 (both unpublished) indicated that 1–2 g/t plus 8 g/t piperonyl butoxide (PBO) was sufficient to control the relevant resistant strains of stored grain pests in Australia for about 9 months.

Field trials were then conducted in large vertical silos over three seasons. Several formulations were tested including a 5% SL (soluble liquid), a 5% EC (emulsifiable concentrate), a 10% WP (wettable powder) and a 5% EW (emulsion in water). The SL and EC were applied as a tank mix with a PBO EC formulation which gave 100% control of all pests over 9 months but resulted in unacceptable irritancy. The WP and EW formulations, applied without synergist, greatly reduced any irritation but were not sufficiently effective against all pests over the required 9 months, especially following the emergence of a pyrethroid resistant strain of *Tribolium castaneum* (Collins 1990).

A 5% cyfluthrin EW formulation is available which is capable of controlling all species of stored product pests over the required 9 months storage and the potential for irritancy is greatly reduced due to the lack of organic solvents in this formulation. A tank mix with piperonyl butoxide will further improve the efficacy. A 5% cyfluthrin + 25% piperonyl butoxide EW combination formulation has also been tested with similar results to the tank mix.

This paper reviews the available efficacy and residue data for cyfluthrin for stored product protection. All rates are expressed in terms of active ingredient.

Efficacy

Residual surface treatment

Behrenz et al. (1983) examined cyfluthrin as a surface treatment against a range of stored-product pests including *Sitophilus granarius* L., *Rhyzopertha dominica* F., *Tenebroides mauritanicus* L., *Tribolium confusum* Duv., *Niptus hololeucus* Feld., *Gibbium psylloides* Czemp. and *Dermestes peruvianus* Cast. and determined that 30 mg/m^2 was sufficient for control of all pests tested.

Subramanyam and Cutkomp (1987) conducted filter paper bioassays on other insects including *Prostephanus truncatus, Plodia interpunctella* and *Ephestia cautella* confirming a strong negative temperature correlation with cyfluthrin 8 times more effective at 20° than at 30°C.

Wheat

Bengston et al. (1987 and unpublished data 1984) report on trials conducted in large-scale vertical concrete silos over three seasons. In total four formulations were tested and bioassayed over the storage period of up to 9 months with *Sitophilus oryzae, S. granarius, Rhyzopertha dominica, Tribolium castaneum, T. confusum* and *Ephestia cautella*. All formulations synergised with PBO remained effective during the storage period; unsynergised formulations were not fully effective over the full storage period with a weakness against OP-resistant strains of *Sitophilus oryzae*. In the third year of

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trials a pyrethroid-resistant strain of *Tribolium castaneum* was found in silos treated without the addition of a PBO synergist.

Krehan (unpublished data 1986) bio-assayed wheat treated with a 5% EW formulation and stored in Argentina for 10 months. He found that 1 g/t was sufficient for *Rhyzopertha dominica* but that 2 g/t was required for complete control of *Sitophilus granarius*.

Bengston (pers. comm. 1993) looked at the synergised formulation against the Australian pyrethroid-resistant strain of *Tribolium castaneum* and found 10-fold better efficacy for the synergised formulation compared with a similar unsynergised formulation. Nevertheless, 4/20 ppm was required for complete control of this strain.

Maize

Bitran et al. (1984) found that 2 g/t cyfluthrin plus 10 g/t PBO was sufficient for 12 months protection against *Sitophilus zaemais* in laboratory trials in Brazil. Laborius et al. (1985) examined the efficacy against *Prostephanus truncatus* in the laboratory and found that 0.5–1.5 g/t was sufficient for 2 years protection. Makundi (1986) confirmed that the addition of PBO improved the efficacy against *Prostephanus truncatus*. Prado et al. in Chile (unpublished data 1989) found that 0.1% dust formulation was effective at 1g/t against *Sitotroga cerealella*.

Laboratory trials in the Philippines (NAPHIRE, unpublished data 1993) against *Sitophilus zeamais* and *Tribolium castaneum* compared a synergised EW formulation with the equivalent unsynergised EW formulation. This trial confirmed that the synergised formulation was at least twice as active as the unsynergised formulation.

Rice

Laboratory trials in Venezuela with paddy rice (unpublished data 1988) showed that 1.9 and 2.5 g/t were effective for 8 months against *Sitophilus oryzae* and *Rhyzopertha dominica* but were only 50% effective against *Tribolium* sp. This is probably due to the short exposure period of only 4 days in the bioassay; in general it is necessary to assess the efficacy against following generations when testing pyrethroids.

NAPHIRE laboratory trials in the Philippines in paddy rice against *Sitophilus oryzae* (unpublished data 1993) show that a synergised EW formulation was twice as active as the equivalent unsynergised EW formulation.

Residues

Linke and Heukamp (unpublished data 1986) investigated the breakdown of cyfluthrin in wheat using radioactive labels. They found that, after 9 months storage, 79% of the applied radioactivity was present as unaltered parent compound and 2% as a metabolite.

Residue studies on wheat in silos have shown that cyfluthrin has a long half-life of about 1 year (Bengston et al. 1987, and unpublished data 1984). Noble and Hamilton (1985) showed that increased temperatures and humidity resulted in faster decomposition of cyfluthrin. The more active cis-isomers were more stable than the trans-isomers.

Residues decline slowly in storage. The results of the above studies from large-scale silo trials in Australia, using 4 different formulations, are combined to give the following results (in ppm cyfluthrin):

Target dose	Initial assay	3 months	6 months	9 months
2.0	1.3	10.5	1.0	1.0

Distribution of residues in downstream milling products

Laboratory-scale milling studies in wheat, rice, sorghum and maize show that the residues largely remain on the surface of the grain with only small quantities penetrating into the flour. Residues were not greatly reduced by baking.

Combination with Organophosphates

Krehan (unpublished data 1988) first looked at combinations of cyfluthrin with the organophosphate fenitrothion. The two active ingredients complemented each other in their spectrum of activity with cyfluthrin, being able to control *Rhyzopertha dominica* better than fenitrothion, and fenitrothion controlling *Sitophilis granarius* better than cyfluthrin. By applying a combination it was possible to reduce the amount of both active ingredients. Two formulations have been developed and are under investigation. These are a DP (dustable powder) formulation containing 4% fenitrothion and 0.1% cyfluthrin, and an EC formulation containing 1000 g/L fenitrothion and 2.5 g/L cyfluthrin.

Discussion

Cyfluthrin has clear potential as a stored-product protectant in cereals including wheat, maize and rice due to its broad spectrum of activity and good persistence. A dosage of 2g/t when synergised with PBO, is sufficient to give at least 9 months protection even against strains of insects resistant to many insecticides.

Residues of cyfluthrin decline slowly with time with a half-life of about 1 year. Most residues are retained on the bran and germ. It is therefore important that an MRL for cyfluthrin is at least as high as the planned application dose because it is not practical to wait for residues to decay over time. The rates required for control, the fate of the residues and the toxicological data for the active ingredient are consistent with a legal residue tolerance level of 2 mg/kg grain. Such a residue has already been established in Australia.

An MRL of 6 g/t has been requested in some countries to allow for multiple applications. Because of the low toxicity of cyfluthrin this remains consistent with the toxicological profile of the product and the distribution of residues in the milled products and will allow considerable flexibility in practical situations..

Combinations of cyfluthrin and organophosphates are under investigation due to their complementary activity spectrums. Such combinations offer the possibility of good protection of stored products with reduced rates of both active ingredients and reduced costs.

In summary, cyfluthrin is an effective protectant for cereal grains in storage. Its properties can best be exploited when it is applied either in combination with the synergist piperonyl butoxide or an organophosphate insecticide.

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