

Insecticides for Empty Grain Bins

Research trials examine efficacy of two insecticides to control insects.

In this column, Blossom Sehgal, a graduate research assistant in the Department of Grain Science and Industry, Kansas State University (KSU), Manhattan, teamed up with Milling Journal's

regular contributor Bhadriraju Subramanyam (Subi), a Don Wilbur Sr. Endowed Professor of Postharvest Protection, Department of Grain Science and Industry, KSU, to explain their key findings from evaluating the effectiveness of two insecticides for treating empty bins.

Stored-grain insect management, prior to storing newly harvested grain, begins with removing residual grain debris and application of an approved insecticide to the concrete floor and interior bin surfaces to kill any live insects present.

Among the insecticides registered

currently by the U.S. Environmental Protection Agency (EPA) for empty bin treatments is Beta (β)-cyfluthrin or Tempo® SC Ultra (manufactured by Bayer CropScience, Research Triangle Park, NC). This is a new and an alternative insecticide to traditionally-used cyfluthrin wettable powder (WP) and emulsifiable concentrate (EC) formulations.

β -cyfluthrin can be applied to surfaces at low and high application rates of 0.01 and 0.02 g (active ingredient or AI) per square meter (m^2), respectively.

The labeled rates for β -cyfluthrin are 50% less than that of the WP or EC

formulations.

Chlorpyrifos-methyl at 3 ppm (mg[AI]/kg of grain) plus deltamethrin at 0.5 ppm (Storcide™ II, Bayer CropScience) was registered in 2004 for direct treatment of barley, oats, rice, sorghum, and wheat intended for storage and for empty bins receiving these grains. This combination product replaced chlorpyrifos-methyl after its tolerances were revoked.

There are other products approved for empty bin treatments, and they include several formulations of diatomaceous earth dusts, methoprene, and a newly registered deltamethrin (labeled as Centynal™). All three products also are registered for use on grain.

A future column in *Milling Journal* will address performance of these three products applied to surfaces. Cyfluthrin is approved only for treating surfaces but not for grain.



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To date, there are no published studies documenting the effectiveness of β -cyfluthrin and chlorpyrifos-methyl plus deltamethrin on concrete surfaces, similar to that of empty bins, against field strains of stored-grain insect populations.

Such an evaluation is necessary to confirm whether or not an approved insecticide will work in practical field situations at the labeled rates.

In the present investigation, we determined susceptibility of adults of red flour beetle, sawtoothed grain beetle, and lesser grain borer field strains from the United States to β -cyfluthrin and chlorpyrifos-methyl plus deltamethrin applied to concrete surfaces in the laboratory.

Research Methods

Farm sites in Kansas were visited in 2011 to collect adults of the three species from farm bins holding mostly wheat, and some corn and sorghum.

Five strains of the red flour beetle collected prior to 2011 were obtained from Dr. James Campbell, U.S. Department of Agriculture's Center for Grain and Animal Health Research, Manhattan, KS.

In total, there were 16 red flour beetle

The results show that β -cyfluthrin is an ideal insecticide to use in clean, empty bin floors prior to storing wheat but only to control lesser grain borer adults.

strains, seven sawtoothed grain beetle strains, and two lesser grain borer strains.

Laboratory strains of each species, which have been in rearing without insecticide exposure since 1999 in the Department of Grain Science and Industry, KSU, served as the standard reference strains and assumed to be insecticide-susceptible.

Concrete-poured Petri Dishes

Ready-mix concrete (Rockite, Hartline Products Co., Inc., Cleveland, OH) was mixed with tap water to make a slurry. This slurry was poured into 9 cm diameter, 1.5 cm high, and 62 cm² area plastic Petri dishes.

Concrete (3,810 g) was mixed with 1,905 ml of tap water to make 100 dishes.

es. These areas simulated the concrete floor of empty bins.

The slurry was allowed to dry and the inside walls of the Petri dishes were coated with polytetrafluoroethylene (Insecta-a-Slip, Bio Quip Products, Inc., Rancho Dominguez, CA) to prevent insects from crawling on the sides of dishes.

Treatment of Concrete Dishes

β -cyfluthrin (11.8% purity) and chlorpyrifos-methyl plus deltamethrin (21.6 and 3.7% purity), were supplied by Bayer CropScience and were diluted in distilled water.

Concrete surfaces of dishes were treated with β -cyfluthrin at the low labeled rate of 0.01 g (AI) m⁻² and the high labeled rate of 0.02 g (AI) m⁻², and with chlorpyrifos-methyl plus deltamethrin at the labeled rate of 0.12 plus 0.02 g (AI) m⁻² by applying 255 μ l (microliter) spray solution per dish using a Badger 100 artist's airbrush (Model 100, Franklin Park, IL).

Dishes sprayed with 255 μ l of distilled water served as the control treatment to determine natural mortality. Treated dishes were allowed to dry ►

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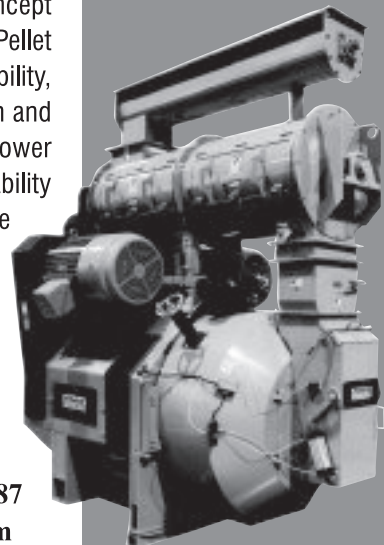


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under room conditions (25 degrees C or 77 degrees F and 25% relative humidity) for 24 hours before exposing insects.

Time-response Tests

The laboratory strains of the red flour beetle, sawtoothed grain beetle, and lesser grain borer were used to establish a time at which 100% or close to 100% knockdown and mortality of adults occurred when exposed to labeled rates of β -cyfluthrin and chlorpyrifos-methyl plus deltamethrin. This time was used to expose field strains of each species to concrete treated with the two insecticides.

Ten unsexed adults each of the three species from laboratory cultures were introduced into separate dishes, and the dishes were covered with Petri dish lids.

Adults were exposed to treated and control dishes for 1, 2, 4, 8, 12, 16, 20, and 24 hours.

Dishes were arranged on a laboratory table, and the temperature and relative humidity were 24 degrees C or 75.2 degrees F and 23%, respectively.

At each exposure time, adults of each species that were knocked down and active were counted.

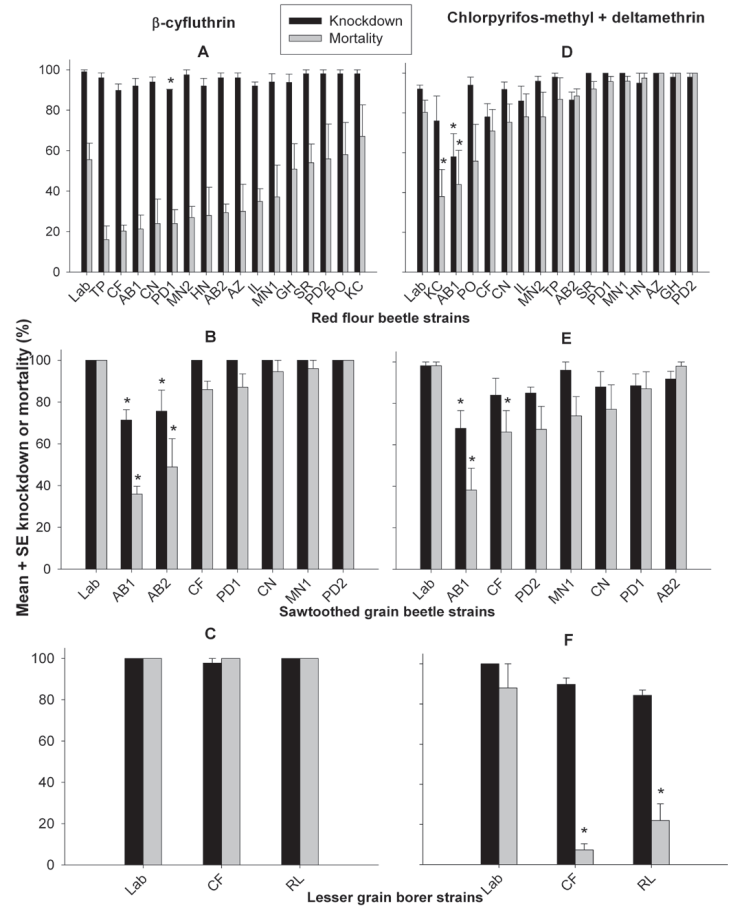
After counting, all adults were transferred to 150-ml round plastic containers with 30g of the respective insect diet.

The plastic containers had perforated lids with wire-mesh screens to facilitate air diffusion. Containers were examined after seven days to determine end-point mortality following insect recovery on rearing diets.

Exposure of Field Strains

The low labeled rate of β -cyfluthrin gave poor control of the

Fig. 1 (A - F)



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Table 1

Strain	Mean knockdown (%) at β -cyfluthrin rate (g[AI]m ⁻²) of:				Mean mortality (%) at β -cyfluthrin rate (g[AI]m ⁻²) of:			
	0.02	0.04	0.06	0.08	0.02	0.04	0.06	0.08
Red Flour Beetle								
Lab.	96.0	100	98.0	98.0	72.0	74.0	84.0	90.0
CF	98.0	100	100	100	54.5	61.0	55.1	77.6
PD1	98.0	100	100	100	66.0	90.0	72.0	78.0
TP	96.0	100	100	100	54.0	82.2	74.7	90.0
Sawtoothed Grain Beetle								
Lab.	100	100	100	100	100	100	100	100
AB1	71.3	93.9	85.8	92.0	58.7	76.9	57.1	70.9
AB2	80.0	98.0	100	96.0	36.0	71.4	60.0	70.2

Each mean is based on 5 replications.

Table 1 above shows the knockdown and mortality of laboratory and select least-susceptible field strains of red flour beetle and sawtoothed grain beetle exposed to concrete surfaces treated at or above the high labeled rate of β -cyfluthrin.

red flour beetle and sawtoothed grain beetle laboratory strains with mortalities of 47% and 83%, respectively, at the maximum exposure time of 24 hours.

Therefore, adults of these two species were exposed for 24 hours to concrete treated only with the high labeled rate of β -cyfluthrin, while the lesser grain borer adults were exposed to this insecticide for two hours, because of its high susceptibility.

All three species were exposed for eight hours to concrete treated with chlorpyrifos-methyl plus deltamethrin. Knockdown and mortality of field strains were determined as explained above.

Results and Responses of Field Strains

The mean knockdown of all red flour beetle field strains exposed to the high rate of β -cyfluthrin-treated concrete ranged from 90 to 98%, and the mean mortality ranged from 16 ▶

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to 67% (Fig. 1-A), as shown on page 36, with recovery on diet ranging from 32 to 83%. The mortality of each field strain was essentially similar to that of the laboratory strain.

The mean knockdown of five of seven sawtoothed grain beetle field strains exposed to β -cyfluthrin was 100%, whereas it was 71% for AB1 and 76% for AB2 strain (Fig. 1-B).

The mean mortality for the five strains that showed 100% knockdown ranged from 86 to 100%, whereas it was 36% and 49% for AB1 and AB2 strains, respectively, indicating recovery when placed on the diet.

Knockdown and mortality responses of AB1 and AB2 field strains were different from that of the laboratory strain.

β -cyfluthrin was extremely effective against the lesser grain borer field strains with more than 98% knockdown and 100% mortality (Fig. 1-C).

The knockdown of 11 out of 16 red flour beetle field strains exposed to chlorpyrifos-methyl plus deltamethrin was greater than 90%, and only eight strains had mortality greater than 90% (Fig. 1-D).

Mortality was less than 50% in AB1 and KC field strains, and the overall recovery on diet ranged from 0 to 50%.

Knockdown response of AB1 strain and mortality of AB1 and KC strains were different from that of the laboratory strain.

Knockdown of all field strains of the sawtoothed grain beetle exposed to chlorpyrifos-methyl plus deltamethrin ranged from 68 to 96%, and the mortality

ranged from 38 to 98% with a recovery of 0 to 44% on the diet (Fig. 1-E).

Knockdown of AB1 strain and mortality of AB1 and CF strains were significantly different from that of the laboratory strain.

The two field strains of the lesser grain borer showed reduced susceptibility to chlorpyrifos-methyl plus deltamethrin (Fig. 1-F), because knockdown ranged from 84 to 90% and mortality from 7 to 22%.

The recovery of the two field strains on diet ranged from 74 to 92%. Mortality responses of both the field strains differed significantly from that of the laboratory strain.

Dose-response Tests with β -cyfluthrin

Three least susceptible strains of the red flour beetle and two of sawtoothed grain beetle were exposed to β -cyfluthrin-treated concrete dishes at one to four times the high labeled rate (0.02 to 0.08 g [AI] m⁻²) to assess knockdown and mortality.

Exposing the three least susceptible strains of the red flour beetle to up to four times the high rate of β -cyfluthrin resulted in 96 to 100% knockdown and 54 to 90% mortality (Table 1), as shown on the previous page.

There was complete knockdown and mortality of the laboratory strain of the sawtoothed grain beetle at all β -cyfluthrin rates. The knockdown of field strains AB1 and AB2 among β -cyfluthrin rates was 71 to 100%, while the mortality was 36 to 76%.

Conclusions

The results show that β -cyfluthrin is an ideal insecticide to use in clean, empty bin floors prior to storing wheat but only to control lesser grain borer adults.

The reduced susceptibility of field and laboratory strains of the red flour beetle and saw-toothed grain beetle may be due to an inherent formulation deficiency or resistance, since four times the labeled rate failed to provide complete control.

Chlorpyrifos-methyl plus deltamethrin was only partially effective against strains of all three species.

There is documented evidence of resistance in field strains of these three species to one or both active ingredients. Based on our results, no single insecticide can be recommended to provide adequate control of all species tested.

More work is needed on the mechanism of detoxification of these chemicals by the three species to understand why some chemicals are effective against some species and strains and not against others.

Evaluation of other recommended empty-bin insecticides with the field strains is also needed to identify a broad-spectrum insecticide that is effective against species commonly found in empty bins.



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