An alternative grain protectant

Grain protectants are liquids or dusts applied to newly harvested grain intended for short- or long-term storage. These products in the U.S. include malathion dust, primiphos-methyl (Actellic), methoprene (Diacon II), chlorpyrifos-methyl plus deltamethrin (Storicide II), synergized pyrethrins, and several formulations of diatomaceous earth such as Insecto, Diasource, Dryside, Perma Guard and ProtectIt.

Protectants should be applied only once to newly harvested grain before it is stored. Application of a protectant is a preventative method, as one application ensures protection against insect infestation from several months to more than a year.

Occasionally grain that is infested is treated with a protectant as the grain is moved from one storage structure into another. Such treatments are only partially effective in suppressing infestations, because some stages, especially those developing inside the kernels, will not be exposed to the insecticide. Research has shown that protectants are not effective when applied to infested grain, and it is imperative that infested grain be treated with a fumigant, such as phosphine. In fact, protectant labels recommend fumigation of infested grain before application of a protectant.

General features of an effective protectant include a broad spectrum of activity against insect pests associated with grain, persistence on treated commodities and low mammalian toxicity. The labeled application rate is usually the tolerance level for protectants on grain, except in the case of diatomaceous earth and methoprene, as they are exempt from a residue tolerance.

Protectants such as diatomaceous earth can be removed from grain before it is milled by cleaning and aspiration. However, residues of protectants such as primiphos-methyl, malathion or Storicide II persist on the grain and in grain fractions at levels well below the established tolerance levels.

Spinosad shows promise in laboratory and field trials; has received EPA approval as a grain protectant

NEWER PROTECTANTS

A majority of the grain on farms is treated with protectants, while the fumigant phosphine is typically used on grain in the marketing channels. The most commonly used grain protectants in the U.S. include the organophosphorus insecticides malathion, chlorpyrifos-methyl and primiphos-methyl. However, under the 1996 Food Quality Protection Act, which sets tougher standards for reviewing registered pesticides, the future of organophosphorus compounds in general and these three protectants in particular remains uncertain.

The sale and distribution of chlorpyrifos-methyl (Reldan) at 0.4 parts per million (ppm) ceased as of Dec. 31, 2004, but chloropyrifos-methyl at 3 ppm is available in Storicide II in combination with deltamethrin. In addition, resistance in key stored-product insects has limited the effectiveness of these three protectants. Therefore, new chemistries or pest management strategies are constantly being explored as alternatives to the traditionally used organophosphates.

Since the passing of the Food Quality Protection Act, two new compounds have been registered as grain protectants. These include methoprene (this was registered in 1992 before the FQPA) or Diacon II, an insect growth regulator (hormone
mics) that affects growth, development, and reproduction of insects, and Storidil II, a formulation that has half the labeled rate of 3 ppm of chlorsulfuron-methyl combined with 0.5 ppm of deltamethrin, a synthetic pyrethroid that has accepted international tolerances.

In January 2005, spinosad received the U.S. Environmental Protection Agency's approval as a grain protectant at 1 ppm on barley, millets (foraw, piste, and pearl), oats, rice, sorghum (milo), triticale, wheat and bi-triticale. The maximum residue limits for spinosad on grain were approved by CODEX in 2005. The U.S. tolerance for spinosad is 1.7 ppm and the CODEX tolerance is 1 ppm.

The registrant of spinosad, Dow AgroSciences, Indianapolis, Indiana, U.S., has been working with the grain industry and various countries for approval of spinosad tolerances on grain. Launch of commercial products will be delayed until international tolerances are in place. Therefore, this is a good time for grain managers to learn about a novel product that can be used in the future for effectively managing insect pests associated with stored grain.

**A REDUCED-RISK INSECTICIDE**

Spinosad, the fermentation product of the bacterium Saccharopolyspora spinosa, is a commercial insecticide that is effective against insect pests associated with field crops. Spinosad is toxic to insects by ingestion or contact; has very low mammalian toxicity and degrades quickly within

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**LESSER GRAIN BOXER MORTALITY**

![Graph showing mortality of lesser grain boxers](image)

Mortality of adults of lesser grain boxers exposed for 14 days to untreated wheat and wheat treated with 0.1, 0.5, 1.0, 1.5, and 4.0 ppm of spinosad. The wheat samples from farm bins were collected monthly over a 12-month period. The OISA-registered are based on three replications (20 bins).

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**GRANIFRIGOR**

The most natural way to protect grain:
- Protection against insects and microbes
- Without chemical treatment
- Short maturation period
- Low energy costs
- Independent of ambient weather conditions

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**FRIGOR-TEC**

Circle No. 120 on the Reader Service Card or see page 86.

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Circle No. 121 on the Reader Service Card or see page 86.

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seven days on exposure to sunlight (UV light). It is labeled for use on over 250 crops in more than 50 countries. The mode of action of spinosad is different from that of other insecticides. Therefore, insects resistant to traditionally used insecticides do not show cross-resistance to spinosad.

EFFICACY ON STORED-GRAIN PESTS

Laboratory and field trials in the U.S., Kenya and Australia have shown spinosad to be an effective compound against a wide variety of insect species associated with stored grain. Tests have been conducted on maize, wheat, and sorghum.

Effectiveness is measured based on adult mortality and failure to produce new generation (eggs) on spinosad-treated grain. As with any insecticide, there is variation in how different insect species and stages of insects respond to spinosad: some are highly susceptible while others are less susceptible.

For instance, the lesser grain borer, a destructive pest of stored wheat worldwide, is highly susceptible to spinosad, even at rates as low as 0.1 ppm, one-tenth of the approved labeled rate.

The larger grain borer, a species in the same family (Pyrrhocoridae) as the lesser grain borer, is also highly susceptible to very low rates of spinosad.

The adults of the red flour beetle and sawtoothed grain beetle are less susceptible to spinosad, even at rates as high as 20 ppm. However, the young larvae of these species are highly susceptible to spinosad, because of spinosad-treated grain. Populations of these two species fail to develop.

Spiriosad is also not very effective against beetles or weevils, which are emerging as economically important pests in African stored grain because of their resistance to phosphine. On all other economically important species of beetles and moth pests associated with grain, spinosad is effective at 1 ppm in killing adults and preventing population growth.

Spinosad is not as fast acting as rice weevils; it is on the lesser grain borer, and the adults therefore have a chance to lay eggs inside the grain. Exposure of weevils to spinosad-treated grains for 14 days results in complete mortality. The larvae of moth pests we have tested so far are also highly susceptible to spinosad.

In all trials, spinosad performed better on wheat against insects when compared with performance on other grains. Research from Australia showed that key stored-grain insects resistant to traditionally used grain protectants were susceptible to spinosad at 1 ppm.
As expected, in tests comparing spinosad-treated whole grain, cracked grain and grain dust at 1 ppm, the insecticide consistently performed better against insects on whole grain. This finding suggests that grain protectants work better on insects when they are applied to clean grain rather than unclean grain.

FIELD TRIALS
Field trials in the U.S. were conducted in Kansas on stored wheat and Indiana on stored maize using farm-size bins (25- to 75-tonne capacity). At the application rate of 1 ppm, there was about 25% to 30% loss of the insecticide during application, resulting in 0.70 to 0.75 ppm spinosad deposition on grain. This percentage loss of applied insecticide can be expected with any grain protectant due to the heterogeneous nature of the grain.

Although spinosad breaks down within a week when exposed to sunlight, spinosad residues persisted for a period of six months to two years with minimal loss in insecticidal activity in grain storage environments. The absence of sunlight in storage environments possibly prevented degradation of spinosad on stored grains.

Very low densities of live adults or no live adults were found in grain samples in bins receiving spinosad treatments, compared with a large number of insects found in untreated grain samples. Grain samples collected monthly from farm bins were exposed to insects in the laboratory to determine insect mortality and production of progeny on treated grain. The species tested included the lesser grain borer, red flour beetle, rusty grain beetle, maize weevil, and others.

AWARE COMPREHENSIVE
Crop protection services are available in the U.S. and Europe, protecting crops from a wide variety of pests.
FEATURE: AN ALTERNATIVE GRAIN PROTECTANT

Spinosad at 1 ppm provided excellent control of all adults of all of these species during the six-month to two-year test period, with the exception of the red flour beetle, which was less susceptible. However, progeny production of all of these species was greatly suppressed, indicating that the red flour beetle.

In Kenya, spinosad dust formulation at 0.35, 0.70, and 1.44 ppm applied once to stored maize provided effective control of large grain borer and maize weevils for a period of six months.

AVAILABILITY OF COMMERCIAL PRODUCTS

Commercial spinosad products for use as a grain protectant will not become available until international tolerances are accepted by countries importing U.S. grains. Two companies — Bayer CropScience and AgriLife — will be marketing commercial spinosad formulations for use on stored grain.

Grain protectants are usually available in liquid and dry formulations, and spinosad will be available in both formulations. In situations where there is no electrical hook-up, the use of dry formulations may be preferable.

Recent research at Kansas State University, Manhattan, Kansas, U.S., showed that the spinosad dust formulation at 1 ppm was as effective as the liquid spinosad against several insect species on wheat, maize and sorghum. In addition, a formulation with spinosad plus pyrimiphos methyl may be available primarily for use on stored maize and sorghum.

The spinosad active ingredient is organic-certified by the United States Department of Agriculture's National Organic Standards Board, and the products are organic formulations for use on organic grains.