# 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, pirimiphos-methyl (Actellic), methoprene (Diacon II), chlorpyrifos-methyl plus deltamethrin (Storcide II), synergized pyrethrins, and several formulations of diatomaceous earth such as Insecto, Diasource, Dryacide, Perma Guard and Protect-It.

Protectants should be applied only once to newly harvested grain before it is stored. Application of a protectant is a preventive 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 pirimiphos-methyl, malathion or Storcide II persist on the grain and in grain fractions at levels well below the established tolerance levels.

by Bhadriraju Subramanyam

**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 organophosphorous insecticides malathion, chlorpyrifos-methyl and pirimiphos-methyl. However, under the 1996 Food Quality Protection Act, which set tougher standards for reviewing registered pesticides, the future of organophosphorous compounds in general and these three protectants in particular remained uncertain.

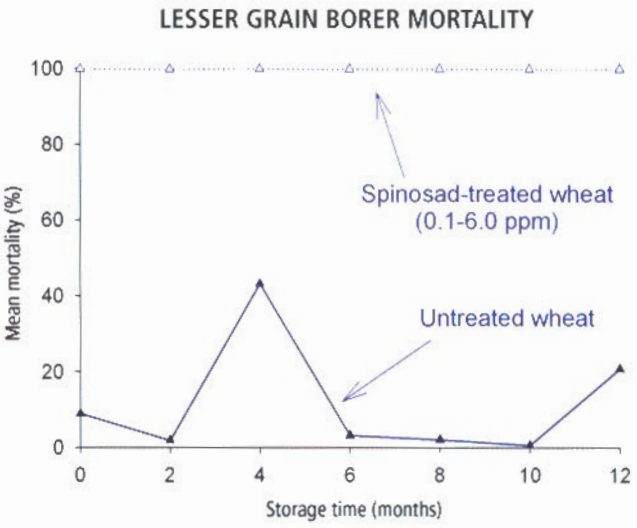
The sale and distribution of chlorpyrifos-methyl (Reldan) at 6 parts per million (ppm) ceased as of Dec. 31, 2004, but chloropyrifos-methyl at 3 ppm is available in Storcide II in combination with deltamethrin. In addition, resistance in key stored-product insects has limited the effectiveness of these 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

mimic) that affects growth, development, and reproduction of insects, and Storcide II, a formulation that has half the labeled rate of 3 ppm of chlorpyrifos-methyl combined with 0.5 ppm of delamethrin, 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 (foxtail, proso, and pearl), oats, rice, sorghum (milo), triticale, wheat and birdseed. The maximum residue limits for spinosad on grain were approved by CODEX in 2005. The U.S. tolerance for spinosad is 1.5 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.




Mortality of adults of lesser grain borer exposed for 14 days to untreated wheat and wheat treated with 0.1, 0.5, 1, 3, and 6 ppm of spinosad. The wheat samples from farm bins were collected monthly over a 12-month period. The data presented are based on three repilications (farm bins).

## 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

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.

## EFFECTIVENESS 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 the next generation (progeny) 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 devastating 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.

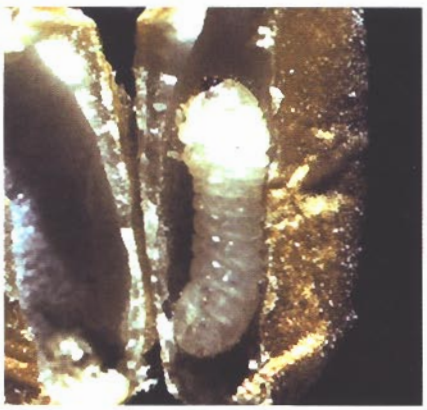
The larger grain borer, a species in the same family (Bostrichidae) as the lesser grain borer, is also highly susceptible to very low rates of spinosad.

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 on spinosad-treated grain, populations of these two species fail to develop.

Spinosad is also not very effective against book lice or psocids, which are emerging as economically important pests in Australian 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/or preventing population growth.

Spinosad is not as fast acting on rice weevils as 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 grain for 14 days provides complete mortality. The maize weevils are more susceptible to spinosad than the rice weevils. Larvae of the moth pests we have tested so far are also highly susceptible to spinosad.

In all tests, 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.



Left: Red flour beetle. Right: Lesser grain borer larva in split kernel.
Photos courtesy of the USDA-ARS-GMPRC web site.

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 wee-

vils and Indianmeal moth.

Spinosad at 1 ppm provided excellent control of adults of all of these species during the six-month to two-year test period, with the exception of the red flour beetle, which is less susceptible. However, progeny production of all of these species was greatly suppressed, including that of 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 larger 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 Agriliance — 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 dry 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 pirimiphos-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 Organics Standard Board, and the prospects of an organic formulation for use on organic grains looks promising.

Spinosad will be another viable product that grain managers can use in the future along with existing protectants. However, it is important to use existing and any new grain protectants by keeping integrated pest management practices in mind.

Some of these practices include sanitation and treatment of empty storage facilities prior to storing grain, disinfesting grain handling equipment, grain cleaning, aeration, temperature and insect monitoring, grain turning and use of fumigants as needed. WG

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