Controlling **insect pests** in stored grain

Research Into Use

Diatomaceous earths are effective, non-toxic alternatives to the synthetic chemical insecticides currently used to fight insect pests in stored grain.

Above: Mixing diatomaceous earths with grain before it is stored can greatly reduce the amounts destroyed by insect pests. Photo: T. Stathers

Insects damage huge amounts of harvested grain in sub-Saharan Africa, causing serious losses for smallholder farmers and traders. This threatens people's food security and their self sufficiency when their seed corn is lost. It also often means that they have to cut their losses and sell their grain early—rather than waiting until the best prices are available.

Use of imported synthetic chemical pesticides can limit insect damage. But, many farmers fear that treating stored grain with pesticides will contaminate their food and damage their health. Those who try to avoid this by using traditional grain treatments such as ash and sand often don't get the results they need. Diatomaceous earths offer a safer alternative to chemical pesticides that small-scale farmers can use to reduce the damage that insects do to their stored grain.

Storage insect pests: a problem faced by every small-scale farmer

The damage that insects cause to stored grain is a major problem for farmers in Africa. In Tanzania, for example, the devastating larger grain borer (*Prostephanus truncates*) causes maize storage losses of as much as 40 percent. Farmers therefore need a cheap, safe and effective method of treating their grain to ensure that it is not destroyed by insects.

Above: For poor and not so poor farmers alike, all the hard work they put into growing and harvesting their crops is wasted if insects attack their stored grains. Photo: T. Stathers

Chemical pesticides are not always the best option, however. Poorer farmers can't afford them, and they can damage people's health if not used carefully. Also the poor quality of some of the pesticides that are being sold at some outlets can result in producers spending their hard-earned cash on popular chemical insecticides like Actellic Super Dust only to find that they don't deter insect attack. Failure to follow manufacturers' instructions, or the absence of easy-to-understand and user-friendly instructions, can also result in poor outcomes.

Diatomaceous earths—a practical, non-toxic alternative to chemical insecticides

Working together in Tanzania and Zimbabwe, farmers, government and NGO extension staff, researchers and other agencies have shown that diatomaceous earths offer a realistic solution to small-scale farmers' and householders' grain storage problems.

Diatomaceous earths are soft, chalky rocks made up of the fossilised skeletons of diatoms—microscopic plants that live in seas, rivers and lakes in incredibly large numbers. These skeletons are made up mostly of silica. Not all diatomaceous earths are suitable for use as grain protectants, however, as some contain high levels of crystalline silica—which is dangerous. So, every source of diatomaceous earth needs to be tested independently to check its effectiveness and safety.

Above: This highly magnified image shows the fossilised diatoms that make up diatomaceous earths. A handful of the earth would be made up of many millions of these diatoms. Photo: Cereal Research Centre, Canada

When they die, diatoms sink to the bottom of the river, lake or sea in which they are living, building

up thick layers of sediment that get compressed to form diatomaceous rocks. This process takes a very long time, and most of the diatomaceous earths being used today were formed more than 20 million years ago in the lakes and seas of the Miocene period.

The diatomaceous earths used to kill the insects that attack stored seed and grain are dried and ground up to make a fine whitish powder that looks and feels a little like talcum powder. This must then be thoroughly mixed with the grain before it is stored.

How do diatomaceous earths kill insects?

Many insects have a waxy coating over their outer skin (or cuticle) which stops them losing too much water and drying out. As they crawl through grain which has been treated with diatomaceous earths, their waxy waterproof covering is absorbed, causing them to dehydrate and die.

So, unlike chemical insecticides, diatomaceous earths don't poison insects—their mode of action is purely physical. In fact, they are recognized to have very low levels of toxicity for humans, and are safely used all over the world for a variety of uses, including filtering fruit juice, beer and wine. This makes them safe to mix with seed and grain, and many types of commercially available diatomaceous earths are already used as officially recognized or registered grain protectants in a variety of countries worldwide, including Australia, Brazil, Canada, China, Germany, Indonesia, Iran, Japan, the Philippines, Saudi Arabia, the United Arab Emirates, the UK and the USA.

Above: Diatomaceous rock from the Kagera river basin, Tanzania.
Photo: T. Stathers

How do diatomaceous earths kill insects? *Cont.*

Diatomaceous earths should not be thought of as a new technology, however. There is evidence that the Chinese were using them to control insect pests as many as 4000 years ago, probably after noticing that birds and animals use them as dust "baths" to kill external parasites.

How are diatomaceous earths used?

Diatomaceous earths (DEs) are effective, relatively cheap and simple to use. However, they should only be used to protect freshly harvested, dry, shelled, and uninfested grain. This is important, because they won't kill larvae that are already developing inside the grains of infested seed. They can only kill those insects that come into contact with the DE dust as they push their way between stored grains in order to eat the grain or lay their eggs.

Above: Diatomaceous earths should be mixed thoroughly with grain on a clean, even floor. Take care not to breathe in the dust. Photo: M. Morris

How much should you use?

How much diatomaceous earth to use for a set weight of grain varies depending upon the type of grain being treated, the different types of insect pests found in the area in question and the DE being used—sorghum, for example, might require a higher dose than maize and cowpea. On-farm trials using commercially available DEs (Protect-It® and Dryacide®) showed that a dose of 0.1 percent weight-for-weight (50 grams of DE per 50 kilograms of grain) was effective in most cases. However, in areas where the devastating larger grain borer is common, a higher dose of 0.25 percent was needed for long-term storage of clean maize grain. Alternatively, a lower dose of 0.1 percent DE could be used in combination with a very low dose of the pyrethroid pesticide permethrin.

Sorghum is frequently attacked by the lesser grain borer (*Rhyzopertha dominica*), and the addition of at least 0.2 percent DE is required to keep clean grain safe from this pest in long-term storage. Different types of insects respond to DEs in different ways because of differences in the characteristics of their waxy layers and in their behaviour. Some insects, for example, have a thick and hard waxy coating which is more difficult to remove than a soft thin layer. Some insects are also more difficult to kill using DEs because they spend most of their time within the grain—which minimises their contact with the DE.

On-farm trials also showed that DEs obtained from local deposits in Tanzania and Zimbabwe also effectively protected stored grain for at least 8 months at application rates of 0.2-0.25 percent.

There is also evidence that using too little diatomaceous earth can do more harm than

good, as it could kill beneficial predatory insects that live in the grain without killing all the pest insects—allowing the pest insects free rein. So, using the right dose of DE for the grain being stored is important.

The researchers also found that there was no advantage in treating newly-harvested, uninfested grain with any protectant if it was to be stored for less than 4 months.

How should you mix the grain and the DE?

Actually mixing the grain and the diatomaceous earth is a simple process, but a very important one. Thorough mixing needs to ensure that all the grains are coated with the fine DE powder so that any insects come into contact with it. Incomplete mixing can allow pockets of insects to develop within the grain bulk.

The grain should be winnowed before it is mixed with the DE. It should then be mixed with the diatomaceous earth in a sheltered place away from the wind—to stop the fine powder blowing around. It's best to do the mixing on a smooth even floor, which should be cleaned thoroughly before work begins to remove dust and debris that might contaminate the grain. If it's available, a strong clean plastic sheet should be laid on the floor so that the grain and diatomaceous earth can be mixed on that.

Above and right: It is important to thoroughly mix protectants into grain to prevent pockets of insects developing within the stored grain. Photos: M. Morris

The best way to mix diatomaceous earths with grain

- Make sure it is not a windy day.
- Place up to 200 kg of grain in a mound on a thoroughly cleaned floor (or plastic sheet).
- Sprinkle the correctly weighed quantity of diatomaceous earth in a circle on the surface of the mound of grain—see photo.
- Using a clean shovel, first gently move grain upwards from the bottom of the pile so that it covers the DE.
- Then, mix the grain and DE by gently shovelling the grain to one side to form a new pile of grain—the first mixing.
- Then shovel the second pile of grain back again—the second mixing, see photo.
- Repeat the process by shovelling the pile to one side again—the third mixing.
- If the treated grain is to be stored in sacks, then put it in a clean sack and sew it up before placing the sack in the store, preferably on a raised platform to prevent the sacks from lying directly on the floor. If it is to be stored in other storage containers (e.g. storage baskets) then make sure that those containers are empty and that they have been thoroughly cleaned.
- Always make sure that the storage room where the sacks or storage baskets are to be stored is clean and that no insects are hiding in crevices in the walls or floors.

Dust masks should always be worn

It is important to always wear a dust mask when mixing grain and diatomaceous earths. Although diatomaceous earths are not toxic in the way that chemical insecticides are, breathing them in directly and regularly when mixing them with grain can cause serious long-term respiratory health problems. Using cheap and easily available dust masks avoids this. If dust masks are not available, then the mixer must at least cover his or her mouth and nose with a thick cloth or scarf to prevent them breathing in the dust. However, proper dust masks should be used if available.

How effective are diatomaceous earths?

Used properly, diatomaceous earths are a very effective method of treating stored grain, and their effects are long-lasting. On-farm trials in Zimbabwe and Tanzania, for example, showed that the commercial diatomaceous earths Protect-It® and Dryacide® protected sorghum, maize, cowpeas and beans against major insect pests for at least 40 weeks of storage.

Damage in the DE-treated grain was very low compared with that in untreated grain or grain treated using farmers' traditional methods, such as ash. What is more, when clean uninfested grain was used, no real difference was found between the performance of these diatomaceous earths and the commonly used chemical insecticide Actellic Super Dust—as long as the Actellic Super Dust was obtained from an approved source and used as per label recommendations. By contrast, most of the farmers who used traditional protectants, such as ash or plant materials, found that their grain contained many insect pests. They therefore had to re-winnow the damaged grain and expose it to the sun before re-treating it—a time-consuming and laborious task for smallholder farmers.

What other benefits do DEs have?

Another benefit of diatomaceous earths is the fact that you don't need to use large amounts. For traditional treatments like sand and ash to have an effect, more than 20 kilograms per 100 kilograms of grain are needed. These treatments often discolour the grain, and removing the sand and ash later is tedious and time-consuming.

Diatomaceous earths, by contrast, effectively control most insect pests when mixed with grain at a rate of only about 0.1-0.25 percent weight-for-weight. So, for every 100 kilograms of grain only about 100-250 grams of diatomaceous earth need to be mixed in. What's more, most of the DE (about 98 percent) is easily removed when the grain is processed.

When will diatomaceous earths be available?

Work to register diatomaceous earths as stored grain protectants has already begun in Zimbabwe and Tanzania, and it is hoped that they will be available commercially within the next couple of years. So, extension workers need to be aware of the benefits that this newly available technology will offer, because

work with farmers has already shown that it is a technology that they readily accept and will be quick to adopt.

During the work done to test diatomaceous earths, researchers also found that many farmers did not know how to correctly apply the chemical pesticides that they were already using. Indeed, a survey of 2121 farmers in Zimbabwe showed that more than half were not applying synthetic (chemical) pesticides according to the manufacturers' instructions.

Bearing this in mind, extension workers need to be ready to provide farmers with comprehensive and detailed information once diatomaceous earths are registered for use as grain protectants in their country. The contact names given at the end of this *Pocket Guide* provide a good first step for finding out more and accessing extension materials.

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For more information,
please see the back page.

How can I find out more?

For more information on small-scale farmers' use of diatomaceous earths during storage some resource material can be accessed for free at http://www.nri.org/de/index.html

Please also contact the RIU Programme, NR International, Park House, Bradbourne Lane, Aylesford, Kent, UK, ME20 6SN, riuinfo@nrint.co.uk.

Further contacts
In all cases, please copy emails to RIU Information **(riuinfo@nrint.co.uk).**

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About this series

Research into Use *Pocket Guides* showcase new technologies that have been tried and tested, and have proven successful in the field. They were produced to demonstrate the importance of high-quality scientific communication.

This *Pocket Guide* was developed from research funded by the UK Department for International Development (DFID), Crop Post-Harvest Research Programme (Projects R7034 and R8179). The views expressed are not necessarily those of DFID.

RIU is managed by Natural Resources International Ltd., in partnership with Nkoola Institutional Development Associates Ltd. (NIDA) and Michael Flint and Performance Assessment Resource Centre. RIU is funded by DFID.

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The *Pocket Guide* series was developed, written, designed and printed for RIU by SCRIPTORIA (www.scriptoria.co.uk)