Efficacy of an amorphous silica dust against bean bruchids

D.P. Giga and P. Chinwada*

Abstract

Amorphous silica dust (Dryacide®) was tested in the laboratory against the bean bruchids *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman). The dust was applied at rates of 1 and 2 g/kg of beans. The efficacy of the silica dust was compared with 2% dust formulations of pirimiphos-methyl and methacrifos applied at a rate of mg/kg. Bioassays were conducted on treated beans aged for 0, 12 and 24 weeks. Mortalities were assessed after exposure for 2 and 5 days. No insects survived the 5-day exposure. The toxic effect of pirimiphos-methyl and methacrifos on *Z. subfasciatus* decreased slightly with age of treatment and required exposures of more than two days to achieve a 100% kill. In all treatments, 100% mortality was achieved after 5 days exposure in both species of bruchid. No progeny developed in any of the treatments. Dryacide® is seen as an ideal substitute to dilute dust insecticides for the small farmer.

Introduction

Admixing grain with 'inert dusts' to reduce infestation by insects is a traditional practice that is still used by small farmers in many countries in Africa. Some of the dusts used include ash, fine sand, clay and powdered formulations of plant products. These protectants are of variable effectiveness. The main impediment to their use is the high amounts needed to provide effective grain protection. Modern equivalents such as diatomaceous earth and silica aerogels have shown a much greater potential as replacements to conventional insecticides. However, a major drawback has again been the unacceptably high application rates required for maximum effectiveness.

Recently a more effective amorphous silica dust formulation (Trade name Dryacide®) was developed in Australia by coating diatomaceous earth with silica aerogels (Desmarchelier and Dines 1987). Unlike its components, Dryacide® is admixed with grain in much smaller quantities, and rates as low as 0.1% (1 kg/t of seed) have been shown to control a broad spectrum of insect pests (Arthur 1981; Aldryhim 1990).

The present study was aimed at evaluating the effectiveness of Dryacide® against the bean bruchids; its efficacy being compared with that of 2% dust formulations of pirimiphos-methyl and methacrifos at 10 mg/kg beans. Previous evaluations of pirimiphos-methyl have shown that complete protection of beans for 24 weeks can be expected (Taylor and Evans 1980; Golob and Kilminster 1982).

* Department of Crop Science, University of Zimbabwe, Harare, Zimbabwe.

Materials and Methods

Dryacide® was applied to 800 g seed batches at rates equivalent to 1 and 2 g/kg of seed. Two percent dust formulations of pirimiphos–methyl and methacrifos were each applied at a rate of 10 mg a.i./kg beans (0.4 g dust/800 g seeds). To minimise losses resulting from the adhesion of dusts to walls of the weighing bottle, the required amounts of each substance were weighed directly onto a small sample of beans withdrawn from the 800 g lot. After weighing, treated seeds were returned to the bulk of seeds and thoroughly mixed by tumbling.

Following treatment, ten 25 g samples were withdrawn from each 800 g batch for bioassays. Five of the samples were infested with 5 male and 5 female pairs of newly emerged *Zabrotes subfasciatus* adults and the remainding 5 infested with 10 unsexed newly emerged *Acanthoscelides obtectus* adults. Five untreated replicates were also set up as controls for each species. All treatments were incubated at 26 ± 2°C and 50–60% r.h. The remaining seeds (treated and untreated) were kept at ambient temperature and humidity conditions till required for bioassays 12 and 24 weeks later.

The efficacy of each treatment was assessed by recording adult mortality (2 and 5 days after infestation), F_1 emergence and percent seed damage. The persistence of each treatment was evaluated by making further infestations to seeds on which dust deposits had aged for 12 and 24 weeks. For each evaluation, a new set of controls was used. Mortality, F_1 emergence and percent seed damage were again recorded.

Results

The results of insect mortality are given in Tables 1 and 2. No insects survived the 5-day exposure in all treatments, and analyses of variance of arcsine–transformed data of percent mortality (2-day exposure) showed significant ($P < 0.05$) treatment effects when dust deposits had aged for 12 and 24 weeks. Dryacide® was similar to insecticides in its effects on adult insects, though in some instances it required slightly longer than 2 days to achieve a 100% kill. The 24-week period was, however, not long enough to show age-effect differences of the treatments. No emergences occurred in any treatments, because of mortalities of insects before oviposition. Emergences were recorded only in the untreated controls.

Discussion

Application of Dryacide® resulted in rapid control of the bean bruchids, the degree of seed protection being similar to that provided by the insecticides pirimiphos-methyl and methacrifos. Its persistence was also not significantly different from that of the two insecticides. Aldryhim (1990) showed that over a 24–week period, Dryacide® remained toxic to adult *Sitophilus granarius* under his experimental conditions of

Table 1. Percent mortality of *Z. subfasciatus* adults on beans treated with Dryacide® and insecticides after different periods of storage

Treatment	Exposure time (days)	
	2	5
Fresh deposits		
p-methyl (10 mg/kg)	100	100
methacrifos (10 mg/kg)	100	100
Dryacide® (1 g/kg)	100	100
Dryacide® (2 g/kg)	100	100
12-week-old deposits		
p-methyl (10 mg/kg)	82[a]	100
methacrifos (10 mg/kg)	84[a]	100
Dryacide® (1 g/kg)	96[b]	100
Dryacide® (2 g/kg)	100[b]	100
24-week-old deposits		
p-methyl (10 mg/kg)	78[a]	100
methacrifos (10 mg/kg)	88[a]	100

For each period of infestation, means followed by the same letter are not significantly different $P < 0.05$.

Table 2. Percentage mortality of *Acanthoscelides obtectus* adults on beans treated with Dryacide® and insecticides after different periods of storage

Treatment	Exposure time (days)	
	2	5
Fresh deposits		
p-methyl (10 mg/kg)	100[a]	100
methacrifos (10 mg/kg)	100[a]	100
Dryacide® (1 g/kg)	86[b]	100
Dryacide® (2 g/kg)	98[a]	100
12-week-old deposits		
p-methyl (10 mg/kg)	100[a]	100
methacrifos (10 mg/kg)	100[a]	100
Dryacide® (1 g/kg)	88[b]	100
Dryacide® (2 g/kg)	92[b]	100
24-week-old deposits		
p-methyl (10 mg/kg)	100[a]	100
methacrifos (10 mg/kg)	100[a]	100

For each period of infestation, means followed by the same letter are not significantly different $P < 0.05$.

20–30°C and 40% r.h. Generally, for maximum effectiveness, seed moisture content should also not exceed 12% (Arthur 1981) so that dust particles do not agggregate. However, this would not be a problem if seeds were properly dried before storage.

The two rates of Dryacide® used were selected from a previous evaluation of the dust for the control of *Rhyzopertha dominica* F., *Tribolium castaneum* Herbst, *Sitophilus oryzae* L. and *S. granarius* L. in stored wheat (Desmarchelier and Dines, 1987). The results of this study show that Dryacide® is equally effective against bruchids in beans. Dryacide® treatment killed all adults before they laid eggs. Observations showed that insects were first immobilised as the dust stuck onto limb joints; rapid desiccation followed with removal of the cuticular wax (Aldryhim 1990).

The persistent effect of Dryacide® makes it an ideal 'non-chemical' treatment on dry grain under non-humid conditions. Most insecticidal treatments are usually very effective in the short term but gradually lose effectiveness through degradation. Ideally, effective grain protection requires not only the ability of a treatment to kill existing pests, but also to remain effective for long enough to kill invading insects and emerging progeny. However, like any other dust, effectiveness of Dryacide® depends on the achievement of an even mix with seeds and maintenance of a dry environment within the grain mass so that dust particles do not aggregate. Unlike commercial grain storage, where the fine dust would pose a health hazard to workers due to mechanical sifting of bulk grain, Dryacide® would be ideal in small-farmer storage systems where the amounts of beans stored are very small.

References

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