Structural treatment with amorphous silica slurry: an integral component of GRAINCO's IPM strategy

B.W. Bridgeman*

Abstract

GRAINCO, the central grain handling organisation in Queensland, Australia, conducted a series of trapping trials in several horizontal bulk grain storages to assess the effectiveness of amorphous silica slurry as a structural treatment strategy to replace residual insecticides traditionally used to disinfest storages.

Amorphous silica structural treatment, if effective, has the potential to reduce GRAINCO's dependence on residual chemicals, as well as adding to the grain protection strategies in the organisations integrated pest management plan.

Preliminary results of the trapping trials highlighted a significant reduction in populations of insects resident in storages after treatment with amorphous silica ($P<0.05$). The percentage of traps infested before and after treatment with amorphous silica (18% to 3% for Coleoptera and 90% to 40% for Psocoptera), indicated good but incomplete control which lasted for several months. These results confirm amorphous silica slurry is an effective replacement for residual chemicals as a structural treatment. The trials also indicated that hygiene alone made little difference to the percentage of traps infested before structural treatment.

Structural treatment with amorphous silica slurry is now an integral component of GRAINCO's integrated pest management plan, which incorporates insecticide resistance management and is characterised by a reduced reliance on residual grain protectant chemicals.

Introduction

GRAINCO, the bulk grain handling authority of Queensland, Australia, operates as a grower-owned cooperative handling a wide range of commodities. During the 1990–91 wheat harvest, GRAINCO developed and implemented a multicomponent, integrated pest management (IPM) plan following an investigation into an increase in insect pest control failures (Collins and Bridgeman 1991). Insecticide resistance management (IRM) strategies are a major component of the plan, as is the focus on reducing the reliance on residual chemicals to protect the grain from insect pests.

Residual chemicals, i.e. grain protectants, have traditionally been used to treat the fabric and structure of empty grain storagesbetween harvests, to control residual insect populations. Control of these populations is an essential resistance management tactic as they have been exposed to, and survived, various chemicals applied to the commodity during the previous season. They are therefore a likely means of resistance development to the various protectants and fumigants used (Collins and Bridgeman 1991). Structural treatments which are either identical, or similar to grain protectants can but accelerate development of resistance to these compounds.

Amorphous silica (Dryacide®) applied as an aqueous slurry (Bridgeman 1991) has potential as a fabric or structural treatment to control populations of grain storage insects resident in bulk grain storages (Desmarchelier et al. 1992). This material is based on an inert, naturally occurring dust that is insecticidal (through desiccation) without the residue problems associated with grain protectants (Desmarchelier and Dines 1987). As such it is a potential replacement for the grain protectants such as fenitrothion and permethrin traditionally used for disinfestation of storages.

In laboratory studies, amorphous silica controlled stored-product insects, and when applied as a dust or powder, gave good but incomplete control in field trials (Desmarchelier et al. 1992). Little information, however, is available on the efficacy of amorphous silica slurry as a fabric treatment in the field, or on its residual activity as a slurry on bulk grain facilities. As pointed out by Desmarchelier et al. (1992) field efficacy of structural treatments cannot be ascertained from laboratory studies alone, principally because of the importance of insect behaviour. They recommended trapping studies of actual storages.

This series of trapping trials reported here was designed to assess the effectiveness of amorphous silica applied as a slurry in disinfesting storages and to gain some information on the duration of effectiveness of the treatment.

An additional question, which became significant during the planning of the trial, was the effect of hygiene on the resident insect populations within the storage. As a consequence these trials also endeavoured to gauge the effectiveness of hygiene as a pest control tactic.

Materials and Methods

The storages

The trials were conducted on four small horizontal storages. These 'Perrin sheds' are used extensively in Queensland by GRAINCO to store a range of commodities. The roof and walls of the structure are constructed from corrugated galvanised iron sheeting; the floors are bitumen. Perrin sheds have a rectangular floor plan of 100 m × 15 m and have 5 m walls which are gabled on the ends to 8 m.

Each storage was swept and washed with clean water during the 'hygiene phase' before application of amorphous silica. It was recognised that each structure provided a variety of havens for residual populations of insects between harvests and that many of these refuges contain grain and dust particles which provide a food source for insects. Such storages were ideal sites for this series of trials on the efficacy of a structural treatment as it is almost impossible to remove all grain particles. A standard of hygiene which would ensure that no havens remained would require that the sheds be dismantled whenever empty after each harvest.

* GRAINCO, P.O. Box 136, Toowoomba, Queensland 4350, Australia.

The application technique

Amorphous silica was applied to walls, roof and floor areas of the trial storages using the GRAINCO Hydra-Cell amorphous silica slurry application technique (Bridgeman 1991). The Dryacide® was applied at 6–8 g/m^2 as recommended by Desmarchelier et al. (1992) and a uniform application achieved (Bridgeman 1992).

The trapping protocol

Thirty flour-baited cardboard traps (Wright 1991) were set in fixed positions throughout each storage and left for weekly intervals.

Trap inspections were carried out once per week for 3 weeks before hygiene phase to establish baseline residual population densities and the effect of the trapping on the insect population. After the hygiene and treatment were completed insect populations were again monitored at weekly intervals for 3 weeks. This protocol was undertaken to ensure that any reductions observed in populations were the effects of the amorphous silica application and not in part to the trapping program or the hygiene activity. After treatment with amorphous silica, the sheds were trapped for 3 more weeks and again 8 weeks later. The trial was terminated when harvest intake was imminent.

Only the presence or absence of insects was recorded for the initial trials reported in this paper. The data were subjected to contingency table analysis (Sokal and Rohlf 1969)

Results

There was no significant change in the percentage of traps infested before and after the hygiene phase (Fig. 1).

In contrast, the proportions of traps containing both coleopterous insects and psocids in all storages decreased significantly ($P<0.05$) from approximately 18 to 3% for coleopterous insects and from 90 to less than 40% for psocids following application of amorphous silica (Fig 1.).

At 11 weeks after treatment, the proportion of traps with insects remained very low (Fig. 1) indicating that control remained effective.

The pre-treatment trap catches indicated clearly that the level of trapping used in this trial did not significantly affect the population of insects in the storage and should not have biased the results (Fig. 1).

Discussion

In these preliminary trials, amorphous silica applied as an aqueous slurry was found to greatly reduce the residual populations of grain storage pests, measured by proportion of traps containing insects and in actual counts during the trial (Bridgeman, unpublished data). The treatment strategy, however, did not give complete control: some insects survived. These were usually detected in damp areas where amorphous silica is known to be much less effective (Desmarchelier and Dines 1987). The degree of control improved

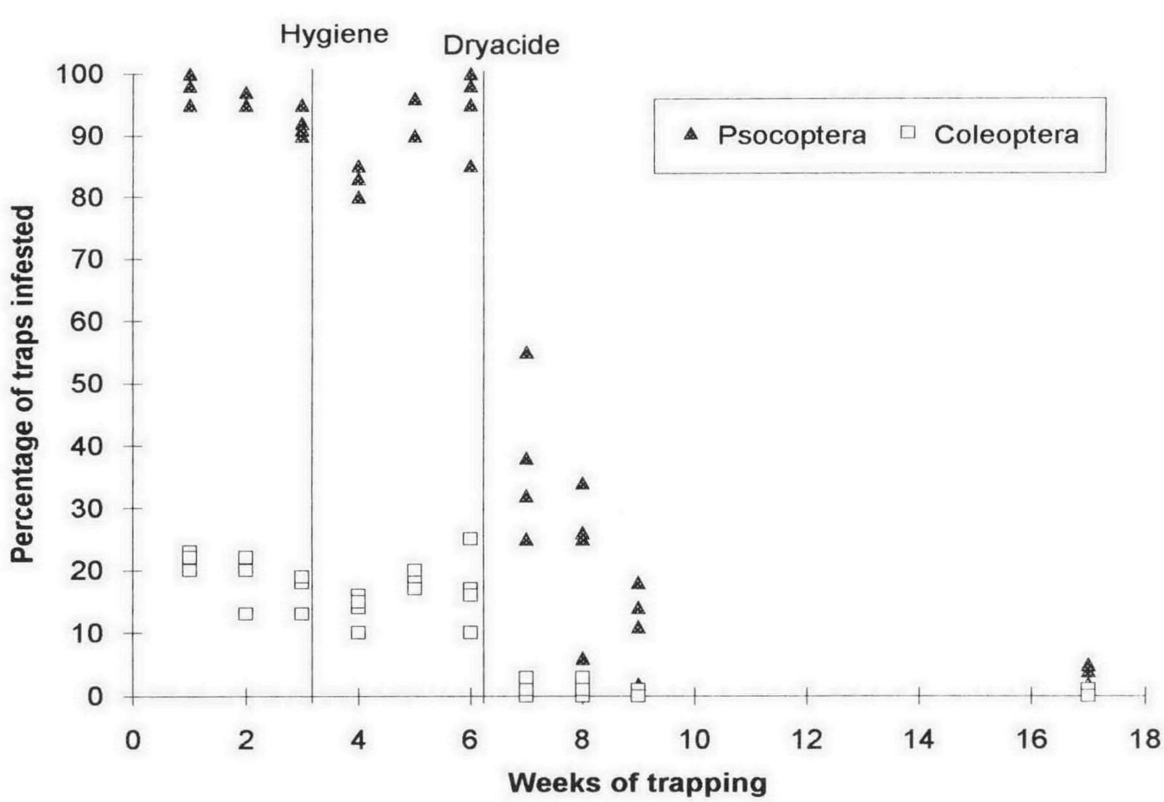

Fig. 1. Percentage of traps infested with Coleoptera and Psocoptera in relation to pest control practices. Four sheds used in this series; sheds were not trapped concurrently.

with time. The data indicated strongly that fewer insects would be trapped with time after application.

Amorphous silica gave control for the duration of this 11-week test period and, as the trial was terminated early, the effective life of the application may be much longer. Trials to establish an effective life of the treatment are planned. Even so, the results compare favourably with the expected effective life of residual chemical controls (retreatment is recommended every 3 months by the manufacturer) and suggest that amorphous silica has a future in stored-grain pest control as a non-chemical fabric treatment.

The effect of cleaning storages was difficult to assess. There was no reduction in proportion of traps infested after the hygiene phase. This may have been due to the storage type rather than the ineffectiveness of hygiene. Trap catches did indicate a significant reduction in number of insects taken per trap after the hygiene phase (Bridgeman, unpublished data). An interpretation of these results might be that hygiene is a valuable IPM strategy but that its effect is enhanced by some form of fabric treatment. Further trials to quantify the significance of hygiene are planned.

Amorphous silica is a physical control agent. As such, it has an important role to play in the management of resistance to chmical protectants. Selection for resistance can be minimised by ensuring that insects surviving a grain protectant treatment from the previous season are effectively controlled by amorphous silica. Past practices of treating the storage structure with grain protectants chemically identical or similar to that being applied to the grain at harvest encouraged the development of resistance by repeated selection of the same insect population.

These trials have shown that use of amorphous silica slurry as a treatment of storage structure will enhance the long-term success of the GRAINCO IPM plan. The strategy has been extended to all GRAINCO storages, including some which are nil treatment sites. At these sites phosphine fumigation is the chemical control used. Amorphous silica treatment of these sites will minimise selection for phosphine resistance.

The active implementation of the GRAINCO IPM plan has not only significantly reduced the levels of infestations detected but has also increased the capability of GRAINCO to store commodities without the use of residual grain protectants (Bridgeman and Collins, these proceedings).

References

Bridgeman, B.W., 1991. Structural treatment manual, an instruction for the application of Dryacide® slurry. Toowoomba, Australia. GRAINCO Training Manual.

Bridgeman, B.W. 1992. Efficacy of amorphous silica in bulk grain storages. Toowoomba, Australia, GRAINCO Internal Report.

Collins, P.J. and Bridgeman, B.W. 1991. Integrated pest management plan for GRAINCO, strategies for the nineties. Toowoomba, Australia. GRAINCO.

Desmarchelier, J.M. and Dines, J.C. 1987. Dryacide® treatment of stored wheat: its efficacy against insects and after processing. Australian Journal of Experimental Agriculture, 27, 309–312

Desmarchelier, J.M., Wright, E.J. and Allen, S.E. 1992. Dryacide®: a structural treatment for stored product insects. In: Proceedings of 5th Australian Applied Entomological Research Conference 1992.

Sokal, R.R. and Rohlf, F.J. 1969. Biometry: the principles and practice of statistics in biological research. W.H. Freeman and Company, 586–591.

Wright, E.J. 1991. A trapping method to evaluate efficacy of structural treatment in empty silos. In: Fleurat-Lessard, F., and Ducom, P., ed., Proceedings 5th International Working Conference on Stored–product Protection, Vol III, 1455–1463.