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INTEGRATION OF INERT DUST INTO CONTROL OF STORAGE PESTS IN BULK GRAIN IN STORAGE IN AUSTRALIA

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ABSTRACT

This paper describes the use of inert dust for the control of storage pests by the bulk grain handling industry in Australia. Inert dusts are used in three main ways, as structural treatments, capping treatments and surface admixture treatments. Structural treatments of chemical insecticides, where they were used, have been largely replaced with use of the inert dust, Dryacide®, that can be blown onto surfaces dry or sprayed as a slurry. Capping treatments are used in combination with flow-through fumigation of phosphine (SIROFLO®) where a thin layer (100 g m^{-2}) of Dryacide® is applied by blowing dust across the surface of the grain bulk. The purpose of the dust layer is to ensure phosphine gas is retained at insecticidal concentration in the surface layers of the grain bulk by retarding the loss of phosphine to the headspace. Surface admixture treatments are used in combination with aeration. In this application, Dryacide® is mixed into the top 0.3 m of grain to protect against insect re-invasion of the grain bulk surface, and to reduce or possibly eliminate some existing populations.

INTRODUCTION

Inert dusts are chemically unreactive dusts that have insecticidal capability, killing by physical rather than chemical means. Insects coated in these dusts dehydrate and die. Because the effect is through desiccation, the effectiveness of inert dusts decreases as relative humidity increases. There is renewed interest in technology associated with use of inert dusts in grain storages and a number of reviews have been written (Ebeling 1971; Banks and Fields 1995; Golob 1997; Subramanyam and Hagstrum 2000). This renewed interest arises in part from the search for alternative methods to some chemical protection procedures whose future use is threatened. In Australia, Dryacide®, a diatomaceous earth inert dust, has been used since 1986 for admixture to grain stored on farm. The National Association of Sustainable Agriculture Australia (NASSA) has approved Dryacide® for use on organic grain.

It has not been used on bulk grain because when inert dusts are admixed with grain, physical properties, such as bulk density and grain flow speed, are altered, this being unacceptable to both grain handlers and marketers. However, in recent years Dryacide® has been introduced to bulk storage both as a structural treatment and as a treatment for the surface of grain bulks.

Although such treatments with inert dusts are not new (Gay 1947), they are needed now more than ever because non-residual treatments such as fumigation, controlled atmospheres and aeration, have replaced contact pesticides to a large degree. As a result, the boundaries of grain bulks are now more vulnerable to insect attack. Some pest insects survive on the grain bulk surface and application of inert dust to the surface can be an effective way to control these insects. Data on the effectiveness of inert dusts against a range of insect species is available (Fields and Korunic 2000; McLaughlin 1994). However, their effectiveness against psocids is not well understood. This is important in Australia as psocids have become a major problem in some parts of Australia is recent years (Rees 1994). Nayak and Collins (1998) showed that Dryacide was ineffective against *Liposcelis* spp. in laboratory structural assays at high humidity (70%) and preliminary work by the author indicates that Dryacide doesn't stick to psocids as well as it does to other insect species.

Inert dust capping treatments used in combination with flow-through fumigation

In Australia, a large proportion of grain storage is not sealed to gas-tightness and is unsuitable for fumigation by traditional means. A flow-through fumigation process SIROFLO was developed to permit fumigation of such storage (Winks and Russell 1994a, 1994b). However with this process, the concentration of phosphine in the surface layers of grain is often less than that within the grain bulk and may drop below insecticidal levels without some form of intervention (Winks and Russell 1994b). As a result, capping with Dryacide or covering the grain surface with tarpaulins is often undertaken to assist the fumigation treatment and protect this small portion of the grain. Dryacide is used in this way by blowing it over the surface of grain at a rate of 100 g m^{-2} using a compressed air gun. An example of what can be achieved is shown in Fig. 1 where data from a field trial at Yeelanna, South Australia during 1988 is reproduced (Masters and Marszel 1998). It compares surface concentrations of phosphine during a SIROFLO fumigation of grain in two similar vertical cells one capped with Dryacide and one uncapped. Similar results were obtained for another three paired cells and comparable observations have been made in both New South Wales and Queensland (Personal communications, B. Bridgeman and G. Sheargold; Bridgeman 1998).

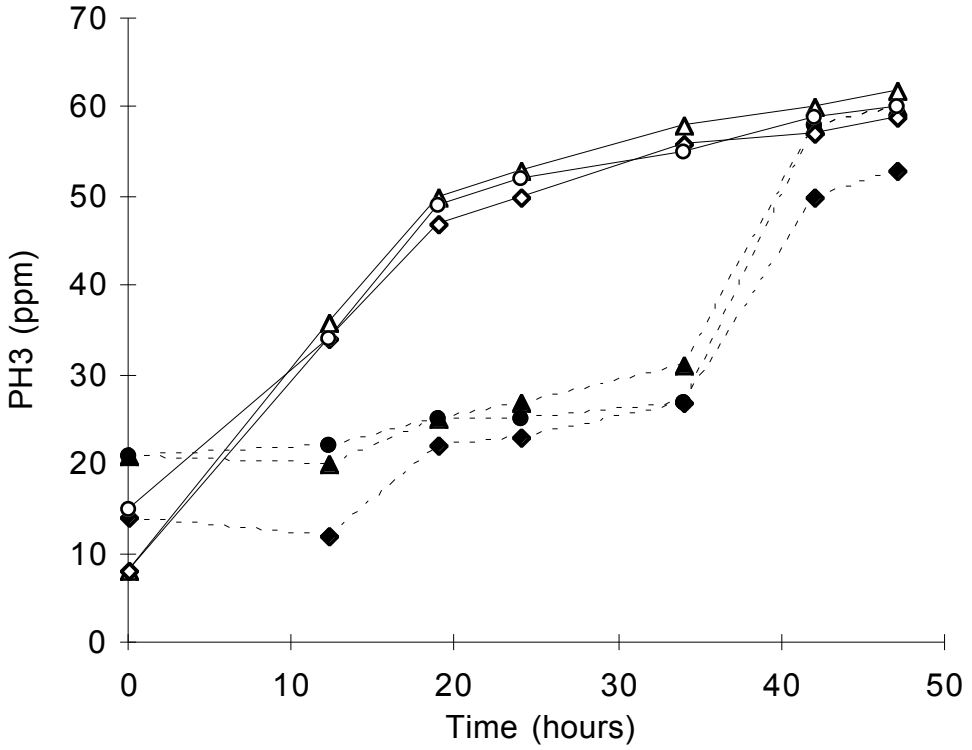

Fig. 1. Phosphine concentrations measured during a SIROFLO® fumigation at Yeelanna, South Australia in a pair of similar bins with or without Dryacide® capping. Concentrations were measured 1m ( ) and 0.1m ( ) below the grain bulk surface and 0.1m below the peak of the grain bulk ( ) in the capped ( ) and uncapped (- - -) bins.

Surface admixture treatments used in combination with aeration

Protection of the surface layers of grain under aeration-cooling is warranted because the surface of the grain may not be cooled sufficiently to prevent insect development. The surface is also vulnerable to invasion by insects from elsewhere. Laboratory studies have been carried out in Australia (Fig. 2), Canada (Korunic 2000) and USA (Subramanyam *et al.*, 1994) to determine either the depth of inert dust treated wheat required to prevent penetration of insects into the untreated wheat below or the progeny suppression from surface admixture of inert dusts. The two insect beetle pests, *Oryzaephilus surinamensis* (Linnaeus) and *Cryptolestes ferrugineus* (Stephens), that are most easily controlled by both admixed and structural inert dusts treatments, surprisingly required the greatest depth (1-1.5 m) of Dryacide® treated wheat (Fig 2) to prevent their penetration into untreated wheat. It appears that other

factors, such as insect mobility, size and behaviour have an important effect on the efficacy of surface layers for some insect species.

Dryacide is used commercially in a surface admixture treatment for grain under aeration. In the Australian rice industry, Dryacide is applied to the surface of paddy rice as a water-based slurry and then raked or walked in to a depth of approximately 10 cm. Manufacturers of organic products have used similar surface admixture procedures to successfully store organic grain (Nickson *et al.*, 1994). That the depth of treated grain required for insect control in commercial situations under aeration-cooling or aeration-drying is less than that determined in laboratory tests, where there was no aeration, warrants further investigation.

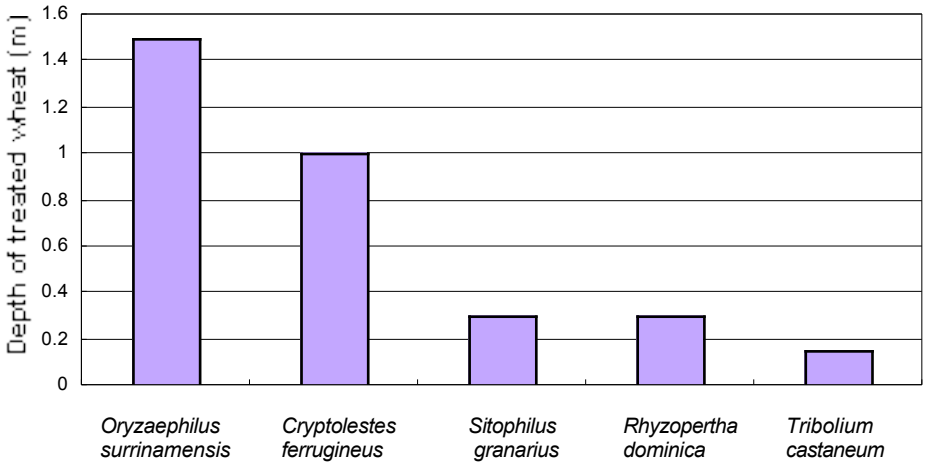

Fig. 2. The depth of Dryacide treated wheat (2 g t^{-1}) in test containers (∅ 10cm) required to prevent penetration of stored grain pests into untreated wheat below.

Structural treatments

In Australia, Dryacide is frequently applied as a structural treatment to empty storage structures, either as a dry blown dust or as a water-based slurry. The dry dust is applied with a compressed air gun at a rate of 1-2 g m^{-2} (Desmarchelier, Wright and Allen 1993); higher applications (>7 g m^{-2}) may cause the dust to flake off. The water-based slurry (11% w/v) is applied using a slurry pump at a rate of 6 g m^{-2}. The slurry application requires a higher application rate but has the advantage of reducing the dustiness of the operation. Both methods of application are used in the industry, and which one is chosen appears to be a matter of worker preference. Generally Dryacide is applied to cleaned empty storage approximately six weeks prior to receiving grain. Once all grain has been received, surfaces above the grain are cleaned and Dryacide is reapplied.

The procedures above are established methods of pest management used by the Australian grain industry. Challenges remain for both the industry and research. A challenge for industry is to out-load grain treated in this manner at maximum through-put without difficulty and within a working environment acceptable to grain handling staff. A current challenge in Australian research is to more full understand the way in which inert dusts and other materials affect gas flow through grain and to use this information to optimise capping and barrier treatments. Inert dusts currently make an important contribution to integrated pest management in the Australian grain storage and handling industry, and will continue to be valuable into the future.

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