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The Effect of Grain Temperature on the Toxicity of Phosphine against Phosphine - Resistant Insect Pests of Stored Grain

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Abstract: The Australian grain industry relies principally on phosphine fumigation to eliminate insect infestations that threaten grain integrity and market access. Currently there is no viable alternative to phosphine and it is likely that the industry will continue to rely on this fumigant at least for the medium term. A significant threat, however, to the on-going use of phosphine has been the development of resistance in target pests.

Our challenge is to effectively manage the threat of resistance until alternative strategies can be researched and implemented. It is well known that concentration and time are important dosage parameters for phosphine, however, little is known of the significance of a third variable, grain temperature, despite anecdotal evidence that it has an effect on the outcome of fumigations. The aim of our work was to quantify the effect of temperature on the toxicity of phosphine and to use this information in the development of fumigation protocols.

Mixed-age cultures (including all life-stages) of purified resistant strains of *Rhyzopertha dominica*, *Sitophilus oryzae* and *Liposcelis bostrychophila* were exposed to phosphine at a range of grain temperatures in the laboratory. Once dosage protocols were developed, these were tested in field trials under commercial conditions in bulk grain.

Toxicity of phosphine was strongly influenced by fumigation temperature. With *R. domincia*, there was no simple relationship between toxity and temp at most concentrations. For example, at 0. 17 mg L^{-1}, time to population extinction was longer at 30℃ than at 35 but it was 10 days shorter at 20 and 25. In contrast, toxicity against *S. oryzae* increased with temperature and this species was comparatively susceptible at higher temperatures. Similarly, increasing temprature had a marked effect on the toxicity of phosphine against populations of *L. bostrichophila*.

Key words: phosphine, resistance, temperature, stored grain, insects

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Study on the Sorption, Desorption and Accumulation of Phosphine Residue on Multi - fumigated Grains

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Abstract: The sorption of phosphine on hard wheat decreased with an increase in the number of fumigation cycles at 11. 3% - 12. 1% moisture content. For example, after the initial physical sorption of phosphine (which can be removed by aeration) the sorption of phosphine decreased by 10% for the second fumigation cycle, and by 20% for the third fumigation cycle. Theoretically, this result shows that there are a limited number of matrices in hard wheat which could react and/or chemically bind phosphine (200 ppm). There was no major difference in the sorption of phosphine with single and multi-fumigation on soft wheat, barley and field peas. This result indicates that there are certain levels of matrices in soft wheat, barley and field peas which could react and/or chemically bind phosphine. After 14 days exposure, 50% - 60% phosphine was absorbed by soft wheat, 75% - 80% by barley and 90% - 95% by field peas. Therefore, in comparison with wheat, the application dose for the fumigation of barley and field peas should increase by 20% and 30% respectively.

Desorption rate of phosphine from wheat (hard and soft), barley and field peas was affected by the number of fumigation cycles. The desorption rate increased with increasing number of fumigation cycles, eg. 5% - 10% more phosphine was desorbed with each successive fumigation cycle. The first

day aeration removed 85% –95% of the phosphine from wheat (hard and soft) and 65% –75% from barley and field peas. Therefore, in comparison with wheat, for barley and field peas a 20% longer period of aeration is required.

The levels of phosphine in wheat (hard and soft), barley and field peas was affected by the number of fumigation cycles. The residue levels increased with increasing number of fumigation cycles, eg. 10% –30% more phosphine residues were present with increasing fumigation cycles. The first 2 days aeration removed 85% –95% of the phosphine from wheat (hard and soft) and 65% –75% from barley and field peas. This result is consistent with desorption. Therefore, in comparison with wheat, for barley and field peas a 20% longer period of aeration is required.

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Ethanedinitrile (C_2N_2) is a Potential Fumigant for Grain, Timber and Soil

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Abstract: Cyanogen (C_2N_2) is a new potential fumigant to replace methyl bromide for certain applications. It is highly toxic to insect pests. Cyanogen was evaluated for its potential as a grain and timber fumigant, where rapid action is important. The most of stored product insects (all stages) can be killed at 1 or 5mg L^{-1} for 6 or 3 hours exposure, e. g. the adult stage of *R. dominica* was completely killed at 1.0mg L^{-1}. Exposure for 6 hours to C_2N_2 at 21 –25℃, all the larval stages of *A. glabripennis* were completely killed at 11mg L^{-1}, workers of *C. acinaciformis*, *C. brevis*, *M. darwiniensis* and *Reticulitermes speratus* were completely killed at 1.61mg L^{-1}, 3.0mg L^{-1} and 2.3mg L^{-1} respectively. In general, C_2N_2 showed high toxicity to all immature and adult stages tested and in this respect is more toxic than methyl bromide. The efficacy of C_2N_2 to other wood related pests shown that for 6hr exposure at 21 ±2℃, the LD_{99} value was 0.65, 4.64 and 0.63mg L^{-1} against *R. speratus*, *T. piniperda* and *H. cunea* adult, respectively. Also, C_2N_2 was highly effective (>95%) to a pinewood nematode (*Bursapelenchus xylophilus*) when applied 97g m^{-3}. The highest dose of C_2N_2 (148g m^{-3}) in the trials showed highest nematocidal activity but didn't achieve 100% mortality. The penetration of C_2N_2 into the Pinewood (Oregon, *Pseudotsuga menziesii*) blocks (10 cm (10 cm (30 cm) with 0.44 –0.45 g cm^{-3} of density and a 7.8% moisture content was much better than the methyl bromide.

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Implementing a No Entry Phosphine Fumigation Strategy

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Abstract: The CBH Group, the central grain storage and handling organisation in Western Australia, has been trialling Vaporphos® as a no entry phosphine fumigation technique. These trials have seen the successful application of phosphine in storages as large as 280 000 tonnes.

As a result of this success the CBH Group has implemented a "Zero Harm" fumigation strategy to minimise potential staff exposure to phosphine during the application phase of the fumigation. The implementation of this strategy involved the adaptation of storage infrastructure, review of fumigation protocols, establishment of rapid fumigation business rules, and inclusion of these rules into the existing Grain Protection integrated pest management program.

This presentation gives an overview of the strategy and outlines the benefits associated with adopting this new approach to using phosphine.