The feasibility of increasing the penetration of phosphine in concrete silos by means of carbon dioxide

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Abstract

Treatments with CO_2 (alone or combined with various gases) are considered to be less effective in concrete than metal silos due to reactivity between CO_2 and concrete. However, field studies conducted on wheat in concrete silos up to 44 m in depth showed that fumigation of the grain was effective. Considerable concentrations of phosphine were detected at the bottom of the bins during the 10-day treatment period, and total mortality of the insects, which heavily infested the wheat, was achieved.

Introduction

The use of fumigant mixtures containing phosphine (PH_3) and carbon dioxide (CO_2) has been proved to be effective in treating large masses of grain in deep silo bins. Good penetration of PH_3 to depths of 10, 22 and 37 m has been achieved (Carmi et al. 1990, Carmi and Shaaya, 1992). These experiments were conducted in metal structures with a satisfactory level of gastightness. However, in Israel, large amounts of grain are stored in concrete structures, which are considered to be less suitable for treatments involving CO_2, owing to its absorption by and chemical reactivity with concrete (Snelson 1987; Newman 1989). Application of the advantages of PH_3 + CO_2 mixtures in treatments of concrete structures is desirable. Reichmuth (1993) achieved considerable penetration of phosphine to 18m depth of grain in a concrete silo using a PH_3 + CO_2 mixture, in conditions of less than optimal gastightness.

Experimental

A PH_3 + CO_2 mixture was tested for fumigation of infested wheat in a 44-m deep concrete bin. A dosage of 2 g/m^3 of magnesium phosphide was applied to the top of the bin, followed by the application of 200 g/m^3 CO_2 as dry ice. The fumigation lasted for 10 days, during which gas samples were taken from depths of 0.5 and 2 m below the surface, and from the bottom of the bin. Phosphine concentrations were determined by the Bedfont EC 80 phosphine monitor, and CO_2 levels were determined by Drager Detector tubes.

Results and Discussion

Considerable amounts of phosphine had already penetrated to the bottom after 24 hours; a peak level of 490 ppm was reached after 48 hours and the final level was 180 ppm after 10 days (Table 1). Though the concentrations of PH_3 in the upper region were higher, the amount that reached the bottom was in the lethal range and was enough to achieve 100% kill of the insects in the grain. Yongsheng (1992) found that 130 ppm of PH_3 mixed with 8–10% CO_2 was effective in control of insects and mites. Hashem and Reichmuth (1989) found that 0.53 mg/L (360 ppm) of PH_3 killed eggs of *R. dominica* in 72 hours. Mueller (1993) found that the combination of 65–100 ppm PH_3 + 4–6% CO_2 at a temperature of 32–37°C was effective in controlling insects in flour mills. In our trial, large amounts of CO_2 penetrated to the bottom, thus making an effective combination with PH_3 concentrations which were already in the lethal range. This trial showed that, in spite of the disadvantages of concrete structures for CO_2 treatments, good results can nevertheless be achieved by using the PH_3 + CO_2 mixture. In future studies optimisation of the treatment should be sought, through better sealing of the concrete surfaces to reduce its effect on the gas.

Conclusion

The method described here has the following advantages

1. An effective strategy for fumigation of deep grain bins.
2. A low dose of phosphine.
3. A single, short and simple application.
4. Inexpensive, with no sophisticated equipment required.
5. Suitable for a wide range of bin structures if they have a fair level of gastightness.

References

Carmi, Y., Golani, Y. and Frandji, H. 1990. Fumigation of a silo bin with a mixture of magnesium phosphide and carbon dioxide by surface application. Proceedings 5th International Working Conference on Stored Product Protection, Bordeaux, France, Vol 2, 767–774.

Carmi, Y. and Shaaya, E. 1992. Penetration of phosphine in deep grain bin by aid of carbon dioxide. Proceedings XIX International Congress of Entomology, Beijing, June 1992.

Hashem, M.Y. and Reichmuth, Ch. 1989. The efficiency of phosphine against eggs of lesser grain borer. Nachrichtenbl. Deut, Pflanzenschutzd. (Braunschweig), 41, 1989.

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Table 1. Concentrations of phosphine (ppm) and carbon dioxide (%) in a 44 m deep concrete wheat bin after fumigaion with PH_3 + CO_2 mixture: 2 g/m^3 + 200 g/m^3.

Depth (m)	Days							
	1		2		3		4	
	PH_3	CO_2	PH_3	CO_2	PH_3	CO_2	PH_3	CO_2
0.5	1750	7.0	1280	4.0	1115	2.0	980	1.5
2.0	730	18.0	690	6.0	1050	2.0	825	1.0
44 (bottom)	270	9.0	490	10.0	360	4.0	180	2.0

Mueller, D.K. 1993. A new method of using phosphine in combination with heat and carbon dioxide. Practical Use of Fumigants and Pheromones. International Technical Conference and Workshop, Lubeck, Germany, 1–3 December 1993.

Newman, C.J.E. 1989. Specification and design of enclosures for gas treatment. In: ACIAR Proceedings No. 25, 108–130.

Reichmuth. Ch. 1993. Controlled atmospheres in stored Product protection. Practical Use of Fumigants and Pheromones. International Technical Conference and Workshop, Lubeck, Germany, 1–3 December 1993.

Snelson, J.T. 1987. Grain protectants. ACIAR Monograph No. 3. Published by the Australian Centre for International Agricultural Research. 448 p.

Yongsheng, Yan, 1992. A study on mixed fumigation of aluminium phosphide and carbon dioxide for controlling stored grain pests. Proceedings XIX International Congress of Entomology, Beijing, June 1992.