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

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Abstract

Treatments with CO₂ (alone or combined with various gases) are considered to be less effective in concrete than metal silos due to reactivity between CO₂ 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.

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 PH₃ 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 PH₃ mixed with 8-10% CO₂ was effective in control of insects and mites. Hashem and Reichmuth (1989) found that 0.53 mg/L (360 ppm) of PH₃ killed eggs of R. dominica in 72 hours. Mueller (1993) found that the combination of 65-100 ppm PH₃ + 4-6% CO₂ at a temperature of 32-37°C was effective in controlling insects in flour mills. In our trial, large amounts of CO₂ penetrated to the bottom, thus making an effective combination with PH₃ concentrations which were already in the lethal range. This trial showed that, in spite of the disadvantages of concrete structures for CO₂ treatments, good results can nevertheless be achieved by using the PH₃ + CO₂ 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.

Experimental

A PH₃ + CO₂ mixture was tested for fumigation of infested wheat in a 44-m deep concrete bin. A dosage of 2 g/m³ of magnesium phosphide was applied to the top of the bin, followed by the application of 200 g/m³ CO₂ 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 CO₂ levels were determined by Drager Detector tubes.

References


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Table 1. Concentrations of phosphine (ppm) and carbon dioxide (%) in a 44 m deep concrete wheat bin after fumigation with PH$_3$ + CO$_2$ mixture: 2 g/m$^3$ + 200 g/m$^3$.

| Depth (m) | | Days |
|-----------|---|---|---|---|---|
|           | 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    |


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