

6	<b>Phostoxin Tablets</b>	-	1	24	60	300	300	24
7	<b>Phostoxin Tablets</b>	-	2	24	60	580	460	21
8	<b>Magtoxin Plates</b>	-	2	24	175	900	750	21
9	<b>Magtoxin Plates</b>	V	1	24	270	400	280	10
10	<b>Phostoxin Tablets</b>	-	3	48	13	770	730	35

\* - non-special-sealed containers

The range of the dates infestation in the control was 3% to 30%. The dates were infested with alive adults of sap beetles (Coleoptera: Nitidulidae) and the larva of moths. Post fumigations no live insects were found. The dates infestation by dead insects in Magtoxin plates using the OMT 501 was 0-1%, in plates without the OMT 501 2%, in the trials with the tablets 2-18% (table 3).

**Tab. 3** The efficacy of Phosphine fumigation in dates disinfestation in the field trials

Trial #	Phosphine formulation	OMT 501	Dosage g/m <sup>2</sup>	Exposure time h	Date infestation %		treatment	
					control alive	dead	alive	dead
1	<b>Magtoxin Plates</b>	V	4	24	6	0	0	0
2	<b>Magtoxin Plates</b>	V	2	24	9	0	0	3
3	<b>Magtoxin Plates</b>	V	2	48	6	0	0	2
6	<b>Phostoxin Tablets</b>	-	1	24	3	0	0	2
7	<b>Phostoxin Tablets</b>	-	2	24	6	0	0	18
8	<b>Magtoxin Plates</b>	-	2	24	12	0	0	2
9	<b>Magtoxin Plates</b>	V	1	24	22	7	0	5
10	<b>Phostoxin Tablets</b>	-	3	48	3	3	0	8

No phosphine residues were found in any of the fumigated dates.

## Discussion

The best results were achieved in the trials with Magtoxin plates using the OMT 501. The plates have significant advantages versus tablets by achieving the highest levels of phosphine concentrations much faster, resulting in dates disinfestation. In addition, plates have obvious safety advantages versus tablets. Standard (common) containers without special sealing are not suitable for fumigation.

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## Determination of phosphine concentration for *Cryptolestes ferrugineus* (S.) control in wheat in Sonora, Mexico

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DOI 10.5073/jka.2018.463.158

The rusty grain beetle (*Cryptolestes ferrugineus*) is one of the most common insect pest of stored products. Phosphine (PH<sub>3</sub>) is a major fumigant used for treating various food commodities, and the wrong application has led to resistance to phosphine. The development of high levels of resistance to phosphine has been reported in México. For that reason, different doses and exposure times were used to control of *C. ferrugineus* in two stages, larvae, and adult. In a warehouse using a Grainbag (GrainPro®) with 50 kg of wheat (*Triticum aestivum* L.) as support. Three doses of phosphine were used, 1.4 gr/m<sup>3</sup>, 2.8 gr/m<sup>3</sup> and 4.2 gr/m<sup>3</sup> and 3, 5 and 7 days to determine the proper dose and exposure time for control *C. ferrugineus*. An application of 2.8 gr/m<sup>3</sup> with 5 days could achieve 100% mortality in both stages.

## **Efficacy Studies on ECO<sub>2</sub>FUME® Phosphine Fumigant for Complete control of *Sitophilus zeamais* and *Tribolium castaneum* in stored maize in Thailand**

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DOI 10.5073/jka.2018.463.159

### **Abstract**

ECO<sub>2</sub>FUME® fumigation of maize bag stacks under gas proof sheets was conducted to establish the optimal dosages (application rate) and exposure times (fumigation period) against mixed-age cultures of *Sitophilus zeamais* and *Tribolium castaneum*. The Complete Randomized Design (CRD) experimental design was employed, with 3 replications and 4 treatments. The experiments were divided into three groups: 1) treatment with a 25 g/m<sup>3</sup> ECO<sub>2</sub>FUME® application rate (350 ppm phosphine) for 3, 4, and 5 days and a control treatment; 2) treatment with an ECO<sub>2</sub>FUME® application rate of 50 g/m<sup>3</sup> (700 ppm phosphine) for 2, 3, and 4 days and a control treatment; and 3) treatment with a 70 g/m<sup>3</sup> ECO<sub>2</sub>FUME® application rate (1,000 ppm phosphine) for 1, 2, and 3 days and a control treatment. The three target phosphine concentrations of 350 ppm, 700 ppm and 1,000 ppm were maintained during the whole fumigation period. Results of the studies showed that no insect was alive at all dosages and exposure times. The studies also indicated that fumigation with ECO<sub>2</sub>FUME® could reduce the fumigation period by increasing the phosphine concentration. The effective fumigation protocols on maize against mixed-age cultures of *S. zeamais* and *T. castaneum* were ECO<sub>2</sub>FUME application rates of 25 g/m<sup>3</sup> for 3 days, 50 g/m<sup>3</sup> for 2 days and 70 g/m<sup>3</sup> for 1 day. The target phosphine concentration must be maintained throughout the fumigation period to achieve 100% mortality of all stages of insects.

**Keywords:** ECO<sub>2</sub>FUME® phosphine fumigant, stored-product insects, *Sitophilus zeamais*, *Tribolium castaneum*, fumigation protocols, stored maize

### **1. Introduction**

Maize is a primary ingredient of animal feed. Thailand's maize demand in 2016 was 5.85 million tons, which increased by 2.77% from 5.72 million tons in 2015. Because of the expansion of the livestock industry, demand for maize for animal feed increased. In 2016, Thailand exported 0.58 million tons of maize with total value of 4,855.34 million baht, a significant increase from 0.08 million tons with total value of 716.79 million baht in 2015. Maize production and value increased 7.25 and 6.77 times, respectively, because maize was increasingly exported to ASEAN markets including The Philippines, Indonesia and Vietnam (Office of Agricultural Economics, 2016).

For use as animal feed, maize must be stored for several months to sustain the continuous supply to the feed processors. When maize is stored at the production sites for a period longer than 3 months, insect infestation becomes a common and serious problem. The major insect pests that negatively affect the quality and quantity of stored maize in Thailand are *Sitophilus zeamais*, *Tribolium castaneum* and *Cryptolestes ferrugineus* among others.