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Gasified Pirimiphos – methyl Control of Stored – grain Insects

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Abstract: We investigated the ability of gasified 50% pirimiphos – methyl EC to control stored-grain insects in a depot with stored-grain, and the ability of 5% pirimiphos-methyl AS to control insects in an empty depot. The results showed that there was no difference in chemical properties between gasified and EC pirimiphos-methyl. A concentration of 5.6 mg/kg gasified pirimiphos-methyl had better penetration into the grain and could effectively control the development of the offspring of stored-grain insects for one year. The effects of 0.5 g/m^3 pirimiphos-methyl AS controlling insects in an empty depot with different sprayers were compared. The gasification applicator was significantly more effective than the common high pressure sprayer. Based on the detection of fatty acid and other residues in stored – grain at different depths, controlling stored-grain insects by pirimiphos-methyl had no significant effect on quality.

Introduction

Pirimiphos-methyl or Chlorthiophos is a broad-spectrum, rapid-acting, and long – lasting pesticide. Organophosphate insecticides and acaricides with dermal and inhalation toxicology are extensively used as repellents for insect and acarid pests in all parts of grain storage (Hong Wang *et al.* 2006).

Other pest control chemicals were considered as candidates. Methyl bromide, a fumigant used for controlling stored-grain insects, was not selected because of its ozone-depleting properties. Phosphine is still the main fumigant to control stored-grain insects, but resistance of stored-grain insects to phosphine is developing rapidly.

The ability of pirimiphos-methyl to control stored-grain insects by gasification was investigated as a potentially effective, low toxicity and pollution-free method to control stored-grain insects while reducing the risk of insect resistance development following the work that had been initiated by others in this field (Pengcheng Fu &Kai Xu 2001; Jing Xie *et al.* 2007).

Materials and Methods

Test Depots

Depot with no stored-grain: Yueyang Depot of State Grain. No. 17 – 1 (common high pressure sprayer), No. 18 – 1 (gasification applicator produced by Yueyang Jinniu Biotechnology Co. Ltd). Horizontal silo, brick-concrete structure, generally sealed and leak-proof: Volume 7480 m^3.

Depot with stored-grain: No. 18 – 1 Yueyang Depot of State Grain. Horizontal silo made of brick and concrete, generally sealed and leak-proof. Volume 4210 m^3.

Test Grain

Harvested in 2005, early long-grain non – glutinous rice, 2452 t, moisture content 12.8 %, volumetric weight 577 kg/m^3, impurity content 1.5 %, brown rice yield 75.1 %, fatty acid value 22.5. Yueyang Depot of State Grain is responsible for routine tests related to grain quality. Hunan Chemical Industry Research Institute is responsible for detection of pesticide residue.

Test Insects

Rhizopertha dominica Fabricius, *Sitophilus zeamais* (Motschulsky), *Cryptolestes ferrugineus* (Stephens) (Chengdu Grain Storage Research

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Institute, State Administration of Grain, P. R. China). The insects were buried to a depth of 30cm in the center and four corners of the grain stack. The population density of wild insects in-depot were lesser grain borer 15 per kilogram grain, maize weevil 3 per kilogram grain, rust red grain beetle 13 per kilogram grain, and many booklice.

Insecticides

50% pirimiphos-methyl EC, 5% Pirimiphos-methyl AS (Hunan Haili Chemical Industry Co., Ltd).

Controlling Insects in Empty Depot

Both the Common High Pressure Sprayer and Gasification Applicator were used in this research. The liquor was sprayed uniformly and as high as possible in the air from Common High Pressure Sprayer.

Controlling Insects in Depot with Stored-grain Using Gasified 50% Pirimiphos-methyl

The liquor was sprayed using the Gasification Applicator under the condition of phosphine recirculation device, with 4 high – pressure centrifugal [fans] [pumps] operating for 48 hours.

Test of Pirimiphos-methyl Chemical Property

The 50% pirimiphos-methyl was evaporated at 190℃ ±10℃ and then liquefied. To verify whether the chemical property of 50% pirimiphos-methyl changed under high temperature condition, the 50% pirimiphos-methyl was evaporated at 190(10℃ and then liquefied. The chemical property of 50% pirimiphos-methyl before and after evaporation was determined using vapour-phase chromatography at the Hunan Chemical Industry Research Institute.

Results and Analysis

Test of Pirimiphos-methyl Chemical Property

Table 1 shows there was almost no change in active ingredient content of 50% pirimiphos-methyl, as the 50% pirimiphos-methyl remained stable at all three temperatures.

Table 1. Active ingredient content change of 50% pirimiphos-methyl before and after evaporation

Evaporation temperature(℃)	EvaporationTime(s)	Active ingredient content(%)	
		Before evaporation	After evaporation
180	0.5	48.4	48.2
	1	48.4	48.2
	2	48.4	48.3
190	0.5	48.4	48.3
	1	48.4	48.3
	2	48.4	48.3
200	0.5	48.4	48.3
	1	48.4	48.3
	2	48.4	48.2

Controlling Insects in Empty Depot

The test started on 6 June 2006 with concentration of 0.5 g/m^3 in depot No. 17 – 1. The effect of the treatment was evaluated on 8 June 2006 (Table 2).

Table 2. Effect of controlling insects in empty depot by common high pressure sprayer

	Number of living insects per square meter			
	Cryptolestes pusillus (*Schonherr*)	*Sitophilus zeamais* (Motschulsky)	Booklice	*Rhizopertha dominica* Fabricius
Before test	2	6	7	10
After test	0	1	2	2
Mortality	100%	84%	72%	80%

Controlling Insects in Empty Depot by Gasification Applicator

The test started on 25 July 2006 with concentration of 0.5 g/m^3 in depot No. 18 – 1. The

effect of the treatment was evaluated on 8 August 2006 (Table 3).

Table 3. Effect of controlling insects in empty depot by gasification applicator

	Number of living insects per square meter		
	Rhizopertha dominica Fabricius	*Sitophilus zeamais* (Motschulsky)	*Cryptolestes pusillus* (Schonherr)
Before test	10	8	7
After test	1	0	0
Mortality	90%	100%	100%

The effects of controlling insects in an empty depot using 0.5g/m^3 pirimiphos-methyl by common high pressure sprayer and gasification applicator were investigated. Compared to common high pressure sprayer, the gasification applicator treatment was better.

Controlling Insects in Depot with Stored-grain Using Gasified 50% Pirimiphos-methyl

The pest density in the stack of grain was evaluated 10 days, 20 days 30 days and a year after application. It took 10 hours to spray all 31 kilograms of 50% pirimiphos-methyl. The results are shown in Table 4.

Table 4. Effect of 50% pirimiphos – methyl controlling insects in Depot with stored – grain by gasification applicator

		Pest density per kilogram grain *														
		Rhyzopertha dominica (Fabricius)					*Cryptolestes ferrugineus* (Stephens)					*Sitophilus zeamais* (Motschulsky)				
		0d	10d	20d	30d	1year	0d	10d	20d	30d	1year	0d	10d	20d	30d	1year
Test depot	1#	4	3	3	2	0	2	2	1	1	1	2	0	0	0	0
	2#	30	22	17	15	0	26	18	14	13	1	2	0	0	0	0
	3#	20	17	12	10	0	10	8	6	5	0	2	0	0	0	0
Control depot	1#	5	2	1	0	10	3	1	1	1	12	1	0	0	0	12
	2#	29	7	2	1	3	27	8	3	1	3	3	0	0	0	12
	3#	18	0	1	1	3	11	5	2	2	13	3	0	0	0	4

* The pest density was determined at the temperature beyond 20℃ at which the large proportion of pests can grow and develop normally.

The pest density of test depot and control depot were determined. Compared to the control depot, firstly, the pest density in different fixed-point of test depot decreased apparently with time. One year later, the pest density of *Rhyzopertha dominica* and *Sitophilus zeamais* decreased to zero. This suggested pirimiphos-methyl could effectively control stored-grain pest for up to one year. Secondly, pirimiphos-methyl controlled three main stored-grain pests well: *Rhyzopertha dominica*, *Cryptolestesferrugineus*, *Sitophilus zeamais*.

Homogeneity of Spraying by Gasification Applicator

The pirimiphos-methyl residues in different point of the stack of grain, which could reflect the homogeneity of spraying by gasification, were determined before spraying and 14 days after spraying, respectively. The sampling points are shown in Figure 1. The results are shown in Table 5.

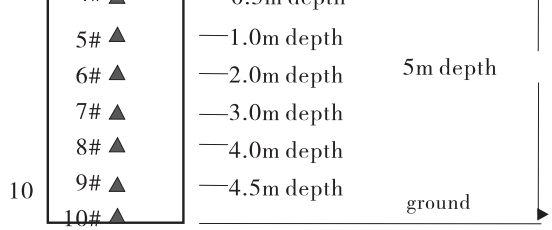

Fig. 1 Samples of resdues of Pirimiphos-methyl

Table 5. Residues of 50% Pirimiphos-methyl controlling insects

Sampling points	Residual quantity of Pirimiphos – methyl (mg/kg)		
	Before spraying	14 days after spraying	1 year after spraying
Surface layer	0	11.0	3.70
0.2m	0	5.10	/
1m	0	3.60	0.07
2m	0	0.50	<0.02
3m	0	0.20	0.04
4m	0	0.10	0.00

The Results Showed

1. According to the distribution of residues, we found pirimiphos-methyl that was sprayed by the gasification applicator to penetrate to a depth of 4 meters;
2. The residual quantity of pirimiphos-methyl decreased with increasing depth in the stack of grain;
3. The highest residual quantity was 11.0 mg/kg 14 days after spraying. It decreased one year later to 3.7 mg/kg, which is lower than the Maximum Residue Limits (MRL 5mg/kg).

Comparison of Side Effects of Pirimiphos-methyl & Aluminum Phosphide on Grain Quality (fatty acid)

The fatty acids of grain from insects treated in the depot with different pesticides were compared. Pirimiphos-methyl was used in depot No. 17 – 1 and aluminum phosphide was used in depot No. 18 – 1. The fatty acids of grain from these two depots were determined before the test and one year later. The results are shown in Table 6.

Table 6. Comparison of the side effects of pirimiphos-methyl and aluminum phosphide on grain quality (fatty acids)

	Value of fatty acids	
	Aluminum phosphide	Pirimiphos – methyl
Before test	22.5	22.5
One year later	27.2	25.2

Cost Comparison of Pirimiphos-methyl & Aluminum Phosphide

The results showed that the application cost of pirimiphos-methyl was higher than aluminum phosphide, but pirimiphos-methyl was easier to apply and less labour-intensive (Table 7).

Discussion

The efficacy of controlling insects in an empty depot using 0.5g/m^3 pirimiphos-methyl using a common high pressure sprayer and a gasification applicator were investigated. Compared to the common high pressure sprayer, the gasification applicator resulted in better pest control and was easier to operate. Furthermore, the cost of using pirimiphos-methyl was relatively low, about 0.05 yuan/m^3.

Table 7. Test cost of controlling insects with pirimiphos-methyl and aluminum phosphide (per tonne grain)

	Test cost (yuan/tonne)	
	Pirimiphos – methyl	Aluminum phosphide
Pesticides	0.83	0.43
Power consumption	0.04	0.02
Depreciation of equipment	0.08	0.08
Total	0.95	0.53

Pirimiphos-methyl was evaporated at 190 (10℃ and then liquefied. The results showed there was almost no change in the active ingredient content of pirimiphos-methyl in this temperature range. Pirimiphos-methyl was very effective for controlling stored-grain insects and inhibiting the growth of offspring, and had no side effects on grain quality.

Pirimiphos-methyl penetrated the grain to a depth of 4 meters when sprayed by gasification. Residues of pirimiphos-methyl decreased with the increase of depth of stack of grain. The highest residual quantity of pirimiphos-methyl was 11.0 mg/kg 14 days after spraying by gasification applicator. One year of grain storage was required for this residue level to reduce to less than the accepted MRL of 5 mg/kg.

As chemical protective additive, pirimiphos-methyl can be applied to grain without insects or with low pest density. However, the potential to control insects using pirimiphos-methyl decreases at high pest density.

As a kind of chemical protective additive of stored – grain, in aqueous solution or as an e-

mulsifiable concentrate, pirimiphos-methyl can be used for controlling insects in stored-grain and in an empty depot. The phosphine recirculation device was effective. The use of the Gasification Applicator combined with the phosphine recirculation device has the potential to be used more widely with other chemical protectants of stored-grain, such as 0.5% celangulin and deltamethrin.

The method of spraying liquor using a Gasification Applicator offers a new way to apply chemical protectants to stored-grain. Further refinements to the application methods could be made to reduce the costs of this new technique.

Recently, the rapid development of resistance to grain protectants or phosphine fumigations in stored grain pest has been reported. In this light, it is essential to take measures to control the increase of resistance. Controlling grain pests by spraying liquor using a Gasification Applicator may be a good choice.

Acknowledgements

This research was strongly supported by China Grain Reserves Corporation and China Grain Reserves Corporation Hunan Branch. We thank Dr Tom Batchelor (Touchdown Consulting Brussels) for editorial comments in this manuscript.

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