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Phosphine Fumigation by Aluminium Phosphide Decomposing in Air Mixed with Dichlorvos

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Abstract: A field trail of phosphine plus dichlorvos fumigation was carried out in a flat storage of wheat. The fumigant was distributed better by recirculation. Some insects common in grain stored grain in China were controlled more effectively.

Key words: phosphine, dichlorvos, fumigation, insect, recirculation

Introduction

Phosphine has been used as fumigant for stored grain fumigation in the application methods of generator or tablet, with and without recirculation. Some fumigations failed in some storages when the fumigation used phosphine solely. In some cases successful fumigation can be achieved by the combination of phosphine and dichlorvos, especially for the control of psocids, weevils, moths, red flour beetle and so on in. Some field trials are reported in this paper.

1 Materials and Methods

1.1 Warehouse

A flat storage was used for the trail that is 29.5 meters in length, 23.2 meters in width and 6 meters in height for wheat bulk. The capacity of the warehouse is 3 200 tons. There were 4 112 cubic meters in volume for bulk and 2 800 cubic meters for head space. There was a polyester foam sparkled on the inter surface of the roof. The half decreasing time from 500 Pa to 250 Pa was 180 seconds for the gastightness.

1.2 Establishment in the Warehouse

There was some ventilation duct on the floor that has 30 per cent holes. The ducts were distributed every 5 meters and used as a part of recirculation fumigation system for phosphine. There were also some pipes and a fan for fumigant recirculation when aluminium phosphide tablets were applied on the top of bulk. An electronic temperature monitoring system was set in the bulk with sensors arranged in five meter intervals horizontally and one and half meter intervals vertically.

1.3 Instruments

An electronic phosphine monitor was used for the concentration monitoring in the range 0 – 1 000 mL/m^3. An electronic phosphine alarm monitor was used for safety monitoring around the warehouse. Some plastic trays were laid in the ventilation duct for application of tablets.

1.4 Methods

Firstly, the whole grain was aerated to even temperature and moisture content.

Three to four plastic trays were put into the entrance of the ventilation duct for the application of tablets of aluminium phosphide. Most tablets of aluminium phosphide were applied on the top of grain in plastic trays. The total dosage of the phosphide was ten kilograms.

Six plastic bottle cages that contained insect and feed were placed on the top near the window to test efficacy. Ten insects of each species were set in the cages containing cracked and wheat seed that included *Cryptolestes ferugineus* (Stephens), *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* (Motschulsk and psocids.

Some empty bags were hung on the frame of the warehouse. DDVP emulsion in water was sprayed on the bags. No liquid was applied directly to the grain.

In the first and second day there was no recirculation. On third day the recirculation fan was started for the fumigant distribution through the bulk. The fan worked until the concentration ratio of lowest to highest was over 0.6, with the phosphine monitored daily. Thereafter the concentration was monitored every three days.

The temperature of grain was also moni-

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tored once a week. Some recirculation operations were carried out for uniformity of phosphine concentration. The fumigation began on 20th July, 2007.

The survival of insect in cages was checked at the first, second, and third weeks. The fumigation was ended after forty days.

2 Results and Analysis

2.1 Temperature Change

The average temperature change of grain during fumigation is shown in table1. Point 1 to point 5 were located on the four corners and the centre and were one meter underneath of bulk surface.

Table 1. Temperature (℃) of grain in the upper layer

Checking date	Point 1	Point 2	Point 3	Point 4	Point 5
2007.07.24	23.7	15.8	20.2	23.8	17.5
2007.07.31	22.8	16.5	20.8	22.9	17.1
2007.08.07	23.6	17	21.2	23.5	17.4
2007.08.14	24.8	17.4	21.6	24.6	18.1
2007.08.21	24.5	18	22.5	24.7	18.1
2007.08.28	25.2	18.4	23.2	26.1	18.5

Table1 indicates that the temperature in upper layer of grain did not increase. The fumigation had less effect on the grain temperature than the climate.

2.2 Phosphine Concentration

Changes in phosphine concentration during the fumigation are shown in table 2.

Table 2. Phosphine concentration changes (mL/m^3)

Checking date	Point 1	Point 2	Point 3	Point 4	Point 5	Head space
2007.07.23	260	309	316	275	240	232
2007.07.27	226	248	260	225	203	199
2007.07.31	190	192	207	195	180	162
2007.08.06	176	175	178	177	182	122
2007.08.10	125	172	182	185	180	150
2007.08.14	123	124	135	130	114	116
2007.08.20	90	108	100	95	90	102
2007.08.26	54	68	117	78	63	56
2007.08.31	45	50	80	65	52	46

A phosphine concentration over 100 mL/m^3 was maintained for more than twenty days (table2). The phosphine distribution in different monitored points was uniform. The recirculation system of the warehouse worked well.

2.3 Killing Effect on Insects

Table 3. Dead number of insect at different time

Checking date	Week 1	Week 2	Week 3	Week 3
Red flour beetle	30	30	30	30
weevil	30	30	30	30
Rust flat beetle	28	30	30	30
psocids	30	30	30	30

The result of mortality of insect in cages indicates that red flour beetle had the greatest tolerance to phosphine. The result that rust flat beetle was easy to kill does not means it has less tolerance to phosphine. It may be that adults died easily in the cages. A shorter time of fumigation had less killing effect on psocids,

3 Conclusions

Phosphine fumigation mixed with DDVP was more effective to insect killing than phosphine alone. A longer time is needed for phosphine fumigation. During this process some adults may produce new eggs that have higher tolerance to phosphine than adults. As DDVP can kill adults in a shorter time, there should be few eggs at the start of fumigation. Therefore phosphine plus DDVP fumigation is a more effective way of insect control than phosphine alone. DDVP does not easily penetrate bulk grains. The recirculation of the fumigation helps the distribution of DDVP. Control of psocide should be more effective by the addition of DDVP and recirculation.

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