A trial of mixed outside-storehouse phosphine and carbon dioxide generator in stored grain fumigation

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Abstract

For the purpose of improving the efficacy of routine phosphine fumigation and minimizing the exposure time of applicators in phosphine, a model XZL outside-storehouse mixed phosphine and carbon dioxide generator was tried to evaluate the efficacy of disinfestation for bulk wheat in horizontal grain stores. The result showed that the use of the generator can greatly expedite the uniform dispersal of phosphine in grain mass and keep more stable concentration so as to obtain higher ct product. This generator appears to have considerable potentials as partial replacement for routine manual application of aluminium phosphide in China.

Introduction

As the most important fumigant for control of stored grain insect pests, phosphine has been used for more than thirty years in China. As is known to all, the problem of resistance of insects to phosphine arose early in the 1970s, which was caused by long-term and unitary use and incorrect applications (Liang Quan 1994). Since 1980s, a need of shortening the exposure time of operators in fumigation has arisen along with the rise of environmental consciousness. The situation was getting urgent in improving the method of phosphine application. In this case, Model XZL-IV outside-storehouse mixed generator of phosphine and carbon dioxide made by Jixiang Grain Machinery Factory (Shangdong Province) was one of the new installation to suit the changed circumstances which had been originally used in Jining Grain Stores in 1991. Now 36 sets of the machine have been installed in 12 counties and 8 state grain reserve depots all over Jining City for 280 thousand tons grain fumigation. This paper presents a trial in Jining grain stores.

Materials and Methods

Materials

XZL-IV outside-storehouse mixed generator of phosphine and carbon dioxide, manufactured by Jixiang Grain Machinery Factory, Shangdong Province (Fig. 1). Cylinderized carbon dioxide, produced by No. 2 Brewery of Jining.

Fig. 1. XZL-IV outside-storehouse mixed phosphine and carbon dioxide generator.

Aluminium phosphide tablets (56%) produced by Jining Chemical Industrial Experimental Plant, Shangdong Province.
Phosphine and carbon dioxide concentration detecting tube and air exhauster produced by Maliandao Grain Storage, Beijing.

Methods

No. 1 and No. 2 storehouses of Jining No. 1 Grain Store
with XZL-IV mixed phosphine and carbon dioxide generator were selected for the trial. No 3 storehouse was selected as a contrast storehouse to which aluminium phosphide tablets were applied onto the grain surface by routine method. The conditions of both trial and contrast storehouses are shown in Table 1.

**Table 1. Conditions of trial and contrast storehouses**

<table>
<thead>
<tr>
<th>No of storehouse</th>
<th>Storage capacity (ton)</th>
<th>Quantity of stored wheat (ton)</th>
<th>Load type</th>
<th>Infested insects (heads/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (trial)</td>
<td>1750</td>
<td>1741</td>
<td>bulk</td>
<td>S zeamais 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R dominica 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R dominica 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C turcicus 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T dimidius (heavily infested)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R dominica 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S zeamais 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T dimidius 20</td>
</tr>
<tr>
<td>2 (trial, sound gastightness)</td>
<td>1750</td>
<td>1461</td>
<td>bulk</td>
<td>S zeamais 4</td>
</tr>
<tr>
<td>3 (contrast)</td>
<td>2000</td>
<td>1615</td>
<td>bulk</td>
<td>S zeamais 3</td>
</tr>
</tbody>
</table>

A proper length of gas tubes was installed at the bottom of No 1 Storehouse with suitable area of apertures for gas entering before loading. No 2 storehouse was soundly sealed with cotton wadding and plastic sheet. There were six ‘X’ shaped gas tubes from the sleeve to grain mass and then they were sealed.

**Technological process of the generator**

(see Fig. 2)

![Diagram of XZL-IV outside-storehouse mixed phosphine and carbon dioxide generator](image)

**Operation of the generator**

**Dose rate**

1. $0 - 1.5$ g/m³ and $2 - 3$ g/m³ aluminium phosphide tablet for control of normal and resistant strains of insects respectively in combination with carbon dioxide $100 - 200$ g/m³.

**Preparation and examination of the generator**

Examine the circuit, the joint of ducts, the indicator and the gas controller carefully to make sure that all of them are kept normally.

Fill the generator and the vapour absorber with water. Be sure to keep the water level lower than the indicator.

Then join the outlet of the generator with duct (50 mm in diameter) to storehouse and join the carbon dioxide cylinder with flow meter.

Calibrate the temperature of the indicator and then turn the switch to ‘measuring’ position and set up the appropriate temperature of gas mixture at the outlet to avoid water condensation while grain mass enters.

**Carbon dioxide releasing and AIP putting**

Then release carbon dioxide into the generator. The
suitable velocity of release is that there is a sound of ‘bubble’. About 5 minutes later, put the total dose of aluminum phosphide tablet into the container and close the lid tightly afterwards.

To start the feeding switch, aluminum phosphide tablet is fed into the phosphine generator. The total dosage should be fed at different time. In order to avoid some unreacted AlP remains in the container, the last feeding should be done 5 minutes later. Subsequent carbon dioxide release should be continued for more than 40-50 minutes.

**Dismantling and cleaning the generator**

After all of the aluminum phosphide tablets have been fed into the generator, the power supply is switched off and the connections of mixed gas outlet and the inlet of carbon dioxide are opened. Then the generator is moved to where there is water tap.

Fill water into the generator and the filter to the highest level. Then the drainage lid is opened to remove the residuals in both containers out. The containers should be washed again till it is completely cleaned.

**The applied dosages and operating personnel in application**

- No 1 trial storehouse: AlP 4kg, CO2 60kg, 3 persons
- No 2 trial storehouse: AlP 2kg, CO2 60kg, 3 persons
- No 3 contrast storehouse: AlP 28kg, 8 persons

**Results and Discussion**

**The changes of phosphine and carbon dioxide concentration during the trial**

The average concentration changes of phosphine and carbon dioxide sampled from upper, middle and bottom layers of wheat mass during the trial are illustrated in Fig 3 and Fig 4.

**The obtained phosphine ct products (ten days exposure) and the costs of AlP and CO2**

- No 1 storehouse: 77mg h/m³, 175 yuan (RMB)
- No 2 storehouse: 67mg h/m³, 125 yuan (RMB)
- No 3 storehouse: 48mg h/m³, 700 yuan (RMB)

**Effectiveness of disinfestation**

No survival adult insects were found at the end of ten days exposure in samples from different layers and positions of every storehouse including the contrast.

To sum up, even if a complete kill of all immature insects could not be assessed and remained to be done in further trials, it still could be seen that like the advanced sureflo method, this outside-storehouse mixed phosphine and carbon dioxide generator also has the following advantages compared with the habitual method for the application of aluminum phosphide onto the surface of grain manually:

- It can keep more stable phosphine concentration in grain mass throughout the exposure period
- Much higher ct product can be obtained even if the dose rate is much lower than that of conventional practice
- It can reduce much more labor intensity and keep application workers from entering the storehouse for aluminum phosphide tablet application
- The total cost of aluminum phosphide and carbon dioxide is much lower than aluminum phosphide alone
- As much information has been proved, carbon dioxide has synergy to phosphine

Therefore, the trial demonstrated again that outside-storehouse phosphine and carbon dioxide generator method holds promise as a substitution for routine method of manual aluminum phosphide application. This generator may be extended in a certain region of China where there is no way to use other advanced method.

**References**

Liang Quan 1980 Effect of modified atmospheres on the
toxicity of phosphine to insects and its application Grain Storage, 1980 (1) 1-11 (In Chinese)
Liang Quan 1994 Meet the challenge of insect resistance to phosphine Grain Storage, 1994(1)3-7 (In Chinese)