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# Application of Economic Threshold Level in Stored Grain Fumigation for Controlling of Pests

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**Abstract**: The principle of economic threshold level for storage pest control is that the cost of control is equal to, or less than, the economic loss caused by pest damage. Fumigants are economical, easy to use and efficient ways of protecting stored grain from insect pests. Of these fumigants, phosphine is most commonly used in warehouses. According to different situations of pest density and time of exposure, we use different dosages to control pests, and develop basic economic thresholds for the control of storage pests with phosphine.

**Key words**: economic threshold level, fumigation, Application

## Introduction

Modern pest control methods are based on the economic threshold level (ETL), which combines the economic efficiency with ecological benefit during pest controlling application, and is often discussed in the economic entomology and pest control fields. Stern et al. (1959) first defined ETL as, "the density at which control measures should be applied to prevent an increasing pest population level from reaching the economic injury level". The principle of an ETL in stored pest control is that cost of control is equal to, or less than, the economic loss caused by pest damage. Insects can cause loss during grain storage, so grain pest control is a major component of the warehouse's daily work. Fumigants are cheap, easy to use and are efficient ways of protec ting stored grain from insect pests. Phosphine ($PH_3$) is most popular fumigant in warehouses in China. Depending on different situations of pest density and time of exposure, we use different dosages and try to reduce pest controlling costs. The aim of the study was to develop a basic rule for an ETL for storage pests in our warehouses.

## Materials and Methods

The experimental barns had the same design dimensions and the grain was stored to a height of 6 m. materials and equipment used included a stored grain monitoring system, 56% purity aluminium phosphide (AlP) tablets, a phosphine concentration detector (Beijing Jiahua HL – 210) and an alarm device, and a phosphine-generator (Zhengzhou Weilai). The experimental conditions are summarized in Table 1.

**Table 1. Summary of experimental conditions.**

| Barn number | Grain intake | Variety | Quantity(t) | Stored grain temp(℃) | Moisture content(%) | Pest species | Pest density/kg | Pressure half-life(s) |
|---|---|---|---|---|---|---|---|---|
| 13 | 2005 | japonica paddy | 3,271 | 13.2 | 13.1 | *Sitophilus zeamais* | 15 | 50 |
| 15 | 2005 | Indica paddy | 2,963 | 14.8 | 13.2 | *Sitophilus zeamais* | 14<br>60 | |

Note: *S. zeamais* has only low levels of $PH_3$ resistance

### Spot Fumigation

In a spot fumigation infested grain was covered in a bell-shape with gas-proof sheets, and fumigated by probing AlP into the grain. The dosage of AlP was 15 g/m$^3$. Phosphine concentrations were monitored throughout the fumigation.

### Fumigation of Whole Stores

Fumigant tablets were distributed on the surface of grain and phosphine was also replenished from a phosphine-generator outside barn. The period of exposure to phosphine for No. 13 barn was 15 – 20 days, and 20 – 25 days for No. 15 barn. The concentration obtained surface using dosage is 2.5 g/m$^3$, and the replenished

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concentration of phosphine is 180 mL/m$^3$. Five points were used for monitoring the phosphine concentration according to Technical Regulation of Grain Storage.

## Results and Discussion

The total amount of AlP tablets consumption in the No. 13 barn is 16.0kg, while the amount is 24.0kg in No. 15 barn. After the released gas diffused away, the rate of mortality in samples taken from all sampling points was 100% both in No. 13 and No. 15 barns. There were no live pests present in samples taken one month later.

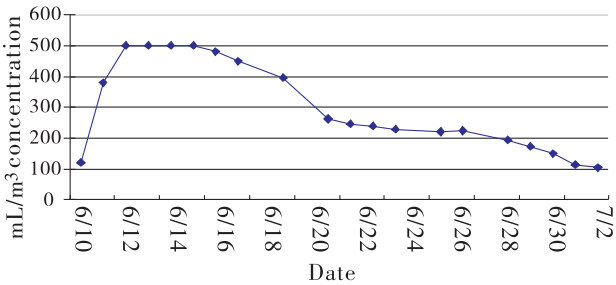


**Fig. 1 $PH_3$ concentration during a 'spot' fumigation**

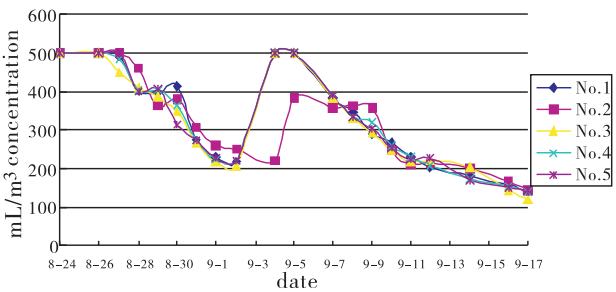


**Fig. 2 $PH_3$ concentration in No. 15 barn**

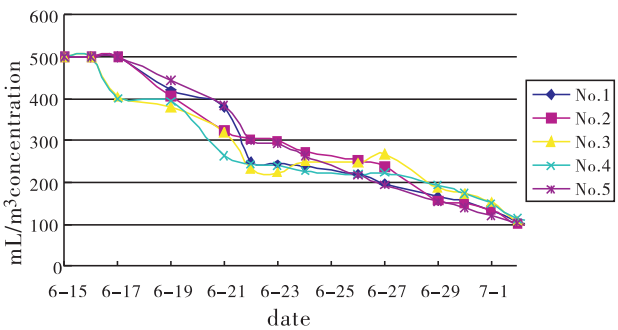


**Fig. 3 $PH_3$ concentration in No. 13 barn**

The main findings were:

- For the spot fumigation (Fig. 1), the period of exposure at a $PH_3$ concentration of 200 mL/m$^3$ must be greater than 20 days to control pests.
- For whole store fumigation of No. 15 barn (Fig. 2), the period of exposure at a $PH_3$ concentration of 150 mL/m$^3$ must be more than 23 days by replenishing phosphine concentration to maintain efficient concentrations of $PH_3$ on 4 September.
- For whole store fumigation of No. 13 barn (Fig. 3), the period of exposure at $PH_3$ concentration of 150 mL/m$^3$ must be greater than 16 days.

Furthermore, it is important to choose the right time and economic methods to control pest. During periods when the grain is cool, especially in winter and spring, pest densities of 5 – 9 adults/kg do not cause significant damage. What we need to do is monitor pest density rather than fumigate immediately. If the pest density is more than 10 adults/kg in summer and autumn, however, the infestation will cause an abnormal increase in grain temperature. At this point, we must disinfest the grain with the proper fumigation methods. When limited portions of the stored grain have abnormal temperature increases, only spot fumigations with phosphine are required. The fumigation dosage is commonly 6 – 15 g/m$^3$. When the infested portion is less than 10 m$^3$, the consumption of fumigant is also less. Therefore, spot fumigations with phosphine are a very economical method of pest control.

## Conclusion

For the normal storage pest with low $PH_3$ resistance such as *S. zeamais*, when the grain temperature is lower than 15℃, the period of exposure at an effective concentration must be more than 15 days to kill all storage pests. If the pest density is more than 10 adults/kg, or the stored grain temperature rises abnormally, we treat the stored grain with spot fumigations or whole store fumigations depending on the size of the area infested and pest density. If only limited portions of the grain are infested, spot fumigations are enough to control pests, which reduces the amount of fumigant used and the cost of control.

The ETL is multi-dimension, dynamic, random, economic, ecological parameter, so it's impossible to get its exact value. What we can do is try to approach it in our research. In our daily work, the ETL is just a parameter index which tells us when we need control pests if the pest damage reaches a certain level. So application and research of the ETL in stored grain fumigation still need more experiments and works.

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