

*Donahaye, E.J., Navarro, S., Bell, C., Jayas, D., Noyes, R., Phillips, T.W. [Eds.] (2007) Proc. Int. Conf. Controlled Atmosphere and Fumigation in Stored Products, Gold-Coast Australia. 8-13th August 2004. FTIC Ltd. Publishing, Israel. pp. 627-633.*

## **ADSORPTION OF PHOSPHINE BY WHEAT, PADDY AND CORN**

YAN XIAOPING\*, QIN ZHANGGUI, GUO DAOLIN AND LI WANWU

*Chengdu Grain Storage Research Insititute, No.95 Huapafang Street, Chengdu, Sichuan, 610031, P. R. of China [E-mail: \*pestcd@mail.sc.cninfo.net]*

### **ABSTRACT**

Adsorption of phosphine by grain has an important practical role in PH<sub>3</sub> fumigation.. Tests were carried out to determine the PH<sub>3</sub> concentrations in storehouses according to the variety of grain, moisture-contents and storage time. Tests indicated that for the newly-harvested paddy without fumigating, when its moisture -content was 11.2%, the adsorption rate was 19.9%/day, and when moisture-content was 15.4%, it was 23.5%/day; while for paddy stored for 4 years, the adsorption rate was 5.1%/day. As for newly-harvested corn it was 16.3%/day; for corn stored for 3.5 years it was 11.2%/day. For wheat stored for 3 years, when its moisture content was 10.0%, the adsorption rate was 1.67%/day, and when moisture-content was 12.0%, the adsorption was 2.37%/day. According to the results, it can be concluded that phosphine fumigation efficiency was dependent not only on the PH<sub>3</sub> concentration, the degree of gastightness, and the degree of the resistant insect strains, but also on the adsorption level of phosphine by the grain.

### **INTRODUCTION**

PH<sub>3</sub> concentration always declines during a fumigation, and this is not only related to the leaks in the treated storage structure, but is also due to the adsorption of phosphine by the grain. The sorption rates of phosphine by various grain types, their storage period, and their various moisture-contents are different. The objective of this work was to study the sorption rate of phosphine in order to maintain the effective concentration of phosphine during a fumigation.

## MATERIALS AND METHODS

### Grain

*Wheat:* Soft winter wheat of 10.0~12.0% moisture content was used. Laboratory tests were carried out on grain stored for three years.

*Paddy rice:* Tests were carried out on paddy rice of 11.2%, 13.0% and 15.4% moisture contents. Paddy of 11.2% and 15.4% moisture contents was obtained by adding moisture or drying the grain until an equilibrium was achieved under laboratory conditions.

*Corn:* Newly harvested corn was used for the tests using phosphine evolved from 3g tablets of aluminium phosphide.

### Test methods

The test was conducted in a controlled-temperature room maintained at 25°C. The fumigation containers were 22L jars and 6.5L desiccators. For fumigation, the wheat grain was filled to about 50% of capacity in the jars, and the paddy and corn to about 95% capacity in the desiccators. The jars were equipped with sealable rubber tops, each rubber contained two gas-transfer tubes fitted with 10 cm lengths of tubing that were sealed with pinch clamps. The desiccators were fitted with a lid that contained a screw septum thread joint (e.g. Quickit SQ13). Sorption of the fumigants by wheat, paddy and corn was determined by monitoring the concentration of gases in each fumigation chamber at regular intervals throughout each fumigation period.

## RESULTS AND DISCUSSION

### Absorption of phosphine by paddy

Results of sorption under laboratory conditions by paddy stored for four and a half year at various moisture contents are shown in Figures 1, 2, and 3, and Table 1.

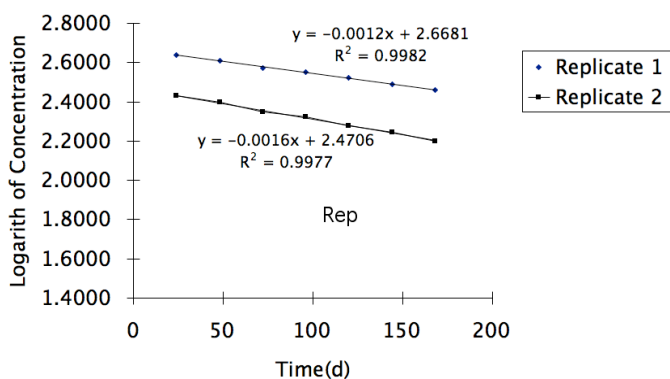


Figure 1: Sorption by four- years old paddy fumigated without CO<sub>2</sub>

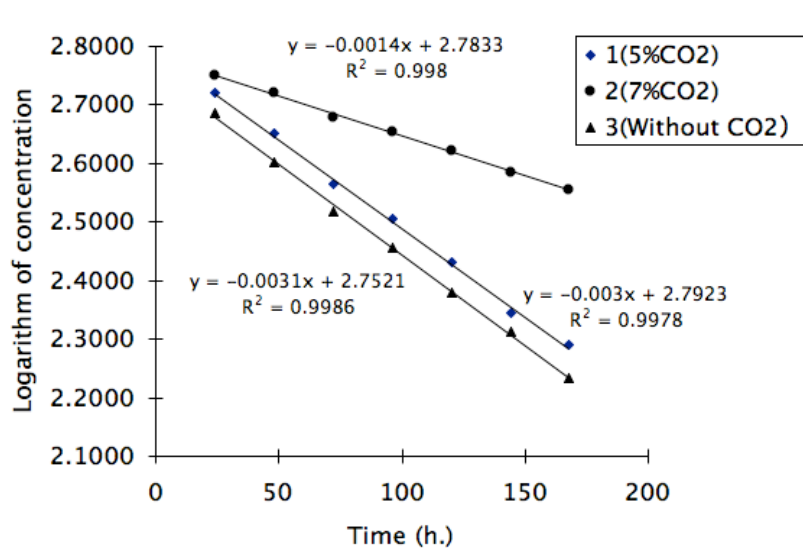


Figure 2: Sorption by four years old paddy fumigated with 5% and 7% CO<sub>2</sub>

TABLE 1  
PH<sub>3</sub> Adsorption-rate of paddy

Paddy		Slope	Absorption rate (%/h.)	Absorption rate (%/d.)
Stored for 4 years	replicate 1, 12.0% M.C.	-0.0021	0.48	
	replicate 2, 12.0% M.C.	-0.0052	1.19	15.1
	replicate 3, 12.0% M.C.	-0.0016	0.37	
Stored for 4 years	+ 5% CO <sub>2</sub>	-0.0030	0.69	15.3
	+ 7% CO <sub>2</sub>	-0.0014	0.32	7.4
PH <sub>3</sub> + CO <sub>2</sub>	Comparative test ( without CO <sub>2</sub> )	-0.0031	0.71	15.7
One-year old paddy	11.2% M.C.	-0.0041	0.94	
	11.2% M.C.	-0.0039	0.89	19.9
	15.4% M.C.	-0.0048	1.10	
	15.4% M.C.	-0.0049	1.12	23.5

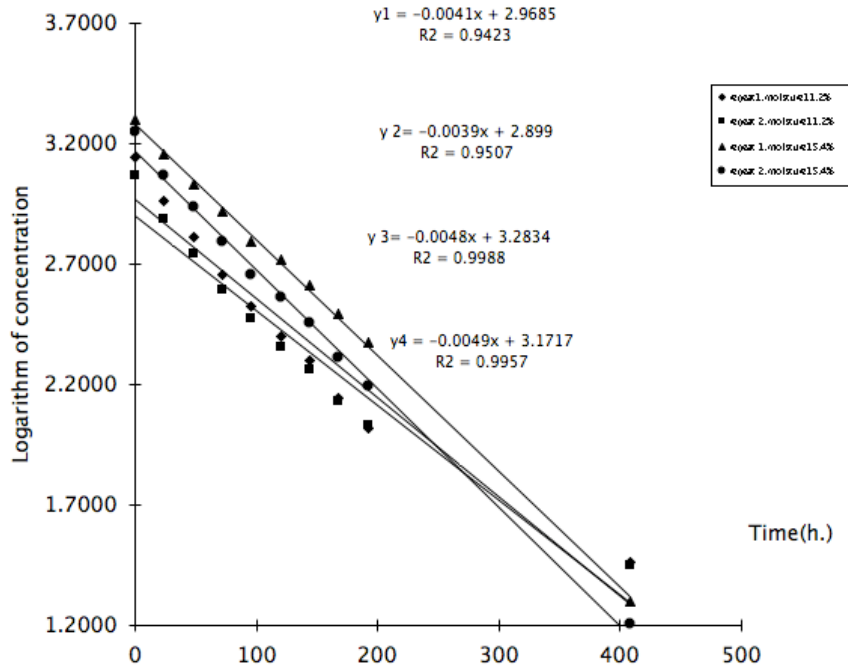


Figure 3: Sorption by one-year paddy old at different moisture contents.

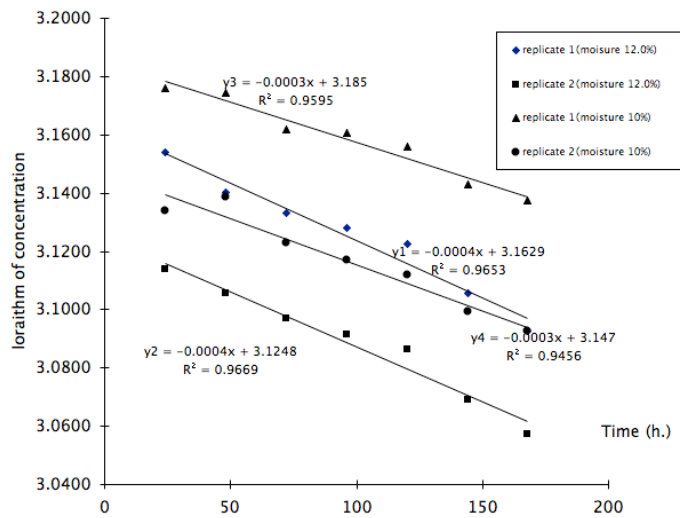


Figure 4: Sorption by three-years old wheat at different moisture contents

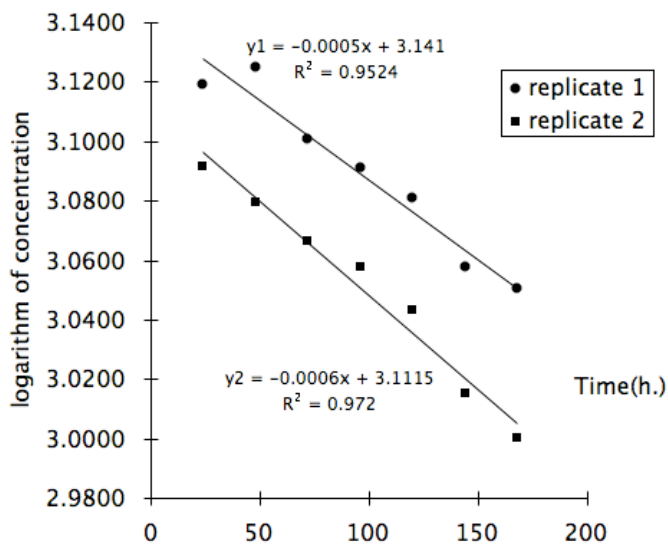


Figure 5: Sorption of phosphine by four-year old wheat

### Absorption of phosphine by wheat

Results of sorption by wheat under laboratory conditions stored for three, and four years at various moisture contents are shown in Figures 4 and 5, and in Table 2.

TABLE 2  
Adsorption rate of  $\text{PH}_3$  by wheat.

Wheat		Slope	Adsorption rate (%/h.)	Adsorption-rate (%/d)
Stored for 3 years	12.0% M.C.	replicate 1	-0.0004	0.10
		replicate 2	-0.0004	0.10
	10.0% M.C.	replicate 1	-0.0003	0.07
		replicate 2	-0.0003	0.07
Stored for 4 years	13.0% M.C.	replicate 1	-0.0005	0.12
		replicate 2	-0.0006	0.14

\*. This wheat has been fumigated two times, this fumigation is the third time

### Absorption of phosphine by corn

Results of sorption under laboratory conditions by corn stored for three years, and half a year are shown in Figures 6 and 7, and in Table 3.

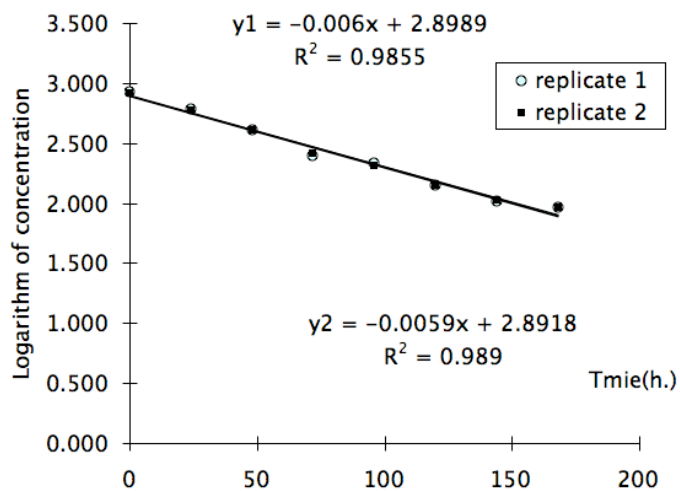


Figure 6: Sorption of phosphine by corn stored for half a year

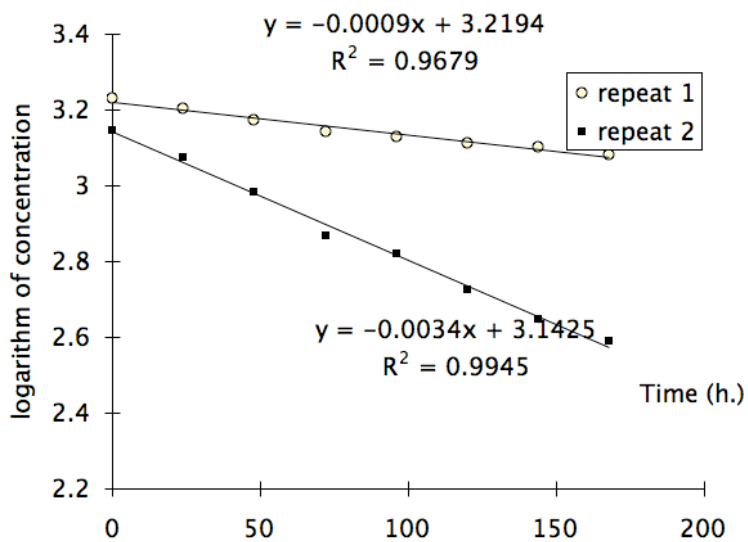


Figure 7: Sorption of phosphine by corn stored for 3 years.

TABLE 3  
Adsorption rate of PH<sub>3</sub> by corn at 13.5% M.C.

Maize		Slope	Adsorption rate (%/h.)	Adsorption-rate (%/d.)
Stored for three years	replicate 1	-0.0009	0.21	11.2
	replicate 2	-0.0034	0.78	
Stored for half a year	replicate 1	-0.0060	1.37	27.9
	replicate 2	-0.0059	1.34	

### Conclusions

Sorption of PH<sub>3</sub> by wheat, paddy rice, wheat and corn stored for various periods of time, at various moisture contents resulted in different rates of sorption. These findings will serve to enable one estimate the decline in concentration of PH<sub>3</sub> during the course of fumigation and to predict the PH<sub>3</sub> concentrations in according the grain type, its moisture content and storage time.

For newly harvested paddy rice which had not been previously fumigated, and its moisture content was 11.2%, the sorption rate was 19.9%/day, and when its moisture content was 15.4%, the sorption rate reached 23.5%/day. The sorption of paddy stored for 4 years was 5.1%/day. Sorption of newly harvested corn was 16.3%/day, and sorption of corn stored for 3.5 years was 11.2%/day. For wheat stored for 3 years at a moisture content of 10.0%, the sorption rate was 1.67%/day, and at a moisture content of 12.0%, the sorption rate was 2.37%/day.

The fumigation effectiveness of phosphine is dependent upon PH<sub>3</sub> concentration, the degree of gas-tightness, the level of resistance in insect resistant strains, the type of the grain, its storage time, and its moisture content. All these factors and the sorption rate of phosphine into the grain, determine the success of the fumigation..

### REFERENCES

- Jiang Ligu, (1999) Comparision of effect of multifactor on grain adsorbing PH<sub>3</sub>., Grain Storage, **28, 4**, 18-21.
- Jiang Ligu, (1990) The effects of grain moisture content on grain absorption capacity to phosphine., Grain Storage, **19, 4**, 20-24