

0421

Application of Phosphine Slow-releasing Fumigation

Lu Jianhua, Liu Shulun, Jia Shengli, Wang Sulin, Wang Fengqi and Liu Guoqi

Abstract: The paper introduced the current status of phosphine application, especially application of phosphine slow-releasing fumigation. For various warehouses (e. g large warehouse, horizontal warehouse and silo), storage ways (e. g bag or bulk storage), insect species and their developmental stages, the corresponding fumigation techniques, dosage and seal time were adopted. e. g. Phosphide aluminium $3\text{g}/\text{m}^3$ was applied in bulk grain in large warehouse; $2\text{g}/\text{m}^3$ and $5\text{g}/\text{m}^3$ in stack of bagged grain and bulk grain respectively in horizontal warehouses, $3\text{g}/\text{m}^3$ for bulk grain in silos. When average temperature of grain was $19 - 28^\circ\text{C}$, phosphine concentration can reach $200\text{ mL}/\text{m}^3$ in all above warehouses at different time and in different seal ways, and can be kept not less than 30 days. About $500\text{ mL}/\text{m}^3$ for resistant insects also can keep not less than 30-day. The lowest effective concentration was $20\text{ mL}/\text{m}^3$ and can keep 75-170-day with different dosage and seal ways.

In recent years, application of phosphine slow-releasing fumigation technique has obtained satisfactory effect against stored grain insects.

Key words: phosphine, slow-releasing fumigation, application

Introduction

Phosphine has been used as a fumigant for more than 70 years since 1930s. It has the advantages of safe, economic and satisfactory effect against insects. China has widely used it since 1960s. The research workers have researched some techniques of phosphine fumigation including conventional fumigation, fumigation with high dosage or low dosage, intermittent fumigation, slow-releasing fumigation, mixture fumigation, recirculative fumigation. Phosphine fumigation has played an important role in protection of postharvest grain. However, insects resistance develop day by day due to misuse of phosphine that fumigation fail. Therefore, we should master knowledge of phosphine, reasonably use to prolong life-span of its use and achieve satisfactory fumigation effect. Phosphine slow-release fumigation has the characteristics of effective concentration persistence and even distribution in grain bulk, effectively killing different species and their development stage.

1 Introduction of Phosphine Slow-releasing Fumigation Technique

Phosphine slow-releasing fumigation is to control releasing speed of fumigant by physical or chemical ways to slowly release phosphine and effectively control insects.

Aluminium phosphide tablets are put into film packets. Speed of resolution and release of

phosphine can be controlled by film so that phosphine can be kept a long-term in grain bulk and get ideal effect against insects. The technique can not only kill adult and larvae, but also kill the adult and larvae which developed by more tolerant egg and pupae. Owing to less content of oxygen in film packets, flammability or explosion can be avoided due to phosphine concentration not excessive high.

2 Procedure of Phosphine Slow-releasing Fumigation

Aluminium phosphide 6-8 tablets (below 10 tablets) are put into polyethylene packets ($0.03 - 0.07\text{mm}$, $8 \times 10\text{cm}$) respectively. Tie up the packets. The packets are put into grain bulk about 0.5m and about more than 3m from the surface of grain bulk respectively for over 6m -high large warehouse; about 0.5m from the surface for about 4m -high horizontal warehouse. It is suitable for that the packets of aluminium phosphide are set in the middle and top of stacks of bagged grain. Space among applying spots is $1.5 - 2.5\text{m}$ for bulk storage, $3 - 4\text{m}$ for bag storage. $2 - 3\text{g}/\text{m}^3$ is suitable for bag storage.

Thickness of polyethylene film depends on grain moisture content and storage period. Thick film can be used for grain of high moisture content and for long-term storage, and vice-versa. For instance, for more than 13.5% of grain moisture content, $0.05 - 0.07\text{mm}$ -thick

film can be selected.

Slow-releasing fumigation should be carried out under the condition of well airtightness. Six-side of stack of bagged grain should be sealed with PVC membrane. For the bag stack with five-side sealed, the joint between floor and the membrane must be sealed strictly. The surface of grain bulk need sealing with PVC membrane, walls, windows and doors must be also sealed. For warehouse in poor airtightness, effective concentration of phosphine can not keep for a long time and insect resistance will develop.

3 Notices in Slow-releasing Fumigation

3.1 Airtightness is the key to success or failure for slow – releasing fumigation. So seal work for warehouse ,grain bulk and bag stack is very important. Pressure decay should not be less 40s from 500Pa to 250Pa for horizontal warehouse ,especially for large warehouse, and not less 60s from 500Pa to250Pa for silo or squat silo. Six – side sealing should be adopted for bag storage, pump air out of the stack and then repair the leaks. The leaks between floor and covered membrane must seal well for bag stack with five-side seal.

3.2 Slow-releasing fumigation is suitable for grain stored for a long time. Sealing period is not less two months.

3.3 Slow-releasing fumigation is suitable for controlling the resistant insects to phosphine not serious. For the insects with obvious resistance, concentration of phosphine is at least more than 500 mL/m³ ,and keep over 30 – day.

3.4 Phosphine concentration should be monitored to determine that the target concentrations are being achieved during fumigation. Phosphine concentration of different warehouses and stacks which have the same dosage and the same applied time will be compared. When concentration of phosphine in some warehouses and stacks lowers, the tablets will be made up in time.

4 Application of phosphine Slow-releasing Fumigation in Different Types of Storages

Trails of phosphine slow-releasing fumigation have been carried out since 2000 in different types of storages including bulk storage ,bag storage in large warehouses and in horizontal warehouses, combination of cloth packets with film packets, and combination of film packets with different thickness in silos and the trials

obtained good results.

4.1 Trial of slow-releasing fumigation with low dosage of phosphine in large warehouse

4.1.1 1Procedure Trial was carried out in a large warehouse in Ninhe storage in Tianjin. 3652t white wheat was in bulk storage. 2 – 3 populations of *Sitophilus zeamais* per kg were detected. Before application each of 18 cages contained 40 populations of insects was set in the top ,middle and bottom of grain bulk respectively. 6 cages were set in each layer. Each cage contained 10 *Sitophilus zeamains* Motschulsky, *Cryptolestes ferrugineus*, *Tribolium confusum* and *Attagenus piceus* Oliv in different development stages respectively

Combination application was adopted such as combination of conventional application at low dosage with slow release application. : ① combination of cloth packets with 0. 05mm – thick polyethylene packet ② combination of probe with 0. 05mm – thick polyethylene packets. 300 application spots altogether were set in the top and low levels respectively (150 spots in each level). The spots distributed evenly and the space among the spots was 2 – 2. 5m. The surface of grain bulk, doors and outlets were sealed with nylon film.

4.1.2 Measurement resultsApplying fumigant and seal for grain bulk were conducted in Jul. 8 – Sep. 21 ,2000. Phosphine concentration was monitored at regular during trial. The results showed that average concentration of phosphine was 200 mL/m³ after application 24h. Phosphine concentration tended to equilibrium after 5 – day ,and achieved 680mL/m³ ; the average highest concentration achieved 790mL/m³ after 7 – day ;210mL/m³ after 30 – day ;20 mL/m³ after 75 – day.

4.1.3 Insect control effectNo live insects were found in 27 application spots (9 spots in the top ,middle and bottom respectively) after ventilation. Average temperature of grain bulk was 29°C . There were also no live insects in 18 cages which were collected from grain bulk. Put the insects in cages into an incubator of 28°C , RH80% . The result showed that no live insects occurred after 30 – day. 100% controlling insect effect was obtained.

4.2 Trial of slow – releasing fumigation for stack of bagged grain in horizontal warehouse

4.2.1 ProcedureThe trial was conducted in Yujiabao State Grain Storage in Tanggu of Tianjin. A stack of bagged wheat of 1 000t was

used for the trial. Before applying insecticide, insect density was 3 and 5 populations per kg for *S. zeamais* and *C. ferrugineus* respectively. Each of 10 cage which contained 20 *S. zeamais*, *C. ferrugineus* and *T. castaneum* respectively were put into the tested wheat stack. Five – side of the bag stack was sealed with PA/PE membrane. The packet was made of 0.05mm and 0.07mm polyethylene film. Dosage of aluminium phosphide was $2\text{g}/\text{m}^3$, each packet contained aluminium phosphide below 30g. Applying spots were set evenly in the middle – upper stack. Space among the spots was about 3m. Membrane around the stack bottom was pressed to seal with nylon bags of sand.

4.2.2 Measurement results Aluminium phosphide tablets were applied in bag stack in May, 9 2002. Phosphine concentration in grain stack was determined regularly from May, 16. The results showed that average concentration of phosphine achieved over $40\text{mL}/\text{m}^3$ after 7 – day, over $140\text{mL}/\text{m}^3$ after 21 – day and kept 78 – day (the highest concentration was $410\text{mL}/\text{m}^3$); the lowest effective concentration $20\text{mL}/\text{m}^3$ kept 170 – day. (average grain temperature 15°C in middle of May, the highest temperature 27°C in Jul. – Aug).

4.2.3 Insect control effect No live insects were found in 15 spots in the grain stack after ventilation. 10 insect cages were collected and also no live insects were found in the cages. Then the insects in the cages were put into the incubator (27°C and RH75%) for 30 – day in which no live insects occurred. Effect of insect control achieved 100%.

4.3 Slow-releasing fumigation in bulk grain in horizontal warehouse

4.3.1 Procedure The trial was carried out in the horizontal warehouse in Hangu State Storage in Tianjin which was 800m^2 , grain bulk 4m-high. 2400 t white wheat was loaded into the warehouse from Jun. 15 to 20, 2003. The loaded wheat was infested by insects which the density was 3 populations, 2 populations and 5 populations per kg for *S. remainze*, *R. dominica* and *C. ferrugineus* respectively. So applying aluminium phosphide tablets was conducted with loading grain. Each pocket with 8 tablets aluminium phosphide was made of 0.06mm polyethylene film. Dosage was $5\text{g}/\text{m}^3$. After finishing loading grain, the surface of grain bulk, doors and windows of the warehouse were sealed.

4.3.2 Measurement results Phosphine concentration of grain bulk was measured at

regular from beginning of Jun. 25, 2003. The results showed that phosphine evenly distributed in grain bulk. Average concentration of phosphine was over $300\text{mL}/\text{m}^3$, over $500\text{mL}/\text{m}^3$ in Jul. 5 and kept more than 30 – day. The lowest concentration was $20\text{mL}/\text{m}^3$ and kept 120 – day. (average temperature 24°C during applying insecticide)

4.3.3 Insect control effect 15 samples were taken from 15 spots (east, west, south, north, centre, top, middle, bottom) in grain bulk. There were died insects but no live insects in the samples. Put 15 samples into the incubator at 28°C and 70% and no live insects occurred after 30 – day.

4.4 Slow-releasing fumigation in silo

4.4.1 Procedure Trial was carried out in a silo in Yujiabao State Storage in Tianjin. The silo with 6.6m – diameter, 9m – high grain bulk which contained 240tonne (t) white wheat. Turnover for the tested grain was conducted for lowering temperature in Jan. 2004. The grain temperature in the surface obviously changed with atmospheric temperature in spring and summer, and lower in middle and bottom in the silo. Applying insecticide was carried out in Jun 6, 2004. Each of pockets made of 0.06mm polyethylene film which contained 30g aluminium phosphide tablets (dosage $3\text{g}/\text{m}^3$). Five cages were put into grain bulk 1m from the surface in which there were different insect species including their different stages. There were 10 populations *S. zeamais*, 15 populations *C. ferrugineus*, 30 populations *Psocids* per kg in the cages respectively. All the entrances, outlets and exits were well sealed.

4.4.2 Measurement results Phosphine average concentration of grain bulk measured was over $100\text{mL}/\text{m}^3$ in 16 Jun. 2004, over $280\text{mL}/\text{m}^3$ kept more than 30 – day, the lowest concentration $20\text{mL}/\text{m}^3$ kept 130 – day (grain temperature 22°C in the top, 18°C in the middle, and 16°C in the bottom during applying insecticide).

4.4.3 Insect control effect After ventilation to disperse, 5 cages collected for inspection. There were no live insects to be found, then the insects in the cages were put into an incubator at 28°C and RH80%, also no live insects occurred after 30 – day. The insect control effect was 100%.

5 Discussion

5.1 Application of slow – releasing fumi-

gation should consider some factor, such as different types of warehouses, grain varieties, different insect species, storage period, seal conditions, and reasonably use film packets with different thickness and their combination use to achieve satisfactory killing effect.

5.2 Phosphine concentration change is related to grain temperature, when grain temperature is high, volatile speed of phosphine is quick, it is also related to grain moisture content, when grain moisture content high, the volatile speed is quick during slow – releasing fumigation.

5.3 Moving of phosphine gas is related to microcurrent in grain bulk during slow – releasing fumigation. Grain temperature is higher

in the top than the middle and bottom in spring and summer, and phosphine gas move from top to the bottom. Under well seal condition, applying insecticide in the top of grain bulk, the ideal insect control effect can achieve with microcurrent effect for all types of warehouses.

References

- [1] Wang Dianxuan, Cao Yang. Technique of Phosphine Fumigation for Control Insect, Chengdu Scientific and Technology University Publishing house, 1999
- [2] Wang Peixiang. Application of Chemical in Stored Grain, China Commercial Publishing house, 1997
- [3] Li Furu. Grain Management, Guandong Higher Education Publishing house, 2004