KW2-2

IPM practice and attempt in last several years in China grain storage

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Abstract

Current IPM practices and some trials in grain storage depots in China are discussed, mainly for the depots belonging to China Grain Reserves Corporation all over China. These practices involve sanitation, introduction of new pest monitoring methods, temperature control through structural improvements and aeration, use of grain protectants and phosphine fumigation. These practices have been introduced as part of the government's investment since 1998 on improvement of grain storage conditions. Sanitation involves upgrading of general hygiene in and around the grain depots, killing pest populations in empty warehouses through DDVP fogging before loading of grain, and seclusion using insect proof barriers. Storage temperature has been kept low (below 20 °C for average) by structural improvements such as insulation through air or adiabatic interlayer in the wall and building air convection layer in roof. Cooling of grain has also been achieved through introduction of aeration such as use of cooler for dispelled or recirculation cooling. Some chemical strategies such as judicious use of grain protectants including malathion, fenitrothion, pirimiphos methyl and deltamethrin, and the fumigant phosphine are also been integrated in the IPM program as part of the resistance management. Monitoring of insect populations through various new trapping methods is used to assess the success of the IPM program and for decision making.

Key words: IPM, grain depots, China.

Introduction

Since 1998, there has been a series of changes in grain storage practices in China, as part of government's priority and investment in improving of grain depots. The main objective of this investment was to maintain the quality of grain during storage and to reduce losses due to pest populations. This paper describes the progress that has been achieved through introduction of an IPM program in grain depots in China over the years to achieve this goal. The various components of this IPM program are described separately with some practical examples.

Sanitation

A range of approach are taken to improve sanitation in the grain depots by following key points from training manuals and many years of experience in IPM practices in China.

Hygiene

This has been a basic practice in Chinese grain storages. The outside of warehouses and depots are required to be kept neat and clean and gardened

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to make it difficult for the pests to hide. All surfaces inside the storage such as walls, structures, cables, equipments are cleaned so that no residues or dust are left to encourage the harborage of any insects. Moreover, care is taken to fill all cracks, holes and other hiding places for insects. This way, the standard of hygiene is strictly maintained to the point of 'no dust when touched by hand or when looked on'.

Elimination of residual insect populations

By using DDVP fogging, it is attempted to kill every insect in empty warehouse, before grain is loaded. Phosphine fumigation is used after grain is loaded, if some insects survived from DDVP fumigation and existed in grain.

Seclusion

This involves a range of tactics to discourage the pest population to reach the stored grain. These include door and window control, insect-proof barriers soaked with insecticides for crawling insects and insect-proof nets for flying insects. Care is also taken to make sure that infestation is not carried from one warehouse to another on the clothing and tools of operators. Usually, among several doors and windows only one entrance is opened for necessary checking, while the others are kept closed and sealed.

Structure improvement

Structural improvements are undertaken where store rooms in warehouses (depots) are not insect-proof and lack 'gas tightness'. These improvements are needed because it is a requirement to fumigate the newly loaded grain with phosphine to control pests.

Keeping the storage temperature at a low level

In China, grain is stored for a long period of time (e.g., 2-3 years for paddy and 3-5 years for wheat). Grain is usually loaded in the summer and fall when temperature is high and stored in state of higher temperature until winter. During storage, temperature is maintained at a low level (below 20 ºC for average in grain mass) through heat insulation and temperature depression as a profitable measure for pest prevention and maintenance of grain quality.

Heat insulation and improvement for storeroom

There are several approaches undertaken to achieve heat insulation in storages. These include white painting on exterior roof and wall, building of air convection layer up on roof, suspended insulation air layer under roof, poly-ammoniac adiabatic layer on inner-roof surface, cover adiabatic materials on the surface of bulk, insulating air or adiabatic interlayer in the wall, and heat-insulation handling on ventilation duct, window, door etc. Heat removal from space in warehouses is necessarily carried out when the inside temperature is higher than the external, particularly after noon in summer in several provinces in China (Zhu et al., 2004).

Cooling of grain through aeration

In all warehouses, aeration is used for cooling grain in the first year of storage. Thereafter, the grain temperature is maintained below 20 ºC in up to 80 % of the grain mass in flat warehouses and squat bins. Usually, in the top layer of the bulk, temperature remains high. Currently, there are attempts to reduce the temperature locally. These include removal of heat using automated or hand held fans, heat balancing by recirculation. And grain coolers are also used for cooling grain in the way of dispelled heat, particularly for paddy stored in southern part of China. However, it is expensive to use coolers in warehouses that have bad insulation. Some field tests have been carried out for recirculation cooling using grain coolers (Cui and Cao, 2004; Zhu etl al., 2006; Wang et al., 2006).

Use of contact insecticides or grain protectants

In China, malathion, fenitrothion, pirimiphos-methyl and deltamethrin are registred as grain protectants. However, only a small proportion of grain is treated with protectants, due to good storage management with high level of sanitation and economic use of phosphine fumigation. Only few depots use some protectant powder admixed to the top layer of bulk (about 30 cm), mainly for psocid control and other insect infection.

Phosphine fumigation

Most grain depots in central and southern part of China are fitted with phosphine recirculation equipment. This is not common in northeast and northwest regions, because the low temperature and dry climate in these areas which is less suitable for insect population growth. Phosphine released from aluminium phosphide tablets kept on trays in the top of the grain mass is recirculated through the grain mass. In some places, the tablets are applied through ventilation ducts, where blowing is required and the number of tablets is restricted to avoid explosion. In many places, on-site use of phosphine generators has been reduced in recent years, due to the difficulty in getting carbon dioxide. In fumigations, phosphine concentration is monitored through electronic monitor and detecting tubes connected at several pump points in the grain mass through special sampling lines (Figures 1-3). Recommended Fumigation Regulations are available for phosphine recirculation with minimum concentrations and exposure periods for different pest species and grain temperatures etc. (Table 1). In many fumigation the exposure time is now determined by insect survival in test cages located where they can be removed easily for inspection.

Phosphine resistance and its management

Phosphine resistance

The phosphine resistance in stored grain insects occurs widely in China as many other countries in the world. The familiar species of insects in stored cereal grains are *Sitophilus zeamais, Tribolium castaneum* and *Cryptolestes spp*. which can be seen throughout China, *Rhyzopertha dominica* occurring in the central and southern parts, and *Sitophilus oryzae in* the southern part. In a recent resistance survey in

Table 1. Recommended minimum phosphine concentration (ppm) for different exposure times, temperatures and insect tolerances.

Insect grouping	Temperature (ºC)[1]	Exposure time ≥ 14	≥ 21	≥ 28
Low tolerance group:	>25	200	150	100
Sitophilus zeamais, Latheticus oryzae,	20~25	250	200	150
Tribolium confusum and other susceptible strains	15~20	~-	250	200
Higher tolerance group:				
Rhyzopertha dominica, Sitophilus	>25	300	250	200
oryzae, Tribolium castaneum,	20~25	350	300	250
Cryptolestes spp. moth and other resistance strains	15~20	-	350	300

[1] Lowest temperature around insect occurred point.

China (Yan et al., 2004), 92 strains of six pest species from fifty depots in twenty three provinces, cities and municipal districts were bioassayed using the recommended FAO method (Anonymous, 1975). The results were that 54.3 % of strains had no obvious phosphine resistance, 13.0 % and 15.2 % of strains had high and very high levels of resistance, respectively. Of particular concern was the widespread and serious phosphine resistance in *Cryptolestes ferrugineus* for the resistance of (with resistance factors (RFs) of over 200 for several strains), *Rhyzopertha dominica* (maximum RF of 315, from Hubei province), *Sitophilus oryzae* (maximum RF of 305, from Hubei province) and *Tribolium castaneum* (maximum RF327, from Henan province). The strains with high level resistance come mainly from the southwest, central and southern regions where the climate is warm and humid and favours insect population growth.

Resistance management

Since the grain is usually stored for more than three years in the state depots, long exposure periods are possible during phosphine fumigation. It is possible, therefore, that any insects in fumigation enclosures can be killed by following the recommendations shown in Table 2 aimed at controlling resistant strains of major stored grain insects. Two groups of small insects are extremely difficulty to control are psocids and *Cryptolestes* spp. Psocids require long fumigations, i.e. 30-40 days at greater than 100 ppm of phosphine. Some experience from Guangdong province shows that *Cryptolestes ferrugineus* can survive concentrations of 300-500 ppm for 28 days but cannot survive exposures that exceed 30 days (Wang and Collins, 2003; Wang et al., 2002).

Insect monitoring

According to the current regulations, insect numbers by sampling and sieving is used as a key parameter to make pest control decisions. Currently, a variety of traps have been evaluated including probe traps, corrugated paper traps and

Table 2. Exposure times and phosphine concentrations required for complete control of adult insects in field trials.

Species	RF[1] of strain	Change in concentration (ppm)	Time to complete control (days)	Fumigation trial site (Place, Province)
Rhyzopertha dominica	-[2], CZRd	100-750	7	Shenqiu, Henan
	189, ZZRd	150-500	28	Zhengzhou, Henan
	S, QRD14	150-300	2	Zhongshan-1, Guangdong
	-, YCRd	200-800-480[3]	15	Zhongshan-2,
	-, field strain	150-600-300[3]	15	Zhongshan-1, Guangdong
Sitophilus zeamais	2, ZZSz	140-490	3	Liaocheng, Shandong
Tribolium castaneum	180, QHTc	100-750	10	Shenqiu, Henan
	2.5, YYTc	100-750	7	Shenqiu, Henan
	2.5, YYTc	90-300	3	Liaocheng, Shandong
	327, SQTc	140-490	15	Liaocheng, Shandong
Sitophilus oryzae	-,field strain			Zhongshan-2, Guangdong
Cryptolestes ferrugineus	-, field strain	150-600-140[3]	21	Zhongshan-1, Guangdong
	-,field strain	200-800-180[3]	30	Zhongshan-2,Guangdong

[1]Resistance factor, [2]Unknown, [3]Concentration increased, peaked and declined during exposure time.

ultraviolet light traps. It is established now that insects can be detected earlier by traps than by sieving. However, the government has funded recently to establish the relationship between trapping and sieving methods for better decision-making on pest control. An electronic grain probe/insect counter system has been tested in a few depots, but inaccurate results and difficulties in probe installation have limited its adoption. In another development, insect pumping and counter system has been introduced in some depots. In this system, insects trapped in probe traps are pumped out through a pipe and sent to a collector situated outdoor for visual inspection. In this system, insects can be counted during the process of pumping and the monitoring order is given by a computer and the message can be transmitted by radio or by temperature monitoring system equipped in the warehouse.

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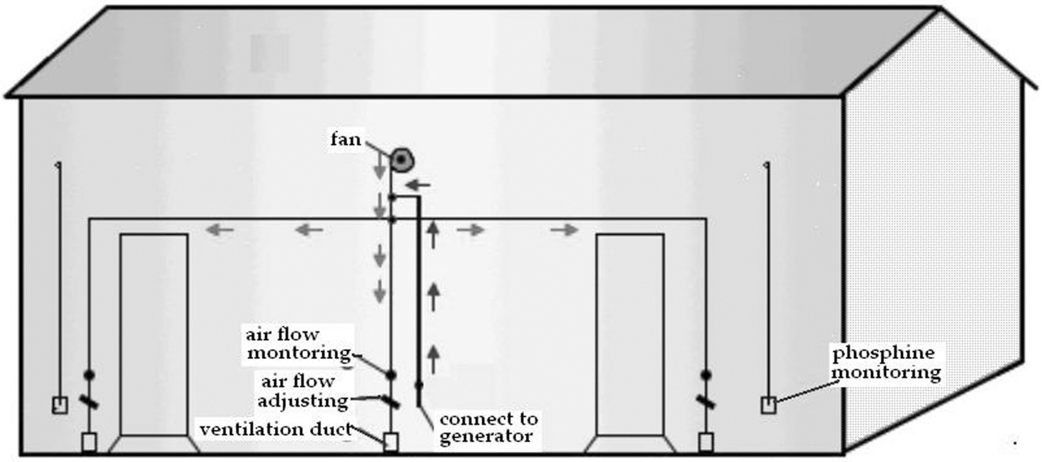

Figure 1. Phosphine fumigation pipe and fan are fixed on the wall of warehouse.

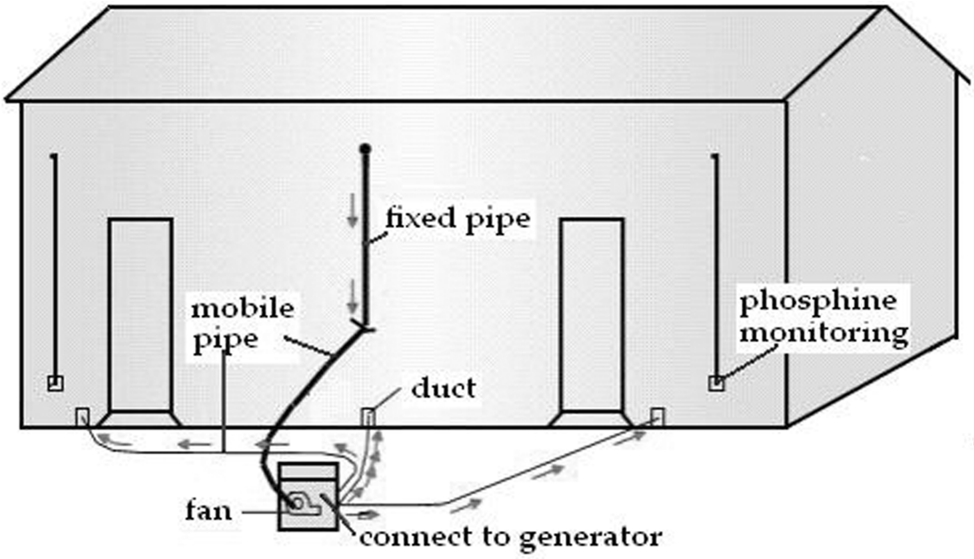

Figure 2. Mobile pipe and fan of phosphine fumigation with on-site generator.

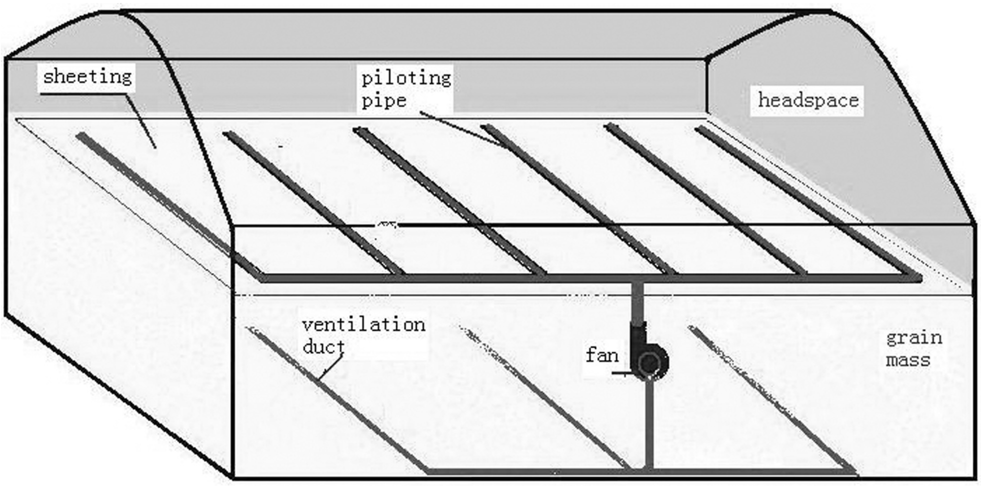

Figure 3. Phosphine recirculation fumigation under plastic sheeting by piloting pipe.