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Integrated protection and fumigation of grain in Russia

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ABSTRACT

An integrated grain protection system in Russia includes preventive measures as well as destructive ones. The preventive measures are storage preparation (repairing, sealing, cleaning, weeds control and disinfestation) and grain preparation (drying, cooling, conservation with liquid insecticides, infestation monitoring). The destructive measures are divided into physical methods (separation, heating or freezing of grain) and chemical methods (phosphine fumigation, methyl bromide quarantine fumigation, treating with Actellic as well as with other liquid insecticides). To protect grain from being contaminated by insects in metal silos, three innovative systems (Stored Grain Condition Remote Monitoring System, Recycling Fumigation in the Unmovable Grain System, and Anti-Insects Grain Preservation with Liquid Insecticides System) are incorporated into the facility.

Key words: Grain, Integrated protection, Preventive and destructive measures

Russia is situated in the north-eastern part of Eurasia. It occupies 17,000,000 km² (first place in the world). In Russia, about 100,000,000 tonnes of grain a year are grown.

There are several types of grain storages in Russia: concrete elevators with general capacity 50-200 thousand tonnes and bins capacity 200-600 tonnes each; flat brick storages (60 m × 20 m × 3 m) with capacity 3000 tonnes each; metal silos of different capacity with bins capacity 1000-15000 tonnes each; hockey rings of different capacity; sleeves of different capacity.

The most wide-spread grain pests in Russia are *Sitophilus* sp., *Rhizopertha dominica, S. cerealella, Tribolium* sp., *Oryzaephilus surinamensis, Laemophloeus* sp., and *Acarina.* These insects and mites live in many countries.

MATERIALS AND METHODS

In Russia, an integrated grain protection system operates. It includes preventive measures as well as destructive ones. Preventive measures include storage preparation (repairing, sealing, cleaning, weeds control and disinfestation) and grain preparation (drying, cooling, conservation with liquid insecticides, infestation monitoring). Destructive measures are divided into physical methods (separation, heating or freezing of grain) and chemical methods (phosphine fumigation, methyl bromide quarantine fumigation, treating with Actellic as well as with other liquid insecticides).

There are three methods of storage disinfestation in Russia. The first method is called wet disinfestation of storage. It means that insecticide is mixed with water. Sprayer produces drops of more than 100 microns. The advantage of wet disinfestation is the fact that it is not necessary to seal storages as such drops quickly fall on the surface. Disadvantages of this method include: quite labour-consuming, water-consuming and insecticides are dispersed unevenly.

The second method is aerosol disinfestation of storage with liquid insecticides. Aerosol generators produce drops of less than 50 microns. Such drops are falling on the surface during 16–18 h. The advantages of aerosol disinfestation are: it is not necessary to mix insecticide with water; even spread of insecticide; drops penetrate into hard-to-reach places; high capacity; low labour consumption. The disadvantages are: it is necessary to seal storages and to wait for 24 h for keeping insecticide inside during its precipitating; it is necessary to clean the storage very well before treatment.

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Table 1 Integrated grain protection system

Preventive measures		Destructive measures	
Storage preparation	Grain preparation	Physical methods	Chemical methods
Repairing	Drying	Separation of grain	Phosphine fumigation of grain
Sealing	Cooling	Heating of grain	Methyl bromide quarantine fumigation of grain
Cleaning	Conservation with liquid insecticides	Freezing of grain	Treating of grain with Actellic
Weeds control	Infestation monitoring		Treating of grain with other liquid insecticides
Disinfestation			

The third method is phosphine fumigation. In the Russian market only tablets are available, so tablets are spread over the floor surface on the trails after cleaning and sealing of building. Then workers periodically read phosphine concentration and calculate the product of average phosphine concentration in g/m^3 and time of exposition in h (C×T product in g·h/m^3).The tablets agent finishes its reaction approximately in a couple of days. When C×T product reaches the standard size, the building is degased. The standard size of C×T product for insects that form hidden infestation of grain (*Sitophilus* sp., *Rhizopertha dominica, S. cerealella)* is 25 g·h/m^3 and for other insects the standard size of C×T product is 7g·h/m^3. Residues are carefully collected and pulled out of the building. They are deactivated and utilized in canalization system.

There are three requirements that should be accomplished to save grain. Water content of grain should be12–13 % or less and the grain temperature should be 12–13 ºC, as molds and mites are not able to evolve under such circumstances. Insect monitoring should be performed. These conditions are sometimes impossible to provide in practice. That is why we have to fumigate grain to save it.

To fumigate grain with phosphine in concrete elevator silos tablets are placed into grain stream during grain moving from one bin to another. The degassing process is started approximately 3–5 days after C×T product turns 25 g·h/m^3. But in order to move grain from one silo to another a lot of electric power is spent. Besides, we get extra 2% of broken kernels. It means we lose about 1% of grain mass according to Russian grain standards.

To conduct phosphine grain fumigation in flat storage, 3 tablets per tonnes of grain are spread with some special devices. The distance between tablets is 2 m in area and 0,1 m in height. After placing of tablets grains are covered with film. Upper grain layer is treated with liquid insecticides.

To fumigate grain with phosphine in trains on the way to the enterprise before train departs, the tablets are mixed with grain and put in sleeves. Sleeves are inserted in the grain mass. Then train is sealed with covers. When the train arrives at the enterprise, the sleeves are pulled out of the grain. Tablets residuals are deactivated. The grains are discharged to storage under phosphine monitoring.

Lately metal silos used for grain storage are built in Russia in quantities. Abrupt temperature changes in autumn from high in the daytime to low at nights lead to the build-up of high moisture of the warm grain top and silo walls adjoining layers. Sometimes grain sweating occurs in metal silo. Storage facilities do not have the proper stored grain condition monitoring system. Neither do they have any mechanism to protect grain from being spoilt by insects and molds. As a result, grains germinate, and are injured by insects and molds.

RESULTS AND DISCUSSION

We have found the solution to the problem by incorporating into the facility two innovative systems: Stored Grain Condition Remote Monitoring System (GRMS) and Recycling Fumigation in the Unmovable Grain System (RFGS).

Briefly the grain protection system is presented in the Recycling Fumigation in the Unmovable Grain System (RFGS)

The RFGS consists of a specially designed phosphine generator, a fan, a system of air ducts and a set of ventilation channels in the silo floor covered with perforated metal sheets. One air duct goes from the fan`s outlet to the inlet of the ventilation system channels. The second air duct joins the phosphine generator inlet with the grain overhead space. RFGS is like SIROCIRC^{TM}, which was used in active fumigation system (Winks and Russell, 1997). The main difference is in fumigants. Winks and

Russell used gas Phosfume 2% PH_3 in CO_2. We used PH_3 received from tablets on-line in the special generator.

Paddy (*Oryza sativa* L.) rise of 1500 tonnes was stored in the metal bin. The bin was equipped with RFGS. Aluminum phosphine tablets in the dosage of 9 g/ m^3 were put into the phosphine generator. The recirculation fan operated for 72 h, with another 3 h to vent the phosphine out of the grain mass. Tests showed a very uniform distribution of phosphine in all the sectors of the grain mass. After the fumigation all adults *S. granarius*, as well as their preimaginal stages, the hidden infestation in the grain, were dead.

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