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Sitophilus Zeamais Motschulsky

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Abstract:
The objective of the paper is to determine the composition of the maize seed beetle in the warehouse stored in the warehouse; Effects of several ecological factors on growth characteristics of the corn weevil Sitophilus zeamais Motschulsky as the scientific basis for suitable methods to preserve grain maize in storage warehouses.
Keywords: *Sitophilus zeamais Motschulsky, corn weevil*

1. Introduction

Agriculture plays a very important role in Vietnam's economy, in which, rice and maize are two important food crops that are indispensable in the agricultural development strategy. These two main food crops ensure domestic demand and export.

In Vietnam, maize has an important position after rice. Maize is considered as the key crop in the poverty alleviation program for mountainous provinces. In addition to serving food needs, corn products are also used to process into many higher value products such as confectionery, wine, beer, animal feed, ... According to the Report of In 2013, the total output of grain food was estimated at 49.3 million tons by the Ministry of Agriculture and Rural Development, an increase of 558.5 thousand tons over the previous year. In particular, the whole year rice output was estimated at 44.1 million tons, up 338.3 thousand tons, maize production was estimated at 5.2 million tons, up 8.3% [1]. With such a large amount of food, the preservation of agricultural products after harvest is an urgent requirement, while the majority of producers mainly preserve post-harvest food products in the traditional way, This not only causes a large loss in quantity, but also significantly reduces the quality of the produce in the storage due to the insect pests that damage the produce after harvest.

In order to maintain the quality and reduce the loss of agricultural products in storage, it is necessary to find out effective measures to prevent agricultural pests in general and corn pests in particular after harvest and storage. warehouse.

In the preservation of agricultural products, in addition to the purpose of reducing the loss in quantity and quality (nutritional value), the application of preventive measures should ensure that it is not toxic to the preserved product. polluting the environment in the warehouse.

For agricultural products such as maize, some insects arise and are harmful in storage; Some species invade from the field, following harvested product to thrive and continue to damage in stock. For some agricultural products preserved after harvest in the form of seeds such as rice, maize and beans, under favorable conditions, some species of weevils thrive, reproduce rapidly, causing large losses, significantly reducing take into account the quality of seeds, especially for seeds, a pest that reduces or completely disrupts the ability to germinate the seed.

Among the corn pests stored in the warehouse, the pests dominate and cause huge losses. So far, in Vietnam, there have been a number of research works on agricultural pests in preserved warehouses. As for Son La province, there is no work that fully mentions the insect pests of post-harvest agricultural products, especially corn, as well as their prevention measures.

Currently, among the pest prevention measures of agricultural pests in storage, the traditional method is still just drying or drying before being put into storage, chemical steam methods often limit the use of It is used to ensure food safety and hygiene, biological methods are almost rarely used due to less effective results as expected. Therefore, up to now, there are no optimal preventive measures to reduce the damage caused by pests of agricultural products stored in the warehouse.

2. OVERVIEW

2.1. Research pests harmful to agricultural products preserved in warehouses around the world

Insects surpass all other pests in number of individuals and number of species, they compete with humans for food, spreading diseases to humans, plants and animals. A distinctive feature of pests is their high adaptability to earth's living conditions, and they can survive and function under drought conditions [2].

Researches on pests that cause harmful insects to agricultural crops have been available at a fairly early stage. It is also from insect research results that humans have found ways to prevent harmful insects.

Insects not only harm crops in the field, many species also damage post-harvest agricultural products that are stored in warehouses. Pests harmful to agricultural products in the warehouse reduce or completely lose their use value. In many cases, they rot the stored grain or cause the seed to lose its ability to germinate.

Around the world have research on pests, often focusing on the species composition statistics. Can be found in seed reserves (Cotton, 1937); on the pest of preserved products of Cotton & Wilbur (1974); insect composition in Australia (Snelson et al., 1987) [3]; seed insects and seed products stored by Cotton (1963) [4]; insect composition on paddy and rice stockpiled in Thailand by Nakakita et al., (1991) [5]; Insect infestation on paddy rice in Indonesia by Hall & McFatane, (1961) [6]. In addition, there are studies on species composition and insect ecology on bagged seeds (Graham, 1970; Smith, 1963; Prevett, 1964), research on insect ecology. in the grain warehouses (Richards & Woodroffe, 1968), about the pest pests of the farmer's warehouse (Markham, 1981: cited from Bui Cong Hien, 1995) [7].

According to Cotton & Wilbur (1974), pest pests in stockpile in the world, including 43 species, are divided into 2 groups: main pest group includes 19 species and 24 species of insect pests. weak but frequently present in seed reserves (cited by Snelson et al., 1987) [3].

In Indonesia, on paddy and rice reserves, 17 species of 12 families and 2 orders have been recorded (Hall & Mcfarlane, 1961 [6]; Prakash, 1980 [8]). Film & Hagstrum (1990) [9] has recorded 41 species of insects in food products stored in several countries around the world. Nakakita et al., (1991) [5] recorded 36 insect species belonging to 17 families and 2 sets of harmful effects in rice and rice preserved in Thailand in 1991.

According to a joint survey between Indonesian scientists from the Center for Tropical Biology in Southeast Asia (Seameo-Biotrop) and the Institute of Natural Resources (NRI) as well as the authors Sukprakarn & Tauthong (1998), Nilpanit & Sukprakarn (1990) Nakakita (1994), ingredient of agro-products of the beetle (Coleoptera) and the scalp suit (Lepidoptera) in Indonesia, Thailand, Malaysia, Philippines and some other countries in the region Southeast Asia has 174 species of 38 families, of which the beetle (Coleoptera) has 153 species of 34 families, accounting for 87.93%; The scalp suit (Lepidoptera) has 21 species of 4 different families, accounting for 12.07%. The above results show that, the Southeast Asia region has a relatively rich and diverse insecticidal composition compared to the US as well as other countries in the world (according to Ha Thanh Huong, 2007) [10]. Reichmuth (2000) recorded 55 species of insects on produce stored in Germany [11].

According to Olsson Christian (1999) [12], the harmful insects on cassava include the serrated beetle (Oryzaephilus surinamensis), the corn beetle (Sitophilus zeamais), the seed borer (Rhizopertha dominica), the coffee weevil (Araecerus fasciculatus). , bamboo weevil (Dinoderus minutus).

For preserved maize, there has been a lot of research on the pest composition, most notably in Mexico (Rojas, 1998) [13], the author investigated and identified 17 species. insect harmful to preserved maize, belonging to 9 families and 2 orders. Among them, the main harmful species are the corn beetle (Sitophilus zeamais), the moth (Sitotroga cerealella) and the seed borer (Rhyzopertha dominica).

Snelson (1987) [14] discovered in Australia the major pests of maize, rice, and wheat, including the seed borer (Rhyzopertha dominica), the red flour beetle (Tribolium castaneum), the rice weevil (Sitophilus oryzae), and the corn beetle (Sitophilus zeamais), serrated beetle (Oryzaephilus surinamensis). According to Arbogast & Throne (1997) [15] there are 43 insect species belonging to 26 families and 4 sets of harmful diseases in corn warehouse in South Carolina (USA).

Olsson Christian (1999) [12] listed the main pest infestations, mainly corn weevil (Sitophilus zeamais), red flour beetle (Tribolium castaneum), bamboo weevil (Dinoderus minutus) and moth (Sitotroga cerealella). .

When studying food reserves in some countries around the world, Freeman (1980) recorded 41 species of insects. Then, another study by Bengstong (1997) showed that the main pest pests are Sitophilus spp., Rhizopertha dominica, Tribolium castaneum, Sitotroga cerealella and Ephestia cautella are distributed around the world and especially in regions. Warm climate, including 200 species of grain pests stored in the warehouse [16].

According to Bolin (2001), the baseline survey of the University of Oklahoma showed that the dominant insect pests include Rhizopertha dominica, Cryptolestes spp., Tribolium castaneum and Indian Sir Plodia interpunctella [17].

To date, there have been successes around the world in preserving agricultural produce after harvest, which has reduced both quantitative and qualitative losses caused by insects and control growth of them in storage. However, with the changing environmental conditions and food sources, to adapt, the pests also change in composition, density and form of harm. In addition, due to the increasing trade and exchange of goods between countries, the possibility of introducing insects from agricultural products is increasing. Therefore, the research on the composition of harmful pests in agricultural warehouses has always been of interest to scientists around the world.

Research on insect damage caused by agricultural products in storage

The preserved agricultural products are attacked by pests, causing great losses in quantity and quality. That is also one of the reasons leading to the decline and loss of a large amount of food in some parts of the world. Subrahmanyan (1962) pointed out that the world's total food could have been increased to 25–30% if the post-harvest loss of agricultural products could be avoided (cited by Bui Cong Hien, 1995) [7].

Postharvest losses of various agricultural products are often underestimated. Published data is usually focused on the loss in volume, while very little data on the quality loss of produce is stored. Dried cassava is one of the agricultural products that are difficult to store because it is easily attacked by harmful insects in the warehouse and climatic factors cause the quantity and quality of cassava to be preserved rapidly. The loss of dried cassava during storage has been assessed to be up to 16% by volume after 2 months of stockpiling in Malaysia [20].

In India, it has been reported that warm water immersion of agricultural produce before storage can be stored for 9 months with only 3% loss in weight, compared with 5% loss if stored in normal place. However, for the dried chips, a loss is about 12–14% when stored in stock. The loss of volume of cassava stored in Ghana was about 8% in farmer households and 21% in concentrated warehouses after 8 months of storage (Stumpf, 1998) [21].

Statistics from the Food and Agriculture Organization of the United Nations (FAO) in 1973 indicated that soon, the world's food supply would not be enough to fight famine caused by crop damage. membrane. In particular, specific figures indicate that at least 10% of postharvest food is lost due to warehouse pests, and losses can be as much as 30% common in many areas of the world (Hall, 1970). (cited from Snelson et al., 1987) [3].

In the United States, according to Pawgley (1963), the annual loss of preserved seeds is reported to be about 15–23 million tons, of which, from 9–16 million tons by insects, and nearly 7 million tons by mice. In Latin America countries, harvested grains and beans lose 25–50% according to the assessment; In some African countries, about 30% of total agricultural output is lost annually (cited by Vu Quoc Trung et al., 1991) [22].

For paddy and rice, post-harvest losses in some Asian countries such as Malaysia are 17%, Japan is 5% and India is 11 million tons / year (cited by Vu Quoc China et al., 1991) [22].

2.2. Research on corn weevil Sitophilus zeamais Motschulsky in the world

Taxonomic location, distribution of the corn weevil Sitophilus zeamais

According to CABI (2010) [29], the corn beetle Sitophilus zeamais Motschulsky is ranked in the following order: Gender (King dom): Animalia

Branch (Phylum): Arthropoda

Subphylum: Uniramia Class (Class): Insecta

Set (Order): Coleoptera

Family: Curculionidae Breed (Genus): Sitophilus

Species: Sitophilus zeamais

Corn beetle Sitophilus zeamais Motschulsky, widely distributed in most countries around the world, causes considerable harm in warm regions, especially in Asia, the Mediterranean (Europe) and North America [7].

Sitophilus zeamais is a common pest and is a primary species. The beetle damages corn and corn kernels at the time when the maize is ripe in the field, they follow the corn into the warehouse and cause continuous damage during storage. The weevil's feeding is complicated because the corn beetle is a polypropylene, it can eat most raw or processed grains such as wheat, oats, barley, sorghum, rye, etc. beans, oilseeds, cottonseed and many other food products. But the most suitable food for it is corn. In the fast-paced, flying, crawling, and faux-dead barn they like to crawl to high positions in the grain. When facing high temperature conditions, weevils often gather in the warehouse, the edge of the bag ... to hide [30].

Harm of the beetle Sitophilus zeamais

Maize (Zea mays L.) is an important food crop, raw material for the animal feed processing industry, pharmaceuticals, industry ... [48]. Tongjura et al., (2010) suggested that maize provides families with many essential nutrients such as carbohydrates, proteins, fats, B vitamins and minerals [49]. Although maize acreage is lower than that of rice and wheat, maize produces a higher average yield (5.5 tons / ha), making it an important role in global food security [47].

Sitophilus zeamais is a major pest of maize in storage and in the field. Sitophilus zeamais penetrates into the corn kernels and attacks the embryo first then to other parts, the corn then becomes hollow and the nutritional value decreases, the germination rate is low or the ability to germinate and the effect is great. to the cost of products in the market [50].

In Africa, a measure to ensure food security is to reduce the damage of grains caused by insects, it is estimated that the loss of 4 billion USD per year in Africa (FAO, 2010) [48]. The harm of Sitophilus zeamais Motsch is a serious damage problem to maize and grain in Africa [51]. Maize production is severely reduced by Sitophilus zeamais in storage to varying degrees, causing food shocks [52]. Worldwide damage caused by the corn weevil Sitophilus zeamais ranges from 20–90%, depending on varieties, regions, and different preservation practices [50].

Bergvinson (2004) found a 20% loss of maize in storage, where corn weevil damages up to 15% of a harvest over several months and reduces the quality of maize kernels [39]. Several authors who have studied the rate of damage caused by corn weevils also report that weevils reduce the volume of hybrid maize stored in well-preserved warehouses by 20%, by 40% in conventional stocks and by 80% in damage on farms in the tropics [35], [42], [53].

The losses caused by the corn beetle include weight loss, nutrient loss and economic losses due to low prices… [54]. The damage caused by the pest is closely related to the length of time corn is stored in stock and the density of the weevil. Tadele et al., (2011) [55] conducted a clean screen, dried (12% moisture) and sprayed with phostoxin for 7 days to destroy all eggs and larvae of pests in corn. These maize samples were then used to study the effect of weevil density and storage time on the weight reduction of corn kernels caused by weevils. The weight loss caused by weevils was determined by Tadele et al., (2011) according to the method of Gwinner et al., (1996) [56].

Analyzing experimental results, Tadele et al., (2011) confirmed that the reduction in corn mass was strongly influenced by the storage time and density of the pest weevil. With the density of 50 heads / 200g of maize grain after 30, 60 and 90 days of storage, the weight of corn kernels decreased by 1.4%, 1.5% and 6.9%, respectively. Insect density tended to increase after days of storage and there was a significant difference in insect population when the first density was 5 / 200g maize seed and 45–50 / 200g maize seed after. 90 days of storage [55].

Surveys in Togo (West Africa) showed an increase in the rate of pest loss in maize stored in storage by 7 to more than 30% during 6–9 months of storage [57] . According to Keil's study (1988), maize damage due to corn weevil increased from 17.9% after 6 months of storage and up to 41.2% after 8 months of storage [58]. Results of the study of losses in stock after 3 months of storage of Boxall (2002), postharvest losses of maize due to insects during storage time ranged from 20 to 30%, mass losses up to 34–40. % and 10–20% are due to Sitophilus zeamais [59].

For research purposes, to assess the resistance to Sitophilus zeamais and to improve the resistance of 22 hybrid maize varieties, Tadele et al., (2013) determined the damage potential of the beetle in these 22 hybrid maize varieties. The results showed that the different maize varieties had different levels of damage. After 56 days of experiment, the level of damage ranged from 3.2 to 22.3% [60].

Natural enemy of the corn beetle Sitophilus zeamais

Visarathanonth et al., (2010) discovered the parasitic bee Anisopteromalus calandrae in Thailand from corn weevil. The authors provided some additional biological characteristics of the parasitic wasps A. calandrae and determined the parasite's ability to control the parasitic weevil that damage its stock. The experiment was conducted to monitor between parasitic bees and the maize beetle host on the feed of milled rice at 32.5 oC, 70% humidity. Results showed that the hatching period was 1 day; larvae 4.1 ± 0.7 days; pupae 6.3 ± 0.9 days and adult life expectancy of 9.6 ± 1.0 days. The time from egg to maturity is 11.4 days. A female wasp produced offspring averaging 37 ± 14 females and 42 ± 14 males for a total of 79 ± 13 individuals. Spawning time was 11 days with a peak of 12 ± 5 eggs on day 5. Sex ratio of parasitic bees (female: male) was 0.88: 1. Corn beetle larvae reared on brown rice at 21 The highest yield of bee eggs at day age (65 ± 17 eggs). At the larvae ages of 19, 23, and 25 days of age, the egg laying power of female bees decreased to 57 ± 17, 56 ± 21 and 40 ± 22 eggs, respectively [61].

2.3. Research on pests and diseases of agricultural products stored in warehouses in Vietnam

Research on the insect pests composition of agricultural products in the warehouse

Researches and survey results on the composition of harmful insects in stock in Vietnam are not much and are less updated. Among them are the results of the investigation of pest insects in the North of Vietnam by Dinh Ngoc Ngoan (1965) [74]; Results of investigating insects in food warehouses in the northern and southern provinces after 1975 liberation by Bui Cong Hien et al. (1975) [75], the insect that damages the loose paddy of Duong Minh Tu (2005) [76]; the results of insect investigation are subject to plant quarantine by Duong Quang Dieu and Nguyen Thi Giang Van (1976) [77]; the composition of harmful insects in the food warehouse of Vu Quoc Trung (1978) [78]; The composition of insect repositories in Vietnam by Nguyen Thi Giang Van et al. (1996) [79].

Le Trong Trai (1980) [80] investigated the spillage reserve paddy warehouse in Hoai Duc, Ha Tay, identified 12 species of harmful insects in the warehouse belonging to 7 families and 2 different insect sets; of which 3 species belong to the primary harm group, 9 species belong to the secondary harmful group.

Nguyen Thi Bich Yen (1998) [81] investigating the insect pests composition of paddy in Hanoi recorded 9 harmful insect species belonging to 8 families and 3 different insect sets; of which 3 species belong to the primary pest group and 6 species of the secondary harmful group.

Vu Quoc Trung et al. (1999) [82] recorded 7 species of harmful insects in bagged grain stockpiles in the Mekong Delta, namely rice weevil, small grain borer, red powder beetle, Thai rice weevil, and the long beard beetle. , the serrated and flat rice weevil.

Nguyen Thi Giang Van et al. (1996) [79] recorded 23 species of pest pests in fallow stockpiles belonging to 14 families and 3 orders. In which, there are 4 species of primary pest group and 19 species of secondary pest group.

The composition of insect pests in stock in Vietnam in 1996-2000 was synthesized by the Plant Quarantine Department, Plant Protection Department (2003). The survey results on insect pests species composition of the Plant Quarantine industry from 1996 to 2000 showed that the total number of insects in the warehouse was 115 species of 44 families, belonging to 8 orders and 1 spider class. Similar study was also evaluated by Nguyen Quang Hieu et al. (2000), results of investigation of insect pests in the stockpile stockpile in Hanoi and Hai Phong, 10 species of weevil belonging to 3 orders [83].

According to Nguyen Kim Vu (2003), when investigating the composition and prevalence of the insect pests in maize storage in the suburbs of Hanoi, there were 18 common species, including species such as maize beetles (Sitophilus zeamais).), rice weevil (Sitophilus oryzae), grain borer (Rhyzopertha dominica), coffee weevil (A.fasciculatus), and serrated beetle (Oryzaephilus surinamensis), appear with high frequency [84].

Bui Minh Hong and Ha Quang Hung (2004) investigated the composition of weevil species and their natural enemies on spilled rice preserved in the book storehouse of the National Reserve Department of Hanoi and surrounding areas. The results obtained 15 species of weevil species of 11 families, belonging to 2 orders and 4 species of natural enemies of 3 families, belonging to 3 orders [85].

The composition of insects and spiders in the warehouse and the prevalence of the Tribolium castaneum red flour beetle (Herbst) populations in some northern provinces of Vietnam were also investigated by Ha Thanh

Huong (2004) [86]. This study has collected 57 species of 26 families, belonging to 4 orders and 2 classes (insect layer and spider layer). In the study results, the authors noted that the insects appeared with the frequency of over 50% such as: R. dominica, Cryptolestes pusillus, S. oryzae, T. castaneum, Lophocateres pusillus. In which, the encountering rate of T. castaneum accounted for 55.64% of the 57 species of insects and spiders collected.

Tran Real Khuat and Nguyen Quy Duong (2004) investigated the composition of the peanut worm in the preservation warehouse in some areas and found that there are 20 species, of 13 families, belonging to 3 orders [87]. Also during this time period, Duong Minh Tu (2005) studied the insect species composition in the fallow stockpile in the North of Vietnam and identified 32 species belonging to 20 families of 5 orders, of which 25 insect pests and 7 beneficial species [76].

Tran Van Hai et al. (2008), a pest survey was conducted in rice, maize and fodder storage warehouses in Can Tho and An Giang for two years, from 2002 to 2003. Research shows that 23 species have been were identified in the storage warehouse in Can Tho, of which 7 species appeared with high densities such as Tribolium castaneum Herbst, Sitophilus oryzae L., Ahasverus advena Waltl., etc. In An Giang, the authors have identified 27 species, of which 6 species appear with high densities such as Tribolium castaneum Herbst, Latheticus oryzae Waterhouse, Cryptolestes minutus Oliv., Etc. Most of the pests of the warehouse are in the set of the Coleoptera [88].

Nguyen Kim Hoa et al., (2008), the composition of the maize pest preserved at home in Bac Ha, Lao Cai includes 10 species belonging to 9 families of 2 sets of insects (Coleoptera and Lepidoptera) and 1 family of the order. Acarina spider. The corn weevil S. zeamais is the most dangerous pest, followed by the hornbill beetle G. cornutus [89]. The Center for Plant Quarantine after Importing I, Department of Plant Protection (2006–2010) conducted a survey of pests on maize in the whole country. Results obtained have detected 57 pests on maize after harvest, including 49 species of harmful insects, 1 species of aphids, 7 species of fungi. The insect species have been found to belong to 18 families in 2 orders of Coleoptera, Lepidoptera, of which mainly belongs to the order Coleoptera [90].

When studying the composition of the preserved bean weevil in Vietnam, Nguyen Quy Duong (2010) identified 28 species of harmful insects and their 7 natural enemies on the preserved pea, of which 19 additional Species list of pea pests. It was discovered for the first time that the Beans beetle Callosobruchus analis is present in Vietnam [91].

According to research by Tran Dang Hoa et al. (2015) [92], the survey results of harmful insect ingredients for imported feed ingredients at Quy Nhon port recorded 35 species of pests. In which, there are 30 species of pests on soybean meal from the US, 29 species of pests on rice bran from India, 13 species of pests on soybean meal from China. The study has also recorded 33 species of pests imported for feed materials in storage. The most common pests identified in this study were: Lasioderma serricorne, Cryptolestes minutus, Sitophilus oryzae, Sitophilus zeamais, Cryptophilus integer, Ahasverus advena, Tribolium castaneum, Plodia interpunctella and Liposcelis bostrychophila.

The most recent results (Nguyen Thi Oanh et al., 2016) with preliminary data on the composition of the beetles and their natural enemies in the warehouse in Dong Thap province. Research data shows that there are 24 species of weevil belonging to 15 families in 6 sets of harmful agricultural products in the warehouse in Dong Thap province. Among them, there are 11 commonly encountered species such as Acarus syrup, Lasioderma serricorne, Callosobruchus maculatus, Sitophilus oryzae, Thorictodes heydeni, Ahasverus advena, Oryzaephilus surinamensis, Alphitobius diaperinus, Tribolium castaneum, Liposcelis sp. and Acrotelsa collaris [93].

Research on insect damage caused by agricultural products in storage

Unlike pests on field cultivars it is possible to assess damages directly. The losses of agricultural products in preservation are often not immediately apparent and are often uncommon, to assess the extent of damage caused by warehouse pests to stored agricultural products is very complicated. The highly adaptable warehouse pest group often causes "underground fires" in the warehouse, causing huge losses [7].

The research on damage caused by insects to the reserved grain in our country is still very limited. Results obtained reflect a loss in volume and cannot reflect a loss in quality of stock.

According to Vu Quoc Trung (1978) [78], the significant damage caused by the warehouse beetle is very noticeable as in ordinary rice after 3 months of storage with a pest density of 100 animals / kg and water content of 13.5. %, the beetle lost 3.5% of its weight and grew 106% more. Wheat flour has 12% water content, pest density is 10 animals / kg, after 3 months of storage they consume 8% of weight and grow 190% more. A barn after 8 months has not been implemented with pest prevention measures, the density of living pests is up to 32 animals / kg. When the paddy surface was examined to a depth of 0.5 m, the average rate of harmful seeds was 13.7%. Weigh 1000 pests-free rice seeds weighing 23.2 g, while 1000 pests-affected seeds weighed only 16.9 g. After milling, from 100 kg of pests-free paddy, 70–73 kg of white rice can be recovered, while with a pest density of 100 heads / kg, only 66 kg of rice can be recovered. That is not to mention the very poor quality of the rice, the low commercial value and the lack of hygiene.

According to Le Doan Dien (1990) [98], the post-harvest loss for grain stored in stock in Vietnam is 10%. Survey data in some suburban districts of Hanoi by Nguyen Kim Vu (2003) [84] show that, postharvest losses caused by insects to rice an average of 6.4%, the degree of damage. the highest can be up to 11.8% / year; for paddy preserved for 6 months is 2.8% in volume and up to 20% in selling price. Research results on post-harvest losses of maize by Tran Van Chuong et al. (2003) showed that at the farm household size, maize reserves suffered an average loss of 15%, particularly in some places up to 20%.

Vietnam is a country with a humid tropical climate, which is a suitable condition for the development of pests, so the damage caused by them is not small. Therefore, prevention of pests and pests has a special importance and significance, if done well, it will bring great economic benefits.

2.4. Research on the maize beetle Sitophilus zeamais Motschulsky in Vietnam.

Taxonomic location, distribution of the corn weevil Sitophilus zeamais

Bui Cong Hien (1995) [7] also ranked the taxonomic position of S. zeamais Motschulsky, no different from CABI (2010) [29]: Gender: Animalia (Animal); Branch: Arthropoda (Arthropod); Class: Insecta; Set: Coleoptera (Hard Wings); Family: Curculionidae (Elephant cock); Variety: Sitophilus.

In Vietnam, maize weevil can be found in all localities [91].

Harm of the beetle Sitophilus zeamais

Vietnam is located in Southeast Asia with a hot and humid tropical climate, so the composition of pests is plentiful. From very early on, many authors have investigated the composition of insects and spiders in the storage of agricultural products in Vietnam such as Dinh Ngoc Ngoan (1964), Vu Quoc Trung (1978), Nguyen Thi Giang Van (1992), Pham Thi. Van (1995) ... collected 144 species of 43 families, 8 orders belonging to two classes of insect and spider harmful to agricultural products in storage in Vietnam [74], [78], [103], [104]. Insect-stored postharvest losses including the corn weevil Sitophilus zeamais are an increasingly serious problem, especially in the tropics and of great interest to many domestic scientists.

In Vietnam, the maize beetle Sitophilus zeamais is a dangerous subject with strong reproductive capacity, with 1 female beetle laying an average of 376.82 eggs [7]. With high prevalence, 100% in maize warehouses and 26.67% in bean storage [91]. According to Le Doan Dien (1990) [98] the damage caused by insects to grain is up to 10%. According to a survey by the Institute of Post-Harvest Technology (1994–1998), storage losses in farmers range from 3.6–6% (in some places up to 15–27%) due to pests. The post-harvest losses of farmer households in the suburban districts of Hanoi are about 5.7–6.5% and the selling price is reduced by 20% [98]. The results of the study on postharvest maize losses by Chuong Tran Van et al., (2003) [105] show that in the farmer household size, maize stockpiling losses are on average 15%, in some regions. up to 20%.

Natural enemy of the corn beetle Sitophilus zeamais

Agricultural warehouses are considered to be special ecosystems, with clear correlations between organisms. Like in the wild, natural enemies play a role in regulating the number of pests. Therefore, many authors have been interested in investigating the composition of the natural enemies of pests in preserved warehouses around the world and in Vietnam. Investigation of Vu Quoc Trung (1978) has discovered 5 species of beneficial insects in 3 orders and a species of spider to catch prey (Miratenus sp.) In the repository [78]. According to Ha Thanh Huong (2007) announced 5 species of bees belonging to 2 families Encyrtidae and Pteromalidae in the granary in Hanoi [10]. Nguyen Quy Duong (2009) discovered 7 species of natural enemies on pea pests preserved after harvest, of which 3 species of parasitic bees and 4 species of prey species belonging to 2 classes of insects and arachnids [91] .

Most recently, there are Nguyen Thi Oanh et al. (2016) [93] discovered 5 species of parasitic bees on maize including: Holepyris sylvanidis Bréthes, Cephalonomia tarsalis Ashmead, Proconura caryobori Hanan, Anisopteromalus calandrae Hovard, Theocolax elegans Westwood, Evania sp, in Dong Thap province, 2015–2016 .

Most of the natural enemies of pests in the preservation of agricultural products are polymorphic species, with small numbers, so it is difficult to use them as a pest prevention agent by biological methods. learn. Currently, very few researches on breeding and using natural enemies in the prevention of harmful insects in the warehouse. In fact, there is little promise in the breeding and use of these natural enemies, but only trying to maintain and encourage their beneficial role as a natural agent in agricultural storage [91] .

3. Conclusion

Measures to prevent insects harmful to agricultural products in storage

There are many measures in the world to prevent pests that cause harm to agricultural products in storage, including adjusting climatic factors (temperature, humidity, ventilation, drying conditions. , ...), from there, select the area to build the warehouse, the type of warehouse, the direction of the warehouse, the type of preservation, preventive measures, and appropriate prevention time will help prevent insect pests.

Some of the measures are related to phytosanitary, biological measures, physical mechanics and chemistry.

Plant quarantine measures are compulsory and have scientific agreement. It is the enactment and implementation of legal regulations on import conditions of agricultural products, plant varieties and other phytosanitary objects in order to limit the introduction and spread of species. insects harmful to the grain in particular and agricultural production in general. The enactment of a phytosanitary list to prevent the introduction and spread of dangerous pests is essential for each country to conduct international or domestic trade.

Biological measure is a research direction that is being prioritized and encouraged thanks to its advantages. As defined by the International Biological Struggle Organization (IOBC, 1971), a biological measure is the use of living organisms or their active products to prevent or reduce harm caused by organisms. damage caused ”(cited from Pham Van Lam, 1995) [23].

To the broader extent, biological prevention also includes the use of bioactive activities of natural origin, repellants or attractants, which can be used in integrated prevention management. larvae in the warehouse, in some cases, these techniques are also known as biotechnology techniques (Reichmuth, 2000). Also according to Reichmuth (2000) [11], the biological method is highly selective and has the advantage of effectively preventing a pest without affecting other beneficial insects.

Some research results on biological methods to prevent pests in stock can be found in the works of some authors such as Nakakita et al., (1991) [5] have recorded three A species of bees that parasitize insects in food warehouses in Thailand, such as Theocolax elegans (Westwood), Proconus sp. and Bracon hebetor (Say); some prey species such as ants (4–5 species), the stink bug Xylocoris flavipes Reuter, Scenopinus fenestralis (Linnaeus) and fake scorpion Chelifer sp.

Reichmuth (2000) [11] reported that the Xylocoris flavipes stink beetle eats eggs, larvae and pupae of many harmful insects in the warehouse such as: Plodia interpunctella, Corcyra cephalonica, Ephestia cautella, Acanthoscelides obtectus, Dermestes maculatus, Sitophilus zeamais, Cryptolestes ferrugine , Sitophilus granarius, Tribolium confusum, Tribolium castaneum, Lasioderma serricorne and Sitotroga cerealella. Also according to Reichmuth (2000) [11], Trichogramma evanescens parasitizes many harmful insects in the warehouse such as Plodia interpunctella, Ephestia kuehniella, Corcyra cephalonica, Ephestia cautella, Acanthoscelides obtectus, Dermestes maculatus.

Researches on parasitic bees in harmful insects in warehouses around the world are still limited because they often focus on investigating and recording species composition or breeding in the laboratory.

Research results at Frankfort (USA), Sedlacek et al., (1998) [24] recorded 7 species of parasitic bees of pests, including 3 species of family Pteromalidae, 3 species of family Bethylidae and 1 species in the family Braconidae.

As well as studies on parasitic bees in harmful insects in the warehouse. Research on the pest disease organisms also has many limitations. Most of the harmful insects in the warehouse belong to Coleoptera, they are often caused by disease-causing organisms such as fungi, nematodes, bacteria, viruses .... However, studies are mainly focused on bacteria that cause disease.

Research on the use of Bacillus thuringensis bacteria to prevent pests was mentioned early (Berliner, 1911; McGaughey, 1980; Subramanyan & Culkomp, 1985; Sukprakarn, 1990) (cited by Bui Cong Hien, 1995 and Pham. Van Lam, 1995) [7], [23].

Berliner (1911) isolated Bacillus thuringiensis from Ephestia kuehniella Zeller larvae in Thuringia. It has been discovered that 525 species of 13 insects are infected with Bacillus thuringiensis, of which the most are scales (318 species), followed by biplane (59 species), beetles (34 species).) and the rest are other orders (about 1–12 species), (cited by Pham Van Lam, 1995) [23].

McGaughey (1980) reported that treatment on the surface seed layer (about 10cm) with a small amount of Bacillus thuringiensis inoculant was limited to about 81% of the Plodia interpunctella and Ephestia cautella populations and fruit has limited their nut intake by more than 92% (cited by Bui Cong Hien, 1995) [7].

Subramanyan & Cutkomp (1985) reported on the role of Bacillus thuringiensis in the prevention of the lepidopteran species (Lepidoptera) in stock. Most studies were conducted in the United States with species such as Plodia interpunctella, Ephestia cautella, E. kuehniella and Sitotroga cerealella. Results showed that only using this product with doses below 10mg / kg limited their damage in grain depots (cited by Bui Cong Hien, 1995) [7].

Sukprakarn (1990) reported on the use of Bacillus thuringiensis for the prevention of rice moth (Corcyra cephalonica) in rice storage warehouses in Thailand (cited by Bui Cong Hien, 1995) [7].

There are different views on mechanical and physical measures. According to Banks (1981), the use of physical factors altering the environment in the warehouse is detrimental to the growth of harmful insects or does not give them access to the stored goods (hence Bui Cong Hien, 1995) [7].

Golob & Webley (1980) summarized the results of experimental research and application of herbal medicine in many parts of the world with different plant species, most notably the creation of herbal medicinal products. carpentry from Indian oval (Azadirachta india), Acorus calamus, Derris spp., tobacco, waterpipe ... The authors have mentioned specific products used for prevention. insect pests from 47 different plant species, of which 40 have been used as extracts (cited by Bui Cong Hien, 1995) [7].

In the Philippines, Indian oval products also used in grain storage in stockpiles obtained satisfactory results at a concentration of 1–2%, mixed Indian oval leaves with paddy, treated 20. Similar results were found in the% extract in storage bags or using dry Indian oval leaves placed between the stockpiles and in the storage bags. Treatment of the seed mass with 5% Indian oval seed extract or 20% of the oval leaf extract was effective against insect infestation for 6 months [25].

There has been a lot of literature documenting the effects of the Indian oval derivatives on different insect species. The first experiments were conducted in India with Schistocera gregaria and the results were very satisfactory at concentrations 10–40µg / l. In India and Pakistan used Indian oval to control pests, more than 60% of farmers in these countries have mixed Indian oval leaves with grain for preservation and more than 80% of cardamom growers use Indian oval seeds applied to the soil except nematodes [25].

Substances present in some plants have the ability to change the behavior of insects. There may be an insect repellant taste; Tastes attractive to insects (baits) or toxic to insects should be used in general prevention. The studies also concluded that the compounds were just as effective as prevention agents and some could even be used as fumigants. The effect of plant extracts on insect pests is synthetic chemicals. Different pests and different growth phases of the same pest react differently to a given extract. The amount of pure compound in a plant extract can vary depending on climatic, geographic and cultivar conditions.

In China, Gu Chong Jing herbal medicine (GCJ) has been produced and widely used in food storage warehouses in Guangxi, Guangdong and many other provinces with good results (Lin et al., 2003) [26].

The technical measures handled in the storage and storage of agricultural products in the warehouse have a direct impact on their growth and development. Cleaning warehouses clean before loading, arranging and arranging goods stored in a neat and tidy warehouse and keeping the warehouse clean throughout the storage process has the effect of eliminating the source of harmful insect infection. for subsequent storage shipments.

Insects in the warehouse often live in parts of the cargo that are left over from shipment or lurk in cracks in the floor walls of the warehouse, in the processing and transport vehicles. Therefore, keeping treasure is always clean during storage combined with periodic inspection to help early detect the appearance of harmful insects for timely treatment. According to the researches of Evans (1981), the measure of cleaning storage is valuable first when applying measures to prevent harmful insects (biological, chemical and physical) (quoted by Bui Cong Hien. , 1995) [7]

The water content of a commodity in storage is one of the most important requirements. Goods stored must have the necessary dryness, which will limit hot flashes in the cargo as well as limit insect infestation and harm. Pests are often harmful because they have strong jaws, but with agricultural products with a low water content plus proper storage conditions, the damage and growth of insects will be much more difficult. much.

Davey & Elcoata (1996) concluded that the safe hydration for grain is about 12-13%; with peanuts 8%; with palm kernel oil is 6%. Hyde (1969) suggested that mold and insects only develop when the relative humidity of the air in the warehouse is greater than 70–75% (cited by Bui Cong Hien, 1995) [7].

Desmarchelier et al., (1979) noted that the combination of refrigeration or dryness with the proper use of pesticides improves prevention effectiveness and is cheaper than the treatment of individual measures. individual. Quinlan (1980) published the results of using Malathion (smoke) with drying to prevent insects. The treatment of 100 tons of seeds in a reflux dryer with a flow of Malathion gas killed most insects and reduced fertility by up to 99% (cited by Bui Cong Hien, 1995) [7].

Closed storage has been around for a very long time. People already know how to use many means of different materials to pack and store preserved goods such as boxes, wooden crates, jars, ceramic jars ... Currently more modern vehicles are designed copper. sets with different materials such as plastics, metals or cellulosic results much better.

Spart (1979) reported experience in Australia in sealed storage when the oxygen content reached 5%, the small seed borer (Rhizopertha dominica) survived and reproduced. In general, the sealed storage method is only suitable for dry seeds and the oxygen concentration is 5–10% and carbon dioxide accounts for the same percentage (refer to Bui Cong Hien, 1995) [7]. Grain storage in Australia and China today mainly uses silo warehouses with modern ventilation systems with a capacity of 50,000–

70,000 tons. With these types of warehouses, it is very difficult for insects to penetrate from the outside into the warehouse to cause harm (Lin et al., 2003 [26]; Qin et al., 2003 [27]). In Australia, there was a closed-ground method of preservation by digging holes 1–2m deep underground, spreading tarpaulins to insulate moisture and heat, and then dropping the wheat seeds; then beam upwards with another canvas and seal the canvas edges together (no need to house and roof for this kind of warehouse). This method is combined with the use of fumigation Phosphine to eliminate harmful insects on wheat seeds. Stored by this method can last for 6 months. Underground storage is also very popular in today's African countries, where the weather is dry and hot. It is much less costly to store underground than to store in silos. However, preservative grain quality also deteriorates faster, so storage time is usually only 6 months (Collins et al., 2002) [28].

Burrell (1967–1974); Sutherland et al., (1970); Evans (1977–1979), both emphasized using modern technology with air conditioners to cool up to 12 C as temperature limits that could limit the growth of many harmful insects. important. In Australia, about 25% of the 20 million tons of wheat has been preserved by refrigeration equipment, in very hot climates (30–40 ºC) (cited by Bui Cong Hien, 1995) [7].

McFarlane, (1970) The packaging of food to prevent pest attack has a long history. Recent developments are only the widespread use of plastics (Wilkin & Green, 1970; Rao et al., 1972) or coating a thin layer of tin powder for tropical use (cited by Bui Cong Hien, 1995) [7].

Prevention measures against the corn beetle Sitophilus zeamais

Cereal stocks can be disinfected with phosphine to remove existing infection, but these treatments do not resist reinfection of corn weevils.

Guedes & Heyde (1996) [62] estimated the toxicity of deltamethrin against some drug-resistant and susceptible S. zeamais populations in traditional corn shops in Togo. In another study, treatment with pirimiphos-methyl and deltamethrin was most effective in traditional grain warehouses after pirimiphos-methyl, deltamethrin and permethrin were applied in a variety of combinations (Richter et al. , 1997) [63]. Srinivasacharayulu & Yadav (1997) [64] evaluated the toxicity of deltamethrin, fluvalinate, chlorpyrifos-methyl, etrimfos and malathion against

S. zeamais, and applied topical biological assays of malathion, pirimiphos- methyl, deltamethrin and permethrin were performed S. zeamais, collected from nine states in Mexico (Perez-Mendoza, 1999) [65].

Guedes et al., (1996) [62] reported 20% carbon dioxide controlled S. zeamais for 5 days. Treatment with 15% carbon dioxide and 5% oxygen controlled insects for 10 days. Santos et al., (1997) [66] describe the use of air controlled carbon dioxide in Brazil to control S. zeamais in maize and wheat. Carbon dioxide at concentrations of 50% and 60% killed all life stages of weevils after 10 days of exposure. In another study with a period of 15 and 20 days, concentrations of 40%, 50% and 60% eliminated all insect stages (Santos et al., 1998) [67].

Research by Li et al., (1998) [68] using the parasite L. distinguendus for control or by Helbig, (1998) [69] has also been reported that Theocolax elegans attacks S. zeamais.

The toxicity of large numbers of essential oils and plant parts of various spices and herbs has been evaluated against S. zeamais. Some citrus oils are slightly toxic to S. zeamais mature; lime, tangerine and grapefruit peel essential oils reduce the appearance of eggs and larvae (Don-Pedro, 1996) [70]. Garlic oil is toxic to adults (Ho et al., 1997) [71], and coconut, sunflower, sesame and mustard oils in combination with eucalyptol, eugenol or camphor have been found to be toxic to S. zeamais (Obeng-Ofori & Reichmuth, 1999) [72].

Abebe et al., (2009) studied the beetle resistance of 13 different maize cultivars through the ability of the F1 generation of Sitophilus zeamais beetle in maize cultivars. After 60 days of the experiment, he got the results, the corn weight decreased after the experiment of the most resistant variety (BHQP – 542) decreased by 3.2%, the rate of damage 3.3% and the variety capable of the lowest resistance to weevil (Melkasa – III) was reduced by 8.3% and the rate of damage of this breed was 18% [73].

Measures to prevent insects harmful to agricultural products in storage

Currently in the preservation of agricultural products, there are many different measures to prevent insect pests. Commonly applied methods include: Mechanical and physical measures are almost exclusively used for small-scale storage by mechanical methods such as: sieving to remove insects from agricultural products. where they are concentrated in high density; drying kills insects by the effect of high temperature; light traps attract phototropic insects ...

Like other countries in the world, chemical drugs used in storage in Vietnam also include two main types: methyl bromide and phosphine. With the prevention threshold of the main harmful pests (rice weevil, small grain borer, red flour weevil and Thai rice weevil) of 20 animals / kg of agricultural products can be used chemical drugs to eradicate. In addition, there is a group of disinfectants, mainly sumithion 50EC, used to disinfect warehouses and items in the warehouse when the old batches are finished and ready to put the new consignment into storage. Sumithion is also used to repel, prevent the infestation of harmful insects in the warehouse by spraying on the cloth curtains at the warehouse door and around the warehouse [15].

In the preservation of stored agricultural products, biological methods have the advantage of creating safe and sustainable agricultural products, while minimizing harmful effects on the environment and balancing the ecosystem. Bui Cong Hien (1995) mentioned the role of the parasitic group of Trichogramma spp. to Mr. Corcyra cephalonica. According to Bui Cong Hien (1995) [7], parasitic bees in harmful insects in the warehouse often kill hosts, such as parasitic bees (Trichogramma spp.) Parasitic eggs of rice moth (Corcyra cephalonica).

In Vietnam, the Institute of Post-Harvest Technology initially researched and produced a trial production of bioproducts in stock since 1998. Test results of two types of Bt inoculants (insecticides) Beetle beetles and mixed products) with corn weevil (Sitophilus zeamais) are highly effective but do not kill red flour beetle (Tribolium castaneum) and effectively kill up to 100% of rice moth (Corcyra cephalonia) [99].

Herbal medicine BQ-01 produced by the Center of Chemical Technology, Institute of Chemistry, Vietnam Academy of Science and Technology and put it to the test in the grain warehouses in the old Ha Son Binh province in 1991. –1992. Medicine BQ – 01 is produced with the main ingredients of kaolin and oval seed powder. The results of the test showed that the drug was ineffective against insects but was effective in repelling insects (Duong Minh Tu and Dinh Ngoc Ngoan, 1993). The downside of BQ-01 is that it leaves a large amount of impurities, dust and unpleasant odors left in preserved agricultural products.

Chinese-made Gung Chong Jing (GCJ) herbal medicine is a synthetic medicine of a variety of vegetable essential oils, carriers and is fortified with the active ingredient deltamethrin. After testing results in Thai Binh and Ha Bac in 1998 (Duong Minh Tu, Bui Thi Tuyet Nhung, 2000) and extensive testing in loose stockpiles in Thai Binh in 1999–2000, the Department of Reserve The National Reserve has allowed Sub-Departments in the North to put GCJ in use to eliminate harmful insects in the warehouse. The results obtained in 2001–2002 are quite satisfactory. The advantages of the drug are ease of use, long potency and reasonable price. The downside is to leave humus (impurities) in agricultural products. However, according to Duong Minh Tu (2005)

[76] When comparing the trial effectiveness of GCJ drugs at some archives in the North, it is found that Chinese GCJs imported into Vietnam in 2000 and those imported in 1998–1999 are different (possibly the content of deltamethrin in the drug changes).

For a long time, farmers have had experience using a number of plants to control crop pests or to preserve agricultural products after harvest. The most commonly used plants are oval, tobacco, tuber, seed, fish, yellow flower ... Currently, herbal medicine is being encouraged for research and development with outstanding advantages. to be dominant and to be a source of drugs that tends to gradually replace chemical drugs in many fields in general and in storage in particular. The identification, extraction and stabilization of active ingredients capable of destroying, causing anorexia, luring or repelling harmful insects are being researched and tested by many units, with many successes.

Some types of plants and its active ingredients used in preservation can be followed by the tree oval (Melia azedarach), also known as the tree oval, oval house, melancholy, tender ... Xoan ta Sapindales; family Meliaceae; chi Melia. As a popular plant in Vietnam, used mainly for timber and shade in the Northwest provinces (Son La, Lai Chau ...) All parts of the oval tree are toxic to humans if eat right. Some birds can eat the oval, which allows the seeds to be spread far away, but just 15 grams of seed is a lethal dose for a 22kg pig. The first symptoms of poisoning appear only a few hours after ingestion. These symptoms include loss of taste, vomiting, constipation or diarrhea, bloody stools, stomach damage, pulmonary congestion, heart failure etc. Death can occur after about 24 hours.

Azalea is used as a natural insecticide to preserve certain foods that are stored, but not edible because it is very toxic. Water soaked with oval leaves and oval bark has the effect of killing deep in the field or in the warehouse because the active element Azadirachtin (Az) belongs to the tetranortriterpenoid group that can cause anorexia, reducing the ability of insects to reproduce.

Azadirachta indica is a tree of the Sapindales order; family Meliaceae; genus Azadirachta. The origin of this plant is in South and Southeast Asia but today it is present in tropical, subtropical regions of Africa, America, and Oceania. Indian oval tree used to control insect pests. The main active ingredient that affects insects from the Indian oval seeds and leaves is Azadirachtin (Az) of the tetranortriterpenoid group, which is resistant to egg-laying, causes anorexia, interrupts the development process, reduces the reproductive performance of insects [100]. In Binh Thuan, farmers have used leaves and fruits to preserve agricultural products for a number of months, such as using dried leaves mixed with seeds to fight insects, Indian oval has become an herbal medicine in agricultural preservation. at the farm household size.

Pterocarya tonkinensis, which grows naturally in the northern mountainous provinces, is used by farmers to preserve paddy and maize, and can be used to control weevils in the preservation. The tree is a large root tree, belongs to the Juglandaceae family; Juglandales set. They are widely distributed in provinces such as Nghe An, Quang Ninh, Hoa Binh, Vinh Phu, Son La and even in Lam Dong.

Bitter leaves, poisonous, have insecticidal and antiseptic effects (water extracted from fresh leaves is effective against Staphylococcus aureus and Bacillus subtilis). The betel leaves are not completely toxic to fish, but toxic to rats. People often use crushed leaves to fish; Also used to treat scabies by taking leaves to wash or using leaf extract to apply 1-2 times a day on the pimples.

Gu Chong Jing herbal medicine produced by China is a synthetic drug of many types of vegetable essential oils: anise, cinnamon, yellow flower, camphor, carrier and supplemented with the chemical drug Deltamethrin with content 0.024%. GCJ drug used at a dosage of 0.04% to preserve paddy and maize is very effective and is particularly suitable for preserving maize in farmer households in Ha Giang province (Nguyen Thi Kim Oanh, 2003) [101] . In the process of perfecting and applying anti-biotic control technology including 9 closed phases from harvesting to preserving maize, paddy on farm and farm scale in Hanoi, GCJ drug has been used with billions. 0.04% rate gave high results [102].

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