ANALYSIS OF GRAIN STORAGE TECHNOLOGIES

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Abstract

Grain storage in elevators poses challenges due to the spread of grain pests and microscopic fungi that spoil grain during storage. The research was carried out between 2020 and 2022 in three different elevators (X_1, X_2 and X_3) located in three different regions in Lithuania. Samples were taken from Triticum aestivum L. and Vicia faba L., sampled for the presence of the following pests: Sitophilus granarius L., Tribolium confusum Jacquelin, du Val, Acanthoscelides obtectus Say, Acarus siro L. and the presence of the microscopic fungi: Fusarium spp. L., Claviceps purpurea (Fr.) Tul. and Tilletia caries (DC.) Tul. & C. Tul. The most abundant fungi in the samples analysed appeared to be bean weevil and Fusarium spp.L.

Keywords: *Grain hopper, elevator, pests, microscopic fungi*

1. INTRODUCTION

Plants are closely linked to their environment throughout the growing season. As a result, their surfaces and tissues are home to a wealth of micro-organisms which, under favourable conditions, start to multiply and spread. These micro-organisms and pests are carried from the fields to the stores. It is essential that the grain meets the quality requirements in terms of pests and microscopic fungi before it arrives at the elevator for storage (Raila, 2013). Severely damaged grain has a deteriorating nutritional value and the resulting toxins can pose a health risk to humans and livestock (Kumar, Kalita, 2017). The quality of stored grain is compromised by adverse environmental conditions and pathogenic micro-organisms. The most favourable conditions for grain to remain intact are dry and cool, as the growth rate of arable pests is mainly dependent on temperature, and that of microscopic fungi on temperature and moisture content (Ziegler, Paraginski, Ferreira, 2021).

According to Šurkus and Gaurilčikienė (2018), the occurrence of plant diseases is influenced by adverse environmental conditions and pathogenic microorganisms.

Fusarium fungi are found in temperate and humid climates where rainy, wet weather prevails during the growing and maturing stages of crops. The climatic conditions in Lithuania are particularly favourable for the spread of Fusarium fungi (Raila, 2013; Marzec-Schmidt, 2021).

The environment around the grain and the species of microscopic fungi in the warehouse change. Microscopic fungi often occur in stored grain. Temperatures above 0°C are suitable for their development and reproduction. When the microclimate in the grain sample is maintained at a suitable temperature, fungal activity and numbers are reduced. Without optimum storage conditions, fungal infestation on the surface of the grain can increase by a factor of 35 to 40 within 3 to 6 months and by a factor of 3 to 4 inside the grain. Grains lose their germination, their nutritional value and technological properties are reduced, and they become worthless (Raila, Zvicevičius, Čiplienė, 2016).

Studies conducted at the Institute of Agriculture of the Lithuanian Research Centre for Agriculture and Forestry have shown that if a sample contains more than 1 percent of Fusarium head blight (FHB) damaged grain, it is dangerous to store it at lower temperatures if the moisture content is higher than 14 per cent (Mankevičienė, Janavičienė, 2019; Janavičienė et al., 2022).

Microscopic fungi reduce the viability and germination of stored grain, fade the colour of the grain, promote heating, moulding, various biochemical changes, toxin formation and weight loss. Each species of fungi requires a certain level of moisture, starting at around 13.5 %. As the moisture content and temperature rise, the conditions for the development and spread of most fungi improve. High temperatures and high humidity are the most important factors affecting the quality of stored grain:

germination, discolouration, malting quality, baking properties and the chemical composition of the grain are reduced. The increase in moisture content of the grain is accompanied by a decrease in protein content and hardness (Kibar, 2016). This environment creates favourable conditions for mycotoxin contamination. Grains of this quality are unsuitable for baking bread and for animal feed as the nutritional value of such feed is reduced. These factors (moisture, reduction in grain hardness, contamination with microscopic fungi) make it difficult to maintain the quality of the grain for transport to another location, especially over long distances (Kumar, Kalita, 2017).

Insect pests of stored grain can take root in the grain in the field, during harvesting, transport or storage. Arable pests are very sensitive to temperature. They reproduce slowly or stop reproducing at temperatures below 16°C and above 42°C. The greatest risk of insect infestation is in the warm autumn, especially after harvest (Skendži´c et al., 2021).

Ventilation during grain storage is essential. Ventilation silos allow for fully mechanised grain handling, as they do not require the grain to be flattened. The grain is self-cleaning when it is unloaded from the silo and can be diverted to transport vehicles. As the grain is self-discharging from the ventilation silo, it can be easily transferred from one silo to the other during drying by mixing. This greatly improves the drying of grain, especially grain with a moisture content of more than 22 %, because grain that has been dried for a long time becomes compressed and sticky, and is less easily penetrated by the blowing air, forming layers of wet grain that are bypassed by the ventilation air. The grain may start to rot (Raila, 2013).

Grain drying is another very important step in preserving the quality of grain. The two main drying methods are spray drying and hot air treatment. It is very important to dry grain that has just arrived from the fields, especially when the moisture content is above 20 %, because during the first 24 hours micro-organisms are active and can damage the grain very severely. Microscopic fungi, especially of the genera *Aspergillus* and *Penicillium*, develop very intensively in stored grain and start to produce aflatoxins, ochratoxins, citrinins and many other metabolites. If the moisture content of the grain is around 22 %, it is advisable to dry the grain by means of an active ventilation system, and to dry the grain several times if it is higher than this. The slower and longer the drying, the greater the risk of mycotoxin formation (Mankevičienė and Janavičienė, 2019).

Inadequate temperature is one of the most important physical factors that cause the greatest loss of stored grain. The lower the temperature, the better the grain will keep, but some fungi (*Fusarium* spp.) are able to multiply at lower temperatures, producing mycotoxins (Mankevičienė, Janavičienė, 2019).

The research problem is that grain pests can breed throughout the year during storage, damaging the quantity and quality of stored grain. Grain infested with pests is of poor quality, has low nutritional value and can have a negative impact on consumer health. Knowing the characteristics of the pests prevalent in elevators and the factors responsible for their spread allows for the timely identification of pest outbreaks and the adoption of preventive measures to stop their spread.

The subject of the study is grain-damaging pests and microscopic fungi stored in grain elevators

The objective of the study is to identify grain pests and microscopic fungi stored in grain elevators (X1, X2 and X3) in three different locations in Lithuania between 2020 and 2022.

2. MATERIALS AND METHODS

The sampling of the grain from the vehicle must be carried out in accordance with the requirements of LST EN ISO 24333 (2016). For the laboratory examination of the quality of the grain, a sample of at least 2 kg is taken for the identification of microscopic fungi and pests.

According to the standard, samples are taken over the entire height of the grain bundle at several points and at regular intervals in a staggered manner. Vacuum samplers (probes) are used. The sampling method varies according to the size of the vehicles. In the case of a small vehicle, the grain is sampled from 5 points: from all four corners and one in the middle. This sample must be 2 kg.

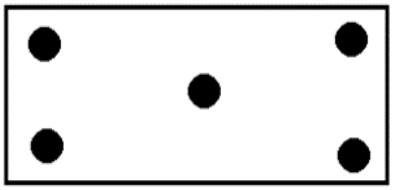

Figure 1. Small vehicle (Plant Production Service, 2016)

The locations and number of individual samples in a one-piece container (e.g. tipper, semi-trailer) with a capacity of more than 10 t, the recommended number of samples is 8 points.

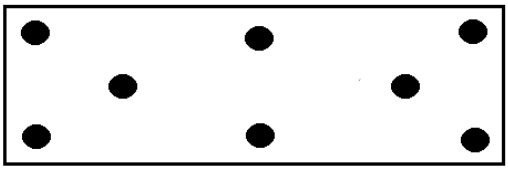

Figure 2. One-part container (Plant Production Service, 2016)

Locations and number of individual samples in a two-part container (chassis with trailer) holding 15 t of cereals. In the example, the chassis has a smaller capacity than the trailer, which results in a difference in the number of sample points - 3 in the chassis and 5 in the trailer.

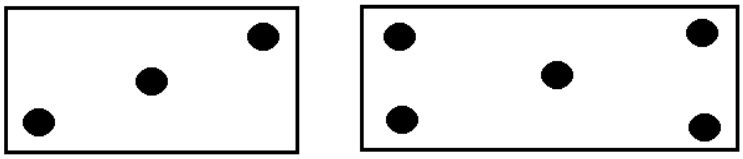

Figure 3. Two-part container (State Plant Production Service, 2016)

Locations and number of individual samples from a larger bin (tractor-trailer, lorry) holding more than 30 t but less than 50 t of cereals. Recommended number of samples is up to 25 points.

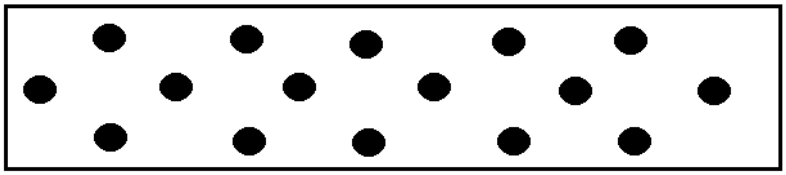

Figure 4. Location of individual sampling sites (State Plant Production Service, 2016)

The individual samples together form a composite sample, which is homogenised (mixed by mechanical or manual means) and divided (by a cone divider) to give the laboratory sample. It is important to ensure that samples are taken both at the surface and throughout the depth of the grain mass. The mass of the

sample for the detection of harmful organisms must be at least 2 kg. The numbers and weights of individual samples are presented in the table.

Table 1. Minimum number of individual samples of grain in containers to obtain the minimum laboratory sample weight (State Office of Plant Production, 2016)

Lot/part of lot size, m	Mass limits for a single sample	Minimum number of individual samples
m ≤ 10 t	400 – 3000 g	3 sampling points
m ≤ 15 t		8 sampling points
15 < m ≤ 30 t		11 sampling points
30 < m ≤ 50 t		15 sampling points
50 < m ≤ 100 t		22 sampling points
100 < m ≤ 200 t		25 sampling points
200 < m ≤ 1000 t		27 sampling points
1000 < m ≤ 1500 t		29 sampling points

After homogenisation and separation of the samples, the resulting laboratory sample is then sent to the laboratory for quality testing.

Each elevator has conditional pest and disease tolerances, which are confirmed by internal documents. In the case of higher levels of microscopic fungi or pests, sedimentation is carried out, the size of which is chosen by each elevator in accordance with its regulations.

Sitophilus granarius L., Tribolium confusum Jacquelin, du Val, Acanthoscelides obtectus Say, Acarus siro L., the authorised rate is 0 units. These insects were identified using Rees (2007) manual.

For *Fusarium* damaged kernels (FDK (mass basis)) (*Fusarium* spp.) 1 %, *Claviceps purpurea* (Fr.) Tul. - 0,05 %, *Tilletia caries* (DC.) Tul. & C. Tul. - 0 %, mould - 1 %.

After determining all the qualitative, infestation and contamination indicators, the grain is assigned a quality class. Wheat is classified into Extra, Class 1, 2, 3 and Forage, oilseed rape into Classes 1, 2, beans into Classes A, B and Forage classes.

3. RESULTS

Between 2020 and 2022, different abundance and intensity of fungal damage were recorded in three Lithuanian grain elevators (X_1, X_2 and X_3).

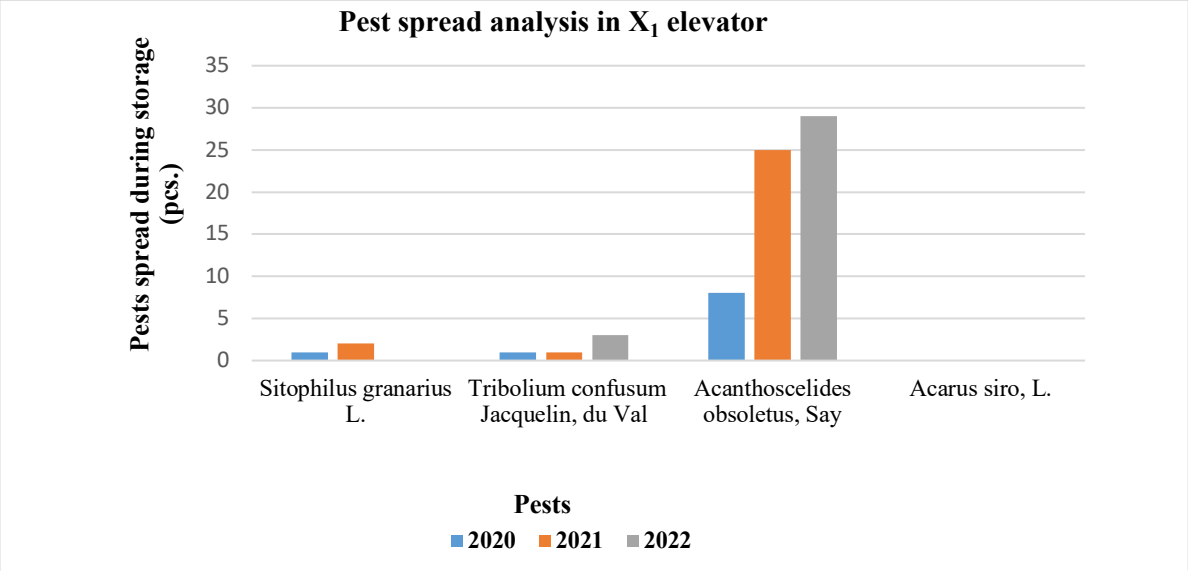

Figure 1: Abundance of insect pests (pcs.) in X_1 elevator

In the samples from Elevator X_1, *Acanthoscelides obtectus*, Say dominated and it was found in all the years of the survey, especially in 2022: 29 units of this pest were found in a 300 g sample. The granary weevil was most abundant in 2021, while the flour mite was not detected in the three years of the survey.

In 2021, *Fusarium* spp. was the main problem in grain storage in elevator X1. The main source of Fusarium head blight (FHB) infection is seeds infected with *Fusarium* microscopic fungi, which are covered with a pinkish mycelium. Most fungi of the genus *Fusarium* can produce toxins that are dangerous to the health of both humans and livestock.

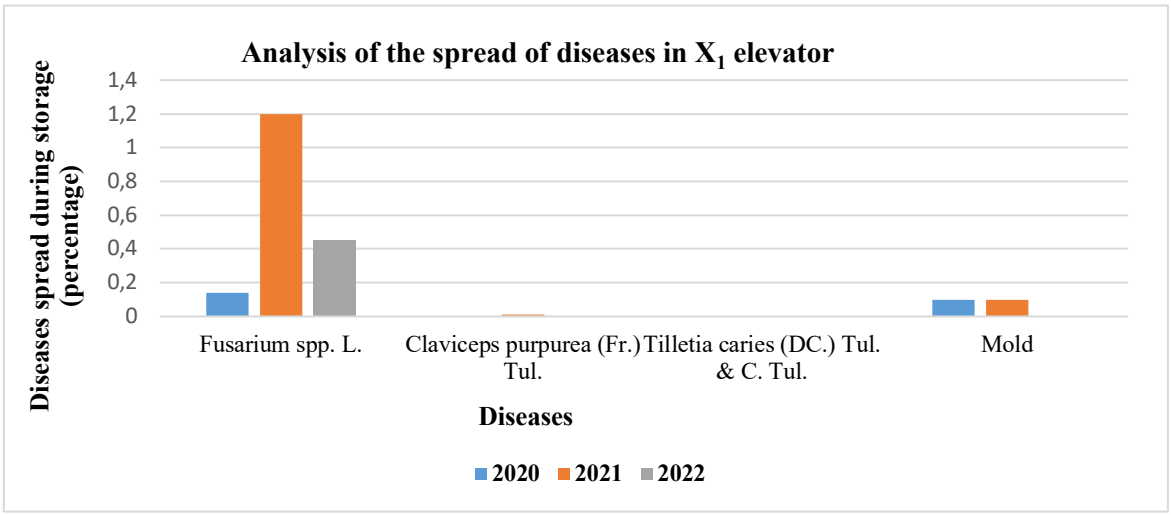

Figure 2: Severity of damaged kernels by fungi in grain samples in X_1 elevator

Microscopic fungi spread more in wetter years. Grain is accepted for storage in the elevator if less than 1 % of fusarium-damaged grain (FDK) is identified in a 50 g sample. The highest incidence of microscopic fungi was in 2021 at 1.2 %.

In the years 2020-2022, Acanthoscelides obtectus, Say was the most prevalent pest in X_2 elevator in 2022, with 21 detections in a 300 g sample. The lowest prevalence of A. obtectus was in 2020, where

only 6 pests were detected in a 50 g sample. Acarus siro was found in 3 units in 2021, with the lowest number of this pest found in 2022, with only 1 pest in a 50 g sample.

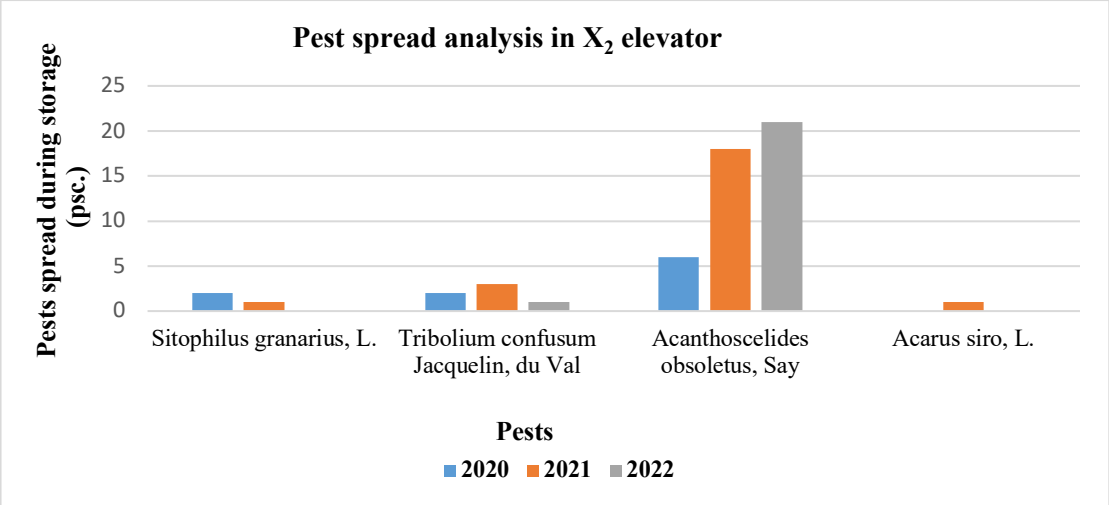

Figure 3: Abundance of insect pests in X_2 elevator

Between 2020 and 2022, the intensity (FDK severity) of microscopic fungi (*Fusarium* sp.) in stored wheat (*Fusarium* sp.) in elevator X_2 was 0.5% in 2020, with the lowest intensity recorded in 2022.

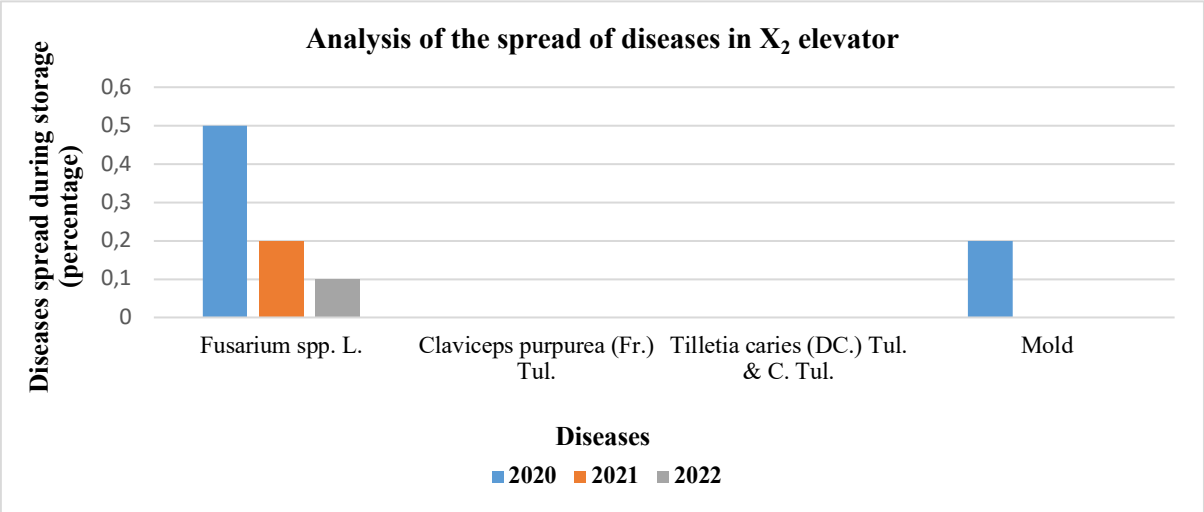

Figure 4: Severity of damaged kernels by fungi in grain samples in X_2 elevator

Claviceps purpurea and *Tilletia tritici* were not been found in grain stored at X_2 elevator between 2020 and 2022.

In X_3 elevator, *Acanthoscelides obtectus* was the most abundant pest in the period of 2020-2022: 22 pests were detected in a 300 g sample. The lowest number of *Acanthoscelides obtectus* was in 2020: 10 pests in a 50 g sample. 4 Acarus siro were found in 2021 and none in 2022.

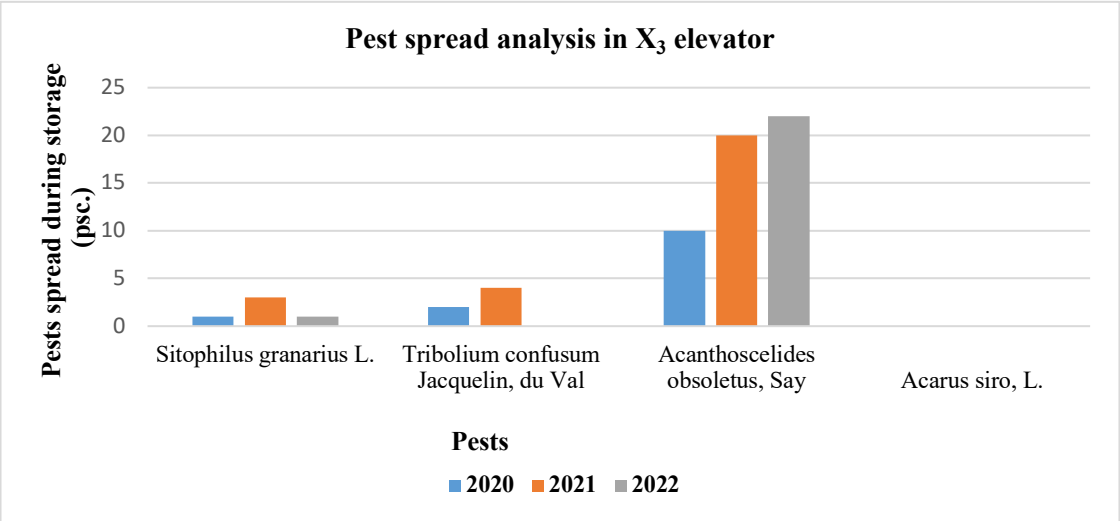

Figure 5: Abundance of insect pests in X_3 elevator

In X_3 elevator, the grain was most affected by *Fusarium* spp. fungi, with an FDK of 1.2%. The damage caused by *Claviceps purpurea* was 0,01 %, compared to the permitted level of 0,05 %. There are no sedimentations.

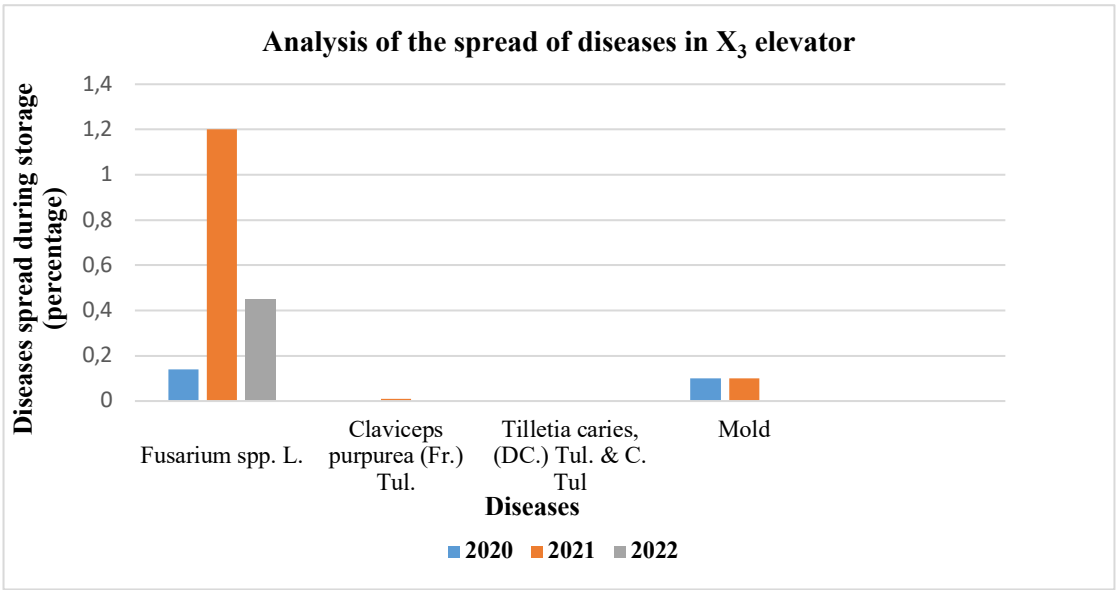

Figure 6: Severity of damaged kernels by fungi in grain samples in X_3 elevator

The intensity of mould damage was 0.1%. The allowable rate is 1%.

4. CONCLUSIONS

Grain sampling and quality determination are carried out in accordance with LST standards. The quality class is assigned on the basis of the quality parameters determined. In the case of the tests above the standard for contamination with pests and microscopic fungi, sedimentations are applied.

The purchased grain is dried to a basic moisture indicator of 14%. During active ventilation, the grain mass is cooled down to 10°C to reduce heating of the grain and the risk of spreading arachnid pests.

The studies carried out show that the most prevalent grain pests in the three Lithuanian elevators in the period 2020-2022 were: *Acanthoscelides obtectus*, Say, *Sitophilus granarius*, L. and *Fusarium* spp. These pests and microscopic fungi damaged winter wheat and beans.

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