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INFLUENCE OF INSECTICIDES FOR STORED GRAIN PROTECTION ON THE TECHNOLOGICAL PROPERTIES OF WINTER WHEAT

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Abstract

During storage, the aim is to keep the quality and quantity of agricultural products at a high level, without the risk of contamination. The most common storage pests are: Sitophilus granarius, Acarus siro, Caulophilus latinasus, Trimbolium consufusum and Trimbolium castaneum. Due to its multiple uses: in human and animal nutrition, winter wheat is one of the most valuable crops in the world. Seed quality can be influenced by the genetic factor also by the phytosanitary aspect during storage. Sitophilus granarius is one of the main storage pests that attacks wheat grains, barley and rye. During storage, the pests can greatly affect the quality of the seeds and also of the food. The flour resulting from the infested grains is unsuitable for consumption, having an unpleasant smell and bitter taste. The paper aimed to present the efficacy of four different concentrations (0.125%, 0.25%, 0.5% and 1%) of a modern liquid pyrethroid formulation against wheat weevil, in a three year experiment conducted in three different sizes grain warehouses. Also, the chemical composition of stored winter wheat seeds was determined using NIR spectroscopy, on unground samples. As expected, the highest percentage of dead insects, in a short period of time, was identified when the product was applied at the recommended dose (1%). Also small differences between studied parameters were revealed, but the quality of the samples was not lowered by the higher concentrations of insecticide.

Key words*: chemical composition, Sitophilus granarius, storage, winter wheat.*

INTRODUCTION

Winter wheat is currently second to rice as the most important crop in the world (Abegunde et al., 2019), bread, the main human food being prepared especially from wheat flour (Pedersen and Eggum, 1983; Shewry, 2009; Keskin and Ozkaya, 2015; Nadarajah and Mahendran, 2015).

In order to appreciate the quality and digestibility specific to each winter wheat geotype (Ceapoiu et al., 1984) the most important parameters, such as: the protein content (%); the wet gluten (GU%); the ash content (%), the relative humidity (RH%); the fat content, the starch content (%); the fibre (%); NCDG (Enzymatic activity of cellulose, %); NDF (Neutral detergent fibre, %) and ADF (acid detergent fibre, %) have to be determined.

Alveograph parameters determination is a way to assess the baking quality of wheat flour. One of the most important parameter, P, is an indicator of dough resistance to deformation being the maximum overpressure needed to inflate the dough bubble measured in mm H_2O (Dubois et al., 2008; Jødal & Larsen, 2021). L is also called the extensibility, as it is a measure of how much the dough can be extended before it breaks and is strong and positive correlated with bread volume (Jødal & Larsen, 2021). The swelling index G is calculated from L and is considered dependent on the product of properties usually described as springiness and shortness (Rasper et al., 1986). Deformation energy, W, represents the energy required to inflate the dough bubble until rupture (Jødal & Larsen, 2021).

Due to the demand for high quality and safe food by the consumers, there is necessary to eliminate the risk of contamination during storage. The wheat weevil (*Sitophilus granarius* L.) is the main pest of stored grain and other stored products in temperate climates (Nawrot et al., 2006; Yildirim et al., 2012). The

insect feeds differently depending on its development stage: grains in the adult stage and endosperm in the larval stage, in this case is more difficult to be detected. In this sense, late detection of the infestation, Strelec et al. (2012) call this "invisible infestation", can cause major issues and losses can reach half of total harvest seeds (Fornal et al., 2007). In unfavourable storage conditions the adults of *S. granarius* can survive for long periods of time (Brader et al., 2002; Strelec et al., 2012). Germinara et al. (2012) point out the important quantitative and qualitative losses produced by the infestation of this insect with repercussions on the nutritional value.

Insecticide residues in cereal products are a real concern for consumers and scientists are interested in reducing chemicals to control stored seeds against pests (Fields, 2006; Nawrot et al., 2006), biological and physical methods being preferred (Warchalewski et al., 2000). Therefore, the present work was undertaken to evaluate the quality of the winter wheat after treatment with different concentration of a commercial pesticide. The aim was to investigate not only the efficacy of these on wheat weevil but also the quality changes on technological properties of winter wheat.

MATERIALS AND METHODS

In order to evaluate the influence of different doses of insecticide on storage pests and also on winter wheat grain quality, a three years experiment, in three different sizes grain warehouses was carried out. As insecticide, a modern liquid pyrethroid formulation containing deltamethrin, synergised with piperonyl butoxide for the control of a wide variety of stored product insects known to infest grain was used (https://www.environmental science.bayer.co.uk).

Four grain samples of 1 kg were taken being identified the presence of one to three specimen of *Sitophilus granarius* in each sample. In each experimental variant, a much larger number of specimens was added to determine the efficacy of the experimental insecticide. All samples were then stored, in the laboratory, individually, in closed plastic bags at a temperature of 24-26°C, at dark for two days. After this period of time it was noticed that the storage pests were on the surface of the product. One l/t insecticide solution with 4 different concentrations: 0.125%, 0.25%, 0.5% and 1% were used. The required dose was calculated for 1 kg of product, requiring 14 jets that were sprayed with a small pump. Each sample was gently mixed during approximately 30 s. Observations were made every 2 hours for 8 hours, counting dead specimens.

Grain unground samples were analysed using NIR spectroscopy for moisture, hectolitre weight (H Weigh), protein on dry matter (protein/DW), ash, gluten, Zeleny sedimentation value and alveograph parameters (deformation energy - W, extensibility - L, dough tenacity - P, P/L, G - swelling index).

RESULTS AND DISCUSSIONS

Europe wants to ensure food safety and security by promoting and using physical, biological or chemical agents environmentally friendly. During the storage, the aim is to keep the quality and quantity of agricultural products at a high level, without the risk of contamination. However, the presence of pests can cause significant crop losses, and the application of insecticides becomes necessary.

The results obtained in this study reveals that in the warehouses from each location studied, an attack of *Sitophilus granaries* (Figure 1), one of the most common storage pests, was found.

Figure 1. *Sitophilus granarius* (Linnaeus, 1758; https://www.biolib.cz/en/image/id370369/)

Regardless of the concentration of insecticides used, all insects were found to have died within 8 hours of application.

As expected, the highest percentage of dead insects, in a short period of time, was identified when the product was applied at the recommended dose (1%).

After two hours, in the sample treated with insecticide of concentration 1%, 27% of the insect were found dead, after 4 hours, 67% of them died, and after 6 hours almost 90% specimens were found dead (Figure 2).

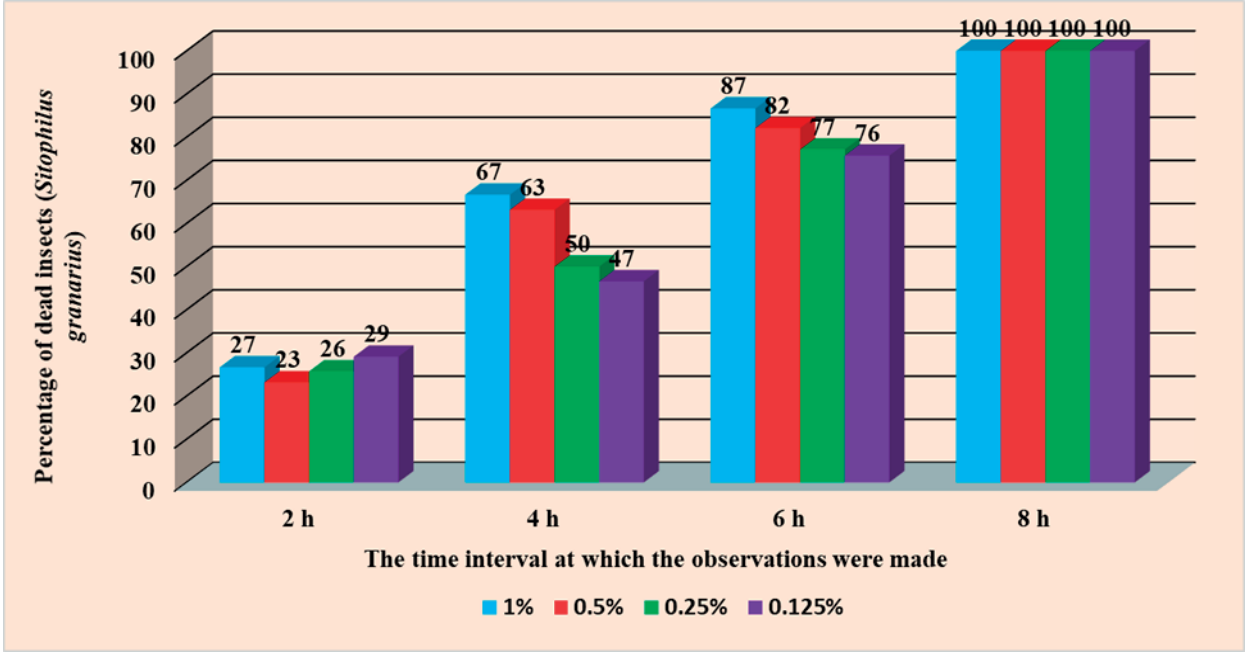

Figure 2. Percentage of dead insects for each time interval and concentration experimented

Statistical analysis of the experimental data indicates a very significant (***) influence of the doses experimented on the studied characters (Table 1). While variation of moisture, H weight was very high influenced by all four studied factors, a statistical distinct significant influence of warehouses (W) on ash content was revealed. If the protein content was very high influenced by the W and D factors, the experimental year (Y) seems to have a small and non significant influence on this quality parameter. In average, similar values for the studied parameters were obtained. Regarding the behaviour at the four doses studied, maximum values for all these features were obtained when insecticide of 1% concentration was applied.

Table 1. ANOVA test for quality of stored winter wheat seed treated with four different doses of insecticide

FACTOR		Moisture [%]	H Weight [kg/hl]	Protein/ DW [%]	Ash [%]	Gluten [%]	Zeleny [ml]
YEAR (Y)	2017	12.8	74.56	13.69	1.42	27.11	45.81
	2018	12.91	74.51	13.72	1.44	27.67	46.94
	2019	12.84	74.05	13.81	1.46	27.26	46.92
	Average	**12.85**	**74.37**	**13.74**	**1.44**	**27.35**	**46.56**
WAREHOUSES (W)	W 1	14.24	72.8	14.11	1.43	29.49	42.44
	W 2	13.57	72.83	14.22	1.43	29.59	43.19
	W 3	10.73	77.48	12.89	1.45	22.96	54.03
	Average	**12.85**	**74.37**	**13.74**	**1.44**	**27.35**	**46.56**
DOSES (D)	0.125 %	12.63	73.83	13.64	1.45	26.49	47.26
	0.25 %	12.71	74.27	13.62	1.41	27.19	46.74
	0.5 %	12.78	74.13	13.61	1.41	27.14	46.07
	1 % (Control)	**13.27**	**75.26**	**14.09**	**1.48**	**28.56**	**46.15**
ANOVA	Y	**	***	ns	***	*	*
	W	***	***	***	**	***	***
	D	***	***	***	***	***	***

Table 2 reveals the influence of experimental year, four insecticide doses applied to seeds and also of the three warehouses on most important alveograph parameters, based on ANOVA Test. Even if these features are controlled especially by the genotype, they can be also influenced by storage condition of seeds. From the analysis of the F test values, while experimental year significantly influenced deformation energy (W) and L parameter, all the analysed quality parameters were distinct significantly or very significantly influenced by the warehouses and by the experimented doses. Generally, higher values were obtained when 1% of liquid pyrethroid formulation was experimented. From the values obtained for alveograph parameters, it could be observed that analysed samples stored did not suffered quality loss when different concentration of chemical product was applied.

Table 2. ANOVA test for alveograph parameters of stored winter wheat seed treated with four different doses of insecticide

FACTOR		P [mm]	L [mm]	G	W [J*10^{-4}]	P/L
YEAR (Y)	2017	62.11	113.44	25.41	252.56	0.66
	2018	65.75	107.47	24.79	244.89	0.76
	2019	61.92	110.75	25.24	252.53	0.69
	Average	**63.26**	**110.56**	**25.15**	**249.99**	**0.70**
WAREHOUSES (W)	W 1	64.44	121.28	24.16	226.75	0.75
	W 2	59.42	118.5	24.91	237.94	0.72
	W 3	65.92	91.89	26.38	285.28	0.64
	Average	**63.26**	**110.56**	**25.15**	**249.99**	**0.70**
DOSES (D)	0.125 %	59.11	111.93	25.67	250.04	0.65
	0.25 %	61.70	112.41	24.87	245.37	0.66
	0.5 %	62.37	107.52	24.43	244.78	0.70
	1 % (Control)	**69.85**	**110.37**	**25.63**	**259.78**	**0.80**
ANOVA	Y	***	***	***	*	*
	W	***	***	***	***	***
	D	***	**	***	***	***

Principal component analysis (PCA) was used for the classification and discrimination of four doses variants. A set of six variables: moisture, hectolitre weight, protein/ DW, ash, gluten and Zeleny sedimentation were analysed with PCA while explaining more than 99 of variance (Figure 3). The model expose a close correlation between the ash and the protein content and higher values for gluten content when insecticide of 1% was experimented.

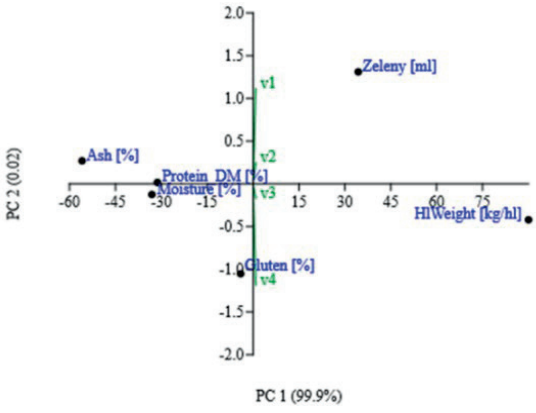

Figure 3. Biplot for the experimental data set

The cluster analysis reveals differences between the extreme concentrations experimented and appropriate values when 0.25% and 0.5% of chemical product was applied (Figure 4).

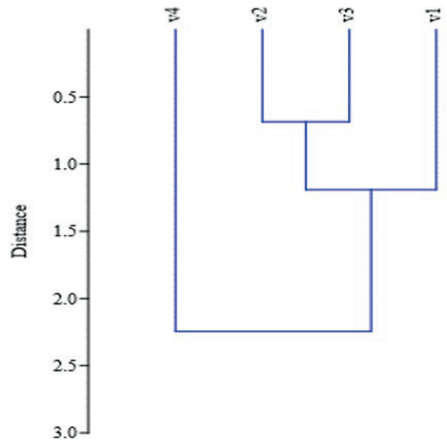

Figure 4. Cluster analyses for all four concentrations of pyrethroid formulation experimented

When as variables for principal component analysis (PCA) were used the alveograph parameters: deformation energy - W, extensibility - L, dough tenacity - P, P/L, G - swelling index, a close correlation between the extensibility and swelling index was revealed (Figure 5).

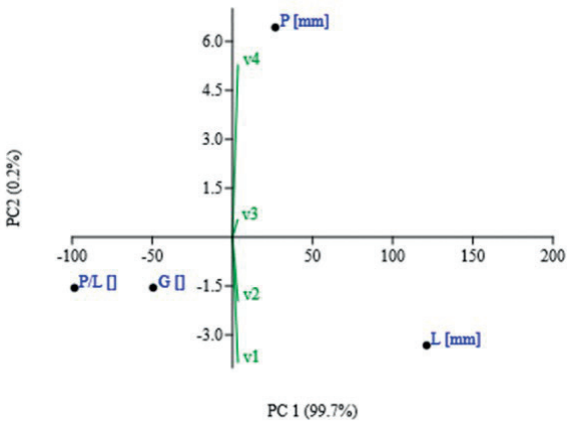

Figure 5. Biplot for the experimental data set

The analysis of clusters in the case of alveographic parameters indicates results similar to those obtained in the previous case for concentrations of 0.125% and 1% respectively (Figure 6).

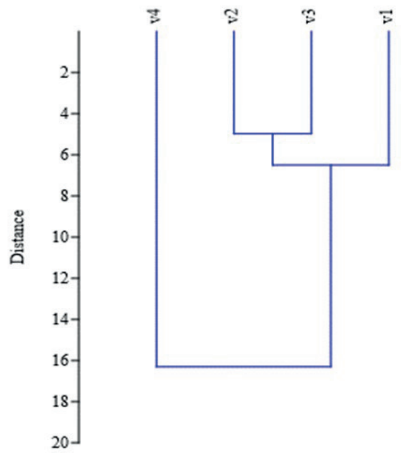

Figure 6. Cluster analyses for all four concentrations of pyrethroid experimented

The calculation of the correlation coefficients is essential to determine the degree of association between the quality parameters of winter wheat. There are significant correlations between the characters studied. The literature of specialty presents positive correlations between the protein content and the wet gluten (Khattak et al., 2005; Hruskova et al., 2000). Similar result was obtained in our experiment and also a strong positive correlation was revealed between Zeleny value and protein content (r=0.7).

In Figure 7, positive correlations were also observed between: protein content and ash (r= 0.95); Zeleny sedimentation value and gluten (r=0.72) and Zeleny sedimentation value and ash (r=0.9).

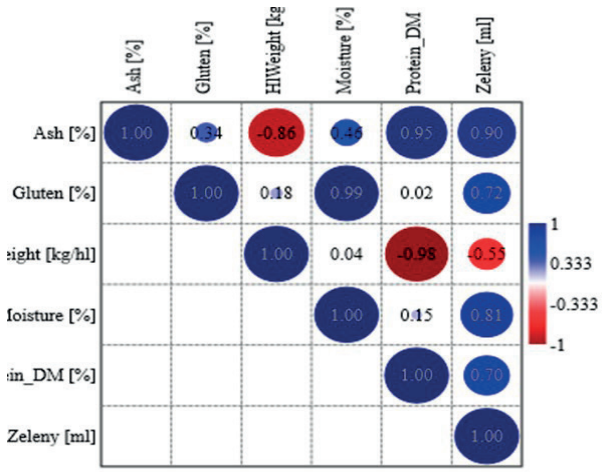

Figure 7. The correlation coefficients (r) between main quality parameters

Regarding the alveographic parameters (Figure 8), as expected, a strong positive correlation was revealed between extensibility and swelling index (r=0.84).

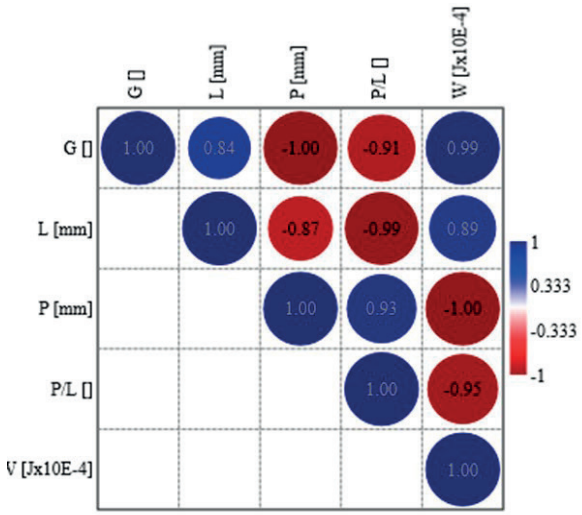

Figure 8. The correlation coefficients (r) between alveograph parameters

CONCLUSIONS

The results clearly showed that liquid pyrethroid formulation had high efficacy at all concentration (0.125%, 0.25%, 0.5% and 1%), all specimens of wheat weevil being found dead after 8 hours.

As expected, the highest percentage of dead insects, in a short period of time, was identified when the product was applied at the recommended dose (1%).

Regarding the quality, good results were obtained for studied parameter in all experimental variants, samples did not suffered

quality loss when different concentration of chemical product was applied.

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