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INFLUENCE OF THE TILLAGE SYSTEM AND FOLIAR FERTILIZATIONS ON YIELD AND *Fusarium* EAR ROT MANIFESTATION IN MAIZE CROP IN THE TRANSILVANIA PLAIN

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Abstract

In the concept of sustainable agriculture, there is no valid universal soil tillage system, and systems are applied in a differentiated way due to the ecological features and the characteristics of the cultivated plants. The purpose of this paper is to study the behavior of a maize hybrid under the influence of tillage systems and foliar fertilizers in terms of tolerance to specific diseases and pests as part of an integrated sustainable agriculture management. The experimental factors studied: soil tillage: a_1- classical system with turning the furrow, a_2- minimum tillage, chisel variant, a_3- minimum tillage, disc harrow variant, a_4- no tillage, sowing directly and foliar fertilizers: b_1- control variant unfertilized; b_2- Haifa 19:19:19 + Mg + ME (5 kg/ha); b_3- Folimax Oleo 12-04-24 + 2.0% MgO + 36.5% SO_3 + ME (1.5 kg/ha), b_4- Folimax Gold 27% N + 1.5% MgO + 0.02% B + 0.2% Cu + 0.02% Fe + 1.0% Mn + 0.02% Mo + 0.02% Zn (3 l/ha). With vegetal remains left at the surface of the soil, conservative soil tillage systems that preserve at least 30% of the vegetal remains of the pre-plant increase the degree of attack of diseases and pests on maize crops having a negative effect on production and quality harvest. The highest maize yield was recorded in the classical tillage system (9566 kg/ha), with a very significant difference of 2192 kg/ha compared to the direct sowing system and 94 kg/ha, respectively 93 kg/ha in minimum tillage systems, and these yield differences are not statistically assured.

Key words*: maize, yield, tillage system, Fusarium ear rot, fertilization.*

INTRODUCTION

Corn, a new plant of culture for the Old World, is native to America, where it is cultivated by natives from ancient times. In Mexico and Peru, traces of old irrigation canals have been discovered, showing the particular attention that native maize culture enjoys (Muntean et al., 2008). Genetic and archaeological evidence suggests that maize domestication began about 9,000 years ago, most studies lead to the idea that the wild ancestor of maize was a herbivorous form of Teosinte (*Zea mays* ssp. *parviglumis*) (Matsuoka et al., 2002; Piperno et al., 2009; Flint-Garcia, 2017).

In the concept of sustainable agriculture development it is widely accepted that there is no valid universal soil tillage system due to local differences, especially climate and soil, but also because of the technical level of endowment. Soil conservation tillage systems in different areas must have certain specific characteristics in relation to ecological features and characteristics of cultivated plants, so they must be applied in a differentiated way (Canarache, 1999; Guş et al., 2004; Moraru & Rusu, 2013; Moraru et al., 2015).

The influence of the soil tillage system on the soil properties is important indicators for soil fertility conservation and the assessment of the sustainability of the agricultural system (Guş, 1997; Rusu, 2001; Rusu et al., 2017).

In the maize crop, by treating the seeds (before sowing) with fungicides, some or almost all of the pathogens present on the maize grain are eliminated, this being an effective measure of protecting plants against pathogens existing in the soil, preventing the transmission of one year to another in cultures (Cheţan, 2017).

Fusarium rot of cobs is one of the most common fungal diseases on corn cobs. It is caused by *Fusarium verticillioides* and by its

symptoms it reduces the quantity and quality of production to 25%. In disease-favorable years, the massive accumulation of *Fusarium* mycelium biomass is recorded on cereals and cobs that lead to mycotoxin contamination, such as deoxynivalenol (DON), zearalenone (ZEA) and fumonisin (FUM) (Horia et al., 2018). Maize is susceptible to a large number of pathogens that invade the ears and seeds causing the rotting of the ear. The disease is prevalent in all regions where maize is grown. Generally, the disease rarely causes severe production losses (Şopterean, 2018).

An important role in *Fusarium* ear rot infections have, together with the genetic factor, the climatic conditions, but also the attack of pests *Ostrinia nubilalis* and *Helicoverpa zeae*, which increase their frequency and intensity (Horia et al., 2018).

The purpose of this paper is to study the behavior of a maize hybrid under the influence of tillage systems and foliar fertilizers in terms of tolerance to specific diseases and pests as part of an integrated sustainable agriculture management.

MATERIALS AND METHODS

The research was carried out in 2018, at Agricultural Research and Development Station Turda (ARDS Turda) located in the Transylvanian Plain, on a faeoziom vertic soil with neutral pH, clay-loam texture, good and very good supply with mobile phosphorus and potassium, soil content in humus medium. The experience is bifactorial, and the area of an experimental parcel is 48 m^2. In the experience, maize sowing was done with the MT 6 - Maschio Gaspardo machine. Sowing density was 65,000 plants/ha and the depth of seed incorporation was 5 cm. The rotation of crops is achieved in a 3 years soybean-wheat-corn system, the previous plant was winter wheat. The biological material was Turda 332 corn hybrid, created at ARDS Turda.

The experimental factors studied: Factor A-soil tillage: a_1- classical system with turning the furrow (CS), a_2- minimum tillage, chisel variant (MTC), a_3- minimum tillage, disk harrow variant (MTD), a_4- no tillage, sowing directly (NT); Factor B - foliar fertilizers: b_1- control variant unfertilized; b_2- Haifa 19:19:19 + Mg + ME (5 kg/ha); b_3- Folimax Oleo 12-04-24 + 2.0% MgO + 36.5% SO_3 + ME (1.5 kg/ha), b_4- Folimax Gold 27% N + 1.5% MgO + 0.02% B + 0.2% Cu + 0.02% Fe + 1% Mn + 0.02% Mo + 0.02% Zn (3 l/ha), doing two treatments. The first treatment was performed in the 8-10 leaves phenophase, and the second treatment was done in the 12-14 leaf phenophase. With the sowing, NPK 27: 13.5: 0, 250 kg/ha was fertilized, and a second fertilization was done in the 6-8 leaf phenophase, a nitrogen fertilizer of 120 kg/ha (a.s. 33 kg/ha N) in all variants.

For weed control, treatments were carried out comprising combinations of herbicides Tender 1.2 l/ha and Merlin Flex 0.4 l/ha at 260 l/ha of water applied pre-emergence and in the vegetation used Starane 1 l/ha at 260 l/ha of water.

The obtained results were statistically processed by the variance analysis method and the lowest significant difference was determined - LSD - (5%, 1% and 0.1%) (ANOVA, 2015).

The degree attack of fusarium ear rot was calculated according to the frequency and severity of the attack on 25 cobs per variant, and the frequency of attack of the pest *Ostrinia nubilalis* was determined by analyzing 25 cobs per variant.

Year 2018 was characterized as a warm year but normal in terms of rainfall recorded at the weather station, but the data analyzed monthly and decadal shows that all the months of crop growing were warm or hot months, except month July when we report average temperatures, as can be seen from the data presented in Figure 1.

The climatic conditions of the first crop period of corn crops were beneficial to optimal development at temperatures slightly higher than normal for this period, correlated with normal rainfall. The precipitations in 2018 and shown in Figure 2 indicate that the amount of rainfall varied monthly, the absence of precipitation during important periods of maize crop being recorded only during the production period. June, which was characterized as a slightly rainy month, recorded a higher amount of rainfall, 13.5 mm above the 60-year average we are reporting, with higher atmospheric humidity in this period being one of the most important factors favoring the attack on *Ostrinia nubilalis*.

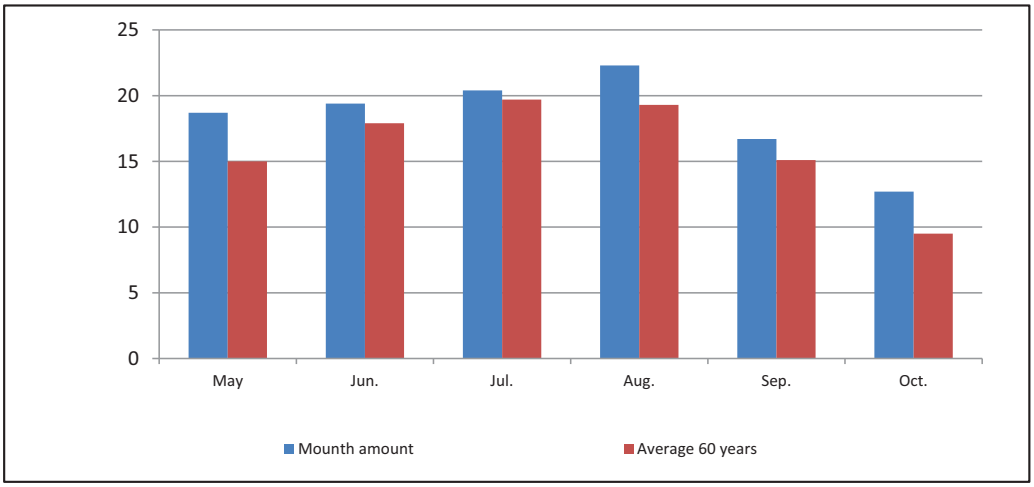

Figure 1. The thermal regime at Turda during 1 May 2018 - 31 October 2018

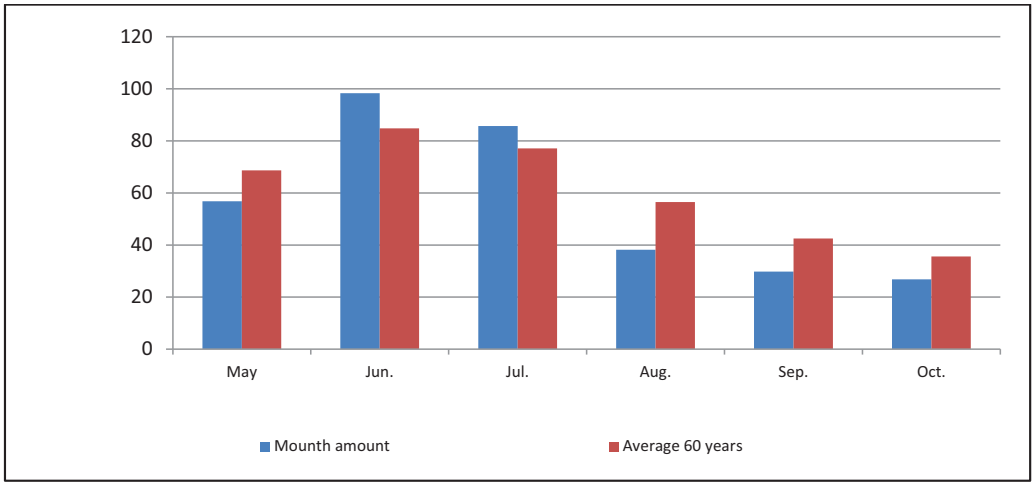

Figure 2. The pluviometric regime at Turda during 1 May 2018 - 31 October 2018

The precipitations that were dropped in early July are in addition to those recorded in June, prolonging the period in which the adults of the corn borer grow and plow.

The lack of rainfall in July and August puts its mark on corn crops by reducing the amount of water available to plants in the production of corn.

In maize culture, the water reserve was above the minimum ceiling in the early stages of vegetation, but due to the low rainfall this reserve decreased at a time when maize has significant requirements for water demand (the period between flowering and baking in the wax because the migration of the substances to the grain is diminished), the lack thereof resulting in a slight decrease in production due to the grain deflection.

RESULTS AND DISCUSSIONS

Maize responds best to the conventional soil cultivation system where the highest yields of 9566 kg/ha (Table 1) were obtained, but also to the minimum of tillage systems, where the soil was processed with the help of the chisel or the disc harrow, where the yields of the obtained are smaller, the differences of 94 kg/ha and 93

kg/ha are not statistically assured, in no tillage system, obtained the smallest yield, values with very significant differences of 2191 kg/ha compared to the control variant.

Similar data was also obtained from the experiments of Şimon et al. (2009-2011), from which it follows that the difference between the classical tillage system and the minimum tillage system was only 18 kg/ha.

Table 1. Influence of the soil tillage system factor on maize yield, Turda, 2018

Tillage variant	Yield (kg/ha)	Difference (kg/ha)	Signification
Classical system (CS) (control variant)	9566	0	Cv.
Minimum tillage (MTC)	9472	-94	-
Minimum tillage (MTD)	9473	-93	-
No tillage (NT)	7374	-2192	000
LSD (p 5%) 221	LSD (p 1%) 405	LSD (p 0.1%) 898	

The use of foliar fertilizers can positively influence production as shown in Table 2, where the use of fertilizers with a variable content of microelements in variants b_2 and b_4 showed very positive yields of 731 kg/ha and 761 kg/ha compared to the unfertilized control variant, the fertilizer used in variant b_3 recorded a significant positive yield of 331 kg/ha compared to the non-fertilized control fertilizer.

From the data presented, it appears that corn has benefited from the intake of microelements contained in the products used, contributing to the increase of yield by using them in vegetative phases where the maize plants have high water requirements, which has decreased with a decrease the amount of rainfall and relatively high temperatures.

Table 2. Influence of foliar fertilization factor on maize yield, Turda, 2018

Fertilization variant	Yield (kg/ha)	Difference (kg/ha)	Signification
b_1- Unfertilized (control variant)	8515	0	Cv.
b_2- Haifa	9246	731	***
b_3- Folimax Oleo	8847	332	*
b_4- Folimax Gold	9276	761	***
LSD (p 5%) 300	LSD (p 1%) 421	LSD (p 0.1%) 594	

From the results obtained from the analysis of the influence of the interaction of the experimental factors on the maize yield and presented in Table 3, it can be noticed that by applying the foliar fertilizers in the minimum tillage system, chisel variant, obtained a yield increase with distinctly significant differences, respectively very significant compared to the control variant to which no foliar fertilizer was applied. The lowest yield differences are registered in the soil tillage system with a disk harrow, which has a significant decrease in yield of 607 kg/ha after application of foliar fertilization, while the other two fertilization fertilizers have gains of non-assured yield. Significant production springs (641 kg/ha and 730 kg/ha respectively) are also obtained in the direct sowing system in the second and fourth treatment variants, the production increase obtained in the case of the application of the fertilizer from the third fertilization variant being not statistically assured.

By applying conservative tillage systems, the risk of specific diseases and pests increases significantly due to soil debris in which the pathogens and pests survive, which are often factors that are important in determining the production and quality of the crop, and as Şopterean and his collaborators say in 2017, in the climatic conditions in Romania, in general and in Transilvania in particular, the most damaging disease of maize crops that is compulsory to be considered in the improvement process is fusarium, produced mainly by two species of the *Fusarium genus (graminearum and moniliformes),* which may appear alone or associated with environmental conditions (soil, climate, technology etc.).

Table 3. Influence of the interaction of experimental factors on maize yield, Turda, 2018

The variant	Yield (kg/ha)	Difference (kg/ha)	Signification
Unfertilized x CS (control variant)	9047	-	Cv.
Haifa x CS	9837	790	*
Folimax Oleo x CS	9428	381	-
Folimax Gold x CS	9952	906	**
Unfertilized x MTC (control variant)	8610	-	Cv.
Haifa x MTC	9893	1283	***
Folima Oleo x MTC	9796	1186	**
Folimax Gold x MTC	9588	978	**
Unfertilized x MTD (control variant)	9465	-	Cv.
Haifa x MTD	9675	210	-
Folimax Oleo x MTD	8858	-607	0
Folimax Gold x MTD	9896	431	-
Unfertilized x NT (control variant)	6940	-	Cv.
Haifa x NT	7581	641	*
Folimax Oleo x NT	7306	366	-
Folimax Gold x NT	7670	730	*
LSD (p 5%) 598 LSD (p 1%) 840 LSD (p 0.1%) 1186			

From the data presented in Figure 3, following the interaction of the two experimental factors, compared to the classical soil management system considered as a control variant, one can notice an increase in the degree of *Fusarium* attack on the cobs in all three soil conservation conservative systems, with significant differences in the unfertilized variant with foliar fertilizer, In the Haifa fertilizer version there are no statistically ensured differences between the four soil cultivation systems; for the Folimax Oleo product, there is a significant increase in the degree of *Fusarium* attack in the application of the MTD system and statistically uninsured increases from the classical system to application of MTC and NT systems respectively. The greatest differences in the degree of *Fusarium* attack on the ear are recorded between the classical soil cultivation system and the conservative soil cultivation systems in Folimax Gold foliar fertilizer application.

Research by Chetan, 2015 on the occurrence of maize *Fusarium* indicates an increase in the degree of attack *Fusarium* on the ear in the minimal tillage system compared to the classic system. The lower attack rate determined in the classical soil cultivation system is considered to be due to the efficiency of the breeding in the prevention and control of this disease, there is a positive correlation between the degree of attack of *Fusarium* and the pests present in the maize culture, the plants attacked by the pests being more prone to disease.

Ostrinia nubilalis is found in all maize cultivation areas and is considered to be one of the most important pests of this crop in Transylvania, especially plants grown in conservative tillage systems.

The conservation of vegetal debris on soil surface in conservative tillage systems leads to a significant increase in the frequency of *Ostrinia nubilalis* attack since these vegetal remains increase the chances of increasing the biological reserve of diseases and pests in maize crop.

Although June was considered a warmer month than normal for this period, the fallen rainfall favored the emergence and development of adults of the species *Ostrinia nubilalis*, also increasing the life of the female, which manages to deposit more potes, thus the climatic conditions of the summer period being crucial in increasing the number of pests, the current climate change being an important factor in the multiplication of phytopathogenic agents and pests specific to maize crops.

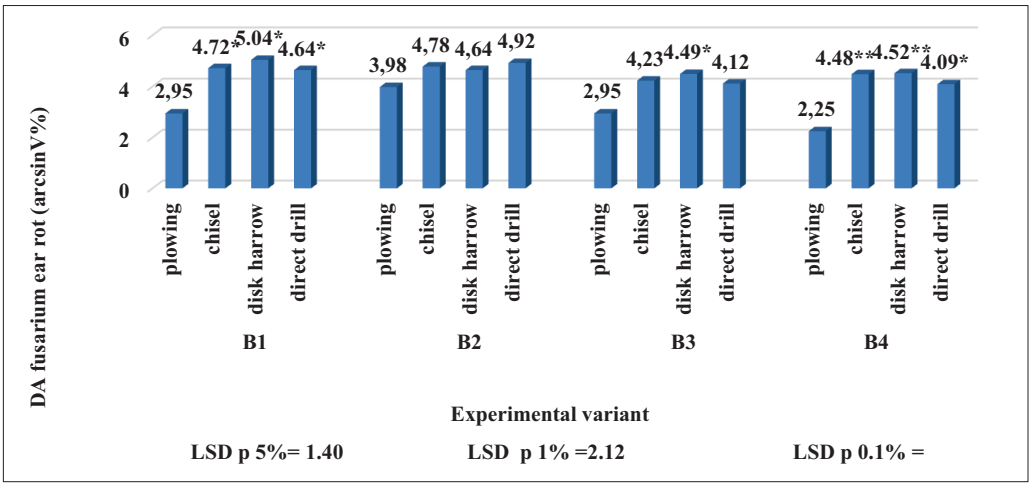

Figure 3. Influence of experimental factors on degree attack of *Fusarium* ear rot, Turda, 2018

The data presented in Figure 4 confirms that plant debris in conservative tillage systems leads to an increase in the frequency of *Ostrinia nubilalis* attack on maize cobs, but after application of foliar fertilizers, the frequency remains between 50,8-56,8% arcsin√% Haifa fertilizer and varies in variants where Folimax Oleo and Folimax Gold have been applied.

From research on maize crop the damage species produce to maize crops is direct, by qualitatively and quantitatively reducing the plant production potential and indirectly by breaking plants and cobs, making the process more difficult harvesting, as well as the fact that the larvae are a vector for blight, *Fusarium* and other diseases.

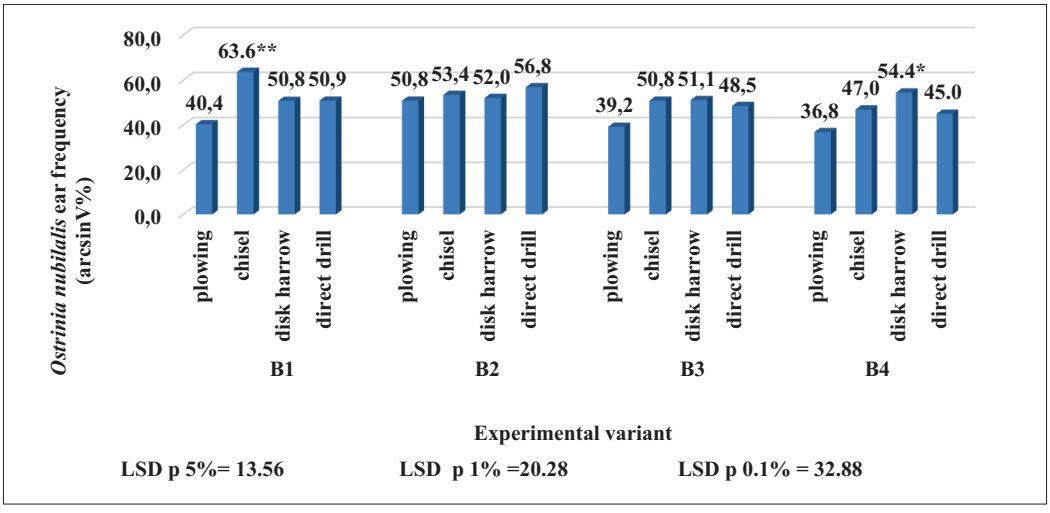

Figure 4. Influence of experimental factors on the ear frequency attack by *Ostrinia nubilalis*, Turda, 2018

CONCLUSIONS

By introducing the minimum soil tillage systems, maize crop yield decreases with statistically significant differences but following the direct sowing system, the yield decreases with a very significant difference of 2192 kg/ha compared to the conventional tillage system.

The application of foliar fertilizers to maize crop bring significant or very significant yield increases in the climatic conditions of 2018.

Soil tillage is of major importance in the emergence and development of phytopathogens of the species *Fusarium* and pest *Ostrinia nubilalis*.

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***ANOVA, 2015, PC Program for variant analyses made for completely randomized polifactorial experiences.

***Staţia Meteo Turda.