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MANAGEMENT OF RISKS FOR WHEAT CONTAMINATION WITH *Fusarium graminearum*

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ABSTRACT

The topic is particularly important because toxins cause mycotoxins in plants and animals and remain in food products obtained from infected organisms and they are mutagenic, teratogenic and estrogenic effects in animal and human bodies. Also, may be a serious threat to human health.

This study presents the mineral nutrition status of winter wheat in connection with the risks of wheat contamination by *Fusarium* toxins in the soil conditions at INCDA Fundulea.

The plants selected for testing were ten wheat cultivars, identified as susceptible to infection with *Fusarium graminearum*. The soil from the experiment was Cambic Chernozem.

Two types of parcels were included in the experiment: one with healthy plants and another with artificially infected plants.

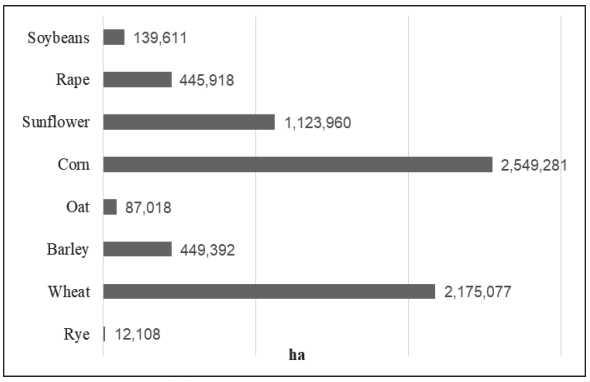
In order to quantify the mineral nutrition status of plant with macro and micronutrients, the plant analyses were being carried out in the ear emergence-flowering phase. The obtained results it was interpreted in connection with the optimum limits of mineral contents in dry matter, mentioned in the specialty literature. The N and K ratios between healthy plant and artificially infected plants it was processed based on analytical data.

Keywords: artificially infection, *Fusarium graminearum*, wheat.

INTRODUCTION

The cultivation of wheat is linked to the history of mankind and the efforts made to secure food. Nowadays, wheat is the main ingredient of a variety of highly valued processed foods, consumers being aware of its high nutritional value: content in fibre, minerals, macro and micronutrients, vitamins (Igrejas and Branlard, 2020).

Romania is one of the main wheat growers in the European Union, a fact proven by the ranking on the 4th place, in 2021. On the first places were France - 5,277,050 ha, Germany - 2,939,000 ha and Poland - 2,390,520 ha. In terms of production, Romania ranked also on the 4th place and the first place being occupied by France - 36,607,120 tons, followed by Germany - 21,459,200 tons and Poland - 11,893,550 tons (Eurostat, 2022).



Source: NIS, own design

Figure 1. Areas cultivated with the main field crops, 2021

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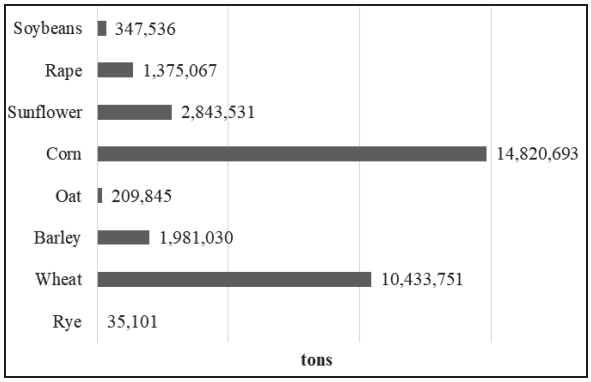
In Romania, the areas cultivated with wheat placed this crop on the 2nd place, in 2021, after those cultivated with corn, as we can see in Figure 1.

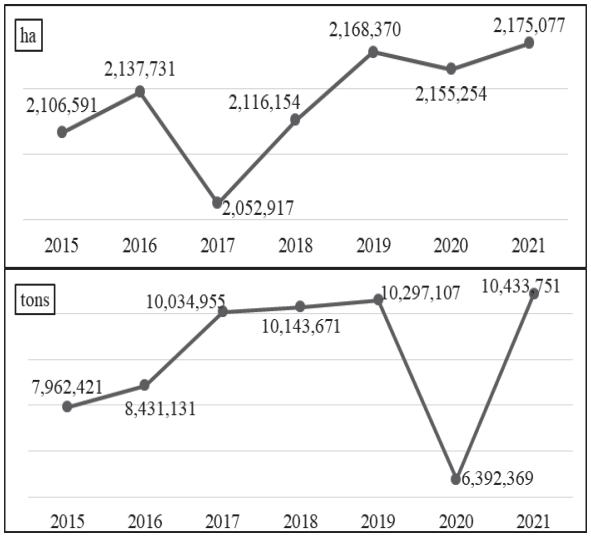
Analyzing the production obtained at the main field crops in Romania, in 2021, wheat was the second crop, as a share, after corn (NIS) (Figure 2).



Source: NIS, own design

Figure 2. Production obtained at the main field crops, 2021

In the period 2015-2021, both the areas cultivated with wheat and the total production of wheat experienced fluctuations, due to meteorological phenomena or The COVID-19 pandemic (Figure 3).



Source: NIS, own design

Figure 3. Cultivated areas and wheat productions obtained, in the period 2015-2021

However, overall increases were seen, with 3.25% for area and 31.04% for total production.

Currently, total wheat production obtained in Romania ensures domestic consumption and offers the possibility to export significant quantities (Medelete et al., 2018).

Annual cereal yield increases of 1.6-2% are needed in the coming years to meet global demand for food, feed, fibres and fuel due to population growth, loss of arable land, depletion of freshwater resources and climate change (Cristina et al., 2018).

Besides climate changes, diseases and pests are important factors that control production, so in order to maintain its hierarchy or occupy a better step in the top producers, Romania must control these factors very well. For this purpose, research must support the knowledge of all aspects that characterize them (Petcu et al., 2020).

Mycotoxins are secondary metabolites of microscopic fungi, which commonly contaminate cereal grains and cereal products. Animal feed is a source of mycotoxins. This topic is particularly important because toxins cause mycotoxicosis of animals and remain in food products obtained from infected organisms. Mycotoxins exert various effects on the animal and human organisms, among others they are mutagenic, teratogenic and estrogenic (Mielniczuk and Bednarz, 2020).

They also have a significant impact on the economy because, in accordance with the provisions of the legal acts, the presence of mycotoxins at a certain level results in the exclusion of agricultural crops, feed and food products from commercial trade.

Among the pathogens that affect the wheat crop stands out *Fusarium graminearum*, the pathogen that causes one the most devastating diseases of wheat (*ear fusariosis*) and reduces production by: inducing sterility of the inflorescences, poor seed filling and reducing grain size (Argyris et al., 2003; Taheri, 2018).

In addition to the significant loss of production from mycotoxin deoxynivalenol (DON), infected ears are unsuitable for food or feed (Humphreys et al., 2001; Liu and Anderson, 2003; Miedaner et al., 2003, Kazan and Gardiner, 2017).

Studies have shown that the intensity of the disease increases when flowering periods coincide with periods of wet and warm weather (Bai and Shaner, 1994; Fernandez et al., 2001; Gilbert et al., 2003).

Fusarium graminearum is transmitted through the soil and through the seed, and therefore preventive measures are particularly effective, such as the use of healthy seeds, treated before sowing, balanced fertilization, compliance with the rotation (Agrointeligența, 2018).

Increased of *Fusarium* attacks in recent years is considered to be due to the transition to culture systems that involve minimal soil processing and an inadequate rotation of crops, which includes many host crops (Capouchová et al., 2012).

Cultivation of varieties resistant to the attack of *Fusarium graminearum* it was being considered the main effective practice in controlling this disease. Several studies have reported differences between varieties in terms of infection severity and resistance (Ribichich et al., 2000; Miedaner et al., 2003; Bernardo et al., 2007).

However, a high degree of resistance to European wheat varieties cultivated for commercial purposes has not yet been obtained (Zrcková et al., 2019).

The paper aims to identify the nutritional status of ten wheat cultivars subjected to experiments due to their sensitivity to *Fusarium graminearum*, in the soil conditions from INCDA Fundulea. A parallel comparison between the results obtained in healthy plants and in those artificially infected with *Fusarium graminearum* it was made.

MATERIAL AND METHODS

In the experimental plot from INCDA Fundulea (the experiences were done in the isolation camp) the ten wheat cultivars susceptible to *Fusarium graminearum* attack were tested on parcels fertilised with the following rates (kg of active ingredients/ha): N-130, P_2O_5-80.

From these, it was collected and analyzed soil samples from ploughed layer and plant samples in the ear emergence-flowering stages.

The analyzes made at the soil samples were: soil reaction (pH), humus total (Ht), total nitrogen (Nt), available phosphorus (P_{AL}) and available potassium (K_{AL}).

In plants, following analyzes were carried out: the content of macronutrients (N, P, K, Mg) and the content of micronutrients (Cu, Zn, Fe, Mn) in dry matter of aerial parts. All analyzes were made according to RISSA methodology (1980, 1981) and the obtained results were compared with the optimum limits from specialty literature (Bergmann, 1992).

To emphasize Romania's place in wheat cultivation and the importance of this culture in our country, we used the following statistical websites: Eurostat and NIS.

RESULTS AND DISCUSSION

For the experiment described in this article were chosen ten wheat cultivars, Glosa, Gruia, Delabrad, Faur, Dropia, Arieşan, Dumbrava, Trivale, Briana and Ciprian, considered susceptible to *Fusarium graminearum* infection. Wheat varieties have different resistance to fusariosis from a genetic point of view.

The selected cultivars are found in the traditional wheat-growing areas of Romania (South of the country, Oltenia, Southern hilly area, Western country, Western hilly area, Transylvania, Central and Southern Moldova, Northern Moldova). Glosa is the most widespread, as it adapts to the conditions of all regions (Roman et al., 2011).

The soils on which the two experimental lots were placed, with healthy plants and with plants artificially infected with *Fusarium graminearum*, are of the Luvic Chernozem type. The characterization of the soil from INCDA Fundulea it is present into the Table 1.

Table 1. Main agrochemicals properties of soil from INCDA Fundulea experimental plots

Agrochemical index	pH (H_2O)	Nt	Humus	P_{AL}	K_{AL}
		%		ppm	
Value	5.7	0.101	3.4	28	174

Source: own determination

From the obtained results, the soil shows a weakly acid reaction, the registered pH value being of 5.7. The pH value of the soil is typical for this type of soil but was also done

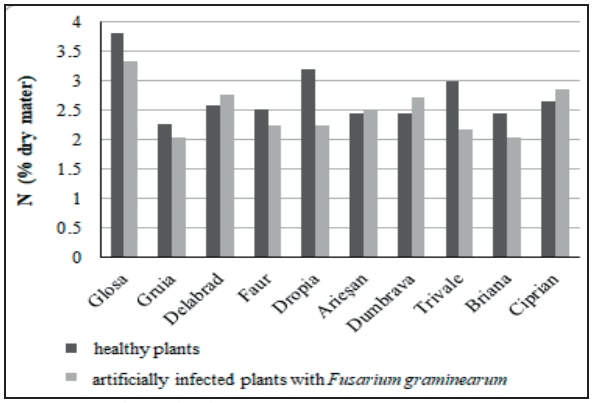
fertilisation with high doses of N. The agrofund of fertilisation was N-130 kg/ha; P_2O_5-80 kg/ha.

The humus supply status is medium and the nitrogen supply status is low. The mobile phosphorus content and the mobile potassium content are medium.

Concerning the analyses regarding the mineral composition of the plants, the following results were registered:

- the N and P contents, in dry matter of the plants, were generally in the optimal range for this stage (Figures 4, 5);

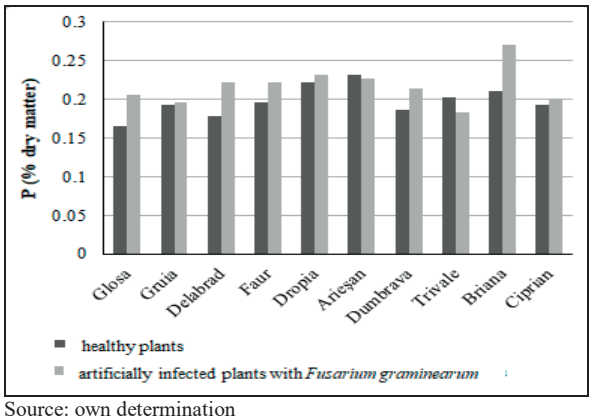
- the cultivar Glosa from the category of healthy plants and also Glosa from the category of artificially infected plants have N contents (% dry matter) with higher values (Figure 4);



Source: own determination

Figure 4. The nitrogen content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea

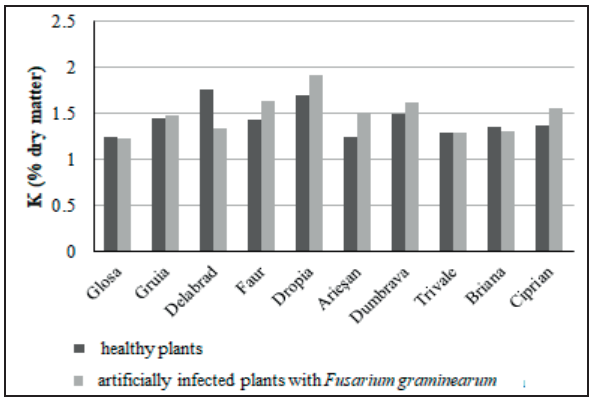
- the phosphorus content (P, % dry matter) recorded higher values for the cultivar Briana (artificially infected plants) and Dropia and Arieşan (healthy plants) (Figure 5);



Source: own determination

Figure 5. The phosphorus content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea

- the lower potassium level in plant may explained due to the lower pH values and the moderate level of supply status of soil with this element (Figure 6);

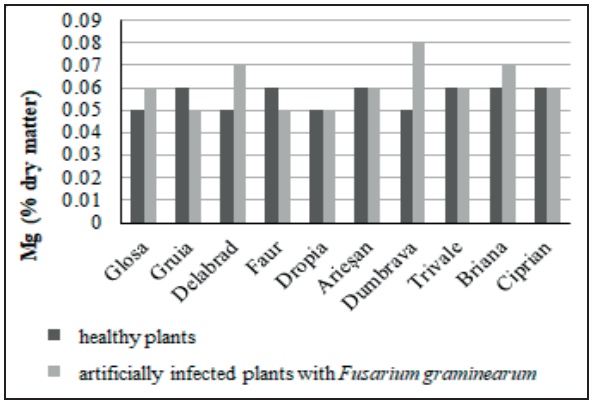


Source: own determination

Figure 6. The potassium content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea

- analyzing the figure above we can conclude that the cultivars: Delabrad and Dropia (healthy plants) and Faur, Dropia and Dumbrava (artificially infected plants) showed the highest values for K (% dry matter);

- the magnesium content presented values within the limits considered optimal (Figure 7);



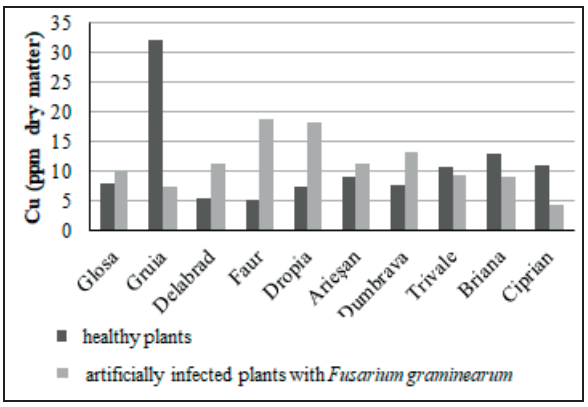
Source: own determination

Figure 7. The magnesium content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea

- the highest magnesium content (% dry matter) was recorded at: Dumbrava cultivar (artificially infected plants), such as Gruia, Faur, Arieşan, Trivale, Briana and Ciprian cultivars (healthy plants) have presented the same high values.

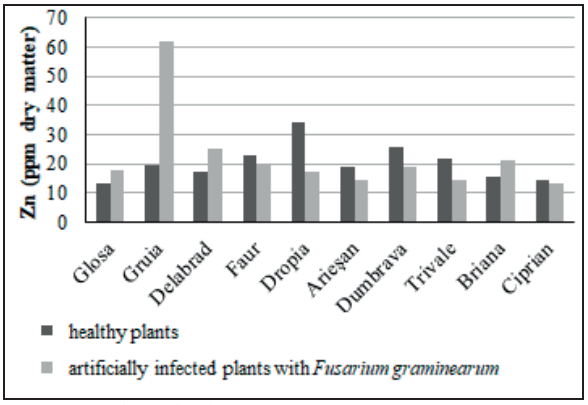
The micronutrients contents in the aerial part of the wheat plants were within the limits of the optimal ranges (Figures 8-11):

- regarding the copper content (ppm dry matter) (Figure 8), it was found in larger quantities in Gruia cultivar (healthy plants) and Faur and Dropia cultivars (artificially infected plants);
- the zinc content (ppm dry matter) had the highest values in Dropia cultivar (healthy plants), respectively, in Gruia cultivar (artificially infected plant) (Figure 9);



Source: own determination

Figure 8. The copper content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea



Source: own determination

Figure 9. The zinc content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea

- the cultivars Dropia and Arieşan, (healthy plants) and, respectively, Glosa and Trivale cultivars (artificially infected plants) showed the highest content of iron (ppm dry matter) (Figure 10);
- the manganese content (% dry matter) showed high values in Glosa, Dumbrava cultivars (artificially infected plants) and Glosa, Trivale and Ciprian cultivars (healthy plants) (Figure 11).

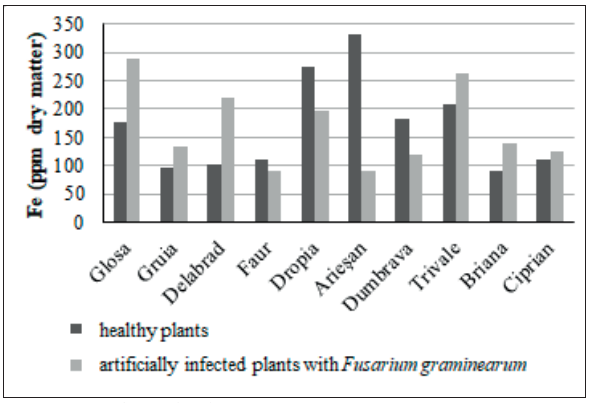


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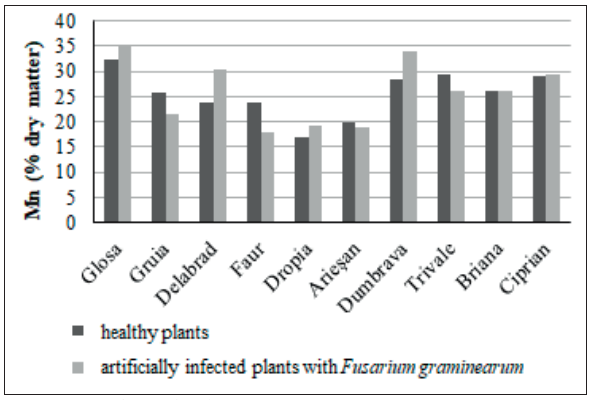
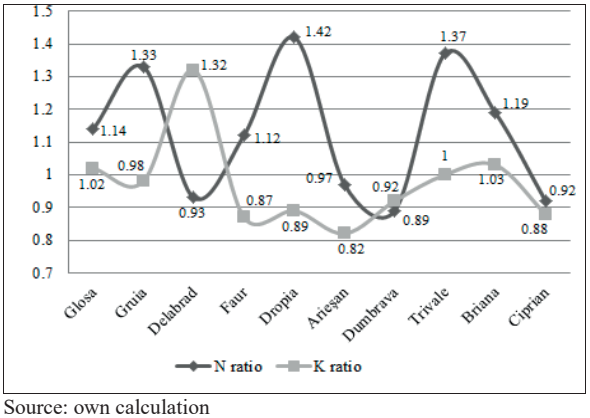
Figure 10. The iron content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea



Source: own determination

Figure 11. The manganese content in the aerial parts of winter wheat plants, ear emergence-flowering stage, INCDA Fundulea

From Figure 12, we can observe that N ratio has higher values than K ratio, due to lower N and higher K contents in dry matter. The values are generally >1, in the case of N ratio, and <1 in general, in the case of K ratio.



Source: own calculation

Figure 12. Data concerning the rations between N contents and K contents obtained from healthy plants and artificially infected plants with *Fusarium graminearum*, INCDA Fundulea

The ratios were made between the values recorded by the N and K content in healthy plants and in those artificially infected with *Fusarium graminearum*.

CONCLUSIONS

The study carried out on the mineral composition of the winter wheat, in the conditions of the Luvic Chernozems from INCDA Fundulea, showed differences in the mineral composition between the healthy plants and those artificially infected with *Fusarium graminearum*.

In general, we found that plants affected by *Fusarium graminearum* have lower N and higher K contents in dry matter.

The rations of N contents showed suprаunitary values for most of the analysed cultivars. In the case of K, these rations were generally subunitary. High doses of N increase the occurrence of *Fusarium graminearum* attack.

Regarding the contents of micronutrients, the artificially infected plants generally had higher Cu and Fe, and lower Zn and Mn contents, compared to the healthy plants.

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REFERENCES

Argyris, J., Van Sanford, D., Te Krony, D., 2003. *Fusarium graminearum infection during wheat seed development and its effect on seed quality*. Crop Science, 43(5): 1783-1788.

Agrointeligența, 2018. *Cultura grâului: soiuri, semănat, fertilizare, tratamente, recoltare, prețuri (Wheat culture: varieties, sowing, fertilization, treatments, harvesting, prices)*. https://agrointel.ro/107545/cultura-graului-soiuri-semanat-fertilizare-tratamente-recoltare-preturi/

Bai, G., and Shaner, G., 1994. *Scab of wheat: Prospect for control*. Plant Disease, 78(8): 760-766.

Bernardo, A., Bai, G., Guo, P., Xiao, K., Guenzi, A.C., Ayoubi, P., 2007. *Fusarium graminearum-induced changes in gene expression between Fusarium head blight-resistant and susceptible wheat cultivars.* Funct. Integr. Genom., 7(1): 69-77. doi:10.1007/s10142-006-0028-1

Bergmann, W., 1992. *Nutritional disorders of plants*. Gustav Fisher, New York, USA.

Capouchová, I., Papoušková, L., Kostelanská, M., Prokinová, E., Škeříková, A., Hajšlová, J., Konvalina, P., Faměra, O., 2012. *Effect of different intensities of fusarium infestation on grain yield, deoxynivalenol content and baking quality of winter wheat.* Rom. Agric. Res., 29: 297-306.

Cristina, D., Ciucă, M., Mandea, V., Cornea, C.P., 2018. *Genetic diversity of TaSAP1-A1 locus and its association with TKW in some European winter wheat cultivars*. Rom. Agric. Res., 35: 3-9. https://doi.org/10.59665/rar3501

Eurostat, https://ec.europa.eu/eurostat/data/database (accessed on 07.08.2022).

Fernandez, M.R., Zentner, R.P., McConkey, B.G., Campbell, C.A., 2001. *Effect of crop rotations and fertilizer management on LEAFSPOT of spring wheat in Southwestern Saskatchewan*. Canadian Journal of Plant Science, 78: 489-496.

Gilbert, J., Conner, R.L., Fernandez, M.R., McLaren, D., Woods, S.M., 2003. *Role of spring wheat seed infested with Fusarium graminearum in spread and development of Fusarium head blight and effects on agronomic performance*. Canadian Journal of Plant Pathology, 25: 73-81.

Humphreys, G., Brown, D., Clarke, J., DePauw, R., Fox, S., Nass, H., Shugar, L., Voldeng, H., 2001. *Progress towards Fusarium head blight resistant spring wheat in Canada*. In Proc. 2nd Canadian Workshop on Fusarium Head Blight, Ottawa, Canada, 3-5 Nov. 2001, Agriculture and Agri-Food Canada, Ottawa: 5-8.

Igrejas, G., and Branlard, G., 2020. *The importance of wheat*. In: Igrejas, G., Ikeda, T., Guzmán, C. (eds.), Wheat quality for improving processing and human health. Springer, Cham. https://doi.org/10.1007/978-3-030-34163-3_1

Kazan, K., and Gardiner, M.D., 2017. *Transcriptomics of cereal-Fusarium graminearum interactions: what we have learned so far*. Molecular Plant Pathology, 19(3): 764-778.

Liu, S., and Anderson, J.A., 2003. *Marker assisted evaluation of Fusarium head blight resistant wheat germplasm*. Crop Science, 43: 760-766.

Medelete, D.M., Pânzaru, R.L., Vladu, M., Matei, G., 2018. *Some considerations regarding the primary wheat supply in Romania and its composition (2014-2016)*. Scientific Papers, Series “Management, Economic Engineering in Agriculture and Rural Development”, 18(1): 245-252.

Miedaner, T., Schneider, B., Gieger, H.H., 2003. *Deoxynivalenol (DON) content and Fusarium head blight resistance in segregating winter rye and winter wheat*. Crop Science, 43: 519-526.

Mielniczuk, E., and Bednarz, S.B., 2020. *Fusarium head blight, mycotoxins and strategies for their reduction.* Agronomy, 10(4): 509. https://doi.org/10.3390/agronomy10040509

NIS (National Institute of Statistics). www.insse.ro (accessed on 07.08.2022).

Petcu, E., Lazăr, C., Marinciu, C., Săulescu, N.N., 2020. *Relationship of seminal roots angle and grain yield of winter wheat cultivars under the continental climate of Romania*. Rom. Agric. Res., 37: 35-39. https://doi.org/10.59665/rar3705

Ribichich, K.F., Lopez, S.E., Vegetti, A.C., 2000. *Histopathological spikelet changes produced by Fusarium graminearum in susceptible and resistant wheat cultivars*. Plant Disease, 84: 794-802.

Research Institute for Soil Science and Agrochemistry (RISSA), 1980. *Methodology of analysis for assessing mineral plant nutrition*.

Research Institute for Soil Science and Agrochemistry (RISSA), 1981. *Methodology of agrochemical soil analysis for determining the needs of amendments and fertilisers*.

Roman, V.T., Tabără, V., Robu, T., Pîrșan, P., Ștefan, M., Axinte, M., Morar, G., Cernea, S., 2011. *Fitotehnie, volume 1 - Cereale și leguminoase pentru boabe*. Universitară Publishing House, Bucharest, Romania. http://agro-bucuresti.ro/images/Admitere/2020/Master/Fitotehnie_vol_I.pdf

Taheri, P., 2018. *Cereal diseases caused by Fusarium graminearum: from biology of the pathogen to oxidative burst-related host defense responses*. European Journal of Plant Pathology, 152: 1-20.

Zrcková, M., Svobodová-Leišová, L., Bucur, D., Capouchová, I., Konvalina, P., Pazderů, K., Janovská, D., 2019. *Occurrence of Fusarium spp. in hulls and grains of different wheat species.* Rom. Agric. Res., 36: 173-185. https://doi.org/10.59665/rar3620