THE INFLUENCE OF TREATMENTS WITH VARIOUS PHYTOSANITARY PRODUCTS (FUNGICIDES) ON THE ATTACK OF SOME PHYTOPATHOGENIC FUNGI ON BARLEY HARVEST, DONAU VARIETY, IN 2023 PEDOCLIMATIC CONDITIONS OF THE EASTERN BARAGAN

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Abstract

This study aims at monitoring the dynamics of the occurrence and evolution of the attack of some pathogens to barley, among which we mention: mildew (*Blumeria graminis* f.sp. *hordei*), leaf stripe (*Pyrenophora graminea*) and barley's rust (*Puccinia hordei*). Also, the influence of applying these fungicides on the harvest, as well as of the number of treatments/ha as compared to the untreated control variant, has been monitored. For this study, an experiment with 6 treatment variants was created, being used the following phytosanitary products: EVALIA (azoxystrobin 250 g/l), RETENGO (200 g/l pyraclostrobin**)** and ORIUS 25 EW (250 g/l tebuconazole). The treatment variants were the following: V1- ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase; V2 – EVALIA 1/L/HA, 1 treatment applied at booting – flowering phase, V3 - RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase, V4 - ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling, V5- EVALIA 1L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling, V6-RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling, V7 – Control variant not treated. The experiment was placed in Latin square, the 7 variants being placed in 7 repetitions. The year 2023 was a year with a relatively wet spring and early summer. The climatic conditions were favorable to the attacks of barley-specific pathogens, earlier than in 2022, year which was very dry. The experiment was not irrigated. The experiment was established after rapeseed. Among the pathogens followed, attacks produced by the *Pyrenophora graminea* fungus, which produces, in barley, the disease known as leaf stripe, were observed. Between the untreated control variant and some of the variants that were treated with fungicides, there were significant yield differences in the climatic conditions of 2023. The variant's yields were: V1- 7335 t/ha, V2–7165 t/ha, V3-7505 t/ha, V4–7305 t/ha, V5–7496 t/ha, V6 - 7622 t/ha and V7–7275 t/ha. The presence of the phytopathogenic fungus *Blumeria graminis* f.sp. *hordei*, which produces barley's mildew, was slightly higher than in 2022.

Key words: (*Pyrenophora*, *Blumeria*, Latin square)

Hordeum vulgare barley is attacked by many pathogenic agents, such as: mildew - *Blumeria graminis* f.sp. *hordei*, leaf stripe - *Pyrenophora graminea*, leaf blotch - *Rhyncosporium secalis*, rust - *Puccinia hordei* (Iacob Viorica, Hatman, M., Ulea, E., Puiu, I. 1998). The first half of 2023 was favorable for obtaining good barley yields. Rainfall was recorded quantitatively higher than the previous year, which was particularly dry. For example, in February, the average temperature was 2.5℃, the rainfall totaled 9.3 l/m² and the average relative humidity was 71%. In March, the average temperature was 9^0C and the average relative humidity was 60%, the rainfall totaled 24 l/m². In April, the average temperature was 14.5^0C, rainfall totaled 53 l/m² and the average relative humidity was 70%. In May, the average temperature recorded was 16.5^0C, rainfall totaled 41 l/m² and the average relative humidity was 59%. The emergence of barley in the autumn of 2022 was relatively good. The winter between 2022 and 2023 was quite warm, as it was the previous winter, which allowed the plants not to freeze, barley being a more sensitive species to cold than wheat. The rainfall between February and May 2023 was higher than that of the previous year, leading to a higher yield of barley compared to the yield obtained in the previous year. Among the pathogens that have appeared, we mention the *Pyrenophora graminea* fungus which produces, in barley, the disease called leaf stripe. This pathogen attacks barley crops every year at attack intensities that vary from year to year.

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Figure 1**. Atack of *Pyrenophora graminea* fungus on the date of 8th April 2023 (original)**

Figure 2**. Aspects from the experimental field (original)**

Table 1

The results of the experiment with fungicide products (6 variants of treatment + 1 untreated control variant) in what concerns the attack (D.A. %) of *Pyrenophora graminea* fungus on barley ("flag" leaf and the next leaf). The observations were performed on the date of 20th May 2023

	The "flag" leaf			The second leaf		
Variant	D.A %	Difference as compared to the control variant	Significance	D.A %	Difference as compared to the control variant	Significance
V1-ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase	30.66	21.26	**	76.21	20.93	*
V2- EVALIA 1/L/HA, 1 treatment applied at booting – flowering phase	20.27	31.65	**	84.43	12.71	_
V3-RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase	16.06	35.86	**	66.93	30.21	**
V4- ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	24.90	27.02	**	90.36	6.78	_
V5- EVALIA 1/L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	11.71	40.21	**	73.50	23.64	*
V6- RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	4.20	47.72	**	57.07	40.07	**
V7 – Control variant not treated	51.92	-	-	97.14	-	-

LD D.A.% for the „flag" leaf
LD 5% =10.71%
LD 1% =14.58%

LD D.A.% for the second leaf:
LD 5% =19.17%
LD 1% =25.85%

Table 2

The results of the experiment with fungicide products (6 variants of treatment + untreated control variant) in what concerns the yield (t/ha) obtained at the treated variants as compared to the untreated control variant

Variant	Yield (t/ha)	Difference as compared to the control variant (t/ha)	Significance
V1-ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase	7.335	0.060	-
V2-EVALIA 1/L/HA, 1 treatment applied at booting – flowering phase	7.165	-0.110	-
V3-RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase	7.505	0.230	*
V4-ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	7.305	0.030	-
V5- EVALIA 1/L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	7.496	0.221	*
V6--RETENGO 0,5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	7.622	0.347	**
V7 – Control variant not treated	7.275	_	_

LD 5% = 0.191 t/ha
LD 1% = 0.258 t/ha

MATERIAL AND METHOD

An experiment with 7 study variants was designed in order to make the observations. This experience included 6 phytosanitary treatment variants (fungicidal products, their combinations, no. of treatments) and an untreated control variant. The variants of the experiment were as follows (Table 1):

- V1 - ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase
- V2 - EVALIA 1L/HA, 1 treatment applied at booting – flowering phase
- V3 - RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase
- V4 - ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling
- V5 - EVALIA 1L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling
- V6 - RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling
- V7 – Control variant not treated

The experiment was placed in Latin square. These 7 variants were placed in 7 repetitions. Each experimental plot had an area of 15 m^2 (5 x 3 m). The total number of the experiment plots was 49. The area of an experimental variant was of 15 m^2 x 7 repetitions = 105 m^2. The total area of the experiment was of 105 m^2 x 7 = 735 m^2. The treatments were performed manually, with a machine of "Vermorel" type. Weed control was achieved with the help of Mustang herbicide (6.25 g / l florasulam + 300 g / l 2,4-D EHE acid) at a dosage of 0.5 l / ha applied, separately, with the vermorel. The experiment has shown the effectiveness of these phytosanitary products, in relation to their price, as well as the efficiency and, respectively, the profitability of applying one or two phytosanitary treatments during barley's vegetation period.

The evaluation of the attack's frequency (F%), of the attack's intensity (I%) and respectively, of the degree of attack (D.A.%) was done separately, on each and every experimental plot, analyzing 10 plants / experimental plot. Their degree of affectation (the intensity of the attack I %) of the last 2 leaves, especially of the "flag" leaf which has the biggest contribution to the ear's yield at cereals, had been assessed. The phytosanitary analyses of the plant's samples were done with the help of the stereomicroscope and optic microscope at Brăila Phytosanitary Office's laboratory – Phytosanitary National Authority, institution subordinated to the Ministry of Agriculture and Rural Development. These analyses had revealed the presence of *Pyrenophora graminea* in the samples analyzed, fungus which produces barley's leaf stripe.

In order to assess the yield of each variant under study, kernel samples from each experimental plot, 5 samples / plot, had been analyzed by sampling. Each sample comprised 20 plants, so, from each experimental plot, 100 plants were taken over, from which the yield was manually weighted. The demarcation of each sample was performed with a metric frame with the area of 0.25 m^2 (0.5/0.5m). The average of the experimental plot samples had served for calculating the production of each and every experimental plot. The statistic interpretation had been done with the help of the limit differences (LD %) (Săulescu N., 1967).

Donau variety was used. This is a new German variety of barley for beer, traded by Soufflet French Company. The variety is early-flowering. It has a good resistance to falling, cold and barley's specific diseases **(**Soufflet Agro Romania, 2020).

Assessing the pest attack can be done with the help of the following values (Prognosis and Warning Methods, 1980):

- Attack frequency (F %);
- Attack intensity (I %);
- Degree of attack (D.A %).
- Attack frequency represents the relative value of the number of plants or organs of the plant under attack (n) reported to the number of plants or organs observed (N). The value of the frequency is established through direct observations on a number of plants or organs, according to the case and to the conditions, existing different methods of collecting the samples and for performing the observations. In the case of our observations regarding the foliar diseases, the number of attacked plant organs from the total of observed plant organs (leaves) had been taken into consideration, establishing thus the frequency of the attack expressed in percentages %. In case of blights, the number of attacked ears reported to the total number of observed ears had been used. The frequency was calculated with the help of the F%= nx100/N formula.
- Attack intensity represents the degree or percentage where a plant or an organ of the plant is attacked and how much from the area of the plant or of the organ analyzed (leaf, fruit) is covered by the disease under study.

The assessment of the area attacked had been done with the naked eye or with the magnifying glass, assessing the percentage occupied by spots or burns caused by the pathogenic agent. The damage percentage can be recorded or grades can be awarded for each plant or organ attacked by the disease or/and by the pest. Grades usage can ease up greatly data summarizing. It can be used a scale with 6 degrees of intensity, as follows:

- Grade 0 no attack
- Grade 1 attack 1 – 3%
- Grade 2 attack 3 – 10%
- Grade 3 attack 11 – 25%
- Grade 4 attack 26 – 50%
- Grade 5 attack 51 – 75%
- Grade 6 attack 76 – 100%

After summarizing the data, the attack intensity had been determined with the following formula:

$$I\% = \frac{\Sigma (i \times f)}{N}$$

Where:

I% – Attack intensity (in %);

i – The intensity according to the grade awarded to the organ or plant attacked;

f – The number of cases (plants, organs) attacked;

n – The number of plants attacked.

In our experiment, grades from 1 to 6 had been separately awarded to the "flag" leaf and to the next leaf situated below it.

- The Degree of Attack is the expression of the attack severity's extension on the crop or of the total number of plants for which we are making the observations. D.A.'s value expression is given by the ratio:

$$D.A.\ (\%) = \frac{F \times I}{100}$$

In most of the cases, there is a negative correlation between the degree of attack of a pathogenic agent or pest and the quantitative and/or qualitative level of a crop's yield.

RESULTS AND DISCUSSIONS

The agricultural year 2022 – 2023 was relatively favorable for barley crop. It must be underlined the very important fact that barley (*Hordeum vulgare*) is a variety more sensitive to disease attack and to wintering than wheat. Contrary to last year, February, March, April and May months were richer in rainfalls compared to 2022. Those months were also cooler compared to the same months in 2022. The autumn of 2022 had been relatively richer in rainfalls than the autumn of 2021. In these conditions, the plants emerged in time in order to go through the winter of 2022-2023 in good conditions. This winter was relatively warm compared to the average of the previous years.

In what concerns the occurrence dynamic of the pathogens' attacks on barley, we mention the following aspects: - *Pyrenophora graminea* had affected barley to a greater extent in 2023, as compared to 2022. The degree of attack (D.A.%) was of 51.92% at V7 - untreated control variant, at the "flag" leaf - on the date of 26th May 2023. This degree of attack on the "flag" leaf of the untreated control variant was higher than in the previous year, 2022, which was very dry.

If we analyze the data from Table 1, we observe that the degree of attack of *Pyrenophora graminea* fungus was differentiated, as follows:

- V1 determined a degree of attack of the *Pyrenophora graminea* fungus of 30.66% in the "flag" leaf, and of 76.21 % in the second leaf, therefore lower by 21.26%, and, respectively, by 20.93% than the untreated control variant (V7).

- V2 determined a degree of attack of the *Pyrenophora graminea* fungus of 20.27% in the "flag" leaf, and of 84.43% in the second leaf, therefore lower by 31.6%, and, respectively, by 12.71% than the untreated control variant (V7).
- V3 determined a degree of attack of the *Pyrenophora graminea* fungus of 16.06% in the "flag" leaf and of 66.93% in the second leaf, therefore lower by 35.86% and, respectively, by 30.21% than the untreated control variant (V7).
- V4 determined a degree of attack of the *Pyrenophora graminea* fungus of 24.90% in the "flag" leaf and of 90.36% in the second leaf, therefore lower by 27.02% and, respectively, by 6.78% than the untreated control variant (V7).
- V5 determined a degree of attack of the *Pyrenophora graminea* fungus of 11.71% in the "flag" leaf, and of 73.50% in the second leaf, therefore lower by 40.21% and, respectively, by 23.64% than the untreated control variant (V7).
- V6 determined a degree of attack of the *Pyrenophora graminea* fungus of 4.20% in the "flag" leaf and of 57.07% in the second leaf, therefore lower by 47.72% and, respectively, by 40.07% than the untreated control variant (V7).
- V7 – The untreated control variant was affected by *Pyrenophora graminis* at a degree of attack (D.A.) values of 51.92% in the "flag" leaf and of 97.14% in the second leaf.

From the analysis of table 2, the yield differences compared to the untreated control variant, V7, can be observed, as follows:

- V1 achieved a yield of 7.335 t/ha, respectively 0.060 t/ha higher than the untreated control variant (V7).
- V2 achieved a yield of 7.165 t/ha, respectively 0.110 t/ha lower than the untreated control variant (V7).
- V3 achieved a yield of 7.505 t/ha, respectively 0.230 t/ha higher than the untreated control variant (V7).
- V4 achieved a yield of 7.305 t/ha, respectively 0.030 t/ha higher than the untreated control variant (V7).
- V5 achieved a yield of 7.496 t/ha respectively an increase of 0.221 t/ha compared to the untreated control variant (V7).
- V6 achieved a yield of 7.622 t/ha respectively an increase of 0.347 t/ha. compared to the untreated control variant (V7).
- V7 untreated control variant achieved a yield of 7,275 t/ha.

CONCLUSIONS

The observations made in the spring of 2023 on barley crop, in the pedoclimatic conditions of the Eastern Băragan, led to the following conclusions and recommendations:

1-The attack of the *Pyrenophora graminea* fungus, which causes the disease popularly known as "leaf stripe", also made its presence in 2023. The attack of this fungus was, this year, stronger than in 2022 and started earlier. This was caused by: the relatively higher amount of rainfalls, slightly lower average temperatures and higher average air humidity, recorded in the first 5 months of 2023, compared to the first 5 months of 2022. The yield differences between the treated variants and the untreated control variant were very small and even negative for V1- ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting-flowering phase, V2-EVALIA 1L/HA, 1 treatment applied at booting-flowering phase and V4- ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling.

2-Variants: V3-RETENGO 0.5 L/HA; 1 treatment applied at booting-flowering phase, V5-EVALIA 1L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling and V6 RETENGO 0.5 LHA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling achieved higher yields compared to the untreated control variant, statistically assured.

3-Compared to previous years, slightly higher attacks of the *Blumeria graminis* f. sp. *hordei* fungus, producing barley's mildew, have been reported.

4-The Donau beer barley variety has proven to be quite resistant to the attack of phytopathogenic fungi of the genera *Pyrenophora* and *Blumeria* in the climatic conditions of the spring of 2023. V7 (untreated control variant) achieved a relatively good production (7.275 t/ha) in the climatic conditions of 2023, which were favorable to the attacks of phytopathogenic fungi of the mentioned genera.

5-The experiment was placed on a plot of land that was cultivated with rapeseed in the previous year. As a result, the inoculum reserve of the *Pyrenophora graminea* fungus left in the soil from the previous year was practically zero. Under these conditions, we appreciate that the general vegetation condition of the crop where the experiment was located was also very good due to the rapeseed that preceded the barley.

6-The price of barley, in mid-2024, stands at approximately 0.85 lei (approx. 0.17 €)/kg (Cereal Exchange 2024)

7-The yields obtained for the studied variants were significantly higher than those achieved in 2022. In 2023, the untreated control variant (V7) achieved 7.275 t/ha compared to 2022, when it achieved 5.508 t/ha.

8-As for the costs/ha of some plant protection products, they vary, in 2023, as follows:

- RETENGO costs about 200 lei/l – about 40 €/l. A single treatment was applied with 0.5 l/ha (100 lei/ha – 20 €/ha) to V3. 2 treatments were applied to V6, with 0.5 l/ha, i.e. a total of 1 l/ha (200 lei/ha – 40 €/ha).
- EVALIA costs 210 lei/l - 44 €/l. 1 l/ha (210 lei/ha - 44 €/ha) was applied to V2. 2 treatments were applied to V5, with 1.0 l/ha, i.e. 420 lei/ha - 88 €/ha.
- ORIUS 25 EW costs 100 lei/l - 20€/l. 0.5 l/ha (1 treatment) was applied to V1, i.e. 50 lei/ha - 20 €/ha. 2 treatments were applied to V4, with 0.5 l/ha, i.e. a total of 1 l/ha (100 lei/ha – 20 €/ha.

7-From the analysis of the economic profitability, it seems that, in the climatic conditions of 2023, which was rainier and cooler in the first 5 months, compared to 2022, the V3 variant turned out to be the most cost-effective (RETENGO 0.5 L/HA-; 1 treatment applied at booting-flowering phase) which at a yield increase of 230 kg compared to V7 (untreated control variant), offered a financial plus of 96 lei/ha, at a barley price of 0.85 lei/kg-0.17 €/kg. A similar financial addition was offered by V6 (RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling) of 95 lei/ha. But, in the case of V6, two treatments were applied and we have an additional cost, compared to V3, in terms of the expense of applying the second treatment.

The variants: V1-ORIUS 25 EW 0.5 L/HA, 1 treatment applied to booting-flowering phase, V2-EVALIA, 1L/HA, 1 treatment applied at booting-flowering phase and V4-ORIUS 0.5 L/HA, , 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling did not prove to be economically profitable

8-Barley grown after rapeseed, even in the conditions of a year more favorable to the attack of specific pathogens, behaves relatively well in terms of general phytosanitary status.

9-The average leu/€ exchange rate in April, May and June 2024 was 4.9751 lei/1€, according to the National Bank of Romania's website.

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