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PARAMETERS ANALYSIS OF THE *Ostrinia nubilalis* Hbn. ATTACK AT MAIZE CROPS IN THE CONDITIONS OF CENTRAL MOLDOVA

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Abstract

Maize is cultivated on 2,678.5 thousand ha in Romania, and its cultivation on large areas attracts a number of pests that attack various parts of the plant in different developmental phases. One of these dangerous pests is Ostrinia nubilalis Hbn., a species that occurs during the growing season of maize and causes production losses by the attack on the stem and cob. The larvae produce various attacks, influenced by climatic conditions, the frequency of attacked plants being between 15.7 and 67.9% in the south-west of the country, in the south-east of the country varies between 43.3-79.4%, in the Transylvanian Plain has values between 60.00% and 81.88%, in the west of the country the attack is around 41%, and in the east of the country by 30.20%. The importance of attacks by Ostrinia nubilalis Hbn. at maize led to the initiation of studies in 2019 at the A.R.D.S. Secuieni to determine the influence of technological factors on the parameters of attack (frequency of attack, average number of holes, galleries and larvae and average length of gallery) produced by larvae. For the maize sown in epochs, the optimal epoch, the IIIrd, recorded the lowest values of the parameters: the frequency of the attack was 18.65%, were identified 0.60 holes/plant, 0.39 galleries/plant and 0.38 larvae/plant, and the average length of the galleries was 8.39 cm. The behavior of genotypes at the attack produced by larvae varied within very wide limits, the frequency of the attack was between 36.56% at the early genotype Vibrion and reached 48.50% at the late genotype Olt.

Key words*: technological factors, frequency of attack, galleries, larvae, correlation.*

INTRODUCTION

Maize occupies important areas both in Romania and in Europe. At the level of 2020, in our country, the cultivated area with maize was 2.68 million ha, obtaining, on average, 4083 kg/ha (FAO STAT DATA, 2022). The temperate climate of the European continent offers favorable conditions for the cultivation of maize on large areas. Thus, the crop occupies 28,250 million ha in the north of the continent, the cultivated area increases significantly in the southern region (2.75 million ha) and western (2.41 million ha), while in Eastern Europe, maize is found on 14 million ha. Average yields range widely between 5449-6829 kg/ha in the eastern and northern regions of Europe and between 8556-9296 kg/ha in the south and west of the continent (FAO STAT DATA, 2022). Due to the wide distribution of maize cultivation, one of the most common pests is *Ostrinia nubilalis* Hbn. Among the stages of the insect, the most damaging is the larva, which creates holes on the stem, on the leaves, on the panicle or eats the grains on the cobs. Most often it bites and penetrates the stem where it creates galleries of different sizes. They weaken the plant's integrity, break the stem and reduce the plant's nutrient supply. The attack produced by the species *Ostrinia nubilalis* Hbn. is favorabile for the installation of fusariosis in a percentage of 23.9-41.9% and contributes to the contamination of grain production with mycotoxins (Jurca et al., 2009).

The literature recommends compliance with prevention measures to reduce the population and reduce the attack of larvae of *Ostrinia nubilalis* Hbn. by chopping maize crop residues, which reduce the chances of survival of mature larvae during the winter, by performing soil work (plowing and phoughed stubble field) which helps to reduce the population of insect larvae, by crop rotation, which reduces the attack of larvae on cultivated

areas with maize, by sowing at the optimum time, by using at sowing genotypes that showed a certain tolerance to larval attack, and in the years when the insect exceeds the Economic Damage Threshold (18% of plants have eggs or 1-2 larvae have been identified/plant), it is recommended to apply measures to control the larvae (Trotuș et al., 2021).

In Romania, one of the objectives regarding the improvement of maize remains the resistance/ tolerance to *Ostrinia nubilalis* Hbn., although for over 40 years, we have been working on the selection of genotypes resistant / tolerant to this pest, the frequency of larval attack is oscillating in hybrids. Analyzing the evolution of the attack, it is noted that between 2002-2004, the frequency of the attack was very low, only 2-17%, due to lower temperatures, below the multiannual average, and between 2018-2020 (23-33%) the frequency decreased damage due to heavy rains, from the period of vegetative growth of maize (Haș et al., 2021a; Haș et al., 2021b).

Internationally, extensive studies and research have been conducted on the tolerance of genotypes to larval attack as the species remains one of the major pests of maize on the European continent.

Bohn et al. (1999) analyzed the tolerance of dentate and flint maize genotypes, establishing that grain production decreased by 0.28% for every 1% of the attacked plant, and each larva identified inside the stem reduced the production potential by 6.05%.

Demirel and Konuskan (2017) found that plant damage caused by larvae was different at sweet maize. The damage of the larvae on the stem and cobs was different for each sweet maize hybrid, at the stem, the attack was between 32.45% (2015) and 59.34% (2016). Regarding the attack of larvae on cobs, it varied between 14.31% (2016) and 25.73% (2015).

Lopez-Malvar et al. (2021) found that there is a link between the high size of the plants and the length of the galleries, these genotypes having a longer vegetation period and a higher degree of susceptibility to larval attack.

Considering the importance of the attacks produced by the species *Ostrinia nubilalis* Hbn., in the maize crops from Central Moldova and not only, at A.R.D.S. Secuieni from 2019, researches have been initiated regarding the influence of the sowing epochs and the maize genotype on the attack produced by larvae.

MATERIALS AND METHODS

In order to achieve our proposed objectives, in the period 2019-2021, a series of experiences were placed in the experimental field of the Secuieni - Neamț Agricultural Research and Development Station.

The unit is located at geographical coordinates of 26°5' east longitude and 46°5' north latitude.

The experiments were placed in the field according to the randomized block method, in three repetitions and included the following experimental factors:

• five epochs sown from the first decade of April to the second decade of May;

• 11 maize genotypes: Deliciul Verii, Vibrion (FAO 290), Inventive (FAO 300) Turda 248 (FAO 300), Turda Star (FAO 370), Turda 344 (FAO 370), Method (FAO 380), Turda 332 (FAO 390); Kerala (FAO 400), Olt (FAO 430) and Messir (FAO 500).

One variant consisted of four rows of maize with a total area of 28 m^2 (10 x 2.8 m).

The experiments were located on a typical cambic chernozem type soil, with a pH of 6.29 in water, a humus content of 2.3, a nitrogen index of 2.1, a P_2O_5 content of 39 ppm, a K_2O content of 161 ppm.

The cultivation technology of this species was specific to the conditions in Central Moldova, in compliance with the experimental protocol (Trotuș et al., 2020).

In order to establish the attack caused by the pest, at the end of the vegetation period, plant samples were collected from each variant/ repetition and were established the parameters of the attack: frequency of attacked plants, average number of holes/plant, average number of galleries/plant, number of larvae/plant and length of galleries (cm).

The results obtained were interpreted using the analysis of variance and the correlation coefficient (r).

RESULTS AND DISCUSSIONS

The attack produced by the larvae of the species *Ostrinia nubilalis* Hbn. was influenced by the experienced sowing epoch.

From the analysis of the obtained results, it was found that the five epochs registered variations of the attack, between 22.5% (Ist epoch - the difference which was ensured statistically as distinctly significant) and 28.07% (IVth epoch - the difference which was ensured as very significant) compared to 18.65% as recorded at the optimal epoch (IIIrd epoch, control), where the attack was much lower (Figure 1).

The average number of holes/plant created by the larvae to enter the stem was between 0.60 holes/plant (IInd epoch) and 1.12 holes/plant (IVth epoch), a value almost double that was recorded in the IIIrd epoch - 0.60 holes/plant (Figure 1).

The average number of galleries/plant created by larvae at the attacked plants showed the lowest values for maize sown in the IIIrd epoch, was of 0.39 galleries/plant compared to maize sown in IVth and Vth epochs which recorded the most galleries (0.75 galleries/plant and 0.96 galleries/plant) (Figure 1).

Regarding the average number of larvae/plant, it is found that the maize sown in the Vth period had the highest number of larvae (1.15 larvae/plant) together with the one sown in the IVth epoch (0,83 larvae/plant) while maize sown in the optimal period (IIIrd epoch) showed the lowest number of larvae (0.38 larvae/plant), indicating that a large number of larvae find favorable conditions for feeding, perforating and consuming plant tissues (Figure 1).

The average length of the gallery/plant recorded values of 15.62 cm (Vth epoch) and 19.20 cm (IVth epoch), higher than the optimal epoch - 9.36 cm, and the differences were statistically assured as distinctly significant and very significant (Figure 1).

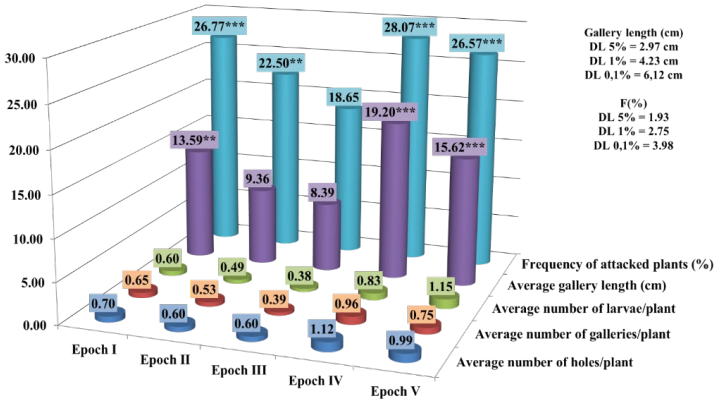

Figure 1. The evolution of the attack produced by the larvae of the species *Ostrinia nubilalis* Hbn. to the maize sown in different epochs, average 2019-2021

In the conditions of the Center of Moldova, it was found that the late sown maize provides favorable feeding conditions for the larvae, the attack being as intense as that recorded in the early sown maize.

The results obtained are in accordance with those published in the scientific literature. Mason *et al*. (1996) observed that the larvae create galleries in the stem and cobs depending on the phenological stage of the maize, in this case it will find the late sown maize more attractive and will produce more aggressive attacks through longer galleries, and the percentage of surviving larvae will increase. Pilcher and Rice (2001) and Anderson et al. (2003) argue that late sowing increases the level of attack by *Ostrinia nubilalis* Hbn. larvae compared to an earlier sowing epoch. The development of the crop is staggered and overlaps with the appearance of larvae that cause more damage to the stem and cob, which leads to a decrease in production of late-sown maize.

Štěpanek et al. (2008) studied the influence of several technological factors, including the sowing epoch, on the level of damage of the species *Ostrinia nubilalis* Hbn. Researchers find that late sowing significantly affects the percentage of plants attacked, reaching 53.9%.

Other important factors that favors the attack of larvae are the varied climatic conditions in June and July when adults appear, lay eggs and

hatch larvae, but also the oscillating population density of *Ostrinia nubilalis* Hbn.

The influence of the sowing epochs on the parameters led to the following correlations:

- a direct and very close correlation was established between the parameters the average number of holes/plant and the average number of galleries/plant, the correlation coefficient (r = 0.9354) was interpreted as distinctly significant, because one or more holes correspond to a single gallery (Figure 2);
- between the average number of galleries/plant and the average length of the gallery, the correlation coefficient was very significant (r = 0.9834), because several galleries were identified and their dimensions increased;

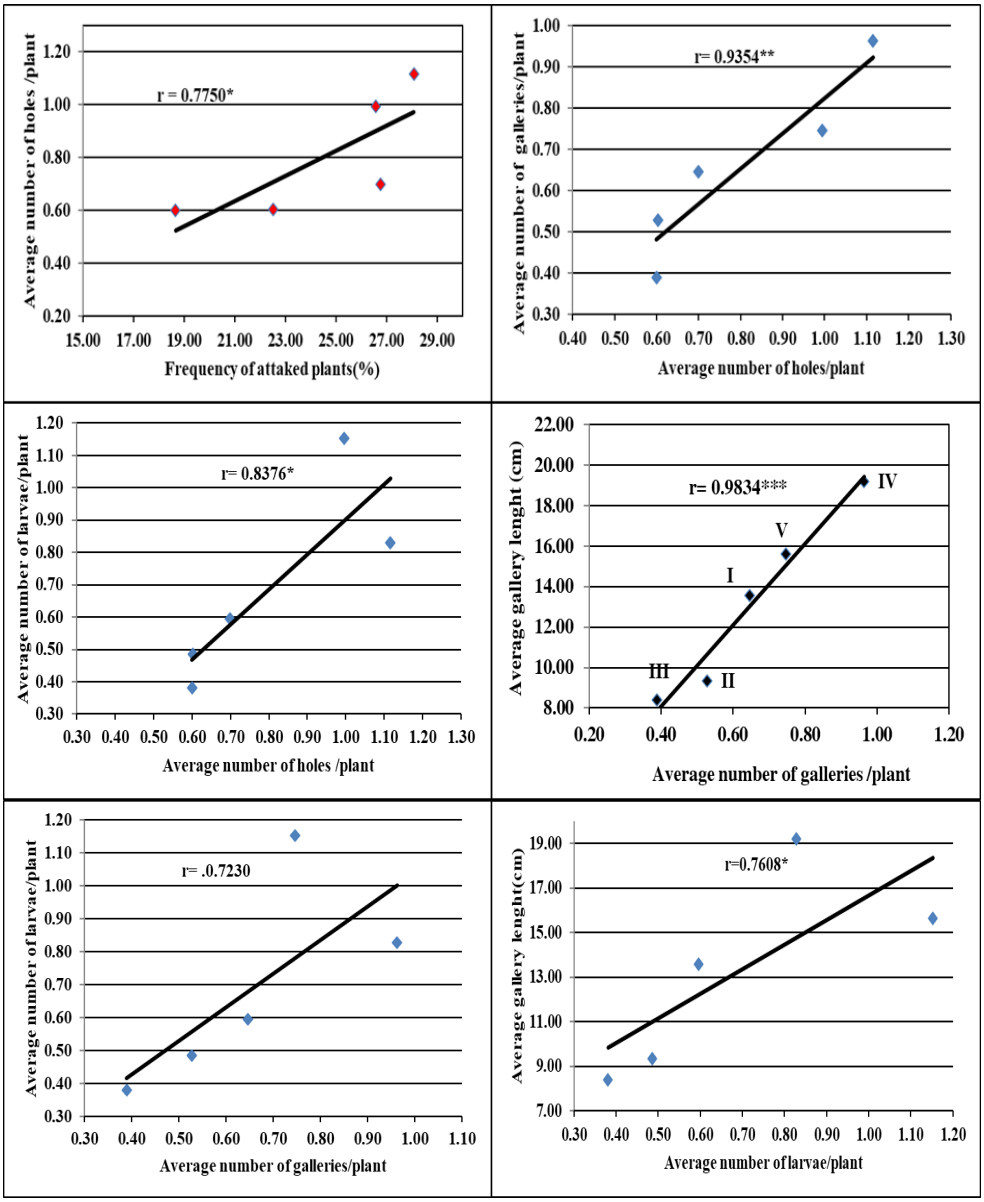

Figure 2. The influence of the sowing epoch on the attack parameters produced by the species *Ostrinia nubilalis* Hbn., average 2019-2021

- the correlation coefficient between the number of holes/plant and the number of larvae/plant was interpreted as significant (r = 0.8376), because the larvae that attack the maize plants create one or more holes on the same plant (Figure 2);
- between the frequency of attacked plants and the number of holes/plant, the correlation was direct, the correlation coefficient was interpreted significantly (r = 0.7750) and is due to the fact that more holes/plant were identified per plant than the percentage of attacked plants;
- regarding the correlation between the number of larvae/plant and the average length of the galleries, this relationship is direct and the correlation coefficient was interpreted as significant (r = 0.7608) due to the fact that parameters are determined at the end of the vegetation period and we cannot say for sure if this is the real number of larvae that have fed in the galleries;
- there was no correlation between the number of galleries/plants and the number of larvae/plants (r = 0.7230) because some of the larvae that enter the plants and create galleries, do not survive until the maturity of the maize, when plant samples were collected and sectioned (Figure 2).

The attack of larvae at maize genotypes varied according to their tolerance to the numerical pressure of the pest population and the climatic conditions during laying and hatching of the larvae.

From the 11 experienced maize genotypes, the highest frequency values had the Deliciul Verii (59.72%) and Turda 344 (64.56%) genotypes, the differences register were ensured as distinctly significant and very significant compared to the average experience (46.43%). The Vibrion, Turda Star and Messir genotypes had obtained lower attack values, the differences were assured and interpreted as significantly negative compared to the average experience (Figure 3).

Analyzing the number of holes created by the larvae per plant, it is observed that the favorite of the larvae was the maize with sweet grains, Deliciul verii (2.79 holes/plant) followed by the Kerala (1.72 holes/plant) and Turda 344 (1.75 holes/plant), which recorded the most holes compared to the average experience (1.29 holes/plant) and showed statistically assured differences and interpreted as very significant and significant (Figure 3).

Regarding the number of galleries/plant created by the larvae, it is found that most galleries were registered in the genotypes Deliciul Verii (2.20 galleries/plant) and Kerala (1.50 galleries/plant), which had statistically assured differences and interpreted as very significant and distinctly significant compared to the average experience (1.10 galleries/plant) (Figure 3).

The genotypes that had the lowest number of galleries/plant were Turda Star (0.57 galleries/plant), Vibrion (0.71 galleries/plant) and Messir (0.77 galleries/plant), the differences being statistically assured and interpreted as significant negative and distinctly significant negative compared to the average experience (1.10 galleries / plant) (Figure 3).

The number of identified larvae/plant varied, being between 0.55 larvae/plant (Messir) and 1.27 larvae/plant (Kerala), the average experience being 0.82 larvae/plant (Figure 3.). It is noted that five of the 11 hybrids had higher values of the average number of larvae/plant compared to the average experience, of 0.83 larvae/plant: Kerala - 1.27 larvae/plant; Method - 1.0 larvae/plant; Deliciul Verii - 1.07 larvae/plant, Inventive - 0.92 larvae/plant; Olt - 0.88 larvae/plant (Figure 3).

Regarding the average length of the gallery, it was found that the genotypes Deliciul Verii (30.94 cm) and Turda 344 (20.16 cm) were the longest galleries, compared to the average experience, the differences being statistically assured and interpreted as very significant and distinctly significant.

The smallest galleries were identified at the Messir (9.16 cm) and Turda Star (11.49 cm) genotypes compared to the average experience (16.87 cm). Also, longest galleries were recorded at Inventive (19.03 cm) and Turda 322 (17.58 cm), the rest of the genotypes having values below the average of the experience (16.87 cm) (Figure 3).

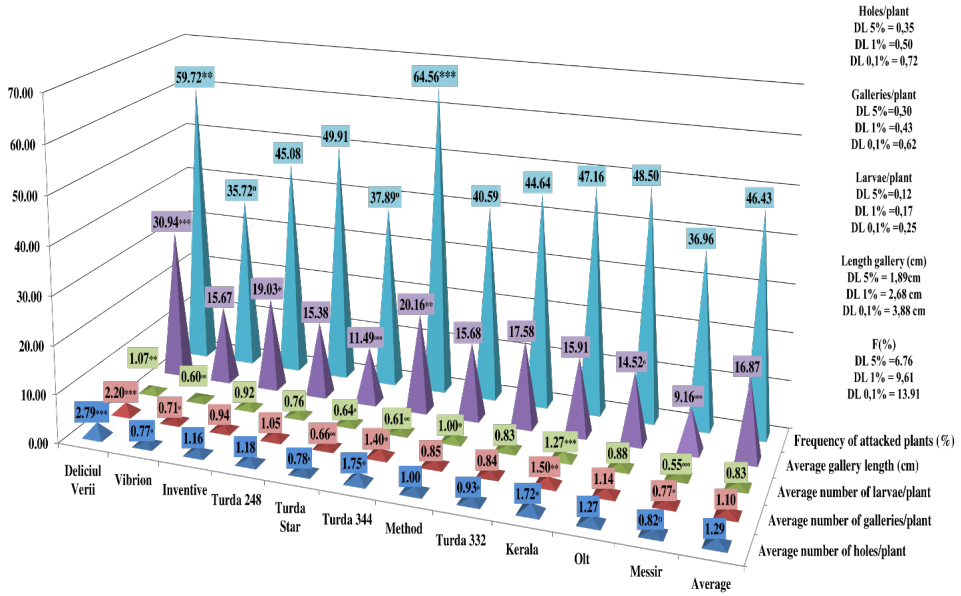

Figure 3. The evolution of the attack produced by the larvae of the species *Ostrinia nubilalis* Hbn. at different hybrids cultivated in the conditions of Central Moldova, average 2019-2021

Analyzing the frequency of attack at the maize genotypes according to the characteristics of the grains, it is observed that the sweet maize was deeply affected by the larval attack. From the point of view of the maturity group, there is an increase in the attack from early hybrids to late hybrids compared to the average experience:

- Kerala genotype has an attack rate (47.16%) close to average (46.43%), but the number of holes/plant (1.72) and galleries/plant (1.50) was much higher than the average experience and also most larvae/plant were recorded (1.27);
- at the Turda 332 genotype, the larvae created galleries of close size (15.91 cm) of average experiance (16.87 cm), and the number of holes/plant (0.93) and galleries/plant (0.84) recorded was below average;
- the attack parameters recorded for the Olt hybrid had values close to average (1.27 holes/plant, 1.14 galleries/plant, 0.88 larvae/plant, average gallery length of 14.50 cm, and attack frequency of 48.50%);
- Method genotype recorded a lower attack (40.59%) than average, several holes/plant (1.00) and galleries/plant (0.85) were identified, but the number of larvae/plant identified (1.00) was higher than the average experience (0.83);
- the Vibrion and Turda Star genotypes had low values of the parameters followed well below the experience average;
- Messir genotype had a lower attack (36.96%) than the average experience number of holes/plant (0.82), galleries/plant (0.77), larvae/plant (0.55) and length the average of the galleries was also much lower (9.16 cm);
- in the conditions of Central Moldova, the genotypes Deliciul Verii and Turda 344 recorded the highest values of the parameters followed compared to the average experience, being the most affected by the attack of larvae:
- the genotypes Inventive and Turda 248, had close values of attack (45.08% and 49.91%) of the average number of holes/plant (1.16 and 1.18), of the average number of galleries/plant (0.94 and 1.05), of the average number of larvae/plant (0.92 and 0.76), of the average length of the galleries (19.03 cm and 15.38 cm) of the average experience (46.43% attack, 1.29 holes/plant, 1.10 galleries/plant, 0.83 larvae/plant, 16.87 cm gallery length).

Analyzing the correlations recorded at the tested maize genotypes established between the parameters, the following were found (Figure 4):

- between the average number of holes/plant and the number of galleries/plant, a correlation coefficient was recorded which was interpreted

as very significant (r = 0.9947), for each hole a gallery was determined (Figure 4);
- a correlation coefficient was recorded between the average number of galleries/plant and the average length of the galleries, which was interpreted as significant (r = 0.8319) (Figure 4);
- the correlation coefficient between the two parameters, the frequency of the attacked plants and the average number of holes/plant was interpreted as significant (r = 0.8160), the attacked plants registering one or more holes;

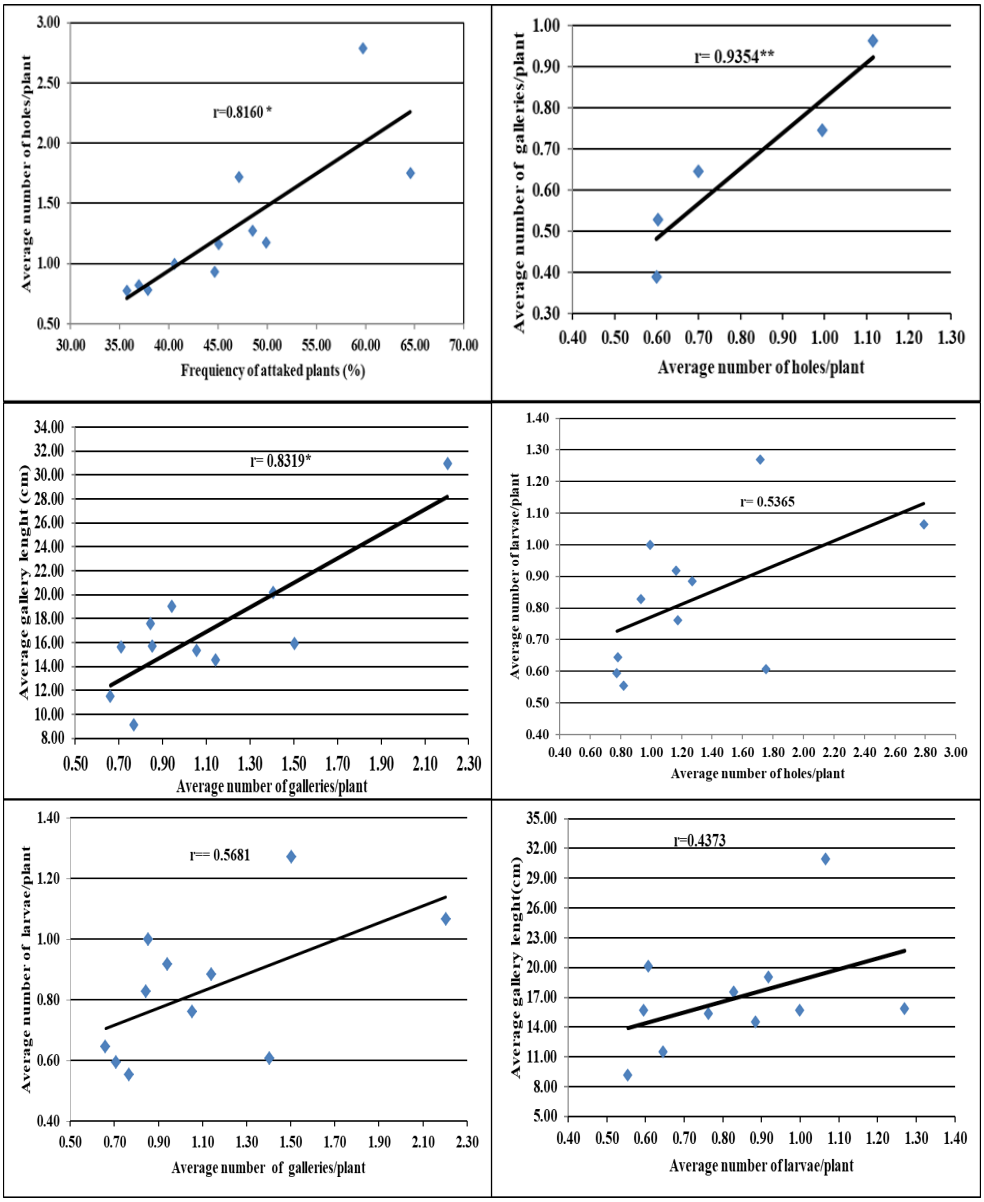

Figure 4. The influence of the Romanian and foreign maize genotypes on the attack parameters produced by the species *Ostrinia nubilalis* Hbn., average 2019-2021

- although the larvae managed to create holes, galleries of different sizes inside the plants, their lack of galleries was noticed, which suggests that they either perished or migrated to

other plants that offered more favorable feeding conditions. Thus, between these parameters, the average number of holes/plant and the average number of larvae/plant (r = 0.5365), the average number of galleries and the average number of larvae (r = 0.5681), the average number of larvae/plant and the average length of the galleries (r = 0.4373) established a positive correlation coefficient, but without statistical assurance (Figure 4).

The results obtained were similar to those published by other researchers in the literature. Lopez-Malvar et al. (2021) argues that the faster rate of development of early genotypes coincides with the appearance of the maximum flight peak, with the laying and hatching of larvae, which shows that the precocity of the hybrid will attract females to lay eggs. Also, as the plant evolves, it increases the hardness of the tissues that begin to lignify and strengthen the cell wall, which interrupts the progress of the larvae.

Sculz et al (1997) and Melchinger et al. (1998) reported significant variations in the genotypes analyzed in terms of production, frequency of attack and average length of galleries. They concluded that the results could help to improve the number of sources for obtaining genotype tolerance for *Ostrinia* attack by identifying genotypes that showed, reduced stem attack and small galleries.

Raspudic et al. (2009) monitored several FAO 450-700 late maturing maize genotypes over two years, finding that the average length of the galleries ranged from 13.70 to 29.20 cm (2007) and 40.84 to 64.42 cm (2008). The average number of larvae/plant ranged from 0,96 to 2.16 in 2007 and from 1.28 to 2.03 larvae in 2008, respectively. Regarding the two parameters, the length of the galleries and the number of larvae it was established that there is a significant positive correlation at all hybrids in both years.

In Croatia, the research conducted by Sarajlić et al. (2017) is highlighted the importance of temperatures and precipitation during the appearance and evolution of the insect. In unfavorable conditions, the appearance of adults is delayed by up to 10 days. The monitored genotypes recorded higher attacks in 2012, which was characterized by being dry and hot, while in 2014, the attack decreased due to the increase in rainfall and the decrease in average temperature. The researchers found that genotypes affected by larvae had 50% increases in the average length of the gallery (2012 - 24.97 cm; 2014 - 22.50 cm) compared to 2013 when the larvae created smaller average galleries of 10.87 cm.

Although Szulc et al. (2021) recorded reduced attacks of stay green genotypes, in our case the attack on genotypes with this trait, Inventive and Method had attack values close to average.

CONCLUSIONS

The largest number of holes, larval galleries and the longest galleries were recorded for maize sown in the IVth and Vth epochs.

From the point of view of the hybrid maturity group, there is a lower tolerance to larval attack on the studied genotypes and an increase in attack from early (Vibrion - 35.72%) to late hybrids (Olt - 48.50%) is observed.

In terms of grain variety, the sugar genotype Deliciul verii had the highest values of the frequency of attacked plants (59.72%) the number of holes/plant (2.79 holes/plant), the average number of galleries/plant (2.20 galleries/plant) and the average length of the gallery (30.94 cm).

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