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The Impact of the Sowing Time on the European corn borer (*Ostrinia nubilalis* Hubner) Attack on Some Romanian Hybrids

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ABSTRACT

European corn borer (*Ostrinia nubilalis* Hubner) it is the most representative maize pest, for the conditions of the Transylvanian Plateau. The reaction of maize hybrids to European corn borer attack can be influenced by several factors, including the sowing time. Certain corn hybrids show variable susceptibility to this pest. The aims of this study were to (i) evaluate the influence of maize sowing time on the natural attack incidence of European corn borer larvae on ear; (ii) determine the reaction of hybrids from different FAO maturity groups regarding the natural attack on ear of this pest. The research was carried out at Agricultural Research and Development Station (ARDS) Turda from 2021 to 2023, using as biological material 12 Romanian maize hybrids. The timing of sowing influences the susceptibility of maize hybrids to the attack of *Ostrinia nubilalis* larvae. When maize was sown at temperature by 10°C in soil, a decrease in natural attack of ECB larvae on ear was observed. Hybrids Turda 248, Turda 165, Turda Star, Turda 344 and Sur 18/399 are the most susceptible to European corn borer attack on ear while the most tolerant Turda 380, Turda 2020, HST 149 and HST 148.

Keywords: maize, hybrids, sowing time, European corn borer, incidence of the attack on ear.

INTRODUCTION

European corn borer (*Ostrinia nubilalis* Hubner) is one of the most important maize pests in Europe and USA (Bažok et al., 2020; Magagnoli et al., 2021). This pest was introduced to the USA from Hungary through the stalks used for brooms (*Sorgum bicolor*), from here the name European corn borer (Ionescu-Șișești, 1955; Kogan et al., 1999). In Romania it is the most representative maize pests.

European corn borer (ECB) is the most important pest following the tassel emergence (Roșca and Rada, 2011), attacking all the aerial organs of the maize plant (Tărău et al., 2024). The damage is caused by mature larvae tunnelling in stalks, tassels and ears (Franeta et al., 2019). The attack on stalks affects plant development, causing their breakage and, implicitly, the decrease in maize yield (Butron et al., 2009; Trotuș et al., 2018). While the yield loss from ECB attack on the ear is less significant than that from stalk tunneling, it is considered an important factor than favors the installation of pathogens (Sobek and Munkvold, 1999; Magagnoli et al., 2021; Kaçar et al., 2023) which depreciates the quality of the kernels (Avantaggiato et al., 2002; Blandino et al., 2015; Tiru et al., 2021; Kovács et al., 2023).

Research on the natural resistance of maize to ECB is and will remain essential (Kaçar et al., 2023). Ear resistance to ECB has been more thoroughly studied in sweet corn than in field maize (Malvar et al., 2008). Therefore, control measures against ECB larval activity are essential to ensure a less contaminated production (Dowd, 2003).

The climatic conditions are very important for the attack of ECB larvae (Georgescu et al., 2013, 2019; Waligóra et al., 2014; Lemic et al., 2019; Pintilie et al., 2023). Several climatic factors can influence the population dynamics of ECB larvae. Warmer temperatures can accelerate larval development, leading to an increase in the number of adults and, also, favour the attack (Georgescu et al., 2019). Adequate rainfall

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can help plant growth and vigor, which can affect the susceptibility of plants to ECB attack. This manifests with increased intensity in years with higher rainfalls (Roșca and Rada, 2011).

The incidence of ECB larvae can be influenced by the choice of maize hybrids. Certain maize hybrids can vary in their resistance or susceptibility to pests like ECB (Butron et al., 2009). In addition to chemical control, the cultivation of transgenic maize varieties expressing *Bt* proteins is one of the most commonly used tactics against ECB attack. In Europe, ECB populations are susceptible to transgenic maize *Bt*, but this technology is prohibited. However, in certain regions of North American countries lower levels of ECB mortality have been observed in response to maize expressing Cry1Ab. (Thieme et al., 2018; Smith et al., 2019).

In the absence of effective control measures for this pest, yield losses can range from 5% to 30% (Meissle et al., 2010).

Considering these aspects, it is necessary to implement various measures to reduce the damage caused by ECB larvae and minimize yield losses in maize crops. Due to climatic changes and in order to avoid the high temperatures during pollination, the adjustment of certain technological aspects is practiced, for example changing the sowing dates. These practices may also help reduce the attack of ECB larvae and (Pintilie et al., 2022) and also ensure satisfactory yields (Șimon et al., 2023).

The maize vegetation period, determined by the FAO maturity group, is a key factor in selecting suitable hybrids for cultivation in different areas of the country (Ursache et al., 2020). Furthermore, FAO maturity groups may vary in their vulnerability to the attack of ECB larvae (Bažok et al., 2020).

In this regard, the aims of this study were to (i) evaluate the influence of maize sowing time on the natural attack incidence of ECB larvae on the ear; (ii) determine the reaction of hybrids from different FAO maturity groups regarding the natural attack on ear of this pest in the Transylvanian Plateau conditions from Romania.

MATERIAL AND METHODS

The incidence of pests is an important parameter to assess when formulating integrated management strategies. Estimating this requires effective sampling strategies and technical expertise for accurately recording observations (Chandran et al., 2017).

In order to evaluate the influence of sowing time and climatic conditions on some maize hybrids in terms of ECB incidence on ear, an experiment was conducted at Agricultural Research and Development Station (ARDS) Turda (situated at a longitude of 23°47', a latitude of 46°35', and an altitude of 427 m). The experiment design was Completely Randomized Design (CRD) in three replications.

Observations and determinations on the natural attack of the ECB larvae on ear were carried out during the period 2021-2023.

The incidence of ECB was assessed on 25 randomly sampled ears at harvest from each plot. This parameter was calculated as the percentage of ears per plot with injury or apical and basal tunnels in the ear due to larva activity (Blandino et al., 2009).

Sowing time

The sowing time was established according to the temperature determined in the soil at a depth of 10 cm, at 8 o'clock in the morning: 4°C, 6°C, 8°C and 10°C (Șimon et al., 2024):

- sowing time I, when 4ºC were recorded in soil for three consecutive days (sowing date: 01.04.2021, 30.03.2022, 11.04.2023);
- sowing time II, when 6ºC were recorded in soil for three consecutive days (sowing date: 12.04.2021, 14.04.2022, 21.04.2023);
- sowing time III, when 8ºC were recorded in soil for three consecutive days (sowing date: 22.04.2021, 02.05.2022, 05.05.2023);
- sowing time IV, when 10°C were recorded in soil for three consecutive days (sowing date: 07.05.2021, 17.05.2022, 22.05.2023).

Biological material

Nine maize hybrids developed and registered at ARDS Turda and three perspective hybrids were studied. The hybrids analyzed in this study were from FAO groups: 270 (Turda 165); 300 (Turda 248); 340 (Turda 201); 350 (HST 148, HST 149, SUR 18/399); 370 (Turda Star) and 380 (Turda 332, Turda 344, Turda 335, Turda 2020, Turda 380).

The FAO groups 210-300 are early hybrids (Căbulea et al., 1999) and FAO groups over 300 are semi-early hybrids (Haş et al., 2017). Recent studies report that semi-early hybrids are better adapted to the conditions of the Transylvanian Plateau (Călugăr et al., 2024).

Statistical analysis

The obtained data were presented using the cluster analysis processed in Past4 statistical program. The Bray-Curtis distance can be used to describe the composition of insect communities which is why it was selected for the graphical representation of the experimental results.

RESULTS AND DISCUSSION

Between 2021 and 2023, the temperatures recorded during the maize growing season were above the multi-year average for most months, with deviations ranging from +1.3 to +4.2°C (Table 1). The summer of 2022 recorded the highest deviations from the average, ranging from 2.8°C to 3.3°C.

Also, Pintilie et al. (2023) noted a warming trend, with temperature deviations of +2.3°C in 2019-2020 and +1.0°C in 2020-2021.

Regarding rainfalls, there was a higher variability of this parameter during the maize vegetation period of the three analyzed years (Table 2). The period from April to October 2023 was the rainiest, while the same period of 2022 can be characterized as dry, compared to the other two years. In 2021, the recorded rainfall was generally normal with the exception of June and October, with a deficit of 39.8 and 24.0 mm, respectively. The conditions in July, with high temperatures and heavy precipitation, were favorable for both corn cultivation and the development of pests.

The occurrence of agricultural droughts in recent years has also mentioned in the Dobrogea region (Tautan et al., 2024).

Also, Mincu and Neculau (2024) noted that, in southern Romania, rainfall was deficient during the period 2021-2023.

Roșca and Rada (2011) stated that excessive temperatures and drought during egg laying reduce female fecundity and larval hatching, while heavy rains and strong winds cause early-stage larval mortality before they reach the leaf sheath or stem.

The data presented in Tables 1 and 2 highlight temperature increases in July 2022, accompanied a reduction in rainfall. It is possible that this trend is reflected in the small number of larvae and, implicitly, in the decrease of the ECB attack.

Table 1. Monthly average air temperature, 2021-2023 ARDS Turda

Month	Monthly average (ºC)	Multi-year average/ 65 years	Deviation	Characterization
2021				
April	7.8	9.9	-2.1	cold
May	14.1	15.0	-0.9	normal
June	19.8	17.9	**1.9**	warmly
July	22.7	19.7	**3.0**	warm
August	19.7	19.3	0.4	normal
September	15.0	15.1	-0.1	normal
October	9.7	9.5	0.2	normal
2022				
April	8.8	10.0	-1.2	coldly
May	16.3	15.0	**1.3**	warmly
June	21.1	18.0	**3.1**	warm
July	23.1	19.8	**3.3**	warm
August	22.3	19.5	**2.8**	warm
September	14.3	15.2	-0.9	normal
October	12.4	9.8	**2.6**	warm
2023				
April	8.8	10.0	-1.2	coldly
May	15.4	15.0	0.4	normal
June	19.0	18.0	**1.0**	warmly
July	21.8	19.8	**2.0**	warm
August	22.1	19.5	**2.6**	warm
September	19.0	15.2	**3.8**	warm
October	14.0	9.8	**4.2**	warm

Table 2. Monthly amount rainfall, 2021-2023 ARDS Turda

Month	Monthly amount (mm)	Multi-year average/ 65 years	Deviation	Characterization
2021				
April	38.4	45.9	-7.5	little dry
May	80.8	68.7	**12.1**	little rainy
June	45.0	84.8	-39.8	very dry
July	123.1	77.1	**46.0**	rainy
August	52.9	56.5	-3.6	normal
September	39.1	42.5	-3.4	normal
October	11.6	35.6	-24.0	excessively dry
2022				
April	42.5	45.6	-3.1	normal
May	82.9	69.4	**13.5**	little rainy
June	41.8	84.6	-42.8	excessively dry
July	25.2	78.0	-52.8	excessively dry
August	94.6	56.1	**38.5**	excessively rainy
September	119.9	42.4	**77.5**	excessively rainy
October	16.3	35.4	-19.1	excessively dry
2023				
April	30.5	45.6	-15.1	very dry
May	33.2	69.4	-36.2	excessively dry
June	144.5	84.6	**59.9**	excessively rainy
July	85.8	78.0	**7.8**	normal
August	98.5	56.1	**42.4**	excessively rainy
September	116.1	42.4	**73.7**	excessively rainy
October	19.8	35.4	-15.6	very dry

In Figure 1, cluster analysis and heatmaps illustrate the incidence of ECB larvae on the ear (%) in relation to climatic conditions, sowing time and hybrid. Gradations of colour from dark blue to red in the colour bar indicate the increase in value of the ECB incidence on ear (Dworak et al., 2016). The red color indicates a higher percentage of ECB incidence on the ear, while the blue color represents a lower percentage (Wang et al., 2020; Shami et al., 2023).

Based on the data (Figure 1), the incidence of ECB larvae on ear was higher in 2021 and 2023 compared to 2022. A decrease in natural attack of ECB larvae on ear was observed when maize was sown at 10°C.

The attack on ear of the analyzed hybrids varied depending on the sowing time and climatic conditions. The lowest attack on ear was recorded in 2022, for the hybrids Turda 201 and Turda 344, when they were sown at 4°C (46%); for the Turda 2020 hybrid, when it was sown at 6°C (48%) and 8°C (36%) for the hybrids Turda 380, SUR 18/399 and HST 148, when they were sown at 10°C (24%).

On the opposite side, in 2021, the hybrid Turda 332 exhibited the highest sensitivity to ear damage in 3 out of the 4 sowing times (4°C - 100%, 6°C - 99% and 8°C - 99%). Generally, a high incidence of the attack was also observed in the Turda Star, Turda 248 and Turda 2020.

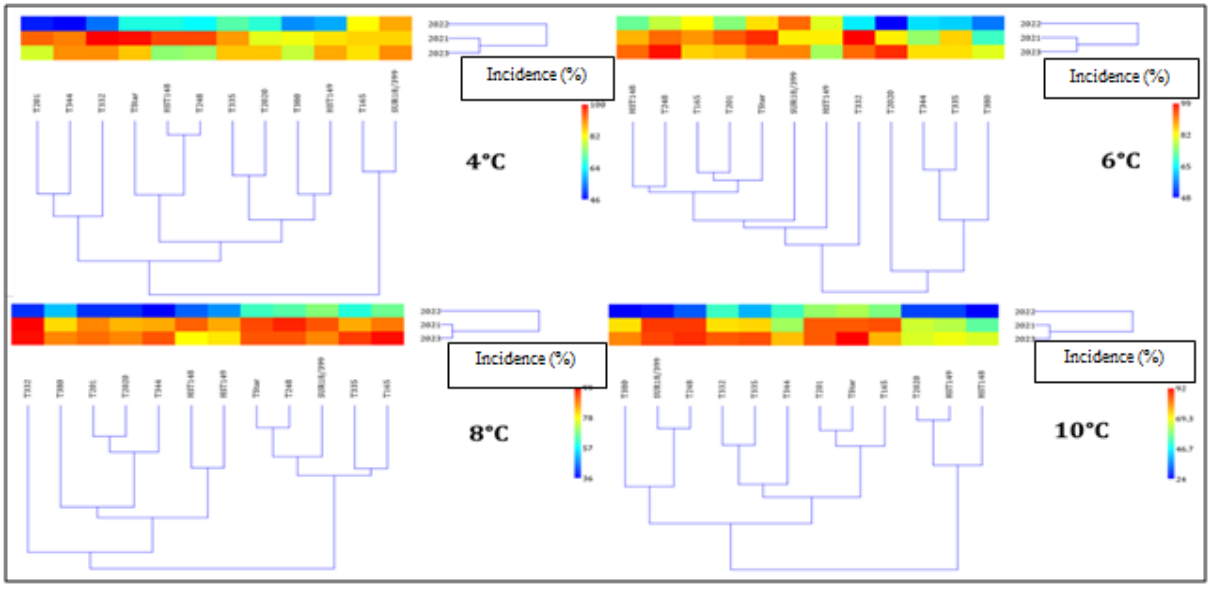

Figure 1. Incidence of ECB larvae on ear (%) depending on climatic conditions, sowing time and hybrid, Turda 2021-2023. The map uses a color scale where cool colors represent low values and warm colors indicate high values, with dark blue corresponding to the minimum and bright red to the maximum.

The incidence of ECB larvae on ear varied depending on the interaction established between experimental year and hybrid (Figure 2A). A very high incidence of ECB attack was observed in 3 of the 12 hybrids analyzed (Turda Star, Turda 165, SUR 18/399), regardless of the experimental year. Based on the cluster analysis, the newly developed hybrids (Turda 344, Turda 2020, Turda 380), as well as the perspective ones (HST 148, HST 149), exhibit high tolerance to ECB attack.

Regarding the impact of sowing time on the average incidence of the attack over the three years, the Turda 2020 hybrid and the perspective hybrids HST 148 and HST 149 were notable for their high tolerance when sown at 10°C (Figure 2B). In general, higher tolerance was observed in all hybrids when the maize was sown at 10°C, while early sowing leads to an increase in the incidence of ECB attack.

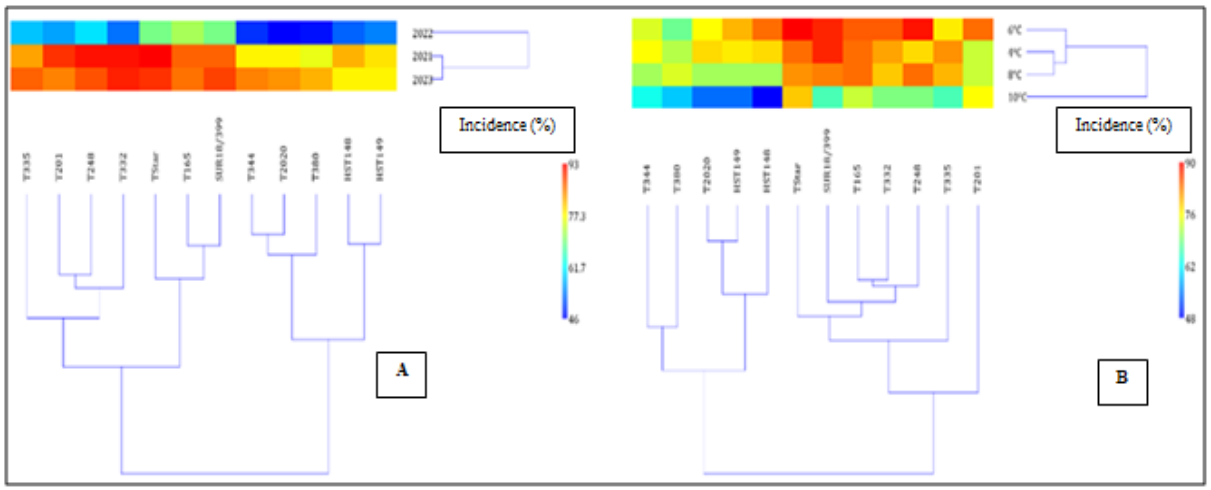

Figure 2. The influence of climatic conditions (A) or sowing time (B) on the incidence of ECB larvae on ear for each hybrid, Turda 2021-2023

The incidence of ECB larvae may vary according to different FAO maize maturity groups. Figure 3 shows a negative relationship between the maturity group of the hybrid and the incidence of ECB larvae on ear, which is significant when the maize was sown at 8°C. The percentage of damaged ears was higher in early hybrids compared to semi-early ones.

Ursache et al. (2020), under the conditions from Romania (in the Center of Moldova), studied 5 hybrids (3 semi-early, 1 semi-late and 1 late) to determine the impact of the FAO maturity group and the attack of ECB larvae. They stated that the low attack occurred in the semi-early hybrids (Turda Star, Turda 248 and Turda 332).

Also, Pereverzev et al. (2005) following a study with 28 maize genotypes in Spain and 23 in Portugal, from different FAO group, identified semi-early maize populations with dent grain that showed higher grain yields and reduced attack of ECB.

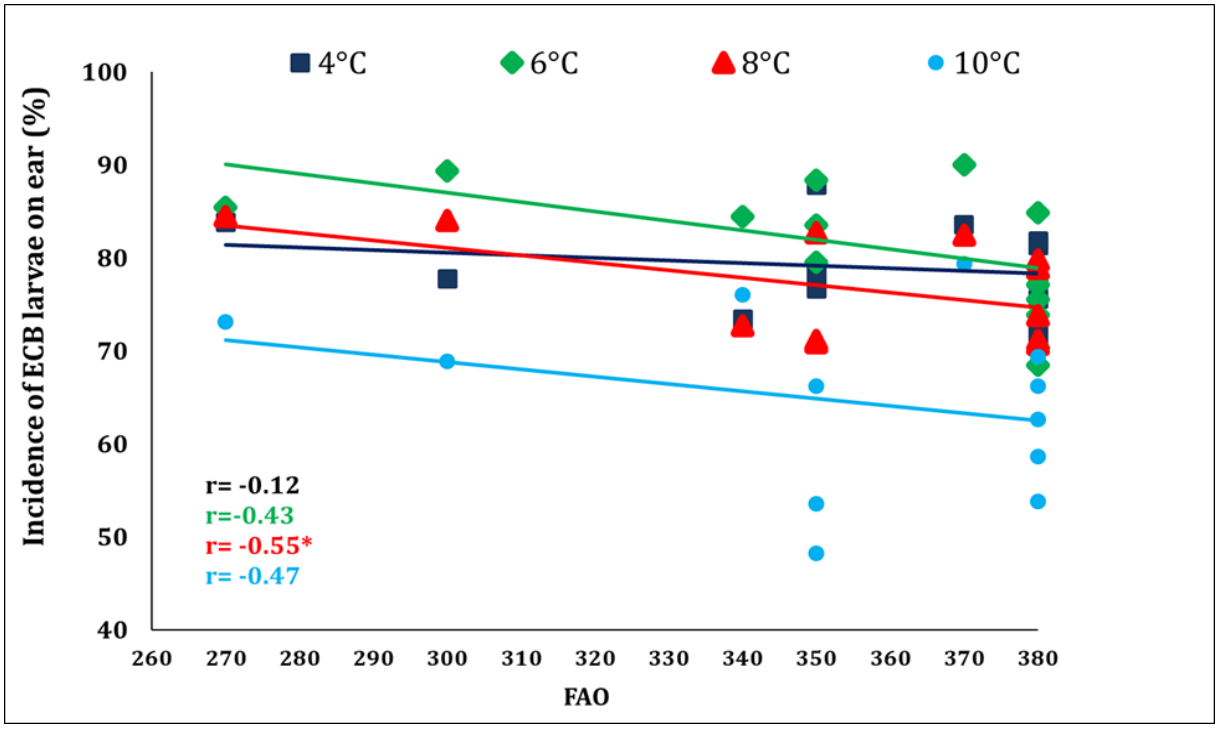

Figure 3. The relationship between the maturity group of the hybrid and the incidence of ECB larvae on ear, Turda 2021-2023

CONCLUSIONS

The sowing time influences the susceptibility of maize hybrids to the attack of European corn borer. When maize was sown at 10°C, a decrease in natural attack of European corn borer larvae on ear was observed.

While Turda 165, Turda Star and Sur 18/399 hybrids were the most susceptible to European corn borer attack on ear, a good tolerance for Turda 344, Turda 380, Turda 2020, HST 149 and HST 148 was observed.

There is a negative relationship between the FAO group and the incidence of European corn borer larvae on ear. The percentage of damaged ears was higher in early hybrids compared to semi-early ones.

Even if the use of hybrids tolerant to European corn borer attack is important, some agricultural practices such as sowing time can significantly reduce the damage caused by this pest.

The results of the study provide essential information for the optimization of agricultural practices and effective management of European corn borer, in order to maximize maize yield.

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