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Cotton bollworm (*Helicoverpa armigera* Hübner) – a key pest on sweet corn

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Abstract

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Cotton bollworm (*Helicoverpa armigera* Hübner) is a particularly dangerous pest on sweet corn. It is characterized by high ecological adaptability and a high life potential. An outbreak of the species is observed under favorable conditions, causing substantial damages, resulting in reduced yield and deterioration of the commercial product quality.

Studies were carried out in the 2016-2018 at the Experimental field of the Agricultural University, Plovdiv, Bulgaria. For our study we used 6 of the most commercial grown in our country sweet corn hybrids: „Challanger F1“, „Erica F1“, „Vega F1“, „Honey Bantam F1“, „GSS F1“ and „Denitsa F1“. The visual observation method was used. The damaged plants and fruit parts were established according to BBCH stages.

The results of the observations showed that the extreme conditions that occurred (high temperatures of 40-41°C, low relative humidity, lack of rainfall favored the outbreak of cotton bollworm (*H. armigera*) and the damaged cobs reached up to 70%.

The different hybrids of sweet corn were infested at various levels by cotton bollworm (*H. armigera*). The largest percentage of damaged fruit parts were established on the hybrids „Vega F1“ and „GSS F1“, 30 and 60%, respectively.

Keywords: cotton bollworm; sweet corn hybrids; damaged cobs

Introduction

Cotton bollworm (*Helicoverpa armigera* Hübner) is one of the species representing a significant economic risk to a number of agricultural crops. It is a cosmopolitan pest feeding on 170 plant species (Zalucki et al., 1994), including cotton, corn, sweet corn, tomato, legumes, asparagus and other vegetable crops (Liu et al., 2004; Talekar et al., 2006; Silva et al., 2017; Yunus, 2019; Schneider et al., 2019) in many regions of the world – Africa, India, Central and South-East Asia, Europe, Australia, New Zealand, etc. (Helson, 1972; Reed & Pawer, 1982; Scott, 1984; Zalucki et al., 1986; Fitt, 1989).

The larvae of *H. armigera* eat mostly the reproductive organs of the plants (Zalucki et al., 1986; Fitt, 1989; Moral Garcia, 2006; Perkins et **al**., 2008, 2009). Polyphagy, high mobility, high fecundity, and facultative diapause enable this pest to survive in various habitats, adapt to seasonal changes, and thus to achieve pest status (Fitt, 1989).

H. armigera is generally regarded as the most serious sweet corn pest worldwide and responsible for significant losses (Wiseman & Widstrom, 1992; Archer & Bynum, 1994).

Capinera (2008) reported that sweet corn (*Zea mays* L. var. *saccharata*) is more susceptible to *Helicoverpa spp.* than field corn. Several hybrid sweet corn varieties have been developed for more uniform maturity, improved quality with 5 to 20% sugar content and disease resistance.

The pest is an extremely adaptability species, some individuals can fly over several hundred meters and due to that it is widely spreader (Zalucki and Furlong, 2005).

According to a number of authors, such as Cameron et al. (1995); Scholz et al. (1998); Rajapaks & Walter (2007); Capinera, (2008), cotton bollworm is the most dangerous pest in

sweet corn in all the countries where the crop is commercially grown – Australia, New Zealand, Canada, the USA.

Sweet corn is much more infested by cotton bollworm, compared to common maize (Capinera, 2008). In some years the losses can reach up to 60-90%. The pest lays the eggs on different parts of the plant, a larger part of the eggs being laid on leaves (70.4%), on cobs (16.6%), on tassel (10.4%) and 2.6% only on the stem (Thanee, 1987). Most serious damages are caused by the second generation (Grigorov, 1976).

According to Firempong & Zalucki (1989) and Ruan and Wu (2001) the host plant has a significant influence on the development of cotton bollworm (*H. armigera*). Firempong & Zalucki (1989) studied the preferences of the species to different host plants under laboratory conditions and they established that the most preferred by cotton bollworm proved to be tobacco, sweet corn, sunflower, the least preferred – cabbage and flax and medium – soybean, cotton and alfa alfa.

According to Jha et al. (2012) most of sweet corn hybrids have uniform maturity and 5-20% sugar content.

Therefore, the aim of the study was to establish the occurrence and outbreak of cotton bollworm in sweet corn fields.

Material and Methods

Studies were carried out in the period 2016-2018 at the Experimental field of the Agricultural University, Plovdiv, Bulgaria, in fields with 6 of the most commercial grown in our country sweet corn hybrids: „Challanger F1“, „Erica F1“, „Vega F1“, „Honey Bantam F1“, „GSS F1“ and „Denitsa F1“. Size on experienced parcels 25 m^2, in each plot were tagged whit 10 plants in 3 replicates.

The results were reported following standard entomological methods: route observations, visual observations on labelled plants arranged in a cheeker board pattern over the entire planted area. Observations were conducted at 7-10 day intervals, throughout the period of season.

Statistical analysis

Significance differences among means between hybrids were determined using Duncan's multi range test. Values of $P<0.05$ were considered significant. Data were analyzed using Statgraphics Plus for Windows software package.

Results and Discussion

Cotton bollworm (*Helicoverpa armigera* Hübner) is a species with high nutritional adaptability and multi-year dynamics of population.

Meteorological conditions and nutritional hosts are determining factors for its development and outbreak.

In 2016, environmental conditions inhibited the pest development. The average daily temperatures in June reached 23.3°C and in July 25.6°C (Table 1). The maximum temperatures were 36°C in June and 36.5°C in July. The first eggs were laid on June 29 and the first caterpillar bites for the second generation on July 9 (Table 2). As a result of adverse conditions for the pest development, it is registered in a low density, resulting in minor damages were established 5% cobs only (Figure 1).

In 2017, the meteorological conditions were suitable for pest multiplying. In June, the average daily temperatures reached up to 23.7°C in July – 25.1°C. They are the result of rising maximum temperatures approaching 41°C in June and in July (Table 1).

Table 1. Agrometeorological characteristic of Plovdiv region

Months	Average day-and night, t°C	Reaching Maximum, t°C	Minimum, t°C	Rainfall, mm	Relative Humidity, %
2016					
April	15.5	31.0	8.58	30.7	69
May	17.0	32.2	11.3	64.7	73
June	23.3	36.0	16.9	59.7	67
July	25.6	36.5	18.2	20.7	56
2017					
April	12.7	27.5	5.00	26.1	62
May	17.6	31.5	11.0	52.7	68
June	23.7	41.2	17.1	15.4	60
July	25.1	41.0	17.8	29.8	58
2018					
April	16.4	30.5	8.70	25.0	65
May	19.9	30.2	14.5	112.3	73
June	22.0	33.2	15.6	118.9	68
July	24.3	34.5	19.3	94.7	67

Table 2. Reported characteristics of cotton bollworm during 2016-2018

Characteristics	Year		
	2016	2017	2018
First eggs observed	29 June	21 June	29 June
First damages observed	9 July	2 July	5 July

The first eggs in 2017 were set on June 21, 8 days earlier in comparison with other years of the investigation, and the first caterpillar bites in early of July, 7 days earlier than the previous year. As a result of the environmental conditions, the egg-laying period was prolonged, the Cotton bollworms were massively reproduced, which resulted to the increase in loses – 70% damaged cobs were reported (Figure 1, Figure 2). The caterpillars damaged the grains on the cobs, resulting in bad quality and low yield.

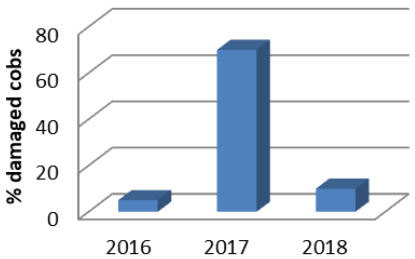

Fig. 1. Percentage of damaged cobs by the caterpillars of cotton bollworm (*H. armigera*) during 2016–2018

Fig. 2. Damages in corn cobs caused by cotton bollworm

In 2018, the cotton bollworm was reported at low density. The first eggs laid were observed on 29 of June, and the first caterpillars were detected on 5 of July. In the months of June-July the average daily temperatures were slightly lower than the previous year and reached up to 22.0°C in June and 24.3°C in July. The maximum temperatures for the period approach 33.2°C in June and 34.5°C in July. As a result of the created conditions, the enemy is found in low density, and therefore less damaged cobs – 10% only.

The differences in the pest development and abundance over the three years of the research are due to differences in environmental conditions and mainly the temperature. It is the highest in 2017, which is reason for the pest massively reproduced; therefore the damaged cobs are highest.

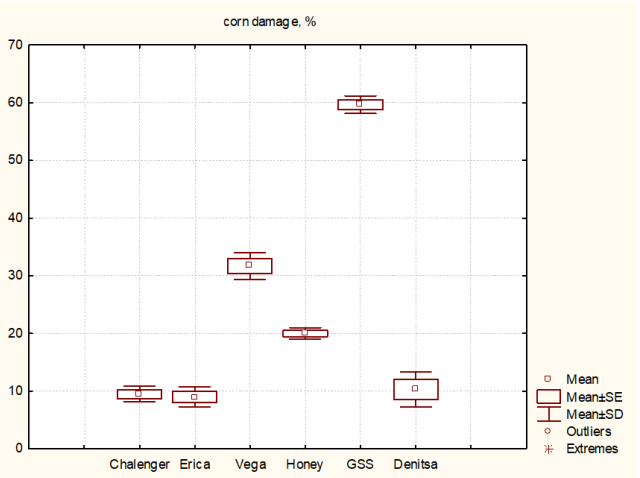

Fig. 3. The average sugar content of individual hybrids of sweet corn damage, %

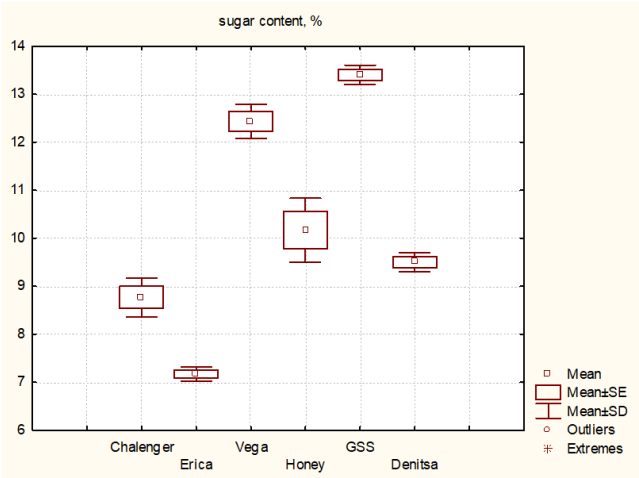

Fig. 4. The average sugar content of individual hybrids of sweet corn

Table 3. The average damage values for individual hybrids of sweet corn Group 1 vs. Group 2. T-test for Independent Samples (Hybrids-Damage)

	Mean 1	Mean 2	t-value	df	p
Chalenger vs.Erica	9.666667	9.00000	0.4000	4	0.709597
Chalenger vs.Vega	9.666667	30.66667	-11.1369	4	0.000370
Chalenger vs.Honey B	9.666667	20.33333	-7.1554	4	0.002019
Chalenger vs. GSS	9.666667	59.66667	-33.5410	4	0.000005
Chalenger vs.Denitsa	9.666667	10.00000	-0.1387	4	0.896408
Erica vs.Vega	9.000000	30.66667	-11.6743	4	0.000308
Erica vs.Honey B	9.000000	20.33333	-7.8001	4	0.001457
Erica vs. GSS	9.000000	59.66667	-34.8712	4	0.000004
Erica vs.Denitsa	9.000000	10.00000	-0.4201	4	0.696008
Vega vs.Honey B	30.66667	20.33333	6.0796	4	0.003699
Vega vs.GSS	30.66667	59.66667	-17.0621	4	0.000069
Vega vs.Denitsa	30.66667	10.00000	8.1410	4	0.001239
Honey B vs. GSS	20.33333	59.66667	-31.5368	4	0.000006
Honey B vs.Denitsa	20.33333	10.00000	4.5707.	4	0.010255
GSS vs. Denitsa	59.66667	10.00000	21.96885	4	0.000025

Note: Variables were treated as independent samples

Table 4. The average sugar content of individual hybrids of sweet corn. T-test for Independent Samples (sugar)

	Mean 1	Mean 2	t-value	df	p
Chalenger vs.Erica	8.566667	7.53333	4.1425	4	0.014347
Chalenger vs.Vega	8.566667	12.43333	-13.2194	4	0.000189
Chalenger vs.Honey B	8.566667	10.26667	-3.8775	4	0.017880
Chalenger vs. GSS	8.566667	13.26667	-17.9070	4	0.000057
Chalenger vs.Denitsa	8.566667	9.73333	-4.4450	4	0.011290
Erica vs.Vega	7.533333	12.43333	-24.8475	4	0.000016
Erica vs.Honey B	7.533333	10.26667	-7.1644	4	0.002009
Erica vs. GSS	7.533333	13.26667	-38.4604	4	0.000003
Erica vs.Denitsa	7.533333	9.73333	-14.7580	4	0.000123
Vega vs.Honey B	12.43333	10.26667	5.27220	4	0.006203
Vega vs.GSS	12.43333	13.26667	-3.90434	4	0.017477
Vega vs.Denitsa	12.43333	9.73333	12.65007	4	0.000225
Honey B vs. GSS	10.26667	13.26667	-7.68922	4	0.001539
Honey B vs.Denitsa	10.26667	9.733333	1.36697	4	0.243420
GSS vs. Denitsa	13.26667	9.733333	20.78831	4	0.000032

Note: Variables were treated as independent samples

Sugar content is an essential criterion for the taste qualities of the various sugar corn hybrids and one aspect of modern crop breeding is its continuous increase. Following the harvesting of the plants, biochemical studies were carried out, which took into account the sugar content of the cobs damaged by the cotton night in six hybrids of corn. The established sugar content in the different hybrids was as followed – „GSS F1“ – 13.2%, „Vega F1“ – 12.45%, „Honey Bantam F1“ – 10.05%, „Denitsa F1“ – 9.75%, „Challenger F1“ – 8.55%, and „Erica F1“ – 7.47% (Figure 4, Table 4).

The highest percentage damaged cobs were reported with „GSS F1“- 60%, and „Vega F1“- 30%, followed by „Honey Bantam F1“- 20% (Figure 3, Table 3). In terms of the parameters determining the overall vegetative habitus, these hybrids have some common morphological and biological features: brotherhood, formed by standard cobs, which implies a better nutrient environment for the development of the host.

The rest of the hybrids – „Challenger F1“, „Erica F1“, „Denitsa F1“ hybrids, with a lower sugar content, have 10% damaged cobs.

Studies have shown that caterpillars cause more damage on hybrids with higher sugar content. Damages, caused by the caterpillars of the second generation of Cotton bollworm leads to a deterioration of the grain quality on the cobs and create conditions for secondary pathogens development.

Conclusions

In 2017, the first egg production and second-generation caterpillar damage occurred earlier than the other two years, because the temperatures, which are significantly highest during the season.

The second generation of cotton bollworm causes the highest level of damages in sweet corn cobs.

The different sweet corn hybrids are infested at various levels by cotton bollworm, because the species prefer hybrids of higher sugar content, such as „Vega F1" and „GSS F1".

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