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PEST MONITORING AND EFFICACY OF PLANT EXTRACTS FOR CONTROL OF COTTON BOLLWORM (*HELICOVERPA ARMIGERA* HÜBNER) (*LEPIDOPTERA*; *NOCTUIDAE*) ON SWEET CORN (*ZEA MAYS SSP. SACCHARATA* STURT.)

SUMMARY

The cultivation of sweet corn is accompanied by a number of plant protection problems. It is attacked by lot of pest, cause significant damage to the cobs, deteriorate the commercial properties and cause significant economic losses. In this regard, surveys were conducted in the period 2019-2020 in the sweet corn fields in the area of the village of Planinitsa, Burgas region, Bulgaria. Standard entomological methods were used to estimate pest densities. A mixture of plant extracts from walnut (*Juglans regia* L.), ailanthus (*Ailanthus altissima* Swing.) and tobacco (*Nicotiana tabacum* L.) was tested against cotton bollworm caterpillars (*Helicoverpa armigera* Hübner).

Sweet corn is attacked by a large number of omnivorous and specialized pests. Two critical periods are: Period I–phase 5^{th}-7^{th} leaf, in relation to weevils; and Period II–the paniclephenophase, when european corn borer (*Ostrinia nubilalis* Hübner) and cotton bollworm (*Helicoverpa armigera* Hübner) appear.

In 2019, 5% of cobs were reported as damaged by corn borer and 35% - by cotton bollworm, and in 2020, 10% and 65%, respectively. The data from the obtained results show that the mixture of plant extracts exhibits good efficacy and can be included as an alternative means of controlling cotton bollworm in integrated plant protection systems.

Keywords: corn, pests, *Helicoverpa armigera*, plant extracts, efficacy

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INTRODUCTION

Sweet corn is attacked by more than 141 pests that affect its vegetative and generative organs (roots, stems, leaves and cobs). They occur from sowing to harvest, resulting in reduced yield and commercial qualities (Reddy and Trivedi, 2008; Rosa *et al*., 2010).

In the initial phenophases of the cropdevelopment, serious damage to underground parts is caused by omnivorous pests: wireworms (family *Elateridae*), cutworms (family *Noctuidae*) and white worms (family *Melolonthidae*) (Li *et al*., 2004; Bessin, 2010; Foster, 2017). They spend most of their lives in the soil and can destroy young plants.

Species of genera *Agrotis, Euxoa, Noctua,* and *Spaelotis* were found among subterranean *Noctuidae* in sweet corn fields (Randall, 2019). During the day they hide in the soil and at night they feed by gnawing on the panicles and underground stems near the soil surface. The most common of them are: Turnip moth (*Agrotis segetum* Schiff.) and *Euxoa temera* Hb. (Randall, 2019).

As the crop growth progresses, the following bring a detrimental effect: maize leaf weevil (*Tanymecus dilaticollis* Gyll.), beet leaf weevil (*Tanymecus palliatus* F.), cereal leaf beetle (*Oulema melanopus* L.), corn leaf aphids (*Rhopalos iphummaidis* Fitch.) and European corn borer (*Ostrinia nubilalis* Hbn).

According to a number of authors Paulian (1972; 1978), Bărbulescu *et al*., (2001), Cristea e*t al*., (2004), Popov and Bărbulescu (2007), Georgescu *et al*., (2014; 2018), Trotus *et al*., (2019) and Toader *et al*., (2020) the maize leaf weevil attacks more than 34 plants and is one of the key pests on sweet corn.

In the 3rd-6th leaf phenophase, the cereal leaf beetle and corn leaf aphids from family *Aphididae* pose a serious threat.

Significant damage to the generative organs is caused by: the cotton bollworm and european corn borer (Randall, 2019).

According to Li *et al*., (2004) the species: *Ostrinia furnacalis* (Guenee), *Spodoptera exigua* (Hubner), *Spodoptera litura* (Fabricius) and *Helicoverpa armigera* (Hubner) are pests with economic risk to the crop.

Worldwide, *H. armigera* is considered the most severe pest on sweet corn (Archer and Bynum, 1994). The cotton bollworm has been identified as a key pest on sweet corn in West Java Province, along with *Ostrinia furnacalis* Guen (*Lepidoptera; Crambidae*).

Popov and Bărbulescu (2007) identified cotton bollworm and European corn borer as key pests on sweet corn in Serbia, especially under global warming conditions. Plant damage caused by these pests greatly impairs the commercial properties (Hagerman, 1987; Hazzard and Westage, 2005), which, combined with inadequate agronomic equipment, can completely compromise the crop.

Cotton bollworm mainly prefers sweet corn rather than cotton and corn (Capinera, 2008). In some years, losses can reach up to 60-90%. The pest lays its eggs on different parts of the plant, the most being laid on the leaves -70.4%, 16.6%-on cobs, 10.4% on silk and only 2.6% on the stem (Thanee, 1987). The most serious damage is caused by the caterpillars of the pest's second generation (Grigorov, 1976).

In a number of countries around the world (Pakistan, China, India, Australia, Thailand and Indonesia) the resistance of *H. armigera* to the insecticides used for controlwas established, therefore alternative methods and means are being researched (Daly and Murray, 1988; Ahmad *et al.*, 1988, 1997, 1998, 1999, 2001; Forester *et al.*, 1991, 1993; Armes *et al*., 1992a, 1992b, 1994; Gunning, 1994; Gunning and Easton, 1994).

Mohammad (2019) indicated that cotton bollworm is a persistent problem for sweet corn farmers. In this regard, he tested the efficacy of various insecticides in order to reduce its population: P1 - biological insecticide (*Beauveria bassiana* 5 gl^{-1}), P2 - botanical insecticide (pandan leaves 5 $ml.l^{-1}$) and P3 - chemical insecticide (*Deltamethrin*, synthetic pyrethroid 3 $ml.l^{-1}$). Of all the applied insecticides, the highest efficacy was reported for the biological insecticide based on *Beauveria bassiana*. The best cost-effectiveness ratio was again observed with the application of the biological insecticide, followed by the botanical and lastly the chemical insecticide.

Botanical insecticides are chemicals with insecticidal properties extracted from the plants. Botanical insecticides allegedly cause little threat to the environment and almost none to plants, affect only targets insects, delay evolution of insecticide resistance, compatible with other pest control strategies, and produce healthy agricultural products free from synthetic insecticide (Subiyakto, 2011). The application of plant-based insecticides is useful in controlling caterpillars and is compatible with biological control techniques and biopesticides (Sunarto, 2009).

Several earlier studies have reported that plant extracts have successfully managed noxious insect pests Ciniviz and Mutlu (2020), Mutlu *et al*., (2020), Teke and Mutlu (2021).

In this regard, the aim of the present study was to identify the harmful entomofauna of sweet corn and to test the efficacy of plant extracts against the cotton bollworm on sweet corn.

MATERIAL AND METHODS

The studies were conducted during the period 2019-2020 in fields sown with Syndon sweet corn hybrid, in the area of the village of Planinitsa (N 42°.89’16’’; E 27°.15’51’’) Burgas region, Bulgaria on an area of 3 ha. Observations were conducted during the entire growing season periodically, every 7-10 days. Standard entomological methods were used to report pest density.

In order to protect the beneficial species and pollinators, a mixture of plant extracts from walnut, ailanthus and tobacco was tested under field conditions.

The experiment was set up by the randomized block design in two variants, each in three replicates: I – treated and II – untreated. Observations and reports on the phenological development of the cotton bollworm in the experimental plot were carried out on 20 marked plants per variant, on the 2^{nd} and 7^{th} day after treatment, respectively.

The obtained results were processed mathematically by comparing the mean values.

RESULTS AND DISCUSSION

Harmful entomofauna in the agrocenosis of sweet corn is characterized by high species diversity. In individual years, the pests multiply massively and have a significant impact on yield formation and production quality.

In the initial phenophases of sweet corn development (sowing–germination), soil-dwelling pests pose a risk. They gnaw the germ and endosperm of the swollen seeds, of which only the shell remains. In germinated seeds, larvae damage panicles. These include: wireworms (family *Elateridae*) genus *Agriotes*, white worms (family *Melolonthidae*) genus *Melolontha*, and cutworms (family *Noctuidae*) genus *Agrotis*. In the corn crops, they were all found in mixed populations and in low density – 1-2 pcs/m^2 during the study period (Fig. 1). At the same time were found larvae of the *Pedinus femoralis* (family *Tenebrionidae*). They were counted in a higher density – 2-3 pcs/m^2

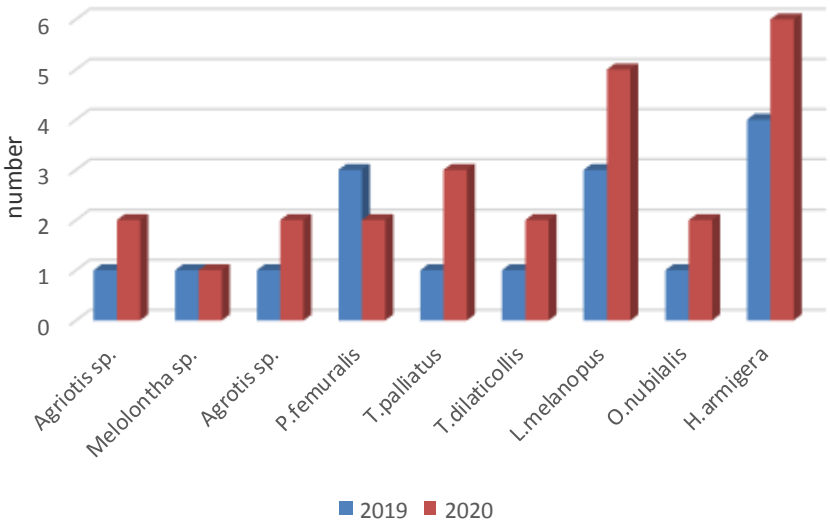

Figure 1. Species composition and density of the most significant pests of sweet corn in 2019-2020

From the emergence phase to the 5th-7th leaf of the sweet corn, serious damage was inflicted by the weevils: maize leaf weevil (*Tanymecus dilaticollis* Gyll.) and beet leaf weevil (*Tanymecus palliatus* F.). They were found in mixed populations. Their density ranged from 1 pc/m^2 in 2019 to 2-3 pcs/m^2 in 2020. At the same time, cereal leaf beetle (*Lema melanopus* L.) appeared in the sweet corn fields. The density was 3 pcs/m^2 in 2019 and 5 pcs/m^2 in 2020 (Fig. 1).

Of the sucking pests, single colonies of corn aphids, specifically *Rhopalosiphum maidis*, were found in the sweet corn fields. In the 6th-8th leaf phenophase, they occurred in low density (score 1) in both study years.

On the generative organs of sweet corn, serious damage was caused by cotton bollworm and European corn borer. The higher density among them was reported for the cotton bollworm at 4 pcs/m^2 in 2019 and 6 pcs/m^2 in 2020, respectively. The European corn borer was reported in a lower density, 1-2 pcs/m^2 in the two years of research. The young caterpillars of cotton bollworm first fed on the silk, made trails in the cobs and filled them with excrement. European corn borer caterpillars damaged the panicle, stem and cob kernels. Damage from these pests directly affected the yield and quality of produce. In 2019, the average yield was 2,300 cobs of first quality, and in 2020–1,900 cobs of first quality.

During the study period, the pest-inflicted damage to the generative organs of the plant and its reflection in the quantitative aspect were monitored.

The conducted observations showed that in 2019 the European corn borer attack was weak -5% of the damaged cobs, and 35% caused by cotton bollworm (Fig. 2). In 2019, the environmental conditions suppressed pest development and as a result the damage from them was also low. During this period, the average temperatures were lower than in 2020 and reached 24°C, whereas the maximum it was 38°C.

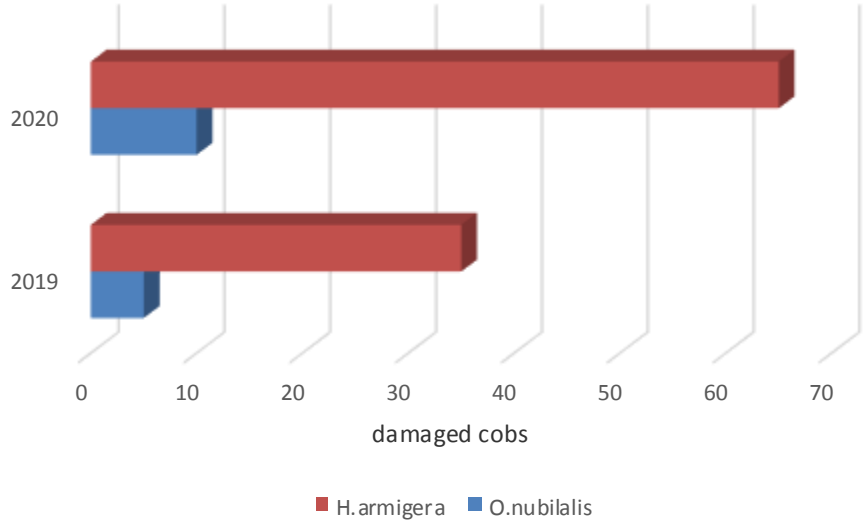

Figure 2. Cobs damaged by European corn borer and cotton bollworm caterpillars in 2019-2020.

In 2020, the European corn borer and cotton bollworm were found in higher densities, resulting in greater damage. The cob damage by the european corn borer reached 10%, and 65% inflicted by the cotton bollworm. The average temperatures for the period reached 26°C, which was due to the higher maximum temperatures approaching 40°C.

The differences in the development of European corn borer and cotton bollworm during the two study years were due to environmental factors, mainly temperature. It was higher in 2020 and, consequently, they multiplied in higher numbers and significant damages were found.

The following plant extracts from: *Juglans regia* L., *Ailantthus altissima* Swing. and *Nicotiana tabacum* L. were tested for the control of cotton bollworm.

Before treatment in the individual variants, there was no proven statistical difference, which can be seen in Table 1 and Figure 3. The calculated significance level p=0.185196 was significantly greater than the threshold p=0.05.

Table 1. Comparison of mean values from the different variants before treatment

T-test for Independent Samples (cotton bollworm before treatment)	
	treated vs. untreated
Mean1	2.833333
Mean2	3.100000
t-value	-1.33271
df	118
p	0.185196
Valid N1	60
Valid N2	60
Std.Dev.1	1.076193
Std.Dev.2	1.115378
F-ratio	1.074146
p	0.784460

Figure 3. Comparison of mean values in the different variants before treatment

On the second and seventh days, the efficacy of the used mixture of plant extracts was clearly visible (Tables 2 and 3). The number of caterpillars in the treated plots was statistically proven to be lower than in the untreated ones. On both the second and the seventh day, the level of significance (p=0.000000) was significantly lower than the marginally acceptable (p=0.05). The above stated is clearly visualized in Figures 4 and 5.

Table 2. Comparison of mean values from the different variants on the 2nd day

T-test for Independent Samples (cotton bollworm after 48 h)	
	treated vs. untreated
Mean1	1.450000
Mean2	3.100000
t-value	-9.43565
df	118
p	0.000000
Valid N1	60
Valid N2	60
Std.Dev.1	0.768556
Std.Dev.2	1.115378
F-ratio	2.106169
p	0.004850

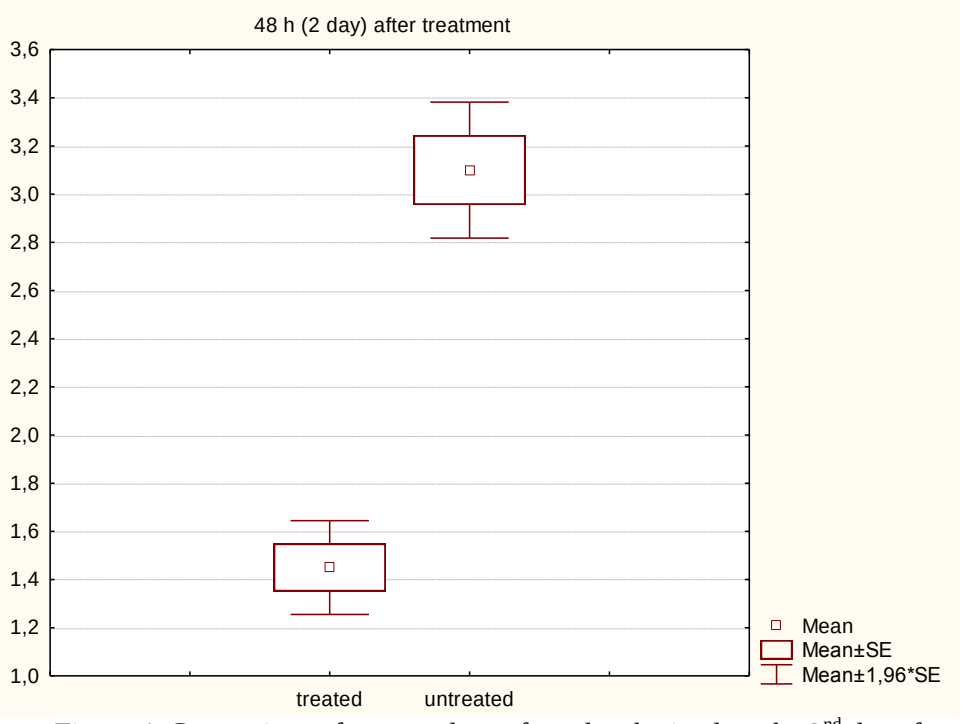

Figure 4. Comparison of mean values of results obtained on the 2nd day after treatment

Table 3. Comparison of mean values from the different variants on the 7th day

T-test for Independent Samples (cotton bollworm after 168 h) Note: Variables were treated as independent samples	
	treated vs. untreated
Mean1	0.333333
Mean2	3.100000
t-value	-17.6752
df	118
p	0.000000
Valid N1	60
Valid N2	60
Std.Dev.1	0.475383
Std.Dev.2	1.115378
F-ratio	5.505000
p	0.004850

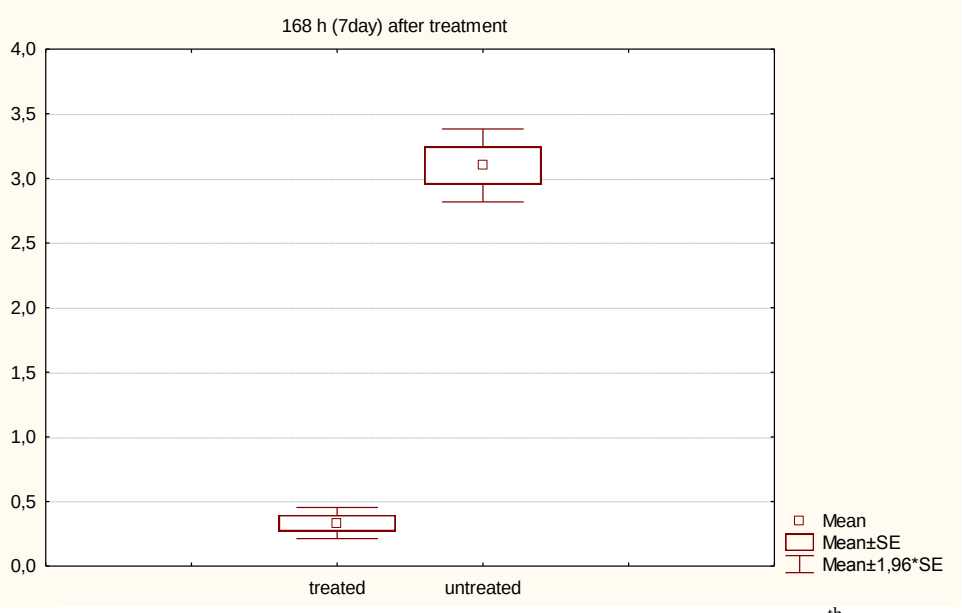

Figure 5. Comparison of mean values of results obtained on the 7th day after treatment

The used mixture of plant extracts can be applied in integrated plant protection systems against cotton bollworm, while protecting the beneficial entomofauna, pollinators and not contaminating the produce.

The results of the study confirm the results of Archer and Bynum (1994), Capinera (2008), Mohammad Y. (2019), according to which the cotton bollworm is a main pest of sweet corn and causes significant damage. Its caterpillars gnaw

the grains in the cobs, and when they feed on the cob silk, they prevent pollination of the plants.

The obtained experimental data regarding the plant extracts are in sync with those cited in the literature. Kamaraj *et al*., (2008), Ali *et al.*, (2021) tested the efficacy of plant extracts of *Citrus sinensis, Ocimum canum, Ocimum sanctum, Rhinacanthus nasutus, Azadirachta indica*, *Curcuma* sp., *Allium sativum,* and *Polygonum hydropiper* against *H. armigera* and found that, that they all exhibit good efficacy against the enemy. The authors recommend their use in practice as an ecological approach to cotton bollworm control.

CONCLUSIONS

As a result of the conducted research, the following conclusions can be drawn:

•Sweet corn is attacked by lot of number pest. The critical periods for control of sweet corn enemies have been established (I period - from the germination phase to the 5-7th leaf, the gray corn borer (*Tanymecus dilaticollis* Gyll.) and the gray beet borer are a serious danger (*Tanymecus palliatus* F.) and II period - phenophase sweeping, serious damage is caused by the corn stem borer (*Ostrinia nubilalis* Hübner) and the cotton bollworm (*Helicoverpa armigera* Hübner.).

•In 2019, the European corn borer and the cotton bollworm were found to be in low density. 5% damaged cobs by the corn stem borer and 35% of the cotton bollworm was reported. In 2020, the environmental conditions favored the multiplication and development of the enemies, as a result of which a higher percentage of damaged cobs was recorded 10% of the corn borer, respectively 65% of the cotton bollworm.

•The mixture of plant extracts from: walnut (*Juglans regia* L.), wild walnut (*Ailantthus altissima* Swing.) and tobacco (*Nicotiana tabacum* L.) show good efficacy against cotton bollworm caterpillars. The obtained results are a prerequisite for the application of the plant extracts in the integrated control systems with the key enemy of sweet corn, in which the environment, the beneficial entomofauna and the pollinators of the cultivated plants are protected.

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