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MONITORING OF HELICOVERPA ARMIGERA USING PHEROMONE TRAPS AND RELATIONSHIP OF MOTH ACTIVITY WITH LARVAL INFESTATION ON TOBACCO[1]

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ABSTRACT

The polyphagous larvae of *Helicoverpa armigera* cause damage to reproductive and vegetative tissues of many crops and weeds.
According to pheromone catches, in the region of Prilep, usual flight pattern of *H. armigera* on tobacco is during July - September. A total of 187 adults were caught in 2019/20.
When male moths have reached their peak catch in pheromone traps, during next week subsequent egg- laying and larval infestation is observed in the tobacco field.
Monitoring the occurrence of moths and early larval detection is necessary for optimal timing of pesticide treatments. Different active ingredients were effective for pest control: Metaflumizone 240 g/L- 1 L/ha; Emamectin 9.5 g/kg- 1.5 kg/ha; Chlorpyrifos 500 g/L + Cypermethrin 50 g/L- 1.5 L/ha.
H. armigera is a pest of major importance in areas in which are produced certified tobacco seed and it is important to lay emphasis on an integrated approach to combat this pest.

KEY WORDS: *H. armigera,* tobacco, pheromone traps, monitoring.

[1] original scientific paper

INTRODUCTION

The tobacco bollworm (*Helicoverpa armigera*) is a pest of immense importance because of its broad host range, high reproductive potential and ability to migrate in long distances. It is also known as tobacco budworm, cotton bollworm, corn earworm, Old World (African) bollworm or scarce bordered straw. The larvae feed on over 100 plant species of cultivated and wild plants.

H. armigera is recognized as one of the most significant agricultural pests in Asia, Europe, Africa, and Australasia, with damages estimated at a couple of billion US dollars annually, not including the socio-economic and environmental costs associated with chemical control and the introduction of GM crops (CABI, EPPO 1996, Tay et al. 2013, Warren 2013 cit. Smith-Pardo, 2014).

Larvae successfully develop on tobacco plants, especially on their generative organs, where they cause serious damages on tobacco seed (Krsteska et al., 2007).

H. armigera is a pest of major importance in areas in which are produced certified tobacco seed (Krsteska, 2015).

Due to the high cost of protecting crops from *H. armigera* with chemical pesticides (Sundaramurthy, 1986; Anonymous, 1990) and the increasing resistance and resurgence to many chemical pesticides (Uthamasamy, 1990; Armes et al., 1992) there is growing interest in the use of pheromones, natural enemies (predators and parasitoids) and other novel methods for controlling such pests cit. Reddy and Manjunatha, 2000.

MATERIAL AND METHODS OF WORK

The investigation was carried out in the experimental field of Scientific tobacco institute in Prilep on a standard variety "P66", during tobacco vegetations in 2019 and 2020.

The male moths of *H. armigera* are monitored by using sticky, sex pheromone traps (RAG, Csalomon®). The plastic trap has the shape of a triangular prism, and in field condition it is installed on wire (hanging on the tree). The bottom sticky liner is 16.5 cm long and 11 cm wide. Pheromone baits are fastened with cotter pin in the top-middle part of plastic trap, on 8-cm space in between the lure and sticky liner.

Two traps were placed; or one trap on every two hectares of tobacco fields with homogeneous lands.

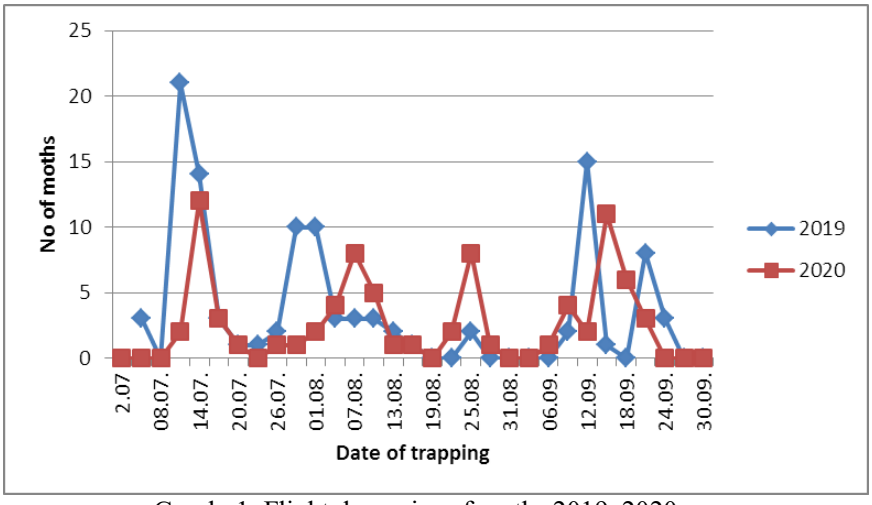
The pheromone traps are placed up the level of the top of the tobacco vegetation, at 1.5 metar height from the ground. The traps are set up on the branches of bushes or trees near fields because moths prefer to aggregate in hedges along the edge of open fields.
During the investigation, trapped adult male moths were collected at three-day intervals.
The lure (rubber septum with pheromone baits) was changed after month to get the most accurate results.The bait contains the female sex hormone and the direct touch of trap by hand may cause repellent effect reducing trap catch. The sticky liner was changed after every 15 days. The sticky insert can become saturated with captured specimens within a relatively short period at high population densities, so frequent renewal of sticky inserts was necessary.
Pheromone traps were controlled from July 1 until October 1 both years.
Monitoring of *H. armigera* larvae on tobacco plants were performed during tobacco vegetation in a 10 -day period, using the method of examining 100 tobacco plants, with Zig-Zag review of pest scouting. The collected eggs, larvae or pupae were additionally grown in a laboratory according to the standard laboratory methodology.
Field applications were carried out for control of *H. armigera*, with three insecticides: Metaflumizone 240 g/L- 1 L/ha; Emamectin 9.5 g/kg- 1.5 kg/ha; Chlorpyrifos 500 g/L + Cypermethrin 50 g/L- 1.5 L/ha.

RESULTS AND DISCUSSION

H. armigera is a serious pest of tobacco plants. In severe infestations larvae, may destroy them completely: flowers, seed capsules, also top leaves.
Pheromone traps are sensitive tools for detecting initial populations of *H. armigera* in the tobacco plantations. Applied sticky, sex pheromone traps (RAG, Csalomon®) capture only males (Figure 1).

Figure 1. Captured moth with sticky, sex pheromone trap

According to investigations, during tobacco vegetation usual starting date for trapping of tobacco bollworm is beginning of July (Figure 1). In the region of Prilep, usual flight pattern on tobacco is during July, August and September. A total of 108 adults were caught in 2019 and 79 in 2020. Generations of H. armigera overlap, some moths grow on tobacco crops, some fly from surrounding crops. According to the flight dynamics, four peaks of insect population are determined per year.



Graph. 1. Flight dynamics of moths 2019–2020

The hunting of the first male moths in the pheromone traps determines the presence of *H. armigera* in the tobacco plantations. The females are characterized with high fecundity and they lay large number of eggs on tobacco plants, singly on the top third of the plant and on growing points.
The presence of the tobacco - bollworm cannot be easily noticed on the tobacco plants because eggs are very small (a diameter of about 0.4-0.6 mm) and they are deposited between young leaves in the beginning of tobacco vegetation.
Eggs are almost spherical with a flattened base, with longitudinal striations which are extending from the micropylar area towards egg base (Figure 2). They are yellowish-white or cream-white and their colour is changing to brown just before the larvae emerge. Eggs hatch after three days.

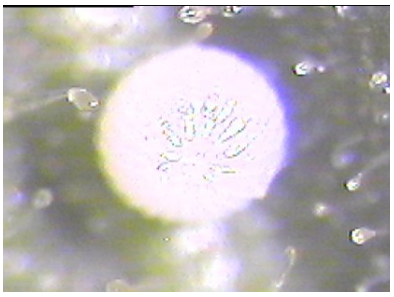


Figure 2. Egg of *H. armigera*

First instar larvae are yellowish-white, with spotted appearance and almost cylindrical body. They are around 2 mm long and almost imperceptible among tobacco leaves. A characteristic pattern develops in subsequent instars. Prolegs are present on the third to sixth, and tenth, abdominal segments.
Larvae are very mobile and feed on soft leaves, and in first and second instar create small holes. In later instars larvae chew tobacco leaves making irregular holes so larval damages can be confused with those of the species of Orthoptera. Therefore the leaves should be carefully examined to determine the presence of larvae or frass- excreta.
The colour of the older caterpillars are variable, and may be green, straw yellow, pinkish to reddish brown or almost black and the body is marked with three prominent longitudinal dark bands and with several pale, wavy, lines run along the body dorsally (Figure 3). The skin surface consists minute tubercles which are placed close together. The head, prothoracic

and supra-anal plates and legs are brown. The final body segment is elongated.

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Figure 3. Larvae of *H. armigera*

During 2019/20 in tobacco vegetation larval development lasts 17-22 days and in six larval stages the caterpillars are 32-38 mm long.
Larvae are rather aggressive and they react to disturbance by raising their head and thoracic segments or they fall from the plant and curl up on the ground. Cannibalism may occur among them, caused by the decrease of resources such as food and territory.
During tobacco development female deposit eggs individually on/near young buds, flowers, seed capsules.
Young larvae feed on top plants part but older larvae make holes in tobacco capsules and leave heaps of dark-brown frass (excreta). Larvae cause great damage and loss of tobacco seeds (Figure 4). They can bore through the stem and the tops of the plant may break (Figure 5).
Larvae can feed during the day or night, regardless of instar. According to our observations larvae of different generations usually overlap.
In prepupal stage the larva becomes slower and shorter. Larvae pupate in the pupal chamber in soil, 3-5 cm deep. After pupation pupa colour is pale brown and the body is soft and smooth (Figure 6). When touched, it moves.


Figure 4. Damaged tobacco plant Figure 5. Damaged tobacco plant


Figure 6. Pupa of H. armigera Figure 7. Pupal chamber

After few days pupa becomes firmer and darker (mahogany-brown or dark brown). Pupa is adecticous and obtect, rounded at both ends and has ten abdominal segments two tapering parallel spines at its posterior tip. They are 14-19 mm long. Pupal development lasts 13-21 days. The species overwinter as pupa in the ground (Figure 7).

Adult emergence is at night. They are 14-20 mm long with wingspan length between 33– 40 mm and body shape of typical noctuid appearance (Figure 8). Head is hypognathous with dark semioval, compound eyes longer than wide. Male and female antenna is filiform and tapering towards apex and covered with fine hairs. Thoracic segments are wide and strong, mesothorax is the largest segment, than follows metathorax. Adults are variable in wings colour. Most often adult forewings are dark brownish -orange in females, and light brownish-gray in males; with network of fine, dark blackish spots and a broad, irregular, transverse brown band. The hindwings are brighter (most often cream) with a dark-brow band near the edge, that contains a paler patch in the middle. Males and females have the same venation pattern. Prothoracic, mesothoraric

and metathoracic legs are well developed. The male has eight abdominal segments, the ninth and tenth are modified into genitalia. The female has seven apparent segments, the eighth, ninth, and tenth are modified into genitalia. Male apical portion is narrower than female and covered with setae. Flights occur at dusk and night and oviposition during night. Longevity of adults is about 20 days.

Figure 8. Adults of H. armigera

According to Graph. 1 on July 4, 2019 the first males were caught in feromone traps. In the first decade there were no larvae on tobacco plants. From 10.07.2019 to 15.07.2019, 35 male adults were caught in total. Subsequent egg laying and larval infestation is observed after 7 to 10 days in the tobacco field. On 20.07.2019 when the individual plots were in the flowering phase, 37 larvae on tobacco stalks were identified (Table 1). After the increased population of *H. armigera* on 18.07. and 22.07.2019 insecticide Metaflumizone was applied at a dose of 1 L/ha. In the period from 28.07.2019 to 2.08.2019, a total of 20 adults were caught when it was the second peak of the male population of *H. armigera*. On 31.07.2019, 53 larvae of *H. amrigera* were identified on tobacco plants. After the increased population of the adults in the traps and the larvae on tobacco stalks, insecticide Emamectin was applied at a dose of 1.5 kg/ha (some plots were sprayed on 5.08.2019 and another plots on 8.08.2019). According to the manufacturer's recommendations, the application was performed in the evening to avoid the decomposition of the insecticide from the sun heat, but also because at this time of day is the adults flight. The larval density was the most numerous in August, on 10.08.2019 69 larvae on tobacco plants were identified and on 20. 08. 2019 67 larvae. For the control of tobacco-bollworm on 20.08.2019 was applied Chlorpyrifos 500 g/L + Cypermethrin 50 g/L at a doze of 1.5 L/ha. From 8.09.2019 to 13.09.2019, 17 adults were caught in total. On 9.09.2019, 46 larvae of *H. amrigera* were identified on tobacco plants. Some tobacco

plots on 10.09.2019 and another plots on 12.09.2019 were sprayed for the second time with the insecticide Emamectin with a concentration of 1.5 kg/ha.On 20.09.2019 and 22.09.2019, 8 adults were caught in total, but in this period tobacco seed are dried and *H. armigera* larvae are not a danger to the seed. Pheromone hunters were controlled until 1.11.2019. The larval population was not identified after first decade of October.

Table 1. *H. armigera* larvae on tobacco stalks

Date of sampling	No of larvae	
	2019	2020
01.07.	-	-
10.07.	4	2
20.07.	37	16
31.07.	53	37
10.08.	69	59
20.08.	67	68
30.08.	32	44
09.09.	46	16
20.09.	23	14
30.09.	9	11
10.10.	1	-
Total	341	267

Monitoring the occurrence of moths and early larval detection is necessary for optimal timing of pesticide treatments. Applied active ingredients were effective for control of *H. armigera*.

The pheromone trap catch data in 2020 reveals the commencement of adult moth activity in tobacco in second decade of July (ie 12.07.2020). In the period 13.07.2020- 18.07.2020, 15 moths were caught in total and this is the first gradation of the adult eclosion. On 20.07.2020 and 31.07.2020, on tobacco stalks were identified 16 and 37 larvae consequently. On 31.07.2020 Metaflumizone at a dose of 1 L/ha was applied for protection from this harmful species. In the period from July 31 until August 5, 2020, 6 adults were caught in total and from August 6 until August 11, 2020, a total of 13 moths were caught. The larval density was most numerous in August and on 10.08.2020 59 larvae were identified, and on 20.08.2020 68 larvae. For control of *H. armigera* on 13.08.2020 and 14.08.2020 Emamectin at a dose of 1.5 kg/ha was applied. During the second half of August tobacco plants were damaged from two heavy hailstorms and these days the catches in pheromone traps did not correlate very well with field counts of the larvae. According to Fite et al. 2020, the population of *H. armigera* moths increased with increasing wind speed while decreased

with increasing average air relative humidity, mean air temperature and rainfall. From August 24 until August 26, 2020, 8 adults were caught in total. On 30.08. 2020, 44 larvae were identified on tobacco plants. From 1.09. to 2.09. 2020 Chlorpyrifos 500 g/L + Cypermethrin 50 g/L was applied at a doze of 1.5 L/ha for the control of tobacco-bollworm.
From 14.09.2020 until 19.09.2020, 17 moths in total were registered in pheromone traps. On 20.09 2020 14 larvae were identified, and after the inspection on September 22, 2020, when the last 3 adults were caught, there was no more catch .This year was less favorable for the development of the tobacco plants and also for tobacco-bollworm. Applied insecticides were effective for control of *H. armigera*.

CONCLUSION

H. armigera is considered as economically important agricultural pest due to the damage it can cause to crops. Larvae cause extensive damage on tobacco plants especially on tobacco seed.
Tobacco damage from larvae can be expected if the tobacco has already reached the phenological phase of blooming.
It is important to lay emphasis on an integrated approach to combat this pest. Sex pheromones of this moth can be used for adult monitoring. Decisions on pesticide application should not be taken solely on the trap catch data. Climatic and biological considerations should be taken in account. Inspection of larvae/tobacco damage in the field has proved to be a valuable tool and improves spray timing.
Chemical control is the most reliable and economic way of protecting tobacco crop from tobacco-bollworm.

REFERENCE

1. Allan H. Smith-Pardo, The Old world bollworm *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae: Heliothinae) its biology, economic importance and its recent introduction into the western hemisphere,https://ciencias.medellin.unal.edu.co/museos/entomologico/images/Boletin/2014-03/4.pdf, 2014.
2. Gadi V. P. Reddy, Mohan, T. M. Manjunath, Laboratory and ®eld studies on the integrated pest management of *Helicoverpa armigera* (HuÈ bner) in cotton, based on pheromone trap catch threshold level. J. Appl. Ent. 124, 213±221 (2000) # 2000 Blackwell Wissenschafts-Verlag, Berlin, 2000.

3. Tarekegn Fite, Tebekew Damte, Tadele Tefera, Mulugeta Negeri, Evaluation of commercial trap types and lures on the population dynamics of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) and its effects on non-targets insects https://researchgate.net/figure/Correlations-between-captured-H-armigera-moths-and-a-wind-speed-b-air-relative_fig2_343755560, 2020.
4. Vesna Krsteska, Vera Dimeska, Petre Stojanoski, *Heliothis armigera* Hbn on tobacco and application of some insecticides in its control. Tutun/Tobacco, Vol.57, No 1-2, p. 42-48, 2007.
5. Vesna Krsteska, Petre Stojanoski, *Helicoverpa armigera* - pest control on tobacco, Scientific conference "Challenges in modern agricultural production", University "Ss. Cyril and Methodius" - Skopje Institute of agriculture – Skopje, Book of proceedings p.123-129, 2015.
6. Vesna Krsteska, Petre Stojanoski, *Heliothis armigera* on tobacco Tutun/Tobacco, Vol. 66, No 7-12, p. 42-50, 2016.
7. *Helicoverpa armigera*, EPPO/CABI, Quarantine Pests for Europe, 2nd edn, pp. 289–294. CAB International, Wallingford (GB), 1997.
8. *Helicoverpa armigera* EPPO Standards Bulletin OEPP/EPPO Bulletin 33, 245–247, PM 7/19, 2003.
9. *Helicoverpa armigera*, http://www.cabi.org/isc/datasheet/26757