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SEASONAL FLIGHT DYNAMICS OF THE POTATO TUBER MOTH *PHTHORIMAEA OPERCULELLA* (LEPIDOPTERA: GELECHIIDAE) ON FLUE CURED TOBACCO

Tania Vaneva-Gancheva[1]*, Yanko Dimitrov[2], Daniela Atanasova[2]

[1]Institute of Tobacco and Tobacco Products, 4108 Markovo, Bulgaria
[2]Agricultural University, Faculty of Plant Protection and Agroecology, Department of Entomology
4000, Plovdiv, Bulgaria

***E-mail: tania_vaneva@abv.bg**

Abstract

Phthorimaea operculella Zeller is one of the most destructive pests of potato and is becoming an important pest of other *Solanaceous* crops including tobacco. Hereby we report on a study of the seasonal flight dynamics of the pest on flue-cured tobacco crop in the region of Plovdiv in Bulgaria during 2008-2010. Male *P. operculella* were monitored using pheromone traps. Adults were present in the field from March through to the end of December even when tobacco was not present in the field. Flight activity started when the average weekly temperature rose above 6.3^{o} C. An expanded flight period of the overwintering generation with low catch was observed from March to the beginning of June. The pest population started to build up from July. During the tobacco growing seasons of 2008 and 2009 the pest flight dynamics showed a similar pattern. The periods of the highest catches were from the end of July to the end of August, the end of September to the middle of October, and the middle of November. The rainfall during June-July 2010 reduced the density and changed the flight pattern. The *Phthorimaea operculella* population increased gradually over several months and two flight peaks were registered in the end of August and in October. The end of the flight activity in the temperate area was associated with the snowfall.

Keywords: seasonal flight dynamics, pheromone trap, *Phthorimaea operculella*; potato tuber moth, tobacco.

INTRODUCTION

Phthorimaea operculella is considered to be one of the most important potato pests worldwide (CABI, 2012). The cosmopolitan distribution of the pest has demonstrated its ability to adjust to a wide climatic range and high adaptability to seasonal changes (Keller, 2002; Kroschel & Koch, 1994). The density of the pest can rapidly increase to uncontrollable population levels because of its high reproductive potential, short generation time, both of which are favoured by dry and hot weather (Foot, 1979; Von Arx et al., 1988). In Bulgaria, the species was first reported on potato and tobacco in 1950 (Stanev & Kaitazov, 1962). The incidence of *P. operculella* damage in Bulgaria has increased during recent years on potato and tobacco crops. The expansion of its distribution in the country and new areas of invasion have been reported earlier (Vaneva-Gancheva & Grigorova, 2010). There is thus a need for a monitoring system to optimize pest control and monitor further spread.

Phthorimaea operculella has been known as a tobacco pest since the nineteenth century, but its biology, ecology, and phenology are still relatively under-researched. Morgan & Grumb (1914) reported that *P. operculella* larva affected only lower tobacco leaves when the infestation is low, and mines were observed on upper leaves when the population became large. Using accumulated degree-days model about moth trap capture peaks, Rivera (2011) determined two to four flights of *P. operculella* per tobacco growing season.

The objective of the research is to study the seasonal flight dynamics of the *P. operculella* on flue-cured tobacco.

MATERIALS AND METHODS

The field trapping experiment was run in a flue-cured tobacco crop at the Institute of Tobacco and Tobacco Products, Plovdiv, Bulgaria in 2008-2010. Pheromone delta traps were used to monitor the seasonal dynamics of the pest. The pheromone capsule contains synthetic components (E4, Z7)-tridecadienyl acetate and (E4, Z7, Z10)-tridecatrienyl acetate. One trap per 1 ha was hung at a height 0.5 m above the ground at the beginning of June 2008. The traps were monitored twice a week, and the catch was checked and removed. The pheromone capsules were changed monthly and sticky liners weekly. The weekly experimental catch was graphed to determine the seasonal dynamics of the pest. The tobacco plants were planted from 10 to 20 May and harvested in August-September, because of seed production use tobacco plants stayed in the field to the end of October. Data were analyzed using ANOVA in SPSS 9 for Windows XP. The comparative evaluation of the average values was determined using Least Significant Differences (LSDs) at the 0.05 probability. Pearson`s correlation coefficient was used to quantify relationships between a mean number of moths and climatic factors temperature and rainfall. The Walter climate diagram was used to relate temperature and rainfall information for a Plovdiv area and to determine the drought period thought the years.

RESULTS AND DISCUSSION

Phthorimaea operculella adults were present in the field from March to the end of December even when tobacco was not present (Figure 1). During the winter months January and February there was not flight activity. In 2009 flight of overwintering generation was first recorded in the 4th week of March, with corresponding average weekly temperature 8.1^{o} C. In 2010 the flight started a few weeks earlier at the lower temperature of 6.3^{o} C. The highest number of this generation was caught on the 3rd week of April. In both years population density was very low during May. An extended flight period was observed from March to the beginning of June. *Phthorimaea operculella* population started to build up from July. During 2008 and 2009 tobacco-growing seasons, there were three well-expressed periods of the highest catches – the first from the end of July to the end of August with stable catches, the second from the end of September to the middle of October and third in the middle of November. The flight pattern during 2010 was different with only two peaks recorded.

Average annual numbers of moths during 2010 was significantly lower compared with those in 2008 and 2009 (F = 3.96 sig. 0.0375). A total of 1630; 1637 and only 698 male moths were trapped in 2008, 2009 and 2010 respectively.

Average monthly number of moths for June and July 2010 were significantly lower compared with those in 2008 and 2009 (F = 31.016 sig. 0.000; F = 4.489 sig. 0.044) (Figure 2).

Phthorimaea operculella adults were present in tobacco fields from March to December, even when the crop was absent during March-May and more obviously during the late autumn period November-December, when the last peak occurred. Trapping data demonstrated that males were active late in the year even when the average weekly temperature was below 0.0^{o} C. For all three years the flight stopped when the first snowfall occurred. This suggests that a large number of developing larvae and pupae were present in the upper layer of soil and under plant residues due to high population's level during tobacco growing season. Many others researchers also reported high numbers of *P. operculella* in the later part of the year (Visser & Schoeman, 2004; Rondon, 2008; Rivera, 2011).

Population levels of the overwintering generation were very low. This could be the result of many factors: low winter survival, favourable weather conditions during the late autumn period which provoked emergence of a large number of wintering stock at the end of previous year, decline of soil conditions: compaction by the snowfall and rainfall during winter-spring month, which closes soil cracks and restricting moths emergence, autumn-spring soil cultivation practices which allocated wintering stock to different soil depths and this way affect moths emergence. Extremely low numbers of overwintering adults were sufficient for later multiple reproductions. During the tobacco growing seasons of 2008 and 2009 *P. operculella* flight had a similar pattern. Their population started to build up quickly, and the number of moths captured increased dramatically for a short period. There were three periods of the highest and stable catches. Lack of a break of the catch from July to September suggested that generations overlapped. Study on the phenology of *P. operculella* on tobacco crop by Rivera (2011) indicated similar flight pattern.

Seasonal dynamics of the pest in 2010 were markedly different. Moth catches were lower and only two periods of highest catch were registered. There were a delay and slow build up the population, the most likely cause of this retardation being the negative effect of heavy rainfalls in June and in July. Registration of the first peak immediately after the rainfalls supports this thesis. On the other hand, we did not find significant negative correlations between catch and rainfall throughout the years. Thus, our results correspond well with Subchev et al. (2013) finding that mean rainfall and air temperature did not strongly affect trap catch. Several researchers, however, reported the negative relationship between moth numbers and rainfall (Foot, 1979; Kroschel & Koch, 1994; Von Arx et al., 1988).

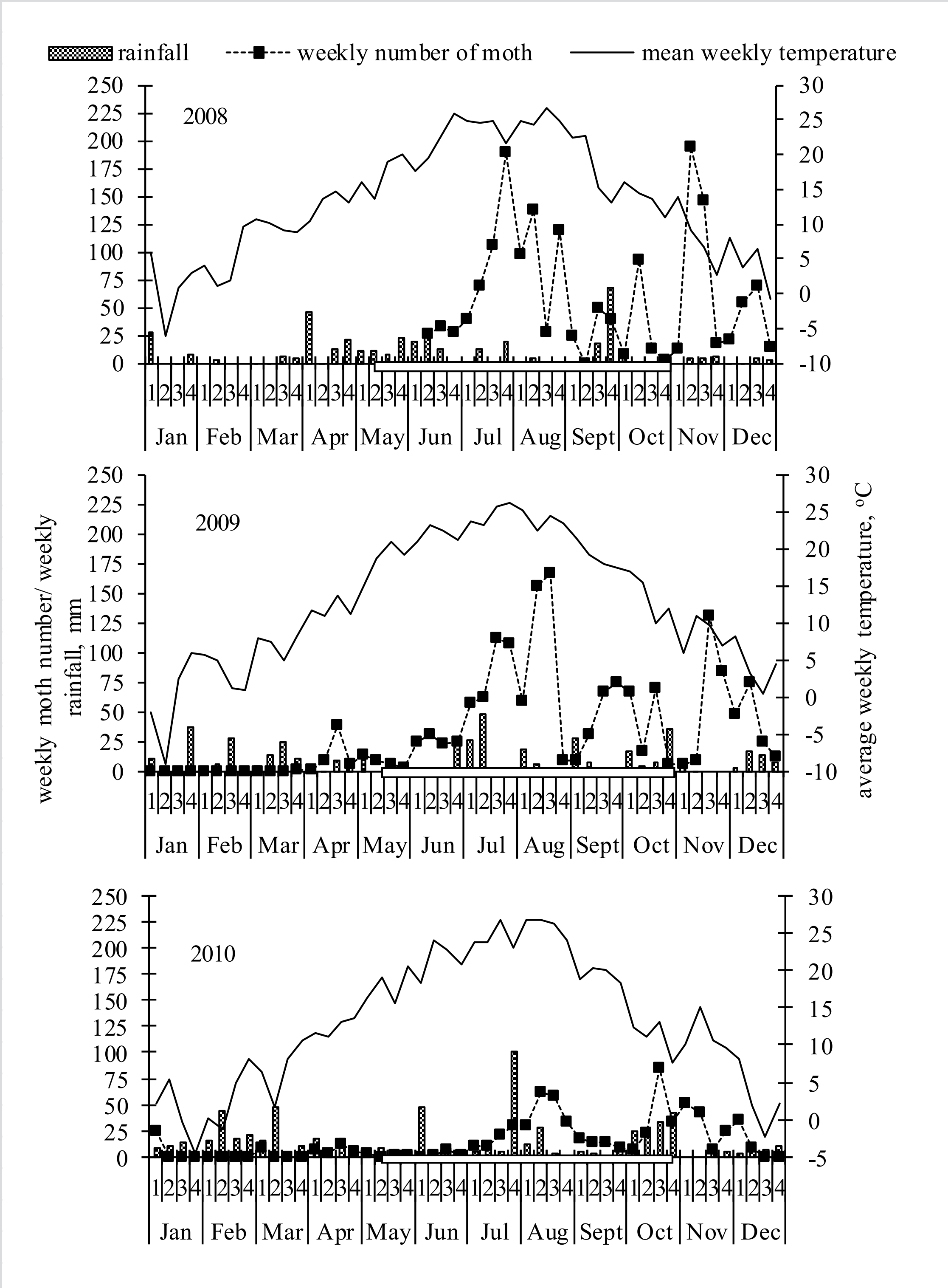

***Fig. 1.** Seasonal flight of the potato tuber moth P. operculella Zeller on flue-cured tobacco crop in Plovdiv region during 2008-2010. The number of caught moth per week and corresponding average weekly temperatures and weekly rainfalls bar tobacco growing season*

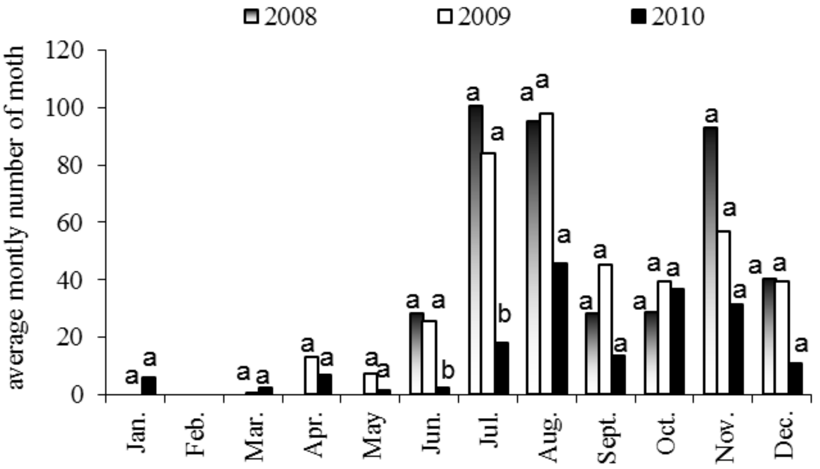

Fig. 2. *The average monthly number of moths caught per tap during 2008-2010 on tobacco crop. Different letters indicate significant difference at the 0.05 level*

A significant positive correlation between average monthly temperature and moth catch occurred in 2009 (Table 1). There was not a significant correlation between catch and rainfall.

Table 1. Pearson`s correlation coefficient between mean number of moths and average monthly temperature and rainfall for each of three years

	2008	2009	2010
Temperature	0.25	0.63*	0.38
Rainfall	-0.46	-0.37	-0.03

** significant at the 0.05 level*

The data from Walter climate diagram showed that high *P. operculella* population level was established during drought periods in the three years (Figure 3).

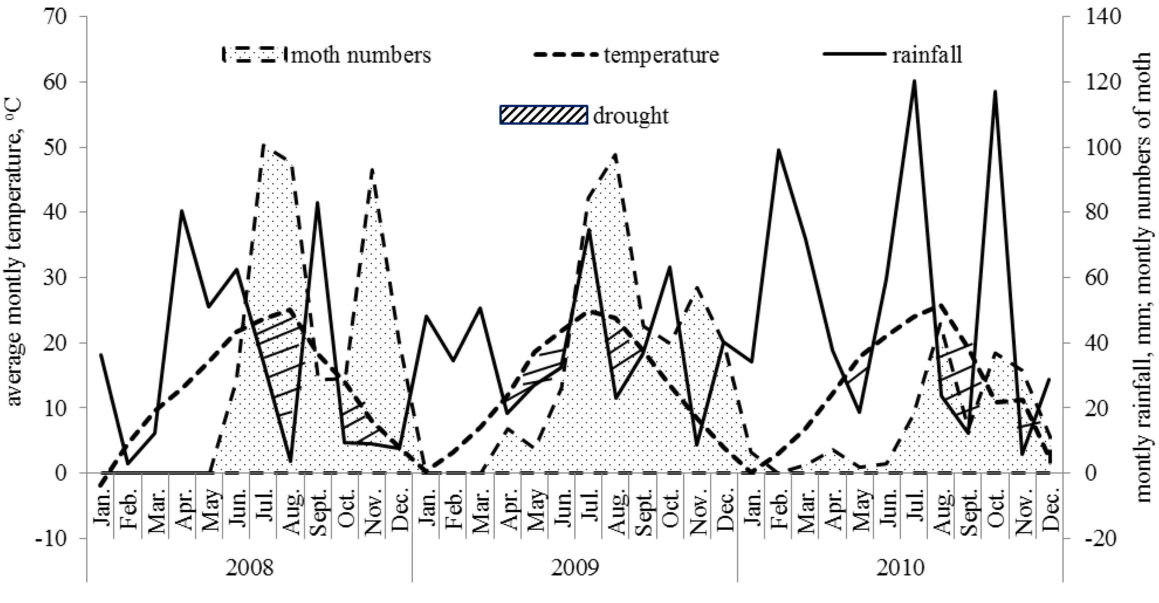

Fig. 3. *Walter climate diagram, average monthly temperatures, total monthly rainfalls and corresponding monthly numbers of caught moths in Plovdiv region during 2008-2010*

According to Keller (2002) flight activity is determined by three principal factors: temperature, rainfall, and availability of food. The temperature is reported to be critical for the rapid increase of potato moth population (Keller, 2002; Kroschel & Koch, 1994) and it indirectly affects moth catch by regulating the rate of larval development. Positive correlations between moth numbers and temperature have been reported by several authors (Foot, 1979; Visser & Schoeman, 2004). We, however, found the positive correlation in only one year. On the other hand, dramatic changes in moth numbers not always followed changes in temperatures. For all three years, the last peak was registered in late autumn, when average temperatures started to decrease but high population level sustained. Visser & Schoeman (2004) found that temperature has a definitive long-term seasonal effect on the catch, while other short-term change in moth numbers could not be explained.

Temperature and rainfall /snowfall/ affect the moth`s flight and are most important factors regulating short and long term changes in moth numbers. During the drought, period population builds up quickly, and density is high, rainfalls cause retardation of pest development and temporary reduce pest`s density, snowfalls cease flight activity.

CONCLUSIONS

The results showed that *Phthorimaea operculella* adults were present in tobacco fields from March to December, even when the crop was absent during March-May and more obviously during the late autumn period November-December when the last peak occurred.

Trapping data demonstrated that males were active late in the year even when the average weekly temperature was below 0.0^{o} C.

For all three years, the flight stopped when the first snowfall occurred. This suggests that a large number of developing larvae and pupae were present in the upper layer of soil and under plant residues due to high population's level during tobacco growing season.

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