Entomol. Croat. 2010. Vol. 14. Num. 1-2: 7-22 UDC 595.789 (497.6)

ISSN 1330-6200

IZVORNI ZNANSTVENI ČLANCI **ORIGINAL SCIENTIFIC PAPERS**

THE USE OF YELLOW STICKY TRAPS FOR FORECASTING THE FIRST GENERATION OF THE CABBAGE MAGGOT (*Delia radicum* (L.), Diptera: Anthomyiidae)

Renata BAŽOK[1] & Mirna CERANIĆ- SERTIĆ[2]

[1]Department for Agricultural Zoology, Faculty of Agriculture Zagreb
Svetošimunska cesta 2510000 Zagreb
e-mail: rbazok@agr.hr
[2]Croatian Agricultural Extension Institute, Office Ogulin

Accepted: October 28th 2010

Due to the increased production of white cabbage in the region of Ogulin, Republic of Croatia, the numbers and the impact of the cabbage maggot (*Delia radicum* (L.)) are increasing as well. In this region, cabbage production fields are limited and cabbage maggot control is often not very successful due to the lack of pest forecasts. Investigations were conducted in 2008 and 2009 to determine if there were correlations between degree-day accumulation and cumulative capture of flies on yellow sticky traps (YST), BioPlantella, and if the correlation between degree-day accumulation or cumulative capture of flies and infestation levels of eggs and larvae of first generation cabbage maggots exists. The presence of flies on YST was determined at the time of cabbage transplanting (mid April). Every seven days the traps were removed, the number of captured flies was recorded and new traps were set up. Cabbage infestation by eggs and larvae was determined once per week by visually inspecting four groups of 100 plants. The percentage of plants with eggs, average number of eggs/plant, egg infestation intensity and percentage of plants showing symptoms of larval infestation were determined. Weather conditions, in terms of average daily temperatures and amount of rainfall, were recorded by CDA. Degree-day accumulations, beginning 1 January each year, were calculated for each date of inspection by the using the lower developmental base temperature of 4.3˚C. The strong positive correlation between degree-day accumulation and cumulative capture of flies on YST was noted for both years (R=0.9771 and 0.991; P=0.0001). These results show that fly emergence and the capture of flies on YST are dependent on temperature. Spring flight of the flies was observed in cabbage fields in both years 7-10 days after cabbage transplanting when degree-day accumulations reached 450-500. The ratio of plants infested with eggs, average number of eggs/plant and intensity of egg deposition are correlated with the cumulative number of flies caught on YST. Correlation coefficients varied between medium (for % of plants infested by eggs, R=0.572) and strong (for average number of eggs/plant, R=0.736 and for infestation intensity, R=0.74). A medium correlation between the percent of plants showing symptoms of larval attack and cumulative capture of flies on YST exists (R=0.432 in 2008 and R=0.499 in 2009). The regression line for both years can be described as a parabola. Lower fly populations in 2008 versus 2009 resulted in higher larval infestation in 2008 than in 2009. This led us to conclude that larval attack is influenced by fly population level, but also by other factors, of which the amount of rainfall during the egg hatching and larval infestation is the most important. The main difference between the years was in the amount of rainfall in May when egg hatching occurs. It is impossible to determine fly capture levels, which will cause certain percent of larval infestation, if the amount of rainfall is not taken into account. The peak of larval numbers occurred at degree-day accumulations between 750-800.

***Delia radicum*, infestation intensity, eggs, larvae, cumulative capture, correlations, degree-day accumulation**

R. BAŽOK i M. CERANIĆ- SERTIĆ. Prognoza prve generacije kupusne muhe (*Delia radicum* (L.), Diptera: Anthomyiidae) pomoću žutih ljepljivih ploča. Entomol. Croat. 2010. Vol. 14 Num. 1-2: 7-22

Zbog porasta proizvodnje kupusa na području Ogulina u posljednje vrijeme raste i štetnost kupusne muhe, *Delia radicum* (L.), kao najvažnijeg štetnika. Do porasta štetnosti dolazi zbog ograničenih proizvodnih površina pogodnih za uzgoj kupusa, ali i zbog često neučinkovitog suzbijanja provedenog bez prethodne prognoze muhe. Istraživanje provedeno 2008. i 2009. godine imalo je za cilj utvrditi postoji li korelacija između sume efektivnih temperatura i prosječnog kumulativnog ulova muha prve generacije na žutim pločama, te između kumulativnog ulova muha ili sume efektivnih temperatura kao neovisnih varijabli i zaraze prvom generacijom kupusne muhe kao zavisne varijable. Praćenje leta provedeno je pomoću žutih ljepljivih ploča (BioPlantella). Postavljene su 3 ploče po polju, ulovi su očitavani tjedno od presađivanja kupusa (sredina travnja) do berbe (kraj srpnja). Zaraza jajima i ličinkama utvrđivana je jednom tjedno pregledom 4 x 100 biljaka. Utvrđen je postotak biljaka s jajima, broj jaja po biljci, intenzitet zaraze i postotak biljaka sa simptomima napada ličinki. Podaci o srednjim dnevnim temperaturama, rasporedu i količini oborina prikupljeni su pomoću CDA uređaja. Od početka godine do svakog datuma pregleda, koristeći temperaturni prag od 4,3˚C, izračunate su sume efektivnih temperatura. Između sume efektivnih temperatura i kumulativnog ulova muha na žutoj ploči postoji jaka pozitivna korelacija (R = 0,9771 u 2008. i 0,991 u 2009. P=0,0001) što pokazuje da su dinamika izlaska muhe iz tla i njezin ulov na žutim pločama ovisni o temperaturama. Proljetni let muhe utvrdili smo u poljima kupusa u obje godine 7-10 dana iza presađivanja, pri sumi efektivnih temperatura od 450-500˚C. Postotni udio biljaka zaraženih jajima, prosječan broj jaja/ biljci i intenzitet zaraze jajima ovise o kumulativnom ulovu muha na žutoj ploči. Korelacije su srednje (za postotak biljaka zaraženih jajima R = 0,572) do jake (za prosječan broj jaja/ biljci R = 0,736, a za intenzitet zaraze R = 0,74). Postoji srednja korelacija između postotka biljaka sa simptomima šteta od ličinki i kumulativnog ulova muha na žutoj ploči (R = 0,432 i 0,499), regresijska linija ima oblik parabole. U 2008. godini zabilježeni su niži ulovi muha na pločama u odnosu na 2009., a postotak zaraze ličinkama bio je viši u odnosu na 2009. To pokazuje da postotak biljaka sa simptomima napada ličinki ovisi i o drugim čimbenicima, prije svega o količini oborina u vrijeme izlaska ličinki iz jaja i napada na biljku. Jedina razlika u klimatskim uvjetima između ove dviju godina zabilježena je u količini oborina tijekom svibnja. Nemoguće je utvrditi koja visina ulova muha na žutoj ploči implicira određeni postotak zaraze ličinkama ukoliko se u obzir ne uzmu raspored i količina oborina. Maksimalni napad ličinki događa se kod sume efektivnih temperatura između 750 i 800˚C.

***Delia radicum*, intenzitet zaraze, jaja, ličinke, kumulativni ulov, korelacije, suma efektivnih temperatura**

Introduction

Cabbage production is impacted by a large number of pests. Among the pests in the region of Ogulin, Republic of Croatia, cabbage maggot, *Delia radicum* (L.), is the most important (Ceranić-Sertić & Bažok, 2009). The damage caused by cabbage maggot is increasing due to the limited agricultural area suitable for cabbage production. Therefore, cabbage is often grown continuously, which results in an increase in the cabbage maggot population. The control of the cabbage maggot is limited by the low number of registered insecticides and the lack of pest forecast data. Depending on the climatic condition in the region of Gorski kotar, the cabbage maggot can develop three to four annual generations (Ceranić Sertić & Bažok, 2009). The first generation, which impacts the production of early cabbage, is usually more numerous than the other generations (Ceranić-Sertić & Bažok, 2009). First generation flies emerge from the soil when average daily temperatures are over 12˚C. Under Croatian conditions, this usually occurs at the beginning of April (Maceljski, 2004). If climatic conditions are not favorable and temperatures are lower, the emergence of the first generation can last for an extended period.

In Croatia, only two insecticides, dimethoate and imidacloprid, are allowed for cabbage maggot control (Cvjetković et al., 2009). Both insecticides are systemic and are recommended either as a preventive measure by application with the seedling flooding and irrigation after transplanting, or as a plant spray after the population is established. Even though preventive pesticide application is not in accordance with the principles of integrated pest management (IPM), flooding of the seedling can be acceptable method because the application of the insecticide is localized, which diminishes the negative impact on the environment and beneficial organisms. Šubić (2008) reported that the efficacy of insecticides applied by flooding of seedlings is satisfactory only if high doses of insecticides are applied. The use of ecologically and toxicologically more suitable insecticides is advertised in IPM. The precondition for the success of such control methods is knowledge of the economic threshold (ET) and optimal timing for spraying.

Optimal time of spraying depends on the flight dynamics of the flies and on oviposition. For the first generation, the timing for spraying can be determined by several means; by calculating the sum of effective temperatures (SET), by recording the emergence of flies from the soil in the old cabbage fields, by following the appearance of the flies in cabbage fields by the use of yellow sticky or yellow water traps, by pheromones or by following the dynamics of oviposition (by soil sampling or by felt traps) (Bligaard et al., 1999). The traits for emergence patterns of flies from overwintered pupae are genetically controlled and populations from different locations can consist of different proportions of early and late emerging individuals (Walgenbach et al., 1993). The populations of *D. radicum* differ in their response to temperature during post-diapause development. Populations that are primarily of the early-emerging type have a low degree-day requirement for emergence and may lack a developmental delay at temperatures above ca. 21˚C. Populations of the late-emerging type have high degree-day requirements and a developmental delay at high temperatures. (Biron et al., 1998.; Turnock & Boivin, 1997). Derves et al. (2006) showed that the mean degree-day accumulations at 10% of spring emergence using a lower and upper developmental threshold of 4,3 and 30˚C beginning 1 January had corresponding degree-day values of 200±50,2˚C. This degree-day value in Oregon was reached at the beginning of March. The mean degree-day accumulations recorded from the beginning to the end of spring flight had corresponding degree-day values of 303±61,5˚C (end of March) to 839±51,9˚C (beginning of June). Joyti et al. (2003) used lower developmental threshold of 4˚C in upstate New York and showed that the mean degree-day accumulations at 10% of spring emergence had corresponding degree-day values of 176.6±3.8˚C.

The decision on applying insecticides depends on population density, oviposition and climatic conditions, which can influence larval development and damage expression.

Even though the adult flies emerge earlier in the season, the appearance of the flies in early cabbage corresponds with the transplanting of the seedlings into the fields. In the area of Gorski kotar, transplanting starts in mid April. At that time the mean degree-day accumulation (above 4.3˚C) has reached, depending on the year, 250-350˚C. Detailed investigations into the ecology of the cabbage maggot have not been conducted yet. Yellow sticky traps are shown to be suitable for detecting the flight activity and population density (Ceranić-Sertić & Bažok, 2009). There are no data on correlations between the capture of the flies on the yellow sticky traps and plant infestation by larvae, which has to be known prior to the establishment of an economic threshold.

The aim of this investigation is to establish if there is a correlation between the degree-day accumulation and the mean cumulative capture of the flies on yellow sticky traps. Cumulative capture of the flies and degree-day accumulations were used as independent variables, while the infestation density was used as dependent variable. Infestation density is expressed as the average percentage of plants surrounded by eggs, the average number of eggs per plant, infestation level by eggs or as the average percentage of plants showing symptoms of the presence of the infestation.

Materials and Methods

Investigations were conducted in 2008 and 2009. Cabbage maggot flight dynamics were followed with the use of yellow sticky traps (Bio Plantella), fixed on 1 m wooden sticks set up in fields planted with the early variety Krautman F1. The fields were located in the vicinity of Ogulin.

Seedlings were produced in containers in a greenhouse. They were transplanted into the fields on 9 April 2008 and 7 April 2009. Pest flight dynamics were followed from the time of transplanting until harvest. Yellow sticky traps were set up in the fields in three replications on the same day seedlings were transplanted. The yellow sticky traps were changed weekly and removed from the field on 1 August in 2008 and 2009 when the cabbage was harvested. Data on number of flies caught in a period of seven days were accumulated until the end of the experiment for both years.

Additionally, every seven days visual surveys were made on 100 plants in each of four rows. The number of plants with eggs, number of egg, and percentage of plants showing symptoms of the larval infestation (wilting) was recorded. For each inspection date we calculated infestation intensity by number of eggs with the use of the equation given by Hađistević (1983):

$$\textbf{INFESTATION INTENSITY} = \left[\; y \times \frac{z}{n} \;\right] \div \mathbf{100} \qquad (1)$$

y - % plants infested by eggs

z - total number of eggs

n - number of plants infested by eggs

After the first larvae emerged from the eggs for each inspection date, we calculated the average percent of plants showing symptoms of larval infestation.

Climatic data on mean average daily temperatures and on daily amount of rainfall were collected by using the CDA ON LINE device. From the collected climatic data starting 1 January we calculated mean degree-day accumulation (above 4.3˚C) according the methodology described by Derves et al. (1996).

Statistical software ARM 7 (Gylling Data Management, Revision 7.2.2, 12 September 2005) was used to calculate correlation coefficients and to conduct regression analysis between the following variables:

- mean degree-day accumulation (independent variable) versus cumulative capture of flies (dependent variable)

-cumulative capture of flies (independent variable) versus average percentage of plants infested with eggs (dependent variable)

-cumulative capture of flies (independent variable) versus average number of eggs/plant (dependent variable);

-cumulative capture of flies (independent variable) versus infestation intensity by eggs (dependent variable);

-cumulative capture of flies (independent variable) versus average percentage of plants that show symptoms of larval infestation (dependent variable);

- mean degree-day accumulation (independent variable) versus average percentage of plants that show symptoms of larval infestation (dependent variable);

The correlation coefficients were established, regression lines were described and in the case of linear regression the coefficient of determination was calculated.

Results and Discussion

Climatic conditions in the two years of the investigation were more or less similar for the period from January until April. In 2008, in a three-month period (January- March) the total amount of rainfall was 323.4 mm, while in the same period in 2009 the total amount of rainfall was 249 mm. In April 2008, the total amount of rainfall was 102.5 mm, while in April 2009 the total was 149.2 mm. The biggest difference in total amount of rainfall between the two years occurred in May when in 2008 87.7 mm of rainfall was recorded, while 24.5 mm was observed in 2009.

Figure 1 shows the degree-day values and cumulative capture of flies on yellow sticky traps recorded for 2008 and 2009.

As was expected, a significant ($P = 0.0001$) positive correlation between degree-day accumulations and cumulative capture of flies was shown for both years. The correlation coefficient was 0.977 in 2008 and 0.991 in 2009, respectively. In both years, the coefficient of determination (r^2) was high, 0.9885 in 2008 and 0.9997 in 2009, respectively. The population density in 2009 was much higher (almost double) than in 2008. The reasons for higher population density could not be determined from differences in temperature levels since we did not see big differences in temperatures between two years. The appearance of the flies in the cabbage field in the region of Gorski kotar started when degree-day accumulations reached approximately 450-500˚C. This is higher than the 303±61.5˚C degree-day accumulation mentioned by Deves et al. (2006). Joyti et al. (2003) reported on the degree-day accumulation of 160.7±8.1˚C as the temperature at which flies start to emerge from the soil. Since we did not observe flight of the flies in the fields where they were supposed to overwinter, we did not observe fly emergence from the soil and thus were only able to note their appearance in early planted cabbage fields from the standpoint of the larval damage. The appearance of flies in the cabbage fields in Gorski kotar corresponds with mid April, while Derves et al. (2006) reported that in Oregon the appearance starts at the end of March. Joyti et al. (2003) reported that in the state of New York flies start to emerge at 160.7±8.1˚C, which corresponds with the end of April. In the same region, over 90% of individuals were early-emerging (Walgenbach et al., 1993).

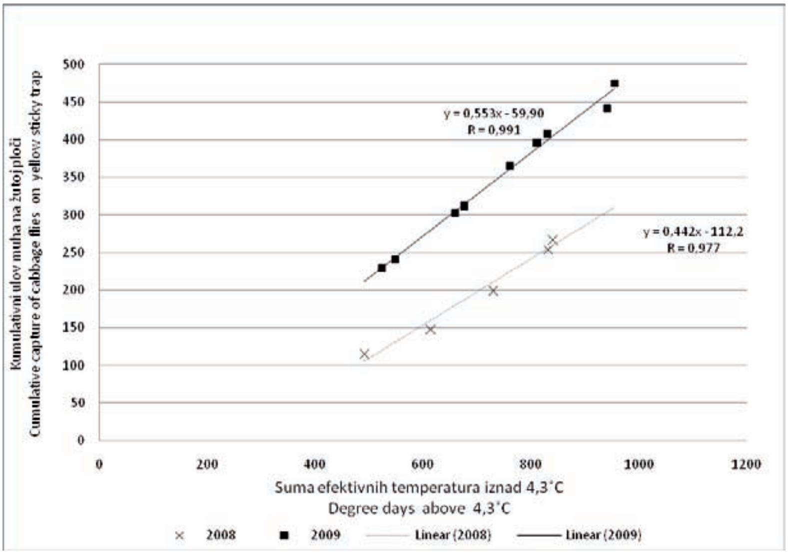

Figure 1. Regression analysis of degree-day accumulation versus cumulative capture of the cabbage fly (*Delia radicum* (L.)) on yellow sticky traps, Ogulin 2008 and 2009.

Slika 1. Korelacija između sume efektivnih temperatura i kumulativnog ulova kupusne muhe (*Delia radicum* (L.)) na žutim pločama, Ogulin, 2008. i 2009.

We do not have data on the makeup of the fly population in the region of Groski kotar, but if we compare our data on degree-day accumulations needed for the spring flight we can conclude that in this region a majority of the flies are late-emerging.

Regression analyses of the average cumulative capture of the flies on yellow sticky traps versus percentage of plants infested by eggs (Figure 2), versus average number of eggs per plant (Figure 3) and versus average infestation intensity (Figure 4) are based on the data collected for both years of the investigation. However, only in the first two observations of each year did we find eggs on the plants.

Correlation coefficient between the cumulative capture of flies versus percentage of plants infested with eggs is mid-range (r = 0.57) and the regression line is negatively exponential (Figure 2). The first egg laying in cabbage fields was recorded after approximately 100 flies were captured on yellow sticky traps. Egg laying starts when flies reach sexual maturity.

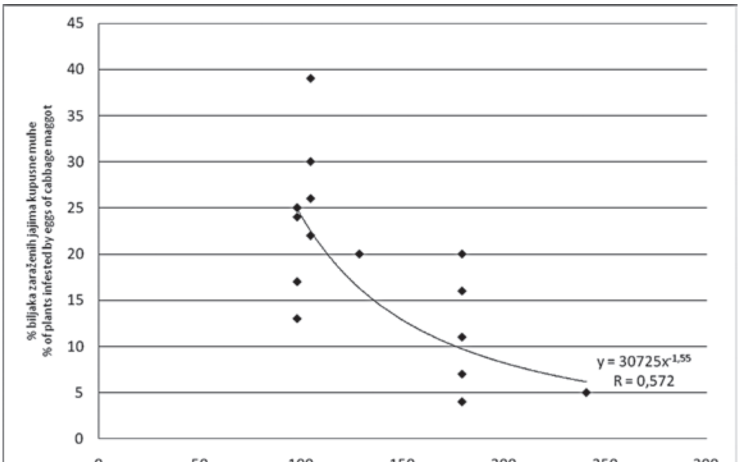

Figure 2. Regression analysis of the average cumulative capture of the cabbage fly (*Delia radicum* (L.)) on yellow sticky traps versus percentage of plants infested by eggs, Ogulin 2008 and 2009.

Slika 2. Odnos između prosječnog kumulativnog ulova kupusne muhe (*Delia radicum* (L.)) na žutim pločama i % biljaka zaraženih jajima, Ogulin 2008. i 2009.

Immediately after their emergence they are not able to mate and oviposit. During the beginning egg-laying period the highest number of eggs are laid. After that, the late emerging flies are laying their eggs and the dynamics of the emergence decreases, which results in a negative correlation. The first significant egg-laying is observed three weeks after transplanting. Average cumulative capture of flies on yellow sticky traps (independent variable) and average number of eggs/plant (dependent variable) and infestation intensity (dependent variable) are highly correlated in both cases with correlation coefficients of 0.736 and 0.740, respectively. The average number of eggs becomes almost equal with the increase of cumulative capture of flies, but afterwards decreases because oviposition has ended. Average number of eggs laid per plant was between 3.5 and 4, which is a low infestation when compared to data of Easter at al. (2005) where 13 or more eggs per plant were shown.

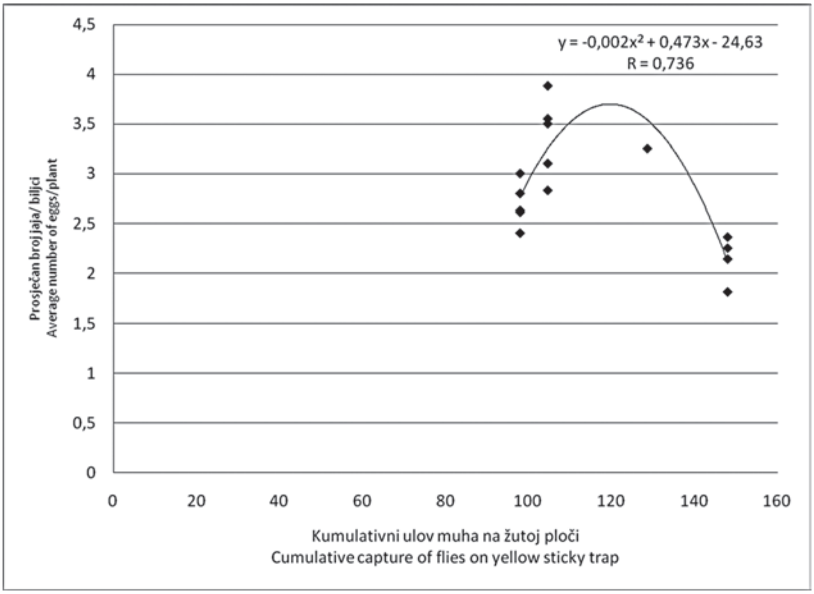

Figure 3. Regression analysis of the average cumulative capture of the cabbage fly (*Delia radicum* (L.)) on yellow sticky traps versus average number of eggs/plant, Ogulin 2008 and 2009.

Slika 3. Odnos između prosječnog kumulativnog ulova kupusne muhe (*Delia radicum* (L.)) na žutim pločama i prosječnog broja jaja/biljci, Ogulin 2008. i 2009.

Bligaard (1999) noted that an artificial infestation with 100 eggs per plant can result in a 5% reduction of plant growth. It was also stated that the percentage of mortality of eggs and larvae is very high (between 47 and 61%) and depends on population density. As an economic threshold (ET), Bligaard (2001) considered an average infestation of 21 eggs/plant, if 30% of plants are infested. If the same infestation is recalculated into the infestation intensity, the economic threshold is 6.2. The highest infestation intensity in our trials was below 1.0, which is much lower than the ET. Kostal et al. (2000) stated that oviposition is influenced by host plant presence, as well as by the quality of the soil in which the plants are growing. For their oviposition sites, females prefer soil rich in organic matter, dry on the surface and moist at a level of 5 mm.

Correlation coefficient between cumulative capture of the beetles and percentage of plants showing symptoms of larval infestation (Figure 5), was in 2008 0.432 in 2008 and 0.499 in 2009.

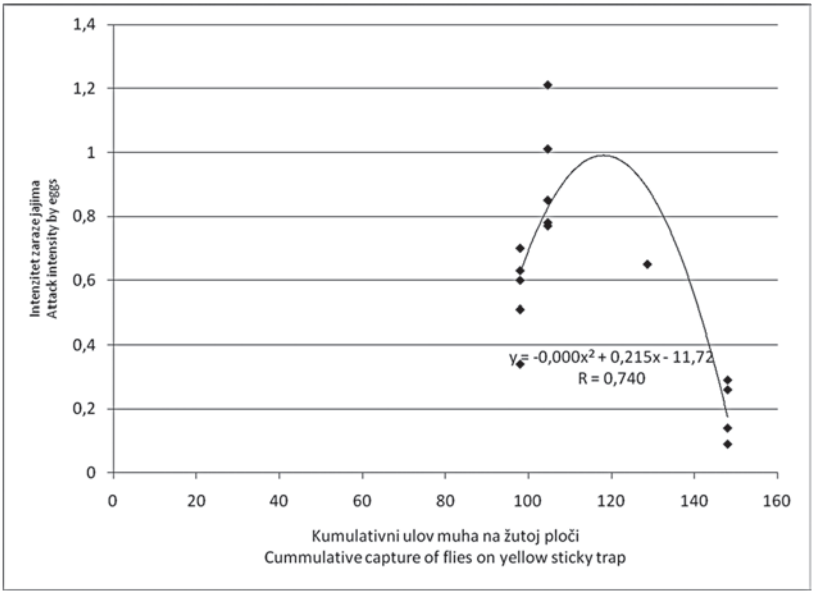

Figure 4. Regression analysis of the average cumulative capture of the cabbage fly (*Delia radicum* (L.)) on yellow sticky traps versus average attack intensity by eggs, Ogulin 2008 and 2009.

Slika 4. Odnos između prosječnog kumulativnog ulova kupusne muhe (*Delia radicum* (L.)) na žutim pločama i intenziteta zaraze jajima, Ogulin 2008. i 2009.

This would be considered a medium correlation between these two variables. In spite of higher capture of flies in 2009, which was almost double that of 2008, the percentage of plants which showed symptoms of larval infestation was lower when than in 2008. In both years, the trials were carried out in the same field so that differences related to edaphic factors mentioned by Kostal et al. (2000) did not exist. In both years similar temperature conditions were observed (Figure 1 and Figure 6). The only difference in climatic conditions was in the amount of rainfall in May when the larvae were emerging from the eggs and beginning plant attack. The amount of rainfall in May of 2009 was only 24.5 mm, while the amount of rainfall for the same month in 2008 was 87.7 mm. We concluded that the distribution and the quantity of rainfall during May were the main factors influencing larval infestation and plant damage.

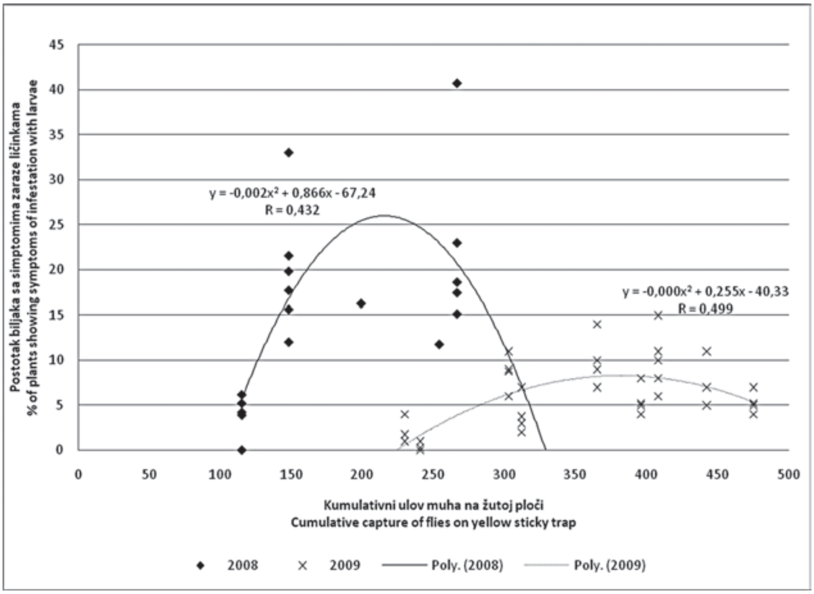

Figure 5. Regression analysis of the average cumulative capture of the cabbage fly (*Delia radicum* (L.)) on yellow sticky traps versus percentage of plants showing symptoms of larval attack, Ogulin 2008 and 2009.

Slika 5. Odnos između kumulativnog ulova kupusne muhe (*Delia radicum* (L.)) na žutim pločama i % biljaka sa simptomima napada ličinki na ranom kupusu- Ogulin, 2008. i 2009.

After a certain level of cumulative captures was reached, the percentage of plants showing symptoms of larval infestation started to decrease. This indicates that cumulative captures could be used as the indicator of population density and the need to apply control measures. As can be seen in Figure 6, the maximum attack by larvae happens when the degree-day accumulations reached between 750 and 800, and the cumulative number of flies 200-250, depending on the year. Derves et al. (2006) stated that at the described climatic conditions at the time of the flight of the first generation, fly activity stops. The level of infestation depends on population density, and on different biotic and abiotic factors the most of which important are distribution and quantity of rainfall.

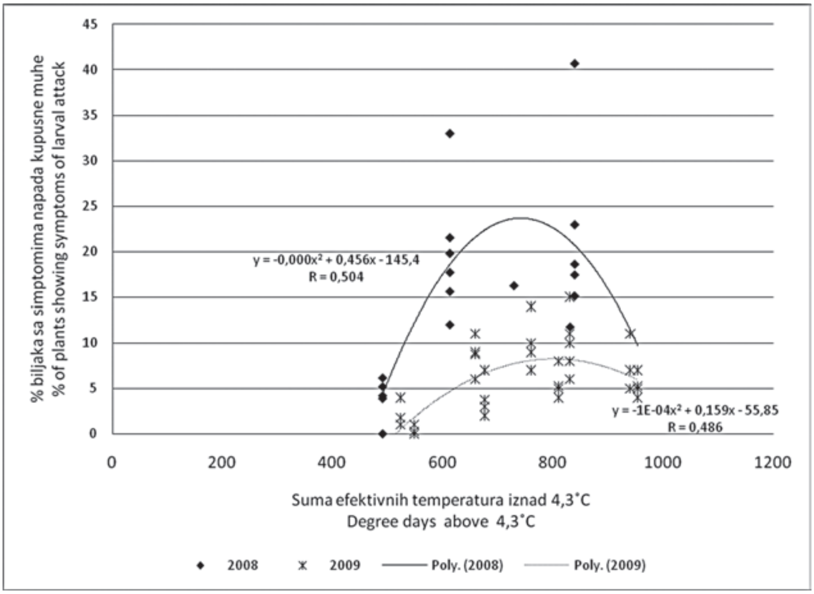

Figure 6. Regression analysis of the degree-day accumulation versus percentage of plants showing symptoms of the attack by larvae of cabbage fly (*Delia radicum* (L.)), Ogulin 2008 and 2009.

Slika 6. Korelacija između sume efektivnih temperatura i % biljaka sa simptomima napada od ličinki kupusne muhe (*Delia radicum* (L.)), Ogulin 2008. i 2009.

Conclusions

There is a strong positive correlation between the degree-day accumulation and cumulative capture of flies on yellow sticky traps. This confirms that the emergence of the flies from the soil and the capture of flies on yellow sticky traps are dependent on temperature. The spring flight of the flies in cabbage fields was observed in both years 7 to 10 days after transplanting, when the degree-day accumulation reached 450-500.

The percentage of plants infested by eggs, average number of eggs per plant, as well as the attack intensity by eggs can be determined by the cumulative capture of flies on yellow sticky traps. Correlations varied between medium for percentage of plants infested with eggs to strong for average number of eggs per plant and for attack intensity.

There is a medium correlation between the cumulative capture of the flies on yellow sticky traps and the percentage of plants infested with larvae.

The percentage of plants showing symptoms of larval attack depends on population density, as well as on other factors among which the amount of rainfall and rainfall distribution at the time of egg hatching are the most important. Therefore, from the two-year trial in which different conditions related to rainfall were present, it is not possible to establish the population density that will result in larval attack.

Maximal larval attack was observed when degree-day accumulation has reached 750-800.

References

BIRON, D., LANGLET, X., BOIVIN, G. & BRUNEL, L., 1998. Expression of early and late emerging phenotypes in both diapausing and non-diapausing *D. radicum* pupae. Entomol. Exp. Appl. 87(2): 119-124.

BLIGAARD, J., 1999. Damage thresholds for cabbage maggot (*Delia radicum* (L.)) in cauliflower assessed from pot experiments. Acta Agric. Scand. Sect. B-Soil plant Sci. 49(1): 57-64.

BLIGAARD, J., 2001. Binomial sampling as a cost efficient sampling method for pest management of cabbage maggot (Dipl., Anthomyiidae) in cauliflower. J. Appl. Ent. 125: 155-159.

BLIGAARD, J., MEADOW, R., NIELSEN, O. & PERCY-SMITH, A., 1999. Evaluation of felt traps to estimate egg numbers of cabbage maggot, *Delia radicum*, and turnip maggot, *Delia floralis* in commercial crops. Entomol. Exp. Appl. 90(2): 141-148.

CERANIĆ-SERTIĆ, M. BAŽOK, R. 2009. Kupusna muha sve važniji štetnik kupusa u Gorskom kotaru. Glasilo biljne zaštite. IX(4): 252-259.

CVJETKOVIĆ, B., BAŽOK, R., IGRC BARČIĆ, J., BARIĆ, K. i OSTOJIĆ, Z. (2009). Pregled sredstava za zaštitu bilja u Hrvatskoj za 2009. godinu. Glasilo biljne zaštite, 1-2

DREVES A.J., DALTHORP, D., STONE, A.G. & FISHER, G., 2006. Spring Emergence and Seasonal Flight of *Delia radicum* L. (Diptera: Anthomyiidae) in Western Oregon. Eniviron. Entomol. 35(2): 465-477.

ESTER, A., de PUTTER, H. van BILSEN, J.G.P.M., 2005. Efficacy of insecticide seed treatment of white cabbage and cauliflower to control cabbage maggot, *Delia radicum.* Integrated Control if Field Vegetable Crops, IOBC wprs Bulletin, 28(4): 135-141.

HAĐISTEVIĆ, D., 1983. *Ostrinia nubialis*. In: Priručnik izvještajne i prognozne službe zaštite poljoprivrednih kultura. (ed: Čamprag, D. et al.) Savez društava za zaštitu bilja Jugoslavije, Beograd: 222-228.

JYOTI, J.L., SHELTON, A.M. & BERNARD, J., 2003. Evaluation of degree-day and Julian day logistic models in predicting cabbage maggot (Diptera: Anthomyiidae) emergence and flight in upstate New York. J. Entomol. Sci. 38(4): 525-532.

KOSTAL, V., BAUR, R. & STÄDLER, E., 2000. Exploration and assessment of the oviposition substrate by the cabbage maggot, *Delia radicum* (Diptera:Anthomyiidae). Eur. J. Entomol. 97: 33-40.

MACELJSKI, M., 2004. Kupusna muha.: MACELJSKI, M. (ur.), Štetočinje povrća, Zrinski, Čakovec: 307-309.

ŠUBIĆ, M., 2008. Mogućnosti suzbijanja kupusne muhe (*Delia radicum* L.) (Diptera: Anthomyiidae) i drugih štetnika potapanjem presadnica u kontejnerima prije sadnje. Glasilo biljne zaštite 1: 33-40.

TURNOCK, W.G. & BOIVIN, G. (1997). Inter- and intrapopulation differences in the effect of temperatures on postdiapause development on *Delia radicum*, Entomol. Exp. Appl. 84: 255-265.

VASILJ, Đ. 2000. Biometrika i eksperimentiranje u bilinogojstvu. Hrvatsko agronomsko društvo, Zagreb: 320

WALGENBACH, J.F., ECKENRODE, C.J. & STRAUB, R.W. (1993). Emergence patterns of *Delia radicum* (Diptera: Anthomyiidae) populations from North Carolina and New York. Environ. Entomol. 22(3): 559-566.