Milena RUSIN, Janina GOSPODAREK
University of Agriculture in Krakow, Faculty of Agriculture and Economics
Department of Agricultural Environment Protection
Al. Mickiewicza 21, 31-120 Kraków, Poland
e-mail: milena_rusin@wp.pl

Received: 2017-05-10 ; Accepted: 2017-07-03

THE EFFECT OF PEPPERMINT AQUEOUS EXTRACTS ON COLORADO POTATO BEETLE

Summary

The aim of the study was to determine the effect of aqueous extracts from fresh and dry peppermint (Mentha piperita L.) matter on the feeding of Colorado potato beetle (Leptinotarsa decemlineata Say.) adults (males and females) and larvae (L_2, L_3 and L_4 stages). The experiment was conducted under laboratory conditions in five replications. Extracts were prepared at concentrations of 2%, 5% and 10% for dry matter and 10%, 20% and 30% for fresh matter. Pest feeding intensity assessment was carried out by dipping leaves of potato in respective solutions of the extracts, and then determining the weight of food eaten by adults and larvae, and changes in larvae body weight once a day. The results of the experiment showed that extracts prepared from dry matter at the two highest concentrations (5 and 10%) and from fresh matter at a concentration of 30% significantly reduced the feeding of L_2 and L_3 larvae of the Colorado potato beetle. None of the extracts was found to have a significant effect on the feeding of potato beetle adults. Moreover, the fresh matter extract at a concentration of 10% stimulated the feeding of L_4 larval stage. Dry plant matter extracts at two highest concentrations caused a significant decrease in the body weight of L_2 and L_3 potato beetle larvae. On the other hand, L_4 larvae feeding on the object where fresh peppermint extracts at a concentration of 10% were applied were characterized by a significantly higher body weight gain than the larvae feeding on the control.
***Key words**: aqueous extracts, peppermint, Colorado potato beetle*

WPŁYW WODNYCH WYCIĄGÓW Z MIĘTY PIEPRZOWEJ NA ŻEROWANIE STONKI ZIEMNIACZANEJ

Streszczenie

Celem badań było określenie oddziaływania wodnych wyciągów przygotowanych ze świeżej i suchej masy mięty pieprzowej (Mentha piperita L.) na żerowanie dorosłych osobników (samic i samców) oraz larw (stadium L_2, L_3 i L_4) stonki ziemniaczanej (Leptinotarsa decemlineata Say.). Doświadczenie zostało przeprowadzone w warunkach laboratoryjnych w pięciu powtórzeniach. Wyciągi przygotowano w stężeniach 2%, 5% i 10% dla suchej masy roślin oraz 10%, 20% i 30% dla świeżej masy. Ocena intensywności żerowania szkodników została przeprowadzona poprzez moczenie liści ziemniaków w roztworach odpowiednich wyciągów, a następnie określeniu masy pokarmu zjedzonego przez osobniki dorosłe i larwy oraz zmiany masy ciała larw, z częstotliwością raz na dobę. Na podstawie przeprowadzonych badań stwierdzono, że wyciągi sporządzone z suchej masy mięty pieprzowej w dwóch najwyższych stężeniach (5 i 10%) oraz wyciąg ze świeżej masy o stężeniu 30% przyczyniły się do istotnego ograniczenia żerowania larw L_2 i L_3 stonki ziemniaczanej. Nie stwierdzono natomiast wpływu żadnego z zastosowanych wyciągów na żerowanie osobników dorosłych analizowanego szkodnika, a co więcej wyciąg ze świeżej masy o stężeniu 10% stymulował żerowanie larw L_4. Wyciągi sporządzone z suchej masy w dwóch najwyższych stężeniach spowodowały istotny spadek masy ciała larw L_2 i L_3 stonki ziemniaczanej, z kolei larwy L_4 żerujące w obiekcie, w którym zastosowano wyciąg ze świeżej masy o stężeniu 10% charakteryzowały się istotnie wyższą masą ciała niż larwy żerujące w kontroli.
***Słowa kluczowe**: wyciągi wodne, mięta pieprzowa, stonka ziemniaczana*

1. Introduction

Throughout its growing season, the potato (*Solanum tuberosum* L.) is subject to attacks from a number of pests, the most dangerous of them being the Colorado potato beetle (*Leptinotarsa decemlineata* Say.). Both the adult and larval forms of that pest feed on the aerial parts of plants. Due to their high fertility and voracity, Colorado potato beetles cause considerable damage to crop yield, which may reach up to 90% [12, 15, 22]. The use of the same chemical products each year in order to reduce potato beetle feeding results in the pests becoming resistant to the active substances contained in those compounds [1, 19]. Therefore, it is extremely important to search for new, non-chemical methods that would be equally effective in reducing the feeding of those pests [21, 23]. One example here are the extracts from herbs, which have a number of positive characteristics, including the availability of raw material, ease of preparation, low production costs. Moreover, they do not accumulate in soil, water and the atmosphere which makes them safe for people and the entire natural environment [3, 9].

The peppermint (*Mentha piperita* L.) is a plant of the family *Lamiacae*, produced by crossing two species: *Mentha viridis* L. and *Mentha aquatica* L. [11]. It is commonly cultivated in Poland due to the possibility of being used in many different branches of industry [14]. In addition to its aromatic benefits, it also has biological and medicinal properties [5, 6, 7]. Essential oil which accumulates in the leaves in an amount of 2.9% is the main and most important component of the peppermint raw material [20].

The aim of the performed study was to determine the effect of aqueous extracts from dry and fresh peppermint matter at various concentrations on the feeding of Colorado potato beetle adults (males and females) and larvae (L_2, L_3 and L_4 stages).

2. Material and methods

The experiment was conducted in the laboratory, in five replicates. Fresh leaves of potato and *Leptinotarsa decemlineata* Say. adults and L_2, L_3, L_4 stage larvae used for the analysis at the beginning of July 2016 were collected. Extracts from dry matter (DM) of *Mentha piperita* L. were prepared at concentration of 2%, 5% and 10% (dried plants + cold double-distilled water in proportions of 2:100, 5:100 and 10:100) and at concentration of 10%, 20% and 30% for fresh matter (FM) (fresh above-ground parts of plants + cold double-distilled water in proportions of 10:100, 20:100 and 30:100). Extracts were stored in the dark at room temperature over a period of 24 hours, filtered through filters paper and immediately used to perform the experiments. Potato leaves were dipped for 3 seconds in an adequate plant extracts and in distilled water which was a control object, and then dried at room temperature. The test was carried out in Petri dishes, and as a substrate wet filter paper was used. In each dish two leaves of potato, suitable for a specific object were placed and then one male, female and L_4 larvae (separately) and also two L_2 and L_3 larvae of *L. decemlineata* were introduced. In determining the effect of extracts of *M. piperita* on pest feeding the leaf mass consumed by adult and L_2, L_3, L_4 larvae and changes of larvae body weight once a day were established.

The obtained results were then subject to analysis by STATISTICA 10.0 software. The significance of differences between the means were tested by univariate analysis of variance, and the means were differentiated by Fisher's LSD test at $\alpha = 0.05$.

3. Results and discussion

The extracts used in this experiment, both those prepared from dry and fresh peppermint matter, did not generally have a significant impact on the feeding of potato beetle adults (Table 1). The only exception was the extract from fresh plant matter at a concentration of 30% which significantly reduced the weight of food eaten by potato beetle males after 24 hours after the beginning of the experiment, and the weight of food eaten by females after 72 hours. It was also noted that irrespective of the extract type and concentration, the feeding intensity in potato beetle females was higher than in males during all phases of the observation.

The extracts prepared from dry peppermint matter at the two highest concentrations (5 and 10%) and from fresh peppermint matter at a concentration of 30% significantly reduced the feeding of L_2 and L_3 larvae of the Colorado potato beetle (Table 2). On the other hand, they had no impact on the feeding of L_4 stage larvae. Furthermore, the extract from fresh peppermint matter at a concentration of 10% contributed to a significant increase in the weight of food eaten by L_4 stage larvae during nearly all phases of the observation. After completion of the experiment, the weight of the leaves eaten by the larvae in that object was almost higher by 25 mg than in the control.

Table 1. The effect of extracts of *Mentha piperita* L. on the leaf mass consumed by adult of *Leptinotarsa decemlineata* Say. [mg]

Tab. 1. Wpływ wyciągów z mięty pieprzowej na masę pokarmu zjedzonego przez imago stonki ziemniaczanej [mg]

Object	12 h	24 h	48 h	72 h
Males				
C	73.5^{a*}	107.5^{b}	126.6^{ab}	187.3^{ab}
DM 2%	75.6^{a}	108.1^{ab}	123.4^{ab}	186.2^{ab}
DM 5%	71.3^{a}	97.6^{ab}	115.4^{a}	176.5^{a}
DM 10%	68.2^{a}	99.8^{ab}	117.8^{ab}	182.1^{ab}
FM 10%	69.3^{a}	104.5^{ab}	125.4^{ab}	192.4^{b}
FM 20%	71.5^{a}	105.3^{ab}	130.2^{b}	194.1^{b}
FM 30%	65.9^{a}	95.3^{a}	112.7^{a}	169.7^{a}
Females				
C	82.4^{ab}	111.4^{a}	152.2^{ab}	212.5^{b}
DM 2%	84.2^{ab}	109.6^{a}	143.5^{ab}	207.4^{ab}
DM 5%	86.1^{b}	116.2^{a}	158.2^{b}	211.9^{b}
DM 10%	74.5^{a}	109.3^{a}	143.5^{ab}	206.8^{ab}
FM 10%	78.3^{ab}	107.9^{a}	141.7^{a}	205.9^{ab}
FM 20%	81.4^{ab}	108.5^{a}	142.8^{ab}	203.5^{ab}
FM 30%	71.2^{a}	103.1^{a}	139.6^{a}	194.2^{a}

C – control, DM – dry matter, FM – fresh matter. *Values for individual terms of observations marked by different letters are statistically different ($\alpha = 0.05$).

Source: own work / Źródło: opracowanie własne

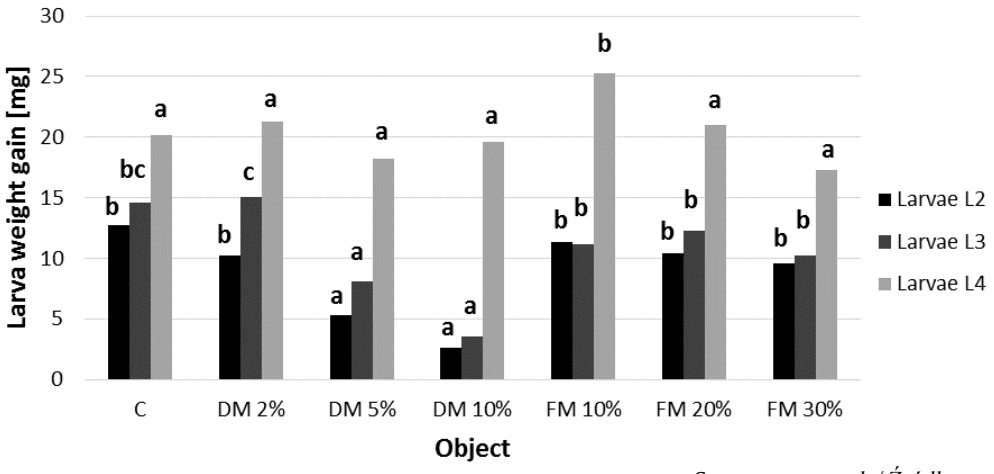
Table 2. The effect of extracts of *Mentha piperita* L. on the leaf mass consumed by larvae of *Leptinotarsa decemlineata* Say. [mg]

Tab. 2. Wpływ wyciągów z mięty pieprzowej na masę pokarmu zjedzonego przez larwy ziemniaczanej [mg]

Object	12 h	24 h	48 h	72 h
Larvae L_2				
C	41.3^{b*}	56.7^{c}	75.6^{c}	102.5^{c}
DM 2%	36.5^{b}	53.2^{c}	71.4^{bc}	99.8^{c}
DM 5%	12.7^{a}	22.4^{a}	32.6^{a}	41.6^{a}
DM 10%	15.3^{a}	31.5^{ab}	39.8^{a}	44.8^{a}
FM 10%	40.7^{b}	49.4^{bc}	70.2^{bc}	96.5^{c}
FM 20%	38.4^{b}	51.3^{c}	68.4^{bc}	94.2^{c}
FM 30%	19.6^{a}	39.6^{b}	50.1^{b}	61.2^{b}
Larvae L_3				
C	51.2^{b}	81.5^{c}	127.3^{c}	169.3^{bc}
DM 2%	52.3^{b}	80.2^{bc}	128.4^{c}	172.5^{c}
DM 5%	47.8^{ab}	67.3^{ab}	91.2^{b}	131.6^{a}
DM 10%	38.6^{a}	50.2^{a}	71.3^{a}	126.2^{a}
FM 10%	50.2^{ab}	78.9^{bc}	118.9^{c}	158.2^{bc}
FM 20%	48.6^{ab}	75.2^{b}	116.3^{c}	155.1^{b}
FM 30%	46.5^{ab}	64.1^{ab}	85.6^{ab}	117.8^{a}
Larvae L_4				
C	58.6^{ab}	92.3^{ab}	143.5^{ab}	216.8^{a}
DM 2%	59.3^{ab}	95.2^{ab}	138.9^{ab}	209.5^{a}
DM 5%	55.2^{a}	89.7^{a}	129.6^{a}	207.3^{a}
DM 10%	62.3^{b}	93.6^{ab}	147.5^{b}	212.5^{a}
FM 10%	71.8^{c}	101.5^{b}	163.8^{c}	241.3^{b}
FM 20%	55.7^{a}	87.9^{a}	128.7^{a}	212.2^{a}
FM 30%	52.3^{a}	86.4^{a}	128.2^{a}	216.7^{a}

Symbols as in tab.1. *Values for individual terms of observations marked by different letters are statistically different ($\alpha = 0.05$).

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 1. The effect of extracts of *Mentha piperita* L. on changes in larvae of *Leptinotarsa decemlineata* Say. weight gain after the end of the experiment (separately for each stage) [mg]. *Values for individual larvae stage marked by different letters are statistically different ($\alpha = 0.05$)

*Fig. 1. Wpływ wyciągów z mięty pieprzowej na zmiany masy ciała larw stonki ziemniaczanej po zakończeniu doświadczenia (oddzielnie dla każdego stadium) [mg]. *Wartości oznaczone różnymi literami dla danego stadium różnią się od siebie istotnie przy α= 0,05*

L_2 and L_3 potato beetle larvae feeding on the object where dried peppermint extracts at a concentration of 5 and 10% were applied were characterised by a significantly lower body weight gain than the larvae feeding on the control (Fig. 1). The extracts used in most cases had no significant effect on body weight gain in L_4 stage larvae. Only the extract from fresh peppermint matter at a concentration of 10% caused a significant increase in the larvae body weight in comparison to the larvae feeding on the control (by over 5 mg).

No research has so far been conducted to study the effect of aqueous peppermint extracts on the feeding activity of pests. However, experiments were carried out to investigate the use of peppermint essential oils that are characterised by a much higher concentration of compounds than the traditional aqueous extracts. Peppermint essential oil is mainly composed of menthol (30%) and menthone (20%) and other components including isomenthol, isopulegol and camphor [20]. Cloyd et al. [4] demonstrated that peppermint essential oil results in over 80% mortality of *Planococcus citri* (Risso). Momen et al. [13] found that it may have a toxic effect on the red spider mite (*Tetranychus urticae* Koch) and mites of the family *Phytoseiidae*, as well as reducing the number of eggs laid by the female. Wild mint essential oil at a concentration of 1% reduces the feeding of the tobacco thrips (*Thrips tabaci* L.) [8] due to the presence of menthol and menthone which have an inhibitory effect on the feeding of crop pests.

Studies concerning the effect of aqueous extracts from herbs on the feeding of Colorado potato beetle were also carried out by other authors. Rusin et al. [16] showed that aqueous wormwood (*Artemisia absinthium* L.), extracts did not in general have a significant impact on the feeding of potato beetle adults. However, highly concentrated extracts from dry wormwood matter may reduce the feeding of potato beetle larvae as well as decreasing their body weight gain. Similar trends were noticed in the present experiment which involved the use of aqueous peppermint extracts. Other experiments conducted by the above-mentioned authors [17,18] demonstrated the adverse impact of tarragon (*Artemisia dracunculus* L.) extracts and wild thyme (*Thymus serpyllum* L.) extracts on potato beetle feeding. Furthermore, adult individuals proved to be more resistant than larvae. Biniaś et al. [2] discovered that the aqueous extracts of St John's wort (*Hypericum perforatum* L.) at a concentration of at least 5% for dry matter and 20% for fresh matter reduced the feeding of L_3 and L_4 larvae of the Colorado potato beetle. Lamparski and Wawrzyniak [10] showed that the extracts obtained from dry matter of *Geranium pusilum* L., *Geranium robertanium* L. and *Pelargonium x hortorum* Bailey at a concentration of 10% reduced the body weight of potato beetle larvae by nearly 70%. In this experiment, also the extracts from dry peppermint matter at a concentration of 5 and 10% contributed to body weight decrease in L_2 and L_3 larval stages. Other studies by Lamparski and Wawrzyniak [9] also confirmed that the aqueous extracts from *Pelargonium x hortorum* Bailey at a concentration of 10 % reduced the body weight of potato beetle larvae by 23 mg compared to the control.

4. Conclusions

1. The extracts prepared from dry peppermint matter at the two highest concentrations (5 and 10%) and from fresh peppermint matter at a concentration of 30% significantly reduced the feeding of L_2 and L_3 larvae of the Colorado potato beetle.
2. None of the extracts was found to have a significant effect on the feeding of potato beetle adults. Moreover, the fresh matter extract at a concentration of 10% stimulated the feeding of L_4 larval stage.
3. Dry plant matter extracts at two highest concentrations caused a significant decrease in the body weight of L_2 and L_3 potato beetle larvae. On the other hand, L_4 larvae feeding on the object where dried peppermint extracts at a concentration of 10% were applied were characterised by a significantly higher body weight gain than the larvae feeding on the control.

5. References

[1] Alyokhin A., Baker M., Mota-Sanchez D., Dively G., Grafius E.: Colorado potato beetle resistance to insecticides. Am. J. Pot Res, 2008, Vol. 85, 395-413.

[2] Biniaś B., Gospodarek J., Rusin M.: Effect of aqueous extract of St. John's wort (*Hypericum perforatum* L.) on the Colorado potato beetle (*Leptinotarsa decemlineata* Say.) behaviour. J. Res. Appl. Agric. Engng, 2016, Vol. 61(3), 25-29.

[3] Bunescu H., Ghizdavu I., Mihai G., Oltean I., Porca M., Bodiş I.: The control of pests in ecosystems by unchemical methods. JCEA, 2003, Vol. 4(1), 7–12.

[4] Cloyd R.A., Galle C.L., Keith S.R., Kalscheur N.A., Kemp K.E.: Effect of commercially available plant-derived essential oil products on arthropod pests. J. Econ. Entomol, 2009, Vol. 102(4), 1567-1579.

[5] Derwich E., Benziane Z., Taouil R., Senhaji O., Touzani M.: Aromatic plants in Morocco: GC/MS analysis of essential oils of leaves of *Mentha piperita*. Adv. Environ. Biology, 2010, Vol. 4, 80-85.

[6] Eteghad S.S., Mirzaei M., Pour S.F., Kahnamui S.: Inhibitory effects of endemic *Thymus vulgaris* and *Mentha piperita* essential oils on *Escherichia coli* O157:H7. Res. J. Biol. Sci., 2009, Vol. 4(3), 340-344.

[7] Jeyakumar E., Lawrence R., Pal T.: Compratative evaluation in the efficacy of peppermint (*Mentha* x *piperita* L.) on growth of some filamentous fungi. Herba polonica, 2010, Vol. 56(4), 60-70.

[8] Koschier E.H., Sedy K.A., Novak J.: Influence of plant volatiles on feeding damage caused by the onion thrips *Thrips tabaci*. Crop Prot., 2002, Vol. 21(5), 419-425.

[9] Lamparski R., Wawrzyniak M.: Effect of water extracts from Geraniaceae (*Gereniaceae*) plants on feeding and development of Colorado potato beetle (*Leptinotarsa decemlineata* Say). EJPAU, 2004, Vol. 7(2).

[10] Lamparski R. Wawrzyniak M.: Effect of water extracts from *Geraniaceae* plants with adjuvant added on feeding and development of Colorado potato beetle (*Leptinotarsa decemlineata* Say). J. Plant Prot. Res., 2005, Vol. 45(2), 115-123.

[11] Lopez V., Martin S., Gomez-Serranillos M.P., Carretero M.E., Jager A.K., Calvo M.I.: Neuroprotective and neurochemical properties of mint extracts. Phytother. Res., 2010, Vol. 24, 869-874.

[12] Maharijaya A., Vosman B.: Managing the Colorado potato beetle; the need for resistance breeding. Euphytica, 2015, Vol. 204(3), 487-501.

[13] Momen F.M., Amer S.A.A., Refaat A.M.: Influence of mint and peppermint on *Tetranychus urticae* and some predacious mites of the family Phytoseiidae (Acari: Tetranychidae: Phytoseiidae). Acta Phytopathol. Entomol. Hung., 2005, Vol. 36(1-2), 143-153.

[14] Newerli-Guz J., Kobylańska A.: Ocena jakości jednoskładnikowych herbatek ziołowych na przykładzie *Mentha piperita*. Probl. Hig. Epidemiol., 2013, Vol. 94(4): 862-865.

[15] Popova E.N.: The influence of climatic changes on range expansion and phenology of the Colorado potato beetle (*Leptinotarsa decemlineata*, Coleoptera, Chrysomelidae) in the territory of Russia. Entomol. Rev., 2014, Vol. 94(5), 643-653.

[16] Rusin M., Gospodarek J., Biniaś B: Effect of water extracts from *Artemisia absinthium* L. on feeding of selected pests and their response to the odor of this plant. JCEA, 2016, Vol. 17(1), 188-206.

[17] Rusin M., Gospodarek J., Biniaś B.: Effect of aqueous extracts from tarragon (*Artemisia dracunculus* L.) on feeding of selected crop pests. J. Res. Appl. Agric. Engng, 2016, Vol. 61(4), 143-146.

[18] Rusin M., Gospodarek J., Biniaś B.: The effect of water extract from wild thyme on Colorado potato beetle feeding. J. Ecol. Eng., 2016, Vol. 17(4), 197-202.

[19] Szendrei Z., Grafius E., Byrne A., Ziegler A.: Resistance to neonicotinoid insecticides in field populations of the Colorado potato beetle (Coleoptera: Chrysomelidae). Pest Manag. Sci., 2012, Vol. 68(6), 941-946.

[20] Tsai M.L., Wu C.T., Lin T.F., Lin W.C., Huang Y.C., Yang C.H.: Chemical composition and biological properties of essential oils of two mint species. Trop. J. Pharm. Res., 2013, Vol. 12(4), 577-582.

[21] Tscharntke T., Klein A.M., Kruess A., Dewenter I.S., Thies C.: Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. Ecol. Letters, 2005, Vol. 8(8), 857–874.

[22] Vilkova N.A., Sukhoruchenko G.I., Fasulati S.R.: Strategy for crop protection from phytophagous insects of adventive species exemplified for the Colorado potato beetle. Plant Protection News, 2005, Vol. 3, 3-14.

[23] Wawrzyniak M.: Effect of extracts from Geraniaceae plants on *Pieris brassicae* L. JCEA, 2009, Vol. 10(4), 361-365.

This research was financed by the Ministry of Science and Higher Education of the Republic of Poland.