EFFECT OF PLANT ESSENTIAL OILS ON THE DEVELOPMENT AND FERTILITY OF GRAIN WEEVIL (SITOPHILUS GRANARIUS L.)

DZIAŁANIE ROŚLINNYCH OLEJKÓW ETERYCZNYCH NA ROZWÓJ I PŁODNOŚĆ WOŁKA ZBOŻOWEGO (SITOPHILUS GRANARIUS L.)

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ABSTRACT

There was analyzed the effect of selected essential oils (orange, lemon, vanilla, linden blossom, thyme, geranium and tea oils) on the development and fertility of the most dangerous cereal grain storage pest, grain weevil. Based on the results obtained, it was observed that a strong effect limiting the population of grain weevil was found for vanilla and orange oils. In the experiment combinations which involved essential oils, there was observed a prolonged pest development cycle and a higher mortality of maternal individuals than in the other tests. On the other hand, the lowest fecundity rate was recorded in the combination in which thyme oil was tested.

Key words: storage product pest, plant oils

ABSTRACT

Analizowano oddziaływanie roślinnych olejków eterycznych (pomarańczowy, cytrynowy, waniliowy, z kwiatu lipy, tymiankowy, geraniowy i herbaciany) na rozwój i płodność najgroźniejszego szkodnika magazynowanego ziarna zbóż, wołka zbożowego. Na podstawie uzyskanych wyników stwierdzono, że silne działanie ograniczające populację wołka wykazały olejki waniliowy i pomarańczowy. W kombinacjach doświadczalnych, w których je stosowano, obserwowano wydłużenie cyklu rozwojowego szkodnika oraz wyższą niż w pozostałych testach śmiertelność osobników macierzystych. Natomiast najniższy wskaźnik płodności uzyskano w kombinacji, w której testowano olejek tymiankowy.

Słowa kluczowe: szkodniki magazynowe, olejki roślinne

DETAILED ABSTRACT

W ramach poszukiwania alternatywnych w stosunku do metody chemicznej, sposobów walki ze szkodnikami produktów przechowywanych, analizowano oddziaływanie roślinnych olejków eterycznych (pomarańczowy, cytrynowy, waniliowy, z kwiatu lipy, tymiankowy, geraniowy i herbaciany) na rozwój i płodność najgroźniejszego szkodnika magazynowanego ziarna zbóż, wołka zbożowego. Hodowlę wołka zbożowego prowadzono w szklanych kolbach, na ziarnie pszenicy konsumpcyjnej, w klimatyzowanym laboratorium. Dla każdej serii obliczano: śmiertelność owadów, czas rozwoju pokolenia, czas trwania pokolenia i wskaźnik płodności. Na podstawie uzyskanych wyników stwierdzono, że silne działanie ograniczające populację wołka wykazały olejki waniliowy i pomarańczowy. W kombinacjach doświadczalnych, w których je stosowano, obserwowano wydłużenie cyklu rozwojowego szkodnika oraz wyższą niż w pozostałych testach śmiertelność osobników macierzystych Natomiast najniższy wskaźnik płodności uzyskano w kombinacji, w której testowano olejek tymiankowy .

Uzyskane wyniki są zgodne z wynikami badań innych autorów badających biologiczną aktywność olejków eterycznych i innych produktó roślinnych stosunku do szkodników produktów przechowywanych [3, 4, 5, 8, 13, 15].

INTRODUCTION

The most effective method of storage pest control method is the application of chemical fumigants. The method, however, can pose a threat of developing resistance of the pests controlled to the preparations used, contamination of the foodstuffs stored and a lowered seed germination capacity. With that in mind alternative pest control methods which would limit the synthetic insecticides consumption are being searched for. One of the ways is to analyze active, towards insects, natural substances of plant origin, including essential oils, of a low toxicity to people and warm-blooded animals which can be a potential source of fumigant production components. Many authors deal with the use of oils as insecticides. [7, 8, 15].

The working hypothesis of the present paper assumes that essential oils of plant origin containing natural substances with insecticidal or deterrent effect can disturb the pest development, and as such they can be considered while selecting the elements of the strategy of an integrated storage product pest control.

And thus the aim of the present research was to determine the effect of selected plant oils on the development and fertility of grain weevil, being the most dangerous pest of stored grain of cereals of the moderate climate.

MATERIALS AND METHODS

Grain weevil was incubated in glass flasks (250ml), on the consumption wheat grain, in the air-conditioned lab at 25^{o} C., at the humidity of 70-80%. Wheat grain was sprinkled with water (10ml/100 g of wheat) and, after drying at the room temperature, it was placed into breeding vessels.

Essential oils, purchased from the herbalist's shop, were added into culture vessels in glass test-tubes,10mg each. The experiment involved 8 series. The first one was the control with no oil added. In the successive ones, the following oils were added to wheat: orange (Citrus aurantium), lemon (Citrus limon), vanilla (Vanilla planifolia), linden blossom (Tilia cordata), thyme (Thymus vulgaris), geranium (Geranium roseum) and tea (Camelia sinensis). Each series involved 10 reps. A single rep corresponded to a single glass flask. 10 males and 10 females at the age of 2-3 days were placed into the flasks filled with 100 g of wheat. The vessels were hermetically covered with the silk cloth and glass plates.

20 days after the culture was started, all the beetles were removed. Then after the appearance of the first individuals of the filial generation, the culture was controlled every two days; beetles were counted and removed. The control and counting took as long as the weevils were still coming out of the grains.

The following were calculated for each series:

- maternal individuals mortality
- generation development time,
- occurrence of imago generation – incubation time,
- fertility index [2] - in all the experiment series, half of the maternal individuals were females, the fertility index was then defined based on ratio of the number of filial generation individuals to the number of females of the initial generation.

The results were verified statistically with a single variance analysis and the Tukey test.

RESULTS

Observations into the parent generation mortality of cereal grain weevil did not show a clear toxic effect of the oils tested on insects. Only after the application of orange, vanilla and geranium oils was there found higher beetle mortality than in the control combination, with no essential oils (Tab. 1).

There were found high discrepancies between the generation development time in respective experiment

Table 1 Effect of the essential oils tested on the grain weevil development
Wpływ testowanych olejków na rozwój wołka zbożowego

Plant oils	Maternal individuals mortality (%) Śmiertelność osobników macierzystych	Development of generation (in days) Rozwój pokolenia (w dniach)			Occurrence of imago generation (in days)I Czas trwania pojawu pokolenia (w dniach)		
		Min.	Medium	Max.	Min.	Medium	Max.
Control-Kontrola	4,5c	39	42,2b	46	27	38,1ab	48
Citrus aurantium	17,0a	42	46,1b	50	27	35,9abc	46
Citrus limon	0c	29	39,8b	47	30	37,1abc	46
Vanilla planifolia	12,36ab	49	58,7a	66	29	35,1abc	47
Tilia cordata	0,5c	33	38,2bc	42	32	38,9a	46
Thymus vulgaris	3,5c	12	24,7d	16	22	29,8c	34
Geraniium roseum	10,6b	26	30,2c	37	27	32,2bc	40
Camelia sinensis	4,46c	32	40,4b	59	25	32,1bc	44
LSD (0,005)	5,69		7,012			6,857	

Table 2 Effect of the essential oils tested on the grain weevil fertility
Wpływ testowanych olejków na płodność wołka zbożowego

Plant oils Olejki roślinne	Number of samples/ Number of individuals on samples Liczba prób/Liczba osobników w próbie	Mean number of individuals from F1 generation Średnia liczba osobników pokolenia F1	Fecundity index Wskaźnik płodności
Control-Kontrola	10/20	2658a	29,37a
Citrus aurantium	10/20	1946bc	21,4ab
Citrus limon	10/20	2419ab	23,18ab
Vanilla planifolia	10/20	2247abc	25,67a
Tilia cordata,	10/20	2418ab	24,2ab
Thymus vulgaris	10/20	1625c	16,89b
Geraniium - roseum	10/20	2296ab	25,41a
Camelia sinensis	10/20	2373ab	24,82ab
LSD (0,005)		631,907	8,441

combinations (Tab. 1). The longest beetle filial generation development time was observed for the vanilla oil tested (58 days), while the filial beetles were incubated fastest in flasks with thyme oil (after 24 days).

Less diverse results were found for the filial generation time (incubation time) of the grain weevil (Tab. 1). The shortest period, 29 days, was demonstrated in the thyme oil combination. In the other combinations filial beetles were incubated from 32 (geranium tea oils) to 38 days (the other oils and the control).

Evaluating the effect of the oils tested on the number of the progeny obtained (Tab. 2), it was found that thyme and orange oils decrease the population of the pest most considerably. In the combinations in which they were used, there were found, respectively, 61 and 73% of weevil beetles, as compared with the values recorded in the control combination, while lemon, linden blossom, geranium and tea oils did not limit the number of the progeny recorded. The data obtained in those combinations do not differ significantly from the control combination data.

The most important indicator of the effect of the oils analyzed on the grain weevil fertility is the fertility index (Tab. 2). The value of that index, the lowest value for the thyme oils tests (16.89), significantly differs from the values obtained in the other combinations and the control (29.48).

DISCUSSION

The results coincide with the reports of other authors investigating the biological activity of essential oils and other plant products towards cereal storage pests [3, 4, 5, 8, 13, 15]. According to Nawrot and Olejarski [14], essential oils can be well used to fumigate rooms against storage and glasshouse pests (aphids, red spider mites and beetles) and sanitary pests (housefly and cockroaches). Oils obtained from different plants have a different composition and concentration of components, which is connected with a varied effect on insects; they can act as insect repellents, discourage from feeding, as well as affect the growth process, disturbing or inhibiting it, which can lead to death [9, 10, 11, 12]. According to Achremowicz [1], essential oils derived from lemon, orange and thyme result in 50% aphid mortality over 48 hours, while in the present research the grain weevil mortality in combinations with these oils ranged from 0 to 17% and in the case of orange oil, there was found a significant reduction in the beetle appearance.

The effect on weevil beetle behavior and reproduction can be determined by a single component or a group of components contained in bioactive substances of the plant material. A limiting effect of the thyme oil on the grain weevil development and fertility must be connected to its content of secondary metabolism compounds, terpenoids. Thyme oil contains mainly phenol-derivatives: thymol and carvacrol, as well as linalol, terpineol, borneol, cineol and bornyl octane. Phenol compounds, due to a potential of forming bonds with enzymes, serve important defense and regulatory functions, are e.g. other effective insect growth and development inhibitors and serve protective functions from pathogens and pests [6].

REFERENCES

[1] Achremowicz J., Badania nowych aficydów pochodzenia roślinnego, Pestycydy (1995) 4: 27 - 36.

[2] Błażejewska A., Płodność wołka zbożowego (Calandra granaria L.) hodowanego na ziarniakach pszenicy traktowanej chlorkiem chlorocholiny (CCC, Roczn. Nauk Roln. (1969) 95: 395 - 399.

[3] Błażejewska A., Cieślińska A., Wpływ suszu i z owoców kolendry siewnej i kopru włoskiego na rozwój i płodność wołka ryżowego, Prog. Plant Protection/Post. Ochr. Roślin (1996) 36(2): 47-50.

[4] Błoszyk E., Nowoczesne metody ochrony roślin przed szkodnikami, Wiad. Zielarskie (1993) 6: 23 - 24.

[5] Góra J., Kurowska A., Kalemba D., Jabłońska L., Wpływ olejków eterycznych na wybrane owady - szkodniki żywności, Pestycydy (1988) 4:29 - 33.

[6] Harborne J. B., Ekologia biochemiczna, PWN, Warszawa, 1997.

[7] Hrudova E., Kocourkova B., Zelena V., Insecticidal effect of extract of plants from family Apiaceae,, Herba Polonica (2005) 51 (l): 184.

[8] Kim S.I., Park C., Ohh M.H., Cho H.C., Ahn Y.J., Contact and fumigant activities of aromatic plant extracts and essential oils against Lasioderma serricorne (Coleoptera: Anobiidae), J.Stored Products Res. (2003) 39 (1):11-19.

[9] Landolt P.J., Hofstetter R.W., Biddick L.L., Plant essential oils as arrestants and repellents for neonate larvae of the codling moth (Lepidoptera, Tortricidae), Environ Entomol. (1999) 28(6):954-960.

[10] Larocque N., Vincent C., Belanger A., Bourassa J.P., Effects of tansy essential oil from Tanacetum vulgare on biology of oblique-banded leafroller, Choristoneura rosaceana. J. Chem Ecol. (1999) 25(6):1319-1330.

[11] Marimuth S., Gurusubramanian G., Krishna S.S., Effect of exposure of eggs to vapours from essential oils on egg mortality, development and adult emergence in Earias vittella (F.) (Lepidoptera: Noctuidae). Biol Agr Horticult. (1997) 14(4):303-307.

[12] Naumann K., Isman M.B., Evaluation of neem Azadirachta indica seed extracts and oils as oviposition deterrents to noctuid moths. Entomol Experimental Appl. (1995) 76:115-120.

[13] Nawrot J., Substancje naturalne w zwalczaniu szkodników magazynów zbożowych. Ochr. Roślin (1983) 11/12: 34 - 35.

[14] Nawrot J., Olejarski P., Olejki eteryczne - nowe perspektywy produkcji naturalnych insektycydów. Ochr. Roślin (2002) 11: 4-5.

[15] Wawrzyniak M., Błażejewska A., Wpływ olejków eterycznych z kopru włoskiego i kolendry siewnej na płodność wołka ryżowego (Sitophilus oryzae L.). Prog. Plant Prot./Post. Ochr. Roślin (2002) 42 (2): 644 - 646.