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# EFFECT OF AQUEOUS EXTRACTS FROM TARRAGON (*Artemisia dracunculus* L.) ON FEEDING OF SELECTED CROP PESTS

*Summary*

*The aim of this study was to determine the effect of aqueous extracts prepared from dry and fresh matter of tarragon (Artemisia dracunculus L.) on feeding of pea aphid (Acyrthosiphon pisum Harris), Colorado potato beetle (Leptinotarsa decemlineata Say.) and cereal leaf beetle (Oulema melanopa L.). The experiment was conducted under laboratory conditions in six replications. Extracts were prepared in concentrations of 2%, 5% and 10% for dry matter and 10%, 20% and 30% for fresh matter. In order to determine the effect of extracts on pea aphid, mortalities of wingless females and larvae were determined in 12-hour intervals. In the case of Colorado potato beetle, the mass of food consumed by imago was determined, and for cereal leaf beetle - the area of leaf parenchyma consumed by the larvae. The results of the experiment showed that all used extracts, prepared both from fresh and dry matter of tarragon, contributed to increase in mortality of wingless females and larvae of pea aphid. Moreover, extracts from dry matter limited feeding of adult Colorado potato beetle. Dry matter extracts with two highest concentrations (5% and 10%) and from fresh matter with the highest concentration (30%) caused decrease in the area of leaf damage caused by the cereal leaf beetle larvae.*
***Key words**: aqueous extracts, tarragon, pea aphid, Colorado potato beetle, cereal leaf beetle*

# WPŁYW WODNYCH WYCIĄGÓW Z BYLICY ESTRAGONU (*Artemisia dracunculus* L.) NA ŻEROWANIE WYBRANYCH SZKODNIKÓW ROŚLIN UPRAWNYCH

*Streszczenie*

*Celem badań było określenie oddziaływania wodnych wyciągów z suchej i świeżej masy bylicy estragonu (Artemisia dracunculus L.) na żerowanie mszycy grochowej (Acyrthosiphon pisum Harris), stonki ziemniaczanej (Leptinotarsa decemlineata Say.) i skrzypionki zbożowej (Oulema melanopa L.). Doświadczenie przeprowadzono w warunkach laboratoryjnych w sześciu powtórzeniach. Wyciągi przygotowano w stężeniach: 2%, 5% i 10% dla suchej masy oraz 10%, 20% i 30% dla świeżej masy. W celu określenia oddziaływania wyciągów na mszycę grochową w odstępach 12-godzinnych określano śmiertelność bezskrzydłych samic i larw. W przypadku stonki ziemniaczanej określano masę pokarmu zjedzonego przez imago, z kolei w przypadku skrzypionki zbożowej – powierzchnię miękiszu liści wyjedzonego przez larwy. Na podstawie badań stwierdzono, że wszystkie zastosowane wyciągi, zarówno ze świeżej jak i suchej masy bylicy estragonu przyczyniały się do wzrostu śmiertelności bezskrzydłych samic i larw mszycy grochowej. Ponadto wyciągi sporządzone z suchej masy ograniczały żerowanie chrząszczy stonki ziemniaczanej. Wyciągi z suchej masy w dwóch najwyższych stężeniach (5% i 10%) oraz ze świeżej masy w najwyższym stężeniu (30%) spowodowały zmniejszenie powierzchni uszkodzeń liści powodowanych przez larwy skrzypionek.*
***Słowa kluczowe**: wyciągi wodne, bylica estragon, mszyca grochowa, stonka ziemniaczana, skrzypionka zbożowa*

## 1. Introduction

Pea aphid (*Acyrthosiphon pisum* Harris) is one of the major pests of pea, causing considerable yield losses [1, 2]. Adult and larvae puncture vegetative as well as generative parts of plants and suck out juice from them, causing their withering and dying. Moreover, these pests constitute vectors of viral diseases [3, 4]. Colorado potato beetle (*Leptinotarsa decemlineata* Say.) is a very dangerous pest of potato, but it also can damage other plants of the Solanaceae family. Both the adults as well as the larvae are harmful and feed on the above-ground parts of plants, and their high fertility and voracity contribute to considerable losses in yield, reaching up to 90% [5, 6]. Adults and larvae of cereal leaf beetle (*Oulema melanopa* L.) damage leaves of cereals and grasses. Feeding of the imago is not of economic importance, but feeding of the larvae can contribute to serious losses in yield of arable crops. This pest causes decrease in the assimilation area of leaves - primarily of the flag and subflag leaves, which have the decisive role in the formation of yield and dry matter of the seed [7, 8].

The most common method of plant protection against the mentioned pests consists in the use of chemical preparations. However, due to the threat posed by these compounds for the entire natural environment and considering the immunization of the phytophages to the active substances contained in the compounds [9, 10], non-chemical methods are becoming increasingly common, also able to limit feeding of the pests to a large extent. One of such methods includes the use of extracts from herbaceous plants, both fresh and dry matter [11, 12]. Tarragon (*Artemisia dracunculus* L.) is a plant species of the Asteraceae family, rich in numerous nutrients. It is cultivated primarily for seasoning purpose, but it is also used in medical care and medicine [13, 14].

The objective of the conducted study was to determine the effect of different concentrations of aqueous extracts prepared from dry and fresh matter of tarragon on feeding of pea aphid, Colorado potato beetle and cereal leaf beetle.

## 2. Material and methods

The experiment was conducted in 2015 under laboratory conditions in six replications. Extracts from tarragon were prepared in concentrations assumed conventionally as 2%, 5% and 10% for dry matter (DM) (dried plant + cold redistilled water in proportions 2 : 100, 5 : 100 and 10 : 100) and 10%, 20% and 30% for fresh matter (FM) (fresh above-ground parts of plants + cold redistilled water in proportions 10 : 100, 20 : 100 and 30 : 100). For the period of 24 hours the extracts were stored in the dark, and then filtered through filter papers and immediately used in experiment. Plant leaves (pea for pea aphid, potato for Colorado potato beetle and wheat for cereal leaf beetle) were soaked for 3 seconds in solutions of the extracts with determined concentrations and in redistilled water used as control, and then dried in room temperature. The test was conducted on Petri dishes, and the substrate consisted of moist filter paper. For a given object, one leaf was placed per each dish, and then pests were introduced - 5 wingless females and separately 10 larvae of pea aphid per each dish, 1 specimen of adult Colorado potato beetle per each dish and 1 larvae of cereal leaf beetle per each dish. The experiment was conducted at room temperature (24 °C) in daylight (day lasted 16 hours and 46 minutes).

In order to determine the effect of extracts from tarragon on pea aphid, mortalities of wingless females and larvae were determined in 12-hour intervals on selected objects. In the case of Colorado potato beetle, the mass of food consumed by imago was determined, and for cereal leaf beetle - the area of leaf parenchyma consumed by the larvae, also in 12-hour intervals.

The obtained results were then subjected 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

The extracts prepared from both dry and fresh matter of tarragon in two highest concentrations (5% and 10%, and 20% and 30%, respectively) already after 12 hours from the establishment of the experiment caused a significant increase in mortality of wingless females and larvae of pea aphid (Table 1). Similar regularity was also noted for extracts with the lowest concentrations, but in slightly later dates of the observations (the extract from dry matter with 2% concentration after 24 hours caused increase in mortality of pea aphid larvae and after 36 hours increase in female mortality, whereas the extract from fresh matter with 10% concentration - after 24 hours caused increase in female mortality and after 48 hours increase in mortality of larvae of the analyzed pest).

All used extracts prepared from dry matter of tarragon in all dates of the conducted observations, caused a significant decrease in the leaf mass consumed by adult individuals of Colorado potato beetle (Table 2). What is more, it was observed, that with the increase in concentration of dry matter extracts their negative effect toward the analyzed pests increases (the extract with 10% concentration caused already during second observation significant decrease in the mass of food consumed by the imago in comparison to the extracts with 2% and 5% concentration). No significant effect of the extracts prepared from fresh matter on the analyzed parameter was observed and the leaf mass consumed in these objects was similar to control.

The extracts prepared from dry matter in two highest concentrations (5% and 10%) and from fresh matter with 30% concentration significantly limited feeding of cereal leaf beetle larvae in all dates of the conducted observations (Table 3). The extract from dry matter with 10% concentration had the most negative effect toward the analyzed pests, causing complete inhibition of feeding of the larvae. The area of leaf damage during the last observation in the objects, where dry matter extract with 5% concentration and fresh matter extract with 30% concentration were used, was over two-fold lower than in control. No significant effect of tarragon dry matter extract with 2% concentration and fresh matter extract with 10% and 20% was observed for feeding of cereal leaf beetle larvae.

Table 1. The effect of extracts from *Artemisia dracunculus* L. dry and fresh mass on mortality of wingless females and larvae of *Acyrthosiphon pisum* Harris [%]

*Tabela 1. Wpływ wyciągów z suchej i świeżej masy bylicy estragonu na śmiertelność bezskrzydłych samic i larw mszycy grochowej [%]*

| Object | 12 h | 24 h | 36 h | 48 h | 60 h | 72 h | 84 h | 96 h |
|---|---|---|---|---|---|---|---|---|
| **Wingless females** | | | | | | | | |
| **C** | $0.0^{a}$ | $0.0^{a}$ | $0.0^{a}$ | $3.3^{a}$ | $10.0^{a}$ | $13.3^{a}$ | $16.7^{a}$ | $23.3^{a}$ |
| **DM 2%** | $0.0^{a}$ | $6.7^{ab}$ | $26.7^{b}$ | $40.0^{b}$ | $63.3^{c}$ | $76.7^{bc}$ | $80.0^{b}$ | $93.3^{bc}$ |
| **DM 5%** | $10.0^{b}$ | $16.7^{b}$ | $23.3^{b}$ | $36.7^{b}$ | $50.0^{b}$ | $86.7^{c}$ | $100.0^{c}$ | $100.0^{c}$ |
| **DM 10%** | $13.3^{b}$ | $26.7^{c}$ | $43.3^{c}$ | $70.0^{d}$ | $83.3^{d}$ | $100.0^{d}$ | $100.0^{c}$ | $100.0^{c}$ |
| **FM 10%** | $6.7^{ab}$ | $16.7^{b}$ | $30.0^{bc}$ | $43.3^{b}$ | $60.0^{bc}$ | $66.7^{b}$ | $73.3^{b}$ | $86.7^{b}$ |
| **FM 20%** | $10.0^{b}$ | $23.3^{bc}$ | $36.7^{bc}$ | $43.3^{b}$ | $56.7^{b}$ | $73.3^{bc}$ | $80.0^{b}$ | $96.7^{bc}$ |
| **FM 30%** | $16.7^{b}$ | $30.0^{c}$ | $43.3^{c}$ | $53.3^{c}$ | $60.0^{bc}$ | $76.7^{bc}$ | $90.0^{c}$ | $100.0^{c}$ |
| **Larvae** | | | | | | | | |
| **C** | $0.0^{a}$ | $3.3^{a}$ | $6.7^{a}$ | $11.7^{a}$ | $16.7^{a}$ | $21.7^{a}$ | $25.0^{a}$ | $31.7^{a}$ |
| **DM 2%** | $8.3^{ab}$ | $15.0^{b}$ | $26.7^{b}$ | $33.3^{bc}$ | $58.3^{c}$ | $75.0^{cd}$ | $86.7^{bc}$ | $100.0^{b}$ |
| **DM 5%** | $13.3^{b}$ | $21.7^{bc}$ | $40.0^{c}$ | $45.0^{c}$ | $61.7^{c}$ | $70.0^{c}$ | $91.7^{bc}$ | $100.0^{b}$ |
| **DM 10%** | $16.7^{b}$ | $25.0^{c}$ | $46.7^{c}$ | $71.7^{d}$ | $80.0^{d}$ | $96.7^{d}$ | $100.0^{c}$ | $100.0^{b}$ |
| **FM 10%** | $0.0^{a}$ | $5.0^{ab}$ | $11.7^{ab}$ | $26.7^{b}$ | $38.3^{b}$ | $55.0^{b}$ | $71.7^{b}$ | $98.3^{b}$ |
| **FM 20%** | $15.0^{b}$ | $26.7^{c}$ | $36.7^{bc}$ | $45.0^{c}$ | $58.3^{c}$ | $83.3^{cd}$ | $100.0^{c}$ | $100.0^{b}$ |
| **FM 30%** | $13.3^{b}$ | $26.7^{c}$ | $41.7^{c}$ | $60.0^{d}$ | $76.7^{cd}$ | $85.0^{d}$ | $98.3^{c}$ | $100.0^{b}$ |

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*: praca własna

Table 2. The effect of extracts from *Artemisia dracunculus* L. on the leaf mass consumed by adult of *Leptinotarsa decemlineata* Say. [mg]
*Tabela 2. Wpływ wyciągów z bylicy estragonu na masę liści zjedzonej przez imago stonki ziemniaczanej [mg]*

| Object | 12 h | 24 h | 36 h | 48 h | 60 h |
|---|---|---|---|---|---|
| **C** | 86.4$^{c}$ | 116.9$^{c}$ | 136.5$^{c}$ | 152.7$^{d}$ | 193.1$^{c}$ |
| **DM 2%** | 53.6$^{b}$ | 74.5$^{b}$ | 99.7$^{b}$ | 112.3$^{bc}$ | 146.1$^{b}$ |
| **DM 5%** | 35.1$^{a}$ | 61.2$^{b}$ | 81.4$^{b}$ | 91.5$^{b}$ | 109.8$^{ab}$ |
| **DM 10%** | 29.0$^{a}$ | 36.7$^{a}$ | 41.2$^{a}$ | 56.4$^{a}$ | 83.2$^{a}$ |
| **FM 10%** | 87.9$^{c}$ | 105.3$^{c}$ | 127.8$^{c}$ | 161.2$^{d}$ | 198.4$^{c}$ |
| **FM 20%** | 73.5$^{bc}$ | 91.2$^{c}$ | 119.8$^{bc}$ | 146.8$^{cd}$ | 174.3$^{c}$ |
| **FM 30%** | 76.6$^{c}$ | 99.6$^{c}$ | 123.7$^{bc}$ | 150.4$^{d}$ | 189.6$^{c}$ |

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*: praca własna

Table 3. The effect of extracts from *Artemisia dracunculus* L. on the area of leaf damage caused by larvae of *Oulema melanopa* L. [mm$^2$]
*Tabela 3. Wpływ wyciągów z bylicy estragonu na powierzchnię uszkodzeń liści powodowaną przez larwy skrzypionek [mm$^2$]*

| Object | 12 h | 24 h | 36 h | 48 h | 60 h |
|---|---|---|---|---|---|
| **C** | 9.6$^{b}$ | 25.8$^{c}$ | 43.9$^{c}$ | 63.4$^{c}$ | 84.6$^{c}$ |
| **DM 2%** | 11.8$^{b}$ | 23.8$^{bc}$ | 39.3$^{c}$ | 64.8$^{c}$ | 78.2$^{c}$ |
| **DM 5%** | 0.0$^{a}$ | 6.4$^{ab}$ | 12.7$^{ab}$ | 29.5$^{b}$ | 41.0$^{b}$ |
| **DM 10%** | 0.0$^{a}$ | 0.0$^{a}$ | 0.0$^{a}$ | 0.0$^{a}$ | 0.0$^{a}$ |
| **FM 10%** | 8.4$^{b}$ | 20.9$^{bc}$ | 40.2$^{c}$ | 58.5$^{c}$ | 75.6$^{c}$ |
| **FM 20%** | 9.2$^{b}$ | 21.7$^{bc}$ | 41.6$^{c}$ | 57.9$^{c}$ | 76.8$^{c}$ |
| **FM 30%** | 0.0$^{a}$ | 0.0$^{a}$ | 18.6$^{b}$ | 32.4$^{b}$ | 40.2$^{b}$ |

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*: praca własna

## 4. Discussion

Until now, studies on the effect of aqueous extracts from tarragon on feeding of arable crop pests were not numerous. Only Metspalu et al. [15] demonstrated, that extracts from this plant exhibit toxic effect for Colorado potato beetle larvae and cause increase in their mortality to almost 50%. In our experiment, the analyzed extracts prepared from dry matter caused decrease in the mass of the material consumed by the imago of the pest. Our previous studies [16, 17] demonstrated, that aqueous extracts from *Artemisia absinthium* L., which also belongs to the Asteraceae family, limit the feeding of pea leaf weevils (*Sitona lineatus* L.), pea leaf aphid, and adult individuals of Colorado potato beetle, and this effect strongly depends on the concentration of the used extract. On the other hand, *A. absinthium* L. dry matter extracts with 10% concentration and from fresh matter with 30% concentration caused decrease in the material consumed by Colorado potato beetle larvae. Similar regularities were observed in the present experiment in reference to tarragon. El-Sharabasy [18] demonstrated, that alcoholic extracts from *Artemisia judaica* L. exhibit toxic and repellent effect toward adult females and nymphs of red spider mite (*Tetranychus urticae* Koch). However, the author emphasized, that these substances may also have a negative effect on *Phytoseiulus persimilis,* which is the natural enemy of the pest.

Relatively greater amount of data can be found in the literature on the effect of essential oils (which are however characterized by higher concentration of substances contained in them) from the herein studied plant species on feeding and survivability of pests. They contribute to the increase in mortality of wheat weevil (*Sitophilus granarius* L.) [19], limit feeding of cowpea weevil (*Callosobrochus maculatus* F.) [20] and other storage pests [21-24], and also cotton aphid (*Aphis gossypii* Glover) and onion thrips (*Thrips tabaci* L.) [25]. Umpiérrez et al. [26] stated, that the essential oils from *Artemisia absinthum* L. exhibit insecticidal effect toward greenhouse whitefly (*Trialeurodes vaporariorum* West.) and tomato leaf miner moth (*Tuta absoluta* Pov.). The authors emphasized, that this effect may be linked not only to direct contact of the pest with the used substance, but also by contact with its vapors. The relationships observed in the present experiment may be also connected with the fact, that in its chemical composition, tarragon contains diverse substances (including tannins and flavonoids), which are characterized by toxic effect toward certain insects [14].

## 5. Conclusions

1. All used extracts, prepared both from fresh and dry matter of tarragon, contributed to increase in mortality of wingless females and larvae of pea aphid.
2. Extracts from dry matter of tarragon limited feeding of adult Colorado potato beetle, but no similar relationships were determined for fresh matter extracts of the analyzed plant.
3. Dry matter extracts with two highest concentrations (5% and 10%) and from fresh matter with the highest concentration (30%) caused decrease in the area of leaf damage caused by the cereal leaf beetle larvae.

## 6. References


[1] Goławska S.: Effect of various host-plants on the population growth and development of the pea aphid. J. Plant Prot. Res., 2010, Vol. 50(2), 224-228.
[2] Kaniuczak Z.: Susceptibility of some field pea (*Pisum arvense* L.) cultivars to pod damage caused by pea moth (*Laspeyresia nigricana* Steph.). J. Plant Prot. Res., 2010, Vol. 50(2), 197-200.
[3] Jones R.A.C., Proudlove W.: Further studies on cucumber mosaic virus infection of narrow-leafed lupin (*Lupinus angustifolius*): seed-borne infection, aphid transmission, spread and effects on grain yield. Ann. Appl. Biol., 1991, 118, 319-329.
[4] Sadeghi A., Van Damme E.J.M., Smagghe G.: Evaluation of the susceptibility of the pea aphid, *Acyrthosiphon pisum*, to a selection of novel biorational insecticides using an artificial diet. J. Insect. Sci., 2009, 9, 5-74.
[5] Alkan M., Gökçe A., Kara K.: Antifeedant activity and growth inhibition effects of some plant extracts against larvae of Colorado potato beetle [*Leptinotarsa decemlineata* Say (Col: Chyrsomelidae)] under laboratory conditions. Türk. Entomol. Derg., 2015, Vol. 39(4), 345-353.
[6] 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. Entomological Review, 2014, Vol. 94(5), 643-653.
[7] Meindl P., Kromp B., Bartl B., Ioannidou E.: Arthropod natural enemies of the cereal leaf beetle (*Oulema melanopus* L.) in organic winter wheat fields in Vienna, Eastern Austria. Integrated Control in Cereal Crops, 2001, Vol. 24(6), 79-86.

[8] Reay-Jones F.P.F.: Spatial Distribution of the Cereal Leaf Beetle (Coleoptera: Chrysomelidae) in Wheat. Environ. Entomol., 2010, Vol. 39(6), 1943-1952.
[9] Pimentel M.A.G., Faroni L.R.D'A., Guedes R.N.C., Sousa A.H., Tótola M.R.: Phosphine resistance in Brazilian populations of *Sitophilus zeamays* Motschulsky (Coleoptera: Curculionidae). J. Stored Prod. Res., 2009, Vol. 45 (l), 71-74.
[10] Wawrzyniak M., Wrzesińska D., Lamparski R., Piesik D.: Wpływ suszu z mięty pieprzowej (*Mentha piperita* L.) na rozwój i płodność wołka zbożowego (*Sitophilus granarius* L.). Zesz. Probl. Post. Nauk Roln., 2015, 580, 141-148.
[11] Dankowska E., Bendowska, J.: Further studies on the effect of plant infusions on the feeding of Deroceras leave (O. F. Müller, 1774). Folia Malacol., 2006, 14, 57-60.
[12] Wawrzyniak M.: Effect of extracts from Geraniaceae plants on *Pieris brassicae* L. JCEA, 2009, Vol. 10 (4), 361-365.
[13] Jadczak D., Grzeszczuk M.: Effect of a sowing date on the quantity and quality of the yield of tarragon (*Artemisia dracunculus* L.) grown for a bunch harvest. J. Elementol., 2008, Vol. 13(2), 221-226.
[14] Zawiślak G., Dzida K.: Composition of essential oils and content of macronutrients in herbage of tarragon (*Artemisia dracunculus* L.) grown in south-eastern Poland. J. Elementol., 2012, Vol. 17(4), 721-729.
[15] Metspalu L., Hiiesaar K., Joudu J., Kuusik A.: The effects of certain toxic plant extracts on the larvae of colorado potato beetle, *Leptinotarsa decemlineata* (Say). AGRIS Science, 2001, 84-89.
[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.: The effect of water extracts from *Artemisia absinthum* L. on feeding of *Leptinotarsa decemlineata* Say. larvae. J. Res. Appl. Argic. Engng., 2015, Vol. 60(4), 80-83.
[18] El-Sharabasy H.M.: Acaricidal activities of *Artemisia Judaica* L. extracts against *Tetranychus urticae* Koch and its predator *Phytoseiulus persimilis* Athias Henriot (Tetranychidae : Phytoseiidae). J. Biopest., 2010, Vol. 3(2), 514-519.
[19] Kordali S., Yildirim E., Yazici G., Emsen B., Kabaagac G., Ercisli S.: Fumigant toxicity of essential oils of nine plant species from Asteraceae and Clusiaceae against *Sitophilus granarius* (L.) (Coleoptera: Curculionidae). Egypt. J. Biol. Pest Co., 2012, Vol. 22(1), 11-14.
[20] Manzoomi N., Ganbalani G.N., Dastjerdi H.R., Fathi S.A.A.: Fumigant toxicity of essential oils of *Lavandula officinalis*, *Artemisia dracunulus* and *Heracelum persicum* on the adults of *Callosobrochus maculatus* (Coleoptera: Bruchidae. Mun. Ent. Zool., 2010, Vol. 5(1), 118-122.
[21] Rajendran, S., Sriranjini, V.: Plant products as fumigants for stored-product insect control. J. Stored Prod. Res., 2008, Vol. 44(2), 126-135.
[22] Negahban, M., Moharramipour, S., Sefidkon F.: Fumigant toxicity of essential oil from *Artemisia sieberi* Besser against three stored-product insects. J. Stored Prod. Res., 2007, Vol. 43(2), 123-128.
[23] Tripathi, A.K., Prajapati, V., Aggarwal, K.K., Khanuja, S.P.S., Kumar, S.: Repellency and toxicity of oil from *Artemisia annua* to certain stored-product beetles. J. Econ. Entomol., 2000, Vol. 93(1), 43-47.
[24] Wang, J., Zhu, F., Zhou, X.M., Niu, C.Y., Lei, C.L.: Repellent and fumigant activity of essential oil from *Artemisia vulgaris* to *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). J. Stored Prod. Res., 2006, Vol. 42(3), 339-347.
[25] Mahmoud, M., Soliman, M.: Phytochemical and toxicological studies of *Artemisia* L. (Compositae) essential oil against some insect pests. Arch. Phytopathology Plant Protect., 2005, Vol. 40(2), 128-138.
[26] Umpiérrez M.L., Lagreca M.E., Cabrera R., Grille G., Rossini C.: Essential oils from Astraceae as potential biocontrol tools for tomato pests and diseases. Phytochem. Rev., 2012, Vol. 11(4), 339-350.

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