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THE EFFECT OF HEMP ESSENTIAL OIL ON MORTALITY *Aulacorthum solani* Kalt. AND *Tetranychus urticae* Koch

WPŁYW OLEJKU ETERYCZNEGO Z KONOPI NA ŚMIERTELNOŚĆ *Aulacorthum Solani* Kalt. I *Teranychus urticae* Koch

Abstract: Investigations concerning the effect of hemp oil on mortality of the foxglove aphid (*Aulacorthum solani* Kalt.) and the two spotted spider mite (*Tetranychus urticae* Koch) were conducted in the years 2014-2015. The tested essential oil was produced at the Institute of Natural Fibers and Medicinal Plants in Poznan. It was obtained by steam distillation of fresh panicles of Polish hemp cultivars, Beniko, Bialobrzeskie and Silesia, with low cannabinoid contents, including THC (max. 0.2% plant fresh matter). The effect of essential oil on the investigated pests was determined following the application of aqueous emulsion solution at 0.02, 0.05 and 0.1%. Mortality of agrophages was determined 24, 48 and 72 h after treatment. In this study a very high efficacy of the essential oil produced from hemp panicles was found in the reduction of population size of the foxglove aphid (*A. solani*). Already at 24 h after its application at a concentration of 0.1% pest mortality rate was 98.20%, while after 48 h it reached 100%. A significant, although much lesser effect of oil on the aphid population was recorded when applying it at 0.05%, with the mortality rate of the true bug after 72 h amounting to 57.33%. Essential oil also showed an effect on the two spotted spider mite (*T. urticae*). Following the oil application, irrespective of its concentration, a significant effect on mite mortality was observed. Its action was the strongest at its highest concentration, *ie* 0.1%, while mortality of the pest at 24, 48 and 72 h after treatment was 83.28, 95.83 and 98.72%, respectively.

Keywords: natural essential oil, *Cannabis sativa* L., mortality, foxglove aphid (*A. solani* Kalt.), two spotted spider mite (*T. urticae* Koch)

Introduction

In recent years we have been observing an increased interest in growing hemp as a crop for industrial applications. EU subsidies have made commercial hemp growing exceptionally profitable**.** As a result the area cropped to hemp has increased from 80 ha in 2003 to 4.8 thousand ha in 2015. However, the dynamic increase in the area of hemp culture is also connected with the problem of hemp panicle management, currently either

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used as fuel material or considered to be a useless waste. The new mechanical harvest technology of hemp, developed at the Institute of Natural Fibres and Medicinal Plants in Poznan, facilitates separate harvest of panicles, from which essential oil may be extracted by steam distillation. In this way it is possible to obtain additionally essential oil from hemp, which may be used to a greater extent to produce cosmetics or foodstuffs, including alcohol [1-3]. Hemp essential oil may also be used in plant protection thanks to its contents of numerous chemicals, of which some exhibit high activity against pests. As it was reported by Turner et al [4] and Ross and Elsohly [5], this essential oil may contain as many as 58 monoterpenes and 38 sesquiterpenes. Contents of monoterpenes are much higher than those of sesquiterpenes and depending on hemp cultivar and time of harvest may range from 47.9 to 92.1% total terpene contents. Contents of sesquiterpenes range from 5.2 to 48.6% total terpene contents. As it was reported by Mediavilla and Steinemann [6], particularly two terpenes contained in hemp essential oil act strongly on pests, *ie* limonene and α-pinene, while Pate [7], apart from the above mentioned, also recorded activity of such terpenes as β-pinene, terpineol and borneol.

At present extensive studies are being conducted on the application of natural origin preparations, including essential oils obtained from various plant species, in plant protection. These studies are considered to be a priority, since an increasing number of chemical pesticides is being withdrawn, as the chemicals they contain are classified by the EU as particularly dangerous for human health and the natural environment [8]. Thus it is necessary to search for new, alternative methods of pest control.

The aim of this study was to evaluate the effect of essential oil obtained from panicles of hemp (*Cannabis sativa* L.) on mortality of the foxglove aphid (*Aulacorthum solani* Kalt.) and two spotted spider mite (*Tetranychus urticae* Koch).

Materials and methods

Investigations on the effect of hemp oil on mortality of the foxglove aphid (*Aulacorthum solani* Kalt.) and the two spotted spider mite (*Tetranychus urticae* Koch) were conducted in the years 2014-2015 at the Department of Entomology and Environmental Protection, the Poznan University of Life Sciences, Poland. The tested essential oil was produced at the Institute of Natural Fibres and Medicinal Plants in Poznan. It was obtained from fresh panicles of Polish hemp cultivars Beniko, Bialobrzeskie and Silesia, with low cannabinoid contents, including THC (max. 0.2% plant dry matter). These cultivars meet the requirements specified in the Act of 29 July 2005 on prevention of drug abuse [9] and they are certified for cultivation in Poland. Essential oil was produced by steam distillation of plant material using demineralised technological water. After purification the produced essential oil was put in dark containers of brown soda-lime glass protecting the product against the adverse effect of sunlight. It needs to be stressed that hemp panicles were harvested at the optimal stage of maturity in order to ensure adequate quality of essential oil. Chemical analysis of hemp essential oil was performed at the Institute of Natural Fibres and Medicinal Plants in Poznan using gas chromatography based on terpene standards (SIGMA-ALDRICH). Terpene contents were determined using a GC gas chromatograph by Perkin Elmer Autosystem XL, equipped with a SPB-5 column (SUPELKO) of 30 cm, inner diameter of 0.32 mm (film - 0.25 μm) and a FID detector. Distillation was run maintaining the following parameters: injector temperature 220ºC, detector temperature 260ºC, oven temperature programme 60-240ºC (3ºC/min), programme

time 52.6 min, carrier gas pressure (helium) 13.3 psi, injection rate 1 mm^3, split 1:50. Contents of identified terpenes in the tested hemp essential oil are presented in Table 1. The data show that among the analysed terpenes the following were found in considerable amounts: trans-caryophyllene at 35.58%, *β*-myrcene 18.45%, *α*-pinene 9.76%, terpinolene 7.40% and ocimene at 6.38%.

Table 1

Contents of terpenes in tested hemp essential oils

Component		Contents terpenes in essential oil [%]
Monoterpenes	**α-pinene**	**9.76**
	camphene	0.16
	β-pinene	4.03
	β-myrcene	**18.45**
	α-phelandrene	0.25
	3-carene	0.29
	limonene	2.07
	1,8-eucalyptol	0.23
	ocimene	**6.38**
	sabinene hydrate	0.06
	terpinolene	**7.40**
	linalool	0.10
	fenchol	0.06
	borneol	0.03
	bornyl acetate	0.04
Sesquiterpenes	**trans-caryophyllene**	**35.58**
	β-humulene	0.03
	α-humulene	9.05
	trans-*β*-farnesene	3.99
	caryophyllene oxide	2.28

Prior to observations the tested pest species were propagated on selected host species grown in containers. The foxglove aphid (*A. solani*) was propagated on eggplant cv. Epic, while two spotted spider mite (*T. urticae*) was propagated on dwarf bean cv. Zlota Saxa. Leaves of the above-mentioned plants infested by tested pests were removed from plants and immersed for 3 s in the prepared solution (water emulsion) containing different concentrations of hemp oil, *ie* 0.02, 0.05 and 0.10%. After leaves were removed from the solution they were placed for several seconds in the vertical position for excess liquid to drip down. In order to obtain a homogenous emulsion an emulsifier, RO-1, was added to solutions of tested oils at a concentration of 0.0125%. In the conducted experiments the effect of the emulsifier RO-1 on mortality of the foxglove aphid and the two spotted spider mite was also tested by treating the pests with its solution at the applied concentration. In the control combination leaves infested by the investigated pests were immersed in water with no hemp oil added. Each combination was performed in 10 replications. After the essential oil was spread, leaves were placed on glass dishes lined with moistened filter paper and next plastic plates with holes of 35 mm in diameter were placed on leaf surface. The number of pests was counted in the location of holes in these plates. After counting was completed, plates with holes were covered with glass plates, constituting a physical barrier preventing migration of bugs and spiders. Filter paper was moistened with water daily in order to maintain leaf turgor.

The effect of hemp oil applied at different concentrations on mortality of *A. solani* and *T. urticae* was determined after 24, 48 and 72 h. Results were analyzed statistically using the Newman-Keuls test at the significance level $p = 0.05$.

Results and discussion

Conducted experiments showed a very high efficacy of the essential oil produced from hemp panicles in the control of the population of the foxglove aphid (*A. solani*) (Table 2). Already at 24 h after its application at a concentration of 0.1% mortality rate of the pest was 98.20%, while after 48 h it reached 100%. A significant, although much lesser effect of the oil on the population size of the aphid was recorded when it was applied at a concentration of 0.05%. In that combination mortality rate of the true bug after 72 h was 57.33%. No significant effect of hemp oil was found on survival rates of the foxglove aphid at its application at the lowest concentration (0.02%). In those experiments no effect of the emulsifier RO-1 applied at 0.0125% was observed on the population size of the foxglove aphid. No significant differences were found in mortality rates of this pest treated with the emulsifier solution in comparison to the control.

Table 2

Average mortality of foxglove aphid (*Aulacorthum solani* Kalt.) on eggplant after application of natural essential hemp oil

Treatment	**Concentration [%]**	**No. of hours after treatment**		
		24	48	72
		mortality [%]		
Cannabis oil	0.02	22.34 a	27.53 a	23.87 a
	0.05	29.42 a	25.90 a	57.33 b
	0.10	98.20 b	100.00 b	100.00 c
Emulsifier RO-1	0.0125	40.27 a	52.43 a	47.47 ab
Control	-	27.92 a	39.15 a	58.45 b

Means in columns denoted with identical letters do not differ significantly ($p = 0.05$) according to the Newman-Keuls test

Table 3

Average mortality of two spotted spider mite (*Tetranychus urticae* Koch) on bean after application of natural essential hemp oil

Treatment	**Concentration [%]**	**No. of hours after treatment**		
		24	48	72
		mortality [%]		
Cannabis oil	0.02	43.55 a	60.31 b	71.14 a
	0.05	66.63 ab	71.40 b	79.80 a
	0.10	83.28 b	95.83 c	98.72 b
Emulsifier RO-1	0.0125	46.57 a	66.24 b	77.88 a
Control	-	37.59 a	47.56 a	69.66 a

Means in columns denoted with identical letters do not differ significantly ($p = 0.05$) according to the Newman-Keuls test

Essential oil produced from hemp panicles exhibited its effect also on the other investigated pest, the two spotted spider mite (*T. urticae*) (Table 3). Following the application of this oil, irrespective of its concentration, a significant effect on mite mortality was recorded. The strongest effect was observed at its highest concentration, *ie* 0.1%, with

pest mortality rates at 24, 48 and 72 h after treatment amounting to 83.28, 95.83 and 98.72%. Similarly as in the case of the foxglove aphid, treatment of the two spotted spider mite with a solution of the RO-1 emulsifier had no significant effect on the population size of this pest.

Literature sources published in other countries contain fragmentary information on the effect of different parts of hemp plants and extracts obtained from this plant on the populations of pests.

Grewal [10] reported a toxic action of dried hemp leaves on *Aphelenchoides composticola* (Franklin), *ie* a nematode infesting cultivated mushrooms. The leaves were added to the compost used in the production of garden mushroom (*Agaricus bisporus* /Lange/ Imbach). Dried leaves may also exhibit a repellent action on pests, *eg* those found in grain silos such as the wheat weevil (*Sitophilus granarius* L.) and the rice weevil (*Sitophilus oryzae* L.) [11, 12], while when placed under a bed mattress protected against bed bugs (*Cimex lectularius* L.) [12].

Hemp seeds may also prove useful in plant protection. Goswami and Vijayalakshmi [13] reduced the population of the root-node nematode (*Meloidogyne incognita* Kofoid & White) in tomato culture after supplementation of substrate with hemp seeds.

In other studies Rothschild et al [14] recorded high mortality in larvae of the garden tiger moth (*Arctia caja* L.) fed hemp shoots.

Strong toxic properties in relation to pests were also observed for aqueous and alcohol hemp extracts. Their strong action was also reported in relation to the Colorado beetle (*Leptinotarsa decemlineata* Say), two spotted spider mite (*Tetranychus urticae* Koch) [12], larvae of mosquitoes from the genus *Anopheles* transmitting malaria [15] as well as nematodes, *eg Heterodera cajani* Koshy, *Hoplolaimus indicus* Sher, *Rotylenchulus reniformis* Linford & Oliveira, *Tylenchorynchus brassicae* Siddiqi [16].

Hemp extracts not only exhibit a toxic action on pests, but also show repellent properties. Researchers observed the repellent effect of hemp extracts towards the large white (*Pieris brassicae* L.) and the Japanese beetle (*Popillia japonica* Newman) [12, 17]. It was also found that hemp growing in the vicinity of various cultures has a repellent action on pests colonizing them, *eg* the large white (*Pieris brassicae* L.) in vegetable growing, the Colorado beetle (*Leptinotarsa decemlineata* Say) on potatoes, the wheat white fly (*Delia coarctata* Fallen) on wheat [12]. Mateeva [18] showed that chemicals secreted by hemp roots repel larvae of the May beetle (*Melolontha melolontha* L.) developing in the substrate. They may also inhibit the development of pest populations attacking underground parts of plants, as it was found in the case of nematodes: the golden nematode (*Globrodera rostochiensis* Wollenweber) [12], the soybean cyst nematode (*Heterodera glycines* Ichinohe) [19], or columbia root-knot nematode (*Meloidogyne chitwoodi* Golden, O'Bannon, Santo & Finley) [20].

The above examples of the effect of hemp on pests did not refer to the action of essential oil produced from this plant. So far a limited number of studies have been conducted on the applicability of hemp essential oil in plant protection. In an earlier publication one of the authors of this paper [21] showed high efficacy of essential oil obtained from hemp panicles in the control of the rosy apple aphid (*Dysaphis plantaginea* Pass.) on apple trees. At 24 h after the treatment 93% mortality of this pest was reported, similarly as it was the case of the application of a phosphorus organic pesticide Mospilan 20 SP.

In other studies Pavela [22] reported marginal insecticidal activity of hemp essential oil against mosquito (*Culex quinquefasciatus* Say) larvae. The major component in the hemp oil, (*E*)-caryophyllene has shown only limited activity against *Aedes aegypti* (L.) [23], *Rhyzopertha dominica* (F.), *Sitophilus oryzae* (L), *Tribolium castaneum* (Herbst) [24] or *Lycoriella ingenua* (Dufour) [25].

Some studies discovered that essential hemp oil demonstrated antibacterial and antifungal activity [26-30].

Conclusions

- Essential oil produced from panicles of hemp (*Cannabis sativa* L.) may be suitable in pest control.
- High mortality rates of the foxglove aphid (*Aulacorthum solani* Kalt.) and the two spotted spider mite (*Tetranychus urticae* Koch) were recorded following the application of hemp essential oil in the solution of aqueous emulsion.
- Efficacy of hemp essential oil was dependent on its concentration. Mortality rates of the analysed pests increased with an increase in its concentration in the emulsion solution.
- It is recommended to use hemp oil in a concentration of 0.1%. With such a concentration of the essential oil was found the highest mortality of investigated pests.

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