

EFFECT OF FENNEL WATER EXTRACTS ON REDUCTION OF FEEDING OF PEA LEAF WEEVIL

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ABSTRACT

The objective of the study was to examine the effect of aqueous extracts from fennel (*Foeniculum vulgare* Mill.) seeds at 2%, 5%, 10% and 20% concentrations on the feeding of pea leaf weevil (*Sitona lineatus* L.) on broad bean (*Vicia faba* L.). The experiment was conducted in the laboratory, in six replicates. Feeding intensity assessment was conducted by dipping leaves of broad bean in respective solutions of the extracts and determining the area of broad bean leaves, eaten by pea leaf weevil beetle in 12 hour intervals. In addition, absolute deterrence index and palatability index were calculated. As a result of the observation no significant limiting effect of fennel seed aqueous extracts on the feeding of the pea leaf weevil females was shown. All of the used fennel extracts had inhibitory effect on the feeding of male *S. lineatus* and the strongest effect of extracts was observed in the first 36 hours of the experiment. The high values of the palatability index (particularly for the females) with relatively low absolute deterrence index, indicate limited possibilities of the use of aqueous extracts from fennel seeds for the protection against the feeding of the beetles from the genus *Sitona*.

Keywords: *Sitona lineatus* L., biological control, *Foeniculum vulgare* Mill., plant extracts

INTRODUCTION

Nowadays a great number of plant protection products exists. Chemical protection products are still most common in modern agriculture. Food manufacturers focus their actions to maximize production. However, the quality and nutritional value of thus obtained food may be decreased.

The use of plant extracts constitutes one of these crop protection methods, which are natural and safe for human health. Their action is often very efficient, does not exhibit phytotoxic effect on plants and does not contribute to the accumulation of harmful substances in plants and soil. Moreover, natural plant protection products do not lead to degradation of the natural environment.

Fennel (*Foeniculum vulgare* Mill.) is a vegetable in the Apiaceae family. The seeds, contained in the schizocarp and referred to as mericarps, are

characterized by a high content of health promoting essential oils, also responsible for the strong aroma of the plant. The bulb-like stem base of fennel has a high nutritional value and constitutes the source of vitamins and mineral salts and an intensive essential oil [Janas 2013]. Fennel is widely used, from the food industry to the pharmaceutical industry. Fennel seeds are primarily used in phytotherapy [Kania et al. 2014]. Fennel is also a recognized phytosanitary plant. Usually, it is used for crop protection against numerous diseases. The study of Gleń and Boligłowa [2012] evaluated the effect of aqueous extracts from fennel on the linear growth of the phytopathogenic fungi *Fusarium* which inhabit broad bean seeds. The fungistatic effect of fennel extracts for *F. culmorum* was demonstrated in as much as 40–79%. A study on the use of fennel extracts in the aspect of natural plant protection

against pests [Błażejewska and Cieślińska 1996, Błażejewska and Wyrastkiewicz 1998, Wawrzyniak and Błażejewska 2001] was conducted and high efficiency of combating and decreasing activity of storage pests was obtained (i.e. wheat weevil and rice weevil).

Pea leaf weevil (*Sitona lineatus* L.) is one of the most important pests of Fabaceae plants in Poland [Strażyński 2013]. The half circle areas of pest feeding on leaves constitute the signs of beetle presence. On the other hand, pea leaf weevil larvae cause damage and necrobiosis of root nodules. An efficient protection against this crop pest primarily consists in chemical treatments [Gospodarek et al. 2012, Borowiecki 2006, Borowiecki and Ksiazak 2001, Borowiecki et al. 2004]. Unfortunately, this mode of plant protection is not allowed in organic farming [Kuś and Jończyk 2009], thus an attempt was made to examine natural methods of protection of broad bean against pea leaf weevil in the form of aqueous extracts from fennel seeds.

The objective of the study was to examine the effect of aqueous extracts from fennel (*Foeniculum vulgare* Mill.) seeds at 2%, 5%, 10% and 20% concentrations on the feeding of pea leaf weevil (*Sitona lineatus* L.) on broad bean (*Vicia faba* L.).

MATERIALS AND METHODS

Fresh leaves of broad bean of the Bartek cultivar were used in the laboratory experiment, collected from the same level of the stem below the apex in order to eliminate the effect of leaf age on the intensity of the pest feeding. The obtained plant material was treated with aqueous extracts from the fennel seeds. 2 g, 5 g, 10 g and 20 g of *Foeniculum vulgare* seeds was weighed (conventionally assumed as 2%, 5%, 10% and 20% concentrations) and then 100 ml of cold redistilled water was added [Wawrzyniak and Dębek-Jankowska 2010]. Extracts were stored for 24 hours in darkness in room temperature. Then, the obtained solutions were filtered through filter papers and were immediately used for the conduct of the experiment. The broad bean leaves were immersed for 3 seconds in the appropriate extract or in redistilled water (control) and then dried in room temperature, and then placed on Petri dishes lined with moist filter paper. Then, 1 pea leaf weevil beetle were placed in each Petri dish. The experiment was conducted in 6 replications, separately for females and males. During

the experiment, filter paper was moistened in the dishes in order to prevent leaf drying and in 12 hour intervals, ninefold, measured area of broad bean leaves, eaten by pea leaf weevil beetle.

After conclusion of the conducted observations, the following values were calculated:

- palatability index – as the ratio of the percentage loss of the leaf blade in various combinations to the percentage loss of the leaf blade in the control,
- absolute deterrence index, which included the relationship between the area of leaf consumed by *Sitona* spp. in the analyzed objects and the area of leaf consumed in the control:

$$Adi = [(K-T) : (K+T)] \cdot 100$$

where:

K – the average area of leaf consumed by the pest in the control [mm²],

T – the average area of leaf consumed by the pest in the analyzed object [mm²] [Kielczewski et al. 1979].

The obtained results were 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 $\alpha = 0.05$.

RESULTS

The conducted study has demonstrated that aqueous extract from fennel seeds had a very little impact on the feeding of *S. lineatus* females (Fig. 1, Table 1). During the entire period of conducted observations, the effect of this extract was not statistically significant.

Contrary to females, fennel seed extracts significantly limited the feeding of pea leaf weevil males at all dates of observation (Fig. 2, Table 2). At 24th and 36th hour, the effect of extracts was further differentiated – the extract with 2% concentration was characterized by lower efficiency than 10% and 20% extracts. In this initial period of feeding, the efficiency of extract increased with its concentration, however, starting from the 48 hour of the experiment till its ending, the significance of differences in the effect of individual extracts was not differentiated.

All used extracts from fennel seeds were characterized by inhibitory effect for female and male feeding on broad bean leaves, which is demonstrated by positive values of the absolute de-

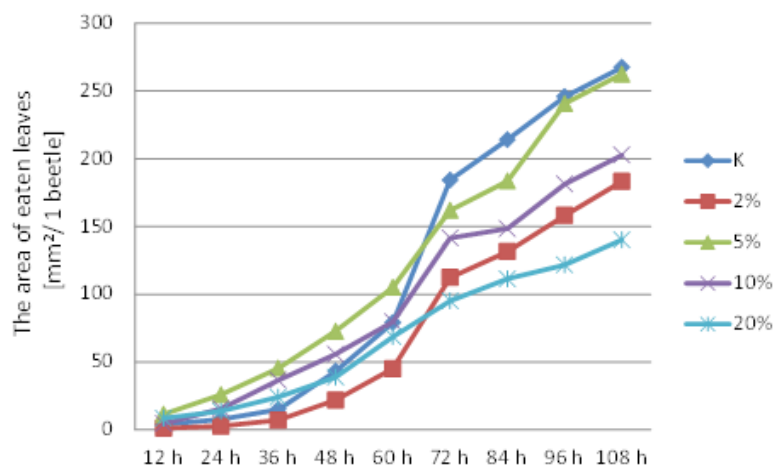


Fig. 1. The effect of extracts from seeds of *Foeniculum vulgare* Mill. at concentrations 2%, 5%, 10% and 20% on the area of feeding on the broad bean leaves caused by the female of *Sitona lineatus* L. [mm²]. K – control.

Table 1. The results of the statistical analysis of the course of feeding of the female of *Sitona lineatus* on the broad bean leaves after application of aqueous extract from fennel seeds. Explanation as in Fig.1.

Treatments	12h	24h	36h	48h	60h	72h	84h	96h	108h
K	ab	a	ab	a	a	a	a	a	a
2%	a	a	a	a	a	a	a	a	a
5%	c	b	b	a	a	a	a	a	a
10%	ab	ab	ab	a	a	a	a	a	a
20%	bc	ab	ab	a	a	a	a	a	a

* The same letters in columns mean that means do not differ significantly at $\alpha = 0.05$.

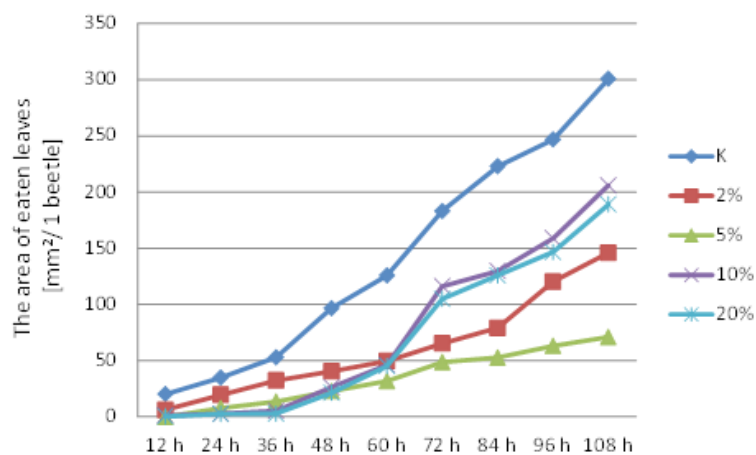


Fig. 2. The effect of extracts from seeds of *Foeniculum vulgare* Mill. at concentrations 2%, 5%, 10% and 20% on the area of feeding on the broad bean leaves caused by the male of *Sitona lineatus* L. [mm²]. K – control.

Table 2. The results of the statistical analysis of the course of feeding of the male of *Sitona lineatus* on the broad bean leaves after application of aqueous extract from fennel seeds. Explanation as in Fig.1.

Treatments	12h	24h	36h	48h	60h	72h	84h	96h	108h
K	b	c	c	b	b	b	b	b	b
2%	a	b	bc	a	a	a	a	a	a
5%	a	ab	ab	a	a	a	a	a	a
10%	a	a	a	a	a	a	a	a	a
20%	a	a	a	a	a	a	a	a	a

* The same letters in columns mean that means do not differ significantly at $\alpha = 0.05$.

terrence index (Fig. 3). No relationship between the high concentration of extract and efficiency of beetle feeding inhibition was determined. The absolute deterrence index demonstrated its highest value for the aqueous extract from fennel seeds at 5% concentration towards males. On the other hand, the same concentration level turned out to be of little efficiency for the feeding of pea leaf weevil females, where the index value was at its lowest level.

The value of palatability index in the case of females was highest for the 5% fennel seed aqueous extract. A reversed relationship was observed for the pea leaf weevil males, in which the 5% extract resulted in the lowest value of the palatability index (Fig. 4). The remaining concentrations, except for the 20% concentration, exhibited higher values for females than males. Only in the case of the strongest fennel seed extract with 20% concentration, similar values for both males and females were observed.

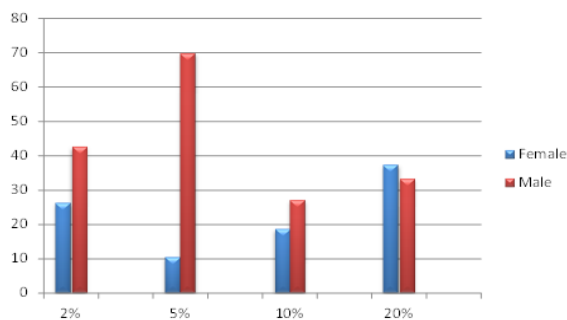


Fig. 3. Absolute deterrence index of extracts from seeds of *F. vulgare* in concentrations 2%, 5%, 10% and 20%, for female and male of *Sitona lineatus*, calculated according to the formula: $Adi = [(K-T) : (K+T)] \cdot 100$, where: K – the average area of leaf consumed by the pest in the control [mm²], T – the average area of leaf consumed by the pest in the analyzed object [mm²]

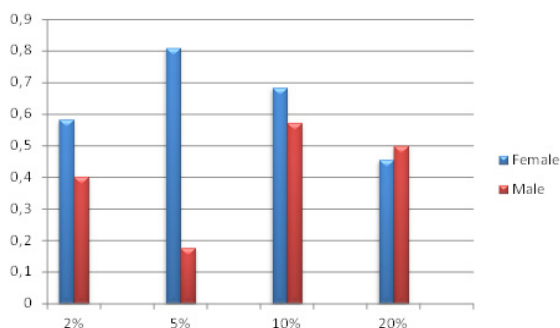


Fig. 4. Palatability index after applying of extracts from seeds of *F. vulgare* at concentrations 2%, 5%, 10% and 20%, calculated as ratio of the percentage loss of leaf blade in analysed objects to the percentage loss of leaf blade in control

DISCUSSION

The conducted experiment demonstrated, that aqueous fennel seed extracts exhibited diversified effect towards females and males of pea leaf weevil. The restricting effect of extracts was observed only for males. The relatively low effect towards females may result from their increased food requirements during the breeding period, as on average the males consumed approximately 50 mg less food than the females.

The available literature provides only few studies on the use of fennel seed extracts in plant protection against pests. A toxic effect of alcohol extracts from *F. vulgare* schizocarps towards *Attagenus unicolor japonicus* larvae (Coleoptera: Dermestidae) was observed. They caused 67% and 100% mortality at respective doses of 2.6 mg/cm² and 5.2 mg/cm² of leaf [Han et al. 2006]. More studies on the use of essential oils can be found. Strong insecticidal properties of fennel essential oils towards wheat weevil (*Sitophilus granarius*) and rice weevil (*Sitophilus oryzae*) were observed already in the 24 hours of experiment [Ebadollahi 2011]. Similarly high toxicity of the plant oil was exhibited towards the mites *Tyrophagus putrescentiae*. The analysis of the essential oil composition demonstrated that its main components, i.e. carvone and naphthalene, are responsible for this effect, [Lee et al. 2006]. A study was also conducted on the effect of *F. vulgare* essential oils on the mosquito *Culex pipiens* L. larvae and pupae. A concentration of 40 mg/l caused approx. 50% mortality in the L2 larvae already at the 2 hour of observation, whereas 60 mg/l concentration after a 4-hour exposition of L4 larvae to the effect of the oil brought 90% mortality. 100% of pupae mortality was obtained only after 24 hours of observation using the 200 mg/l dose [Zoubiri et al. 2014]. On the other hand, for larvae of *Aedes albopictus* (Culicidae), another mosquito species, a solution of 300 ppm oil and 250 ml mineral water with 0.1% Tween80 after 24 hours resulted in 98.3–100% mortality of these insects [Conti et al. 2010].

The available literature lacks data on the effect of extracts or essential oils from fennel in combating weevil beetles. The only data on these pests refer to the use of fennel as a component of mixed cropping. Fennel, as a companion plant in the broad bean cultivation did not have a clear effect on the infestation of the host plant by pea leaf weevil and the level of root nodule damage by *Sitona* spp. larvae [Gospodarek et al. 2011].

Significant differences between individual study seasons were demonstrated, which may result from different weather conditions.

CONCLUSIONS

1. No significant, limiting effect of fennel seed aqueous extracts on the feeding of the pea leaf weevil females was determined.
2. Contrary, all of the used fennel extracts had inhibitory effect on the feeding of male *S. linetaus*. The strongest effect of extracts was observed in the first 36 hours of the experiment.
3. The high values of the palatability index (particularly for the females) with relatively low absolute deterrence index, indicate limited possibilities of the use of aqueous extracts from fennel seeds for the protection against the feeding of the beetles from the genus *Sitona*.

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