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Insecticidal Effect of Three Different Plant Extracts on Potato Tuber Moth [*Phthorimaea operculella* Zeller (Lep.: Gelechiidae)]

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Abstract: Potato tuber moth [*Phthorimae operculella* Zeller (Lep.: Gelechiidae)] is the most important insect causing damage of potatoes. It also causes significant damage to tomato and eggplant. The application of plant extracts to control insects is an effective alternative. In this study, the efficacy of extracts from *Leptospermum petersonii* Bailey (Myrtaceae), *Achillea wilhelmsii* C. Koch (Asteraceae) and *Tanacetum parthenium* L. (Asteraceae) on potato tuber moth using two different methods was investigated. Bioassays were used to determine the effect of varying concentrations (for *L. petersonii* 0.05%, 0.1%, 0.3% and 0.4%, for *A. wilhelmsii* and *T. parthenium* 1%, 3%, 6% and 12%) of extracts. Experiments were carried out using potato tuber of *Solanum tuberosum* L. Fourth instar larva of about were used in tuber dipping and larvae dipping methods. In tuber dipping method, the highest mortality (100%) occurred at concentration of 0.4% while the smallest mortality was at 0.05% the extracts of *L. petersonii*. It was determined that the extract of *A. wilhelmsii* and *T. parthenium* had the highest mortality at the highest concentration 85% and 90% respectively. In larva dipping method, the extracts of *L. petersonii*. *A. wilhelmsii* and *T. parthenium* showed the highest mortality at the highest concentrations 100%, 82% and 87% respectively. The research was undertaken under laboratory conditions at the Plant Protection Central Research Institute.

Key words: Plant extracts, insecticidal effect, potato tuber moth.

1. Introduction

Potato is a culture plant that is important for human nutrition. It is one of the main foodstuffs of many countries due to its good food and various consumption types. Many diseases and pests attack the potato in different periods from plantation to consumption. One of these pests is the Potato tuber moth [*Phthorimae operculella* Zeller (Lep.: Gelechiidae)], which is common in America and is harmful in many countries of Europe [1]. Aryal [2] reported that this pest that opened galleries in the leaves and trunks of potato plants in the field caused great damage by attacking the tubers in the warehouse and damaged the nutritional value and quality of the product with the galleries and filths it opened in the tuber.

In Turkey, chemical pesticides are used intensively to control potato moth. The use of intense chemicals creates resistance to pests, causes residue in the product and environmental pollution occurs. In recent years, researchers have focused on some substances that would be an alternative to chemical to control pests. Several extracts of plants have been evaluated for their activity against agriculturally important insects for a few decades now and are currently being evaluated further for use in plant protection because of their possible ecofriendly characteristics [3-5].

Shelke et al. [6] found that neem oil (*Azadirachta indica A.* Juss) had oviposition deterrent effect on PTM. Essential oils of Basil, European pennyroyal, lavender, mint and savory on PTM [7]. Sharaby et al.

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[8] revealed that vapors of *Cymbopogon citratus*, *Myristica fragrans*, *Menthe citrate* and a-lonone caused highly significant reductions in the life span of exposed moths as well as in new adult offspring.

The flowers and leaves of the extract of *Leptospermum petersonii* Bailey (Myrtaceae) have insecticidal properties [9]. There are many studies carried out about the effect of extract of *L. petersonii* on insects. Hood et al. [10] determined that essential oil volaties *L. petersonii* caused both directly and indirectly on both *Candida albicans* and *Aspergillus fumigatus to* produce growth inhibition. It was found that the extracts obtained from *L. petersonii* showed strong mortality effect against *L. decemlineata* larvae, and caused decrease in the number of eggs laid [11].

Achillea wilhelmsii C. Koch a perennial medicinal herb is belonging to the Asteraceae family. There are few studies about the effect of extracts of *A. wilhemlsi* on insects. Khani and Asghari [12] revealed that the oils of *A. wilhelmsii* showed the strong insecticidal activity against *T. castaneum.* In another study, the extract obtained from *A. wilhemlsii* showed larvicidal effect on the 2nd, 3rd and 4th instar larvae of *Thaumetopoea pityocampa* (Schif.) (Lep.: Thaumetopoeidae)[13].

Tanacetum parthenium (L.) (Asteraceae), is a common perennial herb. The leaves of *T. parthenium* are eaten and used as infusions in condition like arthritis, migraine and asthma [14]. Tiuman et al. [15] found that the medicinal plant *T. parthenium* is indicated for prevention of migraine headache crisis, and investigations have already demonstrated its ant-inflammatory activity. Pyretrum, the most widely used botanical insecticide is extracted from the flowers of *Tanacetum cinerarifolium* (pyrethrum). It is highly effective against houseflies, mosquitoes, fleas and lice. The toxins, namely pyrethrins, cinerins and jasmolins, have unusual insecticidal properties, which cause most flying insects to drop almost immediately upon exposure [16]. There are studies about the effect of extract of *Tanactum* spp. For example, Pavela et al. [17] reported that the extracts obtained from *T. parthenium* were more efficient antifeedants and growth inhibitors to *Spodoptera littoralis* (Boisduval) (Lep.: Noctuidae) larvae.

The aim of this study is to determine insecticidal effect of three different plant extracts on PTM.

2. Materials and Methods

2.1 Insect Material

Larvae of potato tuber moth were collected from Bolu province, where it was abundance. The culture of PTM was reared on Marfona Cultivar of potato and under laboratory conditions at 25±1 ºC, 65±5% RH and 12:12 light: dark photoperiod. The adults were taken to one liter size glass jars and given a 10% sugar solution as a food source. The jar was covered with muslin to laid eggs the adults. Eggs were collected daily and transferred to similar jars containing several potato tubers for larval establishment under similar laboratory conditions. Larvae were reared on potato tubers using the method described by Mandour [18].

2.2 Plant Material

The plants were collected from two different provinces during 2010. *A. wilhelmsii* was collected from Eskisehir province and was collected from Cankiri province in flavoring period. The plant material was dried in room temperature (25±1 °C) under shade for one month.

2.3 Preparation of Extraction

The dried plants were grinded with the help of an electric grinder. Dried plant material was taken from each sample of 200 g from each powdered plant. Ethanol 500 mL (80%) was added to each plant sample and left for 72 hours. A soxhlet apparatus was used for extraction. Extraction was completed in 6 hours. A rotary evaporator was used (50-60 °C) to remove/evaporate ethanol from the crude extraction. Then crude extracts obtained from each plant were reconstituted at a concentration of 20% (W/V) using

ethanol 80% (V/V in distilled water) as stock solutions and stored at 4 °C in colored glass vials.

2.4 Bioassay Methods

Bioassays were used to determine the effect of varying concentrations (for *L. petersonii* 0.05%, 0.1%, 0.3% and 0.4%, for *A. wilhelmsii* and *T. parthenium* 1%, 3%, 6% and 12%) of extracts. Concentrations were prepared with distilled water containing TritonX.100. Experiments were carried out using potato tuber of *Solanum tuberosum* L. Fourth instar larva of about were used in tuber dipping and larvae dipping methods. Experiments and control were carried in six replicates including control. Fife larva were used for each replicate. Experiments were performed in laboratory conditions (25±1 ºC, 65±5% RH and 12:12 light: dark photoperiod). The results were assayed after 1, 3 and 6 days by counting the number of living larva.

2.4.1 Larva Dipping Method

Fourth instar larva were dipped into prepared concentrations for 30 seconds. Then larva were transferred in plastic containers (5×15 cm) with potato tuber. The containers were covered with tulle. After that, the containers were placed in laboratory.

2.4.2 Tuber Dipping Method

Potato tubers were dipped into prepared concentrations for 30 seconds. After that these tubers were left to dry for 30 minutes. After drying tubers were placed into container and larva were transferred into containers. Each container contains one tuber. Then the containers were placed in laboratory [19].

2.4.3 Statistical Analysis

The effect was calculated according to Abbott [20]. Mortality rate was calculated as; mortality = after treatment the number of died larva/before treatment the number of larva × 100). The obtained results were submitted to a variance analysis and the mean values were compared by Duncan's test. All modeling was carried out using SAS version 9.4.

3. Results and Discussion

3.1 Larva Dipping Method

As shown in Table 1, the highest mortality was at concentration 0.4% the extract of *L. petersonii.* The lowest mortality rate was at the control. The extracts obtained from *T. parthenium A. wilhelmsii* the mortality were 87% and 82% respectively at concentration of 12%. It was reported that the extract of *L. petersonii* showed highest effect at concentration of 0.4%. In addition, the extract of *A. wilhelmsii* had the smallest effect at concentration 1%. Statistical analysis showed importance between the treatments ($p < 0.05$), but there was no difference between concentrations 0.3% and 0.4%. According to statistical analysis, the difference between the treatments was significant in the extract of *A. wilhelmsi* ($p < 0.05$). The highest effect occurred at concentration of 12% while the smallest effect was for 1% in the extract of *T. parthenium.* In the same extract, the highest mortality was at concentration 12%.

3.2 Tuber Dipping Method

Tuber dipping data are shown in Table 2. It was revealed that the lowest mortality was at control while the highest mortality was at the concentration 0.4% of the extract *L. petersonii.* For tuber dipped with different concentrations *T. parthenium* of extract, the highest effect occurred at the 12% concentration. In addition, the same extract the highest mortality was at the highest concentration of 12%. Statistical analysis showed significant differences among the treatments, but there was no difference between concentrations 6% and 12% ($p < 0.05$). In the extract of *A. wilhelmsii*, the highest mortality and effect were at concentration 12%. There was statistically significant difference between concentrations 6% and 12% ($p < 0.05$).

The results of the present study show that the extract *L. petersonii.* ethanolic extracts obtained from

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Table 1. The effect of some plant extracts on larva of *Phthorimae operculella* (Mean ± SE)* (Larva dipping method)

Treatments	Concentration (%)	Mortality (%)	Effect (%)
Leptospermum petersonii	0.05	68	56.43±4.05b
	0.1	72	67.62±3.03b
	0.3	90	87.13±3.31a
	0.4	100	100.00±00 a
Achillea wilhelmsii	1	45	39.49±5.07c
	3	60	53.48±4.03b
	6	75	62.29±5.53ab
	12	82	77.58±3.21a
Tanacetum parthenium	1	58	52.35±6.31b
	3	65	56.48±4.03b
	6	72	65.68±5.16a
	12	87	85.81± 2.49a
	Control	9	

*Within columns, means ± SE followed by the same letter are not significantly different (DUNCAN's multiple *F*-test, F = 74.797).

Table 2. The effect of some plant extracts on larva of *Phthorimae operculella* (Mean ± SE)* (Tuber dipping method)

Treatments	Concentration (%)	Mortality (%)	Effect (%)
Leptospermum petersonii	0.05	41	37.78±3.08c
	0.1	72	65.71±4.38b
	0.3	85	81.29±3.37a
	0.4	100	100.00±00 a
Achillea wilhelmsii	1	36	29.78±4.17c
	3	57	46.56±3.90c
	6	73	63.66±2.44b
	12	85	81.35±2.80a
Tanacetum parthenium	1	47	39.54±4.17c
	3	65	58.48±4.03b
	6	82	76.54±3.51a
	12	90	86.99±3.87a
	Control	7	

*Within columns, means ± SE followed by the same letter are not significantly different (DUNCAN's multiple *F*-test, F = 6.180).

A. wilhelmsii and *T. parthenium* had insecticidal effect on PTM. The extracts *L. petersonii.* ethanolic extracts obtained from *A. wilhelmsii* and *T. parthenium* and their effect were first tested on PTM. For the past decades, insecticidal properties of plant extracts have been widely used against harmful pests. There are many of studies on the insecticidal effect of plant extracts on PTM. For example, Salama and Salem [21] revealed that neem seed kernel extract was highly protective and was effective on PTM in the store. In another study, the essential oil of marjoram showed significant contact and fumigation insecticidal activities against different stage of PTM [22]. In addition, Sharaby et al. [8] revealed that vapors of *Cymbopogen citratus* Stapf. (Poaceae), *Myristica fragrans* Houtt. (Myristicaceae), *Mentha citrate* (Lamiaceae) and a-lonone caused highly significant reductions in the life span of exposed PTM. In another study, treated potato tubers by methanolic extract of lavender elicited the lowest percentage of first larval PTM penetration, and studying of oviposition-preference demonstrated that the largest number of eggs were laid on control and fumitory with 28 and 10 eggs after three days, respectively [23].

Moreover, it was determined that dried powders of *Allium cepa* L. (Liliaceae), *Curcuma longa* (Zingiberaceae), *Ocimum basilicum* L. (Lamiaceae), *Dodonaca viscosa* L. (Dodonaea) and *Thuja orientalis* L. (Cupressceae) played a highly significant role in reducing egg deposition on PTM [24]. Lal [25] found that the leaves of *Lantana aculeate* provided most protection to the tubers, reducing damage than *Eucalyptus globulus* and *Bacillus thurungiensis.* It was observed that extracts of *Piper nigrum* and *Matricaria chamomile* showed high mortality, antifeeding and repellent effect on larva of PTM [7]. Similarly, Soliman [26] reported that four plant crude extracts [*Avicennia marina* F. (Avicenniaceae), *Pulicaria incise* Lam (Compositae), *Capparisa egypta* Lam (Capparaceae), *Cleome deoserfolia* (Cleomaceae)] had obvious latent effects which observed later in the larvae, pupae and adults.

There are few literatures about extract of *L. petersoni* on insects. For example, it was reported that extract of *L. petersonii* feeding activity and development were significantly reduced of larval stages on broccoli leaves that had been dipped in LSO against the diamondback moth (*Plutella xylostella* L. (Lepidoptera: Plutellidae)) [27]. It was found that the extracts obtained from *L. petersonii* showed strong mortality effect against *L. decemlineata* larvae, and caused decrease in the number of eggs laid [11].

Khani and Asghari [12] reported that the essential oils of *A. wilhelmsii* showed the same strong insecticidal activity against *Tribolium castaneum* Herbst. (Col.: Tenebrionidae). In another study, it was observed that the essential oils of *Achillea* species (*A. biebersteinii*, *A. wilhelmsii*, and *A. coarctata*) showed significantly toxic effect against Colorado potato beetle [28]. Moreover the extract of *A. wilhelmsii* 12% concentration showed the highest mortality in nymph and adult stages of Green peach aphid [(*Myzus persicae* Sulzer) (Hem.: Aphididae)]. The same study, the mortality of nymphs and adults at the same concentrations were 83.81% and 80.00%, respectively [29].

Erdogan et al. [30] reported that the mortality and highest effect were at a concentration of 12% the extract of *T. parthenium* on *Tetranychus urticae.* In addition, it was demonstrated that the extract of *T. vulgare* showed strongly antifeedant and oviposition deterrent activity on two cabbage pests (*Piers rapae* (L.) and *Plutella xyllostella* (L.) [31]. Moreover, it was determined that the extracts of *Lantana camara*, *Eucalyptus globulus*, *Tagetesminuta*, *Pyreteum* flowers and *Azadirachta indica* showed that a number of potatoes infested and damaged by PTM were significant. In the same study, it can be concluded that *Lantana camara*, *Eucalyptus globules* and *Pyrethrum* flowers can be used to protect seed potatoes from PTM damage in storage [32].

4. Conclusions

It was determined that the extracts obtained from *L. petersonii*, *A. wilhelmsii* and *T. parthenium* mortality larvae were found the highest compared to the control. In addition, it was observed that the extracts showed the insecticidal effect on PTM. This is the first report about insecticidal effect of *L. petersonii*, *A. wilhelmsii* and *T. parthenium* on PTM. According to the results of this study, *L. petersonii*, *A. wilhelmsii* and *T. parthenium* may be used to control PTM in potato storage and carrying out field experiment. Further study is needed to identify the active component of these plant extracts responsible for insecticidal activities under controlled and field conditions.

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Author Contributions

The initial idea of the study was conceived by Pervin Erdogan collected the plants. Pervin Erdogan assisted with the design of experimental protocol and performed all of experiment. Betul Sever Yilmaz prepared plant extracts. All authors read and approved the final manuscript.

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