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Efficiency of Certain Savely Materials on Growth, Production and Protection Against The Potato Leafminer, *Liriomyza huidobrensis* Blanchard (Diptera: Agromyzidae)

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Abstract: Experiments were conducted at Meet Faris village, Dekernes, Dakhlia Governorate, Egypt to study the agronomical performance response of potato cv. spunta grown under average temperature and long photoperiod conditions of winter seasons of 2019 and 2020 to some natural and safe treatments i.e., oils (thyme oil, thymol active ingredient and neem oil) and their interactions compared with the recommended synthetic insecticide (cotch) 20% SC, 25cm^3/100 L and unprotected control (tap water). The response of infestation of potato leafminer, *Liriomyza huidobrensis* Blanchard (Diptera: Agromyzidae) in laboratory. Also, LC_{50} of each treatment was established against larvae of *L. huidobrensis* under semi-field conditions. The obtained results reveal that thyme oil is the most effective material for controlling larvae of *L. huidobrensis* with LC_{50}: 2968.15 and LC_{90}: 41661.26 ppm. Neem oil followed thyme oil in laboratory control of *L. huidobrensis* with LC_{50}: 4549.28 and LC_{90}: 81236.43 ppm. Then, thymol active ingredient with LC_{90}: 6607.91 and LC_{90}: 145252.43 ppm, respectively, for larvae. While, when LC_{50} of these oils applied on the larvae in the semi-field, the results indicated that, thyme oil was the most effective essential oil followed by, neem oil and thymol active ingredient.

Key words: Potato plant · Potato leafminer · Thymol active ingredient · Thyme oil and Neem oil

INTRODUCTION

Potato is one of Egyptian strategic vegetable crops occupying an advanced rank among the crops of local and export consumption. Potato plants are subjected to numerous pathogens and insect pests which cause considerable loss in Egyptian quantitative and qualitative potato yield. Pests and pathogenic diseases are the most important impediments which determine spread potato cultivation and decrease the production in Upper Egypt and Delta regions. The loss in production ranged between 15-60% and may reach 100% in the field and 10 -20% after harvest [1, 2]. Potato crop plants are susceptible to many insect pests such as the leafminer fly (Liriomyza huidobrensis Blanchard). Recently, leafminer larvae have become an economically important pest of potato. Larvae of the potato leafminer fly feeds on the leaf mesophyll tissue, furthermore, these wounding also allows entry of bacterial and fungal diseases [3, 4].

The potato leafminer *L. huidobrensis* is the dominant agromyzid at higher elevations (>1000 m asl) in tropical Asia and has caused much damage to potato in particular [5-7]. While *L. sativae* is the dominant pest in lowland areas [7, 8].

The biology and ecology of polyphagous *Liriomyza* spp. (including *L. huidobrensis*) have been reviewed by Murphy and La Salle [9]; Parrella [10, 11] and Waterhouse and Norris [12].

Pests and disease control by using natural products resulted in resistance of some pests and pathogen to conventional insecticides and fungicides, in addition to the negative impacts in human health and environment. Also, more than 540 insect species are resistant to synthetic insecticides [13].

The target of this study is to protected plants from potato leafminer, *L. huidobrensis* then to improve vegetative growth, yield, tuber quality of potato by using addition methods of thyme oil, neem oil and and thymol under clay loamy soil.

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MATERIALS AND METHODS

Insect Rearing: Potato leaves infested by larvae of the potato leafminer *L. huidobrensis* were collected form the unsprayed farm. The leaves were kept in jars at 27±2°C and 65±5% RH. The colony was maintained for two generations before the beginning of the tests. Then, the leaves with the newly larvae of *L. huidobrensis* were placed in plastic Petri dishes (10 cm. in diameter). Each dish was covered with muslin for aeration and the potato leaves were put on the bottom of the dish [14]. Whenever leaves appeared discolored, they were replaced with fresh ones.

Laboratory Experiments: Potato leaves carrying larvae of the insect pest were collected form the unsprayed farm and were transferred to the laboratory and the experiments were made by using three materials (neem oil, thyme oil and thymol). In this experiment, three replicates were used for each treatment and 10 larvae for each replicate. Different concentrations were sprayed directly on the larvae. The concentrations used were 1000, 5000, 10000 and 15000 ppm. The percentage of mortality was recorded after one, three, five and seven days and the data were corrected relatively to control mortality [15]. LC_{50} values were determined using probit analysis statistical method of Finney [16]. LC_{50} index was determined by the following equation according to Sun [17].

$$\text{Toxicity index for } LC_{50} = \frac{LC_{50} \text{ of the most effective compound}}{LC_{50} \text{ of the least effective compound}} X\ 100$$

Field Experiments: Two field experiments were conducted on potato (*Solanum tuberosum* L.) spunta c.v plants during the two successive winter seasons of 2018 / 2019 and 2019 / 2020 at a private vegetables farm at meet Faris Village, Dekernes, Dakhlia Governorate. It aimed to evaluate the effects of some safe field treatments (neem oil, thymol and thyme oil) compared with the recommended pesticides on potato. Field experiments were laid out in an area of about 1/3 feddan. Potato seed tubers averaging approximately 50 g were hand cut and suberized for approximately 4 days and planted on October 17th and 19th in seasons of (2018 / 2019) and (2019 / 2020), respectively and were harvested after 105 days from planting dates.

LC_{90} was used for this experiment. All cultural practices for potato plants were followed according to the instruction laid down by Egyptian Ministry of Agriculture.

Neem oil (70% azadirachtine) was purchased from Sigma-Aldrich It is very essential to add the emulsifier to neem oil and stirred well before adding water and the same thing for thyme oil. In addition, thymol, is the active ingredient of thyme oil, is obtained from Gomhoria Company for chemicals, Mansoura.

A complete randomized block design with three replicates was adopted in this experiment and the treatments are as follows:

- Control treatment (tap water)
- Insecticide (cotch 20% SC, 25cm^3/100 L)
- Neem oil.
- Thyme oil.
- Thymol active ingredient.

Regular samples of larvae were collected and examined to record the percent of reduction in larval infestation according to Hendrson and Tilton [18] after 3, 5 and 10 days from spraying by assigned treatments according to the formula:

$$\text{Reduction (\%mortality)} = [(C_b/C_a \text{ X } T_a/ T_b) -1] \text{ X } 100$$

where:

C_b = Number of alive insect pest individuals in control before treatment.

C_a = Number of alive insect pest individuals in control after treatment.

T_a = Number of alive insect pest individuals after treatment.

T_b = Number of alive insect pest individuals before treatment.

Data Recorded of Field Experiment: After 70 days from sowing; five plant samples were randomly taken from each plot and carried immediately to the laboratory in both seasons of study for measuring the growth characters of potato plants expressed as follows:

- Plant height (cm).
- Number of leaves per plant.
- Fresh weight of shoots/ plant (gm).
- Dry weight of shoots/plant (gm).
- Chlorophyll contents, Nitrogen, Phosphorus and Potassium contents

Chlorophyll contents (mg/g F.W) were determined. Samples of 100 g from each sample were oven dried at 70 °C tell constant weight was reached.

Then, dry matter was calculated (g/plant) and the dried parts were thoroughly ground and stored for chemical analysis of N, P and K % The dry matter of shoots at 70 days after planting in both seasons were finely ground and wet digested for N,P and K determination. Total nitrogen, phosphorus and potassium were determined
according to the methods described by Jackson [19]; Bremner and Mulvaney [20] and Olsen and Sommers [21] respectively. N, P and K uptake were calculated.

Statistical Analysis: Statistically analyzed of data were done using CoSTATE Computer Software, according to Gomez and Gomez [22].

RESULTS AND DISCUSSION

Effect of Treatments on *L. huidobrensis* in Laboratory: Data presented in Table (1) and Fig. (1) indicated that, thyme oil was the most effective material for controlling larvae of *L. huidobrensis* with LC_{50} 2968.15 and LC_{90} 41661.26 ppm. Neem oil followed thymol oil in laboratory control of *L. huidobrensis* with LC_{50} 4549.28 and LC_{90} 81236.43 ppm. Then, thymol active ingredient with LC_{50} 6607.91 and LC_{90} 145252.43 ppm. The obtained results are in agreement with results of Mujica *et al.* [23] who proved the effectiveness of essential plant oil when mixed with abamectin than abamectin alone.

Vegetative Growth Parameters of Potato and Effect of LC_{90} of Treatments on *L. huidobrensis* Comparing with Chemical Insecticide in Field: Data presented in Table (2) indicated that the effect of the tested treatments, neem, thymol and thyme oil comparing with control on vegetative growth parameters i.e. plant length, number of leaves, fresh and dry weight of potato plant and foliage after 70 days from sowing.

It is clear from the data of Table (2) that; the average values of all plant growth parameters studied for the potato plant treated with the different treatment effect comparing with the control which recorded the lowest values. The differences between these values were significant for all vegetative growth parameters of potato. Treatment thyme oil showed maximum values vegetative growth under investigation. The rate of increase compared with control showed that, the treatment with thyme oil was 81.33, 81.75 for plant height, 43.69, 44, 25 for No. of leaves, 382.66, 380.78 for fresh weight and 35.66, 34.65 for dry weight.

Similar results were indicated by Abd El-Kader *et al.* [24] who indicated that all tested essential oils as peppermint and clove oils treatments caused significant values of sprouting percentage, weight and length of potato tubers while selecron did not cause significant effect.

As well as the results in Tables (3 and 4) indicated that the total reduction caused by thyme oil during the two successive seasons 2018/2019 and 2019/2020 was relatively high against the pest, *L. huidobrensis* after 3 days from treatment, followed by neem oil then thymol then the insecticide. Also, data in the same table showed the same reduction proportion after 5 days and 10 days of treatment. These results were in agreement with Soubeih *et al.* [25] who proved the effectiveness of kaolin natural product, (super nano) for control some potato pests as *L. huidobrensis* as soon as the effectiveness of this product for foliar spraying.

Table 1: Efficiency of some save materials against larvae of the potato leafminer, *L. huidobrensis*.

Treatments	Conc.	Corrected mortality%	LC_{50}	LC_{90}	Slope± S.D.	Toxicity index LC_{50}
Neem oil	1000	30.00	4549.28	81236.43	1.02± 0.150	65.24
	5000	50.00				
	10000	60				
	15000	80				
Thyme oil	1000	26.67	2968.15	41661.26	1.12± 0.150	100
	5000	46.67				
	10000	66.67				
	15000	86.67				
Thymol	1000	26.67	6607.91	145252.43	0.955± 0.151	44.92
	5000	43.33				
	10000	56.67				
	15000	83.33				

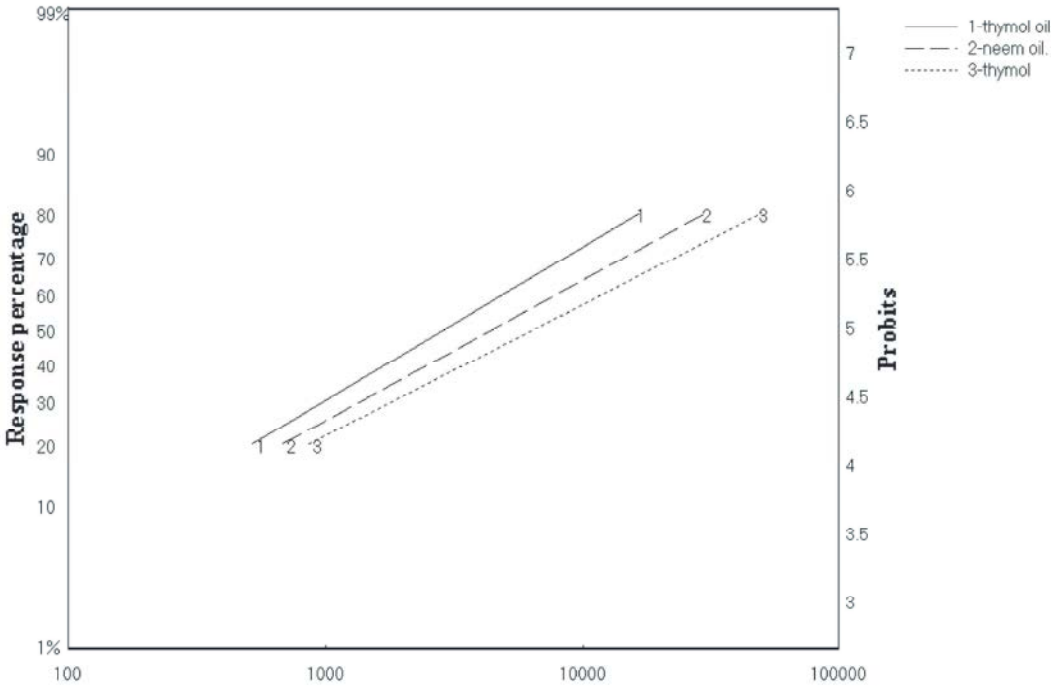

Fig. 1: LC-P lines for efficiency of some save materials against larvae of the leafminer, *L. huidobrensis.*

Table 2: Effect of assigned treatments on vegetative growth of potato plant after 70 days.

	Plant height cm		No of leaves/plant		FW plant g/plant		DW plant g/plant	
Treatments	2018/2019 season	2019/2020 season	2018/2019 season	2019/2020 season	2018/2019 season	2019/2020 season	2018/2019 season	2019/2020 season
Thyme oil	81.33	81.75	43.69	44.25	382.66	380.78	35.66	34.65
Neem oil	71.66	73.85	40.66	41.12	362.65	366.25	33.00	35.12
Thymol	69.00	65.89	38.75	36.33	280.33	282.12	23.66	25.12
Insecticide (cotch 20%)	68.66	69.88	35.14	35.68	272.00	275.26	25.33	24.45
Control	59.89	61.23	33.15	32.66	292.66	290.37	22.66	23.36
LSD $_{at\ 5\%}$	2.20	2.65	1.22	1.35	4.17	4.74	1.24	0.94

Table 3: Effect of assigned treatments on infestation reduction percentage of *L. huidobrensis* after 3, 5 and 10 days of treatments season (2018/19)

	1st replicate			2nd replicate			3rd replicate			4th replicate			Treatment efficiency		
	Pest number			Pest number			Pest number			Pest number			Pest number		
Treatments	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Total Red. %
							After 7 days								
Thyme oil	7	0	100	7	0	100	7	0	100	7	0	100	7	0	100
Neem oil	6	1	91.67	6	1	91.67	6	1	91.67	6	1	91.67	6	1	91.67
Thymol	11	4	80	11	4	80	11	4	80	11	4	80	11	4	80
Cotch 20%	4	3	58375	4	3	58375	4	3	58375	4	3	58375	4	3	58.75
Control	11	20	------	11	20	------	11	20	------	11	20	--------	11	20	------
							After 10 days								
Thyme oil	7	0	100	7	0	100	7	0	100	7	0	100	7	0	100
Neem oil	6	0	100	6	0	100	6	0	100	6	0	100	6	0	100
Thymol	11	6	75	11	6	75	11	6	75	11	6	75	11	6	75
Cotch 20%	4	6	31.25	4	6	31.25	4	6	31.25	4	6	31.25	4	6	31.25
Control	11	24	------	11	24	------	11	24	-------	11	24	-----	11	24	-----
							After 14 days								
Thyme oil	7	1	94.39	7	1	94.39	7	1	94.39	7	1	94.39	7	1	94.39
Neem oil	6	1	93.45	6	1	93.45	6	1	93.45	6	1	93.45	6	1	93.45
Thymol	11	2	92.86	11	2	92.86	11	2	92.86	11	2	92.86	11	2	92.86
Cotch 20%	4	2	80.36	4	2	80.36	4	2	80.36	4	2	80.36	4	2	80.36
Control	11	28	-------	11	28	-------	11	28	-------	11	28	------	11	28	------

Table 4: Effect of assigned treatments on infestation reduction percentage of *L. huidobrensis* after 3, 5 and 10 days of treatment season (2019/20).

	1st replicate			2nd replicate			3rd replicate			4th replicate			Treatment efficiency		
	Pest number			Pest number			Pest number			Pest number			Pest number		
Treatments	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Total Red. %
							After 7 days								
Thyme oil	6	0	100	6	0	100	6	0	100	6	0	100	6	0	100
Neem oil	5	1	88.89	5	1	88.89	5	1	88.89	5	1	88.89	5	1	88.89
Thymol	12	3	86.11	12	3	86.11	12	3	86.11	12	3	86.11	12	3	86.11
Cotch 20%	5	2	77.78	5	2	77.78	5	2	77.78	5	2	77.78	5	2	77.78
Control	10	18	------	10	18	-------	10	18	-------	10	18	-------	10	18	-------
							After 10 days								
Thyme oil	6	0	100	6	0	100	6	0	100	6	0	100	6	0	100
Neem oil	5	0	100	5	0	100	5	0	100	5	0	100	5	0	100
Thymol	12	6	77.27	12	6	77.27	12	6	77.27	12	6	77.27	12	6	77.27
Cotch 20%	5	7	36.36	5	7	36.36	5	7	36.36	5	7	36.36	5	7	36.36
Control	10	22	-------	10	22	-------	10	22	------	10	22	-------	10	22	-------
							After 14 days								
Thyme oil	6	1	92.31	6	1	92.31	6	1	92.31	6	1	92.31	6	1	92.31
Neem oil	5	1	90.77	5	1	90.77	5	1	90.77	5	1	90.77	5	1	90.77
Thymol	12	3	88.46	12	3	88.46	12	3	88.46	12	3	88.46	12	3	88.46
Cotch 20%	5	2	81.54	5	2	81.54	5	2	81.54	5	2	81.54	5	2	81.54
Control	12	26	-------	12	26	-------	12	26	-------	12	26	-------	12	26	-------

Table 5: Mean of total reduction percentage of *L. huidobrensis* infestation season (2018/19).

Treatments	Mean reduction of 1st scan	Mean reduction of 2nd scan	Mean reduction of 3rd scan	Mean of total reduction
Thyme oil	100	100	94.39	98.13
Neem oil	91.67	100	93.45	95.04
Thymol	80	75	92.86	82.62
Insecticide (cotch 20%)	58.75	31.25	80.36	56.79

Table 6: Mean of total reduction percentage of *L. huidobrensis* infestation season (2019/20).

Treatments	Mean reduction of 1st scan	Mean reduction of 2nd scan	Mean reduction of 3rd scan	Mean of total reduction
Thyme oil	100	100	92.31	97.44
Neem oil	88.89	100	90.77	93.22
Thymol	86.11	77.27	88.46	83.95
Insecticide (cotch 20%)	77.78	36.36	81.54	65.23

Tables (5 and 6) showed the mean of total reduction during the two seasons 2018/19 and 2019/20 after the three scan which indicated that, thyme oil recorded the highest reduction 98.13%, followed by neem oil 95.04% then thymol 82.62% and they were the most effective than the insecticide which recorded 56.79%.

These results were agreement with Foba *et al.* [26] carried out Alongitudinal study to identify the species of *Liriomyza leafminer*, their distribution, relative abundance and seasonal variation, including their most range, in vegetable fields. Liriomyza species were collected from all infested incubated leaves of 20 crops surveyed belonging to seven families.

This results are in agreement with Andréa *et al.* [27] which recorded that effectiveness of essential oils in control of *L. huidobrensis*.

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