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RESEARCH ARTICLE

IMPACT OF SELECTED ESSENTIAL OILS AGAINST *SPODOPTERA LITTORALIS* (BOISD.)

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Abstract

The aim of this study was to determine the potential of essential oils (EOs) of thyme (*Thymus vulgaris*; Lamiaceae) and ginger (*Zingiber officinale*; Zingiberaceae) to control cotton leaf worm (*Spodoptera littoralis*; Lepidoptera: Noctuidae) under the laboratory conditions.The nutritional indices of EO-treated *S. littoralis* larvae were reduced compared with the control. At the highest tested conc. of 90 % of ginger and thyme oils, CI values were significantly reduced compared with control being 1.87 and 2.02 vs 3.78 mg/day/mg, respectively. While GR values at the highest tested conc. of 90 % of ginger and thyme oils were 0.09 and 0.15 vs 0.29 % of control, respectively. Therefore, it concluded that ginger oil was more potent than thyme oil against *S. littoralis* larvae. Hence, these essential oils can be an alternative for management of cotton leaf worm and its related species.

Introduction:-

The Egyptian cotton leaf worm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae), is a destructive, polyphagous and multivoltine insect pest. The natural products of plant origin are receiving a considerable attention to avoid the different disadvantages of insecticides use, as they would be non-hazardous, easy to use and specific in their action. Essential oils (EOs) and plant extracts represent an alternative to pesticide for pest control (**Machial et al., 2010 and Fouad et al., 2014**). Botanicals are plant-derived materials and can be used as a major component in IPM for controlling insect pests. Botanical insecticides are fast biodegradable; have little or no harmful effect on the environment and non-target organisms, cheap, easily produced and may retard the development of resistance **(Malarvannan et al., 2008)**. They attended to use plant extracts as toxicants, repellents, synergists, growth regulators and antifeedant for cotton leaf worm **(Ragaei and Sabry, 2011 and El-Zoghby et al., 2011)**. Both Thyme (*Thymus vulgaris*, Lamiaceae) and Ginger (*Zingiber officinale*, Zingiberaceae) essential oils were selected in this study based on their medicinal properties and their safety to human and environment.

Materials and Methods:-

1-Insects:

From Plant Protection Research Institute, Dokki, Giza, Egypt, a colony of the cotton leaf worm, *Spodoptera littoralis* (Boisd.) used in the present study was obtained. For several generations, larval stages were maintained in the laboratory where reared on castor bean leaves *Ricinus communis* (L.), at conditions of a photoperiod of 16:8 hr (L: D), 27 ± 5ºC and 65 ± 5 % R.H. as described by **El-Dafrawi et al. (1964)**.

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2-The Essential oils:
Commercial essential oils of thyme, *Thymus vulgaris* and ginger, *Zingiber officinale* were obtained from El-Captain company (Cap pharm) for extracting oils, natural plants and cosmetics, Cairo, Egypt.

3- Food consumption and utilization assay:
The nutritional parameters were estimated for *S. Littoralis* 2nd instar larvae according to **Waldbauer (1968)**. Fresh weight of food was recorded before and after being given to the larvae. Treated and untreated (control) larvae were weighed before and after feeding. Faeces discharged by larvae were weighed. Feeding rate was expressed as the amount of food consumed during feeding period of a given instar, generally expressed on a "per day per unit body mass basis".

4-Statistical analysis:-
Using one-way analysis of variance **(ANOVA)**, obtained data were statistically analyzed supported by **Duncan's multiple range test (Duncan, 1955)** running on **CoStat statistical software (1990)**. Means were compared using L.S.D. (5% significance level).

Results and Discussion:-

The effect of different concentrations of thyme EO on nutritional indices of *S. littoralis* 2nd instar larvae was discussed in table 1. The maximum CI was in the control (3.78 mg/day/mg) and the high CI was at the 10 % concentration and it was 2.79 mg/day/mg while at the highest conc. (90%) the CI value was 2.02 mg/day/mg of thyme oil. Likewise, the effect of ginger oil on CI of 2nd instar larvae was significant different when compared with control except at low conc. (10, 20 & 30%) (Table 2).

The maximum CI was in the control and the high CI was at the 10 % concentration and it was 2.79 mg/day/mg for the thyme oil while it was 3.76 mg/day/mg at the same conc. for ginger oil. There were lower significant differences ($P < 0.05$) between mean consumption index (CI) values treated with ginger and thyme oils when compared to control, whereas, there was significant difference ($P > 0.05$) between mean CI for ginger and thyme oils treatments (Table 3). Such results are in agreement with **Khosravi et al. (2010)** who stated thatlower CI values probably lead to larval growth retardation and formation of smaller pupa, which results in reduced fecundity and longevity of the adult insect and makes them susceptible to diseases and natural enemies. The reduction in both RCR and RGR due to plant extracts is consistent with the effect of *A. millefolium* on *Pieris rapae* **(Hasheminia et al., 2011)**.

Also, in table (3) there were significant differences between GR values of larvae treated with either thyme or ginger oils compared to control whereas, low conc. (20 & 30 %) of it caused no significant differences of its GR values. While the least GR was 0.09% for the ginger oil at conc. 90 %. Similar results were obtained by **Saroukolai et al. (2014)** who reported that the decreasing RGR in treatment was caused not only by a decrease in RCR but also by a decrease in ECI. The result showed that the effect of six essential oils on RGR of the 4th instar larvae of *Leptinotarsa decemlineata* at different concentrations was also significantly different; RGR index was significantly reduced with increased concentrations of all tested essential oils namely, *Satureja khuzistanica* Jamzad, *Ocimum basilicum* L., *Myrtus communis* L., *Thymus daenensis* Celak, *Mentha spicata* L. and *Eugenia caryophyllus* (Sprengel).

Data indicate that both gingerand thyme EOs significantly reduced CI values. The same trend was observed with the reduction of GR values. These results clearly indicate that both tested EOs show promising effect in control the cotton leafworm.

In addition, the ECI % values after treatment 2nd instar larvae with either thyme or ginger oils were significantly lower than that of control. But most of ECI % values of ginger oil treatments were significantly lower than that of thyme oil. The least ECI % values were at high conc. 70, 80 & 90 % of ginger oil being 3.92, 3.5 & 3.23 % vs 9.84, 9.19 & 8.36 %, respectively at the same conc. for thyme oil (table 3). Our results are in consistent with low ECI which indicates a low digestibility of the feed, which means there is also a disturbance in the digestive process, such as a disturbance in the digestive enzymes of insects (**Syahputra et al. 2006**). Also, ECI is significantly reduced with increasing concentrations in all essential oils in *Leptinotarsa decemlineata* fourth instar larvae. At the lowest concentration (10 ppm) of the essential oil of *S. khuzistanica*, *O. basilicum*, *M. communis*, *T. daenensis*, *M. spicata*, and *E. caryophyllusthe* ECI was 8.357, 5.589, 6.361, 5.309, 6.994, and 5.968%, respectively and at the highest concentration (16 ppm) the ECI was 3.118, 3.228, 3.153, 2.279, 4.099, and 2.526%, respectively and the essential

oils that were studied in this research show a significant difference at all concentrations from the control (**Saroukolai et al., 2014**).

Therefore, the ECD% values after treatment 2nd instar larvae with thyme oil were in turn significantly lower than that of control. The ECD % values at low conc. (10, 20, 30 & 40 %) of thyme oil treatments were 20.49, 14.15, 12.12 & 11.44 %, respectively while at the high conc. (50, 60, 70, 80 & 90 %) were 10.74, 10.74, 9.79, 9.27 & 8.62 %, respectively. While ECD % values at high conc. (70, 80 & 90 %) of ginger oil treatments were4.01, 3.76 & 3.6%, respectively. Both ECD and ECI were significantly lower in larvae that fed on an artificial diet that contained *T. polium* extract compared with control. **Shekari et al. (2008)** also reported similar results showing that *Artemisia annua* plant extract reduced ECI and ECD in *Xanthogaleruca luteola*.

On the other hand, the AD% values after treatment larvae with thyme oil were significantly lower than that of control being 72.58, 67.27, 66.97 & 66.89 %, respectively for low conc (10, 20, 30 & 40%) while 66.65, 66.65, 66.58, 65.22 & 64.7%, respectively for the high conc. (50, 60, 70, 80 & 90%) of thyme oil. Similarly, AD % values of ginger oil treatments were significantly lower than that of thyme oil being 54.42, 52.41, 51.67 & 51.58% at the same low conc., respectively vs 51.35, 51.06, 50.12, 50.06 & 50.05% at the same high conc., respectively.In a similar study, **Ladhari et al. (2012)** observed that the methanol extract of *Cleome Arabica* could significantly reduce AD values of treated *S. littoralis*.

Table 1:- Effect of different concentrations of thyme EO on the nutritional indices of *S. littoralis* larvae.

Concentrations%	Nutritional indices				
	CI	GR	ECI%	ECD%	AD%
Control	3.78a±0.056	0.29a±0.004	71.94a±5.11	44.38a±0.76	76.18a±1.524
10	2.79b±0.041	0.21b±0.003	32.24b±2.29	20.49b±0.36	72.58b±1.452
20	2.74bc±0.04	0.18c±0.002	14.17c±1.01	14.15c±0.24	67.27c±1.345
30	2.61cd±0.038	0.18c±0.002	12.56d±0.89	12.12d±0.21	66.97c±1.339
40	2.52de±0.037	0.18c±0.002	12.41d±0.88	11.44e±0.20	66.89c±1.338
50	2.43e±0.036	0.16d±0.002	10.68e±0.76	10.74f±0.18	66.65c±1.333
60	2.18f±0.032	0.16d±0.002	10.22ef±0.73	10.59f±0.18	66.65c±1.333
70	2.16f±0.032	0.15d±0.002	9.84fg±0.69	9.79g±0.17	66.58c±1.332
80	2.15fg±0.032	0.15d±0.002	9.19g±0.65	9.27g±0.16	65.22d±1.304
90	2.02g±0.029	0.15d±0.002	8.36h±0.59	8.62h±0.15	64.7d±1.294
$LSD_{0.05\%}$	0.132	0.018	0.739	0.648	1.069

Table 2:- Effect of different concentrations of ginger EO on the nutritional indices of *S. littoralis* larvae**.**

Concentrations%	Nutritional indices				
	CI	GR	ECI%	ECD%	AD%
Control	3.78a±0.107	0.29a±0.003	71.94a±1.209	44.38a±1.025	76.18a±0.826
10	3.76a±0.095	0.18b±0.003	31.09b±0.522	19.18a±0.443	54.42b±0.648
20	3.73a±0.087	0.17b±0.002	11.68c±0.196	11.28c±0.261	52.41c±0.624
30	3.70a±0.085	0.17b±0.002	7.70d±0.129	7.72d±0.178	51.67^{d}±0.615
40	3.47b±0.079	0.11c±0.001	4.89e±0.082	5.10e±0.118	51.58d±0.614
50	3.36b±0.077	0.11c±0.001	4.52ef±0.076	4.69e±0.108	51.35d±0.611
60	3.03c±0.069	0.11c±0.001	4.44ef±0.075	4.11f±0.095	51.06d±0.608
70	2.85d±0.066	0.10cd±0.002	3.92fg±0.065	4.01f±0.093	50.12e±0.596
80	2.61e±0.060	0.10cd±0.002	3.50g±0.059	3.76f±0.087	50.06e±0.596
90	1.87f±0.043	0.09d±0.002	3.23g±0.054	3.60fg±0.083	50.05e±0.596
$L.S.D_{0.05\%}$	0.120	0.012	0.738	0.531	0.704

Table 3:- Effect of different concentrations of thyme and ginger EOs on nutritional indices of *S. littoralis* larvae.

Concentrations %	Treatments	Nutritional indices				
		CI	GR	ECI%	ECD%	AD%
Control	-----	3.78a±0.056	0.29a±0.004	71.94a±5.11	44.38a±0.76	76.18a±1.524
10	Thyme	2.79d±0.041	0.21b±0.003	32.24b±2.29	20.49b±0.36	72.58b±1.452
	Ginger	3.76a±0.095	0.18c±0.002	31.09c±0.522	19.18c±0.443	54.42e±0.648
20	Thyme	2.74d±0.04	0.18c±0.002	14.17d±1.01	14.15d±0.24	67.27c±1.345
	Ginger	3.73a±0.087	0.17cd±0.002	11.68f±0.196	11.28f±0.261	52.41f±0.624
30	Thyme	2.61e±0.038	0.18c±0.002	12.56e±0.89	12.12e±0.21	66.97c±1.339
	Ginger	3.70a±0.085	0.17cd±0.002	7.70k±0.129	7.72k±0.178	51.67fg±0.611
40	Thyme	2.52ef±0.037	0.18c±0.002	12.41e±0.88	11.44f±0.20	66.89c±1.338
	Ginger	3.47b±0.079	0.11g±0.001	4.89lm±0.082	5.10lm±0.118	51.58fg±0.614
50	Thyme	2.43f±0.036	0.16de±0.002	10.68g±0.76	10.74g±0.18	66.65c±1.333
	Ginger	3.36b±0.077	0.11g±0.001	4.52lmn±0.076	4.69m±0.108	51.35g±0.611
60	Thyme	2.18g±0.032	0.16de±0.002	10.22gh±0.73	10.59g±0.18	66.65c±1.333
	Ginger	3.03c±0.069	0.11g±0.001	4.44mn±0.075	4.11n±0.095	51.06g±0.596
70	Thyme	2.16g±0.032	0.15e±0.002	9.84h±0.69	9.79h±0.17	66.58c±1.332
	Ginger	2.85d±0.066	0.10gh±0.002	3.92no±±0.065	4.01no±0.093	50.12h±0.596
80	Thyme	2.15g±0.032	0.15e±0.002	9.19i±0.65	9.27i±0.16	65.22d±1.304
	Ginger	2.61e±0.038	0.10gh±0.002	3.50op±0.059	3.76no±0.087	50.06h±0.608
90	Thyme	2.02h±0.029	0.15e±0.002	8.36j±0.59	8.62j±0.15	64.7d±1.294
	Ginger	1.87j±0.043	0.09h±0.002	3.23p±0.054	3.60o±0.083	50.05h±0.596
$L.S.D_{0.05\%}$	Thyme	0.120	0.015	0.642	0.468	0.826
	Ginger					

Conclusion:-

The results of the present investigation reveal significant decrease in all food utilization indices for *S. littoralis* larvae fed on castor leaves treated with low or high concentrations of the tested thyme and ginger oils causing reduction in food consumption index (CI), growth rate (GR), the efficiency of conversion of ingested food (ECI), the efficiency of conversion of digested food (ECD) and approximate digestibility (AD).

Such findings could be exploited for integrated pest management (IPM) programs of the cotton leaf worm and other related species. However, further studies need to be conducted to evaluate the mode of action and cost efficacy of these materials under practical field conditions.

Disclosure statement

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Availability of data and materials

All data during this study are included in this published article.

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