TOXIC AND ANTIFEEDING ACTIVITIES OF CERTAIN PLANT EXTRACTS AND THEIR EFFECTS ON BIOLOGICAL AND BIOCHEMICAL ASPECTS OF THE COTTON LEAFWORM *SPODOPTERA LITTORALIS* (BOISD.)

SHENODA S. YACOUB

Plant protection research institute, ARC, Dokki, Giza

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Abstract

The present work aimed to study the toxic and antifeeding activities of certain plant extracts against *Spodoptera littoralis* (Boisd.) The extracts of lantana and lemongrass leaves were applied at 5 & 10% concentrations, against 2nd and 4th instars larvae of *S. littoralis* under laboratory conditions 27 ± 2 °C and 55 – 65% relative humidity. Results showed that the lemongrass extract in water at 10% conc. on the 2nd larval instar and lantana extract in water at 10% conc. on 4th larval instar were the highest in efficacy as antifeedants. Regarding, conversion of ingested and digested food (ECI) & (ECD) lantana extract in water 10% had the least effect. The highest mortality percentage was attained from the lemongrass extract in acetone 10% and lantana extract in water 5% treatments against both the 2nd and 4th larval instars, respectively. Data showed that all the plant extracts caused significant reductions in respect of larval and pupal durations, pupal weight and % of adult emergence compared with the untreated check. The plant extracts had a clear effect on the carbohydrates hydrolysis enzymes as amylase and trehalse.

INTRODUCTION

In Egypt, cotton leafworm, *Spodoptera littoralis* (Boisdural) [Lepidoptera: Noctuidae], is one of the most serious insect pest as it causes high damage levels to cotton plants and different cultivated crops beside to vegetables (Campion *et. al.,* 1997 and Nasr *et. al.,* 1984)

The use of antifeedants in pest control has attracted the attention of many workers and different compounds were used as inhibiting the feeding of chewing phytophagous insects. Botanical biocides today constitute a major and critical input in the organic products of agricultural and horticultural crops all over the world specially in the developing countries. Various problems associated with the misuse and excessive reliance of synthetic organic pesticides directed the urgent need for effective and selecting biocides (Asher, 1970).

The active principles of various plant materials show value and promise in integrated pest management (IPM), also they are considered soft and owe safer characters. The complex structure of biocomponents may decrease the likehood of rapid resistance development, they are biodegradable, the potential for compatibility

with natural enemies exist and environmentally friendly materials (Kelany, 2001). In a field experiment the effect of ornamental plants on the *Sesamia cretica* infestation, Yacoub *et. al.,* (2011) were examined.

Carbohydrates are one of the vital important since the insect body can utilize them for producing energy or converted to lipids or proteins. Metabolism of carbohydrates is controlled mainly by trehalase, amylase and invertase enzymes that play an important role in digestion and utilization of carbohydrates by insects (Wyatt, 1967).

The present work aimed to determine the efficacy of some plant extracts as antifeedants and their effects on biochemical properties against *S. littoralis* larvae.

MATERIALS AND METHODS

1. Insects

The tested insects were obtained from a culture of *S. littoralis* at the cotton pest research department – Plant Protection Research Institute Agriculture Research Center, Dokki, Giza –in which they were reared on fresh leaves of castor bean leaves *Ricinus communis* for several generations without any insecticidal pressure. The culture was reared under laboratory conditions (27 ± 2° C and 55 – 65% R.H.).

2. Preparation of plant extracts

The scientific and English name of the extracted plant and the used parts are demonstrated in the following table:

Scientific name	Family	English name	Part used
Lantana salvifolia	Verbenaceae	Lantana	Leaves
Cymbogon citrates	Gramineae	Lemongrass	Leaves

The plant leaves were cleaned, water rinsed then spread for drying in shade at room temperature for 2 – 3 weeks for dryness, after that the leaves were finely grained. To obtain the two used concentration 5 and 10%, 50 gm of dried leaf powder were mixed with 1000 and 500 ml of boiled water, respectively, stirred after stoppering the container tightly. The resulting solutions were kept at 5 °C until using, as described by Emara *et. al.,* (1994).

For preparing the extracts with acetone, the grounded plant leaves were mixed with the polaric organic solvent acetone at ratio of 1 gm of leaf powder : 2 cm^3 solvent, blended at high speed electric blender for 15 minutes then filtered. The solvent was evaporated by the aid of an electric fan. All extracts were kept in the refrigerator at – 4 °C.

3. Feeding deterrent and consumption of plant extracts

Antifeedant experiments were carried out using 2nd and 4th instar larvae of *S. littoralis* obtained from a laboratory culture. One hundred and eighty larvae were starved for 3 hours before the beginning of the experiment, divided into 4 replicates each contained 5 larvae for each treatment and all larvae were weighed. For the control, the same number of replications were kept in similar containers in which the larvae were supplied with the untreated castor leaves. Fresh castor leaves were dipped for 10 seconds in the different plant extracts. The treated leaves were left in shade to dry. Each larva was daily weighed for 3 days. The amount of consumed food and larval weight were calculated. The larvae and the amount of feaces were daily weighed. The antifeedant index (AFI) was calculated according to Sadek (2003).

AFI = [(C-T) / (C + T)] X 100

C: food consumed (leaves) in the control

T: food consumed (leaves) in the treatment

Efficacy of conversion of ingested food (ECI) and efficacy of conversion of digested food (ECD) were calculated by Woldbauer, (1968) and Farra *et. al.,* (1989)

where:

ECI = (Δ B / I) x 100 *,* **ECD =** [ΔB / (I – F)] x 100*,* **I:** weight of food consumed*,* **Ba:** mean of insect weight during the experiment*,*

T: feeding period in days*,* **Δ B:** change in body weight*,* **F:** weight of feaces produced during the feeding period

4. Biological studies

Laboratory experiments were conducted to determine the antifeedant and toxic activity of the forementioned extracts against 2nd and 4th instar of *S. littoralis* larvae reared at 27 ± 2 °C and 55 – 65% R.H. All experiments were carried out using dipping method, in which fresh castor leaves were dipped for 20 seconds in the different tested extracts. Then they were left in shad to dry. Two hundred and seventy larvae were divided into three replicates each of 10 larvae where they were kept in plastic cups.

Larval mortality was daily recorded until pupation. Mortality percentage was determined according to Meglla (1984) and corrected percentage mortality was determined according to Abbott's formula (1925):

$$\% \text{ Mortality} = \frac{\text{No. of dead larvae}}{\text{Total No. of larvae}} \times 100$$

$$\text{Corrected \% mortality} = \frac{X - Y}{100 - Y} \times 100$$

X: % mortality in treatment

Y: % mortality in check

The duration of larvae and pupae were determined. Also, percentage of malformed pupae, pupal weight and adult emergence were calculated.

$$\% \text{ Malformed pupae} = \frac{\text{No. of malformed pupae}}{\text{Total No. of pupae}} \times 100$$

$$\% \text{ Emergence} = \frac{\text{No. of emerged adults}}{\text{Total No. of adults}} \times 100$$

5. Statistical analysis

The obtained data of the biological studies were statistically analyzed through Excel program for Windows 7 computer to determine the F value and least significant difference L.S.D. at 0.05% confidence degree.

6. Biochemical studies

6.1. Chemicals

Bovine albumin standard was purchased from Stanbio laboratory (Texas, USA). Commasie brilliant blue G-250 was obtained from sigma (Sigma Chemical Co.). P- nicotina (purity 97%) was obtained from Ubichem Ltd. (Ham pshire), while nicotinamide ademine dinucleotide phosphate (reduced form, $NADP.H_2$) was supplied from BDH chemicals Ltd. (Poole, England).

6.2. Apparatus

Telfon tissue homogenizer (ST-2 Mechanic-Preczyina, Poland). After homogenation, supernatants were kept in a deep freezer at – 20 °C till use for biochemical assays. Double beam ultraviolet / visible spectrophotometer (spectronic 1201, Milton Roy Co. USA) was used to measure absorbance of colored substances or metabolic compounds.

6.3. Preparation of insects for analysis

The insects were homogenized in distilled water (50 mg / 1 ml) for biochemical analysis in a chilled glass. Homogenates were centrifuged at 8000 r.p.m. for 15 min at 5 °C in a refrigerated centrifuge. The deposits were discarded and the supernatants were kept in a deep freezer till use.

6.4. Determination of tested enzymes

6.4.1. Amylase & trehalase determination

Digestive enzymes were determined according to the method described by Ishaaya and Swirski (1976) using trehalose, sucrose and soluble starch as substrates for trehalase, invertase and α-amylase, respectively. Generally, 20 µl of diluted enzyme solution was incubated for 10 min at 30 °C with 250 µl 1% starch (soluble potato starch – Lintner grade – Sigma Chemical Co.) in 50 mM acetate buffer pH 5.0 containing 20mM NaCl and 0.1 mM $CaCl_2$. The reaction was stopped by adding 250 µl DNS reagent to each tube in boiling water for 5 min. Samples were cooled diluted with 2.5 ml H_2O and read at 550 nm on Spectronic 1201 (Beckman, USA).

Glucose was used as a standard. Appropriate dilutions of enzyme supernatant to obtain a linear production of glucose equivalents.

Generally, for each test amylase activity was determined from triplicate analyses of three groups of seedlings. The enzyme activity was expressed as µg glucose released / min / gm fresh weight.

7. Statistics

The results were analyzed by one – way of variance (ANOVA) using costat statistical software (cohort software, Berkeley). When the ANOVA statistics were significant ($p < 0.01$) and means were compared by the Duncan's multiple range test.

RESULTS AND DISCUSSION

1. The antifeedant properties of different plant extracts

Antifeedant effects of the plant extracts against 2nd and 4th *S. littoralis* larvae were estimated and calculated after 24, 48 and 72 hours from the beginning of the experiment through the consumption of treated leaves of castor oil beans (Table, 1). It is worth to note that (AFI) values increased with the increase of tested concentration of used plant extracts. The rate of increase was progressively recorded by elapse of time after applications showing 27.78 – 61.53, 36.67 – 63.73 and 41.09 – 78.24% for first, second and third days, respectively, for the 2nd *S. littoralis* larval instar. While, for the 4th larval instar, the AFI values ranged from 12.75 – 36.87, 13.02 – 51.58 and 25.14 – 59.28% for the previous three days, respectively (Table, 2).

Lemongrass extract in water at 10% concentration caused the highest antifeedant activity being 61.53, 63.73 and 78.24% three days after inspection for 2nd instar larvae. In case of 4th instar larvae lantana extract in water 10% caused the highest antifeedant efficacy being 36.87, 51.58 and 59.28% for the three days, respectively.

On the contrary, lemongrass extract in acetone at 5% had the lowest antifeedant value among all the tested extracts achieving 27.87, 36.67 & 41.09% for 2nd larval instar and 12.75, 13.02 and 25.14% for the 4th instar after 1, 2 and 3 days, respectively.

2. Efficacy of the conversion of ingested and digested food (ECI) & (ECD)

All the tested extracts reduced the nutritional indices ECI & ECD in either of 2nd and 4th instar larvae. Data in table (2) clearly showed that the values of the two parameter – conversion of ingested food (ECI) and conversion of digested food (ECD) for 2nd and 4th larval instar were (12.6 – 16.31%) & (22.79 – 27.94%) for lantana extract in water 10%, respectively. Followed by the same extract at 5% concentration being (15.60 – 22.61%) for the 2nd larval instar, lemongrass extract in acetone 10% (30.7 – 33.18%) 4th larval instar, respectively. While the maximum percentages for these parameter were recorded in the control achieving (33.35 – 73.64%) & (63.54 – 90.86%), respectively.

The role of deterrents *i.e.* secondary plant substances inhibiting feeding or oviposition (Fenny *et. al.,* 1988). These results were coincided with that reported by El-Gegahi *et. al.,* (1996) who found a significant reduction in the food consumption and a considerable decrease in the larval body weight 4th *S. littoralis* larval instar. The same author reported that the bestachia crude extract reduced consumption growth, utilization of ingested and digested food.

3. Biological effects of treated extracts on the 2nd and 4th larval instars *S. littoralis* which treated

3.a. Effect on percentage mortality

Data in Table (3), showed that the highest mortality percentage was obtained from treatment of 2nd larval instar of *S. littoralis* at 10% concentration of lemongrass in acetone followed by lantana extract in water 5% causing exhibiting 73.32% mortality.

On the other hand, for the 4th instar the highest percentage larval mortality was 70.73% by lantana extract in water at 5% concentration followed by lemongrass extract in acetone 10% causing 68.75% larval mortality. The remaining six extracts could be classified into two groups, the first had an intermediate effect as lantana extract in acetone and water both of them at 10% concentration and lantana extract in acetone 5% being 64.15, 64.15 and 54.15% for 2nd larval instar. In case of the 4th

instar larvae it caused 67.9, 64.15 and 64.15% mortality, respectively. The second group which had low effect on the percentage mortality including lemongrass extract in water at 5 & 10%, lemongrass extract in acetone at 5% recording 40.83, 39.58 and 25.83% mortality for 2nd larval instar larvae and 39.58, 55.8 and 35% mortality for 4th larval instar larvae, respectively, Table (3).

3.b. Larval duration

Data presented in table (3) showed that the effect of plant extracts on larval duration as one of the biological activities of *S. littoralis* larvae, representing significant differences at ($P < 0.05$) with averages 14.75 and 14.25 days for lantana extract in water and lemongrass extract in acetone at 5% conc., respectively. While, the shortest mean of larval duration resulted from treatment by lemongrass extract in water 10% (8.75 days) opposite to (21.25 days) for the untreated check followed by lemongrass extract in water at 5% (9.75 days). The remaining tested extracts achieved averages of larval duration ranged from 10.25 days by lantana extract in acetone to 13.25 days for lantana extract in water both of them at 10% concentration.

3.c. Pupal duration

As shown in Table (3), all extracts reduced the pupal period (8.5 – 12.25 days) when compared with the check (14.25 days). The longest pupal period (12.25 days) resulted from the treatment of lemongrass extract in water 10%, followed, insignificantly by lantana extract in acetone 5% (12 days) and lantana extract in water 10% (11.75 days). Lantana extract in water 5%, in acetone 10% and lemongrass extract in acetone 5% led to a approximately similar pupal period showing 9.75, 9.75 and 10 days, respectively. While, lemongrass and lantana in acetone 10% caused a high significant pupal period 8.5 and 9.75 days, opposite to 14.25 days for the check.

3.d. Pupal weight

Data in Table (3) indicated that all treatments caused high significant reductions in the pupal weight averaged from 0.2131 to 0.2997 gm / pupa opposed to 0.3105 gm in the check. The highest effect was recorded in case of lantana extract in water 5% (0.2131 gm) followed insignificantly by lemongrass extract in acetone 10% (0.2311 gm), lantana extract in acetone 5% (0.2444 gm) and lantana extract in water 10% (0.2591 gm). On the contrary, the lowest effect on the weight was proved with lantana extract in acetone 10% and lemongrass extract in water 10%, respectively, (0.2928 and 0.2997 gm).

3.e. Pupal malformation

As. Shown in Table (3), all treatment caused high significant pupal malformation and all the malformed pupae showed clearly deformities than the check.

The highest percentage of malformation was 77.05% resulted from lemongrass extract in acetone 10% followed insignificantly by lantana extract in acetone 10% (73.75%), the same extract in water 5% caused 71.65%. The remaining extracts were lemongrass in water 5% & 10% resulted (59.13 & 58.28% malformed pupae) in which they were considered to have intermediate effect and had significant percentage with the highest percentages of malformed pupae.

Malformations of *S. littoralis* pupae mostly appeared with different degrees of abnormalities of body shrinkage, moulting integument remain with pupae and colored by black, larval cuticle remain patches and moulting failure at the last instar larvae.

3.f. Adult emergence

Data presented in Table (3), showed that the lowest percentage of adult emergence resulting from treating larvae with the tested extracts recording 18.33% as a result of lemongrass extract in acetone 10%. Insignificantly, followed by lantana extract in acetone 10% (25.83%). The remaining extracts could be classified into two groups the first had intermediate effect on percentage of emergence including lemongrass extract in acetone 5% (29.15%), lemongrass extract in water 5% (29.15%) and lantana extract in water 10% (31.22% adult emergence), respectively. The second group represented by lantana extract in acetone 5% (49.98%) and lemongrass extract in water 10% (58.30%) while the percentage was 93.23% for the control.

These results are in agreement with that of Gaaboub *et. al.,* (2005) who examined the activity of the biochemical extracts from *Neotorularia aculeolata* against 4th instar larvae of *S. littoralis* using five solvents differ in their polarity (benzene, ethyl acetate, chloroform, ethanol and water) and all caused the high mortality percentages and antifeedant activity. Recently, Rajapaksa and Ratnasekera (2008) obtained plant oils from leaves of lemongrass and they were used to protect stored legumes against cowpea weevil and bean seed weevil and it caused significant adult mortality and reducing egg production. Amany. S. El-Hefny *et. al.,* (2011) stated that leaves of lantana extract in acetone achieved reductions in mealy bug population.

4.Biochemical studies

4.a. Amylase enzyme assessment

Table (4), showed changes in the rate of amylase enzyme when it was determined in the 2nd *S. littoralis* larval instar after treatments with the tested extracts. Lantana extract in water at 5% decreased the amylase activity achieving 158.33 µg glucose with 35.37% opposite to check which achieved 245 µg glucose. On the contrary, the highest concentration (10%) from the same extract caused 247.66 µg glucose. From these results it was clear that the increase amylase enzyme activity

increase was correlated positively with the increase concentration of the same plant extract. In case of *S. littoralis* 4th instar larvae the results showed that lantana extract in water 10% achieved µg glucose decrease in mean of amylase enzyme (188 µg glucose. For the lemongrass extract in acetone 10% it caused 334.33 µg glucose in comparison with the check that was 227 µg glucose.

4.b. Trehalase enzyme assessment

Table (4), showed the activity of trehalase enzyme was differed based on the treated extracts against 2nd instars larvae. Lantana extract in water at both concentrations 5 & 10% caused 415.33, 627 µg glucose, respectively.

Also, for 4th *S. littoralis* larval instar Lantana extract in water 10% caused 442 µg glucose and lemongrass extract in acetone 10% achieved 926.33 µg glucose, while the rate of trehalase was 794 µg glucose in the check. The results obtained was in the same trend with that recorded by Mead *et. al.,* (2008) who observed a pronounced decrease in the carbohydrate hydrolyzing enzymes activity especially amylase and invertase after treating *S. littoralis* 4th larval instar with spinosad and triflumuron either alone or as mixture with the two surfactants Triton X – 100 and Tween – 20 causing a high significant decrease in the enzymes activity.

5. Correlation between food consumption, AFI parameters and the carbohydrate hydrolyzing enzymes at 2nd & 4th *S. littoralis* larval **instar**

Data presented in Table (5), demonstrated that the percentage of consumption of ingested food (ECI) had a positive relationship with the activity of the amylase and trehalase enzymes r^2 0.59042 and 0.66277 for the 2nd *S. littoralis* and for 4th *S. littoralis* instars 0.256529 and 0.3813243, respectively.

The efficacy of consumption food (ECD) had direct proportion with the activity of the amylase and trehalase enzymes achieving positive r^2 values being 0.687521, 0.751347 for and 0.351805, 0.4717701 for 4th *S. littoralis*, respectively, (Table 6).

On the other hand, the percentage of antifeedant index (AFI) had an absolute positive relationship with the amylase and trehalase enzymes for the 2nd *S. littoralis* instar in which r^2 = 1& 1, respectively. Opposite to that obtained in 4th *S. littoralis* instar AFI had an absolute negative relationship with the same two enzymes r^2 = (– 1&– 1), respectively.

Hendy *et. al.,* (1994) examined the toxic of hexan and chloroform dodonia extract against *S. littoralis* larvae and recorded in adults emergence being 60%, percentage pupation and number of egg deposited were decreased. Finally, the authors stated that dodonia had a repellent effect on *S. littoralis* adults.

Table. 1. Parameters the efficiency against of some extracts S. littoralis 2nd instar larvae.

Treatments	% conc.	**AFI** days after treatment				ECI %	ECD %
		1	2	3	Mean		
Lantana extract in water	5	32.32	39.30	53.76	41.79	15.60	22.61
	10	53.09	55.98	60.02	56.36	12.60	16.31
Lantana extract in acetone	5	46.26	48.39	48.44	47.69	27.58	33.85
	10	61.20	63.21	64.38	62.93	22.90	33.01
Lemon-grass extract in water	5	42.84	54.41	54.99	50.74	27.99	38.25
	10	61.53	63.73	78.24	67.77	17.40	31.61
Lemon-grass extract in acetone	5	27.78	36.67	41.09	33.84	19.40	32.52
	10	52.75	53.13	56.50	54.12	23.35	38.29
Check		–	–	–	–	33.35	73.64

AFI : Antifeedant index
ECI: Efficacy of conversion of ingested
ECD: Efficacy of conversion of digested food

Table. 2. Parameters of the efficiency of some extracts against S.littoralis 4th instar larvae.

Treatments	% conc.	**AFI** days after treatment				ECI %	ECD %
		1	2	3	Mean		
Lantana extract in water	5	12.89	18.70	29.66	20.41	33.70	49.86
	10	36.87	51.58	59.28	49.24	22.79	27.94
Lantana extract in acetone	5	22.24	23.48	25.37	23.69	44.89	49.56
	10	25.51	30.29	33.18	29.66	39.52	41.75
Lemon-grass extract in water	5	20.20	24.23	31.68	25.37	34.55	44.14
	10	25.65	26.21	32.59	28.15	38.68	39.86
Lemon-grass extract in acetone	5	12.75	13.02	25.14	16.97	35.48	47.18
	10	35.30	39.89	57.87	44.35	30.70	33.18
Check		–	–	–	–	63.54	90.86

AFI : Antifeedant index
ECI: Efficacy of conversion of ingested food
ECD: Efficacy of conversion of digested food

Table. 4. Effect of plant extracts on Amylase and Trehalse enzymes; of the 2nd & 4th instar larvae of S. littoralis.

	Treatments	Mean of µg glucose / min / g.b.wt	
		Amylase	Trehalse
2nd instar	Lantana extract in water 5%	158.33	415.33
	Lantana extract in water 10%	247.66	627
	Control	245	644
4th instar	Lantana extract in water10%	188	442
	Lemongrass extract in acetone 10%	334.33	926.33
	Control	277	794

Table. 5. Correlation coefficient between certain parameters against 2nd and 4th instar of S. littoralis.

Larval instar	Parameters	Coefficient of correlation r^2	
		amlayse	trehalse
Second instar	AFI	1	1
Fourth instar		– 1	– 1
Second instar	ECI	0.59042193	0.66277773
Fourth instar		0.25652960	0.38132430
Second instar	ECD	0.68752170	0.751947510
Fourth instar		0.35180520	0.471770184

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خواص السمية ومانعات التغذية لبعض المستخلصات النباتية وتأثيراتها البيولوجية والبيوكيميائية على يرقات دودة ورق القطن

شنوده سيد يعقوب

معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقى – الجيزة

تم اختبار تأثير بعض مستخلصات أوراق نباتى اللانتانا وحشيشة الليمون اللذين ينتميان لعائلتين نباتين مختلفتين بمذيبين (الماء والاسيتون) بتركيزين مختلفين على العمر الثانى والرابع ليرقات دودة ورق القطن تحت الظروف المعملية على درجة حرارة ٢٧ °م، ٥٥ – ٦٥ % رطوبة نسبية. بعد الدراسة اظهرت النتائج ان مستخلص حشيشة الليمون فى الماء بتركيز ١٠% حقق اعلى كفاءة كمانع للتغذية على العمر اليرقى الثانى بينما كان مستخلص اللانتانا فى الماء بتركيز ١٠% الاكثر كفاءة على العمر اليرقى الرابع. حقق مستخلص اللانتانا فى الماء بتركيز 10% أقل كفاءة فى معدل الاستفادة من كل من الغذاء المقدم و الغذاء المهضوم لكلا العمرين. تحققت أعلى نسبة موت عند المعاملة بمستخلص حشيشة الليمون فى الاسيتون بتركيز ١٠% و مستخلص اللانتانا فى الماء بتركيز ٥% لكل من العمر الثانى والرابع على التوالى. وأظهرت النتائج المتحصل عليها ان جميع المعاملات حققت خفضا معنويا عن المقارنة بالنسبة لبعض صفات الاقتدار الحيوى مجال الدراسة. اظهرت المعاملة بالمستخلصات تأثيرا واضحا على الانزيمات المحللة للكربوهيدرات مثل الاميليز والتريهاليز ليرقات العمر الثانى والرابع. اوضحت دراسة الارتباط دراسة الارتباط العلاقة بين كفاءة هذه المستخلصات كمانعات تغذية والقدرة على الاستفادة من الغذاء المقدم والمهضوم وبين نشاط هذه الانزيمات. وعموما يمكن القول ان هذه المستخلصات النباتية ذات كفاءة عالية فى مكافحة دودة ورق القطن بحسب نوع المذيب ونسبة التركيز المستخدم .