Impact of Certain Novel Insecticides on Food Utilization Ingestion and Larval Growth of the Cotton Leafworm *Spodoptera littoralis* (Boisd.)

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Abstract: In laboratory study the effect of five novel insecticides, emamectin benzoate, rynaxypyr, indoxacarb, spinetorm and spinosad was studied on antifeedant activity, the consumption and utilization of food by 4th instar larvae of the cotton leafworm, *Spodoptera littoralis*, Larvae were fed for 24 hrs on castor bean leaves treated with sublethal concentrations (LC_5 and LC_1) of the tested insecticides, followed by feeding on untreated leaves for five days. The tested insecticides exhibited moderate antifeeding activity, relatively higher in rynaxypyr and indoxacarb at LC5 than other treatments. The consumption index (C.I.) was relatively reduced in rynaxypyr whereas spinetoram and spinosad recorded significant increase. Comparison based on overall mean during the whole experimental period indicated significant reduction in consumption index (C.I), growth rate (G.R) and approximate digestibility (A.D) in both of LC_5 and LC_1 treatments of rynaxypyr, emamectin benzoate and LC_5 of indoxacarb. The approximate digestibility (A.D) as well as growth rate (G.R) was significantly decreased for larvae fed on leaves treated with LC_5 of emamectin benzoate, rynaxypyr and indoxacarb, than other treatments, whereas A.D. was increased for larvae fed on LC_1 of indoxacarb and spinetoram over all treatments including control. The higher concentration (LC_5) of most tested insecticides resulted in significant decrease in efficiency of conversion of ingested (ECI) and digested (ECD) food compared with control.

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1. Introduction

Knowledge of the nutritional requirements of insects and their interaction with food sources and types are basic for an understanding of their biology and development where three criteria have been used in judging the utilization of the food by insects: (1) the digestibility of the food; (2) the conversion of ingested or digested food into body substance; (3) the rate of consumption. It is obvious that these three parameters are interrelated.

Feeding and reproduction in insects are very closely related to nutritional factors, the qualitative and quantitative aspects of which have impact on the rate of growth and development, but also on fecundity. Since the amount, rate and quality of food consumed by a larvae influence its performance, growth rate, development time, final body weight and survival (Slansky and Scriber, 1985). Therefore an understanding of the nutritional indices in relation to the rate of ingestion, digestion assimilation and conversion by the growing larvae would be useful. However, the amount and quality of food affect the growth rate at immature stages and subsequent adult body size and fecundity (Scriber and Slansky, 1981). Also, reduction in feeding activity of insect may reduce normal development, weight gain, fecundity and increase mortality (Van Duyn, 1971).

The existing data on the rate of consumption are either those reported by Waldbauer (1964) whose studies on utilization of the food by *Protoparce sexta* serves as a basic modal for our present study or/and information recorded laterly by several authors. However, during the last three decades many studies have been done to determine any specific effects of environmental pollutant (insecticides and others) factors on consumption and utilization of food by insects, i.e., *Nuclear polyhydrosis* virus on *Spodoptera littoralis* (Boisd.) (Eid *et al.*, 1982-1983; Abd El-Aziz, 2007); Abamectin and JH on *S. littoralis* (Boisd.) (Abo El-Ghar, 1993), Acylurea (IGRs) on *Spodoptera littoralis* (Radwan *et al.*, 1986); gamma irradiation on *Trogoderma granarium* Everts. (Abdel-Kawy, 1997), and on *Sesamia cretica* Ltd. (Abdel-Kawy and El-Nagar, 1992,1993); nonsteroidal ecdysone agonist, tebufenozide on *Spodoptera littoralis* (Boisd.) (Bream *et al.*,1999); spinosad on *S. littoralis* (Boisd.) (El-Malla *et al.*, 2003) and the limonoid fraxinellone on *Ostrina furnacalis* (Liu, *et al.*, 2008).

During the recent two decades efforts has been made to develop novel insecticides with selective properties that are designed to act on specific biochemical sites or physiological processes of the target pest.

Here, the present study was carried out aiming to study the effect of five of these novel compounds on the consumption and utilization of food by *Spodoptera littoralis* larval stage.

2. Material and Methods

2.1. Insects:

The culture of *Spodoptera littoralis* (Boisd.) used in the present study originated from eggs obtained from a susceptible strain established in the Cotton leaf worm Department, Plant Protection Institute, Dokki, Giza. The larval stage was reared and fed on castor bean leaves in the laboratory under constant conditions of 27 $\pm$ 2 and 65 $\pm$ 5 R.H according to El-Defrawi *et al.* (1964) reared technique.

2. Experimental insecticides:

The tested compounds include five insecticides which are members of different classes of insecticides with novel modes of action introduced in recent years. Most of these insecticides belong to reduced risk insecticides with low mammalian toxicity and a benign profile for non target (avian and aquatic) organisms.

Commercial formulations of the following five novel compounds were used:

1. rynaxypyr (Coragen 20% SC)
2. spinosad (Tracer 24% SC.)
3. indoxacarb (Avaunt 15% SC)
4. emamectin benzoate (Radical 1.9% EC)
5. spinetoram (Radiant 12% SC)

A stock solution or emulsion of each insecticide was prepared by diluting the formulated compounds with water (w/v) to obtain serial aqueous concentrations ranging from 100-0.001 ppm. Castor bean leaves were dipped in each concentration level for 5 sec., then left to dry at room temperature for 0.5 hrs. Three Replicates (10 larva/ rep.) for each concentration were allowed to feed on treated leaves for 24 hrs. Mortality was recorded at 24 and 48 hrs post-treatment and corrected for natural mortality by Abbott formula (Abbott, 1925). The data were then subjected to probit analysis (Finney, 1971) to obtain the LC_5 and LC_1 values.

Treatment and measurement of nutritional indices

In the present study larvae within 24 hrs of their molt to fourth instar and weighing mg were used. Leaf dipping technique was followed for all treatments in which castor bean leaves were dipped for ca. 5 sec., in each concentration/ insecticide and then left to dry. Leaves dipped in water served as control.

For each concentration (LC_5 or LC_1), six replicates of 10 larvae/each were introduced inside glass rearing jar (300 ml.). At the beginning the larvae in each jar in addition to the treated leaves were weighed. Larvae were allowed to feed on treated leaves for only the first 24 hrs, then provided daily with untreated fresh leaves for five successive days (experimental period 6 days). Dead larvae were discarded, while the fresh weights of survivors, faeces discharged by larvae and remaining treated leaves in each replicate was recorded daily and related to the number of survivors in each replicate.

Fresh leaves were kept in a similar rearing jar under the same conditions to estimate the natural loss moisture, which was used for calculating the corrected weight of consumed treated leaves.

The nutritional indices determined in the study were calculated according to equations described by Waldbauer (1968) as follow:

1. Consumption index (C1)= C/TA.
2. Growth rate (GR) = G/TA.
3. Approximate digestibility (AD) = [(C-F)/C] x 100
4. Efficiency of conversion of ingested food to body tissue (ECl) ECl = (G/C) x 100
5. Efficiency of conversion of digested food to body tissue (ECD) ECD = [G/(C-F)] x 100

Where:

C = fresh weight of leaves consumed.

T = duration of feeding period.

A = mean fresh weight of the larva during the feeding period.

G = fresh weight gain of the larvae.

F = faeces weight during the feeding period.

During the experiment the calculated mean weight (fresh) of the consumed treated leaves corrected as follow:

The corrected wt of leaf consumed = [1-a/2] [w-(L+bL)] where: a = the ratio of loss of water to the initial weight of the aliquot.

B = the ratio of water to the final weight of the aliquot.

W = wt of food introduced.

L = wt of untreated food.

Statistical analysis:

Data was subjected to analysis of variance (ANOVA) and means were separated by Duncan multiple range test (Duncan, 1955).

3. Results and Discussion

3.1. Antifeeding activity

Antifeedant is defined as a chemical that inhibits feeding without killing the insect directly, while the insect remains near the treated foliage and dies through starvation.

Antifeedant activity of the tested insecticides was studied at two different concentrations (LC_5 and LC_1) and results are presented in Table (1). Antifeedant activity of tested insecticides was assessed based on antifeedant index (Pavela *et al.*, 2008). Higher antifeedant index normally indicates decreased rate of feeding. In the present study data pertaining to the above experiment clearly revealed that indoxacarb and rynaxypyr led to the highest inhibition of food intake, with antifeedant index recording 39 and 34% for LC_5 and 23 and 28% for LC_1 for both treatments, respectively. Spinosed and spinetoram at the low concentration tested LC_1 showed the lowest inhibition of food intake with antifeedant index estimated as 1.8 and 7%, respectively where at the higher concentration (LC_5) relatively higher antifeedant index (13 and 14%) was recorded. However, emamectin benzoate recorded almostly similar low antifeedant index (15 and 10%) for LC_5 and LC_1, respectively. Today, the environmental safety of an insecticide is considered to be of paramount importance. An insecticide does not have to cause high mortality on target organisms in order to be acceptable. Antifeedant and growth inhibiting activity reduces pest damage to products even without killing the pest.

Table (1): The antifeedant activity (%) of tested insecticides against the 4th instar larvae of *Spodoptera littoralis* (Boisd.).

Treatments	Conc. ppm	Antifeedant index (%) at days post treatment when larva fed on						
		Treated leaves	Untreated Leaves					
		1st	2nd	3rd	4th	5th	6th	Mean
Emamectin benzoate	LC_5 (0.061)	24	15	12	18	10	11	15
	LC_1 (0.017)	17	14	7	13	6	4	10
Rynaxypyr	LC_5 (0.5)	25	49	27	31	34	38	34
	LC_1 (0.17)	28	31	26	32	31	22	28
Indoxacarb	LC_5 (0.76)	20	39	41	46	42	49	39
	LC_1 (0.32)	21	26	24	30	21	16	23
Spinetoram	LC_5 (8.59)	12	12	11	26	16	8	14
	LC_1 (4.43)	8	7	6	17	10	-4	7
Spinosad	LC_5 (79)	14	17	13	24	10	5	13
	LC_1 (15.7)	5	1	0.7	12	-7	-0.9	1.8

3.2. Consumption index

Consumption index is one of the factors associated with feeding rates. Comparison between different treatments can be the basis of intake relative to the main weight of an animal during a feeding period. Data in Table (2) indicate that the consumption index was significantly reduced for larvae fed for 24 hrs on LC_5 of emamectin benzoate, recording negative value for C.l. in this respect, Abo Elghar (1993) found that the consumption index (Cl) was decreased for cotton leadworm 4th instar larvae fed on abamectin-treated leaves below that of control during the whole experiment (10 days). Also, El-Malla and Radwan (2008) recorded relatively lower C.l. in abamectin and spinosed treatment when compared with control.

Table (2): Consumption index (C.I) for 4 th instar larvae of *Spodoptera Littoralis* after feeding for 24 hr on leaves treated with the tested insecticides followed by 5 days on untreated leaves.

Insecticide	Rate	Mean consumption index (C.I) at indicated days after treatment						Mean± S.D
		1st	2 nd	3rd	4th	5th	6th	
Emamectin Benzoate	LC5	-0.229^{b}	0.46^{a}	0.859^{bc}	0.643^{b}	0.727^{ab}	0.590^{a}	$0.51±0.077^{BC}$
	LC1	0.171^{ab}	0.67^{a}	1.030^{bc}	0.680^{b}	0.650^{b}	0.527^{ab}	$0.62±0.077^{AB}$
Rynaxypyr	LC5	0.315^{ab}	-0.79^{c}	1.323^{bc}	1.267^{a}	0.710^{ab}	0.082^{cb}	$0.48±0.077^{C}$
	LC1	0.046^{ab}	0.28^{a}	1.083^{bc}	0.747^{b}	0.376^{b}	0.420^{ab}	$0.49±0.077^{C}$
Indoxacarb	LC5	0.150^{ab}	-0.51^{bc}	1.867^{a}	0.830^{b}	1.045^{a}	-0.300^{c}	$0.51±0.077^{BC}$
	LC1	0.636^{ab}	0.10^{ab}	1.030^{bc}	0.547^{b}	0.617^{b}	0.600^{a}	$0.59±0.077^{B}$
Spinetoram	LC5	0.577^{ab}	0.41^{a}	0.923^{bc}	0.600^{b}	0.707^{ab}	0.607^{a}	$0.64±0.077^{AB}$
	LC1	0.805^{a}	0.67^{a}	0.847^{bc}	0.560^{b}	0.677^{ab}	0.563^{ab}	$0.69±0.077^{A}$
Spinosad	LC5	0.295^{ab}	0.67^{a}	0.928^{bc}	0.767^{b}	0.693^{ab}	0.553^{ab}	$0.65±0.077^{AB}$
	LC1	0.916^{a}	0.54^{a}	0.697^{bc}	0.540^{b}	0.667^{ab}	0.357^{ab}	$0.62±0.077^{AB}$
Control	control	0.729^{a}	0.59^{a}	0.599^{c}	0.547^{b}	0.660^{ab}	0.310^{ab}	$0.51±0.077^{BC}$

Means in a column followed by the same letter are not significantly different ($P<0.05$, Duncan's multiple range test).

On the other hand, both spinosad and spinetoram at LC_1 recorded C.l. significantly similar to control. However it is of interest to note that both concentrations of rynaxypyr exhibited the least C.I whereas spinosad at LC_1 recorded the highest C.l. Also the reduction of consumption index was reversely correlated with the concentration level tested (Bream *et al.,* 1999).

Comparison, on the basis of overall mean C.l. within the whole testing period (6 days) revealed that no significant difference in C.l. could be detected between both concentrations of spinosad and spinetoram in addition to LC1 of emamectin benzoate, where the C.l. was generally similar to that for larvae in control. On the other hand, it was obvious that spinetoram at LC_1 recorded C.l. higher than control which came in agreement with results of El-Malla *et al.* (2003) indicating that larvae fed spinosad recorded C.l. remarkably higher than control.

3.3. Growth rate (G.R.)

Growth rate measures amount of weight gained per unit time relative to the mean weight of larvae during the feeding period. As shown in Table (3) it was clear that all treatments except spinosed at LC_1 recorded significant reduction in G.R. at the first 24 hrs of feeding on treated leaves compared with control. Also, emamection benzoate (LC_5) and both concentrations of rynaxypyr exhibited extremely high reduction expressed as negative G.R. values.

On the other hand, comparison based on overall mean G.R. during the whole testing period revealed that both concentration of rynaxypyr and the high one of indoxacarb exhibited G.R. significantly lower than other treatments and control. The growth of locust can be correlated with the supply of food materials and the growth cases when feeding activity decreases (Hill and Goldsworthy, 1968). Also, insecticides treatments caused a reduction in growth rate (GR) of *Pieris rapae* (Turunen, 1975). In this respect, Woodering *et al.* (1978) and Sundramurthy (1977) indicated that the amount of growth reduction was proportional in general to reduced food consumption.

This explanation was confirmed by results of Dahlman (1977) who suggested that reducing the conversion efficiency of ingested and assimilated food may give a depression of growth rate. Also, Bream *et al.* (1999) found that feeding 4^{th} instar larvae on tebufenozide-treated leaves inhibited growth rate depending on the detrimentally reduced the assimilation rate (AR) and relative metabolic rate (RMR).

3.4. Efficiency of conversion of ingested food (E.C.I)

ECI is an overall measure of the larvae ability to utilize ingested food to body tissue. The ECI was significantly lower in larvae fed for 24hrs on leaves treated with both concentrations of emamectin benzoate and indoxacarb in addition LC5 of rynaxypyr when compared with each of spinetoram and spinosad and control (Table 4). It was of interest to note that fresh weight gain by larvae was remarkably low relative to fresh weight of food ingested which resulted in negative ECI values at most of the 2 first days in the testing period. On the hand comparison based on the overall mean values of ECI during the whole testing period revealed significant reduction for all treatments of emamectin benzoate, rynaxypyr, spinetoram and also for the high concentration of indoxacarb and spinosad compared to control. However, the decreases in ECI values are associated with energy consumption during physiological activities with recent molt and the approach of maturity (Carne, 1966). In this respect, El-Shazly (1993) indicated that ECI will vary with the digestibility of food and proportional amount of the digestible portion of food which is converted to body substance and metabolized for energy to maintain life.

Table (3): Growth rate (G.R) for *Spodoptera Lottoralis* larvae after feeding of 4^{th} instar larvae for 24 hrs on leaves treated with the tested insecticides followed by 5 days on untreated leaves.

Insecticide	Rate	Mean Growth rate (G.R) at indicated days after treatment						Mean$\pm$ S.D
		1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}	
Emamectin Benzoate	LC_5	-0.159^{f}	0.320^{a}	0.410^{ab}	0.305	0.297	0.323^{ab}	0.25 ± 0.030^{AB}
	LC_1	0.095^{de}	0.333^{a}	0.403^{ab}	0.305	0.317	0.267^{ab}	0.29 ± 0.030^{AB}
Rynaxypyr	LC_5	-0.33^{g}	-0.08^{b}	0.417^{ab}	-0.014	0.427	0.247^{ab}	0.11 ± 0.030^{D}
	LC_1	-0.225^{fg}	-0.028^{b}	0.587^{a}	0.279	0.337	0.337^{ab}	0.21 ± 0.030^{BC}
Indoxacarb	LC_5	0.001^{de}	-0.030^{b}	0.267^{b}	0.261	0.297	0.330^{ab}	0.19 ± 0.030^{C}
	LC_1	0.160^{d}	0.084^{b}	0.427^{ab}	0.249	0.383	0.273^{ab}	0.26 ± 0.030^{B}
Spinetoram	LC_5	0.180^{cd}	0.367^{a}	0.490^{ab}	0.278	0.277	0.327^{ab}	0.32 ± 0.030^{AB}
	LC_1	0.305^{bc}	0.356^{a}	0.387^{ab}	0.272	0.243	0.320^{ab}	0.31 ± 0.030^{AB}
Spinosad	LC_5	0.182^{cd}	0.317^{a}	0.387^{ab}	0.283	0.270	0.353^{a}	0.30 ± 0.030^{AB}
	LC_1	0.344^{ab}	0.360^{a}	0.427^{ab}	0.294	0.273	0.200^{b}	0.32 ± 0.030^{AB}
Control	control	0.464^{a}	0.317^{a}	0.500^{ab}	0.317	0.273	0.250^{ab}	0.35 ± 0.030^{A}

Means in a column followed by the same letter are not significantly different (P<0.05, Duncan's multiple range test).

Table (4): Efficiency of conversion of ingested food to body tissue (E.C.I) after feeding of 4 th instar larvae of *S. Littoralis* for 24 h on leaves treated with the tested insecticides, followed by 5 days on untreated leaves.

Insecticide	Rate	Mean of (E.C.I) at indicated days after treatment						Mean± S.D
		1 st	2 nd	3rd	4th	5th	6th	
Emamectin Benzoate	LC_5	-58.000^{e}	106.33	45.333^{ab}	47.667^{a}	40.333^{ab}	39.667^{ab}	36.89±14.924^{BC}
	LC_1	6.000^{d}	70.67	42.333^{ab}	45.333^{ab}	49.333^{ab}	43.000^{ab}	42.78±14.924^{B}
Rynaxypyr	LC_5	13.667^{cd}	-98.00	40.667^{ab}	11.667^{c}	69.667^{a}	0.667^{bc}	6.39±14.924^{D}
	LC_1	67.333^{a}	-49.67	46.667^{ab}	38.000^{ab}	53.000^{ab}	43.667^{ab}	33.17±14.924^{C}
Indoxacarb	LC_5	-53.66^{e}	-17.00	8.000^{b}	31.333^{b}	31.667^{b}	-52.667^{c}	-8.72±14.924^{E}
	LC_1	23.667^{c}	95.67	42.00^{ab}	46.333^{a}	45.667^{ab}	47.667^{ab}	50.17±14.924^{AB}
Spinetoram	LC_5	48.000^{ab}	-86.33	50.00^{ab}	35.333^{ab}	39.333^{ab}	59.000^{ab}	24.22±14.924
	LC_1	40.333^{b}	47.67	45.00^{ab}	48.000^{a}	36.667^{ab}	57.000^{ab}	45.78±14.924^{B}
Spinosad	LC_5	28.333^{bc}	54.67	41.667^{ab}	42.000^{b}	40.333^{ab}	64.667^{ab}	45.28±14.924^{B}
	LC_1	37.000^{b}	72.00	52.000^{ab}	55.667^{a}	44.667^{ab}	69.667^{a}	55.17±14.924^{A}
Control	control	71.000^{a}	54.33	88.333^{a}	62.667^{a}	40.667^{ab}	33.000^{ab}	58.33±14.924^{A}

Means in a column followed by the same letter are not significantly different (P<0.05, Duncan's multiple range test).

3.5. Efficiency of conversion of digested food (ECD)

Efficiency of conversion of digested food to body tissue (ECD) is on overall measure of the larvae ability to utilize digested food for growth. It was obvious from data shown in Table (5) that the ECD was significantly decreased for larvae fed for 24 hrs on leaves treated with all tested insecticides when compared with control. However, the ECD was severly reduced in rynaxypyr (LC_5) treatment. Such performance indicate existence of antifeeding effect of the tested insecticides. In agreement with Hassan (2009) recorded an inhibitory effect of *Spodoptera littoralis* larvae feeding on leaves treated with indoxacarb which indicate that the compound act as antifeedant. Likewise Beach and Tadd (1985) recorded that abamectin appear to inhibit larval feeding after treatment. Also, Pinkowski and Mehring (1983) noted that abamectin reduced feeding of larvae of alfalfa weevil *Ypetra postica*.

Table (5): Efficiency of conversion of digested food to body tissue (E.C.D) after Feeding of 4th instar larvae of *S. Littoralis* for 24 h on leaves treated with the tested insecticides, followed by 5 days on untreated leaves

Insecticide	Rate	Mean of (E.C.D) at indicated days after treatment						Mean ± S.D
		1 st	2 nd	3rd	4th	5th	6th	
Emamectin Benzoate	LC_5	42.00^{b}	111.00	65.67^{ab}	68.00^{abc}	56.67	83.333	71.11±14.235^{B}
	LC_1	8.33^{c}	82.67	57.00^{ab}	62.67^{abc}	75.000	94.667	63.39±14.235^{BC}
Rynaxypyr	LC_5	-9.00^{d}	17.33	35.33^{b}	12.67^{c}	93.333	40.333	31.67±14.235^{D}
	LC_1	48.00^{b}	29.33	58.00^{ab}	49.67^{abc}	80.000	98.333	60.56±14.235^{BC}
Indoxacarb	LC_5	38.33^{b}	4.67	9.333^{d}	36.33^{bc}	41.000	38.333	28.00±14.235^{D}
	LC_1	23.33^{b}	101.0	91.33^{ab}	72.67^{abc}	68.000	70.667	71.17±14.235^{B}
Spinetoram	LC_5	54.67^{b}	19.67	70.33^{ab}	44.33^{bc}	54.333	113.333	59.44±14.235^{C}
	LC_1	56.33^{b}	81.00	60.66^{ab}	67.33^{abc}	52.667	126.333	74.06±14.235^{B}
Spinosad	LC_5	61.67^{b}	97.00	54.00^{b}	55.33^{abc}	58.667	100.000	71.11±14.235^{B}
	LC_1	46.33^{b}	140.33	70.66^{ab}	92.66^{ab}	78.667	-11.667	69.50±14.235^{BC}
Control	control	106.0±^{a}	98.00	142.3^{a}	107.33^{a}	80.000	108.333	107.00±14.235^{A}

Means in a column followed by the same letter are not significantly different (P<0.05, Duncan's multiple range test).

Comparison based on overall means for all testing periods revealed remarkable and significant reduction in ECD for all insecticides compared with control particularly at the LC_5 of rynaxypyr and indaxacarb which recorded the highest reduction. The variations in ECD found during the experimental period (6 days) in all treatment including control were in agreement with the results reported by Smith (1959), who suggested that the ECD rise early in the nymphal stage of *Melanoplus bilituratus* (Walker) and falls near the end of the stage.

3.6. Approximate digestibility (A.D.)

The approximate digestibility in insects is based on differences between the weight of food ingested and the weight of the faeces, actually represents the food which is stored or metabolized.

Therefore the AD estimates the percentage of ingested food that is digested and assimilated (Slansky and Scriber, 1985). Data shown in Table (6) revealed that AD values within the first 24 hrs and 48 hrs post treatment was significantly decreased for both levels of emamectin benzoate and rynaxypyr (LC_1) and indoxacarb (LC_5). The reduction in ECD continued during the second day for rynaxypyr and indoxacarb at both levels (LC_5 and LC_1) in addition to LC_5 treatment of spinetoram as compared with control. Comparison based on overall mean within the end of testing period elucidate that mean AD was significantly decreased for both concentrations of rynaxypyr and LC_5 of emamectin benzoate, indoxacarb whereas indoxacarb and spinosad at the LC_1 resulted significant increase than control. In general, the AD declined gradually with larval age progression. Evans (1939) reported that the reasons for the decline of AD can be interpreted since insects as small individuals chew off smaller pieces of food and thus present a greater surface area for digestion, the composition of the food selected by leaf feeding insects changes as they grow older.

Table (6): Approximate digestibility (A.D) for 4 th instar larvae of S.Littoralis after feeding for 24 hrs on leaves treated with tested insecticides, followed by 5 days on untreated leaves.

Insecticide	Rate	Mean of (A.D) at indicated days after treatment						Mean± S.D
		1 st	2 nd	3rd	4th	5th	6th	
Emamectin Benzoate	LC_5	-289.247[e]	53.33a	72.333[ef]	70.333[bc]	71.333[abc]	67.333[a]	7.57±15.591[D]
	LC_1	14.333[b]	66.67[a]	76.000[cde]	71.667[bc]	65.333[abcd]	55.000[a]	58.17±15.591[B]
Rynaxypyr	LC_5	58.127[a]	-82.6[b]	87.000[b]	79.667[ab]	75.667[ab]	35.667[a]	42.24±15.591[BC]
	LC_1	-100.0[d]	-19.00[ab]	80.000b[cd]	77.000[ab]	60.667[bcd]	44.000[a]	23.78±15.591[C]
Indoxacarb	LC_5	-46.667[c]	-109.0[b]	95.333[a]	86.000[a]	81.333[a]	41.667[a]	24.78±15.591[C]
	LC_1	84.333[a]	21.67[ab]	84.333[bc]	70.000[bc]	72.000[abc]	69.000[a]	66.89±15.591[A]
Spinetoram	LC_5	56.000[a]	-48.33[ab]	73.333[ef]	79.667[ab]	70.333[abc]	59.667[a]	48.44±15.591[BC]
	LC_1	73.667[a]	71.00[a]	74.000[ef]	72.333[bc]	71.000[abc]	44.333[a]	67.72±15.591[A]
Spinosad	LC_5	-11.333[c]	67.67[a]	78.000[cde]	78.000[ab]	69.000[abcd]	56.000[a]	56.22±15.591[B]
	LC_1	85.333[a]	56.67[a]	70.000[fg]	62.333[c]	53.667[d]	-6.000[b]	53.67±15.591[B]
Control	control	71.000[a]	60.00[a]	63.000[g]	61.333[c]	56.667[cd]	40.667[a]	58.78±15.591[B]

Means in a column followed by the same letter are not significantly different (*P*<0.05, Duncan's multiple range test).

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