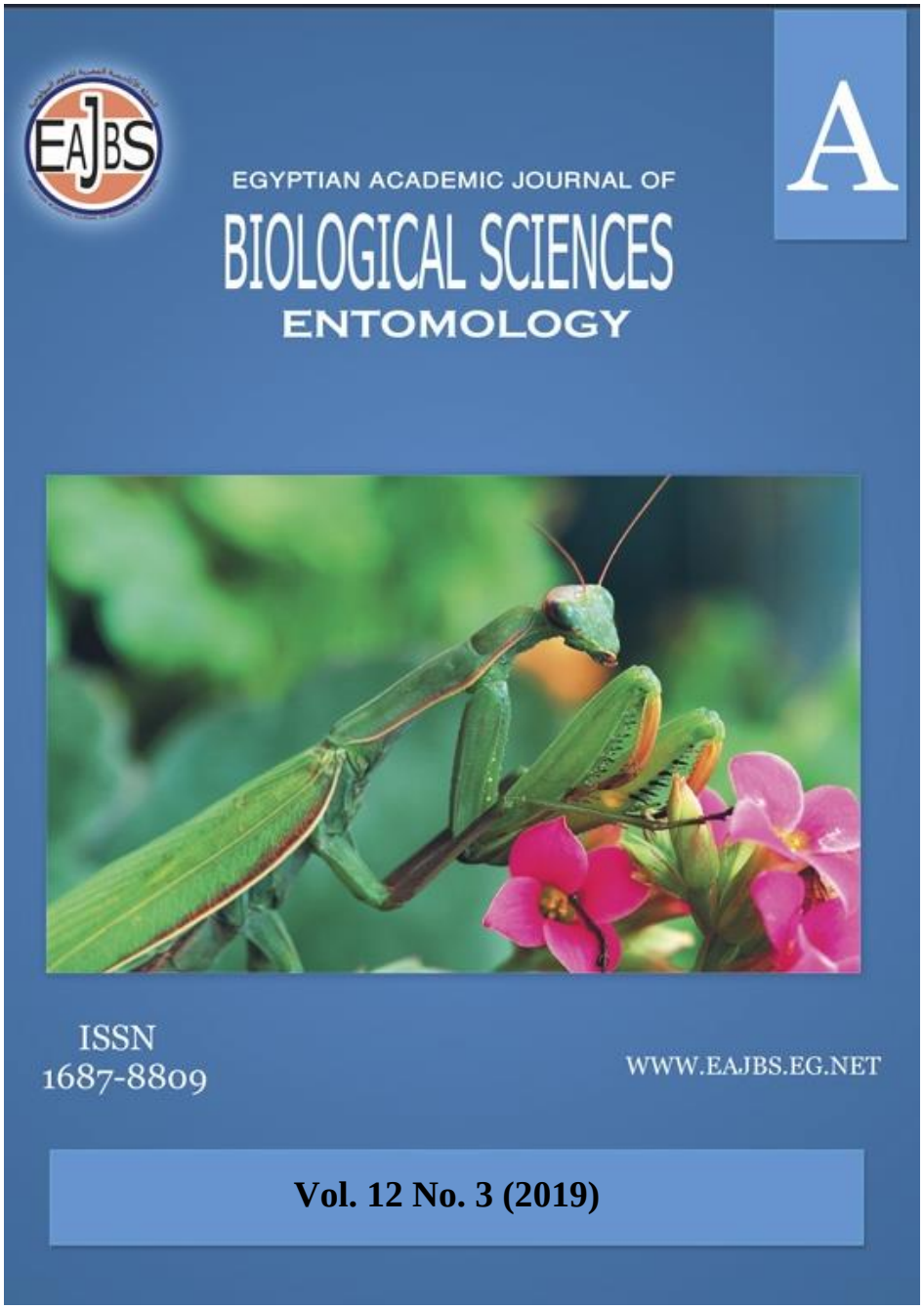

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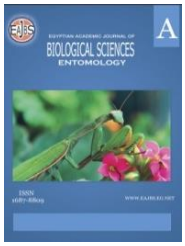

Impact of Host Plants on Detoxification Enzyme Activities to Certain Compounds Efficacy against the Cotton Leafworm, *Spodoptera littoralis* (Boisd.)

Soheir, F. Abd El-Rahman[1]; Salem, M.S. [1]; Yacoub, Sh.S. [1] and Nancy, H. Naguib[2]
[1]Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt.
[2]Depart. of Econ. Entomol. & Pesticide, Faculty of Agriculture, Cairo University, Giza
Email: Msalem3030@gmail.com; Whitehorse3050@gmail.com

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ABSTRACT

Bioassay and life table parameters of insect pest, *Spodoptera littoralis* (Boisd.) as affected with feeding on host plants of alfalfa and cabbage in comparison to feed on castor leaves. Also, the changes in detoxification enzyme activities in *S. littoralis* as a result of feeding on three host plants used were determined. In addition, the susceptibility of *S. littoralis* larvae to three compounds (Indoxacarb, Lufenuron and Uphold "Spinotorum+Methoxy fenozide") as influenced by feeding on the aforementioned host plants was studied under laboratory conditions. The obtained results showed that:

S. littoralis larvae feeding on castor leaves caused the decreasing in larval, pupal, adult durations and mortalities. However, the weights of larval and pupal were increasing comparing with rearing on alfalfa and cabbage, respectively.

Life table parameters of *S.littoralis* affected by feeding on the host plants used. Female progeny/female (Mx), survival rate (Lx), net reproductive rate (Ro), intrinsic rate of natural increase (r_m), finite rate of increase (e^{rm}) and doubling time (DT) had affected by the kind of host plant used.

Detoxification enzyme activity determinations cleared that α and β esterases were the highest activities in *S. littoralis* larvae fed on alfalfa, followed by cabbage, then castor leaves. While acetylcholine esterase as well as carboxyl esterase activities levels were the highest in *S. littoralis* larvae fed on cabbage. Meanwhile, glutathion S transferase was the highest activity in *S. littoralis* larvae fed on castor leaves.

In comparison to larvae feeding on castor leaves with those feeding on alfalfa or cabbage, the *S. littoralis* 4th instar larvae susceptibility had variation in estimation. The results showed in depending on LC_{50}, LC_{90}; the larvae of *S. littoralis* feeding on alfalfa were tolerant to indoxacarb; while that feeding on cabbage tolerant to lufenuron; on the other hand, the larvae fed on castor leaves was tolerant to uphold compound.

So, the susceptibility of *S. littoralis* differs with the kind of host plant that had the role of impact on detoxification activity enzyme changes and leads to the susceptibility of pest.

INTRODUCTION

Spodoptera littoralis (Boisd.) is one of the most devastating pests of cotton and other vegetables in Egypt as well as Mediterranean and Middle East countries. The ability to metabolize and detoxify plant chemicals is considered one of the major responses that arthropod herbivores have evolved during their coevolution with plants. Thus, the vast majority of insect herbivores are associated with no more than one or a few plant species (Bernays and Chapman, 1994), potentially reflecting the need for specialized mechanisms to cope with plant chemicals. Host plants can modify the susceptibility of herbivorous arthropods to pesticides (Brattsten, 1988). For example with in several aphid species, populations from different host plants showed different susceptibilities to pirimicarb (Furk *et al.*, 1980). Similar phenomena have been reported in herbivorous Homoptera (Heinrichs *et al.*, 1984), Coleoptera (Mahdavi *et al.*, 1991), and Lepidoptera (Robertson *et al.*, 1990). Different susceptibilities of insect pests maintained on special plants have been related to different levels of metabolizing enzymes, presumably induced by the plants (Tan and Guo, 1996). Many enzymes involved in detoxification pathways act on a broad array of substrates, including both naturally occurring plant allelochemicals and artificial pesticides (Gordon, 1961). Therefore, the physiological response of herbivores to host plants may lead to enhanced metabolism of pesticides because mechanisms that function in the detoxification of plant allelochemicals in their diets may also be effective at detoxifying pesticides. General esterase's and glutathione S-transferases (GST) are common detoxification enzymes that metabolize pesticides in arthropods. General esterase's, which are capable of degrading or sequestrating pesticides, can play a significant role in the detoxification of OP and pyrethroid pesticides (Valles, 1998). Yu (1982) demonstrated in fall armyworm that host plants such as cowpea, turnip, and mustard-induced 7- to 10-fold increases in GST activity relative to soybean.

So, investigate the feeding of *Spodoptera littoralis* (Boisd.) on two host plants (alfalfa and cabbage) in comparison with feeding on castor leaves was to aim of the current work to study the biology, life table parameters and detoxification enzymes changes towards the susceptibility of the pest to three compounds (Indoxacarb, Lufenuron and Uphold "Spinotorum+Methoxy fenozide").

MATERIALS AND METHODS

Insects:

A laboratory strain of *S. littoralis* larvae were reared at Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt. It was maintained under constant conditions at 27 ± 2 ˚C and 65 ± 2 % RH and kept away from any contamination with chemicals to obtain a susceptible strain (El-Defrawi *et al.*, 1964).

Chemicals:

a. Indoxacarb (15% SC.), (oxadiazine insecticide), the trade name is King Loda, the application rate is 25 ml/100L water and it is the product of Kafr El-Zayat pesticides & chemicals company, Egypt.

b. Lufenuron (5% EC.), the trade name is Magic Smart, the application rate is 160 ml/100L water and it is the product of Zhejiang sega science & technology Co., Ltd. China.

c. Spineforam 6% + **Methoxy fenozide** 30% (36% SC.), the trade name is Uphold, d Sterility observed percentages rate is 100 ml/400L water and it is the product of Dao chemical IMAGMPH, Egypt.

Biological Aspects:

First instar larvae of *S.littoralis* were fed at three host plants of castor leaves (*Ricinus communis* L.), alfalfa (*Medicago sativa* L.) and cabbage (*Brassica oleracea* C.) to investigate some biological aspects of the different stages of the pest as affected by host plants mentioned were examined daily to record the biological aspects as follows:

a. Larval and Pupal Stages: Duration (days), weights (g) and mortality percentages. Also, pupation% (No. produced pupae/Total tested larvae X 100).

b. Moth Stage: Pre-oviposition (days), oviposition (days), post-oviposition periods (days), ♂ adult moth longevity (days), ♀ adult moth longevity (days), sex ratio (female/total), no. of egg/female, % hatchability, moth emerged and % observed sterility.

c. Hatchability Percentage: No. hatched egg/ No. deposited egg X 100

d. Sterility Observed Percentages: Were calculated according to Zidan and Abdel-Megeed (1987) as follows:

% Sterility observed = 100 – Egg hatchability

e. Life Span: From egg to adult moth death.

Life Table Parameters:

Data of life table were analyzed by using life 48 basic computer program of (Abou - Setta *et al.*1986). The program has output data include information for each interval of adult female age: (egg laying rate) (M), number of females alive at age x (L), mean female age at each interval mid-point (X), female progeny per female produced during the day (Mx), rate of survival (Lx). In addition, generation time (T), net reproductive rate (Ro), intrinsic rate of natural increase (r_m), the finite rate of increase (e^{rm}) and the number of times in which the population multiplies in a unit time (doubling time, DT).

Bioassay:

Bioassays were performed on 4th instar larvae using the leaf dip technique (Immaraju, *et al.*, 1990). Castor–bean leaves were dipped for 30 sec in an aqueous solution of the prepared concentrations (0.5, 0.125, 0.0313 and 0.00781 ml/L) of Indoxacarb, Lufenuron and Uphold then left to dry for 1 h in room temperature before being offered to the 4th instar larvae; in addition, larvae treated with water served as control. Larvae were fed for 24 h on the treated leaves, and then transferred to fresh untreated leaves for three days. The knocking down effect was recorded at 48 h after treatment. All tests were conducted of six doses, with three replicates/dose and 30 individuals per replicate. The corrected mortality was calculated by using Abbott's formula (1925), data were subjected to probit analysis as described by Finney (1971). The lethal concentration (LC_{50}, LC_{90}) and slope values of the mentioned compounds were investigated.

Fold change was calculated according to Guo, *et al.* (2006) as follows:

(F.C.= Final value (B)/ initial value (A))

Quantification of Detoxification Enzymes Activity:

The activity of α- and β-esterase, Carboxylesterase and GST, AChE enzymes were analyzed in 4th *S. littoralis* untreated larva.

a. Acetylcholin Esterase: AchE (acetylcholinesterase) activity was measured according to method described by Simpson *et al.* (1964), using acetylcholine bromide (AchBr) as substrate. The decreasing in AchBr as a result of hydrolysis by AchE was read at 515 nm.

b. Carboxylesterases: Carboxylesterase activity was measured according to the method described by Simpson *et al.* (1964), using methyl n butyrate (MeB) as substrate. The decreasing in MeB as a result of hydrolysis by carboxylesterases was read at 515 nm.

c. Glutathione S-transferase (GST): catalyzes the conjugation of reduced glutathione (GSH) with 1-chloro 2,4-dinitrobenzene (CDNB) via the -SH group of glutathione. The conjugate, S-(2,4-dinitro-phenyl)-L- glutathione could be detected as described by the method of Habig *et al.* (1974). The increment in absorbance at 340 nm was recorded against

a blank containing everything except the enzyme to determine the nanomole substrate conjugated/ min/ larva using a molar extinction coefficient of 9.6/ mM/ cm.

d. α- and β- Esterase Assay (Nonspecific esterases): Alpha esterases (α-esterases) and beta esterase (β-esterases) were determined according to Van Asperen (1962) using α-naphthyl acetate or β-naphthyl acetate as substrates, respectively.

7. Statistical analysis: Data were subjected to statistical analysis using the two-way analysis of variance (ANOVA) [Costat statistical program, 1990] and separated by the least significant difference (LSD) test and the probability level $P < 0.05$ was considered statistically significant by Duncan (1955).

RESULTS AND DISCUSSION

Biological Aspects:

The first larval stage of untreated *S. littoralis* was feeding on host plants of alfalfa and cabbage with comprising to feeding on castor leaves for studying some biological changes as a result of feeding on host plants mentioned, some biological aspects were studying as follows:

1. Larval Stage Aspects. Castor leaves as a mean host plant had the shortest period of *S. littoralis* larval duration (18 days) as mentioned in Table (1); while, feeding the *S. littoralis* larvae on alfalfa increased that duration to 20.7 days. Also, the longer larval time recorded in feeding *S. littoralis* larvae on cabbage (25.3 days). Meanwhile, larval mortality percentage was 5% during feeding on castor leaves, while it was 10 & 15% during feeding on alfalfa and cabbage, respectively.

Sixth larval stage of *S. littoralis* that feeding on castor leaves had 0.85 g; while, the 6th larval stage of *S. littoralis* was 0.44 and 0.31 g when the larvae feed on alfalfa and cabbage, respectively as in Table (1).

2. Pupal Stage Aspects. Table (1) appeared that pre-pupa stage of *S. littoralis* was 1.67 days in case of larvae feeding on castor leaves as well as alfalfa. Cabbage had a slightly effect on that stage (2 days) in comparison with other host plants used.

The host plant of castor had *S. littoralis* pupal duration of 10.3 days; that value increased about two days when *S. littoralis* larvae feeding on alfalfa leaves and about three days when feeding on the cabbage as shown in Table (1).

The same trend was found in pupal weights of *S. littoralis* when 1st instar larvae feeding on castor leaves, alfalfa and cabbage (0.27, 0.23 and 0.21 g, respectively).

Percentages of pupal mortality reached 20% that reared on cabbage; while it was 10& 15 in pupae reared as larvae on castor and alfalfa, respectively.

3. Adult Stage Aspects. That duration had the shortest time (14 &20 days) in males and females of *S. littoralis* feeding as 1st instar on castor leaves, followed by alfalfa and cabbage host plants (13 & 22 and 12&19 days, respectively) as illustrated in Table (1). On the other hand, percentages of moth emerged were 95, 90 & 80% for moths feeding as the 1st larval stage on castor, alfalfa and cabbage, respectively.

The sex ratio (female/total) was 0.67, 0.63 and 0.4 in moth feeding as the 1st larval stage on host plants of castor, alfalfa and cabbage, respectively.

The pre-oviposition period was the same value (2 days) in female moths rearing as larvae on castor or alfalfa; meanwhile, increased one day to become 3 days in female moths rearing as larvae on the cabbage as mentioned in Table (1).

The oviposition period was the longest time in female moths rearing as larvae on castor (12 days), followed that rearing on alfalfa and cabbage (10&8 days, respectively).

The post-oviposition period was the longest time in female moths rearing as larvae on alfalfa (10 days), followed by cabbage (8 days) and castor (6 days).

Table (1). Impact of host plants on some biological aspects of *S. littoralis*

Biological parameters	Host plant			L.S.D$_{0.05}$
	Castor	Alfalfa	Cabbage	
Larval duration (day)	18c	20.7b	25.3a	7.079
6th Larval weight (g)	0.85a	0.44b	0.31b	0.190
Larval mortality %	5b	10ab	15a	5.21
Pre pupae duration (day)	1.67a	1.67a	2a	1.489
Pupal duration (day)	10.3a	12.3a	13.3a	3.46
Pupal weight (g)	0.27a	0.23a	0.21a	0.072
Pupal mortality%	10b	15ab	20a	5.431
Pupation%	95a	90ab	85b	5.110
Moth emerged%	95	90	80	5.884
Male adult duration (day)	14a	13a	12a	2.751
Female adult duration (day)	20a	22ab	19a	2.164
Sex ratio (Female/total)	0.67a	0.63b	0.4c	1.719
Pre-oviposition period (day)	2a	2a	3a	2.312
Oviposition period (day)	12ab	10b	8a	4.123
Post-oviposition period (day)	6a	10ab	8b	2.123
No. egg/female (no. batches)	1442 (8)a	977 (6)b	760 (5)c	5.690
% Hatchability egg	75b	89a	65c	5.642
% Observed sterility	25b	11c	35a	4.112
Life span	53.9b	60.7ab	63.6a	3.334

No. egg per female was the highest number deposited by females rearing as larvae on castor (8 batches/female or about 1442 egg/ female), followed by that feeding on alfalfa (6 batches or about 977 egg/female) and feeding on cabbage (5 batches or about 760 egg/female).

Egg hatchability percentage was 75% of egg deposited by females that rearing as larvae on castor in spite of the highest number of egg deposition. While, the egg hatchability was 89 and 65% of eggs deposited by females that rearing as larvae on alfalfa and cabbage, respectively.

Observed sterility percentage was 25, 11 and 35% for female moths rearing as larvae on castor, alfalfa and cabbage, respectively.

AL-Mousway, *et al.* (2009) reported that the leaves of castor bean contain glycosides, tannins, resins, coumarins, alkaloids, water extract was acidic pH : 5.71, oil percentage 2.1 , protein: 13.5 , Moisture: 12.8, tannins: 6.7, crude fiber: 15.6, total ash: 12.15, ash soluble in water: 30.33, and ash insoluble in acid 21.25. All of those compounds in castor leaves are considered to make it the best host plant for *S. littoralis* than another two host plants used and that reflects on larvae duration or mortality.

Life Table Parameters:

The relationship among the developmental responses and life table parameters was to clear for appearing the different responses and life history or eradication as affected by feeding on the kind of host plants.

1. Female Progeny/Female (Mx) and Survival Rate (Lx):

Female progeny/femal (Mx) and survival rate (Lx) of *S. littoralis* adult moth feeding on castor, alfalfa and cabbage as 1st larval stage cleared in Figure (1). Female progeny/female ranged between 20 to 335 in *S. littoralis* feeding as larvae on castor leaves; whereas, it ranged between 31.5 to 218.9 and from 10 to 145 female progeny/ female in *S. littoralis* feeding as the 1st larval stage on alfalfa and cabbage, respectively.

S. littoralis rate of survival (Lx) of adult moths that fed as 1st larval stage on castor ranged between 0.5 to 0.75 times as in figure (1). The survival rate (Lx) of *S. littoralis* adult moths fed as 1st larval stage on alfalfa and cabbage were between 0.67 to 0.89 and 0.3 to 0.6 times that observed.

2. Generation Time (T). *S. littoralis* feeding as the 1st larval stage on host plant of castor spent 38.83 days; meanwhile, host plants of alfalfa and cabbage had values of 42.99 and 50.04 days as in Table (2) that showed increasing days compared with feeding on castor.

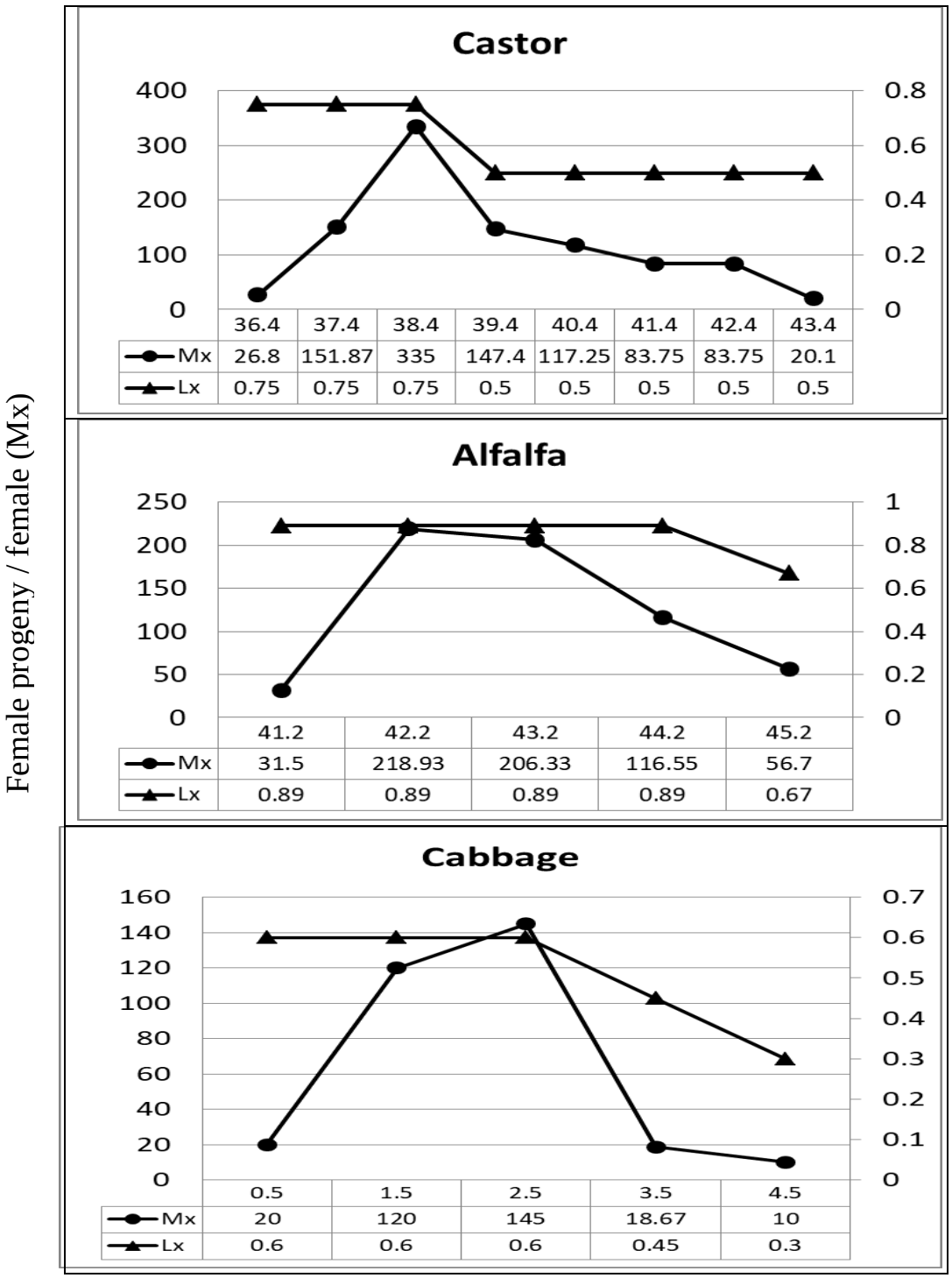

Fig.1: Impact of host plant on the female progeny/ female (Mx) and rate of survival (Lx) of *S. littoralis* fed as the 1st larval stage

3. Net Reproductive Rate (Ro). Host plant of castor when *S. littoralis* fed on it, the female capacity was increased in the population in each generation as in Table (2) (Ro: 611.4 females/female); whereas, *S. littoralis* fed as 1-day old larvae on alfalfa and cabbage had Ro: 548.08 and 182.4 females/female as described in Table (2).

Increase Rate:

1. Intrinsic Rate of Natural Increase (r_m). The ability of inheriting increase in daily or intrinsic rate of natural increase (r_m) of *S. littoralis* fed as 1st larvae on castor was 0.165 times/female/day; that value decreased to 0.147 and 0.046 times/female/day when fed as 1-day old larvae on alfalfa and cabbage (Table 2).

2. Finite Rate of Increase (e^{rm}). *S. littoralis* daily populations per female or finite rate of increase were 1.179, 1.158 and 1.032 times/female/day when fed on host plants of castor, alfalfa and cabbage as in Table (2).

Doubling Time (DT):

The time that doubling the population or become twice (DT) was 4.196 and 4.725 days in *S. littoralis,* when fed as 1st larvae on castor and alfalfa, respectively. While, the values increased to 15.07 days when *S. littoralis* fed as 1-day old larvae on cabbage.

Table (2). Life table parameters of *S. littoralis* feeding as larval stage on certain host plants.

Host plants	T (days)	(Ro)	Increase rate		DT (days)
			r_m	e^{rm}	
Castor leaves	38.83^c	611.4^a	0.165^a	1.179^a	4.196^b
Alfalfa	42.99^b	548.08^b	0.147^b	1.158^b	4.725^b
Cabbage	50.04^a	182.4^c	0.046^c	1.032^c	15.07^a
L.S.D. $_{0.05}$	3.996	14.13	0.0048	0.0065	3.460

(T) = The generation time (Ro) =The net reproductive rate
(r_m) = The intrinsic rate of natural increase (e^{rm}) = The finit rate of increase

Amer, *et al.* (2015) had results nearly from current study values. They reported that normal *S. littoralis* that rearing on castor leaves had life table parameters of 37.21 days (T), 425 (Ro), 0.31 (r_m), 1.36 (e^{rm}), 2.24 (DT) and 0.5 (sex ratio).

Detoxification Enzymes Determination:

Three host plants of castor leaves, alfalfa and cabbage were feeding by *S. littoralis* larvae to determine its effects on detoxification enzymes as α, β, acetylcholine and carboxyl esterases; glutathione-S- transferase as shown in Table (3).

The highest α-esterase activity was determined in *S. littoralis* larvae feeding on alfalfa (1857.3 µg α-naphthol/min/g.b.wt); whereas, the highest activity of β-esterase was found in *S. littoralis* larvae feeding on castor leaves (1296 µg β-naphthol/min/g.b.wt) as well as GST esterase activity (172.7 m mole sub. conjugated/min/g.b.wt). Acetylecholine esterase had the highest activity in *S. littoralis* larvae feeding on the cabbage as in Table (3) as well as carboxylesterases activity that was 124.3 µg Meb/min/g.b.wt in *S. littoralis* larvae feeding on cabbage.

Various detoxifying enzymes confer insecticide resistance to insects. In insect, AchE is the major target for organophosphate (OP) and carbamate insecticide (Kranthi *et al.*, 2001). Glutathion-S- transferase (GST) belongs to a protein family involved in detoxification of xenobiotics, protection from oxidative damage and intracellular metabolites and exogenous chemicals.

Carboxy esterase (CarE) is the cytoplasmic enzyme that plays an important role in neutralizing xenobiotics (Tang *et al.,* 1990); these esterases detoxify organophosphate (OP), carbamate and synthetic pyrethroid by two main ways hydrolysis of the ester bond and binding of the OP to the active site of CarE (Crow, *et al.,* 2007).

Table (3). Detoxification enzymes determination in *S. littoralis* larvae as affected by certain host plants

Detoxification analysis	Host plant			L.S.D$_{0.05}$
	Castor	Alfalfa	Cabbage	
Alpha esterases (µg α-naphthol/min/g.b.wt)	1384.3^{c}	1857.3^{a}	1467.7^{b}	26.23
Beta esterases (µg β-naphthol/min/g.b.wt)	1296^{a}	959.3^{b}	956^{b}	32.55
Ach E (µg AchBr/min/g.b.wt)	217.7^{c}	265.3^{b}	361^{a}	17.86
Carboxylesterases (µg Meb/min/g.b.wt)	96.67^{b}	69^{c}	124.3^{a}	8.835
GST (m mole sub. conjugated/min/g.b.wt)	172.7^{a}	94.67^{b}	81^{c}	9.204

Biochemical component of untreated 4th larval instars after 24 hours showed that, the number of total carbohydrates, total proteins, carbohydrate hydrolyzing enzymes (invertase, trehalase and amylase) and acid & alkaline phosphates were significantly decreased. Where the acetylcholine esterase activity was significantly increased (Elbarky *et al*., 2008).

Impact of Host Plants on the Susceptibility of *S. Littoralis* to Certain Compounds:

Fourth instar larvae of *S. littoralis* feeding on certain host plants of castor leaves, alfalfa and cabbage had devasting affected by certain compounds of Indoxacarb, lufenuron and uphold (Spinotoram+methoxy fenozide). The changes in *S. littoralis* larvae susceptibility towards the tested compounds were cleared as in Tables (4, 5& 6).

Treated larvae with Indoxacarb were the most susceptible when it feeding on cabbage (LC_{50}: 0.016 m/L), followed by feeding on castor leaves, then alfalfa that had the larvae tolerant towards indoxacarb (7.69 fold) at 3-day passed from treatment. The same trend was found at different registered time (1, 5, 7, 10 & 15 days) after treatment.

Ismail (2018) conducted bioassay of *S. littoralis* 4th instar larvae showed that 2nd instar were more susceptible than 4th instar to indoxacarb treatment as the LC_{50} and LC_{90} values that were 0.63 and 3.1 ppm for 2nd instar larvae and 2.0 and 18.75 ppm for 4th instar, respectively. Indoxacarb treatment caused decrease in the content of carbohydrates and lipids and slightly increased in total protein. The disturbance in the carbohydrate level was expressed by ingairment in the activity of carbohydrate enzymes in treated larvae was a significant increase in the enzyme activity of alpha and beta esterase as well as glutathione -S- transferase. Meanwhile, a significant decrease in the enzyme activities of both acetylcholinesterase and acid phosphatase was recorded in treated larvae.

Fourth instar larvae feeding on alfalfa was the most susceptible to lufenuron treatment (LC_{50}: 0.252 m/L), followed by feeding on castor leaves and cabbage (LC_{50}: 0.364 and 0.4 m/L, respectively) at 3-days from treatment as shown in Table (5). Also, the same trend appeared at different periods used 1, 5, 7, 10 & 15 days from treatment.

Table (4). Impact of host plants on *S. littoralis* susceptibility to Indoxacarb efficacy

Host plant	LC_{50} m/l	Lower limit ± Upper limit	LC_{90} m/l	Lower limit ± Upper limit	Slope± SE	Fold Change
After 1-day						
Castor	0.039	0.0032± 0.253	1.929	0.623± 10.91	1.298± 0.327	1.77
Alfalfa	0.199	0.131± 2.607	1.951	0.721± 11.23	0.655± 0.290	9.05
cabbage	0.022	0.002± 0.340	0.258	0.013± 2.402	1.559± 0.311	0.0
After 3-day						
Castor	0.024	0.008± 0.325	0.312	0.154± 5.789	1.187± 0.315	1.5
Alfalfa	0.123	0.092± 2.222	1.036	0.434± 9.472	0.988± 0.318	7.69
cabbage	0.016	0.002± 0.28	0.285	0.158± 1.654	1.383± 0.312	0.0
After 5-day						
Castor	0.0195	0.0064± 0.297	0.3303	0.025± 6.256	0.595± 0.337	8.48
Alfalfa	0.0621	0.0023± 0.413	3.461	0.525± 13.46	0.417± 0.294	27
cabbage	0.0023	0.0004± 0.0275	0.189	0.0119± 3.501	1.298± 0.328	0.0
After 7-day						
Castor	0.012	0.002± 0.223	0.132	0.088± 2.272	1.151± 0.309	5.45
Alfalfa	0.028	0.0011± 0.423	0.362	0.0185± 4.815	0.722± 0.365	12.73
cabbage	0.0022	0.0004± 0.054	0.129	0.034± 1.329	1.231± 0.349	0.0
After 10-day						
Castor	0.0065	0.00024± 0.0451	0.1182	0.022± 1.102	1.017± 0.361	2.6
Alfalfa	0.018	0.006± 0.271	0.141	0.097± 1.343	0.939± 0.393	7.2
cabbage	0.0025	0.0002± 0.031	0.058	0.0034± 0.424	1.430± 0.341	0.0
After 15-day						
Castor	0.006	0.0003± 0.0161	0.068	0.0055± 0.172	1.131± 0.387	2
Alfalfa	0.007	0.0004± 0.0461	0.078	0.0055± 0.192	0.939± 0.393	2.33
cabbage	0.003	0.0001± 0.032	0.058	0.0012± 0.112	1.331± 0.387	0.0

Table (5). Impact of host plants on *S. littoralis* susceptibility to Lufenuron efficacy

Host plant	LC_{50} m/l	Lower limit ± Upper limit	LC_{50} m/l	Lower limit ± Upper limit	Slope± SE	Fold Change
After 1-day						
Castor	0.733	0.0555± 7.273	8.295	0.667± 16.56	1.372± 0.312	1.16
Alfalfa	0.633	0.0455± 6.581	6.295	0.467± 15.56	1.572± 0.312	0.0
cabbage	0.794	0.0832± 8.124	13.63	2.166± 22.36	0.869± 0.302	1.25
After 3-day						
Castor	0.364	0.0239± 3.291	5.912	0.0184± 17.82	1.059± 0.3001	1.44
Alfalfa	0.252	0.0126± 9.345	3.855	0.649± 13.92	1.082± 0.303	0.0
cabbage	0.4	0.0342± 6.283	13.39	2.441± 31.31	0.840± 0.298	1.59
After 5-day						
Castor	0.139	0.013± 3.241	4.375	0.423± 18.22	0.898± 0.305	1.36
Alfalfa	0.102	0.0902± 2.881	1.988	0.986± 13.95	0.994± 0.319	0.0
cabbage	0.163	0.067± 2.002	12.35	0.894± 22.53	0.654± 0.302	1.6
After 7-day						
Castor	0.089	0.0042± 0.989	1.399	0.642± 11.05	1.073± 0.329	4.38
Alfalfa	0.0203	0.0011± 0.136	0.725	0.0506± 9.915	1.295± 0.362	0.0
cabbage	0.74	0.098± 5.163	5.605	0.793± 19.14	0.525± 0.322	36.5
After 10-day						
Castor	0.017	0.0045± 0.665	0.758	0.067± 8.345	0.945± 0.395	1.2
Alfalfa	0.0142	0.0028± 0.565	0.376	0.0587± 7.212	1.023± 0.363	0.0
cabbage	0.042	0.0012± 0.998	0.83	0.098± 11.423	0.725± 0.367	2.96
After 15-day						
Castor	0.017	0.0019± 0.889	0.284	0.088± 9.124	0.991± 0.404	18.89
Alfalfa	0.0009	0.000085± 0.0042	0.2125	0.055± 8.422	0.539± 0.416	0.0
cabbage	0.029	0.0056± 0.994	0.341	0.0221± 10.101	1.291± 0.468	32.22

Table (6). Impact of host plants on *S. littoralis* susceptibility to Uphold efficacy

Host plant	LC_{50} m/l	Lower limit ± Upper limit	LC_{90} m/l	Lower limit ± Upper limit	Slope± SE	Fold Change
After 1-day						
Castor	0.514	0.0219± 6.513	9.362	0.931± 29.64	0.423± 0.107	34.3
Alfalfa	0.467	0.0151± 4.77	5.526	0.857± 19.24	0.538± 0.151	31.13
cabbage	0.015	0.004± 0.282	3.587	0.612± 13.23	0.984± 0.208	0.0
After 3-day						
Castor	0.314	0.0135± 2.404	8.272	0.354± 19.44	0.431± 0.148	62.8
Alfalfa	0.061	0.0039± 0.119	4.409	0.761± 18.86	0.653± 0.165	12.2
cabbage	0.005	0.0002± 0.093	2.802	0.108± 12.291	0.772± 0.155	0.0
After 5-day						
Castor	0.121	0.068± 3.391	8.394	0.488± 28.03	0.469± 0.153	60.5
Alfalfa	0.008	0.0002± 0.067	1.769	0.387± 11.72	0.555± 0.153	4
cabbage	0.002	0.0008± 0.015	1.157	0.564± 9.43	0.696± 0.157	0.0
After 7-day						
Castor	0.0365	0.0021± 0.692	3.689	0.768± 14.07	0.587± 0.157	26.07
Alfalfa	0.0054	0.0007± 0.0814	0.818	0.0234± 15.93	0.518± 0.159	3.857
cabbage	0.0014	0.00053± 0.047	0.407	0.0125± 12.05	0.639± 0.1513	0.0
After 10-day						
Castor	0.008	0.0003± 0.014	0.564	0.021± 14.695	0.467± 0.170	26.67
Alfalfa	0.005	0.0001± 0.086	0.174	0.077± 8.391	0.696± 0.157	16.67
cabbage	0.0003	0.00002± 0.0066	0.159	0.017± 6.39	0.718± 0.171	0.0
After 15-day						
Castor	0.003	0.0003± 0.074	0.222	0.096± 6.98	0.473± 0.198	30
Alfalfa	0.0002	0.00001± 0.0095	0.0404	0.00192± 0.9363	0.567± 0.177	2
Cabbage	0.0001	0.00008± 0.006	0.028	0.0082± 0.132	0.671± 0.167	0.0

Another trend was found in Table (6) when *S. littoralis* larvae treated with uphold compound. The *S. littoralis* was more susceptibility to compounds when feeding on cabbage, followed by alfalfa, then castor leaves (LC_{50}: 0.005, 0.061 and 0.314 m/L, respectively) at 3-days from treatment.

Sabri *et al*. (2016) mentioned that the lethal effects of biorational insecticides (methoxy fenozide), spinosad, emamectin benzoate, indoxacarb and lufenuron as well one control treatment against different life stages of *Spodoptera litura* were examined. The least possible mortality was caused by lufenuron; while highest mortality level was observed in methoxyfenozide treatment (25%), so the highly toxic insecticide against the *S. litura* is methoxyfenozide at its higher concentration after 48 hours. Order of insecticides toxicity on the basis of mortality was methoxyfenozide > spinosad > indoxacarb > emamectin > lufenuron. Elevated levels of carboxylesterase (20.72-fold) were observed in larvae reared on cauliflower as compared to the diet fed larvae. The activity of glutathione S-transferase (1.56 fold) was higher in larvae reared on soybean. Enhanced activity of detoxification enzymes in larvae of *S. litura* reared on different host plants could be correlated with insecticide susceptibility (Muthusamy, *et al.,* 2011).

Differential susceptibility of *S. litura* population could be correlated with the diet/host plants and levels of detoxifications enzymes like carboxylesterases and glutathione S-transferase (Karuppaiah *et al*., 2015).

Spinosad showed a variable degree of toxicity against 4th instar larvae of *S. littoralis* when different host plants were used for feeding. The highest activity of spinosad was recorded when treated cotton leaves were used for feeding, the 48 h of LC_{50} and LC_{90} values were 5 and 60 ppm respectively at 48 h passed from treatment. The lowest toxicity of spinosad was noticed when okra leaves were used in the bioassay, the 48 h of LC_{50} and LC_{90} values were 20 and 540 ppm respectively at 48 h passed. The efficacy of spinosad against *S. littoralis* took an intermediate position when castor, lablab and maize leaves were used in the bioassay. Conclusion: Morphological and physiological structure of various host plants may have an effect on both insect and compound which in turn affect the toxicity of the compound (Ahmed *et al*., 2015).

Flufenoxuron and chlorfluazuron increased the activity of both alpha & beta esterases in *S. littoralis* and can facilitate the development of truly selective insecticides that can be employed in integrated pest management strategies (Abdel-Mageed *et al.,* 2018).

Al-Mousway, *et al.* (2009) showed that the castor oil leaves, contained: glycosides, tannins, resins, coumarins, alkaloids are positive results; however, with saponins and flavones are negative results. While, Moshileh, *et al.* (2005) showed a quality characteristic of alfalfa in protein, carbohydrates, fiber except for fat percentage. Meanwhile, Deepleta and Rao (2013) showed that cabbage had chlorophyll a&b, carotenoid, sugar, starch, proteins and phenols. So, *S. littoralis* more susceptible to compounds used, followed by alfalfa and castor leaves.

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ARABIC SUMMARY

تأثير العائل النباتى على نشاط إنزيمات نزع السمية تجاه كفاءة بعض المركبات فى مكافحة دودة ورق القطن

سهير فاروق عبد الرحمن[١] ، محمد سالم محمد سالم [١] ، شنودة سيد يعقوب[١] و نانسى حسن نجيب[٢]

[١] معهد بحوث وقاية النباتات – مركز البحوث الزراعية – دقي – جيزة-ج.م.ع.
[٢]قسم الحشرات الإقتصادية والمبيدات-كلية الزراعة – جامعة القاهرة- الجيزة- ج.م.ع

تأثرت القياسات الحيوية وجداول الحياة للآفة الحشرية لدودة ورق القطن بنوع التغذية على العوائل النباتية للبرسيم والكرنب مقارنة بالتغذية على أوراق الخروع. كما تم تقدير التغيرات فى نشاط الانزيمات المسئولة عن نزع السمية لدودة ورق القطن نتيجة التغذية على العوائل النباتية. بالإضافة إلى حساسية يرقات دودة ورق القطن لثلاثة مركبات (اندوكساكارب- لوفينيرون- أبهولد "سبينوتورم+ ميثوكسى فينوزيد") متأثرة بالتغذية على العوائل السابقة تحت الظروف المعملية. وقد أشارت النتائج المتحصل عليها ما يلي:

تغذية يرقات دودة ورق القطن على أوراق الخروع سبب نقصا فى فترات الأطوار اليرقية والعذرية والبالغة. بينما زادت أوزان اليرقات والعذارى وذلك مقارنة باليرقات المغذاة على البرسيم والكرنب.

أظهرت قياسات جداول الحياة لدودة ورق القطن من عدد الإناث الناتجة/أنثى (Mx) وفترة البقاء (Lx)- معدل التناسل (Ro)- القدرة التناسلية الموروثة (r_m)- معدل الزيادة النهائى (e^{rm})- فترة الجيل (T) وفترة تضاعف الجيل (DT) تأثرا بنوع العائل النباتى المستخدم.

تقدير نشاط إنزيمات نزع السمية أظهر زيادة فى نشاط إنزيمات كلا من ألفا وبيتا استيريز فى يرقات دودة ورق القطن المغذاة على البرسيم يليها فى ذلك الكرنب ثم الخروع. بينما زادت نشاط إنزيمات الأستيل كولين إستيريز والكربوكسى إستيريز فى يرقات دودة ورق القطن المغذاة على الكرنب. كما زاد نشاط إنزيم جلوتاثيون-إس- ترانسفيريز فى اليرقات المغذاة على أوراق الخروع.

اليرقات المغذاة على البرسيم والكرنب مقارنة بالمغذاة على أوراق الخروع أدت إلى تفاوت فى حساسية اليرقات تجاه مركبات الإندوكساكارب- لوفينورون- أبهولد. فقد أظهرت النتائج أن يرقات دودة ورق القطن المغذاة على البرسيم كانت أكثر تحملا لمركب الأندوكساكارب. بينما اليرقات المغذاة على الكرنب أكثر تحملا لفعل مركب اللوفينيرون ومن ناحية أخرى اليرقات المغذاة على الخروع أكثر تحملا لمركب الأبهولد.

لذلك تختلف حساسية يرقات دودة ورق القطن للمركبات المختبرة حسب نوع العائل المتغذية عليه الآفة مما له دور فعال فى حدوث التغيرات فى نشاط إنزيمات نزع السمية والتى بدورها تؤدى إلى زيادة حساسية الآفة ومدى تحملها للمبيد.