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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 6 (19): 1649-1654, 2003
ISSN 1028-8880

Entomocidal effects of *Sorghum* seedlings extract on the cotton leafworm, *Spodoptera littoralis* Boisduval and its parasitoid, *Microplitis rufiventris* Kokujiv

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Abstract: All larval instars of the cotton leafworm, *S. littoralis* were found susceptible to sorghum seedlings extract which markedly affected the viability of eggs, particularly 3-day old eggs and neonate larvae. Latent effects of the extract on subsequent instars of survivors was also obvious as retarding development, shortening of adult longevity and reducing egg production / female moth. Indirect effects of *sorghum* extract on the parasitoid, *M. rufiventris* were studied in relation to egg-larval development, pupal period, percent parasitoid emergence and adult longevity.

Key words: Sorghum extract, *Spodoptera littoralis*, *Microplitis rafiventris*, biological control

INTRODUCTION

Sorghum plant seedlings in the early stages were found free from insect infestations and were reported as non-hosts (Branson *et al*., 1969). This encouraged researches to investigate its entomotoxic property. Branson *et al.* (1969) found also that the aqueous extract of *sorghum* was toxic to the larvae of the western corn rootworm, *Diabrotica virgifera* Leconte. They attributed this toxicity to the action of a beta glucosidase on endogenous cyanogenetic glucosides dhurrin which resulted in liberating free toxic cyanide. Narety (1981) reported that dhurrin is present in high concentrations in the immature plant, but slowly drops as the plant matures. *Sorghum bicolor* seedlings water extract showed also, marked larvicidal effects on some dipterous larvae (Jackson *et al*., 1990 and Nassar *et al*., 1997).

Our objective was studying how far such seedlings extract could be viewed as botanical insecticides against one of the most injurious pests in Egypt, *Spodoptera littoralis* and their safety levels to the very efficient associated parasitoid, *Microplitis rufiventris*.

MATERIALS AND METHODS

Plants: Seedlings of *Sorghum bicolor* (Poaceae) plant aged 4-7 days were collected from the farm of Faculty of Science, Cairo University, washed gently with water, air dried and then squeezed out using handling squeeze gadget. The fresh crude extract was filtered using Whatman filter paper Qualitative 4, grade 113. The extract was dried under vacuum till it became in the form of a crude gum, then weighed and dissolved in the appropriate amount of water to obtain a 10% stock solution (w: v), which was stored under refrigeration until needed. Different concentrations of *Sorghum* extract were prepared as (mg) crude extract per ml water as required for the bioassay tests.

Insects: Standard laboratory strain of *S. littorlis* was reared under controlled conditions (25±1°C, 70±5% RH and 11:13 LD) in a way that all developmental stages were available at a time of needing.

The parasitoid, *M. rufiventris* was obtained as pupae from Dr. M. Edris, Faculty of Agriculture, Alexandria University. After parasitoid emergence, each five females with five males were placed in a plastic cup (12x6 cm), provided with few drops of honey on the inner side of its upper portion. For maintaining a culture of *M. rufiventris*, each adult parasitoid female was left with an adequate number of host larvae (2nd or 3rd instar) for about 2-hours and then transferred to a new cup containing another unparasitized host individuals. This method was repeated daily. All cups were covered with plastic covers and provided with new fresh food daily and kept till adult parasitoid emergence.

Susceptibility of *S. littoralis* larvae to *Sorghum*: Fresh castor oil leaves were immersed for 10 seconds in the desired concentration, then left to dry. The larvae were distributed in suitable vials 10 larvae per vial and 5 vials were used per each concentration level. To assure homogenize larval feeding, the larvae were starved for 4 h and then allowed to feed on the treated leaves for 24 h. Thereafter, they were removed and placed in new cups containing non-treated fresh castor oil leaves.

Percentages of mortality were calculated daily and corrected according to Abbott (1925). The slope, LC_{50}, LC_{90} and 95% confidence limits were calculated according to Finney (1964).

Effect on the developmental stages and adult emergence of *S. littoralis*: Egg masses of *S. littoralis* were treated with a concentration of LC_{50} and LC_{90} of *Sorghum* at different interval days after deposition. For this purpose, leaves of *Nerium oleander* on which eggs have been laid were immersed in the prescribed extract concentration for 15 seconds. The (%) of hatching was determined and also the survival of the hatched larvae was observed. To show the effects of *Sorghum* on the developmental period of the larvae, three-day old larvae (2nd instar) were treated with the LC_{25}, LC_{50} or LC_{90}. Larvae were confined with the treated leaves for 24 hours. Larvae that fed on treated leaves were individually reared and kept, each in a separate cup. The developmental time of survivors were recorded and averaged. One hundred larvae were treated at LC_{25} or LC_{50}-concentration levels while one hundred and fifty larvae were used for LC_{90} to spare reasonable number of survivors after treatment. Thirty larvae reared on untreated leaves were used as control.

Percentage of emergence, in each treatment was estimated. Observations were taken on the longevity and egg production of the emerged moths. Ten pairs of moths were used for each concentration, the produced eggs were weighed and the percent reduction in the mean weight was calculated in each case

$$\% \text{ reduction of oviposition} = \frac{\text{Mean egg wt. (control)–Mean egg wt. (treated)}}{\text{Mean egg wt. (control)}} \times 100$$

Effect of *Sorghum* on the parasitoid, *M. rufiventris*: Groups (10 per each) of 2nd instar larvae parasitized as one egg per larva were left starving for 4 h, then subjected to castor leaves treated with *Sorghum* extract at the LC_{25}, LC_{50} or LC_{90} concentration level for 24 h. Thereafter, the larvae were offered untreated leaves. The treatment day was designated as 0-day. Parasitization took place on days 1, 3, 5 and 7-days or –1, -2, -3, -5 and – 7 days relative to *Sorghum* treatment. Fifty survivor host larvae were used per concentration per time interval, while another fifty parasitized larvae were not subjected to treated diet and used as control group.

The (%) of host larval mortality, the developmental time of the parasitoid and percent parasitoid emergence were calculated in each case. The larvae that failed to be parasitized and complete their development to moth, were not considered and were deleted from the counts. The percent reduction in the number of emerging parasitoids from treated group as compared with those emerged from the corresponding controls was calculated according to the equation of Hendrson and Tilton (1955) modified by Matter (1993). The emerged parasitoids from each treated group at each interval day were used to determine the adult longevity. Records of longevity were taken daily and averaged in each case.

Statistical analysis: All experimental data were statistically analyzed using analysis of variance, regression coefficient and F-test (ANOVA) using computer program, soft ware, copy right © 1989 by H.J. Motulsky, version 1.0, Dr. Leo P. Schouest, UC Riverside, serial # 890168s (sigma service).

RESULTS AND DISCUSSION

Susceptibility of the cotton leafworm to *Sorghum*: Comparing LC_{50} values in different intervals, the fourth larval instar was found to be 2.01, 1.32, 3.62 and 4.0 times more susceptible than 2nd, 3rd, 5th and 6th instars respectively. Statistically, significant differences ($P < 0.05$) between the LC_{50} values of 3rd and 4th instars and those of 5 and 6th instars were obtained as indicated by non-overlapping of the corresponding 95% confidence limits. However, these differences were not significant ($P>0.05$) between the 2nd, or the 3rdinstar and those of 4th instar, since the 95% confidence limits were overlapped. Also no significant difference ($P > 0.05$) was obtained between 5 and 6th instars. On the other hand, susceptibility of the larval instars to *Sorghum* at the LC_{90} level showed no significant difference ($P>0.05$) as indicated by the 95% confidence limits overlapping (Table 1).

Table 1: Susceptibility of *S. littoralis* larvae to *Sorghum*

Instar	Slope±S.E	LC_{50}* (mg/ml)	95% Confidence limits lower–upper	LC_{90}* (mg/ml)	95%Confidence limits lower-upper
2nd	1.12±0.159	0.606a	0.417-0.871	6.25a	3.95-6.38
3rd	1.21±0.145	0.396b	0.285-0.551	4.35a	2.33-8.79
4th	1.09±0.144	0.301ab	0.208-0.434	4.49a	2.13-9.35
5th	1.79±0.195	1.089c	0.778-1.545	5.62a	2.88-10.94
6th	1.88±0.232	1.204c	0.804-1.567	5.76a	2.74-12.16

* Values followed by the same letter in the same column are not significantly different (P>0.05)

Table 2: Effect of *Sorghum* treatments on hatchability and percent survival of *S. littoralis* larvae hatched from treated eggs

Intervals day after treatment	Conc. (mg/ml)	No. of eggs *	% egg hatch (mean±SE.)	% larval survival (mean±SE.)
1-day	LC_{50}	1122	87.3±1.2a	83.8±1.7ac
	LC_{90}	1136	61.3±4b	55.8±3.3b
	Control	1230	91.6±1.6a	96.4±1.1a
2-days	LC_{50}	1140	84.6±1.5a	70±3.3c
	LC_{90}	1205	61.6±3.6b	52±3.3b
	Control	1262	92.3±1.1a	94±1.9a
3-days	LC_{50}	1251	90.5±2.5a	46.8±5.4b
	LC_{90}	996	50±4.1b	28.4±3.6ld
	Control	1170	91.6± 0.9a	93.2±1.2a

- Means followed by the same letter in the same column are not significantly different (P>0.05)

Table 3: Effect of *Sorghum* on the duration of different *S. littoralis* instars exposed to different concentration for 24 h

	Developmental time (mean±SE.) days Larval instar							
Conc.	1st	2nd	3rd	4th	5th	6th	Pupae	Total larval-pupal duration (means±S.E.) days
LC_{25}	2.3±09a	2.8±.1ac	2.4±.09af	2.4±.09a	2.3±.08a	3.6±0.1a	11.8±0.2a	27±0.2a
LC_{50}	2.2±.08a	2.9±.09a	2.5±.09ab	2.5±.09a	2.4±0.1a	3.8±0.2a	11.9±0.1a	28.4±0.3b
LC_{90}	2.4±.09a	4.1±0.1b	3±0.1bc	2.7±0.1ab	2.3±0.1a	3.9±0.1a	12±0.1ab	29.1±0.3b
Cont.	2.3±.08a	2.2±.09c	2.1±.08f	2.1±.07a	2.2±.08a	3.5±0.1a	11.6±0.1a	25.8±0.2f

Table 4:Latent effect of *Sorghum* treatments on *S. littoralis* adults

Conc.	% adult emergence (mean±SE.)	Adult longevity (mean±SE.) days	Egg production wt./female (mean±SE.) mg	%reduction
LC_{25}	70±5a	8.9±0.2a	32.5±3.3ac	16.4
LC_{50}	44±2.8b	9.7±0.3a	25.5±2.3ab	34.4
LC_{90}	6±2c	8.6±0.2a	20.9±1.2b	46.3
Control	98±1d	10.9±1.2b	38.9±2.5c	.....

- Means followed by the same letter in the same column are not significantly different (P>0.05)

Effect of egg treatment on hatchability and neonate larvae: LC_{50} of *Sorghum* had no effect on the percentage of egg hatchability when it was applied directly to the eggs after 1, 2, or 3 days of deposition, while significant difference (P<0.05) was obtained by using *Sorghum*-LC_{90} (Table 2). The highest retardation in egg hatching (50±4.1%) was obtained with treated-3 day old eggs.

The percentage of neonate larvae surviving treatment was inversely correlated with the concentration used and also with the age of the treated eggs. Statistical analysis proved that both tested concentration significantly affected the viability of neonate larvae, particularly those emerged from treated 3-day old eggs.

Effect on the larval-pupal development: Cotton leafworm larvae, exposed as 2nd instar to different concentrations of *Sorghum* for 24 h and then reared on normal castor oil leaves showed various increases in the larval development and pupal duration (Table 3). The duration of the 2nd larval instar lasted 2.4 ± 0.09 days in the control group. 16.7, 20.8 and 70.8% prolongations, as compared with control were evaluated when the larvae fed on leaves treated with the LC_{25}, LC_{50}, or LC_{90} of *Sorghum*, respectively. Statistical analysis, showed significant retardation (P<0.05) in growth of the 2ndlarval instar for those treated with each of the *Sorghum* concentrations as compared with control except those treated with the LC_{25} of *Sorghum* (P>0.05) The same results were obtained in case of the 3rd larval instar. Through the 5th and 6th instars, no significant differences (P>0.05) were obtained between larvae exposed to *Sorghum*-concentrations and those of the corresponding controls. The pupal duration was not significantly affected (P<0.05) when the 2nd instar larvae were treated with *Sorghum* concentrations. Statistical analysis also showed significant differences (P<0.05) in the total larval-pupal developmental time between those treated with different concentrations of *Sorghum* and those of control.

Similar prolongation in the larval-pupal period of parasitized *Pieris rapae* larvae, due to neem treatment, was recorded by Matter *et al.* (2002).

Effect on adults emergence: Percentage of moth emergence decreased from 98% to 70, 44 and 6% after larval exposure for one day to LC_{25}, LC_{50} and LC_{90} of *Sorghum*, respectively (Table 4).

The longevity of the emerged adults were significantly affected (P<0.05) being shorter in case of adults treated as larvae with *Sorghum* compared with the mean longevity of control (10.95±1.2 days).

Egg production of the females was also significantly affected. Obviously a detectable decrease in the egg production weight per single female was obtained with the increase of *Sorghum* concentration. The high percentage of reduction in the egg production weight per female (46.3%) was obtained with females emerged from those treated with *Sorghum*-LC_{90}. Statistically, significant differences (P<0.05) were also obtained between the eggs weight per female of those emerged from larvae treated with *Sorghum*-LC_{50}, or LC_{90} and those of control.

The present study showed that, eggs, larvae, pupae and adults of the cotton leafworm, *S. littoralis* were affected by *Sorghum*. High concentration of *Sorghum* showed a significant reduction in the percentage of egg hatchability when applied directly to the eggs after 1, 2, or 3 days of deposition. Also retarded effect was observed with the survival of the larvae that hatched from treated eggs. The larval survival was highly reduced when egg masses were treated with high concentration just before hatching. Also, the ovicidal activity of some plant extracts on *Spilosoma obliqua* (Wk.), *S. litura* and *Dysdercus koenigii* was reported by Ghatak and Bhusan (1995) and Suryakala *et al.* (1996). They concluded that, high concentration levels of many plant extracts produced complete inhibition of hatching for the last insect species. From the previous data, it appears that, significant retardation in the larval-pupal duration of those larvae survived *Sorghum* treatment. Also the pupal weight was reduced due to *Sorghum* treatment. The longevity of moths resulting from treated larvae was significantly

Table 5: Effect of 24 h-exposure of *S. littoralis* larvae to *Sorghum*-LC_{25}'s on the parasitoid, *M. rufiventris* [parasitization preceded treatment]

Days before treatment	Treatment	Developmental time of the parasitoid (mean±S.E.) days: Egg-larval period	Developmental time of the parasitoid (mean±S.E.) days: Pupal period	**% host mortality (mean ± SE.)	Parasitoid emergence: Longevity (mean±SE.) day	Parasitoid emergence: % emergence (mean±SE.)	Parasitoid emergence: % parasitoid reduction
-1-day	*Sorghum.*	8.60±0.1a	5.80±0.1a	26.4±4ab	18.1±1.1a	74±3.8abc	18.3
	Control	8.50±0.1a	5.90±0.1a	8±2c	17.9±1.5a	90±3.7f	.....
-3-days	*Sorghum*	8.80±0.1a	5.85±0.1a	28±2ab	19.5±1.6a	65±2c	28.2
	Control	8.60±0.1a	5.95±0.1a	6±2.4c	18.1±1.1a	88±2.4f	.....
-5-days	*Sorghum.*	8.70±0.1a	5.70±0.1a	34±2.4b	18.3±1.4a	64±2.4c	30.5
	Control	8.50±0.1a	5.87±0.1a	4±2.4c	19.5±1.6a	92±2f	.....
-7-days	*Sorghum*	8.48±0.1a	5.90±0.1a	36±2.4b	19.8±1.5a	57±3.2c	62.3
	Control	8.45±0.1a	5.80±0.1a	4±2.4c	16.6±1.3a	92±2f	.....

Table 6: Effect of 24 h-exposure of *S. littoralis* larvae to *Sorghum*-LC_{50}'s on the parasitoid, *M. rufiventris* [parasitization preceded treatment]

Days before treatment	Treatment	Development: Developmental time of the parasitoid (mean±S.E.) days: Egg-larval period	Development: Developmental time of the parasitoid (mean±S.E.) days: Pupal period	**% host mortality (mean ± SE.)	Parasitoid emergence: Longevity (mean±SE.) day	Parasitoid emergence: % emergence (mean±SE.)	Parasitoid emergence: % parasitoid reduction
-1-day	*Sorghum*	8.70±0.1ab	5.87±0.1a	54±4a	17.6±1.3a	36±2.3ac	60
	Control	8.50±0.1a	5.90±0.1a	8±3.77f	17.9±1.5a	90±3.7f	…
-3-days	*Sorghum*	8.80±0.1ab	5.70±0.1a	56±2.4ab	18.7±1.4a	42±1.9a	52
	Control	8.60±0.1a	5.95±0.1a	6±2.4f	18.1±1.1a	88±2.4f	…
-5-days	*Sorghum*	8.60±0.1a	5.78±0.1a	62±2a	20.1±2.3a	34±2.4ac	64
	Control	8.50±0.1a	5.87±0.1a	4±2.4f	19.5±1.6a	92±2f	…
-7-days	*Sorghum*	8.65±0.1a	5.90±0.1a	66±2.4a	17.2±1.3a	24±9c	74
	Control	8.45±0.1a	5.80±0.1a	8±3.7f	16.6±1.3a	92±2f	…

Table 7: Effect of 24 h-exposure of *S. littoralis* larvae to *Sorghum*,-LC_{90}'s on the parasitoid, *M. rufiventris* [parasitization preceded treatment]

Days before treatment	Treatment	Development: Developmental time of the parasitoid (mean±S.E.) days: Egg-larval period	Development: Developmental time of the parasitoid (mean±S.E.) days: Pupal period	**% host mortality (mean ± SE.)	Parasitoid emergence: Longevity (mean±SE.) day	Parasitoid emergence: % emergence (mean±SE.)	Parasitoid emergence: % parasitoid reduction
-1-day	*Sorghum.*	8.60±0.1a	5.80±0.1a	26.4±4ab	18.1±1.1a	74±3.8abc	18.3
	Control	8.50±0.1a	5.90±0.1a	8±2c	17.9±1.5a	90±3.7f	.....
-3-days	*Sorghum.*	8.80±0.1a	5.85±0.1a	28±2ab	19.5±1.6a	65±2c	28.2
	Control	8.60±0.1a	5.95±0.1a	6±2.4c	18.1±1.1a	88±2.4f	.....
-5-days	*Sorghum*	8.70±0.1a	5.70±0.1a	34±2.4b	18.3±1.4a	64±2.4c	30.5
	Control	8.50±0.1a	5.87±0.1a	4±2.4c	19.5±1.6a	92±2f	.....
-7-days	*Sorghum*	8.48±0.1a	5.90±0.1a	36±2.4b	19.8±1.5a	57±3.2c	62.3
	Control	8.45±0.1a	5.80±0.1a	4±2.4c	16.6±1.3a	92±2f	.....

shorter than that of untreated ones. Also, reduction in the egg production per female was evaluated. This proved that, the botanical extract *Sorghum* has detrimental effects on the eggs, larvae, pupae and adults of *S. littoralis*.

Effect of *Sorghum* on the parasitoid, *M. rufiventris*

Parasitization preceded *Sorghum treatment*: Within the host larvae of the different treated groups, no significant differences were obtained concerning the mean parasitoid egg-larval or pupal period as well as the longevity of the adult emergence. The same results were also obtained when comparing each test group with the corresponding control (Table 5).

Also, larval mortality was positively dependent on the interval time from parasitization till treatment. Statistically, significant differences ($P<0.05$) were obtained between the percentage of host larval mortality after treatment with *Sorghum* at –1, -3, -5 and -7-days and those of corresponding control.

Considering both host mortality and parasitoid emergence, it was found that, premature host death was the probable cause of parasitoid death within the infected host. Consequently, increasing the time intervals caused an increase in the percent reduction of the parasitoid emergence. For example percent reductions of parasitoid emergence were 18.3, 28.2, 30.5 and 62.3% at -1, -3, -5 and -7-days relative to *Sorghum*-LC_{25} treatment, respectively (Table 5).

Considering the egg-larval period of the parasitoid developed in *Sorghum*-treated larvae, it was found that, statistically, significant differences ($P<0.05$) were obtained only between parasitoids developed in host larvae treated with LC_{50} or LC_{90} *Sorghum*-treatments at -5 and -7-days. While no significant differences ($P>0.05$) were obtained in the developmental time of the immature parasitoids developed in *Sorghum*-LC_{25} and those of controls at the different intervals day (Table 6 and 7).

Parasitization followed *Sorghum* treatment: Statistically, no significant differences were obtained in the developmental time and longevity of the parasitoids that

Table 8: Effect of 24 hours-exposure of *Spodoptera littoralis* larvae to *Sorghum* and *B. thuringiensis*-LC_{25}'s on the parasitoid, *Microplitis rufiventris* [parasitization after treatment]

		Development			Parasitoid emergence		
		Developmental time of the parasitoid (mean±S.E.) days					
Days before treatment	Treatment	Egg-larval period	Pupal period	*% host mortality (mean ± SE.)	Longevity (mean±SE.) day	% emergence (mean±SE.)	%parasitoid reduction
1-day	*Sorghum*	8.4±0.09a	5.7±0.1a	10±3.2ab	16±1.2a	84±2.4ac	5
	Control	8.5±0.1a	5.8±0.1a	6±2.4ab	17.9±1.5a	88±2a	
3-days	*Sorghum*	8.5±0.1a	5.9±0.1a	8±3.7ab	16.6±1.3a	90±3.2ac	0
	Control	8.7±0.1a	5.9±0.1a	4±2.4b	20.4±2.4a	90±3.2a	
5-days	*Sorghum*	8.6±0.1a	5.8±0.1a	4±2.4b	17.4±1.3a	90±3.2a	(+ 90)
	Control	.....	.....	38±3.7c	.....	0±0f	
7-days	*Sorghum*	.....	.....	0±0a	.....	0±0f	0
	Control	.....	.....	0±0a	.....	0±0f	

Table 9: Effect of 24 h-exposure of *Spodoptera littoralis* larvae to *Sorghum* and *B. thuringiensis*-LC_{50}'s on the parasitoid, *Microplitis rufiventris* [parasitization after treatment]

		Development			Parasitoid emergence		
		Developmental time of the parasitoid (mean±S.E.) days					
Days before treatment	Treatment	Egg-larval period	Pupal period	*% host mortality (mean ± SE.)	Longevity (mean±SE.) day	% emergence (mean±SE.)	%parasitoid reduction
1-day	*Sorghum*	8.50±0.09a	5.87±0.1a	24±4acd	17.2±1.1a	76±4ac	13.6
	Control	8.50±0.1a	5.79±0.1a	6±2.5cf	17.9±1.5a	88±2a	
3-days	*Sorghum*	8.50±0.1a	5.80±0.1a	12±2dc	18.4±1.3a	82±3.7a	8.9
	Control	8.85±0.1a	5.80±0.1a	4±3.7cf	20.4±2.4a	90±3.2a	
5-days	*Sorghum*	8.76±0.1a	5.90±0.1a	8±3.7c	19.5±1.7a	88±3.2a	(+ 88)
	Control	.....	.....	38±3.7ab	.....	0±0f	
7-days	*Sorghum*	8.90±0.15a	5.80±0.1a	28±3.7abd	16.6±12.a	44±4b	(+ 44)
	Control	.....	.....	0±0f	.....	0±0f	

Table 10: Effect of 24 h-exposure of *Spodoptera littoralis* larvae to *Sorghum* and *B. thuringiensis*-LC_{90}'s on the parasitoid, *Microplitis rufiventris* [parasitization after treatment]

		Development			Parasitoid emergence		
		Developmental time of the parasitoid (mean±S.E.) days					
Days before treatment	Treatment	Egg-larval period	Pupal period	*% host mortality (mean ± SE.)	Longevity (mean±SE.) day	% emergence (mean±SE.)	% parasitoid reduction
1-day	*Sorghum*	8.5±0.09a	5.87±0.1a	40±3.2a	18.9±1.4a	50±3.2a	43.2
	Control	8.5±0.1a	5.8±0.1a	6±2.4c	17.9±1.5a	88±2c	……..
3-days	*Sorghum*	8.5±0.1a	5.82±0.1a	8±3.7c	17.4±1.3a	84±5.1c	7
	Control	8.7±0.1a	5.9±0.1a	4±2.4c	20.4±2.4a	90±3.2c	……..
5-days	*Sorghum*	8.7±0.1a	5.9±0.1a	6±5.5c	16.6±1.3a	84±2.4c	(+ 84)
	Control	.....	.....	……	.....	0±0b	…….
7-days	*Sorghum*	8.75±0.1a	5.9±0.1a	32±3.7a	17.9±1.5a	60±0a	(+ 60)
	Control	.....	.....	……	.....	0±0b	……

- Means followed by the same letter in the same column, are not significantly differ (P > 0.05)
* Parasitizied host larvae could not complete their development to moth, or parasitoid

emerged from treated or untreated hosts at different interval days.

Percentage of host larval mortality decreased by increasing the interval days of parasitization after *Sorghum*-treatment. A remarkable decrease in percent host mortality was obtained with *Sorghum*-treatments with the increase of the interval day. As a result of decreasing the host larval mortality, the percent parasitoid emergence increased. Increase in the percent parasitoid emergence with the increase in the interval time from treatment till parasitization was obtained for all tested concentration. Also as a result of decreasing the host larval mortality a decrease in the percent reduction of the parasitoid was obtained. For example, percent reduction of parasitoid emergence was 5 and 0% for *Sorghum*-LC_{25} as a result of decreasing the percent host larval mortality which was 10 and 8% at interval time of 1 and 3-days, respectively (Table 8). A remarkable decrease in percent parasitoid emergence was also obtained when parasitization occurred after 7-days of *Sorghum*-LC_{50}, or LC_{90} (Table 9, 10).

Cotton leafworm larvae exposed to different concentrations of *Sorghum* apparently provided adequate information about development and emergence of its internal parasitoid, *M. rufiventris*. In general, no significant differences in the parasitoid egg-larval period were obtained by treatment of the host larvae with *Sorghum*-treatments after or before parasitization.

Deleterious effects were obtained concerning the percent parasitoid emergence. The percentages of adult parasitoid emergence from hosts exposed to *Sorghum* treatments at different intervals day before parasitization were greater than those emerged from hosts parasitized before treatments. This indicated that, *Sorghum*-treatments scored the highest effects only through the first day of treatment. High increase in percent parasitoid

emergence obtained from hosts parasitized after 5 and 7 days of *Sorghum*-treatments. On the other hand, the lower percent of parasitoid emergence obtained with control (untreated) larvae when parasitization took place at 5 and 7 days of treatments. This result showed that, the control larvae developed normally to 5th larval instar at the time of parasitization and so the immature parasitoids can not complete their development while delay in the development of treated larvae enables parasitoids to complete their development

Many authors assessed effects of some botanical extracts on other parasitoid species. Schauer (1985) found that the braconid parasitoid, *Dieraetiella rapae* (M'Intosh) enclosed from aphid mummies that had been sprayed with neem seed kernel extract. Beckage *et al.* (1988) found that, injection of azadirachtin into *Manduca sexta* (L.) larvae parasitized by *Cotesia congregata* (Say) killed the parasitoid when the compound was administered before the first larval ecdysis. However, when azadirachtin was injected into *M. sexta* after the parasitoids had ecdysed to the second instar, parasitoids developed normally. Bentz and Neal (1995), Reddy and Srikanth (1996), Reitz and Trumble (1997) and Matter *et al.* (2002) assessed the effects of several botanical extracts on the adult emergence of the parasitoids, *Encarsia formosa*, *Cotesia flavipes, Achytas marmoratus* and *Hyposoter ebeninus* respectively from their hosts. They demonstrated that, increase in the concentration of the botanical extract increased mortality of both the host and the parasitoid.

Therefore, it can be concluded that, *Sorghum bicolor* extract was effective in suppressing the population size of *S. littoralis* either directly through their acute toxic effects on the larvae or indirectly through their delayed effects on the pupae and adults. Also, the present study indicates that, *Sorghum* extract appears to be more effective in controlling the cotton leafworm, *S. littoralis* but at the same time it may be incompatible with biological control in the presence of the parasitoid, *M. rufiventris*. This may be resulting from the high mortality of the immature parasitoid specially when *Sorghum*-treatment followed parasitization.

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