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The Ovicidal Effect of Jatropha (*Jatropha curcas*) and Argel (*Solenostemma argel*) On Eggs of the Spiny Bollworm [*Earias insulana* (Lepidoptera: Noctuidae)]

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Abstract:

The aim of this study was to evaluate the effect of aqueous and oil extracts of jatropha, *Jatropha curcas* seeds, and argel, *Solenostemma argel* leaves on egg hatchability of the spiny bollworm (*Erias insulana*). The study was carried out under laboratory conditions at temperature ranged from 25 to 30°C and relative humidity 60-70%. The extracts were tested at concentrations of 5%, 10%, 15% and 20% (w/v). The commercial formulation of emamectin benzoate (as proclaim®) at a rate of 750 mg L^{-1} was used as a standard insecticide. Treated (*n*-hexane) and untreated controls were included. The findings of the study showed that a significantly lowest ($P \leq 0.05$) percentage of egg hatching (1.81%) was detected on eggs sprayed with standard insecticide compared with that of eggs sprayed with all aqueous and oil extracts of both plants. On the other hand, a significantly highest ($P \leq 0.05$) percentage of egg hatchability (90.0%) was recorded on untreated eggs compared to that on eggs sprayed with the aqueous and oil extracts of jatropha and argel. The percentage of hatched eggs (36.4%) on eggs that treated with 20% aqueous extract of jatropha seeds was significantly higher ($P \leq 0.05$) compared to the other aqueous concentrations of the same plant. The percentage of hatched eggs (39.0%) was significantly higher ($P \leq 0.05$) on eggs treated with 5% aqueous extract of argel leaves compared to the other aqueous concentrations of the same plant. No significant differences ($P \geq 0.05$), however, were detected in egg hatchability on eggs sprayed with all concentrations of oil extracts of jatropha and argel. The study recommends the use of aqueous extracts of jatropha seeds at a concentration of 10% and argel leaves at a concentration of 15%. The study also recommends the use of aqueous extracts of jatropha and argel for their ease of preparation. The study suggested other work to validate these results under field conditions.

Keywords **—Emamectin, Jatropha, Argel, Hatchability, Spiny bollworm.**

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I. INTRODUCTION

Okra, *Abelmoschus esculentus* L. (Moench) is an economically important crop grown in tropical and sub-tropical parts of the world. World okra production in 2017 was 6.9 million tons, while in the Sudan okra production was estimated to be 297353 tons with an average cultivated area of 28147 ha [1]. The crop is one of the most popular vegetables in Sudan and is associated with the native food. It is consumed by almost all the Sudanese people either as green immature pods (fried or cooked or in soup or stews) or sun-dried and ground into powder locally known as “waika”

which is used as an ingredient in the preparation of a favourable Sudanese "molah" [2]. Okra pods in the immature edible stage are a rich source of vitamins and minerals. It is an excellent source of iodine so it is useful for the control of goitre [3]. Their seeds have been occasionally used as a source of oil or as a meal [4]. Okra has many problems of diseases and insect pests that caused a drastic reduction in the yield. The spiny bollworm (*Earias insulana* Boisduval, 1833) (Lepidoptera: Noctuidae) is a very serious and polyphagous pest attacking many Malvaceous plants. Cotton and okra are economically the most important crops attacked by this pest. Two species, viz. *Earias insulana* and *Earias vittella* which are widely distributed in North Africa [5] are very important pests of vegetables in Sudan. Chemical control using insecticides is considered effective management for this pest. The misuse of these chemicals created problems for both man and animals [6].

Botanical extracts (oils, aqueous, powder,….etc.), have long been proposed as alternatives to synthetic insecticides for pest management [7-11]. Botanical extracts are eco-friendly, economical, usually target-specific, and biodegradable. Furthermore, they are cheap, readily available, and affordable; these are important qualities of pest control products for smallholder farmers in Africa [12].

The importance of the present study stems from the hazards posed by synthetic insecticides to the environment and human health. The present study was carried out with the objective of demonstrating the biological activity of both aqueous and oil extracts of jatropha seeds and argel leaves against the spiny bollworm and to determine the efficacy and potentials of using any of these materials as choice candidates in the control of this insect pest.

The objectives of the present investigation are to answer the following questions:

- Do the aqueous extracts of jatropha seeds and argel leaves have any harmful effects on egg hatchability of the spiny bollworm?
- Do the oils extracted from jatropha seeds and argel leaves have any harmful effects on egg hatchability of the spiny bollworm?

II. MATERIALS AND METHODS

The experiment was conducted at the Laboratory of Entomology, Department of Crop Protection, Faculty of Agriculture, University of Khartoum. The experimental work was carried out from November 2018 to February 2019 under controlled temperature (25-30°C) and relative humidity (60-70%).

Insect rearing

The rearing of the insect was done following the method described by Eisa *et al.* [11]; the larvae of the spiny bollworm (SBW) were collected from okra fruits, obtained from the Bahri Central Market, Khartoum State. The newly collected larvae were transferred each to a separate rearing plastic bowl and provided with okra fruits as food. The okra fruit in the rearing bowl was renewed daily until pupation of the larvae. The pupae were kept individually in plastic bowls until adult emergence. The newly emerged adults were sexed depending on the posterior end of the pupa according to Abdel Fattah (Personal communication).

Insect eggs collection

Thirty newly emerged adult males and females were kept in four cages (27×19×14.5 cm) covered with muslin cloth. Three small plastic vials, fitted with cotton wick impregnated with a 10% sucrose solution, were fixed in each cage as a food source for the adult moths. Three okra fruits, wrapped with muslin cloth, were introduced into each plastic cage for egg-laying. Pods of okra, wrapped with muslin cloth, were provided inside each cage for the deposition of eggs. These pods were renewed daily, and the deposited eggs were collected daily. The pods wrapped with muslin cloth, containing the eggs were then transferred to plastic bowls (20 cm wide and 8 cm deep). The obtained eggs were divided into two groups, one was used for bioassay and the other was used for raising further generations of the insect.

Plant collection

Fresh jatropha (*Jatropha curcas*) seeds were collected from Zalingei area in Central Darfur State. The seeds were then cleaned, de-shelled and subsequently, the kernels and hulls were separated

manually. The kernels were dried, ground to a fine powder and stored in glass vials at 4°C until used. Leaves of argel (*Solenostemma* argel) were purchased from Omdurman market. The dried leaves were ground, powdered, stored at 4ºC and protected from light for further use.

Preparation of the plant aqueous extract

The aqueous extracts of the powdered of jatropha seeds and argel leaves were prepared following the method of Eisa *et al*. [11] by adding 25g of each powder to 250 ml of distilled water in a 500 ml conical flask. The mixtures were left to stand for 24 hours at room temperature, according to the method described by the Environmental and National Resources and Desertification Research Institute. The mixtures were then thoroughly shaken by hand every 5-8 hours for 5-10 minutes within a period of 24 hours. The mixtures were then filtered using a clean muslin cloth. The filtrates (stock solutions, 25 w/v) were kept in the refrigerator at 4ºC for bioassay. Four concentrations (5%, 10%, 15%, and 20%) from each extract were prepared and used in the bioassay.

Preparation of oil extracts

Jatropha seed oil extract: twenty-five gram of jatropha seeds powder (prepared as above at the Pesticides Centre in U of K) defatted in a soxhlet apparatus using 250 ml of *n*-hexane (95% pure). The *n*-hexane was removed using a rotary evaporator apparatus at 40ºC. The extracted seed oil was kept in amber glass bottle and stored in the refrigerator for subsequent application.

Argel leaves oil extract: twenty-five grams of argel leaves powder were used for oil extraction with 250 ml *n*-hexane (95% pure) using the soxhlet apparatus. The *n*-hexane was removed using a rotary evaporator apparatus at 40ºC. Extracted leaves oil was kept in amber glass bottle and stored in the refrigerator for subsequent application. Four concentrations (5%, 10%, 15% and 20%) from each extract were prepared and used in the bioassay.

Treatments and experimental layout

Four concentrations (5%, 10%, 15%, and 20%) of both aqueous and oil extracts of each of jatropha seeds and argel leaves were compared with emamectin benzoate (proclaim®) at a rate of 75 g/100L. The treatments were applied by spraying method. The treatments were arranged in a Completely Randomized Design with three replicates and the collected data were subjected to ANOVA using SAS software.

Effect of aqueous extracts of jatropha seeds (AEJS) and argel leaves (AEAL) on egg hatchability of the spiny bollworm (SBW)

Effect of AEJS on egg hatchability of the SBW

Seven egg groups, each consisting of 30 eggs which were laid on a muslin cloth, were kept each in a Petri-dish (9 cm in diameter). Five treatments were tested viz. four concentrations (5%, 10%, 15%, and 20%) of AEJS and emamectin benzoate (proclaim®). The sixth group of eggs was sprayed with water and the seventh was left untreated. These treatments were randomly assigned to the seven egg groups. The plant concentrations and the emamectin benzoate were sprayed on the eggs. The Petri-dishes were arranged in a Completely Randomized Design and the treatments were replicated three times. The Petri-dishes were incubated at 25-30°C for 6 days. The Petri-dishes were inspected 2, 4 and 6 days after treatment application for the presence of unhatched eggs. The percentage of hatched eggs was calculated.

Effect of AEAL on egg hatchability of the SBW

Seven egg groups, each consisting of 30 eggs which were laid on a muslin cloth, were kept each in a Petri-dish (9 cm in diameter). Five treatments were tested viz. four concentrations (5%, 10%, 15%, and 20%) of AEAL and emamectin benzoate (proclaim®). The sixth group of eggs was sprayed with water and the seventh was left untreated. These treatments were randomly assigned to the seven egg groups. The plant concentrations and emamectin benzoate were sprayed on the eggs. The Petri-dishes were arranged in a Completely Randomized Design and the treatments were replicated three times. The Petri-dishes were incubated at 25-30°C for 6 days. The Petri-dishes were inspected 2, 4 and 6 days after treatment application for the presence of unhatched eggs. The percentage of hatched eggs was calculated.

Effect of oil of jatropha seeds and argel leaves on egg hatchability of the spiny bollworm

Effect of jatropha seeds oil on egg hatchability of the SBW

Seven egg groups, each consisted of 30 eggs which were laid on a muslin cloth, were kept each in a Petri-dish (9 cm in diameter). Six treatments were tested, viz. four concentrations (5%, 10%, 15%, and 20%) of jatropha seeds oil, emamectin benzoate (proclaim®) and *n*-hexane. The control was left untreated. These treatments were randomly assigned to the seven egg groups. The oil concentrations, the insecticide, and *n*-hexane were sprayed on the eggs. The Petri-dishes were arranged in a Completely Randomized Design and the treatments were replicated three times. The Petri-dishes were incubated at 25-30°C and 60-70% R.H. for 6 days. The Petri-dishes were inspected 2, 4 and 6 days after treatment application for the presence of unhatched eggs. The percentage of hatched eggs was calculated.

Effect of argel leaves oil on egg hatchability of the SBW

Seven egg groups, each consisting of 30 eggs which were laid on a muslin cloth, were kept each in a Petri-dish (9 cm in diameter). Six treatments were tested, viz. four concentrations (5%, 10%, 15%, and 20%) of argel leaves oil, emamectin benzoate (proclaim®) and *n*-hexane. The control was left untreated. These treatments were randomly assigned to the seven egg groups. The oil concentrations, the insecticide, and *n*-hexane were sprayed on the eggs. The Petri-dishes were arranged in a Completely Randomized Design and the treatments were replicated three times. The Petri-dishes were incubated as previously described for 6 days. The Petri-dishes were inspected 2, 4 and 6 days after treatment application and the percentage of hatched eggs was calculated.

Statistical analysis

The collected data were transformed using Arc Sine transformation. Data were subjected to the Analysis of Variance (ANOVA) at 0.05 level of significance using SAS 2004 and the means were separated using the Least Significant Difference (LSD).

III. RESULTS

Effect of aqueous extracted from jatropha seeds and argel leaves on hatchability of the spiny bollworm

Effect of aqueous extract of jatropha seeds on eggs hatchability of the SBW 2, 4 and 6 days after treatment application

Significantly high percentage ($P \leq 0.05$) of hatched eggs (90%) was obtained when the eggs were left untreated. Eggs sprayed with emamectin benzoate (proclaim®) exhibited significantly ($P \leq 0.05$) the lowest percentage (1.81%) of hatched eggs (Table 1). All the tested concentrations of aqueous extract of jatropha seeds have resulted in a significantly ($P \leq 0.05$) low percentage of hatched eggs compared to the untreated eggs and eggs sprayed with water. Eggs sprayed with a 20% aqueous extract of jatropha seeds exhibited a significantly high percentage (36.4%) of hatched eggs compared to other concentrations. It is observed that the effect of the four concentrations of the aqueous extract of jatropha seeds and the synthetic insecticide appeared in the first counting date after treatment application. The maximum percentage of egg hatching of unsprayed eggs was attained in the first counting date (Figure 1).

TABLE I
EFFECT OF JATROPHA SEEDS AND ARGEL LEAVES EXTRACTS ON HATCHABILITY OF THE SPINY BOLLWORM EGGS AFTER 6 DAYS OF TREATMENT APPLICATION

Treatments	Aqueous extract		Oil extract	
	Jatropha	Argel leaves	Jatropha	Argel Leaves
5%	30.5^{d}	39.0^{c}	26.8^{c}	29.7^{c}
10%	23.5^{d}	29.9^{d}	27.0^{c}	34.0^{c}
15%	28.6^{d}	23.3^{d}	32.9^{c}	30.0^{c}
20%	36.4^{c}	28.7^{d}	28.7^{c}	28.2^{c}
Emamectin benzoate (proclaim®)	1.81^{e}	1.81^{e}	1.81^{d}	1.81^{d}
Control sprayed with water	67.2^{b}	68.1^{b}	ND	ND

Untreated control	90.0[a]	90.0[a]	90.0[a]	90.0[a]
n-hexane (%) control	ND	ND	54.3[b]	54.3[b]
LSD	7.8	7.1	8.2	10

Means followed by the same letter are not significantly different at ($P \leqslant 0.05$) according to LSD. Numbers in parentheses are actual means. ND = Not applicable.

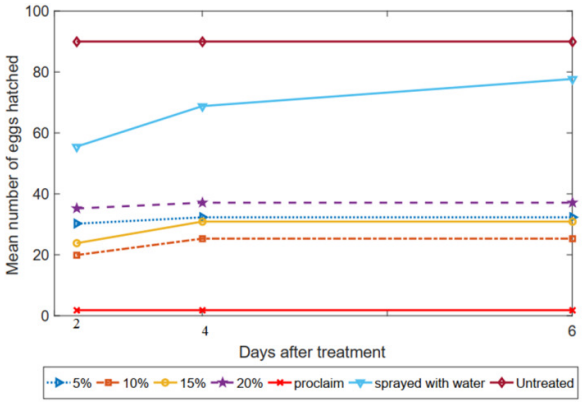

Figure 1: Effect of aqueous extract of jatropha seeds on hatchability of the spiny bollworm eggs 2, 4 and 6 days after treatment application.

Effect of aqueous extract of argel leaves on hatchability of the SBW eggs 2, 4 and 6 days after treatment application

Significantly ($P \leq 0.05$) high percentage of hatched eggs (90%) was obtained when the eggs were left untreated. Eggs sprayed with emamectin benzoate (proclaim®) exhibited significantly ($P \leq 0.05$) the lowest percentage (1.81%) of hatched eggs (Table 1). All the tested concentrations of aqueous extract of argel leaves have resulted in significant ($P \leq 0.05$) reduction in the percentage of hatched eggs compared to the untreated eggs. Eggs sprayed with 5% aqueous extract of argel leaves exhibited a significantly high percentage (39.0%) of hatched eggs compared to the other concentrations. No significant difference ($P \geq 0.05$) in the percentage of hatched eggs was obtained in egg groups treated with 10%, 15% and 20% of the aqueous extract of argel leaves. It is observed that the effect of the four concentrations of the aqueous extract of argel leaves and the synthetic insecticide appeared in the first counting date after treatment application (Figure 2).

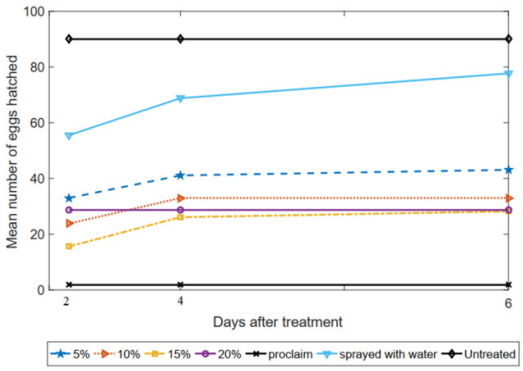

Figure 2: Effect of aqueous extract of argel leaves on hatchability of the spiny bollworm eggs 2, 4 and 6 days after treatment application.

Effect of oil extracted from jatropha seeds and argel leaves on hatchability of the spiny bollworm eggs 2, 4 and 6 days after treatment application

Effect of jatropha seeds oil on hatchability of the SBW eggs 2, 4 and 6 days after treatment application

Significantly ($P \leq 0.05$) high percentage of hatched eggs (90%) was obtained when the eggs were left untreated. Eggs treated with emamectin benzoate (proclaim®) exhibited significantly ($P \leq 0.05$) the lowest percentage (1.81%) of hatched eggs (Table 1). All the tested concentrations of oil extract of jatropha seeds have caused significant ($P \leq 0.05$) reduction in the percentage of hatched eggs compared to the untreated eggs. No significant difference ($P \geq 0.05$) in the percentage of hatched eggs was detected in egg groups treated with 5%, 10%, 15% and 20% of jatropha seed oil. It is observed that the effect of the four concentrations of jatropha seed oil and the synthetic insecticide appeared in the first counting date after treatment application. Hatching of the unsprayed eggs (control) increased through time on one hand. On the other hand, hatching of the eggs sprayed with *n*-hexane decreased through time (Figure 3).

Effect of argel leaves oil on eggs hatchability of the SBW eggs 2, 4 and 6 days after treatment application;

Significantly ($P \leq 0.05$) a high percentage of hatched eggs (90%) was obtained when the eggs were left untreated. Significantly ($P \leq 0.05$) low percentage (1.81%) of hatched eggs was obtained

when the eggs were sprayed with the synthetic insecticide (proclaim®) (Table 1). All the tested concentrations of oil extract of argel leaves have caused significant ($P \leq 0.05$) reduction in the percentage of hatched eggs compared to the untreated eggs. No significant difference ($P \geq 0.05$) in the percentage of hatched eggs was detected in egg groups treated with 5%, 10%, 15% and 20% of argel leaves oil. It is observed that the effect of the four concentrations of argel leaves oil and the synthetic insecticide appeared in the first counting date after treatment application. Hatching of the unsprayed eggs (control) increased through time, while hatching of eggs sprayed with n-hexane decreased through time (Figure 4).

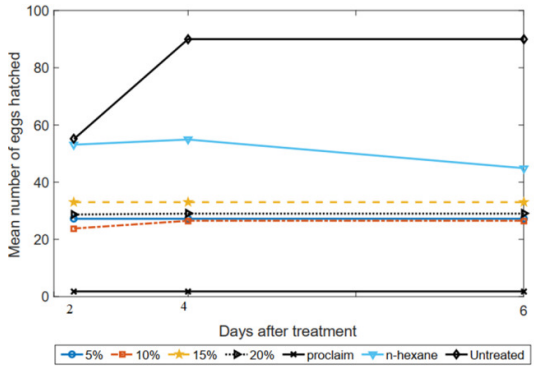

Figure 3: Effect of jatropha seeds oil on hatchability of the spiny bollworm eggs 2, 4 and 6 days after treatment application

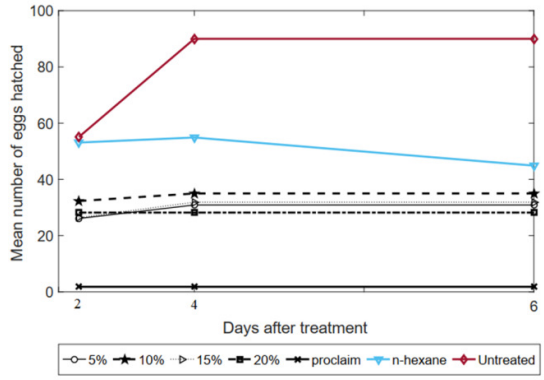

Figure 4: Effect of argel leaves oil on hatchability of the spiny bollworm eggs 2, 4 and 6 days after treatment application

Comparison of the effect of the aqueous and oil extracts of jatropha seeds and argel leaves on the hatchability of the spiny bollworm eggs 2, 4 and 6 days after treatment application

Among the tested plant extracts, the best reductions in the egg hatchability (28.9, 18.9 and 23.3) were obtained with the jatropha seed aqueous extract of 5%, 10%, and 15% concentrations, respectively. On the other hand, the best reductions in the egg hatchability (25.0, 17.8 and 23.3) were obtained with the argel leaves aqueous extract of 10%, 15%, and 20%, respectively (Figure 5).

On the other hand, oil extract of jatropha seeds and argel leaves induce a similar effect on the hatchability of the eggs of tested insects (Figure 5).

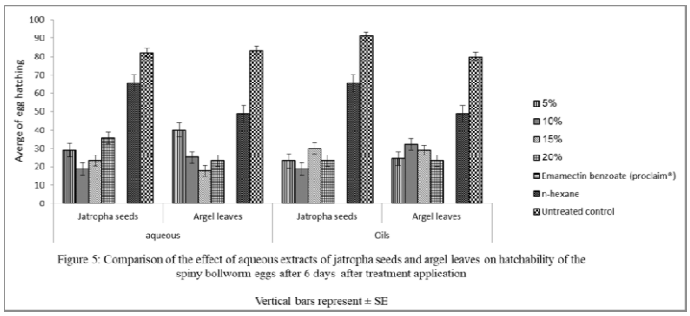

Figure 5: Comparison of the effect of aqueous extracts of jatropha seeds and argel leaves on hatchability of the spiny bollworm eggs after 6 days after treatment application

Vertical bars represent ± SE

IV. DISCUSSION

The increasing problems of pesticides, especially those associated with the large-scale use of broad-spectrum synthetic pesticides, have directed the need for effective, biodegradable pesticides with greater selectivity. They must be pest-specific, non-toxic to mammals, biodegradable, less prone to pest resistance, relatively less expensive and safe to non-target organisms [13].

The effect of the aqueous extracts of jatropha seeds and argel leaves was found comparable to that caused by the conventional insecticide (proclaim®). This result justifies the use of extracts of these plants instead of synthetic insecticides since they are readily available, cheap, environmentally-friendly and easy to use by farmers.

The results in Table 1 showed that the effect of aqueous extract of jatropha seeds on egg hatchability of the SBW at 10% concentration

significantly reduced the number of hatching eggs by 23.5%. A similar result was obtained by Khanam *et al*. [14] who reported that food treated with Jatropha gossypifolia seed extract strongly inhibited the fecundity of *Tribolium castaneum*. They also attributed this action to compounds including piperine, caryophyllene, limonene, oleic acid, linoleic acid, menthone, menthol, α-pinene, and β-pinene.

Generally, oil extracted from jatropha seeds and argel leaves reduced the eggs' hatchability percentage of the SBW. This finding is in line with the results reported by Bashir and EL Shafle [15] who found that extracts of the jatropha seed oil and argel leaves caused a significant reduction in egg hatching of the desert locust (*Schistocerca gregaria*). A similar outcome was also obtained by Boateng and Kusi [16] who stated that petroleum ether extract of jatropha seed oil was highly effective in reducing the hatching percentage of cowpea beetle (*Callosobruchus maculatus*). Similar findings were also reported by Sir El Khatim *et al*. [17] and Sir El Khatim and Abdelbagi [9] and Ahmed *et al*. [18] who studied the ovicidal and oviposition inhibitory effect of some store pests such as *Bruchidius incarnatus* and *C. maculatus*.

Finally, this study investigated the influence of jatropha seeds and argel leaves on the spiny bollworm became they are readily available, cheap and eco-friendly. The results showed that those plants have potential ovicidal and ovipositional effect on SBW eggs. Therefore the jatropha seeds and argel leaves could serve as an alternative to conventional synthetic pesticides, notably in developing countries such as Sudan due to their mentioned merits.

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