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Use of neem-based insecticides against southern armyworm, *Spodoptera eridania* (Stoll) (Lepidoptera: Noctuidae)

Hail K. Shannag[1], John L. Capinera[2] and Nawaf M. Freihat[1]

[1]Jordan University of Science and Technology, Faculty of Agriculture, Department of Plant Production, P. O. Box (3030), Irbid 22110, Jordan. [2]University of Florida, Institute of Food and Agricultural Sciences, Department of Entomology and Nematology, P. O. Box 110620, 1881 Natural Area Drive, Gainesville, Florida 32611, USA

ABSTRACT

Laboratory bioassays were carried out to study the insecticidal, antifeedant, developmental, and reproductive effects of three commercial neem oil-based formulations (Pure Neem Oil, Azatrol, and Triple Action Neem) on *Spodoptera eridania* when used at recommended concentrations. Neem-derived insecticides significantly reduced the food intake of all instars tested, often limiting the feeding activity on neem-treated leaf areas to a fraction of that occurring on controls, in both choice and no-choice bioassay tests. Pure neem oil, followed by Azatrol, demonstrated up to 96% antifeedant activity against larvae; consequently, both biopesticides are effective antifeedants. A two-day feeding period on leaves treated independently with pure neem oil and Azatrol induced the prolongation of the second larval instars by 4.5 and 2.7 days, and by 2.4 and 1.3 days for fourth larval instars, respectively. Mortality and pupal ecdysis of *S. eridania* were also negatively impaired by neem-based biopesticides, with the greatest efficacy attributable for pure neem oil. When administered orally, commercial formulations induced significant reduction in longevity by 0.8-4.1 days, and fecundity of adults was significantly reduced compared to those fed on untreated diet.

KEYWORDS: southern armyworm, *Spodoptera eridania*, biopesticide, neem oil, antifeedant

INTRODUCTION

One of the principal constraints in increasing crop productivity in the world is infestation by pestiferous insects. Southern armyworm, *Spodoptera eridania* (Stoll), is an example of such destructive pests. It attacks a very broad range of hosts, including vegetable, fruit, and ornamental crops.

As a consequence of the lack of knowledge and the absence of alternative plant protection strategies in many countries, the most frequent method used by growers to protect their crops from pest attack is the use of traditional chemical pesticides. In view of the well-known detrimental effects of synthetic insecticides [1], development of sustainable and non-polluting plant protection strategies has become important for the global populations' food supply, and ecosystem conservation. Thus, some producers are progressively adopting more environment friendly integrated pest management and organic farming approaches, which are increasingly considered to be core practices in plant protection [2].

Many pesticides of botanical origin are characterized by their relatively low toxicity, biodegradability and other factors that make them acceptable in the environment, and which would favor their incorporation into integrated pest management programs [3]. With the robust growth of safer insecticides in the global pesticide market, azadirachtin, a steroid-like tetranortriterpenoid derived from the Indian neem tree (*Azadirachta indica*),

is uniquely positioned as a key insecticide in the botanical market segment [4]. Based on its advantages, there is increasing interest in the use of azadirachtin to suppress phytophagous insects, particularly in cropping systems that rely on natural enemies as a major component of integrated pest management. In spite of there being commercial neem-based products labeled for many insect species, their efficacy under field and greenhouse conditions has been proven to be variable [5]. Evaluation of azadirachtin is confounded by the insect growth regulator actions of neem products [6]. Similarly, the impacts of neem-based pesticides on many other aspects of insect biology, including feeding behavior, reproduction, growth, fitness and mobility of the insects seem to vary among insects, as well as challenging to assess. The variable effects of azadirachtin could be attributed to the insect species tested, the application dose, and application [7]. Other components in neem extracts, along with the methods of extraction, storage conditions, origin of neem, or contamination with mycotoxins, can also influence performance [3].

Even with the several advantages of neem-based insecticides, their use may be limited by their susceptibility to environmental variability, particularly by photodegradation. As neem extracts are mainly applied as spray treatments onto the crop canopy, they are subject to environmental influences, sometimes resulting in erratic levels of success on a variety of arthropod pests [8]. Therefore, there are many efforts underway to stabilize such biopesticides by using photostabilizers to achieve persistence as desired for specific control situation. Insecticidal adjuvant formulations such as stilbene-derived optical brighteners, particularly Tinopal LPW, has been used over the past decade in some bio-pesticide formulations, mainly with baculoviruses [9, 10, 11]. Soil treatment making use of the systemic properties of azadirachtin is another option that may lessen instability and prolong persistency of the neem-derived insecticides, although this approach is accompanied by higher costs [12, 13].

Therefore, this study was performed to evaluate the response of the southern armyworm to three commercially formulated biopesticides, namely Azatrol (EC), Triple Action Neem Oil, and Pure Neem Oil, under laboratory conditions. We assessed their potential effects on feeding, development, mortality, fecundity and longevity. Use of such innovative, effective, and practical options could offer the opportunity for further use of sustainable pest management systems for many other crops, particularly where traditional pesticide inputs are undesirable or restricted.

MATERIAL AND METHODS

Plant and southern armyworm rearing

The experiments were carried out at Department of Entomology and Nematology, University of Florida, Gainesville, Florida, USA. A stock culture of *S. eridania* was established from larvae collected from a farm near Gainesville, Florida, immediately before the research, and the progeny used subsequently throughout the studies. They were moved from their natural plant diet to synthetic bean-based diet [14] shortly before studies commenced, and maintained on this diet for the duration of the investigations.

Adults of southern armyworm were kept in screen mating cages (50 cm x 50 cm x 70 cm) and nourished on a 20% honey solution as a source of energy that was offered in a small plastic bottle with screw plastic cap. An absorbing wick (1 cm in diameter x 7.5 cm long) was inserted through a hole punctured in the lid of feeding bottle. The artificial diet used to feed adults was replaced as appropriate. Pieces of folded wax paper were placed in the rearing cage for egg-laying. Oviposition substrates occupied with eggs were removed daily and maintained independently in a plastic container. After hatching, neonate larvae were reared on the artificial bean-based food until they pupated. A thick layer of vermiculite furnished at the bottom of a cylindrical plastic container (25 cm diameter x 10 cm height) was provided for pupation. Insect rearing and all bioassays were conducted in the same experimental conditions, in a controlled room at 25 ± 1 °C and long-day photoperiod of 16:8 h (L:D).

Neem-based insecticides

Commercially formulated Azatrol (1.2% azadirachtin) manufactured by Pbi/Gordon Corporation, Kansas City, Missouri, USA; Triple Action Neem Oil (70% neem oil) from Southern Agricultural Insecticides Inc, Palmetto, Florida, USA; and Pure Neem Oil (100% neem oil) produced by Dyna-Gro,

San Pablo, California, USA, were used in all experiments as water-based solutions at recommended field concentrations: 31.2 ml/l for Azatrol, 7.8 ml/l for Triple Action Neem Oil, and 7.8 ml/l for Pure Neem Oil.

Antifeedant bioassays

Feeding responses of *S. eridania* larvae to either treated or untreated leaf disks were examined by no-choice, choice, and multiple choice methods. Fresh cucumber leaf disks measuring 28.3 cm^2 were punched immediately before application of treatment solutions to minimize changes in leaf quality and then dipped for a minute into the prepared solutions of formulated neem-derived chemicals. Leaf disks immersed only into water were used as a control. All treated leaf disks were left dry at room temperature.

Plastic Petri dishes (9 cm x 1.5 cm) lined at the bottom with wet filter paper were used for no-choice tests, whereas cylindrical plastic containers (25 cm x 10 cm) with moist tissue at the bottom were applied for choice and multiple-choice tests in order to maintain high humidity and to avoid early drying of the leaf disks. In no-choice tests, one leaf disk and a single, second, third, or fourth instar larvae were transferred individually into Petri dish after a 12 h period of starvation and allowed to feed freely for 24 h. Leaf area consumed by each larva in both treated and control leaves was measured using a leaf area meter (LI-3000A, LI-COR, Lincoln, Nebraska, USA).

In choice tests, one treated and one control disk were placed in each container containing either a single, second or fourth instar larva. The distance between the two disks was approximately 10 cm. In order to determine the neem-based product with the most effective antifeedant activity, multiple-choice bioassays that included all the four treatments in the same container were carried out for 24 h for all bioassays. For every chemical substance evaluated and each instar larva, 10 larvae with three replicates were used. The consumed area in all tests was obtained by subtracting the remaining area from the initial area of each leaf disk. The percentage of antifeedant activity was calculated using the formula: antifeedant index = [(leaf area consumed in control - leaf area consumed in treatment)/leaf area consumed in control] x 100.

Larvicidal and pupicidal activity

Water-based solutions of Triple Action Neem Oil, Azatrol, and Pure Neem Oil were applied at recommended concentrations using a leaf dip method. Treated cucumber leaves were presented to 25 insects in the second or fourth instar after a 12 h period of starvation. A feeding period of two days was chosen to ensure that all larvae were fed. Afterwards, the larvae were transferred into new plastic containers and provided continuously with plain artificial diet until they fully developed. Once larvae molted to the pupal stage, pupae were kept in new containers with a layer of vermiculite as a pupation substrate until they reach the adulthood. Six replicates were used for each treatment with 25 larvae per replicate (150 larvae/ treatment). Larval mortality, length of larval development, and proportion of pupae developing into adults were recorded. Percent mortality was calculated according to Abbott's formula (Abbott, 1925): corrected mortality = [(% mortality in treatment - % mortality in control)/(100 - % mortality in control)] x 100. Pupicidal activity was computed by subtracting the number of emerging adults from the total number of pupae.

Fecundity and longevity of *S. eridania* adults

Effects of ingestion of commercially formulated neem products on the fecundity and life span were studied by allowing recently emerged adults (24 h old) to feed on 20% honey solution containing either Triple Action Neem Oil, Azatrol, or Pure Neem Oil at concentrations of 7.8 ml, 31.2 ml, and 7.8 ml per liter, respectively. Control insects were offered plain 20% honey solution. Groups of five pairs of adults (5 females and 5 males) were confined in an aluminum screen cage (20 cm x 20 cm x 20 cm) containing folded wax paper as oviposition substrate. Insecticide solutions were offered continuously to adults in a small plastic bottle with screw cap (5 cm diameter x 5 height) provided with a piece of absorbant wick through the lid. Diet solutions were replaced every two days to prevent fungal growth. Three replicates, each replicate consisting of one screen cage with five pairs of adults, were used per neem product, plus a control. Longevity was determined by checking adult moths daily until death occurred, and the number of eggs they produced was recorded daily until the death of all adults.

Data were subjected to analysis of variance by means of SAS software version 9.2 [15] and means were compared using the Least Significance Differences (LSD) test at $P \leq 0.05$. Mortality counts of *S. eradania* were evaluated by using Abbot's formula [16]. Values of antifeedant activity were transformed to $\log_{10}(X - 100)$.

RESULTS

Feeding activity in no-choice test

There is strong evidence that neem-based products inhibited food intake in the different instars evaluated using no-choice tests (Table 1). On an average, 8.3% of untreated leaf disks of cucumber plants were consumed by the second instars, whereas the larvae consumed only 0.3-6.5% of treated leaf disks, depending on the chemical tested. The antifeedant index was 16.6% for Triple Action Neem Oil, 96.3% for Pure Neem Oil and 89% for Azatrol (Table 2).

Neem-based products also significantly reduced feeding by third instars. Triple Action Neem Oil showed the least inhibition of food intake (19.8%) with the antifeedant index estimated as 14.8%. Pure Neem Oil and Azatrol were much more effective antifeedants, displaying antifeedant activity of 94.8% and 80.9% (Table 2), with larvae consuming only 0.5% and 3.2% of leaf area, respectively (Table 1).

The same trends, but at a lower magnitude, were observed by the fourth instars, which were less sensitive to Triple Action Neem Oil behaviorally, displaying a slight inhibition of leaf consumption (3.8% antifeedancy), whereas Pure Neem Oil and Azatrol markedly reduced food consumption by *S. eradania* larvae by 78.4 and 65.6%, respectively.

Feeding activity in choice tests

On average, the second and fourth instars of *S. eridania* preferred significantly more untreated leaf disk material when presented simultaneously with treated, but at the same time they did not reject the neem-treated food completely (Table 3).

Table 1. Average leaf area (cm^2) and proportion of cucumber disks consumed by *S. eridania* larvae in no-choice bioassays.

Treatments	2nd instar	3rd instar	4th instar
Control	2.34 a (8.3%)	6.67 a (23.6%)	20.13 a (71.1%)
Triple Action Oil	1.84 b (6.5%)	5.60 b (19.8%)	19.36 a (68.4%)
Azatrol	0.26 c (0.9%)	0.91 c (3.2%)	7.67 b (27.1%)
Pure Neem Oil	0.08 c (0.3%)	0.14 d (0.5%)	4.18 c (14.8%)
	LSD 0.24	LSD 0.05	LSD 1.53
	DF 3, F 178.33	DF 3, F 336.1	DF 3, F 221.7

Mean values of leaf consumption within column for each instar followed by the same letter are not significantly different at $P \leq 0.05$.

Table 2. Antifeedant indexes and their proportional feeding reduction for the three neem-based pesticides when evaluated on different instars of *S. eridania*.

Treatments	2nd instar	3rd instar	4th instar
Triple Action Oil	4.67 a (17.4%)	4.72 a (14.4%)	4.62 a (2.4%)
Azatrol	5.23 a (89.0%)	5.22 b (84.6%)	5.10 b (64.0%)
Pure Neem Oil	5.28 b (96.3%)	5.29 c (98.2%)	5.18 c (78.3%)
	LSD 0.174	LSD 0.056	LSD 0.049
	DF 2, F 30.18	DF 2, F 236.2	DF 2, F 297.5

Mean antifeedant indexes within column for each instar followed by the same letter are not significantly different at $P \leq 0.05$. Data are transformed to $\log_{10}(X - 100)$.

However, the amount of leaf material consumed by larvae exposed to leaves treated with Triple Action Neem Oil did not differ significantly from those of untreated leaves. In contrast, Pure Neem Oil and Azatrol induced significant inhibition of food intake, with about 20 times as much leaf area consumed in untreated foliage as compared to neem-treated.

Feeding activity in multiple-choice test

The multiple-choice bioassays demonstrated that Pure Neem Oil and Azatrol were the most effective feeding deterrents for the second and fourth instars of southern armyworm (Table 4). Both insecticides exerted a deleterious effect on feeding behavior that was statistically superior to that of the Triple Action Neem Oil and control treatments. In comparison to the control, the average leaf consumption of treated leaf disks by second instars was reduced by 85.2% for Triple Action Neem Oil, 95.6% for Pure Neem Oil, and 94.8% for Azatrol. The second and fourth instar larvae behaved similarly with respect to the treatments. For trials with fourth instars, leaf consumption of treated disks was reduced by 72.9% for Triple Action Neem Oil, 97.5% for Pure Neem Oil, and 96.2% for Azatrol in comparison with the control.

Table 3. Total area of consumed cucumber leaf (cm^2) and proportion consumed by *S. eridania* in choice bioassays.

Treatment	2nd instar	4th instar
Control	0.86 a (3.0%)	12.63 a (44.6%)
Triple Action Oil	1.01 a (3.5%)	9.69 a (34.2%)
	LSD 0.49	LSD 5.27
	DF 1, F 1.01	DF 1, F 1.24
Control	2.16 a (7.6%)	21.95 a (77.6%)
Azatrol	0.10 b (0.3%)	1.25 b (4.4%)
	LSD 0.29	LSD 2.68
	DF 1, F 203.10	DF 1, F 236.7
Control	1.62 a (5.7%)	17.51 a (61.9%)
Pure Neem Oil	0.06 b (0.7%)	0.72 b (2.5%)
	LSD 0.20	LSD 1.74
	DF 1, F 245.0	DF 1, F 372.2

Means within column for each paired control and treatment values for each instar followed by the same letter are not significantly different at $P \leq 0.05$.

Table 4. Total leaf area (cm^2) consumed by *S. eridania* larvae in multiple-choice bioassays.

Treatment	2nd instar	4th instar
Control	2.32 a	15.53 a
Triple Neem oil	0.34 b	4.63 b
Azatrol	0.12 b	0.65 c
Pure Neem oil	0.11 b	0.43 c
	LSD 0.28	LSD 2.56
	DF 3, F 114.2	DF 3, F 60.2

Means within column followed by the same letter are not significantly different at $P \leq 0.05$.

Mortality, development and pupal ecdysis

When larvae were fed cucumber leaves dipped in commercial neem-based products at recommended concentrations, some treatments induced mortality (Table 5). Mean mortality of second instar *S. eridania* was 12.2% for Azatrol and 35.5% for Pure Neem Oil, whereas larval mortality was negligible for both Triple Action Neem Oil and control treatments. The same trend, but at higher levels, was observed for both neem products fed to fourth instars, with mean mortality of 26.8% for Azatrol and 45.2% for Pure Neem Oil.

Pupal ecdysis was affected in second instars fed with neem-treated diet for 24 h and reared to the pupal stage. However, the effect varied among products. The greatest reduction in the number of pupae reaching adulthood was observed for *S. eridania* fed on foliage treated with Pure Neem Oil. The other neem-based products induced similar but lesser effects, also leading to significant decreases in the number of adults emerging from the pupal stage.

The effects of neem-derived insecticides on the development time of *S. eridiana* are presented in Table 6. Increased larval development periods were observed among second instars fed with neem-treated food for 48 h when compared to those kept on untreated food, although the degree of delayed development varied among treatments. The Pure Neem Oil and Azatrol treatments induced significant prolongation of larval development time relative to the control, extending mean development time by 4.74 and 2.69 days, respectively. On an average, Triple Action Neem Oil delayed mean larval development for less than a day, which did not significantly differ from control treatment.

In contrast, the development time of the fourth instars did not differ significantly between the control, Triple Action Neem Oil, and Azatrol. However, Pure

Table 5. Mean *S. eridania* mortality (%) and successful adult emergence (%) caused by feeding of second or fourth instars for 24 hours on cucumber leaves treated with different neem-based pesticides.

Treatment	2nd instar	4th instar	Adult emergence
Control	2.67 a	2.67 a	82.88 a
Triple Action Oil	1.94 a	2.67 a	74.78 b
Azatrol	14.67 b	28.77 b	74.82 b
Pure Neem Oil	37.33 c	46.67 c	63.13 c
	LSD 6.11	LSD 8.12	LSD 5.52
	DF 3, F 57.1	DF 3, F 61.0	DF 3, F 18.84

Means within each column followed by the same letter are not significantly different at $P \leq 0.05$.

Table 6. Mean development times (days ± SE) for second and fourth instars of *S. eridania* to complete larval development when fed for 48 hours on diet treated with different neem-based pesticides.

Treatment	2nd instar (days)	4th instar (days)
Control	14.54 ± 0.14 a	8.66 ± 0.08 a
Triple Action Oil	15.01 ± 0.12 b	9.24 ± 0.08 b
Azatrol	17.07 ± 0.13 c	9.94 ± 0.10 c
Pure Neem Oil	19.20 ± 0.14 d	11.10 ± 0.11 d
	Critical T value 1.96	Critical T value 1.96
	F 264.6	F 111.3

Means ± SE within column followed by the same letter are not significantly different at $P \leq 0.05$.

Table 7. Effects of neem-derived insecticides on fecundity and mean longevity of *S. eridania* adults continuously provided with 20% honey solution mixed with neem-based products at recommended concentrations.

Treatment	Fecundity (5 pairs)	Longevity (d)
Control	6621.66 a	9.73 a
Triple Action Oil	2311.67 b	8.93 a
Azatrol	810.33 b	6.07 b
Pure Neem oil	646.33 b	5.63 b
	LSD 1731.60	LSD 1.40
	DF 3, F 27.5	DF 3, F 16.7

Means within each column followed by the same letter are not significantly different at $P \leq 0.05$.

Neem Oil significantly prolonged the duration of larval development for 2.44 days relative to those maintained on untreated food.

Fecundity and longevity of adults

Fecundity and longevity of *S. eridania* adults were significantly affected by prolonged ingestion of the neem-based products (Table 7). However, as with other aspects of insect biology, the magnitude of the effect varied among the products. Young adults fed with honey solutions containing neem-derived insecticides at recommended concentrations produced significantly fewer eggs over their life span, with egg production decreased to as little as one-tenth the egg production of insects fed with untreated foliage, though Triple Action Neem Oil was not as effective as Azatrol and Pure Neem Oil. Except in the case of Triple Action Neem Oil, ingestion of the neem products significantly decreased adult longevity. Longevity was reduced by 3.66 d and 4.10 days by Azatrol and Pure Neem Oil, respectively.

DISCUSSION

Commercially available neem seed extracts have shown a wide range of bioactivity against insects, affecting reproductive fitness, hatchability, molting, development rates, and feeding behavior [17, 18]. Our results provide clear evidence that commercially formulated Pure Neem Oil and Azatrol applied to cucumber leaf disks induce potent feeding deterrent activity against *S. eridania,* though not entirely preventing insect feeding even in choice tests where the larvae have an alternative neem-free food source. This is likely because the active ingredients of neem compounds are non-volatile substances and the insect must taste them in order to respond to their presence [19]. Previous studies revealed that the antifeedant effects caused by formulated neem-based products appear to vary with insect species and the formulated neem product tested. However, similar reductions in food uptake has been documented for *S. lituralis* [20], *Salix exigua* [21], *Mamestra brassicae* [22], and *Heliothis viridescens* [23] during one- or two-day feeding periods on leaves treated with different neem products. The feeding inhibition has been credited to a direct action of neem products on the centers of control that regulate feeding and metabolism [24] and/or the inhibition of feeding behavior by stimulation of deterrent chemoreceptors on the mouthparts, or blockage of input receptors for phagostimulants [25]. However, azadirachtin and other neem extracts have been reported not to exhibit antifeedant activity in *Manduca sexta* [26] and *Peridroma saucia* [27].

In addition to having generalized antifeedant properties, neem-based preparations induce a variety of disruptive developmental phenomena in lepidopteran larvae. In the present study, the second and fourth instars of *S. eridania* exposed to Pure Neem Oil and Azatrol took considerably longer time to reach the pupal stage when compared to control insects. Such prolonged time of larval development may be as a result of a reduction of food intake and lack of converting food into biomass, as reported for *S. littoralis* [28]. Prolonged larval periods were associated with increased larval mortality in *S. eridania*, but

death was delayed a week or longer. Similar effects were found in *S. exigua* [23] and *Cnaphalocrocis medinalis* treated with different neem-derived biopesticides [29].

Adults of several important lepidopteran pests have been reported previously to respond in different ways to exposure to neem-based products, either through topical application or by ingestion. As was observed in other studies, our results clearly indicate that neem-based products adversely affected not only the larvae, but the longevity and the reproductive potential of adults treated orally. Similar to these results, other commercially available neem seed extracts adversely affected the fecundity of several insect pests of significant importance such as *S. littoralis* [30], *S. exempta* [31], *Pieris brassicae* [32], and *Plutella xylostella* [33]. These consequences could be induced by interference of neem-based biopesticides with vitellogenin synthesis or uptake in developing oocytes, along with the accumulation of proteins in the eggs that is required for maturation of insect eggs [31, 34]. Moreover, [35] attributed this effect to the incorporation of the neem compound into the eggs during copulation, through sperm transport, transovarial transport, or both together. Although our results provide no insight into the mechanism of disruption, they clearly indicate that neem-containing products have potential for being utilized in food-based traps to disrupt the biology of some insects.

In a recent study, azadirachtin demonstrated a significant effect on the longevity of *S. littoralis* adults only at the higher concentrations [36], whereas in other investigations, longevity of *Phthorimaea operculella* [37], *Trichoplusia ni*, *Peridroma saucia*, and *S. litura* [38] were not influenced by azadirachtin. Such disparate outcomes may be caused by differences in azadirachtin content of the various parts of the neem tree [39], as well as inherent differences in the insect species tested. Adult susceptibility to neem products is not well understood; the biochemical target sites for neem are not yet identified.

Commercial formulations of neem-based insecticides seem to have considerable potential to protect plants from *S. eridania,* though additional studies are needed to evaluate their efficacy under field conditions. Of particular interest would be combinations with stilbene-derived optical brighteners in order to improve persistence of azadirichtin and/or other additives. Also, the differing effectiveness of the various commercial formulations is of considerable importance, as their effects on insect biology and survival can be markedly different.

CONCLUSION

1. Neem-based products evaluated were not able to completely inhibit food intake of *Spodoptera eridania* larvae, but they limited effectively the feeding activity at different magnitudes depending on the product.

2. A short-term exposure of *S. eridanian* larvae to diet treated with neem-based products prolonged significantly the duration of larval development.

3. The magnitude of the negative effect on the larval mortality and pupal ecdysis varied considerably among neem-drived insecticides tested.

4. A reduction in the fecundity and longevity followed by the ingestion of commercial neem oil-based formulations by adult females clearly indicate that neem-containing products may have potential for being utilized in food-based traps to disrupt the biology of some insects.

5. Insecticides based on neem oil seem to have potential to protect plants from *S. eridania*, although additional studies are needed to evaluate their efficacy under field conditions.

6. Caution in making assumptions on neem products is advised, as their effects on insect biology and survival can be markedly different.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest.

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