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Research Article
Solanum pseudocapsicum L. A Potential Pesticide Against *Helicoverpa armigera* (Hub.) and *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae)

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Abstract

Background and Objective: Nowadays, chemical pesticides applied to control the field pests have deleterious effects on the ecosystem. Hence, there is an urgent need to find alternative pesticides to synthetic pesticides towards the control of selected 2 lepidopteran pests. To study the bioefficacy of the novel nonadecanoic acid isolated from the ethyl acetate extract of *S. pseudocapsicum* L. **Materials and Methods:** Using Thin Layer Chromatography (TLC), column chromatography, High Performance Liquid Chromatography (HPLC), Ultraviolet (UV), Fourier Transform-Infrared spectroscopy (FT-IR), Nuclear Magnetic Resonance (NMR) (^{1}H, ^{13}C), Gas Chromatography-Mass Spectrometry (GC-MS) the above said phytocompound was isolated and evaluated for its antifeedant, larvicidal and ovicidal activities against *Helicoverpa armigera* and *Spodoptera litura* at different concentrations of 250, 500, 750 and 1000 ppm. **Results:** The compound showed significant antifeedant, larvicidal and ovicidal activities against *H. armigera* and *S. litura*. Remarkably, the antifeedancy (86.30 and 81.10%), larvicidal (83.20 and 80.20%), ovicidal (81.70 and 80.10%) activities observed in the novel nonadecanoic acid at 1000 ppm concentration. **Conclusion:** The activities were concentration dependent for both the insects. Novel nonadecanoic acid compound well is used as an agent to prepare botanical new pesticidal formulations.

Key words: Nonadecanoic acid, *Helicoverpa armigera*, *Spodoptera litura*, antifeedant, larvicidal, ovicidal activity

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The Insect pests play a significant role in damaging the crops and the crop loss varies between 10-30% for major crops[1]. The insect pests have developed resistance to a variety of insecticides due to the indiscriminate use of chemical pesticides. Insecticides affect the non-target organisms and human body organs. The Plant compounds are effective against agricultural insect pests and also beneficial for both the environment and agriculture product consumers[2]. Azadirachtin, a natural plant compound is considered superior over other compounds since it has a wide range of insecticidal activities. Azadirachtin has been studied at many researchers and used as a positive control[3].

Many more workers have highlighted the importance of developing botanical insecticides from plants. The cotton bollworm *H. armigera* (Hübner) (Lepidoptera: Noctuidae) is a polyphagous pest of extensive crop damage in India to the sum of 1 billion dollars annually[4]. This insect occurs as a major pest in many economically important crops, including cotton, tomato, chickpea, pigeonpea, okra and blackgram. The tobacco armyworm *S. litura* (Fabricius) (Lepidoptera: Noctuidae) once recognized as a significant pest of tobacco alone and now it has become a severe pest also in tomato[5].

Biological activities of many plant extracts and their bioactive compounds against several insect pests have been demonstrated[6,7]. The application of pesticides to limit pest problems is age-old. Day by day, the world population is increasing in an alarming condition. Hence, it is necessary to provide sufficient food for the growing population. In this circumstance, the application of pesticides may be the most important factor in improving food production, particularly in developing countries. However, indiscriminate and heavy use of chemical pesticides results in severe ecological degradations and unadorned health problems among living beings. This situation has triggered considerable anxiety among scientists in the world. The constraints of pesticidal hazards can be solved effectively by formulating and practicing plant-based pesticides. In recent years, considerable interest arose among the scientists and a relatively right amount of data has generated on several plant species having pest control potential. The leaf ethyl acetate extract of *S. Pseudocapsicum* showed some promising biological activities against *H. armigera* and *S. litura*[8]. The present investigation carried out with the objective of ethyl acetate extracts and a compound from *S. pseudocapsicum* for their antifeedant, larvicidal and ovicidal activity against *H. armigera* and *S. litura*.

MATERIALS AND METHODS

Study area: This present investigation was carried out at the laboratory, Department of Zoology, Government Arts College (Autonomous), Coimbatore, Tamil Nadu, India from January-November, 2019.

Processing of plant materials: The leaves of *Solanum pseudocapsicum* were collected during the flowering season (January-April, 2018) from Puliansolai, Namakkal District (11° 13' 46.5312'' N and 78° 10' 16.1688'' E.), Tamil Nadu, India. The voucher specimen of *S. pseudocapsicum* (IPH No. 23) was prepared and deposited in Department of Zoology, Government Arts College, (autonomous) Coimbatore, Tamil nadu, India. The plant materials were washed thoroughly with tap water and shade dried under room temperature (27.0±2°C and 75±5% Relative Humidity (RH)). After complete drying, the plant materials were powdered using an electric blender and sieved through a kitchen strainer. About 2500 g of plant powder was extracted by soxhlet extraction methods with ethyl acetate solvents and filtered through Whatman's No. 1 filter paper. The solvent from the crude extract was evaporated to air-dried at room temperature. The crude extracts were collected in clean borosil vials and stored in the refrigerator at 4°C.

Thin layer chromatography (TLC): Thin layer chromatography was done on pre-coated plates silica gel G (0.2 mm thick, Merck, India) were trimmed with strips and the position of the origin marked by a straight line. Ethyl acetate extracts of *S. pseudocapsicum* and their fractions were dissolved in methanol and were spotted on the plate with fine capillary tube at the height of 0.8-1.0 cm from the base. In the present study, different solvent mixtures viz., hexane and ethyl acetate were used for developing the TLC plates to get better results. After putting the plates in the solvent system, the appropriate distance moved by the solvent was measured to find the retention factor. The plates were air-dried and developed with iodine in the iodine chamber, under UV light 254 and 365 nm and spraying the TLC plates with 10% sulfuric acid. The Retention Factor (Rf) values of all compounds isolated were calculated by the following formula:

$$Rf = \frac{\text{Distance moved by the sample}}{\text{Distance moveg by the solvent front}}$$

Column chromatography (CC): The ethyl acetate extracts of *S. pseudocapsicum* for the isolation of fraction used by column chromatography. Silica gel (100-200 mesh) was

packed in a column (size 60×4 cm) with petroleum ether solvent using the wet slurry method. This involves preparing a solution of silica gel, with hexane in this case, in a beaker and subsequently adding this unto the column till it is about 3-4th filled. The solution was stirred for dispersal and quickly added to the column before the gel settles. This method was used to prevent the trapping of air bubbles. A ball of wool was pushed into the column to settle a top of the packed silica gel.

For the elucidation of components, the polarity of the solvent (mobile phase) was increased using a combinations of hexane, hexane:ethyl acetate (9:1, 8:2, 7:3, 6:4, 5:5, 4:6, 3:7, 2:8 and 1:9) then ethyl acetate and similarly the column was run over ethyl acetate, then ethyl acetate: methanol (9:1, 8:2 and 1:9) and then methanol, respectively. The volume of the collected fractions was 10 mL each test tubes. About 182 fractions of *S. Pseudocapsicum* were collected. TLC plate was run on every column fraction and it was exposed to iodine vapor to investigate the spots to calculate Rf values. Fractions in which similar spots appeared were collected in one pool. The fractions with similar Rf values were pooled and isolates designated as 14 fractions for *S. pseudocapsicum* were obtained. All the isolated fractions were stored in solid form for further experimentation.

High-performance liquid chromatography analysis (HPLC): About 20 µL of 6 and the 9th fractions of *S. pseudocapsicum* were injected into the HPLC. Chromatography was performed using shimadzu HPLC (Model SPD-10A UV-VIS Detector) and Luna C-18 column (25 cm×4.6 mm, 5 m) with a mobile phase consisting of acetonitrile, methanol and mile pore water (35:40:15). The flow rate maintained was 1.0 mL min^{-1} with a back pressure of 250 psi and the compounds were read at 210-364 nm using a UV detector. The total run time was 20 min.

Ultra violet spectrometry analysis (UV): The 6th and the 9th fraction of *S. pseudocapsicum* was diluted to 1:10 with methanol and scanned in the wavelength ranging from 200-800 nm Shimadzu make and IR Prestige 21 model UV spectrophotometer and characteristic peaks were detected.

Fourier transform infrared spectrophotometer (FT-IR) spectral analysis: FT-IR spectra were recorded on a Fourier transform spectrometer shimadzu make and IR Prestige 21 model. All spectra were recorded at room temperature. The molar concentration of 1 varied from 5×10^{-5}-5×10^{-3} M (in saturated solutions) and of models from 5×10^{-4}-5×10^{-1} M. Depending on the concentration of the compound and the IR region studied different cells were applied:quartz cells from 1-50 mm and KBr cells from 0.066-2.66 mm. The ν (C = O) frequency region was decomposed with the help of the PEGRAMS program using the mixture of Gaussian and Lorentzian functions. The second derivative was used to determine the exact position of the partial ν (C = O) bands.

Nuclear magnetic resonance (^{1}H NMR and ^{13}C NMR) spectral analysis: Nuclear magnetic resonance is usually observed when the nuclei of individual atoms are placed in a static magnetic field and exposed to a second oscillating magnetic field. Nuclei of the atoms, which are considered to spin, experience this phenomenon, depending upon whether they possess ½ spin act like tiny bar magnets. One such nucleus is the proton. NMR samples were prepared by dissolving them after purification in a denatured solvent NMR spectroscopy can provide a principal of additional information about peptide in solution. Nuclear magnetic resonance ^{1}H-NMR and ^{13}C-NMR for purified from 6th and the 9th fraction of *S. pseudocapsicum* spectra were recorded using Bruker DRX 300 spectrometers and $CDCl_3$ as the solvent. Chemical shifts reported in δ units (ppm) are related to Tetramethylsilane (TMS) as internal standard (s: singlet, d: doublet, t: triplet and m: multiplet).

Gas chromatography and mass spectrometer (GC-MS) spectral analysis: GC-MS analysis was performed on a 6th and 9th fraction of *S. pseudocapsicum* of using a shimadzu make and IR Prestige 21 with QP2010 plus gas chromatography and column RTX 5 ms with 0.532 dia×30 cm long. The oven temperature was automated to be 290°C at a rate of 10°C/min, helium was used as carrier gas with a flow rate of 1 mL min^{-1}. The sample was injected in the ratio of 1:10 using the split sampling technique. Retention Indices (RI) of the compounds determined by comparing its retention index either with those of authentic compounds or with data in the literature. The total GC running time was 36 min. The components were identified based on a comparison of their relative retention time and mass spectra with those of Wiley 7N library data. The spectrum of the unknown components was compared with the spectrum of known components stored in the Wiley 7N library. The name, molecular formula, molecular weight and chemical structure of the components of the test materials were determined.

Field collections and rearing of *Helicoverpa armigera* and *Spodoptera litura*: Different larval stages of *H. armigera* and egg masses and larvae of *S. litura* were collected from bhendi

and caster fields at Aanaipatty near Arignar Anna, Government Arts College Musiri, Tiruchirappalli District, Tamil Nadu, India. The collected *H. armigera* larva was reared in fresh bhendi vegetables on individually in a plastic container (for avoiding cannibalistic activity) and eggs and larvae of *S. litura* were reared on leaves of castor (*Ricinus communis*) till they attain the pupal stage under laboratory conditions (27±2°C and 75±5% RH). Sterilized soil was provided for pupation. After pupation, the pupae were collected from soil and placed inside the oviposition samplers' (46×40.5×40.5). After adult emergence, cotton soaked with 10% sugar solution with a few drops of multivitamins was kept inside oviposition cage for adult feeding. After hatching newly emerged larvae will be providing bhendi for feeding of *H. armigera* and castor leaf for *S. litura*. Generally, healthy and uniform sized 4th instar larvae, pupae, meat and eggs were used for the experiments and the cultures were maintained throughout the study period.

Antifeedant assays: Antifeedant activity was studied using leaf disc no choice method[9]. The required concentration of nonadecanoic acid was prepared by dissolving in acetone and mixing with dechlorinated water. Polysorbate 20 (Tween 20) at 0.05% was used as an emulsifier[10]. Fresh cotton leaf (for *H. armigera*) and castor leaf (for *S. litura*) discs of 3 cm diameter were punched using a cork borer and dipped in 250, 500, 750 and 1000 ppm for nonadecanoic acid separately and air-dried for 5 min. After air drying, treated leaf discs were kept inside the petri dishes (15×90 mm diameter) separately containing wet filter paper to avoid drying of the leaf disc and single 2 h post-starved 4th instar larva of *H. armigera* and *S. litura* was introduced on each treated leaf disc. Neemazal was considered as constant. Ten replications were maintained for each treatment. A progressive consumption of leaf area by the larva in 24 h period was recorded in control and treatments using a leaf area meter (Systronics 211). Leaf area consumed in nonadecanoic acid treatments was corrected from the control. The percentage of the antifeedant index was calculated using the formula[11]:

$$\text{Antifeedant index}\left(\text{AFI}\right)\left(\%\right)=\frac{C-T}{C+T}\times 100$$

Where:

AFI = Antifeedant index
C = Area protected in control leaf disc
T = Area protected in treated leaf disc

Larvicidal assays: For the evaluation of the larvicidal activity of the nonadecanoic acid against the selected pest, the nonadecanoic acid was tested on a wide range of concentrations, from that a narrow range of concentration was derived. Thus 250, 500, 750 and 1000 ppm concentrations for nonadecanoic acid were tested against the freshly moulted (0-6 h) 4th instar larvae of *H. armigera* and *S. litura*. The branches bearing cotton leaves were tied with wet cotton plug to avoid early drying and placed in a plastic trough (29×8 cm). In each concentration 10 pre-starved (2 h) 4th instar larvae were introduced individually and covered with a muslin cloth. Neemazal was considered as constant. Five replicates were maintained for each concentration, each replicates comprised of 25 numbers of larvae. After 24 h of the exposure period, the number of dead larvae was recorded from each replicates at all the concentrations and the percentage of larval mortality was calculated by using Abbott's formula[12]. The larvae with no symptom of a movement or shake while touching with soft camel brush were considered as dead:

$$\text{Corrected mortality }(\%)=\frac{\text{MT }(\%)-\text{MC }(\%)}{100\ (\%)-\text{MC }(\%)}\times 100$$

Where, MT (%): Larvae mortality in treatment (%) and MC (%): Larvae mortality in control (%). The LC_{50} and LC_{95} values were calculated by probit analysis using Microsoft Excel 2007 software[13].

Ovicidal activity: For ovicidal activity, the freshly laid twenty individual eggs of *H. armigera* and *S. litura* (for removal of scales from egg masses by using camel brush) were separated and dipped in various concentrations (as mentioned in antifeedant activity). Five replicates were maintained (n = 100). Positive and negative control groups were maintained individually. After the exposure periods, the number of eggs hatched in control and treatments was recorded and the percentage of ovicidal activity was calculated by using Abbott's formula[12]. For each experiment, 5 replicates and hatch rate was assessed 48 h post-treatment:

$$\text{OA }(\%)=\frac{\text{EHC }(\%)-\text{EHT }(\%)}{100-\text{LC }(\%)}\times 100$$

Where:

OA (%) = Ovicidal activity (%)
EHC (%) = Eggs hatched in control (%)
EHT (%) = Eggs hatched in treatment (%)

Statistical analysis: Data analysis was carried out using Microsoft Excel 2007. One-Way ANOVA was performed for all the experimental data from that least significant difference was calculated and the significant differences ($p<0.005$) were marked with a different alphabet. LC_{50} and LC_{90} was carried out using SPSS 16.00.

RESULTS

Isolated and purification of ethyl acetate extracts of *S. pseudocapsicum* against 4th instar larvae *S. litura* and *H. armigera*: HPLC analysis of VII fraction of *S. pseudocapsicum* was carried out by using methanol: acetonitrile: water in the ratio 25:35:40 as the mobile phase showed one peak was 100% pure and height of 720 µV at retention time 10.62 min. UV-VIS profile of VII fraction of *S. pseudocapsicum* was studied at a wavelength range of 200-800 nm. Two major bands were noticed at 240 and 280 nm, respectively. UV λ_{max} MeOH (abs): 240 and 280 nm. FT-IR spectrum was performed to identify the functional groups present in fraction VII isolated from *S. pseudocapsicum* based on the peak values in the region of infrared radiation. The major bands were observed at V^{KBr} cm^{-1}: 2950.01, 1219.01, 1020.43, 773.46, 451.34 and 422.41. The peak at 2950.0 cm^{-1} indicates the stretching vibrations that might be the presence of O-H. The peak at 1219.01 cm^{-1} indicates the absorption arising from C = O corresponds to the disubstituted moiety in the aromatic. In addition, some weak absorption bands were also recorded in the spectra (unpublished data).

^{1}H NMR analysis of VII fraction of ethyl acetate crude extract of *S. pseudocapsicum* showed a number of peaks at δ 5.27 (1H,s,OH), 1.53 (2H, d, CH_2), 1.35-1.22 (30H, m, CH_2), 1.18 (2H, m, CH_2) and 1.21 (3H, s, CH_3) protons in the carboxylic acid position. ^{13}C-NMR ($CDCl_3$): 130.24- C = O, 127.89 (2H-CH_2), 72.38 (2H-CH_2), 69.69 (2H-CH_2), 66.80 (2H-CH_2), 62.92 (2H-CH_2), 31.92 (2H-CH_2), 31.51 (2H-CH_2), 29.70 (2H-CH_2), 29.35 (2H-CH_2), 27.19 (2H-CH_2), 29.12 (2H-CH_2), 25.62 (2H-CH_2), 24.88 (2H-CH_2), 22.68 (2H-CH_2), 22.56 (2H-CH_2), 20.62 (2H-CH_2), 17.61 (2H-CH_2), 14.12 (2H-CH_2). GC MS analysis of VII fraction isolated from *S. pseudocapsicum* was recorded compound formula:

$$C_{19}H_{38}O_2, \text{ m/z: } 298.0$$

Compound name: Nonadecanoic acid. Positive ion HR-FAB-MS: m/z 298.0 $[M-H]^+C_{19}H_{38}O_2$ require: 299.0 (Fig. 1a-c).

Biological activities of nonadecanoic *S. pseudocapsicum* isolated from *S. pseudocapsicum*

Antifeedant activity of nonadecanoic acid isolated from *S. pseudocapsicum*: Biological activities of nonadecanoic acid from *S. pseudocapsicum* tested against fourth instar larvae of *H. armigera* and *S. litura*. The feeding deterrent activity was found more at the maximum concentration, i.e., 1000 ppm induced 81.10% antifeedant activity with the AI_{50} value of 486.46 ppm and at the same time the AI_{90} value of 1208.08 ppm. In the same way, the antifeedant activity of 69.20, 51.30 and 33.10% were observed against 750, 500 and 250 ppm concentrations of the isolated compound against the important polyphagous pest, *S. litura*. Whereas, the same phytocompound has also produced significant activity 80.20% antifeedant activity with the AI_{50} value of 574.91 ppm and at the same time the AI_{90} value of 1189.34 ppm. In the same way, the antifeedant activity of 61.20, 49.30 and 30.20% were observed against 750, 500 and 250 ppm concentrations of the isolated compound against the important polyphagous pest, *H. armigera* (Table 1 and 2).

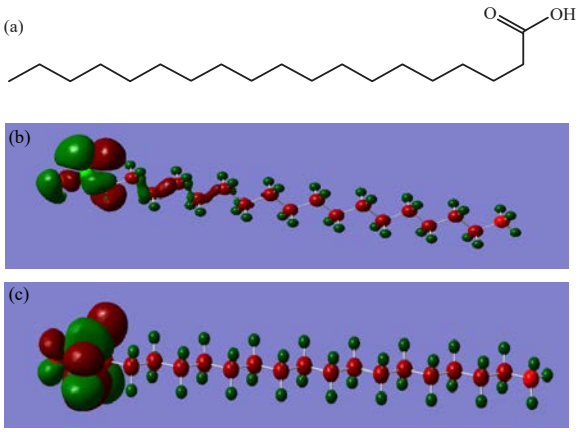

Fig. 1(a-c): Nonadecanoic acid have, (a) Chemical, (b) Homo and (c) LUMo 3D structures isolated from *S. pseudocapsicum* was recorded $C_{19}H_{38}O_2$, m/z: 298.0

Larvicidal activity of nonadecanoic acid isolated from *S. pseudocapsicum*: The larvicidal activity of nonadecanoic acid of *S. pseudocapsicum* was tested against the 4th instar larvae of *S. litura* and *H. armigra* with the same concentrations as stated in the previous experiment and the data of the experiments are shown in Table 3, 4. It was noticed that as the concentration increases the percent mortality of the larvae also increased. The maximum larvicidal activity was recorded in 1000 ppm of nonadecanoic acid with 83.20% larval mortality. Similarly, 70.10, 53.20 and 33.40% mortalities were observed with the 750, 500 and 250 ppm concentration of the compound (Table 3) against the 4th instar larvae of *S. litura*. In the same way the similar trend was

Table 1: Antifeedant activity of nonadecanoic acid of *S. pseudocapsicum* tested against 4th instars larvae of *S. litura*

Compounds name	Concentration (ppm)	Antifeedant activity (%)	AI_{50} (LCL-UCL)	AI_{90} (LCL-UCL)	X^2 (df = 4)
Nonadecanoic acid	250	39.42±1.19[a]	445.80 (382.96-504.97)	1084.05 (974.03-1239.27)	3.395
	500	58.34±0.51[b]			
	750	70.20±1.40[c]			
	1000	86.30±0.73[d]			
Neemazal	250	59.45±0.84[a]	249.51(166.60-367.32)	653.13 (512.77-977.23)	8.397
	500	79.00±1.55[b]			
	750	91.10±0.26[c]			
	1000	99.10±0.49[d]			

Value represents the Mean±SE of 5 replications, AI_{50}: Lethal concentration brings out 50% mortality, AI_{90}: Lethal concentration brings out 90% mortality, LCL: Lower confidence limit, UCL: Upper confidence limit, values in a column with a different superscript alphabet are significantly different at p<0.05 (ANOVA, LSD-Tukey's test)

Table 2: Antifeedant activity of nonadecanoic acid of *S. pseudocapsicum* tested against 4th instars larvae of *H. armigera*

Compounds name	Concentration (ppm)	Antifeedant activity (%)	AI_{50} (LCL-UCL)	AI_{90} (LCL-UCL)	X^2 (df = 4)
Nonadecanoic acid	250	33.10±0.89[a]	486.46 (394.68-560.22)	1208.08 (1063.47-1441.49)	0.132
	500	51.30±1.31[b]			
	750	69.20±1.20[c]			
	1000	81.10±0.23[d]			
Neemazal	250	50.30±0.23[a]	366.21(188.50-504.99)	816.93 (646.35-1228.68)	9.952
	500	69.40±1.45[b]			
	750	80.30±0.56[c]			
	1000	99.20±0.89[d]			

Value represents the Mean±SE of 5 replications, AI_{50}: Lethal concentration brings out 50% mortality, AI_{90}: Lethal concentration brings out 90% mortality, LCL: Lower confidence limit, UCL: Upper confidence limit, values in a column with a different superscript alphabet are significantly different at p<0.05 (ANOVA, LSD-Tukey's test)

Table 3: Larvicidal activity of nonadecanoic acid of *S. pseudocapsicum* tested against 4th instars larvae of *S. litura*

Compounds	Concentration (ppm)	Larval mortality (%)	LC_{50} (LCL-UCL)	LC_{90} (LCL-UCL)	X^2 (df = 4)
Nonadecanoic acid	250	33.40±1.50[a]	318.96 (401.22-532.20))	1165.05 (1038.09-1350.14)	0.096
	500	53.20±1.64[b]			
	750	70.10±1.20[c]			
	1000	83.20±1.33[d]			
Neemazal	250	53.40±0.80[a]	80.08 (229.92-324.47)	694.77 (632.03-777.59))	5.201
	500	73.20±1.50[b]			
	750	89.25±1.33[c]			
	1000	98.20±0.88[d]			

Value represents the Mean±SE of 5 replications, LC_{50}: Lethal concentration brings out 50% mortality, LC_{90}: Lethal concentration brings out 90% mortality, LCL: Lower confidence limit, UCL: Upper confidence limit, values in a column with a different superscript alphabet are significantly different at p<0.05 (ANOVA, LSD-Tukey's test)

Table 4: Larvicidal activity of nonadecanoic acid of *S. pseudocapsicum* tested against 4th instars larvae of *H. armigera*

Compounds	Concentration (ppm)	Larval mortality (%)	LC_{50} (LCL-UCL)	LC_{90} (LCL-UCL)	X^2 (df = 4)
Nonadecanoic acid	250	30.20±0.80[a]	574.91 (437.83-730.60)	1189.34 (963.99-1703.69)	5.963
	500	49.30±1.10[b]			
	750	61.20±1.60[c]			
	1000	80.20±0.43[d]			
Neemazal	250	50.30±0.30[a]	345.53 (127.72-498.56)	819.07 (633.89-1330.17)	1.218
	500	65.30±1.10[b]			
	750	79.20±0.23[c]			
	1000	98.20±0.78[d]			

Value represents Mean±SE of 5 replications, LC_{50}: Lethal concentration brings out 50% mortality, LC_{90}: Lethal concentration brings out 90% mortality, LCL: Lower confidence limit, UCL: Upper confidence limit, values in a column with a different superscript alphabet are significantly different at p<0.05 (ANOVA, LSD-Tukey's test)

also noticed with the larval mortality induced by the nonadecanoic acid against the 4th instar larvae of *H. armigera*.

Antifeedant activity of nonadecanoic acid isolated from *S. pseudocapsicum*: Ovicidal activity of nonadecanoic acid of *S. pseudocapsicum* against *S. litura* and *H. armigra* and the results pertaining to different concentrations (ppm) are shown in the Table 3. It was observed that 1000 ppm concentration of nonadecanoic acid of *S. pseudocapsicum* induced statistically significant activity on the experimental eggs of *S. litura* and *H. armigera,* i.e., 81.70% egg mortality against

Table 5: Ovicidal activity of nonadecanoic acid of *S. pseudocapsicum* tested against *S. litura*

Compounds name	Concentration (ppm)	Ovicidal activity (%)	LC_{50} (LCL-UCL)	LC_{90} (LCL-UCL)	X^2 (df = 4)
Nonadecanoic acid	250	31.00±0.78[a]	463.49 (395.76-527.66)	1164.05 (1036.87-1349.11)	2.302
	500	58.50±1.62[b]			
	750	70.40±1.60[c]			
	1000	81.70±0.23[d]			
Neemazal	250	45.10±1.86[a]	337.11 (171.15-461.80)	808.16 (647.50-1167.07)	7.804
	500	65.30±0.13[b]			
	750	81.00±0.33[c]			
	1000	98.20±1.30[d]			

Value represents Mean±SE of 5 replications, LC_{50}: Lethal concentration brings out 50% mortality, LC_{90}: Lethal concentration brings out 90% mortality, LCL: Lower confidence limit, UCL: Upper confidence limit, values in a column with a different superscript alphabet are significantly different at p<0.05 (ANOVA, LSD-Tukey's test)

Table 6: Ovicidal activity of nonadecanoic acid of *S. pseudocapsicum* tested against of *H. armigera*

Compounds name	Concentration (ppm)	Ovicidal activity (%)	LC_{50} (LCL-UCL)	LC_{90} (LCL-UCL)	X^2 (df = 4)
Nonadecanoic acid	250	30.10±0.28[a]	578.34 (513.83-647.43)	1283.05 (1141.39-1492.02)	1.208
	500	41.20±0.62[b]			
	750	60.20±1.30[c]			
	1000	80.10±0.93[d]			
Neemazal	250	39.40±1.80[a]	394.65 (346.17-440.49)	856.89 (784.59-951.97)	4.585
	500	59.10±1.13[b]			
	750	79.42±0.83[c]			
	1000	98.10±1.80[d]			

Value represents the Mean±SE of 5 replications, LC_{50}: Lethal concentration brings out 50% mortality, LC_{90}: Lethal concentration brings out 90% mortality, LCL: Lower confidence limit, UCL: Upper confidence limit, values in a column with a different superscript alphabet are significantly different at p<0.05 (ANOVA, LSD-Tukey's test)

the eggs of *S. litura* and 80.10% egg mortality against the eggs of *H. armigera* (Table 5, 6).

DISCUSSION

The antifeedant, larvicidal and ovicidal activities of nonadecanoic acid from *S. pseudocapsicum* against *H. armigera* and *S. litura* showed significant results, respectively. The ethyl acetate extract of *Syzygium lineare* against *S. litura* and *Atalantia monophylla* exhibited antifeedant activity against *Earias vittella*[14,15]. The isolation and purification of rhein from *Rheum officinale* and have isolated seven anthraquinone and triterpenoids from *Prismatomeris fragrans* with antifungal activity[16,17]. The evaluated anthraquinone[18] (emodin, citreorosein and emodic acid) from *Cassia nigricans* against *Helicoverpa zea*, *Heliothis virescens, Bemisia tabacci* (white fly) and *Anopheles gambiaea* (mosquito larvae) and 80% mortality was recorded on *A. gambiaea.* Ethyl acetate extract of *C. fistula* and compound rhein did not show significant activity against *S. litura* instead it showed good activity against *H. armigera*.

The results of the present work coincided with the findings of Shu *et al*.[19]. (+)-syringaresinol obtained from *Caesalpinia sappan*. 1α, 7α-diacetoxy-5α,6β-dihydroxyl-cass-14(15)-epoxy-16,12-olide and 12 α -ethoxy-1 α,14β-diacetoxy-2 α,5 α-dihydroxy-cass-13(15)-en-16,12-olide isolated from *Caesalpinia minax.* A novel 6-(4,7-hydroxy-heptyl)[20] quinone compound isolated from *Pergularia daemia* was exhibited more significant antifeedant activity against *H. armigera* and *S. litura*. The isolated (2E)-1- (2-hydroxy phenyl) pent-2-en-1-one (I) compound[21] and 1-[(3-hydroxy-5, 5-dimethyl cyclohex-3-en-1yl)oxy] hexan-3-one (II) isolated from *Hyptis suaveolens* showed significant antifeedant and ovicidal activity against *H. armigera* and *S. litura*. Kaempferol-3-O-α-L-rhamnopyranosyl-(1-2)-β-D-xylopyranoside-$C_{26}H_{28}O_{14}$ isolated from the seeds of *Drabanemorosa*[22]. The 5, 7-dihydroxy-8-methoxy flavone-7-O-β-D-glucopyranoside, 5, 7, 2',5'-tetrahydroxy-6-methoxy-flavanone -O-.β-D-glucopyranoside, oleanolic acid and 4', 5, 7-trihydroxy flavone -7-O-β-D-glucopyranoside-4'-O- methyl ether compounds[23,24] isolated compounds from *Scutellaria scanden* sand, *Hyptis suveolens* showed significant antifeedant and growth inhibition activity against *S. litura*[25]. Antifeedant, larvicidal and pupicidal activities of *Atalantia monophylla* (L) Correa against *H. armigera*[26].

The antifeedant, larvicidal and ovicidal activity of nonadecanoic acid could be attributed to the presence of long-chain aliphatic residue and of primary and secondary alcoholic functional groups. The long aliphatic chain is responsible for a hydrophobic nature, the result that the feeding rate of the larvae was significantly reduced. The isolated compound, nonadecanoic acid also caused malformation and mortality in larval, pupal and adult stages. This is the first report on the bioactivity of the newly isolated compound from *S. pseudocapsicum* and it could possibly be used as a component in biopesticide formulation.

CONCLUSION

Based on the above facts and findings we conclude that the extensive use of synthetic insecticides is ineffective and as a consequence this the soil microbes are eradicated thereby, the soil becomes sterile. Many insecticides do achieve the intended task of controlling pest populations in the fields. However, their detrimental health and environmental effects make them an inadequate long term solution. Also, most synthetic pesticides are ineffectiveness due to resistance buildup in insects causing pest resurgence. Thus the only feasible solution for the future is isolation and formulation of new novel phytopesticides and a part in integrated pest management.

SIGNIFICANCE STATEMENT

This study discovered the novel phytopesticide nonadecanoic acid from *S. pseudocapsicum* for the successful control of 2 significant lepidopteran pests, *S. litura* and *H. armigera*. This study will help the researchers to uncover the critical areas of pest control with phytopesticides and their exact mechanism through which they elicit their biological activities that many researchers were not able to explore. Thus a new phenomenon on biocontrol of pests may be arrived at.

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