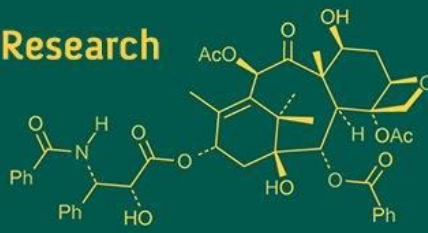


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Bioefficacy of methanol crude plant extracts against the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae)

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Abstract

The methanol extract of certain botanical extracts were evaluated in the laboratory for their insecticidal activity a 0.5,0.75,1.00,1.25 and 1.50% against fall armyworm, *Spodoptera frugiperda* at the Biocontrol Research Laboratory, Department of Agricultural Entomology, Junagadh Agricultural university, Gujarat during 2022-23. Among all the treatments, neem @ 1.5% followed by custard apple @ 1.5% and recorded the highest mortality with the values of 96.67% and 90.00%, respectively. The pongamia @ 1.5% (86.67%), vitex @ 1.5% (83.33%), eucalyptus @ 1.5% (80.0%) and neem @ 1.25% (70.00%) were next in the order of toxic effect on fall armyworm. The methanol extract of neem and custard apple which were used in this study showed highly potent larvicides effect on *S.frugiperda* larvae and can be recommended to be used as components for integrated pest management (IPM) programme and possibly in the management of other crop pests especially lepidopterans.

Keywords: Botanical insecticides, *S. frugiperda*, neem and methanol crude extracts

Introduction

Fall armyworm (FAW) (*Spodoptera frugiperda*), an insect pest native to the tropical and subtropical regions of America. It is a severe polyphagous pest with a wide host range of 186 plant species including many economically important crops such as maize, sorghum, rice, wheat, sugarcane, groundnut, cowpea, soybean, potato and cotton (Casmuz *et al.*, 2010) [2]. The fall armyworm population is growing in India due to their high fecundity, extensive host range and notorious nature. The extensive use of chemical insecticides for controlling insect pests cause many problems such as increased risk to human health, development of insect resistance, harmful effects on non-target organisms and environmental concerns (Yigezu *et al.*, 2020) [13]. These toxic chemicals enter into the food chain and causes pollution to the environment (Pimentel *et al.*, 2009) [8]. To obviate the effects of chemical insecticides, there has been increased demand for the selective and alternative pest control agents particularly biodegradable pesticides especially botanical plants. Botanical pesticides is regarded as more beneficial than pesticide-based control due to their eco-safety, yield and quality improvement, higher acceptability and export value of produce and suitability for rural areas. The previous research studies have demonstrated that in India mostly botanical plants and their commercial products have been studied for controlling different pests in agriculture and horticulture crops. As an alternative to these studies, crude extract isolated from different botanical plants also have insecticidal properties against insect pests (Isman, 2006; Deepthy *et al.*, 2010) [6, 4]. By keeping all these in view, the present experiment was conducted in laboratory conditions to evaluate the insecticidal efficacy of methanol crude extracts of botanicals against fall armyworm.

Materials and Methods

Preparation of Plant Extracts

The treatments used in the experiment were seeds parts of Neem (*Azadirachta indica*), Pongamia (*Pongamia pinnata*), Custard apple (*Annona squamosa*) and leaves parts of Eucalyptus (*Eucalyptus globulus*), Tulsi (*Ocimum sanctum*), Vitex (*Vitex negundo*), Datura (*Datura stramonium*), Jatropa (*Jatropa curcas*), Calotropis (*Calotropis gigantea*), Henna (*Lawsonia inermis*) and Pink oleander (*Nerium oleander*).

During the years 2022-23, leaves and seeds of different botanical plants were collected from location around the Junagadh Agriculture University. The botanical materials were thoroughly wash with tap water and then distilled water, they were let to dry in shade. An electric grinder was used to ground the dried samples into a coarse powder. The powdered samples were stored in plastic polythene (PP) bags apart for further analysis.

The preparation of botanical crude extracts were followed according to the protocol of Deepthy *et al.*, 2010^[4] and Purkait *et al.*, 2019^[9] with some minor modifications. The methanol solvent was used to the extract phyto-constituents from each botanical plant sample by using the soxhlet apparatus. 25 g of dried plant sample and 400 mL of methanol solvent was used to extract the soxhlet apparatus for 3-5 h. A rotary evaporator set at 60 °C was used to remove excess extraction solvent from the sample, and Whatman No. 41 filter paper was used for filtration. Before being used in bioassays, the extracts were kept in 4 °C refrigerator in airtight dark colored glass vials.

Mass rearing of insects

Initial culture of *S. frugiperda* was taken from Biocontrol Research Laboratory, Department of Entomology, JAU, Junagadh as well as the crop grown at Instructional Farm,

COA, JAU, Junagadh. The *S. frugiperda* was reared on maize leaves under laboratory condition until pupation (27 ± 2 °C; $70 \pm 2\%$ RH) (Shareef *et al.*, 2022)^[12]. Larvae obtained from the second generation were used for the study.

Insecticidal bioassay

Fresh castor leaves were washed, sterilized and air dried. The different concentrations of botanical crude extracts were tested against *S. frugiperda* second instar larvae at different concentrations (0.5, 0.75, 1.00, 1.25 and 1.50 % of water). The leaves were then of uniformly sized (approx. 6 cm in size) and dipped in different insecticidal concentrations for 10 minutes. Leaves were again air dried and placed in petri plates having moist cotton swab so as to avoid desiccation of leaves. The sterile distilled water was used for insects in control treatment. Each treatment was replicated three times with 10 larvae/replication. The larvae were transferred to fresh untreated leaves after 24 hrs of treatment. The mortality was recorded after 24, 48 and 72 hours of treatment for each insecticidal treatment at each concentration. The mortality in control was recorded, and the corrected mortality (Abbott, 1925) for each treatment was calculated.

$$\text{Corrected larval mortality (\%)} = \frac{(\% \text{ Mortality in treatment} - \% \text{ Mortality in control})}{(100 - \% \text{ Mortality in control})} \times 100$$

Statistical analysis

All the corrected larval mortality of different treatments were subjected to arcsine transformations. Analysis was done with ANOVA and the means were compared by following Duncan's multiple range test (DMRT) at $p = 0.05$ (Gomez and Gomez, 1984) °.

Results and Discussion

The total eleven botanical crude extracts were evaluated against *S. frugiperda* larvae in their second instar larvae. The results of bioassay revealed that the evaluated methanol extracts of botanicals exhibited varied mortality ranging from 10.00% to 96.67% after 24 to 72 hrs after exposure.

The mortality of third instar larvae of *S. frugiperda* varied from 10 to 60.00% after exposure with 24 hrs of exposure (Table 1). The significantly highest mortality of 60.00% was recorded in the neem 1.50% and custard apple 1.50% treatments. The next best effective treatments were pongamia 1.50% and neem 1.25%, which both had mortality of 50% and 46.67%, respectively. The remaining treatments showed a mortality rate of less than 40.00% on *S. frugiperda*. At 48 hrs after exposure of treatments, corrected mortality ranged from 10.00 to 86.67%. Neem 1.50% had the highest mortality (86.67%) followed by custard apple, pongamia, vitex and eucalyptus 1.50% with 76.67, 70.00, 66.67 and 60.00%, respectively. Whereas, henna, calotropis and tulsi 0.50% recorded the lowest mortality with 10.00% on *S. frugiperda*. The cumulative mortality ranged from 10.00 to 96.67% after 72 hrs of exposure. Neem followed by custard apple 1.50% had greater than 90% mortality which was at par with each other. These two treatments were significantly superior to the rest of the treatments. The next effective treatments were pongamia, vitex and eucalyptus

recorded 80.00% mortality and these stood at par with each other. The least effective treatments were henna 0.5%, tulsi 0.5%, tulsi 0.75%, calotropis 0.5% and datura 0.5% showed larval mortalities of 10.00, 10.00, 16.66, 20.00 and 20.00%, respectively on *S. frugiperda*.

The results indicated that the neem and custard apple are the most harmful to *S. frugiperda*. The mortality of larvae increased progressively with the increases in the crude extract concentrations. These results are in conformity with the earlier ones of the present study corroborated with the findings of Chan *et al.*, 2023 who found that the *A.indica* (Neem) and *Annona squamosa* (Custard apple) 50 mg ML⁻¹ caused 80-100% mortality on second instar larvae of *S. frugiperda*. The levels of mortality of larvae were increases as the extract concentration were increase. Sathyaseelan and Bhaskaran, 2010 also observed that methanol extract of *A.indica* 10% recorded 99% mortality at 48hrs after *M. hirsutus* released into the mulberry crop. The neem seed has several chemicals including azadirachtin compounds and other liminoids group. These compounds causes abnormal moults, deceased growth, and high mortality rates in insects by interfering their growth and moulting processes (Nisbet, 2000)^[7]. The neem causes lethal toxicity during the pupal stage, which then results in morphological deformations such as malformed adults, incomplete ecdysis, and moult blockage that defers and inhibits adult formation according to Chaudhary *et al.*, 2017^[3]. Seffrin *et al.* (2010)^[11], the methanolic extract of *A. squamosa* showed the highest mortality against third instar larvae of *Trichoplusia ni*. The neem and custard apple treatments showed a higher mortality rate of *S. frugiperda* larvae, which could be attributed to the previously mentioned reasons.

Table 1: Mortality of *S. frugiperda* larvae after treatment with methanol crude extracts of botanicals

Treatments	Percent corrected mortality														
	24					48					72				
	0.50	0.75	1.00	1.25	1.50	0.50	0.75	1.00	1.25	1.50	0.50	0.75	1.00	1.25	1.50
T ₁ -Neem	31.00 (30.00)	31.00 (30.00)	35.80 (40.00)	38.62 (46.67)	43.86 (60.00)	40.04 (50.00)	40.04 (50.00)	43.86 (60.00)	43.86 (60.00)	52.72 (86.67)	43.86 (60.00)	43.86 (60.00)	47.39 (70.00)	47.39 (70.00)	55.69 (96.67)
T ₂ -Pongamia	25.31 (20.00)	25.31 (20.00)	29.10 (26.67)	35.80 (40.00)	40.04 (50.00)	35.80 (40.00)	35.80 (40.00)	40.04 (50.00)	41.31 (53.33)	47.39 (70.00)	42.59 (56.67)	43.86 (60.00)	43.86 (60.00)	45.04 (63.33)	52.72 (86.67)
T ₃ -Custard apple	25.31 (20.00)	31.00 (30.00)	34.20 (36.67)	35.80 (40.00)	43.86 (60.00)	37.21 (43.33)	38.62 (46.67)	40.04 (50.00)	43.86 (60.00)	49.57 (76.67)	43.86 (60.00)	43.86 (60.00)	45.04 (63.33)	45.04 (63.33)	53.75 (90.00)
T ₄ -Eucalyptus	25.31 (20.00)	25.31 (20.00)	27.21 (23.33)	31.00 (30.00)	35.80 (40.00)	31.00 (30.00)	31.00 (30.00)	35.80 (40.00)	38.62 (46.67)	43.86 (60.00)	35.80 (40.00)	37.21 (43.33)	40.04 (50.00)	41.31 (53.33)	50.67 (80.00)
T ₅ -Tulsi	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	20.36 (13.33)	17.89 (10.00)	22.84 (16.67)	25.31 (20.00)	29.10 (26.67)	31.00 (30.00)	17.89 (10.00)	22.84 (16.67)	25.31 (20.00)	27.21 (23.33)	32.60 (33.33)
T ₆ -Vitex	25.31 (20.00)	25.31 (20.00)	31.00 (30.00)	32.60 (33.33)	35.80 (40.00)	31.00 (30.00)	35.80 (40.00)	40.04 (50.00)	40.04 (50.00)	46.21 (66.67)	38.62 (46.67)	40.04 (50.00)	40.04 (50.00)	43.86 (60.00)	51.69 (83.33)
T ₇ -Datura	17.89 (10.00)	17.89 (10.00)	25.31 (20.00)	25.31 (20.00)	29.10 (26.67)	25.31 (20.00)	25.31 (20.00)	29.10 (26.67)	32.60 (33.33)	35.80 (40.00)	25.31 (20.00)	29.10 (26.67)	32.60 (33.33)	35.80 (40.00)	40.04 (50.00)
T ₈ -Jatropha	17.89 (10.00)	17.89 (10.00)	25.31 (20.00)	29.10 (26.67)	31.00 (30.00)	29.10 (26.67)	31.00 (30.00)	32.60 (33.33)	37.21 (43.33)	42.59 (56.67)	32.60 (33.33)	35.80 (40.00)	37.21 (43.33)	40.04 (50.00)	46.21 (66.67)
T ₉ -Calotropis	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	25.31 (20.00)	25.31 (20.00)	17.89 (10.00)	25.31 (20.00)	29.10 (26.67)	31.00 (30.00)	32.60 (33.33)	25.31 (20.00)	25.31 (20.00)	31.00 (30.00)	32.60 (33.33)	37.21 (43.33)
T ₁₀ -Henna	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	17.89 (10.00)	20.36 (13.33)	25.31 (20.00)	25.31 (20.00)	29.10 (26.67)	17.89 (10.00)	25.31 (20.00)	27.21 (23.33)	31.00 (30.00)	35.80 (40.00)
T ₁₁ -Nerium	17.89 (10.00)	25.31 (20.00)	25.31 (20.00)	25.31 (20.00)	27.21 (23.33)	25.31 (20.00)	27.21 (23.33)	31.00 (30.00)	32.60 (33.33)	38.62 (46.67)	31.00 (30.00)	31.00 (30.00)	35.80 (40.00)	40.04 (50.00)	43.86 (60.00)
Control	8.95 (0.00)					8.95 (0.00)					8.95 (0.00)				
S.Em. $\pm$: Treatment (T)	0.32					0.45					0.40				
C.D. at 5%	1.27					1.77					1.55				
S.Em. $\pm$: Concentration (C)	0.21					0.29					0.26				
C.D. at 5%	0.82					1.14					1.00				
S.Em. $\pm$: T $\times$ C	0.72					1.01					0.88				
C.D. at 5%	2.83					3.96					3.47				
C.V. %	4.82					5.23					4.13				

* Mean of three repetitions (N=10); values in parenthesis are original values, while those outside are arc sin transformed values.

Conclusion

Methanol extracts of neem and custard apple showed a high insecticidal activity against *S. frugiperda* larvae. It was also discovered that all extracts had a negative impact on the larvae of *S. frugiperda*. Therefore, the methanol extract of neem and custard apple based bio-pesticide as an alternative to the use of synthetic insecticides, this study, contributes to the sustainable management of the fall armyworm.

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