Biological Forum – An International Journal 15(10): 488-492(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Bitter Gourd, *Momordica charantia* (L.) a Potential Botanical Pesticide for the Management of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith)

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(Received: 29 July 2023; Revised: 30 August 2023; Accepted: 24 September 2023; Published: 15 October 2023)
(Published by Research Trend)

ABSTRACT: An experiment was conducted to determine the efficacy of different botanical extracts against fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), under lab conditions at Kanayo F Nawanze Crop Protection Laboratory, ICRISAT, Patancheru. FAW is a transboundary highly destructive pest that continue to spread because it has unique biological characteristics, its high migration and reproductive ability. Its high pestiferous nature poses an immense challenge to Indian agriculture because India is a tropical country that favours high multiplication year-round and reliance on chemicals causes' pesticides resistance, expensive for farmers and cause potential environmental contamination. Hence authors were focused on locally available bitter gourd extracts to evaluate the insecticidal properties and management of *S. frugiperda.* The results were revealed that bitter gourd seed, leaf, and pulp extract caused over 62.0, 54.0, 46.0% larval mortality after 72 hours of application. The experiment with three treatments and three replications in completely randomized design (CRD). The study clearly shows that botanical extracts are very effective in controlling FAW under lab bioassays. Bitter gourd extracts that demonstrated high efficacy against FAW larvae could be used in integrated pest management (IPM) strategies for small and marginal holder farmers in semi-arid tropics regions of Asia and Africa.

Keywords: *Momordica charantia, Spodoptera frugiperda*, Toxicity, and Integrated Pest Management.

INTRODUCTION

Fall army worm, *Spodoptera frugiperda* (J.E. Smith), belongs to the genus *Spodoptera*, known as armyworms, the group of Noctuidae that causes the highest monetary losses to agriculture worldwide (Pogue 2002). FAW a well-known polyphagous insect pest in both developing and developed countries, causing economic losses in a wide range of crops such Maize (*Zea mays*); Sorghum (*Sorghum bicolor*); Rice (*Oryzae sativum*); Cotton (*Gossypium hirsutum*); Beans (*Phaseolus vulgaris*), *Soybean* (*Glycine max*); Oat, (*Avena strigose*); wheat (*Triticum aestivum*) and other grasses (Jaba *et al*., 2020). Because of its wide host range and migratory behaviour of *S. frugiperda* described as harmful and threatening insect pest of annual crops in the tropical regions (Andrews, 1980; Cruz *et al*., 1999) and is known to live on 353 plant species from 76 families (Montezano *et al*., 2018). Fall armyworm consists of two genetically differentiated strains names; Rice stain and Corn strain, however, it prefers mostly on corn host plants and giving faster life cycle than other crops.

This pest is a native pest from the tropical and subtropical regions of America, namely South America and the Caribbean, also found in several southern states of the United States (FAO, 2018). In winter, this pest is usually only found in South Florida and South Texas. In early 2016, this pest was first discovered in Central and West Africa (Benin, Nigeria, Sao Tome and Principe and Tago) (Goergen, 2016). Then, it has spread throughout Southern Africa, threatened the nearby countries in Africa and Europe. Sharanabasappa first reported *S. frugiperda* attacking maize in India in 2018 (Sharanabasappa *et al*., 2018, Deshmukh *et al*., 2021). FAW also known as a transboundary highly destructive pest that will continue to spread because it has unique biological characteristics, its high migration and reproductive ability (Baloch *et al*., 2020). The temperature factor is known to influence the level of development of *S. frugiperda,* the higher temperature tends to increase the reproduction rate (Schlemmer *et al*., 2018). Its high pestiferous nature poses an immense challenge to Indian agriculture because India is a tropical country that favours high multiplication year-round. It causes severe damage to maize, feeding on virtually all parts of the plant, leading to considerable damage and sometimes resulting in total crop failure. Hence, control of this pest is challenging because possible alternate host plants have different phenologies and are grown during different seasons of the year though in proximity to each other, which can facilitate movement of the pest between alternate host crops. And most of the current pest management strategies include using chemical pesticides, which are expensive for farmers and cause potential environmental contamination, and developing resistance (Colborn, 1995; Crowe & Booty 1995). However, none of these techniques has yet produced a practical choice for the efficient control of FAW, which is why researchers are looking for substitute strategies, such as those based on plant extracts and their byproducts. Because they have fewer effects on non-target organisms and may even promote growth, some pesticidal plants and botanical insecticides are efficient, and their use may lessen the need for synthetic pesticides (Rioba & Stevenson 2020). Botanicals are cheap, readily available, and affordable, which are essential qualities of pest control products for smallholder farmers in India. Therefore, this study aims to evaluate selected locally available bitter gourd powder extracts having insecticidal properties and controlling *S. frugiperda* larvae under laboratory conditions.

MATERIALS AND METHODS

Insect. *S. frugiperda,* larvae were reared on standardized an artificial diet (Jaba *et al*., 2020) with using maize leaf powder under gregarious conditions at 26± 2°C, relative humidity 70± 5% and a 12 L and 12 D photoperiod at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, located on the longitude of 78.27° East, the latitude of 17.53° North and at an average elevation of 522 meters (1712 feet) from mean sea level (MSL) in Sanga Reddy district of Telangana.

Plants. Bitter gourd or Karela, *Momordica charantia* (L.) a member of the Cucurbitaceae family. The fresh leaves, dried seeds and mature fruits were collected, washed under tap water and freeze dried in a lyophilizer (Modulyo D, Thermo Savant, Japan) at -45ºC temperature and pressure of 436 mbar for 3 to 4 days to avoid changes in chemical composition of the leaves, seeds and fruit. The plant parts were then milled into powder using an electric blender (Binatone®, Model BLG400) and stored in a refrigerator at 2-5 °C till used.

Preparation of Hexane Extraction. The powders of each 100 grams of leaves, seed and fruits were extracted with 500 mL *n*- Hexane (Analytical grade solvents of 99% purity) was prepared by soaking on mechanical shaker with 120 rpm and the container used for soaking covered with aluminium foil to prevent light exposure. The powdered solutions were filtered with Whatman filter paper No. 1 at around 72 hours after soaking. The filtrates were concentrated in rotary evaporator at 45ºC. After complete evaporation of solvents, the final crude extracts were weighed and a 10 per cent (w/v) extract was prepared after that transferred into dark bottles for stored in refrigerator at -4ºC until used.

Bioassay for toxicity. The culture of *S. frugiperda* was obtained from the Department of Entomology, ICRISAT, Patancheru, India. To study the efficacy of *n*-Hexane plant powder extract against *S. frugiperda* at 10 per cent of each extract of bitter gourd were mixed on freshly prepared artificial diet (Jaba *et al*., 2020) which was poured into each cell well in a 25-cell plate thereafter, the neonates of *S. frugiperda* larva released on the cell wells individually. There were three replications for each treatment and each replication had 25 larvae under laboratory conditions. Data was recorded on larval survival, per cent mortality were calculated through direct contact toxicity test at 12, 24 and 72 hours after treatment and also the following observations were recorded on numbers of egg laying, egg duration, larva days, pupal period, pupal length, weight and width, wing span and life cycle.

RESULTS AND DISCUSSION

Larval survival and mortality: The survival rates varied across the treatments, with the control group (no treatment) having the highest survival rate of 70.17%. The bitter gourd fruit treatment showed the highest survival rate among the bitter gourd treatments, with 53.31%, followed by the bitter gourd leaf treatment with 45.17%. The bitter gourd seed treatment had the lowest survival rate of 38%. These results indicate that the bitter gourd treatments had varying effects on the survival of fall armyworm larvae, with the bitter gourd fruit treatment showing a relatively higher survival rate compared to the bitter gourd seed treatment. The results of bioassay test of bitter gourd extracts against larval mortality exhibited significantly greater in comparison to untreated control. Bitter gourd seed indicated that highest larval mortality (62.00) followed by bitter gourd leaf (54.83) and bitter gourd fruit (46.69). The lowest mortality was recorded from untreated control (29.83). The present findings are more or less similar with Mukanga *et al*. (2022) who reported a no-choice bioassay set up prior to a field trial revealed that extracts of *Azadirachta indica*, *Gliricidia sepium*, *Nicotiana tabacum*, *Ricinus communis*, and *Tephrosiavogelii* exerted more than 40% FAW larvae mortality. According to Sisay *et al*. (2019) among the botanicals tested, *Azadirachta indica*, *Schinnus molle*, and *Phytolaccado decandra* resulted in the highest percentage larval mortality (>95%) 72 h after application. Nada Elsheikh*et al*., (2021) reported that results of bioassay tests of Usher leaves extract indicated that at 10 % concentration caused 100% larval mortality of FAW. Jaba *et al*. (2021) reported that insecticides, including chlorantraniliprole, spinetoram and emamectin benzoate, along with biopesticides such as *Metarhizium rileyi*, *Streptomyces* sp., Ecolaid Freedom, and neem oil were evaluated and found to be effective in reducing the FAW larval population in both sorghum/maize crops under field conditions.

Larval and Pupal Periods: The larval period, which represents the time from hatching to pupation, was shortest in the bitter gourd seed treatment with 13.40 days, followed by the bitter gourd fruit treatment with 14.04 days and the bitter gourd leaf treatment with 14.69 days. The control group had the longest larval period with 16.62 days. Similarly, the pupal period, representing the time from pupation to adult emergence, was shortest in the bitter gourd seed treatment at 4.25 days, followed by the bitter gourd leaf treatment at 5.12 days and the bitter gourd fruit treatment at 6.07 days. The control group had a pupal period of 6.92 days. These results suggest that the bitter gourd seed treatment may have accelerated the development of fall armyworm larvae, resulting in shorter larval and pupal periods compared to the other treatments.

Length, Width and Weight: Regarding the physical characteristics of fall armyworm pupae, the bitter gourd leaf treatment exhibited the longest length (14.08 mm) and widest width (3.88 mm) among the treatments. The bitter gourd fruit treatment had a slightly shorter length (13.72 mm) and narrower width (4.05 mm), while the bitter gourd seed treatment had the shortest length (12.47 mm) and narrowest width (3.47 mm). The control group showed intermediate values. In terms of weight, the bitter gourd fruit treatment had the highest average weight (187.32 mg), followed by the bitter gourd leaf treatment (182.46 mg), the control group (195.10 mg), and the bitter gourd seed treatment (168.41 mg). These results indicate that bitter gourd treatments may have influenced the physical development of fall armyworm larvae, with the bitter gourd leaf treatment promoting longer and wider larvae, while the bitter gourd fruit treatment resulted in higher weight. The present findings are in corroboration with Magrini *et al*. (2015) who reported that the ethyl acetate and ethanol extracts of fruits and seeds of *C. canjerana* and the fractions of the ethyl acetate seed extract influenced significantly the weight and consequently the size of FAW larvae, as demonstrated after measurements for 20 days, during the development.

Adult Parameters: The adult parameters varied across the treatments. The bitter gourd seed treatment had the shortest egg period (4.39 days) among the treatments, followed by the bitter gourd leaf treatment (3.25 days), the bitter gourd fruit treatment (3.04 days), and the control group (2.59 days). The control group had the highest fecundity (645.78 eggs), followed by the bitter gourd leaf treatment (605.24 eggs), the bitter gourd fruit treatment (577.15 eggs), and the bitter gourd seed treatment (485.07 eggs). The wing span, representing the size of the adult fall armyworm, was the largest in the control group (31.24 mm), followed by the bitter gourd fruit treatment (30.65 mm), the bitter gourd leaf treatment (29.17 mm), and the bitter gourd seed treatment (28.61 mm). The control group showed the largest wing span and highest fecundity, which clearly implies there is a significant negative impact of bitter gourd on the development of *S. frugiperda*. Magrin *et al*. (2015) reported that the various types of abnormalities observed in larvae, pupae and adults of the FAW, described in other studies involving representatives of *Meliaceae* and *Spodoptera*, particularly the influence of azadirachtin (Martinez and Van Emden 1999, 2001; Roel *et al*., 2000 a,b; Ma *et al*., 2000; Bogorni and Vendramim 2005; Greenberg *et al*., 2005; Roel and Vendramim 2006) are related to physiological changes resulting from modifications of the endocrine system, which controls growth and ecdysis (Mordue (Luntz) and Blackwell, 1993; Mordue (Luntz) and Nisbet, 2000).

Table 1: Insecticidal properties of *Momordica charantia* (L) on growth and development of *Spodoptera frugiperda* in lab conditions.

Treatment (Conc.)	Larval Survival per cent	Larva l period	Pupal period	Length (mm)	Weight (mg)	Width (mm)	Wing span (mm)	Incubation period	Fecundity	Life cycle
Bitter gourd fruit (10 %)	53.31	14.04	6.07	13.72	187.30	4.05	30.65	3.04	577.20	31.34
Bitter gourd leaf (10 %)	45.17	14.69	5.12	14.08	182.50	3.88	29.17	3.25	605.20	31.00
Bitter gourd seed (10 %)	38.00	13.40	4.25	12.47	168.40	3.47	28.61	4.39	485.10	29.69
Control	70.17	16.62	6.92	14.37	195.10	4.44	31.24	2.59	645.80	33.58
Fp	<0.001	0.282	0.185	<0.001	<0.001	0.014	<0.001	0.002	<0.001	<0.001
Vr	154.51	1.62	2.23	32.76	632.67	8.42	37.89	18.79	50266.65	272.46
Mean	51.66	14.69	5.59	13.66	183.32	3.96	29.92	3.32	578.31	31.40
SE ±	1.11	1.10	0.77	0.15	0.45	0.14	0.20	0.18	0.30	0.10
LSD (P 0.05)	3.85	3.79	2.68	0.50	1.54	0.48	0.69	0.61	1.05	0.34
CV (%)	3.70	12.90	24.00	1.80	0.40	6.10	1.20	9.20	0.10	0.50

CONCLUSIONS

The experiment demonstrated that bitter gourd treatments influenced various parameters of fall armyworm, including survival rates, larval and pupal periods, physical characteristics of larvae, and adult parameters such as egg period, fecundity, and wing span. Due to the promising biological results, *Momordica charantia* extracts can be potentially used for the development of new pesticide formulations for the alternative control of *S. frugiperda* and other pest insects.

FUTURE SCOPE

The *Momordica charantia* extracts, especially those obtained with *n*Haxane, showed potent negative effects on all developmental stages of the FAW. These effects, including high mortality indices, larval survival, pupae morphometrics and fecundity. The plant extract can be used instead of synthetic pesticides or can be supplemented to avoid excessive use of chemicals for the safe and friendly environment. Because of its easily availability, cost effective, and it could be interesting lead compounds for the synthesis of new agents for pest control working as biopesticides contributing with the sustainability of different ecosystems.

Acknowledgement. The author thanks to research technicians Mr. Rajendra Kumar, Venkata Ramana and Rajendra Prasad for their help during insect rearing and authors acknowledge Suraj Prasad Mishra who assisted in editing the manuscript for his valuable input.

Conflict of Interest. None.

REFERENCES

Andrews, K. L. (1980). The fall army worm, *Spodoptera frugiperda*, in Central America and neighboring areas. *Florida Entomologist, 63*, 456-467.

Baloch, M. N., Jingyu Fan, Haseeb, M. and Zhang, R. (2020). Mapping Potential Distribution of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Central Asia. *Insects*, *11*(11), 1-10.

Bogorni, P. C. and Vendramim, J. D. (2005). Efeitosubletal de extratosaquosos de *Trichilia* spp. sobre o desenvolvimento de *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) emMilho. Neotrop. *Entomol*., *34*, 311–317.

Colborn, T. (1995). Pesticides–How research has succeeded and failed to translate science into policy: Endocrinological effects on wildlife. *Environmental Health Perspectives, 103*(6), 81.

Crowe, A. and Booty, W. G. (1995). A multi-level assessment methodology for determining the potential for groundwater contamination by pesticides. *Environmental Monitoring and Assessment*, *35*(3), 239-261.

Cruz, I., Figueiredo, M. L. C., Oliveira, A. C. and Vasconcelos, C. A. (1999). Damage of *Spodoptera frugiperda* (Smith) in different maize genotypes cultivated in soil under three levels of aluminium saturation. *International Journal of Pest Management, 45*, 293-296.

Deshmukh, S. S., Prasanna B. M., Kalleshwaraswamy, C. M., Jaba, J. and Choudhary, B. (2021). Fall armyworm (*Spodoptera frugiperda*). In Omkar (eds): Polyphagous pests of crops. Springer, Singapore. https://doi.org/10.1007/978-981-15-8075-8_8FAO. (2018). Integrated Management of Fall Armyworm on Maize. A Guide for Farmer Field

Goergen, G., Kumar, P. L., Sankung, S. B. and Togola, A. T. M. (2016). First Report of Outbreaks of the Fall Armyworm *Spodoptera frugiperda* (J E Smith) (Lepidoptera, Noctuidae), a New Alien Invasive Pest in West and Central Africa. *PLoS One*, *11*, 10 p. e0165632.

Greenberg, S. M., Showler, A. T. and Liu, T. X. (2005). Effects of neem-based insecticides on beet armyworm (Lepidoptera: Noctuidae). *Insect Science*, *12*, 17–23.

Jagdish Jaba, Vinod Kukanur, Jatin, Suraj Prashad Mishra, Gopalakrishnan S. and Pankaj Makanwar, Sharnabasappa Deshmukh (2021). Bioecology and sustainable management of invasive fall armyworm in sorghum crop, Agroecology thematic file, *Agropolis International*, 14page.

Jagdish, Jaba, Sathish, K. and Mishra S. P. (2020). Biology of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on three different crop-based artificial diets under lab condition. *Indian Journal of Entomology, 82*(3), 543-546.

Ma, D. L., Gordh, G. and Zalucki, M. P. (2000). Biological effects of azadirachtin on *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) fed on cotton and artificial diet. *Aust. J. Entomol*., *39*, 301–304.

Magrini, F. E., Specht, A., Gaio, J., Girelli, C. P., Migues, I., Heinzen, H. and Cesio, V. (2015). Antifeedant activity and effects of fruits and seeds extracts of *Cabralea canjerana canjerana* (Vell.) Mart. (Meliaceae) on the immature stages of the fall armyworm *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae). *Industrial Crops and Products*, *65*, 150–158.

Martinez, S. S. and Van Emden, H. F. (1999). Sub lethal concentrations of azadirachtin affect food intake, conversion efficiency and feeding behavior of *Spodoptera littoralis* (Lepidoptera: Noctuidae). *Bull. Entomol. Res*., *89*, 65–71.

Martinez, S. S. and Van Emden, H. F. (2001). Growth disruption, abnormalities and mortality of *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) caused by azadirachtin. *Neotrop. Entomol*., *30*, 113–125.

Montezano, D. G., Specht, A., Sosa-Gómez, D. R., Roque-Specht, V. F., Sousa-Silva, J. C., Paula-Moraes, S. V. D., Peterson, J. A. and Hunt, T. (2018). Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African Entomology*, *26*, 286–300.

Mordue (Luntz), J. A. and Blackwell, A. (1993). Azadirachtin: an update. *J. Insect Physiol*. *39*, 903–924.

Mordue (Luntz), J. A., Nisbet, A. J. (2000). Azadirachtin from the neem tree *Azadirachta indica*: its action against insects. *An. Soc. Entomol. Bras*., *29*, 615–632.

Mweshi Mukanga, Owen Machuku, Gilson Chipabika, Matthews Matimelo, Kelvin Mumba, Gilson Chipabika, Ndalamei Demaino Mabote, Vincent Simwinga, Isaiah Nthenga, Marian Lupulula, Sylvia Misengo Tembo and Kabosha Lwinya (2022). Bio-efficacy of Crude Aqueous Leaf Extracts against the Fall Armyworm (*Spodoptera frugiperda*) and Maize Ear Rots in Zambia. *Advance in Biological Research*, *3*(1), 38-49.

Nada Elsheikh M. Kona, Awad Khalafalla Taha, Abubaker Haroun Mohamed Adam, Mohammed E. E. and Mahmoud (2021). The Efficacy of Some Plants Extracts on Fall armyworm (*Spodoptera frugiperda*, J.E. Smizh) in Sudan. *Journal of Agronomy Research*, *3*(4), 31-37.

Pogue, M. G. (2002). A world revision of the genus *Spodoptera* Guenée (Lepidoptera: Noctuidae). American Entomological Society Philadelphia. https://www.ars.usda.gov/ research/publications/ publication/?seqNo115=110657

Rioba, Naomi B., and Philip C. Stevenson (2020). Opportunities and Scope for Botanical Extracts and Products for the Management of Fall Armyworm (*Spodoptera frugiperda*) for Small holders in Africa. *Plants*, *9*(2), 207.

Roel, A. R. and Vendramim, J. D. (2006). Efeito residual do extrato de acetato de etila de *Trichilia pallida* (Swartz) (Meliaceae) para lagartas de diferentesidades de *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae). *Ciência Rural, 36*, 1049–1054.

Roel, A. R., Vendramim, J. D., Frighetto, R. T. S. and Frighetto, N. (2000a). Atividadetóxica de extratosorgânicos de *Trichilia pallida* (Swartz) (Meliaceae) sobre *Spodoptera frugiperda* (J.E. Smith). *An. Soc. Entomol. Bras., 29*, 799–808.

Roel, A. R., Vendramim, J. D., Frighetto, R. T. S. and Frighetto, N. (2000b). Efeito do extratoacetato de etila de *Trichilia pallida* Swartz (Meliaceae) no desenvolvimento e sobrevivência da lagarta-do-cartucho. *Bragantia, 59*, 53–58.

Schlemmer, M. (2018). Effect of Temperature on Development and Reproduction of *Spodoptera frugiperda* (Lepidop: Noctuidae) North-West Univ. Evanston, IL, USA. Schools in Africa, 1–103.

Sharanabasappa, Kalleshwaraswamy, C. M., Maruthi, M. S. and Pavithra, H. B. (2018). Biology of invasive fall

army worm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on maize. *Indian J. Entomol.*, *80*(3), 540–543.
Sisay, B., Tefera, T., Wakgari, M., Ayalew, G. and Mendesil, E. (2019). The Efficacy of Selected Synthetic Insecticides and Botanicals against Fall Armyworm, *Spodoptera frugiperda*, in Maize. *Insects, 10*(2), 45.

How to cite this article: Pavan Kumar Annepu, Kota Sathish, Arunsaikumar K., Vavilapalli Rajesh, Lokesh Kondreddi, Snehanjali Boni, Anitha Madapakula and Jaba Jagdish (2023). Bitter Gourd, *Momordica charantia* (L.) a Potential Botanical Pesticide for the Management of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith). *Biological Forum – An International Journal*, *15*(10): 488-492.