



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFA 2026; 8(2): 450-454
www.agriculturaljournals.com
Received: 06-01-2026
Accepted: 09-02-2026

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Evaluation of biorationals against fall armyworm *Spodoptera frugiperda*, in rabi sorghum

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DOI: <https://www.doi.org/10.33545/2664844X.2026.v8.i3f.1279>

Abstract

Experiment on “Evaluation of biorationals against fall armyworm *Spodoptera frugiperda*, in rabi sorghum” was conducted during the Rabi season 2024-25 at the All India Coordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722 (M.S.). Among the seven biorational treatments, chlorantraniliprole 18.50 % SC @ 0.4 ml/L recorded lowest per cent plant damage (3.88 %) while, untreated control recorded highest per cent plant damage (18.33 %). It was revealed that maximum ICBR 1:14.6. was obtained from treatment with emamectin benzoate 5 % SG @ 0.4 g/L followed by chlorantraniliprole 18.50 % SC @ 0.4ml/L (1:8.47) and spinetoram 11.7 % SC @ 0.5 ml/L (1:7.15). It could be interpreted from the present results that although there was low net profit in treatment with emamectin benzoate 5 % SG @ 0.4 g/L, the highest ICBR was observed due to low cost on plant protection measures. *Metarhizium anisopliae* 1.15 % WP was moderately effective and can be recommended as safer, eco-friendly alternatives, particularly for organic or low-residue farming systems. Azadirachtin (10000 ppm) and Karanj oil showed the least efficacy among the tested biorationals but may still contribute as a component of integrated pest management when used in combination.

Keywords: *Spodoptera frugiperda*, fall armyworm, *Sorghum bicolor*, Chlorantraniliprole, Spinetoram, ICBR

Introduction

Sorghum bicolor, commonly known as jowar, is an important cereal crop cultivated widely in semi-arid and tropical regions for both food and fodder purposes. It plays a crucial role in ensuring food and nutritional security, particularly in developing countries. However, sorghum production is severely affected by several insect pests. Among them, the fall armyworm, *Spodoptera frugiperda* (J.E. Smith), has recently emerged as a serious threat. Native to the Americas, this highly destructive lepidopteran pest has rapidly spread to Africa and Asia, including India. Its high reproductive potential, migratory behaviour and polyphagous feeding habit enable it to cause extensive damage to sorghum and other cereal crops. Larvae feed voraciously on leaves, leading to defoliation, reduced photosynthetic activity and significant yield losses. Therefore, effective and sustainable management strategies are essential to minimize the impact of fall armyworm on sorghum cultivation.

In recent years, the invasive fall armyworm has emerged as a serious threat, causing nearly 16% yield loss in sorghum (Abrahams *et al.*, 2017) ^[1]. Owing to its high fecundity, voracious feeding habit and polyphagous nature, it inflicts severe damage on crops, with reported yield losses in maize reaching up to 94.72% (Sena *et al.*, 2003) ^[10], along with its rapid spread across different regions (Goergen *et al.*, 2016) ^[5]. Although chemical insecticides are widely used for its control, their excessive and indiscriminate application has resulted in the development of resistance, environmental pollution and adverse effects on non-target organisms. Therefore, sustainable management approaches, particularly the incorporation of host plant resistance within integrated pest management (IPM) strategies, are essential for effective control of fall armyworm.

Materials and methods

The research experiment entitled, “Evaluation of biorationals against fall armyworm *Spodoptera frugiperda*, in rabi sorghum” was conducted during rabi season, 2024-2025 at the Sorghum Improvement Project, MPKV, Rahuri, Maharashtra. The field efficacy of commercial biorationals against *S. frugiperda* on sorghum was evaluated in a randomized block design (RBD) with seven treatments replicated thrice including untreated control, with a plot size of 4.0 m x 2.7 m with inter and intra row spacing of 45 cm and 15 cm. The treatment details are mentioned in Table 1. All the recommended agronomic practices given by MPKV, Rahuri were followed to raise the crop. Observations were recorded after infestation was noticed in sorghum.

Methodology

The spraying was done manually as per given biorationals treatments by a hand-operated knapsack sprayer with a hollow cone nozzle. Two foliar sprays of each treatment were given at an interval of 14 days at ETL. The first spray was given after the incidence was noticed. Untreated control was maintained by spraying water in the plot. The observation on per cent plant damage were recorded from each treatment plot. The data was recorded one day before spraying as a pre-count while post-treatment counts were taken at 5, 10 and 14 days after spraying (DAS). Observation at 14 days after first spray was related as pre count before second spray.

Table 1: Treatment Details

Tr. No.	Treatment Details	Dose (g or ml/litre of water)
T ₁	Chlorantraniliprole 18.50 % SC	0.4 ml
T ₂	Emamectin benzoate 5 % SG	0.4 g
T ₃	Spinetoram 11.7 % SC	0.5 ml
T ₄	<i>Metarhizium anisopliae</i> 1.15% WP	5 g
T ₅	Azadirachtin 10000 ppm	2 ml
T ₆	Karanj oil	3 ml
T ₇	Untreated control	-

Per cent plant damage

The per cent damage was recorded from 30 plants per plot and calculated by using formula given by Mallapur *et al.* (2018)^[7]. Per cent plant damage = $N/T \times 100$

Where, N = Total number of damaged plants per plot. T = Total number of plants per plot

Results and Discussion

After first spray

The data pertaining to effect of different treatments on per cent plant damage due to *S. frugiperda* at 5, 10 and 14 days after first spray is presented in the Table 2.

The pre count observation were nonsignificant indicating uniform FAW infestation in experimental field.

The data pertaining to mean per cent plant damage after first spray revealed that, mean per cent plant damage ranged from 5.89 to 16.67 % per 30 plants. The treatment chlorantraniliprole 18.50 % SC @ 0.4 ml/L was the significantly superior over all the treatments which recorded minimum per cent plant damage (5.89 per cent/30 plants). However, it was statistically at par with spinetoram 11.7 % SC @ 0.5 ml/L and emamectin benzoate 5 % SG @ 0.4 g/l which recorded 6.67 % and 7.78 % plant damage, respectively. The next best treatments were *Metarhizium anisopliae* @ 5 g/L, azadirachtin @ 2 ml/L and karanj oil @ 3 ml/L which recorded 11.11 %, 11.67 % and 11.85 % plant damage, respectively and were statistically at par with each other.

Table 2: Evaluation of biorationals against *S. frugiperda* in Sorghum (first spray)

Tr. No.	Treatments	Dose g or ml/l	Pre count	Per cent plant damage/30 plants			Mean
				5 DAS	10 DAS	14 DAS	
T1	Chlorantraniliprole 18.50 % SC	0.4	13.33	7.67	4.44	5.56	5.89
			(21.32)*	(16.10)	(12.00)	(13.48)	(13.86)
T2	Emamectin benzoate 5 % SG	0.4	14.99	8.89	6.67	7.78	7.78
			(22.78)	(17.28)	(14.56)	(16.12)	(16.12)
T3	Spinetoram 11.7 % SC	0.5	12.67	7.78	5.56	6.67	6.67
			(20.86)	(16.12)	(13.48)	(14.97)	(14.97)
T4	<i>Metarhizium anisopliae</i> 1.15 % WP	5	14.44	12.00	10.00	11.11	11.11
			(22.31)	(20.27)	(18.43)	(19.43)	(19.43)
T5	Azadirachtin (10000 ppm)	2	14.33	11.78	10.33	12.22	11.67
			(22.24)	(19.84)	(18.67)	(20.42)	(19.54)
T6	Karanj oil	3	13.00	12.22	11.11	12.00	11.85
			(21.13)	(20.42)	(19.43)	(20.27)	(20.13)
T7	Untreated control	-	13.67	15.56	16.67	17.78	16.67
			(21.66)	(23.50)	(24.10)	(24.94)	(24.09)
	S.E. m $\pm$		1.47	0.83	0.85	0.98	0.88
	CD @ 5 %		NS	2.51	2.56	2.96	2.67
	CV		11.68	8.24	8.13	9.42	8.59

*Figures in the parentheses are arc sin transformed values,

NS: Non-significant, DAS= Days after spraying.

After second spray

The data pertaining to mean per cent plant damage after second spray revealed that, mean per cent plant damage ranged from 2.22 to 20.00 % per 30 plants. The treatment chlorantraniliprole 18.50 % SC @ 0.4 ml/L was superior over all the treatments which recorded minimum per cent plant damage of 2.22 per cent per 30 plants. However, it was

statistically at par with spinetoram 11.7 % SC @ 0.5 ml/L and emamectin benzoate 5 % SG @ 0.4 g/L which recorded 3.33 % and 4.44 % plant damage, respectively. The next best treatments were *Metarhizium anisopliae* @ 5 g/L, azadirachtin @ 2 ml/L and karanj oil @ 3 ml/L which recorded 9.55 %, 10.00 % and 10.77 % plant damage, respectively and were statistically at par with each other.

Table 3: Evaluation of biorationals against *S. frugiperda* in Sorghum (second spray)

Tr. No.	Treatments	Dose g or ml/l	Per cent plant damage/30 plants			Mean
			5 DAS	10 DAS	14 DAS	
T1	Chlorantraniliprole 18.50 %	0.4	3.33	1.11	2.22	2.22
	SC		(10.51)*	(6.11)	(8.30)	(8.30)
T2	Emamectin benzoate 5 % SG	0.4	5.56	3.33	4.44	4.44
			(13.43)	(10.51)	(12.00)	(12.00)
T3	Spinetoram 11.7 % SC	0.5	4.44	2.22	3.33	3.33
			(12.00)	(8.30)	(10.51)	(10.51)
T4	<i>Metarhizium anisopliae</i>	5	10.00	8.67	10.00	9.55
	1.15 % WP		(18.43)	(17.13)	(18.43)	(18.03)
T5	Azadirachtin (10000 ppm)	2	11.11	8.89	10.33	10.00
			(19.43)	(17.28)	(18.67)	(18.43)
T6	Karanj oil	3	11.22	10.00	11.11	10.77
			(19.56)	(18.43)	(19.43)	(19.13)
T7	Untreated control	-	18.89	20.00	21.11	20.00
			(25.74)	(26.57)	(27.34)	(26.57)
	S.E. m $\pm$		0.97	0.88	0.82	0.89
	CD @ 5 %		2.92	2.72	2.55	2.73
	CV		9.96	9.69	9.26	9.63

*Figures in the parentheses are arc sin transformed values, NS: Non-significant, DAS= Days after spraying

Cumulative effect of first and second sprays

Data pertaining to cumulative mean efficacy of different biorationals against per cent plant damage showed that, treatment with chlorantraniliprole 18.50 % SC @ 0.4 ml/L. was found to be superior over all the treatments with minimum cumulative mean per cent plant damage of 4.07 % per 30 plants. However, it was followed by the treatment with spinetoram 11.7 % @ 0.5 ml/L. and emamectin benzoate 5 % SG @ 0.4 g/l. with cumulative mean per cent

plant damage of 5.00 % and 6.11 % per 30 plants which were at par with each other. Next best treatments were *M. anisopliae* @ 5 g/l., azadirachtin @ 2 ml/L. and karanj oil @ 3 ml/L. with 10.33, 10.62 and 11.31 per cent plant damage per 30 plants respectively and were statistically at par with each other. On the other hand, untreated control recorded maximum mean per cent plant damage of 18.33 % per 30 plants after spray.

Table 4: Cumulative effects of biorationals against *S. frugiperda* in Sorghum

Tr. No.	Treatments	Dose g or ml/l	Per cent plant damage/30 plants			Mean
			5 DAS	10 DAS	14 DAS	
T1	Chlorantraniliprole 18.50 % SC	0.4	5.00	2.77	3.89	4.07
			(13.21)*	(9.05)	(10.89)	(11.15)
T2	Emamectin benzoate 5 % SG	0.4	7.20	5.00	6.11	6.11
			(15.38)	(12.74)	(14.06)	(14.06)
T3	Spinetoram 11.7 % SC	0.5	6.11	3.89	5.00	5.00
			(14.06)	(10.89)	(12.74)	(12.74)
T4	<i>Metarhizium anisopliae</i> 1.15 % WP	5	11.00	9.44	10.55	10.33
			(19.23)	(17.85)	(18.93)	(18.67)
T5	Azadirachtin (10000 ppm)	2	11.14	9.61	11.11	10.62
			(19.53)	(17.98)	(19.43)	(18.98)
T6	Karanj oil	3	11.72	10.55	11.66	11.31
			(19.92)	(18.93)	(19.92)	(19.63)
T7	Untreated control	-	17.22	18.33	19.44	18.33
			(24.62)	(25.33)	(26.14)	(25.33)
	S.E. m $\pm$		0.90	0.86	0.90	0.88
	CD @ 5 %		2.76	2.64	2.75	2.71
	CV		9.10	8.91	9.34	9.11

*Figures in the parentheses are arc sin transformed values, DAS: Days after spraying.

The results obtained from the present investigation are in agreement with the findings of Bajracharya *et al.* (2020) [2],

who reported that emamectin benzoate (3.33 % plant infestation) was significantly superior to neem oil 1500 ppm

(40.0 % plant infestation) in managing *S. frugiperda* infestation in maize. Similarly, Deshmukh *et al.* (2020) [3] found that efficacy testing of insecticides applied to crops planted in June and September 2018 revealed chlorantraniliprole 18.5% SC as the most effective treatment, followed by emamectin benzoate 5% SG. These insecticides not only provided effective control of *S. frugiperda* but also resulted in higher grain yields compared to the untreated control.

Dileep Kumar and Murali Mohan (2020) and Masthan Shareef *et al.* (2020) [4] also reported that chlorantraniliprole 18.50% SC, emamectin benzoate 5% SG and spinetoram 11.7% SC were highly effective against *S. frugiperda*. Likewise, Sharanabasappa *et al.* (2020) [11] observed that chlorantraniliprole 18.5% SC @ 0.5 ml/l, emamectin benzoate 5% SG @ 0.4 g/l and spinetoram 11.7 SC @ 0.05 ml/l were highly toxic to *S. frugiperda*, indicating their strong efficacy in reducing the larval population of fall armyworm.

Thumar *et al.* (2020) and Deshmukh *et al.* (2020) [13-3] concluded that emamectin benzoate was on par with flubendiamide in its efficacy for managing *S. frugiperda* on sorghum and maize. Wayal *et al.* (2021) [14] revealed that

Metarhizium anisopliae @ 50 g/10 l was the most effective biopesticide in reducing plant damage (57.04 %) caused by *S. frugiperda*. Similarly, Jahan (2022) [6] reported the highest per cent reduction (52.02 %) of leaf infestation in the treatment with *M. anisopliae* @ 8 g/l. Furthermore, Ramanujam *et al.* (2020) [9] concluded that *M. anisopliae* ICAR-NBAIR Ma 35 strain exhibited a 70 % reduction in *S. frugiperda* infestation.

Grain yield

The data of grain yield presented in Table 5. revealed that grain yield ranged from 35.00 to 51.80 q/ha, showing substantial variation among the treatments. Significantly higher grain yield was recorded in the plot treated with chlorantraniliprole @ 0.4 ml/l (51.80 q/ha), which was superior to all other treatments. The next best yield was obtained from the plot treated with spinetoram @ 0.5 ml/l (50.32 q/ha), followed by emamectin benzoate @ 0.4 g/l (47.36 q/ha). The plot treated with *Metarhizium anisopliae* @ 5 g/l (40.44 q/ha) which was statistically at par with azadirachtin @ 2 ml/l (40.00 q/ha) and karanj oil @ 3 ml/l (39.80 q/ha). The lowest grain yield was recorded in the untreated plot (35.00 q/ha).

Table 5: Impacts of biorationals on yield of sorghum

Tr. No.	Treatment	Dose (g or ml/l.)	Grain yield (qt/ha)	Fodder yield (qt/ha)
T1	Chlorantraniliprole 18.50 % SC	0.4	51.80	136.16
T2	Emamectin benzoate 5 % SG	0.4	47.36	125.8
T3	Spinetoram 11.7 % SC	0.5	50.32	131.72
T4	<i>Metarhizium anisopliae</i> 1.15 % WP	5	40.44	106.56
T5	Azadirachtin (10000 ppm)	2	40.00	99.16
T6	Karanj oil	3	39.80	96.20
T7	Untreated control	-	35.00	91.00
	S.E m. $\pm$		0.41	0.90
	CD @ 5 %		1.22	2.73

Table 6: Economics of different biorationals treatment in sorghum

Tr. No.	Treatment	Dose (g or ml/L.)	Quantity of insecticide for 2 spray (g or ml/ha)	Grain Yield (qt/ha)	Increase in grain yield over control (qt/ha) (A)	Fodder Yield (qt/ha) (B)	Increase in fodder yield over control (qt/ha) (C)	Additional income over control (Rs/ha) (D)	Cost of plant protection for 2 spray (Rs/ha) (E)	Net profit (Rs) (F) = (D - E)	ICBR (G) = (F/E)
T ₁	Chlorantraniliprole 18.5 % SC	0.4	400 ml	51.80	16.80	136.16	45.16	69386	7320	62066	1: 8.47
T ₂	Emamectin benzoate 5% SG	0.4	400 g	47.36	12.36	125.8	34.80	51300	3280	48020	1: 14.6
T ₃	Spinetoram 11.7% SC	0.5	500 ml	50.32	15.32	131.72	40.72	63199	7750	55449	1: 7.15
T ₄	<i>Metarhizium anisopliae</i> 1.15% WP	5	5000 g	40.44	5.44	106.56	15.56	22618	3000	19618	1: 6.53
T ₅	Azadirachtin (10000 ppm)	2	2000 ml	40.00	5.00	99.16	8.16	19806	7440	12366	1: 1.66
T ₆	Karanj oil	3	3000 ml	39.80	4.80	96.20	5.20	18480	7850	10630	1: 1.35
T ₇	Untreated control	-	-	35.00	-	91.00	-	-	-	-	-

Fodder yield

The data on fodder yield presented in Table 5. revealed that the yield varied from 91.00 to 136.16 q/ha, showing substantial variation among different treatments. Significantly higher fodder yield was recorded in the plot treated with chlorantraniliprole @ 0.4 ml/l (136.16 q/ha), which was superior to all other treatments. The next best yield was obtained from the plot treated with spinetoram @ 0.5 ml/l (131.72 q/ha), followed by emamectin benzoate @ 0.4 g/l (125.80 q/ha). The plots treated with *Metarhizium anisopliae* @ 5 g/l (106.56 q/ha), followed by azadirachtin @ 2 ml/l (99.16 q/ha) and karanj oil @ 3 ml/l (96.20 q/ha) recorded comparatively lower yields. The minimum fodder yield was recorded in untreated plot (91.00 q/ha).

The present findings are in agreement with those of Sharanabasappa *et al.* (2020) [11], who reported that chlorantraniliprole 18.50% SC recorded the highest grain yield of maize (66.50 q/ha), followed by emamectin benzoate 5 SG (65.17 q/ha) and spinetoram 11.7% SC (64.67 q/ha) whereas, the untreated control recorded the lowest grain yield (32.46 q/ha).

Similarly, Sunilkumar *et al.* (2020) [12] demonstrated that the application of chlorantraniliprole 18.5% SC resulted in the highest maize grain yield (77.42 q/ha), followed by spinosad 45% SC, spinetoram 11.7% SC and emamectin benzoate 5% SG, due to their effective control of *Spodoptera frugiperda*. Furthermore, Thumar *et al.* (2020) [13] concluded that spinetoram 11.7% SC was highly effective in suppressing

the larval population of maize fall armyworm, which was reflected in higher grain and fodder yields, followed by emamectin benzoate 5% SG, chlorantraniliprole 18.50% SC and thiodicarb 75% WP.

Incremental cost benefit ratio of biorationals on yield of sorghum

The incremental cost benefit ratio (ICBR) presented in Table 4.19 revealed that maximum ICBR (1:14.60) was obtained from treatment with emamectin benzoate @ 0.4 g/l. The next highest ICBR was recorded in chlorantraniliprole @ 0.4 ml/l (1:8.47), followed by spinetoram @ 0.5 ml/l (1:7.15). The plots treated with *M. anisopliae* @ 5 g/l recorded an ICBR of (1:6.53), followed by azadirachtin @ 2 ml/l (1:1.66) and karanj oil @ 3 ml/l (1:1.35).

Conclusion

Among the evaluated biorational insecticides, chlorantraniliprole 18.5% SC and spinetoram 11.7% SC demonstrated superior performance by significantly reducing the percentage of plant damage after both spray applications. With respect to the incremental cost benefit ratio (ICBR), emamectin benzoate 5% SG emerged as the most economical option, primarily due to its lower plant protection cost. *Metarhizium anisopliae* 1.15% WP exhibited moderate effectiveness and may be recommended as a safer and environmentally sustainable alternative, especially for organic and low-residue production systems. In contrast, azadirachtin (10000 ppm) and karanj oil recorded comparatively lower efficacy; however, they can still play a supportive role in integrated pest management programs when applied in combination with other control measures.

Acknowledgement

I am grateful to Dr. U.K. Kadam, Dr. U.S. Dalvi Dr. R.S. Bhoge and Dr. V.B. Shinde for their invaluable guidance and support throughout my research work. Their expertise and encouragement have been instrumental in shaping this endeavour.

References

1. Abrahams P, Bateman M, Beale T, Clotey V, Cock M, Colmenarez Y, *et al.* Fall armyworm: Impacts and implications for Africa. Wallingford: CAB International; 2017. (CABI Evidence Note No. 2).
2. Bajracharya AS, Bhat SR, Sharma P. Field efficacy of selected insecticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize. *J Plant Prot Soc.* 2020;8(6):127-131.
3. Deshmukh S, Pavithra HB, Kalleshwaraswamy CM, Shivanna BK. Field efficacy of insecticides for management of invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize in India. *Florida Entomol.* 2020;103(2):221-227.
4. Dileep Kumar NT, Murali Mohan K. Bio-efficacy of selected insecticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize. *J Entomol Zool Stud.* 2020;8(4):1257-1261.
5. Goergen G, Kumar PL, Sankung SB, Togola A, Tamo M. First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (J.E. Smith), a new alien invasive pest in West and Central Africa. *PLoS One.* 2016;11(10):e0165632.
6. Jahan M. Eco-friendly management approaches of fall armyworm: Experiences and prospects in Bangladesh. In: *Fall armyworm (Spodoptera frugiperda)—status, challenges and experiences among SAARC member states.* Dhaka: SAARC Agriculture Centre; 2022. p. 107-121.
7. Mallapur CP, Naik AK, Hagari S, Praveen T, Patil RK, Lingappa S. Potentiality of *Nomuraea rileyi* against fall armyworm, *Spodoptera frugiperda* infesting maize. *J Entomol Zool Stud.* 2018;12(4):1062-1067.
8. Mastan Shareef SD, Madhumathi T, Swathi M, Kumar AV. Bio-efficacy of newer insecticides for management of fall armyworm, *Spodoptera frugiperda* on maize. In: *Proceedings of International Seminar on Transboundary Pest Management; 2020 Mar 4-5; Coimbatore, India.* Coimbatore: TNAU; 2020. p. 237.
9. Ramanujam B, Poornesha B, Shylesha AN. Effect of entomopathogenic fungi against invasive pest *Spodoptera frugiperda* in maize. *Egypt J Biol Pest Control.* 2020;30(1):1-5.
10. Sena DG, Pinto F, Queiroz DM, Viana PA. Fall armyworm-damaged maize plant identification using digital images. *Biosyst Eng.* 2003;85(4):449-454.
11. Sharanabasappa D, Pavithra HB, Kalleshwaraswamy CM, Maruthi MS, Mota-Sanchez D. Field efficacy of insecticides for control of invasive fall armyworm, *Spodoptera frugiperda* on maize in India. *Florida Entomol.* 2020;103(2):221-227.
12. Sunilkumar M, Basavaraju BS, Vijaykumar L, Sanathkumar VB, Thimme GP. Efficacy of new generation insecticide molecules for controlling fall armyworm, *Spodoptera frugiperda* in maize. *Int J Chem Stud.* 2020;8(6):91-96.
13. Thumar RK, Zala MB, Varma HS, Dhobi CB, Patel BN, Patel MB, *et al.* Evaluation of insecticides against fall armyworm, *Spodoptera frugiperda* infesting maize. *Int J Chem Stud.* 2020;8(4):100-104.
14. Wayal A, Undirwade D, Jawanjal K, Chopade G. Biorational management of *Spodoptera frugiperda* on maize. *Indian J Entomol.* 2021;24(5):352.