

**“Field efficacy and economics
certain chemicals and botanical against fall army worm, [(*Spodoptera frugiperda* (J.E. Smith.))]
on maize (*Zea mays*)”**

ABSTRACT

The present investigation was carried out in a Randomized Block Design having 3 replications and 8 treatments (seven insecticides and one control) during *Kharif* season 2023 conducted at the (CRF) Central Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (U.P.) to evaluate the field efficacy of certain chemicals and botanicals against fall army worm [(*Spodoptera frugiperda*)] on maize [(*zea mays* Linn.)]. The order of effectiveness was observed in Chlorantraniliprole 18.5% SC (3.25) > Spinosad 45 SC (3.46) > is found to be the next best treatment followed by Lambda-cyhalothrin 5% EC + Chlorantraniliprole 18.5% SC (3.99) > followed by Emamectin benzoate 5% SG (4.16) > Lambda-cyhalothrin 5% EC (4.44) > followed by Flubendiamide 39.35% SC (4.87) > Neem oil 1500 ppm (5.18) is found to be least effective but comparatively superior over the control. Among all the treatments the most economical treatment and highest Benefit Cost ratio was recorded in Chlorantraniliprole 18.5% SC with of (1:2.96) followed by Spinosad 45 SC (1:2.82), Lambda-cyhalothrin 5% EC + Chlorantraniliprole 18.5% SC (1:2.60), Emamectin benzoate 5% SG (1:2.53), Lambda-cyhalothrin 5% EC (1:2.36), Flubendiamide 39.35% SC (1:1.81), Neem oil 1500 ppm (1:1.74) respectively as compared to untreated Control plot (1:1.52).

Keywords: - *Spodoptera frugiperda*, Chlorantraniliprole, Spinosad, neem oils.

INTRODUCTION

Maize (*Zea mays* L.) is important cereal crop grown all over the world as food for human consumption, animal feed, fodder and an industrial product. It has the highest genetic yield potential among cereals. Among the cereal crops, due to its highest genetic yield potential

globally Maize is also known as “queen of cereals”. It is also known as the "Miracle Crop" because of its high solar use efficiency and immense potential for increased production. **(Panigrahi et al., 2023)**.

Globally India ranks sixth in global maize production and fifteenth position in its productivity in world, contributing to 2.4 per cent of world production with almost 5 per cent share in world harvested area. It is cultivated on nearly 150 million hectares in about 160 countries having wider diversity of soil, climate, biodiversity and management practices. It contributes 36% (782 MT) in the global grain production. **(Sangleet et al., 2020)**. “India produced 31.51 million tonnes in an area of 9.9 million hectares in 2020-21, whereas in kharif 2021-22, maize production was 21.24 million tonnes (1st advance estimates) in an area of 8.15 million hectares”. **(Panigrahi et al., 2023)**.

The area of cultivation under maize in india is 9.47 million hectares with production of 28.72 million tonnes and with average productivity of 3032 kg per hectare during 2017-18 **(Bharadwaj et al., 2020)**. A general view of the pest problem in maize in india reveals that this crop is attacked several by number of pests stem borers, armyworm (*Mythimna separata*) and *Helicoverpa armigera*. Out of these pests, maize fall armyworm, *Spodoptera frugiperda* is considered to be the most destructive and has become a great threat to maize cultivation.

Maize is affected by as many as 141 insect pests. Among these, only few are considered as major pests in India viz., shoot fly, stem borers, armyworm (*Mythimna separata*) and *Helicoverpa armigera*. However, the recent invasion of the fall armyworm, *Spodoptera frugiperda* (Noctuidae: Lepidoptera) has become a great threat to maize cultivation.

The fast and widespread of this pest is mainly attributed to its strong flying ability, higher fecundity and polyphagous nature having ample number of alternate hosts coupled with the availability of host crops throughout the year **(Mallapur et al., 2019)**.

It is also reported to cause major damage to economically important crops. Damage due to this pest attack can reduce corn grain yield up to 34 per cent in Brazil, 20 to 50 per cent in Africa has the potential to cause maize yield losses in a range from 8.3 to 20.6 million tonnes per annum, in the absence of any control methods **(Day et al., 2017)**.

The bio-pesticides play an important role in insect pest management by their various inhibitory actions on insect physiology and behavior. They are the best alternative to chemical insecticides against Fall armyworm on maize. They are locally available, relatively cheap, biodegradable and easy to handle. They are bringing about the balance back to the ecosystem. As the agriculture

shift toward organic farming the organic farming, they have much better scope in the management tactics. (Warghatet *al.*,2019)

Materials and Methods

The present investigation was conducted at the experimental research plot of the Department of Entomology, Central Research Farm, Sam Higginbottom University of Agriculture Technology And Sciences, during the *Kharif* season of 2023, in a Randomized Block Design (RBD) with eight treatments three replication using variety Komal seeds in a plot size of 2m×1m at a spacing of 60cm×20cm with a recommended package of practices excluding plant protection. The soil of the experimental site was well drained and medium high.

Pest population was estimated by observing five plants selected randomly from each treatment for presence of larvae at one day prior to insecticide application and at 3rd, 7th and 14th days after each application. The larval population over control against fall army worm was calculated by considering the mean of three observations recorded at 3rd, 7th and 14th days after first and second spraying.

Data collection

LARVAL POPULATION

The observation of maize fall army worm larval population and damaged plants was recorded 1 day before spraying and on 3rd, 7th and 14th day after insecticidal application. The observation will be recorded on randomly select 5 plants in each plot. At harvest the grain yield per plot was recorded and converted into Q/ha for comparison.

The result obtained are converted into percent plant damage work out using the following formula.

$$\text{Mean larval population} = \frac{\text{Number of larvae}}{5 \text{ randomly plant selected}}$$

Cost benefit ratio

Based on the yield data, the gross returns and net returns were calculated for each treatment. Gross returns were calculated by multiplying total yield with the market price of the produce. The ratio of gross return and cost of cultivation will be work for each treatment and was used as benefit: cost ratio (BCR) to compare the performance of different treatments. Benfit cost ratio was calculated by using the following equation.

$$\text{Gross return} = \text{Marketable yield} \times \text{Market price}$$

$$\text{Net return} = \text{Gross return} - \text{Total cost}$$

$$B: C \text{ Ratio} = \frac{\text{Gross returns}}{\text{Total Cost}}$$

(Thuppukonda and Kumar 2022)

Where, BCR = Benefit Cost Ratio

Results and Discussion

The data on the mean (3rd, 7th and 14th DAS) population of *Spodoptera frugiperda* after first spray revealed that all the treatments except untreated control are effective. Among all the treatments lowest population was recorded in Chlorantraniliprole @ 18.5% EC (4.4). Spinosad 45 SC (4.63) was found to be the next best treatment followed by Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC (4.95), Emamectin benzoate @ 5% SG (5.1), Lambda cyhalothrin @ 2.5% EC (5.23), Flubendiamide 39.35% EC (5.23) and Neem oil 1500 ppm (5.8) was found to be least effective but comparatively superior over the control.

The data on population of *Spodoptera frugiperda* on second spray revealed that all the treatments were significantly superior over control. Among all the treatments, in Chlorantraniliprole @ 18.5% EC (2.09). Spinosad 45 SC (2.29) was found to be the next best treatment followed by Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC (3.02), Emamectin benzoate @ 5% SG (3.22), Lambda cyhalothrin @ 2.5% EC (3.64), Flubendiamide 39.35% EC (4.27) and Neem oil 1500 ppm (4.55) was found to be least effective but comparatively superior over the control.

The yields among the different treatments were significant. The highest yield was recorded in Chlorantraniliprole @ 18.5% EC (51.52 q/ha). Spinosad 45 SC (45.40 q/ha) was found to be the next best treatment followed by Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC (46 q/ha), Emamectin benzoate @ 5% SG (40 q/ha), Lambda cyhalothrin @ 2.5% EC (37 q/ha), Flubendiamide 39.35% EC (35.18 q/ha) and Neem oil 1500 ppm (28.82 q/ha) as compared to control plot (22.26 q/ha).

When cost benefit ratio was worked out, interesting result was achieved. Among the treatments studied, the best and most economical treatment was Chlorantraniliprole @ 18.5% EC (1:2.96). Spinosad 45 SC (1:2.82) was found to be the next best treatment followed by Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC (1:2.60), Emamectin benzoate @ 5% SG (1:2.53), Lambda cyhalothrin @ 2.5% EC (1:2.36), Flubendiamide 39.35% EC (1:1.81) and Neem oil 1500 ppm (1:1.74) as compared to control plot (1:1.52). (Table 3).

Table.1

Efficacy of certain chemicals and biopesticides against larval population of *Spodoptera frugiperda* on maize after (1st spray).

Number of larva <i>Spodoptera frugiperda</i> / five plants						
Treatments no.	Treatments	1 st DBS	3 rd DAS	7 th DAS	14 th DAS	Overall mean
T ₁	Spinosad 45 SC	5.93	4.6	3.8	4.2	4.63
T ₂	Chlorantraniliprole 18.5% SC	5.86	4.26	3.46	4	4.40
T ₃	Emamectin benzoate 5% SG	6.33	5.06	4.33	4.66	5.10
T ₄	Lambda-cyhalothrin 5% EC + Chlorantraniliprole 18.5% SC	5.8	4.8	4.73	4.46	4.95
T ₅	Flubendiamide 39.35% SC	5.8	5.6	5.13	5.33	5.47
T ₆	Lambda-cyhalothrin 5% EC	6.13	5.26	4.53	5	5.23
T ₇	Neem oil 1500 ppm	5.93	6.2	5.4	5.66	5.80
T ₀	Control	6	6.26	6.6	5.77	6.16
F-test		NS	S	S	S	S
S.Ed(±)			0.22	0.18	0.16	0.21
C.D.(P=0.05)			0.46	0.390	0.347	0.367

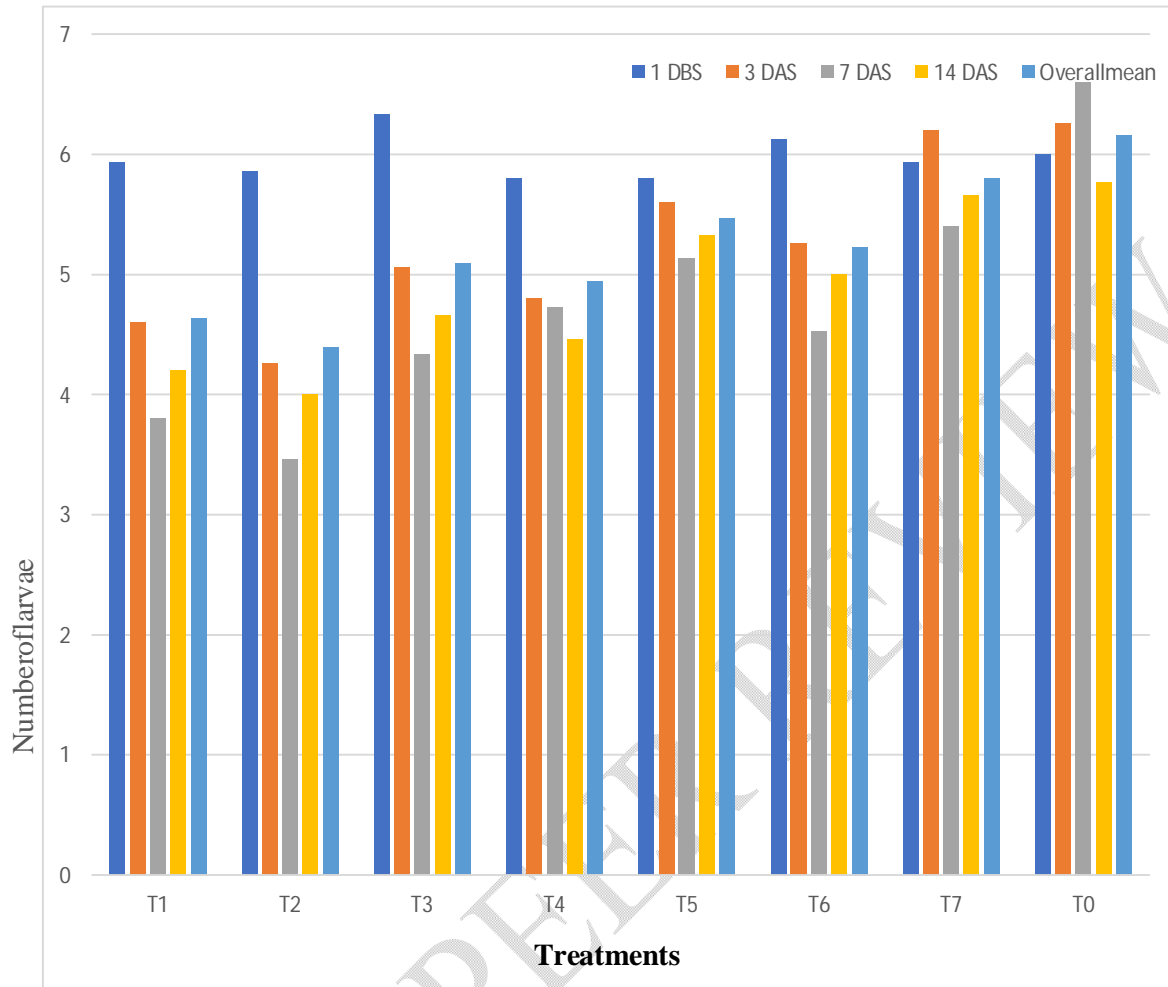


Fig.1 Effect of different treatment on maize fallarmyworm, *Spodoptera frugiperda* after first spray (Larval population).

Table.2 Efficacy of certain chemicals and biopesticides against larval population of

Spodoptera frugiperda on maize after (2nd spray).

Number of larva <i>Spodoptera frugiperda</i> / five plants					
No.oft.	Treatments	3 rd DAS	7 th DAS	14 th DAS	Overall mean
T ₁	Spinosad 45SC	2.86	1.8	2.2	2.29
T ₂	Chlorantraniliprole 18.5%SC	2.8	1.6	1.86	2.09
T ₃	Emamectin benzoate 5%SG	3.73	2.73	3.2	3.22
T ₄	Lambda-cyhalothrin 5%EC + Chlorantraniliprole 18.5%SC	3.53	2.53	3	3.02
T ₅	Flubendiamide 39.35%SC	4.6	4	4.2	4.27
T ₆	Lambda-cyhalothrin 5%EC	4.13	3.26	3.53	3.64
T ₇	Neem oil 1500ppm	4.93	4.26	4.46	4.55
T ₀	Control	7	7.13	7.33	7.15
F-test		S	S	S	S
S.Ed(±)		1.03	1.22	0.19	1.17
C.D.(P=0.05)		0.398	0.366	0.413	0.406

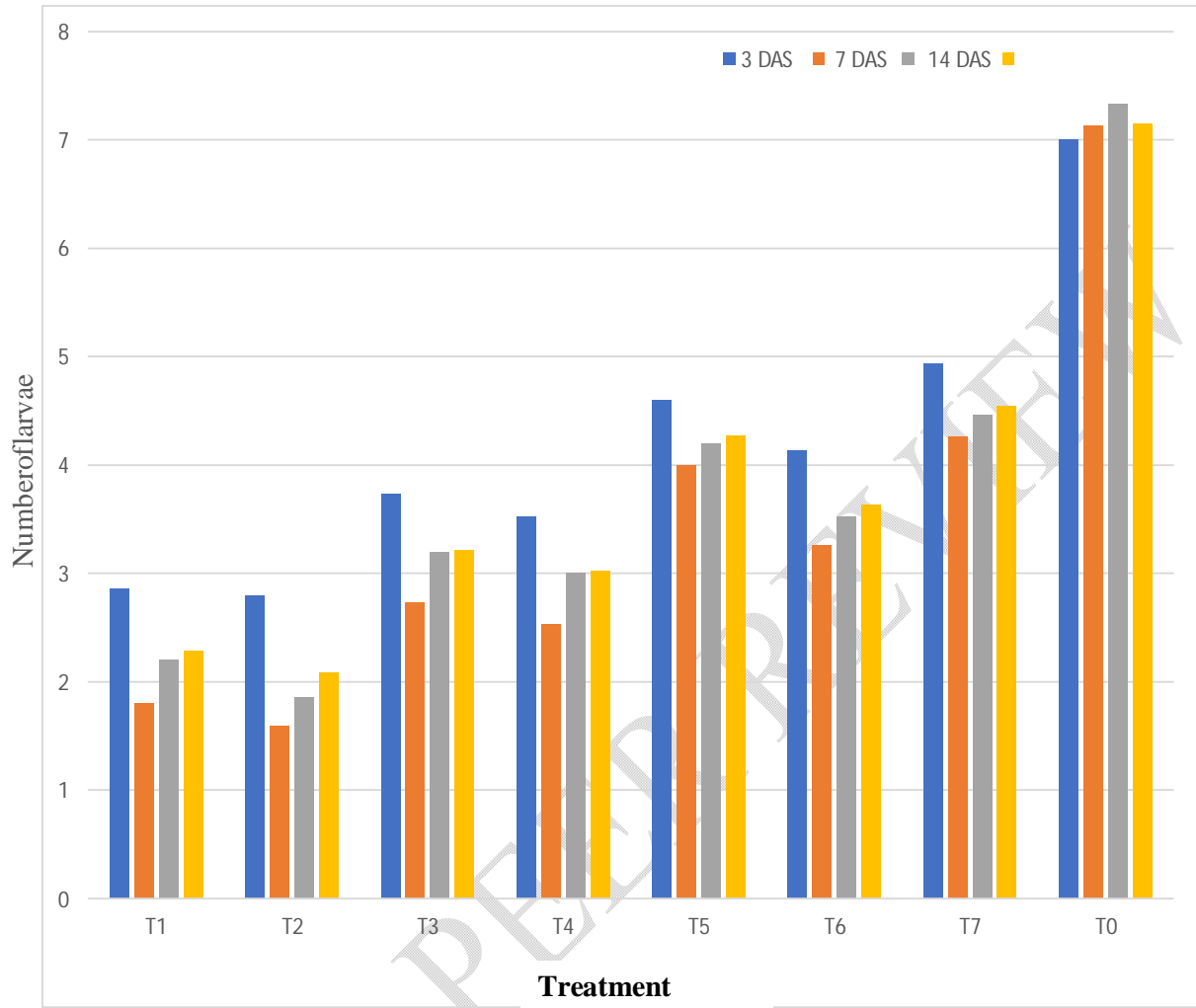


Fig.2 Effect of different treatment on maize fall armyworm, *Spodoptera frugiperda* after second spray (Larval population).

UNDEP

Table.3 Economics of Cultivation

S.N	Treatments	Yield (q/ha)	Cost of yield / (₹)	Total cost of yield (₹)	Common cost (₹)	Treatment cost (₹)	Net Return (₹)	Total cost (₹)	C:Bratio
T ₁	Spinosad 45 SC	45.40	1800	81720	26222	2737	52761	28959	1:2.82
T ₂	Chlorantraniliprole 18.5% SC	51.52	1800	92736	26222	5040	61474	31262	1:2.96
T ₃	Emamectin benzoate 5% SG	40	1800	72000	26222	2236	43542	28458	1:2.53
T ₄	Lambda-cyhalothrin 5% EC + Chlorantraniliprole 18.5% SC	46	1800	82800	26222	5525	51053	31747	1:2.60
T ₅	Flubendiamide 39.35% SC	35.18	1800	63324	26222	8645	28457	34867	1:1.81
T ₆	Lambda-cyhalothrin 5% EC	37	1800	66600	26222	1885	38493	28107	1:2.36
T ₇	Neem oil 1500 ppm	28.82	1800	51876	26222	3500	22154	29722	1:1.74
T ₀	Control	22.26	1800	40068	26222	-	13846	26222	1:1.52

Discussion

In the present research work lowest percent of maize fall armyworm population was recorded in T₂ Chlorantraniliprole@18.5% EC (3.25%) Similar findings were made by **Baurtetet et al., (2017)**, **Triboniet et al., (2019)** and **Viteri et al., (2019)** who reported that T₂Chlorantraniliprole @ 18.5%EC was the most effective treatment indicating recorded lowest population of fall armyworm (*Spodoptera frugiperda*). Followed by T₁Spinosad 45% SC (3.46) was the most effective treatment in reducing the population of *S.frugiperda* which is in line with the findings of **Belay et al., (2012)**, **Sharma et al., (2018)** and **Rebeca et al., (2018)**.

In the present research work lowest percent of maize fall armyworm population was recorded in T₂Chlorantraniliprole@18.5%EC(51.50q/ha)thesefindingsweresupportedby **Bharadwajet al., (2020)**, **Dileep et al., (2020)** and **Jeyarajan et al., (2021)** followed by T₁Spinosad 45% SC (45.50 q/ha) these findings were supported by **Siddhartha et al., (2019)** and **Sharma et al., (2018)**, T₄Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole@ 18.5% EC (46 q/ha.) and T₃Emamectin benzoate @ 5% SG (40 q/ha) these findings were supported by **Mallapur et al., (2019)**and**Rebecaetal.,(2018)**.Thenextbesttreatmentwas T₆Lambdacyhalothrin@2.5%EC (37 q/ha) which is in line with the similar findings of **Ingavale (2021)** and **Nboyineet al., (2020)**.T₅Flubendiamide @ 39.35 SC (35.18 q/ha) which is in line with the similar findings of **Sangleetal.,(2020)**,**Deshmukh etal.,(2018)**and**RameshandTayde(2022)**.

Whencost-benefitrationiowasworkedout, aninterestingresultwasachieved.Amongthetreatments studied,thebestandmosteconomicaltreatmentwasT₂Chlorantraniliprole@18.5%EC(1:2.96).

T₁Spinosad 45 SC (1:2.82) was found to be the next best treatment followed by T₄ Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC (1:2.60), T₃ Emamectin benzoate @ 5%SG(1:2.53), T₆ Lambdacyhalothrin@2.5%EC(1:2.36), T₅Flubendiamide39.35%EC(1:1.81) and T₇ Neem oil 1500 ppm (1:1.74) as compared to control plot (1:1.52).

Conclusion

From the analysis of the present findings of the field efficacy of certain chemicals and botanicals against fall armyworm [*Spodoptera frugiperda*] on maize *zea mize* (Linn.), it can be concluded that T₂ Chlorantraniliprole @ 18.5% EC is more effective in controlling population of maize fall armyworm followed by T₁ Spinosad 45% SC, T₄ Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC, T₃ Emamectin benzoate @ 5% SG, T₆ Lambda cyhalothrin @ 2.5% EC, T₅ Flubendiamide @ 48% SC and T₇ Neem oil 1500 ppm managing *Spodoptera frugiperda*.

Among the treatments studied was T₂ Chlorantraniliprole @ 18.5% EC (1:2.96 and 51.52 q/ha.). T₁ Spinosad 45 SC (1:2.82 and 45.40 q/ha.) was found to be the next best treatment followed by T₄ Lambda cyhalothrin @ 2.5% EC + Chlorantraniliprole @ 18.5% EC (1:2.60 and 46 q/ha.), T₃ Emamectin benzoate @ 5% SG (1:2.53 and 40 q/ha.), T₆ Lambda cyhalothrin @ 2.5% EC (1:2.36 and 37 q/ha.), T₅ Flubendiamide 39.35% EC (1:1.81 and 35.18 q/ha) and T₇ Neem oil 1500 ppm (1:1.74 and 28.82 q/ha.) as compared to control plot (1:1.52 and 22.26 q/ha.). as such more trials are required in future to validate the findings.

REFERENCES

Bharadwaj, G. S., Mutkule, D. S., Thakre, B.A. and Jadhav, A. S. (2020). Bio-efficacy of different insecticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on Maize. *Journal of Pharmacognosy and Phytochemistry*, **9**(5): 603-607.

Chandar, A. S., and Tayde, A. R. (2023). Field Efficacy of Insecticides against Fall Army Worm, *Spodoptera frugiperda* (J.E. Smith) on Maize (*Zea mays* L.). *International Journal of Environment and Climate Change*, **13**(11), 3010-3020.

Divya, J., Kalleshwaraswamy, C. M., Deshmukh, S., Ambarish, S. and Sunil, C. (2021). Evaluation of whorl application of insecticides mixed with sand against fall army worm *Spodoptera frugiperda* in maize. *Indian Journal of Entomology*, **84**(3):617-621.

Deshmukh, S., Pavithr, A.H.B., Kalleshwaraswamy, C.M., Shivanna, B.K. and Maruth, M. S. (2018). Field efficacy of insecticides for management of invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on maize in India. *Florida Entomological Society*, **103**(2): 221-227.

Dileep, N. T., Murali K., Prabhu C., Ganiger. and Mahesh, H. M. (2020). Safe and cost-effective management of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) using green insecticide baits. *International Journal of Chemical Studies*, **8**(5): 106-110.

Ingavale, D. (2021). Control of Fall Armyworm (*Spodoptera frugiperda*) by Using Some Selective Chemical Insecticides. *International Journal of Innovative Science and Research Technology*, **6**(2): 2456-2165.

Kachave, S. B. and Tayde, A. R. (2023). Efficacy and economics of selected chemicals and biopesticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize (*Zea mays* L.). *Journal of Experimental Zoology India*, **26**(2).

Kalleshwaraswamy, C. M., Asokan, R., Swamy, H. M., Maruthi, M. S., Pavithra, H. B., Kavita, H. and Goergen, G. (2018). First report of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), an alien invasive pest on maize in India. *Pest Management in Horticultural Ecosystems*, **24**(1), 23-29.

Mallapur, C.P., Naik, A.K.S., Hagari, T., Praveen. and Naik, M. (2019). Laboratory and field evaluation of new insecticide molecules against fall armyworm, *Spodoptera frugiperda* (J.

E.Smith)onmaize. *JournalofEntomologyandZoologyStudies*,**7**(5):729-733.

Nagesh, C. and Tayde, A. R (2023). Efficacy of different Chemicals and Neem Products against Fall Army worm,[*Spodoptera frugiperda*(JE Smith)] in Maize (*Zea mays* L.) *Biological Forum – An International Journal* **15**(6): 432-436.

Panigrahi, C. K., Yadav, U. and Sarangi, D. (2023). Field Efficacy of Certain Insecticides against Fall Army worm, *Spodoptera frugiperda*(JESmith)onMaize(*Zeamays*L.)under Prayagraj Region of India. *International Journal of Environment and Climate Change*, **13**(9), 1207-1215.

Patidar, S., Das, S. B., Vishwakarma, R., Kumari, P., Mohanta, S. and Paradkar, V. K. (2022). Field evaluation of insecticides against fall army worm infesting maize. *The Pharma Innovation Journal*, **11**(4): 892-895.

Ramesh, M. and Tayde, A. R. (2022). Comparative efficacy of selected chemicals and biopesticides against fall army worm, *Spodoptera frugiperda*(J.E.Smith)onmaize(*Zea mays*L.). *International Journal of Plant and Soil Science*, **34**(23):466-470.

Sangle. S. V., Jayewar, N. E. and Kadam, D. R. (2020). Efficacy of insecticides on larval population of fall army worm, *Spodoptera frugiperda* on maize. *Journal of Entomology and Zoology Studies*, **8**(6): 1831-1834.

Suthar, M., Zala, M. B., Varma, H. S., Lunagariya, M., Patel, M. B. and Borad, B. P. P. (2020). Bioefficacy of granular insecticides against fall army worm, *Spodoptera frugiperda*(JESmith) in maize. *International Journal of Chemical Studies*, **8**(4):174-179.

Viteri, D. M., Linares, A. M., Cabrera, L. and Sarmiento, L. (2019). Presence of corn earworm and fall army worm (Lepidoptera: Noctuidae) populations in sweet corn and their susceptibility to insecticides in Puerto Rico. *Florida Entomology*, **102**(2):451-454.

Zhao, Y. X., Jing Mei, Huang Huan, Ni, Guo D. L., Feng, Yang, Xin, Wang Shun, Fan Wu. and Cong, Fen Gao. (2020). Susceptibility of fall army worm, *Spodoptera frugiperda*(J.E.Smith), to eight insecticides in China, with special reference to lambda-cyhalothrin. *National Center for Biotechnological Information*, **168**:104-623.