Original Research Article

"Efficacy and economics of certain insecticides and neem oil against tomato fruit borer, *Helicoverpa armigera* (Hubner) on tomato"

ABSTRACT

The current study was carried out at Kothapalli village Ananthpur District, Andhra Pradesh, India, in Randomised Block Design, each replicated thrice during the *kharif* season of 2021. Two applications were used against *Helicoverpa armigera* (Hubner), and the results revealed that the highest incremental percent reduction of larvae was recorded in the plot treated with T_6 Indoxacarb 14.5% SC (48.47) which was at par with T_4 Spinosad 45%SC (42.24), T_2 Emamectin benzoate 5%SG (33.7), T_3 Chlorantraniliprole 18.5%SC (33.17), T_1 Flubendamide 480 %SC (30.89), T_7 Fipronil 5%SC (29.42) and T_5 Neem oil 4% (25.06) is found to be least effective than all other treatments. Cost-benefit ratio were found highest in Indoxacarb 14.5% SC (1:12.6), followed by Spinosad (1:11.7), Emamectin benzoate 5% SG (1:9.85), Chlorantraniliprole 18.5%SC (1:9.82) Flubendiamide 480 SC (1:8.7), Fipronil 5% SC (1:6.7), Neem oil 0.03% EC (1:7.9) as compared to control T0 (1:5.06).

Comment [A1]: Dear author, I have , in addition to the review of your manuscript, modified some of the sentences for correctness of grammar, easy flow, correct punctuation, and readability.
Do feel free to contact me if the modificaions have altered your intended meanings.

Keywords: Benefit-Cost ratio, *Helicoverpa armigera*, Tomato fruit borer.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetables in the world, ranking second in importance to potatoes in many countries. It is a warm-season crop and native of Peru and Mexico. It is grown as an off-season vegetable in the hills of India, and farmers fetch good income after sending their produce to the plains from June to September. It is popularly known as Wolf apple, Love of apple or *Vilaayati baingan*. **(Choudhary, 2002)[3].** It ranks the third largest vegetable crop after potato and sweet potato, but it's top in the list of canned vegetables. It can be used fresh in salad, curries or by bi-product like *chutney*, pickle, soups, ketchup, sauce, powder, *purees* and as a whole *etc.* **(Patil *et al.*, 2018)[15]**. In terms of nutrition, tomato contains a double amount of nutritive elements compared to apple. It is the cheapest source of vitamins (A, B and C), minerals like calcium and proteins, which the majority of people can buy easily **(Bose and Som, 1990; Pedro and Ferreira, 2007)**[2]. Lycopene in ripe tomatoes is a potent antioxidant that reduces the risk of prostate cancer in humans**.** Regular consumption of tomatoes can prevent short-sightedness, night blindness, and other eye diseases. It is also helpful in preventing joint pain problems and respiratory disorders as well **(Friedman, 2013)**[5]**.**

Globally, India ranks second in tomato production after China. The area under cultivation of vegetables was 10383 thousand hectares with a production of 179692 thousand metric tons during 2017-18. In India, tomato was grown in an area of 786 thousand hectares with a production of 19377 metric tons during 2017- 18. Around 11% of the total world production of tomatoes is cultivated in India. Andhra Pradesh still holds the top position in tomato production, even after the creation of Telangana.

The important insect pest of tomato is fruit borer, *Helicoverpa armigera* (Hubner); whitefly, *Bemisia tabaci* (Gen); jassids, *Amrasca devastans* (Ishida); leaf miner, *Liriomyza trifolii* (Blanchard); potato aphid, *Myzus persicae* (Thomas) and hadda beetle, *Epilachana dedecastigma* (Widemann). But in India, the fruit borer is one of the most important pests of tomato, limiting production and the market value of crop production. The fruit borer, *Helicoverpa armigera* (Hubner), is the most destructive pest of tomato in India, which is commonly known as gram pod borer, American bollworm and fruit borer **(Meena and Raju, 2014)**[12]**.**

Young larvae feed voraciously on foliage, flower buds and flowers, while the later instars of these insects bore into fruit and render them unmerchantable. Due to its wider host range, multiple generations, migratory behavior, high fecundity and existing insecticide resistance, this insect has become a difficult pest to handle. All over the world, this pest alone causes an annual loss of 5 billion US dollars.

The problem of pests is magnified due to its direct attack on fruiting structure, voracious feeding habits, high mobility, fecundity and multivoltine overlapping generations. Losses solely due to this pest up to Rs. 10,000 million have been reported in various crops like chickpea, cotton, pigeon pea, groundnut, tomato and other crops of economic importance. Tomato being a commercial vegetable crop, farmers have a tendency to overuse and even abuse insecticide in an over-ambitious approach to knock down this destructive pest. As a result, it has caused turbulence in the Agri-ecosystem. It has led to many problems like the buildup of insecticide resistance, pest resurgence, reduction or killing of natural enemies and insecticide residue in the tomato fruit. In such a situation, a newer group of insecticides and biological insecticides offer great scope as they maintain higher toxicity to insects at lower doses and are not persistent as the conventional group of insecticides**.** Several new groups of insecticides like Indoxacarb, Fipronil, and Spinosad, belonging to a novel class of insecticides, have been introduced which have unique chemical structures and have been reported to be effective against insect pests of many crops. These are also reported safe to natural enemies and the environment. In order to avoid the adverse consequences of traditional insecticides on a non-target organism, environmental pollution, health hazard and the development of resistance, it becomes necessary to evaluate the new insecticides which not only safe for natural enemies and the environment but also effective at very low doses.

MATERIALS AND METHODS

The field experiment was conducted during the *kharif* season of 2021 at Kothapalli village Ananthpur District, Andhra Pradesh, India, in Randomised Block Design, each replicated thrice. The experiment was laid out in RBD with 8 treatments comprising of Flubendamide 480 %SC (100 ml/lit), Emamectin benzoate 5%SG (0.4 g/lit), Chlorantraniliprole 18.5%SC (0.4 ml/lit), Spinosad 45%SC (0.3 ml/lit), Neem oil 4% EC (40ml/lit), Indoxacarb 14.5%SC (0.65 ml/lit), Fipronil 5%SC (1.5 ml/lit) and untreated control. All the treatments were randomly distributed among the plots and replicated three times. Observations were recorded on healthy and infected fruits on 5 randomly selected plants in each plot. The incidence of the pest was recorded one day before the spray as pre-treatment observations taken on the first observation were recorded before the spray of each plot, and 3,7 and 14 after each spray. After the last picking, all pickings of individual plots produced were calculated to work out the yield of the treatments. The yield of healthy fruits was converted into quintal per hectare. As the experiment was conducted on fruit borers, the economics of the treatments were calculated in terms of the cost-benefit ratio.

Percent reduction by fruit borer

The total number of infested and uninfested plants at the fruiting stage was counted from the five selected plants of each plot. Thus the larva was calculated using the formula:

$$\text{Per centage reduction} = \frac{\text{Control- Treatment}}{\text{Control}} \text{X100}$$

Benefit-cost ratio

Gross returns were calculated by multiplying the total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns to find out the net returns and cost-benefit ratio by the following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Gross return}}{\text{Total cost}}$$

RESULTS AND DISCUSSION

The present study is entitled, **"Efficacy and economics of certain insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner)".** The data so obtained through observation of various aspects were subjected to statistical analysis wherever necessary, and the compiled mean data are tabulated in the following pages.

The data on the percent population reduction of fruit borer on the mean (3^{rd}, 7^{th} and 14^{th}) day after the first spray revealed that all treatments were significantly superior to control. Among all the treatments highest percent population reduction of fruit borer was recorded in T_6 Indoxacarb 14.5 %SC (67.85), followed by T_4 Spinosad 45% SC (65.71), T_3 Chlorantraniliprole 18.5% SC (58.52), T_2 Emamectin benzoate 5% SG (51.85) T_7 Fipronil 5%SC (50.07) T_1 Flubendiamide 480% SC (44.5) and T_5 Neem oil 4 % EC (40.48)was found to be least effective than all the treatments and is significantly superior over the control.

Comment [A2]: Dear author, all abbreviations must be de4fined at first use.List of abbreviations should be provided.

The data on the percent population reduction of fruit borer on the mean (3^{rd}, 7^{th} and 14^{th}) day after the second spray revealed that all treatments were significantly superior to control. Among all the treatments highest percent population reduction of fruit borer was recorded in T_6 Indoxacarb 14.5% SC (48.58), followed by T_4 Spinosad 45% SC (42.4), T_2 Emamectin benzoate 5% SG (33.72), T_3 Chlorantraniliprole 18.5%SC (32.77) T_1 Flubendamide 480 %SC (31.04), T_7 Fipronil 5% SC (29.95), and T_5 Neem oil 4% (25.22) was found to be least effective than all the treatments and is significantly superior over the control.

The overall data on the percent population reduction of fruit borer on the overall mean of the first and second spray revealed that all treatments were significantly superior to the control. Among all the treatments highest percent population reduction of fruit borer was recorded in T_6 Indoxacarb 14.5% SC (58.21), followed by T_4 Spinosad 45% SC (54.05), T_3 Chlorantraniliprole 18.5%SC (45.64), T_2 Emamectin benzoate 5% SG (42.78), T_1 T_7 Fipronil 5% SC (40.01), Flubendamide 480 %SC (37.77), and T_5 Neem oil 4% (32.85) was found to be least effective than all the treatments and is significantly superior over the control.

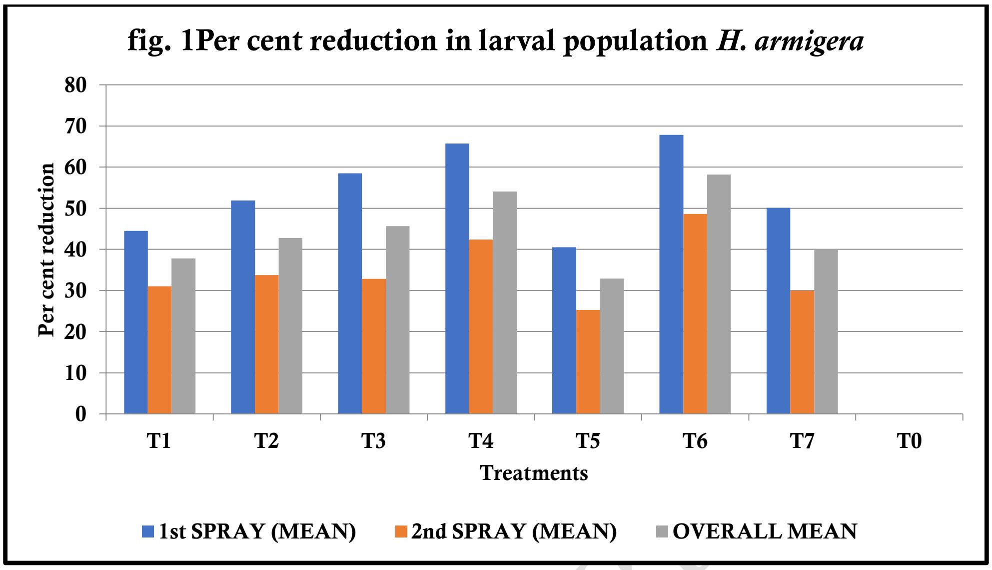
All the treatments were found to be significantly superior to control in reducing fruit infestation. The maximum larval population reduction was recorded in Indoxacarb. The results were similar to the findings reported by **Reddy *et al.* (2021)[16], Singh *et al.* (2017)[21], Wajid *et al.* (2016)[23]** spinosad **was** found to be the next best. The results of Spinosad were supported by **Islam *et al.* (2020)[7], Meena *et al.* (2014)[12], Sushma *et al.* (2016)[22], Sharma and Kumar *et al.* (2020)[20].**

Emamectin benzoate was found to be the next best effective treatment. These results were similar to the findings of **Khademul *et al.* (2020)[9]**, **Kumar *et al.* (2015)[11].** Chlorantraniliprole was found to be the next best effective treatment. These results were similar findings of **Reddy *et al.* (2019)[17], Patil *et al.* (2018)[15], Sapkal *et al.* (2018)[18].** Flubendiamide was found to be the next effective treatment, and its results are supported by **Jat *et al.* (2013)[8], Kubendran *et al.* (2008)[10]** and **Deshmukh *et al.* (2010)[4].** Fipronil is found to be an effective treatment, and the results were similar to findings reported by **Ghosal *et al.* (2016)[6]**, **Satish *et al.* (2018)[19]** and **Meena *et al.* (2014)[12].** Neem oil was found to be effective in reducing the larval population, and the results were supported by **Bhati *et al.* (2020)[1].**

A higher yield (226q/ha) and higher cost-benefit ratio (1:11.6) were obtained from Spinosad, and the lowest was in the control plot (100q/ha). Similar findings made by **Nitharwal *et al.* (2017)[13]** recorded the highest cost-benefit ratio. **Pal *et al.* (2018)[14]** reported that Indoxacarb is the best and most economical treatment recorded (220q/ha) and cost-benefit ratio (1:10.6). **Khademul *et al.* (2020)**[9] reported that the highest grain yield was recorded in Emamectin benzoate and cost-effectiveness of Emamectin benzoate was also very high and very favorable with incremental benefit ratio. **Sapkal *et al.* (2018)**[18] reported that the cost-effectiveness of clorantranpriole was high with a cost-benefit ratio. Recorded yield (200q/ha) and cost-benefit ratio (1:9.03).

Table 1. Comparative ~~efficacy~~ Efficacy of certain insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner)

Treatment		Before spray (Average mean of larva/5 plants)	Per cent reduction of larvae of *H. armigera* / 5 Plants				Percent reduction of larvae of *H. armigera* / 5 Plants				Overall Mean
			First Spray				Second Spray				
			3rd DAS	7th DAS	14th DAS	Mean	3rd DAS	7th DAS	14th DAS	Mean	
T_1	Flubendamide 480 %SC	3.33	53.59	41.04	38.87	44.5	36.56	28.83	27.75	31.04	37.77
T_2	Emamectin benzoate 5%SG	3.06	59.28	46.29	49.98	51.85	39.45	31.54	30.19	33.72	42.78
T_3	Chlorantranilprole 18.5%SC	3.46	67.22	58.22	50.14	58.52	36.41	31.67	30.24	30.24	45.64
T_4	Spinosad 45%SC	3	77.29	61.44	58.42	65.71	47.18	38.92	41.10	42.40	54.05
T_5	Neem oil 4%	3.33	45.72	37.21	38.53	40.48	30.48	22.96	22.23	25.22	32.85
T_6	Indoxacarb 14.5%C	3	75.2	65.05	63.31	67.85	53.24	44.66	47.84	48.58	58.21
T_7	Fipronil 5%SC	3.26	55.45	48.14	46.64	50.07	34.97	25.86	29.03	29.95	40.01
T_0	Control	3.2	0	0	0	0	0	0	0	0	0
	F-test	**NS**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
	C.D. at 5%	**NS**	**7.632**	**8.373**	**8.526**	**6.033**	**0.237**	**0.254**	**0.332**	**0.232**	**16.008**
	S.Ed. (+)	**0.243**	**34.56**	**29.07**	**27.51**	**30.27**	**22.36**	**18.80**	**19.93**	**20.30**	**19.95**



Efficacy and economics of certain insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner) (Over all mean)

Table: 2. Comparative ~~efficacy~~ Efficacy of certain insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner) on Economics and benefit cost ratio.

Treatments	Yield (q/ha)	Selling price (Rs/q)	Gross return (Rs)	Total cost of cultivation (Rs)	Net return (Rs)	B: C Ratio
Spinosad 45%SC	240 q/ha	2000	480000	40689	439311	1:11.7
Indoxacarb 14.5% SC	260q/ha	2000	520000	41051	478949	1:12.6
Chlorantranilprole 18.5%SC	200q/ha	2000	400000	40701	359299	1:9.82
Emamectin benzoate 5%SG	210q/ha	2000	420000	42636	377364	1:9.85
Flubendamide 480 %SC	180 q/ha	2000	360000	41301	318699	1:8.71
Fipronil 5%SC	140 q/ha	2000	280000	41651	238349	1:6.72
Neem oil 4%	130 q/ha	2500	325000	40801	284199	1:7.9
Control	100 q/ha	2000	200000	39451	160549	1:5.6

Yield q/ha

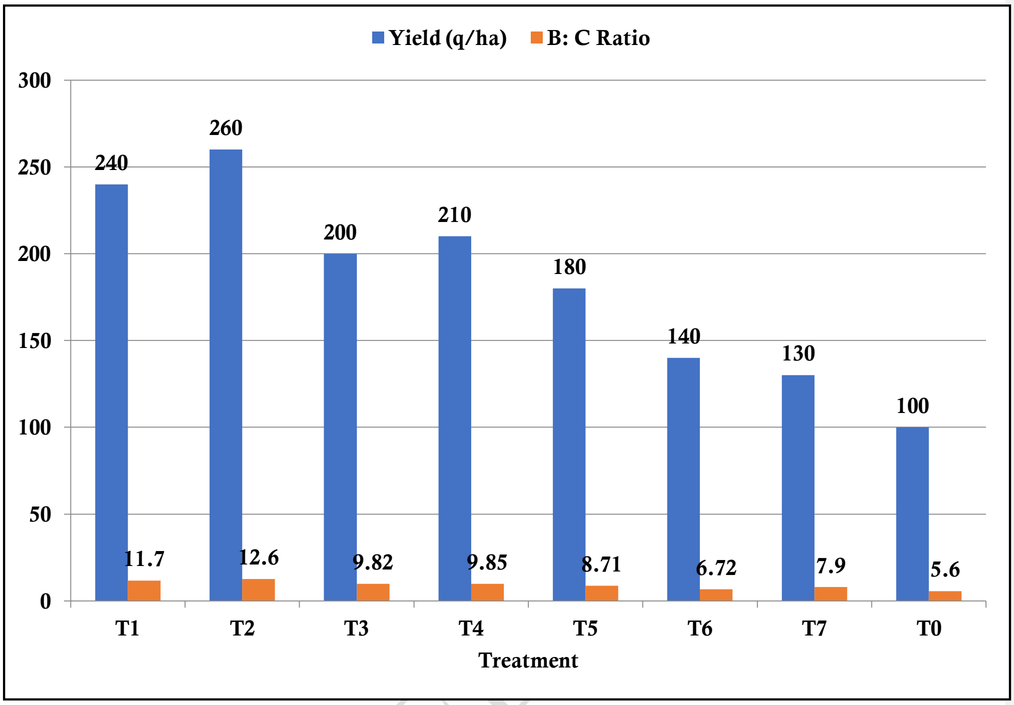


Figure 2 : Treatment wise Yield (q/ha) ratio

Economics of various Treatments: -

Higher cost benefit ratio (1:12.6) was obtained from Indoxacarb and lowest in control plot (100q/ha). Similar findings made by **Nitharwal *et al.*, (2017)**, recorded the highest cost benefit ratio. **Pal *et al.*, (2018)** who reported that the Spinosad is the best and most economical treatment recorded (210q/ha) and cost benefit ratio (1:9.85). **Khademul *et al.*, (2020)** reported cost highest grain yield was recorded in Emamectin benzoate and cost effectiveness of Emamectin benzoate was also very high and very favorable with incremental benefit ratio. **Sapkal *et al.*, (2018)** reported that cost effectiveness of clorantraniliprole was high with cost benefit ratio. Recorded yield (200q/ha) and cost benefit ratio (1:9.82).

Conclusion :

Results showed that among all the treatments highest per cent population reduction of fruit borer was recorded in T_6 Indoxacarb 14.5% SC (58.21) which was significantly superior over the control followed by T_4 Spinosad 45% SC (54.05) and T_3 Chlorantraniliprole 18.5%SC (45.64) was least effective treatment against gram pod borer with highest mean larval population 2.25 of *Helicoverpa armigera* due to their mode of action compare to other selected Insecticides and Neem product.

REFERENCES

1. **Bhati. R., Singh. R. and Singh. G., (2020).** Efficacy of Bio-pesticide and Novel Insecticides against Tomato Fruit Borer (*H. armigera*). *International Journal of Current Microbiology and Applied Sciences*, 11:2889-2896.

2. **Bose, T. K. and Som. M. G., (1990).** Vegetable crops in India, Naya Prokash, 206, Bidhan Sarani, Calcutta, India. p. 249.

3. **Choudhary, R., Kumar, A., Jat, G.C., Vikram. and Deshwal, H.L. (2017)**. Comparative Efficacy of Certain Bio-Pesticides against Tomato Fruit Borer, *Helicoverpa armigera* (Hub.). *International Journal of Current Microbial Applied Sciences.* **6**(8): 1068- 1081.

4. **Deshmukh, S.G., Sureja, B.V., Jethva, D.M. and Chatar, V.P. (2010)**. Field efficacy

of different insecticides against *Helicoverpa armigera* (Hubner) infesting chickpea. *Legume Research*. **33**(4): 269 – 273.

5. **Friedman, M. (2013).** Anticarcinogenic, Cardioprotective, and Other Health Benefits of Tomato Compounds Lycopene, α-Tomatine, and Tomatidine in Pure Form and in Fresh and Processed Tomatoes. *Journal Agriculture Food Chem,***61**:9534-9550.

6. **Ghosal, A., Dolai, A.K. and Chatterjee, M. (2016).** Plethora (Novaluron + indoxacarb) insecticide for the management of tomato fruit borer complex. *Journal of Applied and Natural Science.* **8** (2):919-922.

7. **Islam, M.M., Nasrin, S., Mannan, M.A. and Khan, S.A.K.U. (2020).** Evaluation of Tomato Varieties Against Resistance to Fruit Borer (Helicoverpa Armigera Hub.)January 2021SAARC *Journal of Agriculture* **18**(2):87-99

8. **Jat, S.K. and Ameta O.P. (2013)**. Relative ~~efficacy~~ Efficacy of biopesticides and newer insecticides against *Helicoverpa armigera* (hub.) in tomato. *The Bioscan.* **8**(2):579-582.

9. **Khademul, MD.I., Howlader, M.T.H. and Ahmed, K.S. (2020)**. Management of *Helicoverpa armigera* (Hubner) infesting tomato using bio-pesticides under field condition and its effect on tomato yield. *Journal of Bangladesh Agriculture University.* **18**(1):1-5.

10. **Kubendran, D., Bojan, V. and Kuttalam, S. (2008).** Evaluation of flubendiamide 480 SC against tomoto fruit borer *Helicoverpa armigera* (Hubner). *Pestology*. **32**(10) 54-57.

11. **Kumar GVS and Sarada O.(2015).** Field efficacy and economics of some new insecticide molecules against lepidopteran caterpillars in chickpea. Journal of Current Biotica 2015; **9**(2):153-158.

12. **Meena, L.K and Raju, S.V.S. (2014)**. Bio efficacy of newer insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner) on tomato, *Lycopersicon esculentum* mill under field conditions. *International Quarter Journal of Life Science*. **347**-350.

13. **Nitharwal, R.S., Kumar, A., Jat, S.L. and Chula, M.P. (2017)**. Efficacy of newer molecules against gram pod borer, *Helicoverpa armigera* (Hub.) on chickpea (*Cicer arietinum* L.). *Journal of Pharmacognosy and Phytochemistry*. **6**(4): 1224-1227.

14. **Pal, S., Singh, D.K., Umrao, R.S. and Sharma, O. (2018)**. Eco-Friendly Management of Tomato Fruit Borer, *Helicoverpa armigera* under Hill Condition, Uttarakhand, India. *International Journal of Current Microbiology and Applied Sciences.* **7**(10): 3008- 3013.

15. **Patil, P.V., Pawar, S.A., Kadu, R.V. and Pawar, D.B., (2018).** Bio-efficacy of newer insecticides, botanicals and microbial against tomato fruit borer *Helicoverpa armigera* (Hubner) infesting tomato. *Journal of Entomology and Zoology Studies*. **6**(5):2006- 2011.

16. Reddy R.D., Kumar A., and Sai K.P., (2021). Field efficacy of some insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner). *Journal of Entomology and Zoology Studies*. **9**(1): 1434-1436.

17. **Reddy, K.V.N., Lekha, A.V. and Chhangani, G. (2019)**. Bio-efficacy of insecticides against fruit borer, *Helicoverpa armigera* (Hub.) infesting tomato (*Solanum lycopeRsicum* L.). *Indian Journal of Applied Entomology.* **33**(1):24-28.

18. **Sapkal, S.D., Sonkamble, M.M. and Gaikwad, B.B. (2018).** Bio efficacy of newer insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner) on tomato, *Lycopersicon esculentum* (mill) under protected cultivation. *International Journal of Chemical Studies.* **6**(4):3326-3330.

19. **Sathish, B.N., Singh, V.V., Kumar, S. and Kumar, S. (2018)**. Efficacy of different chemical insecticides and bio-pesticides against tomato fruit borer *Helicoverpa armigera* (Hubner) on tomato crop. *Bulletin of Environmental Pharmacol and Life Sciences*. **7**(12): 107-110.

20. **Sharma, V.G. and Kumar, S., (2020).** "Bio-efficacy of different insecticides against fruit borer (helicoverpa armigera hubner) and its impact on yield of tomato (*Lycopersicon esculentum* mill.)", ijrar - *International Journal of Research and Analytical Reviews.* **7** (2): 380-386

21. **Singh, N., Dotasara, S. K., Kherwa, B. and Singh, S. (2017**). Management of tomato fruit borer by incorporating newer and biorational insecticides. *Journal of Entomology and Zoology Studies*. **5**(2): 1403-1408.

22. **Sushma, D**. **and Bharpoda (2016)**. Field evaluation of biopesticides against *Helicoverpa armigera* (Hubner) in tomato, *Lycopersicon esculentum* Mill. Under middle Gujarat

condition. *International Journal of Applied Agriculture and Horticulture Sciences.* **8**(1):1266-1518.

23. **Wajid, H., Chhibber, R.C. and Singh, C.P. (2016)**. Effect of Indoxacarb against tomato fruit borer (*Helicoverpa armigera* Hub.) and phytotoxicity to tomato plants. *Advances in Plants and Agriculture Research.* **3**(2):51-54.