Original Research Article

Field efficacy and economics of different insecticides against tomato fruit borer [*Helicoverpaarmigera* (Hubner)]

ABSTRACT

ThefieldexperimentonEfficacy and economics ofdifferentinsecticidesagainsttomatofruitborer[*Helicoverpaarmigera*(Hubner)]wasconducteddurin g*rabi*2021-2022,atCentralResearchField,DepartmentofEntomology,SHUATS,Naini,Prayagraj, U.P.Thedataonincrementalpercentreductionofdifferenttreatmentsrevealedthattheт5 Spinosad 45%SC(81.379)followedbyT1 Indoxacarb14.5%SC(75.140),T7 Emamectinbenzoate5%SG(74.634), T2 Flubendiamide 39.5% SC (68.634), T3 Novaluron 10%EC (65.647), T4 Fipronil 5% SC(54.225), T6 Neem oil 0.03% EC (49.533) found to be least affective than all other treatments.Among the treatment studied the bestand most economical treatment was Spinosad (1:6.72), Indoxacarb 14.5% SC 14.5SC (1:6.42),followedbyEmamectinbenzoate5%SG(1:6.3),Novaluron45%SC(1:5.09),Flubendiamide 20%WG (1:4.45), Fipronil5%SC(1:7.9),(1:3.92),Neemoil 0.03% EC(1:3.45)ascompared to control T0 (1:3.04).

Key words: -Efficacy, Economics, Insecticides, *Helicoverpa armigera*, Tomato fruit borer.

Comment [IG1]: I think it is rather …efficient

Comment [IG2]: treatments

INTRODUCTION

Tomato, *Solanum lycopersicon* (Miller) is one of the most important herbaceous crops belonging to the*Solanaceae* family. It is popularly known as wolf apple, love of apple or Vilaayati baingan. It ranks thirdlargest vegetable crop after potato and sweet potato, but it tops in the list of canned vegetables. It can beused fresh in salad, curries or by-product like chutney, pickle, soups, ketchup, sauce, powder, purees andasawholeetc. **(Patil *et al.*,2018)[12].**

This crop is severely attacked by various insect pests *viz.*, fruit borer, *Helicoverpa armigera* (Hubner):whitefly, *Bemisia Tabaci* (Gennadius); aphid, *Aphis gossypii* (Glover); leaf eating caterpillar, *Spodopteralitura* (Fabricius); American serpentine leaf miner, *Liriomyza trifolii* (Burgess) and red spider mite,*Tetranychus urticae* (Koch) Ignacimuthu. Among these, fruit borer, *Helicoverpa armigera* is an importantpest responsible for major yield loss in tomato. *Helicoverpa armigera* has attained the status of nationalpest in recent years in the form of economic damage caused to different agricultural crops throughoutIndia.**(Sathish*et al.*, 2018)[16]**

The *Helicoverpa armigera* (Huner) (Lepidoptera: Noctuidae), a highly polyphagous species anda pest of major economic importance on a wide range of crops, particularly cotton, soybeans, tobacco,chickpea and pigeon pea. The polyphagous pest of worldwide occurrence inflicting annual crop damagein India worth US $1 billion.This pest accounts for the consumption of half of the total insecticide usedin India for protection of different crops. In Tamil Nadu, losses of fruit range 40-50%. Similarly, inNorthernIndia,30%lossofthefruitwasobservedduetotomatofruitworm.reported5–55%lossesfromthis insect pest in the tomato growing areas of India.Tomato fruit worm has also caused 35% yield lossintomato and 37.79%specifically inKarnataka,India. **(Wajid *et al.*,2016)[21].**

Comment [IG3]: is a highly…..
cut the comma

Comment [IG4]: Who said that? Mention a source and put it in the References list at the end.

Comment [IG5]: The phrase should be reformulated. It's not coherent. I suggest:
<The pest is polyphagous with a wide worldwide distribution. In India alone, it causes $1 billion worth of damage annually.>

Comment [IG6]: My suggestion:
<Half of all insecticides used in India for the protection of various crops are used for this pest. >

Comment [IG7]: My suggestion:
<In Tamil Nadu, fruit losses range from 40 to 50%>

Comment [IG8]: The percentage is not similar if it is 30%, it is actually lower, 40-50%. Do not use similar but simple: In Northen India….

Comment [IG9]: Source? Who said that?

Comment [IG10]: something is missing from the sentence
please provide all information

Comment [IG11]: This phrase is ambiguous. What did you mean by the percentage of 37.79...is it for another crop or for tomatoes? Maybe you wanted to say that the percentage varies between 35 and 37.79 especially in....???

Comment [IG12]: You have several ideas and a single reference, which is not enough. Add more references.

MATERIALSANDMETHODS

The experiment is conducted during the *Rabi* season 2021- 2022 at SHUATS, CentralResearchfield, Prayagraj, is situated at 25.27^0 North latitude 80.50^0 East longitude and at an altitudeof98mt. above sea level in a randomized block design with eight treatments replicated three timesusingavariety**Lakshmi**wereboughtfromPrayagrajusedforfieldtrail.Thesowingwasdoneonthe15th Nov2021.Seed rate400-500 g/ha.Theseedlingsofthe onemonth theretransplantedplant toplant and row to row spacing of 60 X 45 cm was maintained. Gap filling was done 10 days after toseeuniform plant population ineach plot.

Fertilizerswereappliedattherateofhalfdoseofnitrogenandfulldoseofphosphorousandpotassiumwas given at the time of transplanting. The remaining dose of nitrogen was applied one month aftertransplanting.Fertilizerswere applied alongthefurrows intheformofurea,DAPandMOP.

The crop was sown in *Rabi* season 2021-2022, one main irrigation channel of 1m width prepared inthe experimental field and two sub irrigation channels of 0.5 m each were made tomeet out theirrigation requirement. Crop depends on rainy water but irrigation was practiced to meet the waterrequirements.

Observation were recorded on the number of larvae per 5 plants in 2m row length at 5 differentlocations of all treatments were randomly selected and total number of larvae were recorded 1daybeforeapplicationand3rd 7thand14thdaysafterapplicationineachtreatment.Theresultobtainedareconvertedinto percentlarval populationand reductionpercent withfollowing formula.

Larvalpopulation =No.oflarvae/5plants in2m

$$\textbf{Percentagereductionovercontrol} = \frac{\text{Control-Treatment}}{\text{Control}} \times 100$$

BenefitCostRatio:

Comment [IG13]: Unclear sentence. Please clarify.

Comment [IG14]: What is mean DAP, and MOP?

Comment [IG15]: to meet

Comment [IG16]: Observations

Comment [IG17]: Made
Usually, observations are made not recorded

Comment [IG18]: Who belongs this formula?

Comment [IG19]: I don't understand what the formula wants to reflect? Number of larvae? Or what are you talking about? Give a quantitative and qualitative measure of these factors used in the formula: control, treatment...

Cost effectiveness of each treatment was assessed based on net returns. Net return of each treatmentwas worked out by deducting total cost of the treatment from gross returns. Total cost of productionincludedboth cultivation as well as plantprotection charges.

Grossreturn	=	Marketable YieldxMarketprice
Netreturn	=	Grossreturn–Totalcost
Benefit:Cost Ratio	=	Grossreturn
		Totalcost

RESULTSANDDISCUSSION

Among all the treatments highest percent population reduction of fruit borer was recorded in T5Spinosad45%SC(81.379)thesefindingsareinsupportwith**Reguri*etal*.,(2021)[14],Sushma*etal*.(2016)[19] and Amalendu *et al*.,(2010)[2]**proved their superiority over other insecticides in reducingpercentage of larval population (82.6) followed by T1 Indoxacarb 14.5 %SC (75.140) thesefindingsareinsupportwith**Santosh*etal*.,(2020)[07],Reguri*etal*.,(2021)[14]**provedtheirsuperiority over other insecticides in reducing percentage of larval population (85.04),(65.56)followed by T7Emamectin benzoate 5%SG (74.634) these findings are in support with **Gulam *et al*., (2015)[04],Khademul *et al.* (2020)[05],kumar *et al*.,(2014)[06]**proved their superiority over other insecticides inreducing percentage of larval population(78)and (62.52), T2 flubendiamide 39.5%SC (68.634)these findings are in support with **Gulam *et al*., (2015)[04], Padhan and Raghuraman (2019)[11]**inreducingpercentageoflarvalpopulation(78.10),T3Novuluron10%EC(65.647)thesefindingsare in support with **Satish *et al.* (2018)[16]**and **Singh *et al*.,(2017)[17]**in reducing percentage oflarvalpopulation(61.85),T4Fipronil5%SC(54.225)thesefindings areinsupportwith**Ghosal*etal.* (2016)[3]**, **Meena *et al.* (2014)[08]and Santosh *et al*., (2020)[07]**proved their superiority overother insecticides in reducing percentage of larval population(81.78) and T6 Neem oil 0.03% EC(49.533)supportedwith**Sultana*etal*.,(2015)[09]**and**Ojha*etal*.(2017)[10]**inreducingpercentageoflarvalpopulation(49.2)wasfoundtobeleasteffectivethanallthetreatmentsandissignificantlysuperiorover thecontrol.

The yield among the treatments was significant. The highest yield was recorded in Spinosad 45%SC(250q/ha)followedbyIndoxacarb14.5%SC(220q/ha),Emamectinbenzoate5%SG(210q/ha), Novaluron 10%EC (170q/ha), Flubendiamide 39.5% SC (160q/ha), Fipronil 5% SC(130q/ha), Neem oil 0.03% EC (120q/ha) as compared to T_0 control (100q/ha). When the benefitcost ratio was worked out, interesting results was achieved. Among the treatment studied the bestand most economical treatment was Spinosad (1:6.72), Indoxacarb 14.5% SC 14.5SC (1:6.42),followedbyEmamectinbenzoate5%SG(1:6.3),Novaluron45%SC(1:5.09),Flubendiamide 20%WG (1:4.45), Fipronil5%SC(1:7.9),(1:3.92),Neemoil 0.03% EC(1:3.45)ascompared to

Comment [IG20]: Here is a very very long sentence. Incoherent and repetitive. Please separate each tangible result with a point. Make shorter sentences that have cursive. Do not repeat the same words for each result interpretation (effective insecticide). For example, you used the following expression n times:…<proved their superiority over other insecticides in reducing percentage of larval population>…and others

Comment [IG21]: is it significant? what compared to what?
Better cut it

controlT0(1:3.04).

The present are similar with **Tejaswari and Kumar (2021)[20]**, **Indira *et al*., (2014)[06], Game *etal*.,(2018)[1] and Satish *et al.* (2018)[06]**reported that the cost benefit ratio obtained in Spinosadtreated plot was (1:7.07),(1:0.86),(1:0.78) and (1:11.42).**Hemasreelatha and Yada(2021)[22],Indira*et al*., (2014)[06]**, **Satish *et al.* (2018)[16]**concluded that, in terms of higher cost benefit ratio,Indoxacarbrecorded(1:8.25),(1:0.85)and (1:14.73).,**YadavandHemasreelatha(2021)[22]Sapkal*etal.*, (2018)[15]**observed highest C:B ratio in with Emamectin benzoate 1:6.7,1:5.04. **Reddy *et al*.,(2021)[14],Sapkal*etal.*,(2018)[15]**reportedthatthecostbenefitratioobtainedinNovalurontreatedplot was (1:7.15),(1:0.95).**Tejaswari and Kumar (2021) [20],Ghosal *et al*.,(2012)[2], Meena *etal*.,(2014)[08]** concluded that, in terms of higher cost benefit ratio, Flubendiamide and neem oilrecorded(1:6.4)and (1:5.6).

Comment [IG22]: this paragraph is identical to the one in the abstract, including the mistakes... it must be reformulated

Comment [IG23]: What are you referring to here?
Maybe results???

Table 1: Evaluation of different insecticides on per cent reduction of larvalpopulationoftomatofruitborer,*H.armigera*during*rabi*2021-2022(1st spray)

Treatment		Percent Population reduction of *Helicoverpaarmigera* /Five plants				
		1DBS(No.of.larva/five plants	3 DAS	7 DAS	14DAS	Mean
T_1	Indoxacarb14.5% S	2.33	60.910	76.613	69.343	68.955
T_2	Flubendaimide39.5%SC	2.067	52.793	68.390	61.010	60.731
T_3	Novaluron10%EC	2.467	41.643	56.437	60.713	52.931
T_4	Fipronil5% SC	2.000	28.403	48.317	49.700	42.140
T_5	Spinosad45% SC	2.333	72.100	82.657	76.190	76.982
T_6	Neemoil0.03%	2.000	33.020	45.937	43.450	40.802
T_7	Emamectinbenzoate5%SG	2.267	58.347	72.070	65.473	65.297
T_0	Control	2.200	---	---	---	---
	F-test	**NS**	**S**	**S**	**S**	**S**
	C.D.at 5%		**11.355**	**10.590**	**9.718**	**6.591**
	S.Ed.(+)	**0.040**	**5.211**	**4.860**	**4.459**	**2.66**

Comment [IG24]: The reference in the text (description) of table 1 is missing. Make association with the existing description (where appropriate). These data must be interpreted somewhere.

Comment [IG25]: What is mean DBS? But DAS?
Explain in the description in the text or immediately below the table

Table2:Evaluationofdifferentinsecticidesonpercentreductionoflarvalpopulationofto matofruitborer,*H.armigera*during*rabi*2021-2022(2nd spray)

Comment [IG26]: The reference in the text (description) of table 2 is missing.

Treatment		Per cent Population reduction of *Helicoverpaarmigera* /5plants			
		3rd DAS	7th DAS	14th DAS	Mean
T_1	Indoxacarb14.5% SC	75.422	84.470	84.080	81.324
T_2	Flubendaimide39.5%SC	67.840	81.013	80.757	76.537
T_3	Novaluron10%EC	73.460	80.783	80.847	78.363
T_4	Fipronil5% SC	61.173	71.063	66.690	66.309
T_5	Spinosad45% SC	83.773	92.357	91.203	85.776
T_6	Neemoil0.03%	53.060	63.653	58.087	58.263
T_7	Emamectinbenzoate5%SG	77.647	88.420	85.847	83.971
T_0	Control	---	---	---	---
	F-test	**S**	**S**	**S**	**S**
	C.D.at 5%	**9.416**	**6.760**	**7.702**	**4.464**
	S.Ed.(+)	**4.320**	**3.102**	**3.534**	**2.048**

Figure:1YIELDOFDIFFERENTTREATMENTS(q/ha)

Comment [IG27]: The reference in the text (description) of figure 1 is missing. Make association with the existing description (where appropriate). These data must be interpreted somewhere.

Table:3Economics andbenefitcostratio.

Comment [IG28]: The reference in the text (description) of table 3 is missing.

Treatment Symbols	Yield(q/ha)	Selling price(Rs/q)	Gross return (Rs)	Total cost ofcultivation (Rs)	Net return(Rs)	B: C Ratio
Indoxacarb 14.5%SC	220	1200	264000	41176	222824	1:6.42
Neem oil 0.03%	120	1200	144000	41701	102299	1:3.45
Fipronil 5% SC	130	1200	156000	39783	116217	1:3.92
Emamectinbenzoate 5% SG	210	1200	252000	39951	212049	1:6.3
Novaluron 10%EC	170	1200	204000	40051	163949	1:5.09
Spinosad45% SC	250	1200	300000	44641	255359	1:6.72
Flubendiamide 39.5%SC	160	1200	192000	43051	148949	1:4.45
Control	100	1200	120000	39451	80549z	1:3.04

CONCLUSION

From the above discussion it was found that, spraying of insecticides significantlyreduced thefruit borer population in tomato. The present findings conclude that the new generationinsecticideslikeSpinosad,Indoxacarb,Navuluron,emamectinbenzoateandFlubendiamide,Fipronil
,neemoil were found effective against lepidopteran caterpillar *Helicovera armigera* along with anadditional yield level in tomato. Further, it was observed that the cost benefit ratio was also high withSpinosad and Indoxacarb. Hence, it is suggested that the effective insecticides may be alternated inharmony with the existing Intergrated pest management programes in order to avoid the problemsassociatedwith insecticidalresistance, pestresurgenceetc.

Comment [IG29]: From here it appears that they all had the same level of effectiveness, or the results say otherwise. You refer especially to the most effective ones, because you have had comparative studies. They can't all be very good/effective.

Comment [IG30]: Emamectin

Comment [IG31]: cut

Comment [IG32]: and

Comment [IG33]: programs

REFRENCES

1. **Game,L. , Nagar ,S.and Simon ,S. (2018)** Comparative efficacy of selected chemicalinsecticidesandneemproductsagainsttomatofruitborer[Helicoverpaarmigera(Hubner)]inAllahabad. *Journal ofPharmacognosyand Phytochemistry*.**7**(4): 2215-2218.

2. **Ghosal, A., Chatterjee, M. L. and Manna, D. (2012)**. Studies on some insecticides withnovel mode of action for the management of tomato fruit borer (*Helicoverpa armigera*Hub.).*Journal of Crop and Weed*. **8 (2):**126-129.

3. **Ghosh,A. , Chatterjee,M. and Roy,A.(2010)**Bio-efficacy of spinosad against tomatofruit borer (Helicoverpa armigera Hub.) (Lepidoptera: Noctuidae) and its natural enemies.*Journalof Horticultureand Forestry*.**2**(5): 108-111.

4. **Ghulam, A., Najamul, H., Muhammad, F., Ikramul, H. and Haider, K. (2015).** Effectof selected insecticides on *Helicoverpa armigera* Hubner (*Lepidoptera:* Noctuidae) ontomato (*Lycopersicon esculentum* Miller) and their successful management. *Advances inEntomology*.**3**:16-23.

5. **Khademul,MD.I.,Howlader,M.T.H.andAhmed,K.S.(2020)**.Managementof*Helicoverpa*

armigera(Hubner)infestingtomatousingbio-pesticidesunderfieldconditionanditseffectontomatoyield. *Journal ofBangladeshAgricultureUniversity*.**18(1):**1-5.

6. **Kumar,K.I and Devi,M. (2014)** Field Efficacy, Net Profit and Cost Benefit Ratio ofCertainInsecticidesagainstFruitBorer,Helicoverpaarmigera(Hubner)inTomato.*InternationalJournal of Agriculture, Environment& Biotechnology*. **7**(2):343-346.

7. **Kumar,S. ,Umrao,R.S. , Kumar,A. , Patel V.K. , Debnath,R. and Kumar,A. (2020)**Evaluation of the efficacy of insecticides and biopesticides against *Helicoverpa armigera*(Hubner)on tomato. *Journal of Entomologyand Zoology Studies.* **8**(3): 555-558**.**

8. **Meena,L.K.,Raju,S.V.S.(2014)**.Bioefficacyofnewerinsecticidesagainsttomato fruitborer, *Helicoverpa armigera* (Hubner) on tomato, *Lycopersicon esculentum* mill underfieldconditions. *International Quarter Journalof LifeScience*. **347**-350.

9. **Mustafiz,S.S.B.,Chowdhury,M.T.I.,andAkter,A.(2015)**EfficacyofSomeBotanicalsinControllingFruitBorer(*Heliothisarmigera*)inTomato.*AcademicJournalofEntomology*.**8**(3): 140-149.

10. **Ojha, P.K., Kumari, R. and Chaudhary R.S. (2017)** Field evaluation of certain bio-pesticides against *Helicoverpa armigera* Hubner (Noctuidae: Lepidoptera) and its impacton pod damage and per plant yield of chickpea. *Journal of Entomology and ZoologyStudies*.**5 (2):**1092-1099.

11. **Padhan,S. and Raghuraman,M. (2019)** Bio-efficacy of some contemporary insecticidesagainst Tomato fruit borer Helicoverpa armigera Hubner in Varanasi region. *The PharmaInnovationJournal*.**8**(6):1113-1116.

12. **Patil,P.V. , Pawar,S.A. , Kadu, R.V. ,and Pawar,D.B.(2018)** Bio-efficacy of newerinsecticides, botanicals and microbial against tomato fruit borer *Helicoverpa armigera*(Hubner)infestingtomato. *Journalof EntomologyandZoologyStudies*. **6**(5):2006-2011.

13. **Ravi,k.k., Rao,S.C. , Vemuri,S.B.and Reddy,K.N.(2014)** Bio-efficacy of insecticidesagainst fruit borer (*helicoverpa armigera*) in tomato (*lycopersicomesculentum*).*InternationaljounrnalApplied Biologyand Pharmaceutical technology*.**5**(1):239-243

14. **Reddy,D.R.,Kumar,A.andSai,P.K.(2021)**Fieldefficacyofsomeinsecticidesagainsttomato fruit borer, *Helicoverpa armigera* (Hubner).*Journal of Etomology and ZoologicalStudies***9**(1): 1434-1436.

15. **Sapkal,S.D.,Sonkamble,M.M.andGaikwad,B.B(2018)**Bioefficacyofnewerinsecticidesagainsttomatofruitborer,*Helicoverpaarmigera*(Hubner)ontomato,*Lycopersiconesculentum* (mill)underprotectedcultivation.*InternationalJournalofChemicalStudies*.**6**(4):3326-3330.

Comment [IG34]: point

16. **Sathish,B. N. , Singh,V.V. , Kumar,S. and Kumar,S.(2018)**Efficacy of differentchemical insecticides and bio-pesticides against tomato fruit borer *Helicoverpa armigera*(Hubner)ontomatocrop.*BulletinofEnvironment,PharmacologyandLifeSciences*.7 (12)107-110.

17. **Singh,N. ,Dotasara,S.K. , Kherwa ,B. and Singh, S. (2017)**Management of tomatofruitborerbyincorporatingnewerandbiorationalinsecticides.*JournalofEntomologyandZoologyStudies*. **5**(2): 1403-1408.

18. **Solange,M.,França,J.V.,Oliveira,Badji,C.A.,Guedes,C.A.,Barbara,L.R.,DuarteandBreda,M.O.(2015)**"ResearchIntegratedmanagementoftomatofruitborer(*Neoleucinodeselegantalis*)". *AfricanJournal of Agriculturei*.**10**(10):4561-4569.

19. **Sushma, D. and Bharpoda (2016)** Field evaluation of biopesticides against *Helicoverpaarmigera*(Hubner)intomato,*Lycopersiconesculentum*Mill.UndermiddleGujaratcondition.*InternationalJournalofAppliedAgricultureandHorticulture*Sciences.**8**(1):1266-1518.

20. **Tejeswari,K.andKumar,A.(2021)**Comparativeefficacyofchemicalswithbiopesticidesagainsttomatofruitborer,*JournalofEntomologyandZoologyStudies*.**9**(5):425-429

21. **Wajid, H.,Chhibber,R.C.andSingh,C.P.(2016).**Effectof indoxacarbagainsttomatofruitborer*Helicoverpaarmigera*(Hub.)andphytotoxicitytotomato plants.*AdvancesinPlantsand AgricultureResearch*. **3**(2):51-54.

22. **Yadav,U.andlatha,T.H.S.(2021**)Fieldefficacyofselectedinsecticidesagainsttomatofruitborer [Helicoverpa armigera (Hubner)] on tomato. The Pharma Innovation Journal .**10**(10):841-843

Comment [IG35]: italicized

Comment [IG36]: italicized