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Comparative bio efficacy of weed extracts against tomato fruit borer (*Helicoverpa armigera*) on tomato (*Lycopersicon esculentum*)

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Abstract
Repeated application of synthetic insecticides has resulted into the pest resistance and resurgence of minor pests. Thus, aroused the quest for the search of highly selective and bio-degradable pesticides to solve the problem of long-term toxicity to mammals and techniques to be developed to reduce pesticides use while maintaining crop yield. The present investigation entitled "Comparative bio efficacy of weed extracts against tomato fruit borer (*Helicoverpa armigera)* on tomato (*Lycopersicon esculentum*)" was carried out in Department of Entomology, SHUATS, Naini, Prayagraj (211007) U.P during the *rabi* season 2018-2019. Field studies were conducted by incorporating 10% aqueous extracts of some weeds and weed parts viz. *Parthenium hysterophorus, Lantana camera, Ageratum conyzoides, Calotrophis gigantea, Argemone mexicana, Acyranthes aspera* and Emamectin benzoate 5 SG. The plant extracts were found effective in reducing the percentage of infestation of target pest (*Helicoverpa armigera*) with the least (5.19%) in *C. gigantea* and highest (15.04%) in *Acyranthes aspera* extracts. Apart from reducing the *H. armigera*'s percentage infestation, weed leaf extracts also proved to yield higher cost benefit ratio, highest (1:2.38) in Calotropis leaves and lowest (1:1.51) in *Acyranthes aspera*. Reduced percentage infestation of *H. armigera* in plots treated with leaf extracts were reflected in their resultant parallel action of significantly lower fruit damage (5.19 to 15.04%) than untreated control (35%). Subsequently, the impact of reduced fruit damage by *H. armigera* larvae was observed in proportionate increase in fruit yield of tomato (35 to 55.60 q/ha), significantly higher than untreated control (6.6 q/ha).

Keywords: *Helicoverpa armigera*, eco-friendly, aqueous extract, cost benefit ratio

Introduction
Tomato (*Lycopersicon esculentum* Miller) is one of the most important commercial vegetable crop grown all over the world and occupies the third position among vegetables in area and production in the world Sharma and Dahiya, (2004) [18]. It belongs to the family Solanaceae and said to be the native of tropical America. The major tomato producing states of India are Maharashtra, Bihar, Karnataka, Uttar Pradesh, Himachal Pradesh, Orissa, Andhra Pradesh, Madhya Pradesh and Assam.

In Uttar Pradesh, the total area, production of tomato during 2018-2019 were 8.01M/ha and 223.37MT respectively National Horticulture Board, (2018-19) [9].

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) [8]. *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) is a polyphagous migratory noctuid which is widespread in Asia, Africa and Oceania Lammers and Macleod, (2007) [6]. The caterpillars feed on flowers if suitable vegetation is not available. It attacks more than 180 cultivated species from cereals, legumes, vegetables, fruits and wild species Patil *et al*., (2018) [5]. *Helicoverpa armigera* is also characterized by its high mobility and fecundity and it has shown great capacity to develop resistance to synthetic insecticides used in its management Ramasubramaniam and Regupathy, (2004) [15].

Frequent use of synthetic insecticides has led to the pest resistance and outbreak of minor pests. Negative impacts on non-target organisms including man and the environment has been observed Singh *et al*. (2000) [19]. Thus, one needs to search the new highly selective and biodegradable pesticides to solve the problem of long-term toxicity to mammals and, on the other hand, one must study the environmental friendly pesticides and develop techniques that can be used to reduce the amount of pesticides use while maintaining crop yields. Such difficulties have caused natural products to gain attention.

Among the natural products, plant derived pesticides are more acceptable. This acceptance is due to their abundance, their being nature-friendly, being less toxic to natural enemies, their effect on limited species, fast degradation, low phytotoxicity and low toxicity to vertebrates Kim *et al*. (2003) [3], less persistence in the environment.

In view of the above facts, the present studies in tomato entitled "Comparative bio efficacy of weed extracts against tomato fruit borer (*Helicoverpa armigera)* on tomato (*Lycopersicon esculentum)*" have been carried out.

Objectives

1. To evaluate the different weed extracts for the management of larvae of *Helicoverpa armigera*.
2. To study the cost-benefit ratio of different treatments

Materials and methods

A field trial was conducted during 2018-19 with tomato variety Naveen 2000 at the Central research field, SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), Prayagraj, Uttar Pradesh, India. The experiment was conducted in Randomized Block Design (RBD) with a plot size of 2m x 2m with 0.45 x 0.30 m spacing and sub irrigation channel of 0.5m.

Source of material

Required weeds and plant leaves were collected from the university campus of SHUATS, Prayagraj during the morning hour while Emamectin benzoate was purchased from local market.

Method of Extract Preparation

Collected plants and leaves were washed thoroughly under tap water to remove dust and surface contamination. Washed leaves were allowed for drying in shade until the surface moisture dry off. The 100 g of cleaned leaves were ground with little water by using domestic electric grinder to form the chunky paste. To prepare 10 percent of plant extracts, 100 g of the ground paste was immersed in 1L of distilled water for overnight. In the next day, that solution was filtered and squeezed through the muslin cloth. Around two pinches of detergent powder added to the filtrate to serve as a sticker and wetting agent. The obtained 10 per cent formulations were used for spraying on tomato crop against *H. armigera.* Kumara and Tiwari, (2018) [5].

Recording observations of fruit borer

Observation 1

The observations on the number of pests were made on the five randomly selected and tagged plants from each plot. The number of pests per plot was calculated based on the number of infected fruits. The observations are made a day before followed by 3rd, 7th, 14th days after spraying. Observations were recorded without disturbing the plants to minimize the observational errors. The percentage of the infestation of the insect population was calculated according to the following equation:

$$\text{Percent fruit damage} = \frac{\text{No. of infected fruits}}{\text{Total number of fruits}} \times 100$$

Benefit Cost Ratio

Cost effectiveness of each was assessed based on net returns. Net return of each treatment was worked out by substracting total cost of the treatment from gross returns. Total cost of production included both cultivation as well as plant protection charges.

- Gross return = Marketable Yield x Market price
- Net return = Gross return –Total cost

$$\text{Benefit: Cost Ratio} = \frac{\text{Net returns}}{\text{Total cost}} \times 100$$

Statistical Analysis: The data on incidence *H. armigera* were subjected to arc sine transformation, these arc sine values are analyzed with RBD design. Then analysis of co-variance is done, to find significance between the treatments.

Grain yield

Yield was calculated for different treatments as per formula:

Yield (kg / ha) = Factor x Grain yield/ plot (kg)

Where, Factor = (10000)/ (Net plot size) in sq.m

Results and Discussion

The Experiment was laid out in RBD design with 3 replications during investigation, the two spraying were carried out at an interval of 15 days. The treatments consisted of spraying of the data obtained were subjected to statistical analysis after appropriate transformation and are presented in tables. The observations and their findings are discussed here under different treatment. The data pertaining to the efficacy of different treatments in percent fruit damage of *Helicoverpa armigera* on tomato is shown in Table.1.

The observation on the reduction in percentage of infestation and damage to fruit by *Helicoverpa armigera* and thus coming to conclusion about which weed extract is more efficient among all the weed extracts taken at 3DAS, 7DAS and 14DAS at each of the two sprays were recorded.

The eight treatments comprising, spray application of *Parthenium hysterophorus, Lantana camera, Ageratum conyzoides, Calotropis gigantea, Argemone mexicana, Acyranthes aspera,* Emamectin benzoate and control.

Assessment of infestation

First spray

The efficacy of certain weed extracts and synthetic insecticide against fruit borer of tomato are depicted in Table.1.

Percent infestation in 3 Days after spray (DAS)

The observations of infestation of *Helicoverpa armigera* on tomato was recorded on 3rd day after spraying revealed that the average number of *H. armigera* accounted 9.11% in the Emamectin benzoate treatments as against 26.22% in untreated control. The treatment with Emamectin benzoate was most effective against and recorded minimum number of *Helicoverpa armigera* population (9.11%) and was significantly superior followed by *Calotrophis gigantea* with 12.9% followed by *Ageratum conyzoides* with 14.75% infestation, *Lantana camera* with 15.26% infestation.

Argemone mexicana and *Acyranthes aspera* with percent infestation of 19.33% and 22.90% were less effective. The maximum *Helicoverpa armigera* population and infestation was observed in *A. aspera* with percent infestation of 22.90% and it was found to be inferior amongst weed extracts tested (Table no 1).

Percent infestation in 7 Days after spray (DAS)

The observations on percent infestation of *Helicoverpa armigera* recorded on 7th day after spraying revealed Emamectin benzoate 5SG was most effective treatment against *Helicoverpa armigera* and recorded minimum percent infestation of 1.11% and was significantly superior followed by *Calotrophis gigantea* 3.23%, followed by *Ageratum conyzoides* 6.22 %, *Lantana camera* 7.14%, *Parthenium hysterophorus* 8.12%. *Argemone mexicana* and *A. aspera* recorded 9.66% and 11.33% respectively and was less effective treatment. The maximum infestation was recorded *in Acyranthes aspera* with infestation percentage of 11.33% and it was found inferior treatment amongst weed extracts tested**.** (Table no 1)

Percent infestation in 14 Days after spray (DAS)

The average percentage infestation of *Helicoverpa armigera* after 14 DAS of weed extract spraying indicated that the entire weed extract treatments were significantly superior over untreated control. The lowest infestation percentage of *Helicoverpa armigera* was observed in plot treated with Emamectin benzoate 5SG with percentage infestation of 5.55% and was found significantly superior treatment, followed by *Calotrophis gigantea* with percent infestation of 7.94%, *Ageratum conyzoides* 10.42%, *Parthenium hysterophorus* 13.19% was found to be effective treatment.

The maximum percentage infestation by *Helicoverpa armigera* was observed in *Argemone mexicana and Acyranthes aspera* with percentage infestation of 14.75% and 17.22% respectively and found to be inferior over all other weed extracts treatments. (Table no 1)

Percent infestation of Mean (3, 7 and 14DAS)

It has shown that the various weed extracts treatments significantly reduced the fruit damage infestation. Among all the treatments evaluated Emamectin benzoate found effective which recorded the lowest percent infestation of fruit borer (5.5) at 3, 7, 14 DAS and then *Calotrophis gigantea.* (Fig. 1)

Second spray

The efficacy of certain weed extracts and synthetic insecticide against fruit borer of tomato are depicted in table 2.

Percent infestation in 3 Days after 2nd spray (DAS)

The percentage infestation of *Helicoverpa armigera* three days after second spray indicated that all the weed extracts treatments significantly reduced the percentage infestation by *Helicoverpa armigera* compared to untreated check.

The treatment with Emamectin benzoate 5SG was most effective against *Helicoverpa armigera* and recorded minimum percentage infestation of 2.24% and was significantly superior followed by *Calotrophis gigantea* 2.44%, *Ageratum conyzoides* 8.45%, *Lantana camera* 10.66%, *Parthenium hysterophorus* 11.33%, *Argemone mexicana* and *Acyranthes aspera* with percentage infestation of 13.55% and 15.23% was recorded. The maximum percentage infestation was observed in *Acyranthes aspera* and it was found to be inferior amongst weed extracts tested. (Table no 2)

Percentage infestation of *Helicoverpa armigera* 7 Days after 2nd spray (DAS)

The data recorded on percentage infestation of *H. armigera* on 7th days after second spraying revealed that the Emamectin benzoate 5SG was most effective treatment against *H. armigera* and recorded minimum percentage infestation of *Helicoverpa armigera* of 0.99% and was significantly superior followed by *C. gigantea* 1.22%, *Ageratum conyzoides* 4.32, *P. hysterophorus* 7.13%, Lantana camera6.21%, *Argemone mexicana* and *Acyranthes aspera* with percentage infestation of 8.66% and 11.22% respectively were less effective. The highest percentage infestation was observed in *Acyranthes aspera* 12.11% and it was found inferior treatment amongst weed products tested**.** (Table no 2)

Percentage infestation of Helicoverpa armigera 14 Days after 2nd spray (DAS)

The observations on percentage infestation *of H. armigera* was recorded on14th day after second spraying indicated that all the weed extracts treatments were significantly superior over untreated control. The lowest incidence of 1.11% was observed in plot treated with Emamectin benzoate 1.11% and was found significantly superior treatment, followed by *C. gigantea* 1.8%, *Ageratum conyzoides* 5.44% was next best treatment. *Lantana camera and Parthenium hysterophorus* was also effective against larvae of *H. armigera* was found to be effective treatment. The *Acyranthes aspera* was less effective treatment and found to be inferior over all other weed extracts treatment. (Table no 2)

Percent infestation of Mean (3, 7 and 14DAS)

It has shown that the various weed extracts treatments significantly reduced the fruit damage infestation. Among all the treatments evaluated Emamectin benzoate found effective which recorded the lowest percent infestation of fruit borer (5.5) at 3, 7, 14 DAS and then *Calotrophis gigantea* (7.94) followed *Ageratum conyzoides* (10.42), *Lantana camera* extract (11.53), *Parthenium hysterophorus* (13.19), *Argemone mexicana* extract (14.75**)** and *Acyranthes aspera* extract (17.22) recording percent infestation. (Fig no.2)

Benefit: Cost ratio Economics of various treatment (Table 4 and 5)

In Table 4, the cost of various treatments, the total cost of the preparation of weed extracts is mentioned. There was a significant difference in fruit yield among different treatments. Highest fruit yield was recorded in *Calotropis gigantea* treated plots (55.60q/ha), which was significantly superior to the rest of the treatments and was followed *Ageratum conyzoides* @ 10%(w/v) (52q/ha). However, all the treatments were found to be superior over untreated plot (Table 5). Maximum net profit and CBR was obtained from *Calotropis gigantea* treated plots (Rs 1,16,760 /ha and 1:2.38), followed *by Ageratum conyzoides* @ 10% (Rs1,09,200/ha and 1:2.35), respectively (Table 5).

The highest yield was observed in *Calotropis gigantea* (55.60q/ha) which was reported by Kumara and Tiwari (2018) [5].

Table 1: Efficacy of selected weed extracts against fruit borer [*Helicoverpa armigera*] on tomato, (1st spray percent fruit infestation)

S. No.	Treatment	Dose	Infestation Percentage				
			Before Spray	After First Spray			
				3das	7das	14das	Mean
T1	*Parthenium hysterophorus*	10%(w/v)	24.97 (29.95)	18.12 (25.09)	8.12 (16.34)	13.33 (21.09)	13.19 (21.05)
T2	*Lantana camera*	10%(w/v)	22.90 (28.54)	15.26 (22.77)	7.14 (15.31)	12.21 (20.25)	11.53 (23.56)
T3	*Ageratum conyzoides*	10%(w/v)	26.00 (31.99)	14.75 (22.39)	6.22 (14.14)	10.31 (18.42)	10.42 (19.6))
T4	*Calotrophis gigantea*	10%(w/v)	24.97 (29.95)	12.19 (20.15)	3.23 (11.47)	8.41 (16.42)	7.94 (14.88)
T5	*Argemone mexicana*	10%(w/v)	23.90 (28.13)	19.33 (26.07)	9.66 (18.07)	15.26 (22.77)	14.75 (22.39)
T6	*Acyranthes aspera*	10%(w/v)	23.95 (29.23)	22.90 (28.54)	11.33 (19.64)	17.45 (24.34)	17.22 (23.55)
T7	Emamectin benzoate	5 SG	24.87 (29.95)	9.11 (17.44)	1.11 (9.88)	6.44 (14.14)	5.55 (11.64)
T8	Control (water spray)		25.10 (30.59)	26.22 (33.45)	29.44 (33.8)	32.11 (35.41)	29.25 (32.62)
Overall mean			24.07	17.24	9.53	14.44	13.73
F-test			NS	S	S	S	S
S.Ed. (+-)			2.99	0.57	0.59	0.35	1.97
C.D.(P=0.05)			6.40	1.19	1.27	0.74	4.23

Fig. in parenthesis are arc sine transformed values

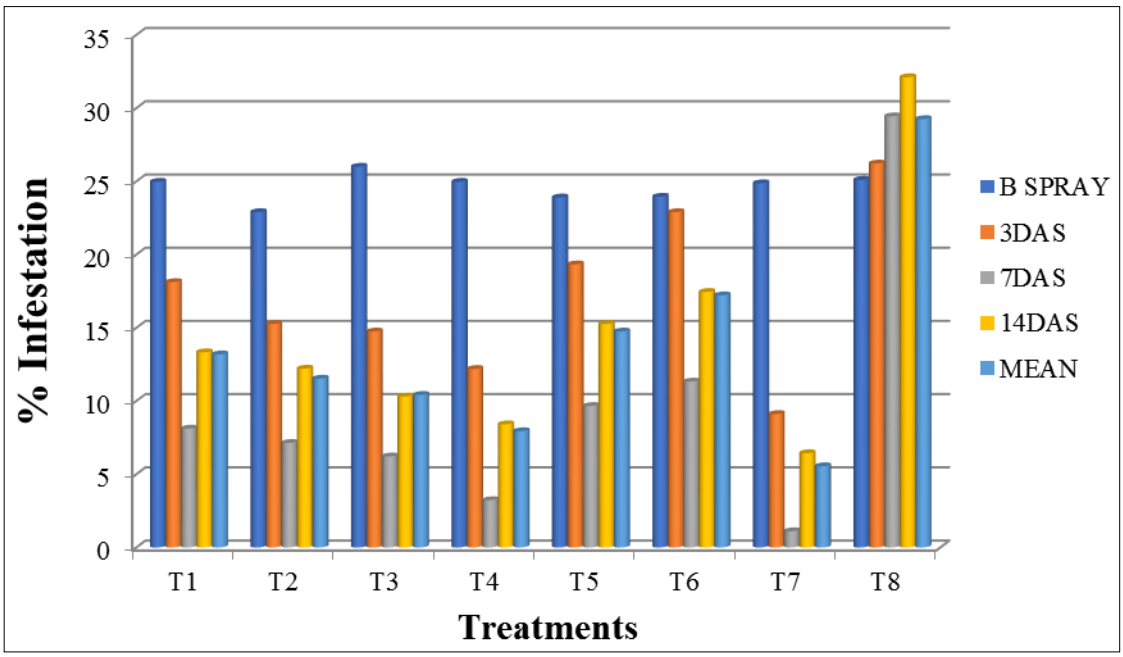

Fig 1: Graphical representation of fruit borer [*Helicoverpa armigera*] on tomato, (1st spray percent fruit infestation).

Table 2: Efficacy of selected weed extracts against [*Helicoverpa armigera* (Huber)] on tomato, (2nd spray percent fruit infestation)

S. No.	Treatment	Infestation Percent			
		After Second Spray			
		3das	7das	14das	Mean
T1	*Parthenium hysterophorus*	11.33 (19.65)	7.11 (15.48)	9.22 (17.66)	9.22 (17.60)
T2	*Lantana camera*	10.66 (19.04)	6.22 (14.43)	8.66 (17.11)	8.51 (16.87)
T3	*Ageratum conyzoides*	8.45 (16.89)	4.32 (11.99)	5.44 (13.48)	6.07 (14.12)
T4	*Calotrophis gigantea*	4.22 (11.85)	1.22 (6.32)	1.8 (7.86)	2.44 (8.69)
T5	*Argemone mexicana*	13.55 (21.57)	8.66 (17.11)	10.11 (13.58)	10.77 (19.07)
T6	*Acyranthes aspera*	15.23 (23.01)	11.22 (19.55)	12.11 (20.36)	12.85 (20.96)
T7	Emamectin benzoate	2.24 (8.61)	0.99 (5.69)	1.11 (6.03)	1.44 (6.78)
T8	Control (water spray)	32.16 (34.56)	33.41 (34.69)	35.24 (36.41)	35.60 (36.42)
Overall mean		12.24	9.15	10.47	10.61
F –Test		S	S	S	S
S.Ed. (+-)		0.62	0.52	0.19	1.11
C.D.(P =0.05)		1.32	1.11	0.42	2.38

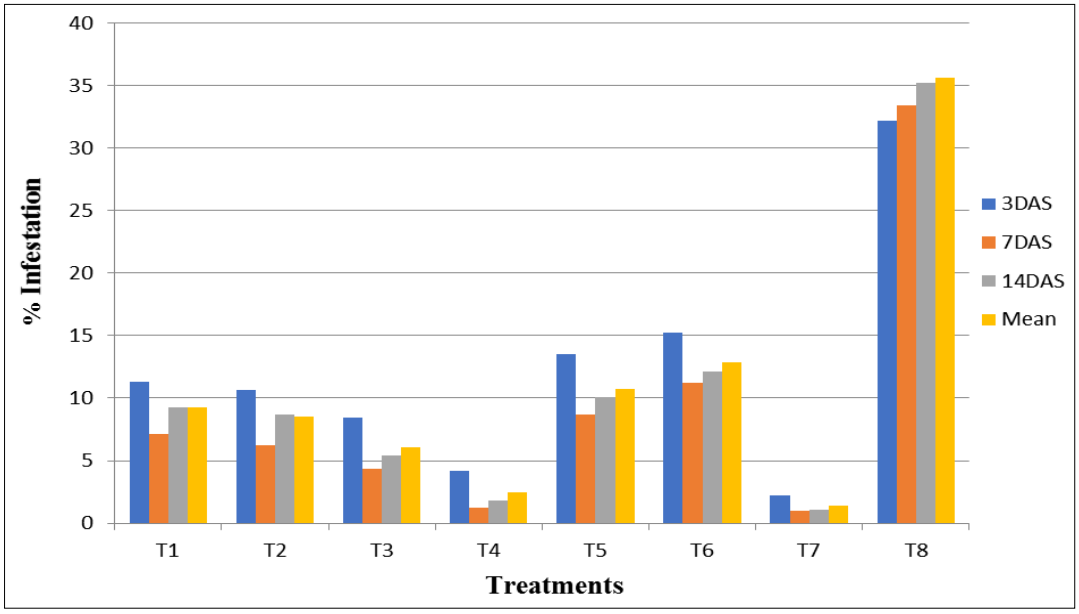

Fig 2: Graphical representation of fruit borer [*Helicoverpa armigera*] on tomato, (2st spray percent fruit infestation).

Table 3: Cost Benefit Ratio: Cost of agronomical practices of cultivation/ha

S. No.	Particular	Requirements	Rate/Units Rs	Cost
(A)	**Land preparation**			
1.	Ploughing	3hours	500Rs/hrs	1500
2.	Harrow	2 hours	500Rs/hrs	1000
3.	Layout of field	10 hours	150Rs/hrs	1500
(B)	**Manures and fertilizers**			
1.	FYM	20tons	100Rs/q	20000
2.	Urea	260kg	10Rs/kg	2600
3.	SSP	312kg	9RS/kg	2808
4.	MOP	100kg	12Rs/kg	1200
5.	Labour	8 labourer	150Rs	1200
©	**Seed sowing**			
1.	Seed material	1.5kg	800Rs/kg	1200
2.	Sowing and transplanting	20 labourer	150	3000
(D)	Weed management	15labourerX 3 times	150Rs/laborer	6750
(E)	Harvesting	30 labourer	150Rs/laborer	6750
(F)	Total Cost of Cultivation			47258

Table 4: Economics of treatments

S. No.	Treatment	Use of weed extract and chemical for2 sprays	Cost of weed extracts and chemicals (Rs)	Total cost weed extracts and chemical (Rs)	Labor charges (Rs)	Total cost of treatment (Rs)
T1	*Parthenium hysterophorus*	24L/ha	58Rs	1400	600	2000
T2	*Lantana camera*	36L/ha	27Rs	1000	600	1600
T3	*Ageratum conyzoides*	24L/ha	27Rs	650	600	1250
T4	*Calotrophis gigantea*	18L/ha	61Rs	1100	600	1700
T5	*Argemone Mexicana*	30L/ha	32Rs	950	600	1550
T6	*Acyranthes aspera*	36L/ha	17Rs	600	600	1200
T7	Emamectin benzoate	2L/ha	5250Rs/kg	2100	600	2700
T8	Control (water spray)	-	-	_	_	_

Table 5: Economics of Cultivation

S. No.	Treatment	Yield in quintal/ha	Cost of yield (Rs)	T. cost of yield (Rs)	Common cost (Rs)	Treatment cost (Rs)	Total Cost (Rs)	B:C ratio
T1	*Parthenium hysterophorus*	46	2100	96,600	47258	4200	49258	1:1.96
T2	*Lantana camera*	49	2100	102,900	47258	1600	48858	1:2.1
T3	*Ageratum conyzoides*	52	2100	109,200	47258	1250	48508	1:2.25
T4	*Calotrophis gigantea*	55.60	2100	116760	47258	1700	48958	1:2.38
T5	*Argemone Mexicana*	43	2100	90300	47258	1550	48808	1:1.85
T6	*Acyranthes aspera*	35	2100	73500	47258	1200	48458	1:1.51
T7	Emamectin benzoate	66.70	2100	140070	47258	2700	49958	1:2.8
T8	Control (water spray)	6.6	2100	13,860	47258	-	47258	1:0.29

Discussion

Prohibitive expense to meet the challenges of increasing resistance in insects, resurgence of pests and escalating environmental pollution caused by synthetic pesticides call for the discovery of less-expensive, nonhazardous alternatives in the management of insect-pests. Plants are endowed with a potential to produce a wide spectrum of allelo-chemicals Norduland and Sauls (1981) [10]. Insects have been influential in the evolution of allelochemicals in plants which in turn affects the insects. Some of compounds affect the feeding behavior of the insects and inhibit feeding, while few others disrupt hormonal balance there by inhibits growth, metamorphosis and reproduction. Due to aforesaid reasons there is resurgence of interest in plant derived compounds for developing them novel eco-friendly insecticides on commercial scale.

Efficacy of weed extracts against fruit borer of tomato

Among all the experimental findings of 1st spray, it is observed that all the treatments have performed better over the treatment of untreated plot control at 3DAS, 7DAS, 14DAS.We had a comparative study between 1 chemical insecticide and 6 weed extracts to check how far these weed extracts work better as compared to chemical insecticide.

Among the weed extracts, *Calotrophis gigantea (*7.94%) proved more superior as compared to rest of treatments taken. *Calotropis procera* at the doses level of 25 ppm, 50 ppm, 75 ppm and 100 ppm on larvae of *Helicoverpa armigera* breaks the midgut, dismantle it and gets intermingled with the totally displaced epithelial cells the same results and finding are in line with the findings of Manikantan (2003) [7], Koul *et al.* (2000) [4], Pari *et al.* (1988) [11], Bakavathiappan *et al.* (2012) [1]. *Ageratum conyzoides* (10.42%) was found as the best next to Calotropis gigantea which is in line with Kumara and Tiwari (2018) [5]. *Lantana camera* (11.53%) was found best treatment next to *Ageratum conyzoides* which is in line with the findings of Paul and Choudhary, (2016) [12]. The next best treatment is *Parthenium hysterophorus* (13.19%) which is in line with the findings of Basavaraj *et al.* (2014) [2]. The least effective treatments were *Argemone mexicana* (14.75%) and *Acyranthes aspera* (17.22%).

Among all the experimental findings of 2nd spray, it is observed that all the treatments have performed better over the treatment of untreated plot control at 3DSA, 7DAS, and 14DAS. Among the weed extracts, *Calotrophis gigantea (*2.44%) proved more superior as compared to rest of treatments taken. These finding are in line with the findings of Bakavathiappan *et al.* (2012) [1]. *Ageratum conyzoides* (6.07%) was found as the best treatment which is in line with the findings of Kumara and Tiwari (2018) [5]. *Lantana camera* (8.51%) was found best treatment next to Ageratum conyzoides. The next best treatment is *Parthenium hysterophorus* (9.22%) which is in line with the findings of Basavaraj *et al.* (2014) [2]. The least effective treatments were *Argemone mexicana* (10.77 %) and *Acyranthes aspera* (12.85%) which is in line with the findings of Kumara and Tiwari (2018) [5].

The overall effectiveness of eco-friendly insecticides and biopesticides against *Helicoverpa armigera* for mean data the descending order was *Calotropis gigantea* > *Ageratum conyzoides* > *Lantana camera* >*Parthenium hysterophorus* >*Argemone Mexicana*>*acyranthes aspera* Cost benefit ratio:

All the weed extracts treatments had significantly higher fruit yield than untreated control (17.60 q/ha). Among the weed extracts treatments, *Calotrophis gigantea* was recorded significantly highest fruit yield (55.60q/ha) which is in reference to Prabhu *et al*. (2018) [14], followed by *Ageratum conyzoides* extract 5% (52 q/ha) than rest of the treatments. All the weed extracts treatments were applied two times at an interval of fifteen days. Thus, the cost per hectare of these treatments was not very high. Among different weed extracts, *C. gigantea and A. conyzoides* were most effective treatments against the major insect pests of tomato. *C. gigantea* and *A. conyzoides* gave highest net return (Rs. 1, 16,760 and1, 09,200/ ha) with cost benefit ratio of 1:2.8, 1:2.38, 1:2.25, respectively. *Parthenium hysterophorus, Argemone mexicana, Acyranthes aspera* were less effective against major pests of tomato in comparison to *C. gigantea, A. conyzoides* as they were moderately effective against major insect pests in tomato. The main aim of providing protection to crop against insect pests by means of various insecticides and biopesticides is to increase the production at economical level by reducing the pest damage. Therefore, before recommending any effective insecticides and biopesticides to protect the crop from injurious pest, *Helicoverpa armigera* the per cent increase in yield over control and net monetary return obtained by these operations are to be taken into consideration.

Conclusion

From the above study it can be concluded *Calotropis gigantea* @10% leaf extract have greater potent to control tomato fruit borer, *Helicoverpa armigera*. Further, the present work sufficiently gives an indication that the weed extracts have been found to be very promising. This work should be further continued so as to study the efficacy of weeds against the major insect pests and their impact on potent parasite/s and predator/s so that they can be incorporated in the Integrated Pest Management modules.

And the highest yield was observed in *Calotropis gigantea* and *Ageratum conyzoides having* the best benefit ratio. Therefore, weed extracts as it has short residual effect and may be useful in devising proper integrated pest management strategy against *Helicoverpa armigera*. Weed extracts are of minimal cost and easy to prepare without having adverse effect on environment, human and animals.

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References

1. Bakavathiappan GA, Baskaran S, Pavaraj M, Jeyaparvathi S. Effect of *Calotropis procera* leaf extract on *Spodoptera litura* (Fab.) Journal of Biopest, 5 (Supplementary), 2012, 135-138.
2. Basavaraj K, Mohan I, Naik J, Shadakshari YG. Efficacy of biorationals and botanical formulations against *Helicoverpa armigera* Hub. In sunflower. Journal of Biopest. 2014; 7:94-98.
3. Kim S, Roh JY, Kim DH, Lee HS, Ahn YJ. Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*.

Journal of Stored Products Research. 2003; 39(3):293-303.
4. Koul O, Jain MP, Sharma VK. Growth inhibitory and antifeedant activity of extracts from *Melia dubia* to *Spodoptera litura* and *Helicoverpa armigera* larvae. Indian Journal of Experimental Biology. 2000; 38(1):63-68.
5. Kumara AKM, Tiwari R. Field Efficacy of Plant Leaf Extracts against *Helicoverpa armigera* (Hubner) on Chickpea at Pantnagar, Uttarakhand International Journal of Pure & Applied Bioscience. SPI. 2018; 6(1):6-13.
6. Lammers JW, Macleod A. Report of a pest risk analysis: *Helicoverpa armigera* (Hubner 1808). European Union, 2007.
7. Manikantan R. Studies on the bio-efficacy of Calotropis gigantea plant extracts against *Spodoptera litura* Fab. (Noctuidae: Lepidoptera). M.Sc. (Ag.) Thesis, Annamalai University, Annamalainagar, Tamil Nadu, India, 2003.
8. Meena LK, Raju SVS. Bio efficacy of newer insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner) on tomato, *Lycopersicon esculentum* Mill under field conditions. The Bioscan, 2014; 9(1):347-350.
9. National Horticulture Board, 2018-19. www.nhb.gov.in
10. Norduland DA, Sauls GE. Kairomones and their use for the management of entomophagous insects. International Journal of Ecology. 1981; 7:1057-1061.
11. Pari K, Rao PJ, Devakumar C, Rastogi JN. A novel insect antifeedant non-protein amino acid from *Calotropis gigantea*. Journal of Natural Products 1998; 61(1):102-104.
12. Paul D, Choudhury M. Larvicidal and antifeedant activity of some indigenous plants of Meghalaya against 4th instar *Helicoverpa armigera* (Hubner) larvae Journal of Crop Protection. 2016; 5(3):447-460.
13. Patil VM, Patel ZP, Oak PS, Chauhan RC, Kaneriya PB. Biology of fruit borer, *Helicoverpa armigera* (Hubner) on chili fruits International Journal of Entomology Research ISSN: 2455-4758, 2018.
14. Prabhu S, Priyadharshini P, Thangamalar A. Evaluation of antifeedant activity of different parts of *Calotropis gigantea* against *Helicoverpa armigera* International Journal of Current Microbiology and Applied Sciences. 2018; 6(10):655-660.
15. Ramasubramaniam T, Regupathy A. Pattern of cross resistance in pyrethroid selected populations of *Helicoverpa armigera* from India. Journal of Applied Entomology. 2004; 128:583-587.
16. Ramya S, Rajasekaran C, Kalaivani T, Sundararajan G, Jayakumararaj R. Biopesticidal effect of leaves extracts of *Catharanthus roseus* L (G) Don. On the Larvae of Gram Pod Borer - *Helicoverpa armigera* (Hubner). Ethno botanical Leaflets. 2008; 12:1096-1101.
17. Reed W, Pawar C. Heliothis: A global problem. Bulletin of entomological research. 1982; 56:117-25.
18. Sharma SM, Dahiya RH. Economics of tomato cultivation in Jaipur district of Rajasthan. Annals of Horticulture. 2004; 6(1):1-11.
19. Singh RN, Saratchandra B. an Integrated Approach in the Pest Management in Sericulture. International Journal of Industrial Entomology. 2002; 5:141-151.