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A Combined Chemical Management Approach Towards An Invasive Alien Pest Pinworm, *Tuta absoluta* (Meyrick), Fruit Borer, *Helicoverpa armigera* Hübner and Red Spider Mite, *Tetranychus urticae* Koch in Tomato

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ABSTRACT: The tomato pinworm, *Tuta absoluta* (Meyrick), fruit borer, *Helicoverpa armigera* (Hübner) and red spider mite, *Tetranychus urticae* (Koch) are destructive pests exerting a high crop loss in India. A field experiment was carried out to evaluate the effectiveness of different treatments at College of Agriculture, Vijayapura, UAS, Dharwad. The treatment Chlorantraniliprole 18.5% SC @ 0.15ml/l was recorded lowest pinworm larvae (1.76/plant), least number of live mines (1.50/plant), less fruit damage (2.02 per cent fruit damage) at fifth day. Similarly less number of fruit borer larvae (1.10/plant) and least fruit damage (2.06/plant) were observed in the same treatment. The treatment Spiromesifen 22.9 % SC recorded lowest number of red spider mite population (1.07 mites/sq inch) at third day. The combination treatment of chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by spiromesifen 22.9 % SC @ 0.5 ml/l was the best one to control pinworm, fruit borer and red spider mites on collective basis and which was also recorded highest yield (19.22 t/ha), Benefit-Cost ratio (2.70).

Keywords: Destructive, Spiromesifen, Chlorantraniliprole, Treatments, Benefit-Cost ratio, Yield.

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is the important vegetable crop of world after potato and its origin is Central and South America. Tomato is majorly grown in tropics and subtropics. It comes under the genus *Lycopersicon*, which is in the family of Solanaceae. Tomato is an important "protective food" because of its unique nutritional significance (Vavilov, 1951). There are 10 to 50 different insect pest species which attack various crop stages and damage all parts of tomato crop which leads to incidence of different insect pest throughout the crop season at different intervals (Lange and Bronson 1981).

Pinworm, *Tuta absoluta* feeds on the leaves of several species of Solanaceae plants. There are host records on many Solanum species, including aubergine (*Solanum melongena*), pepino (*Solanum muricatum*) and black nightshade (*Solanum nigrum*). Hosts in other genera in the Solanaceae include peppers (*Capsicum* spp.), devil's apple (*Datura stramonium*), and tree tobacco (*Nicotina glauca*). Larvae preferentially feed in new growth, *e.g*. apical shoots, thus affecting the overall growth and yield of the plant. Up to 100% losses have been reported in tomato crops, and even where chemicals control are implemented, losses can still exceed 5% (Korycinska and Moran 2009).

Fruit borer, *Helicoverpa armigera* one of the most serious agricultural insect pests worldwide, alone causes huge losses due to its high reproductive potential and polyphagy (Atwal, 1976). The production and productivity of the tomato crop is greatly hampered by the fruit borer, *H. armigera* which causes damage to developing fruits and results in yield loss ranging from 20 to 60% (Tewari and Krishnamoorthy 1984; Lal and Lal 1996). Due to wider host range, multiple generations, migratory behavior, high fecundity and existing insecticide resistance this insect became a difficult pest to tackle (Ahmed *et al*., 2000).

Tetranychids are important group of phytophagous mites attacking most of the plants. The two spotted spider mite, *Tetranychus urticae* Koch is responsible for significant yield losses in many horticultural, ornamental and agricultural crops (Zhang, 2003). It is also a major concern in vegetables causing heavy damage leading to 7-48% yield losses (Srinivasa and Sugeetha 1999). Spider mites are assuming the status of serious pest on many crops of which tomato suffers heavily due to spider mite attack. Under protected condition as well as field grown tomato, two spotted spider mite, *T. urticae* appears as serious pest causing remarkable damage to the crop mostly at late flowering or fruiting stage (Aji, 2005).

This injury results in a yellowish to whitish discoloration of the leaf tissue, often referred to as bronzing. The resulting injury can severely affect plant physiological processes, leading to changes in growth intensity, flowering, and yield (Tomczyk, 1985). In the present study considering all these facts the combination treatments were set in an experiment to manage the three important destructive pests of tomato.

MATERIALS AND METHODS

This study was conducted during kharif at the College of Agriculture, Vijayapura, University of Agricultural Sciences, Dharwad, during 2018. The experiment was conducted with eleven treatments and three replications, and the variety Lakshmi (hybrid) transplanted in July and grown following all recommended agronomic practices except for plant protection measures. The insecticides treatments were imposed two times as a spray in the cropping period at vegetative and fruit development stage after observing pest incidence. The treatment details are: spiromesifen 22.9%SC @ 0.5ml/ l (T1), dicofol 18.5%EC @ 2.5ml/ l (T2), fenazaquin 10%EC @ 2.0 ml/ l (T3), propargite 57%EC @ 3.0 ml/ l (T4), chlorantraniliprole 18.5%SC @ 0.15 ml/ l (T5), flubendiamide 39.35%SC @ 0.075 (T6), emamectin benzoate 5%SG 0.20 g/ l (T7), untreated check (T8), chlorantraniliprole 18.5%SC @ 0.15 ml/ l followed by spiromesifen 22.9% SC @ 0.5 ml/ l (after one week spray of T5) (T9), chlorantraniliprole 18.5%SC @ 0.15 ml/ l followed by fenazaquin 10 % EC @ 2.0 ml/ l (after one week spray of T5) (T10) and chlorantraniliprole 18.5%SC @ 0.15 ml/ l followed by propargite 57%EC @ 3.0 ml/ l (after one week spray of T5) (T11). Five plants were randomly selected from each treatment and number of live mines and larvae/ plant was recorded at one day before spray and one, three, five, seven and 15 days after spray. Number of damaged fruits and healthy fruits were selected separately for calculating % fruit damage during harvesting. The % fruit damage by *T. abosoluta* was calculated by using the formula as described by Usman *et al*. (2012). Observation on the number of active mites/ square inch of leaf area (top, middle and bottom leaves of plant) was taken from five randomly selected plants of each treatment at one day before spray and one, three, five, seven and 15 days after spray.

RESULTS AND DISCUSSION

A. Efficacy based on number of pinworm, T. absoluta

In the present investigation results revealed that, there was significant decrease in pinworm larvae per plant was recorded in chlorantraniliprole 18.5 % SC @ 0.15 ml/l (1.76/ plant) and was on par with chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by propergite 57 % EC @ 3ml/l (1.78/ plant) and untreated check recorded highest pinworm larvae (9.49/ plant) (Table 1). Mashtoly and Helal (2016), results support that chlorantraniliprole was the most effective formulation against *T. absoluta* larvae, followed by indoxacarb had moderate activity levels, but emamectin benzoate showed low levels of activity at affordable concentrations. Mwangi (2019) results showed that insecticides Coragen (chlorantraniliprole), Belt (Flubendiamide), Radiant (spinetorum), Escort (Emamectin Benzoate) were majorly used by farmers. Among them Coragen (chlorantraniliprole) was the best one due to its specific mode of action on several pests on lepidoptera group. It has good efficacy against *T. absoluta* larvae. About 46.37% of the respondents agreed that chlorantraniliprole insecticide used by farmers were effective on the control of pests.

B. Efficacy based on number of live mines of pinworm, T. absoluta

Five days after spray, significantly lowest live mines was noticed in treatments chlorantraniliprole 18.5 % SC @ 0.15 ml/l (1.50/ plant), flubendiamide 39.35 % SC @ 0.075 ml/l (1.53/ plant), and untreated check recorded highest number of live mines (9.42/ plant) (Table 2). Abdel-Baky *et al*. (2019) revealed that laboratory results showed that emamectin-benzoate was effective against larval stages of insects under laboratory conditions. All four concentrations of emamectin-benzoate caused a significant percentage of mortality after 24 hours of treatment as the percentage of mortality increased gradually with time. But almost all concentrations caused 100% mortality of larvae in both species on the 4^{th} and 5^{th} day of treatment.

C. Efficacy based on per cent fruit damage by pinworm, T. absoluta

After five days of spray, per cent fruit damage was least in treatment chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by spiromesifen 22.9 % SC @ 0.5 ml/l (2.02/ plant) and untreated check recorded highest per cent fruit damage to pinworm larvae (27.18/ plant) (Table 1). Sridhar *et al.* (2016) reported that the most efficacious insecticides identified effective against *T. absoluta* were flubendiamide 480 SC @ 0.3 ml/L, spinetoram 12 SC @ 1.25 ml/L, cyantraniliprole 10 OD @ 1. 8 ml/L and spinosad 45 SC @ 0.3ml/L in reducing leaf and fruit damage. Ahmed *et al*. (2020) the present study was carried out to determine the efficacy of different insecticides against the 3^{rd} larval instar of *T. absoluta*. It is clear that emamectin benzoate was the most toxic compound. Results indicated that emamectin benzoate can be used as a good element in integrated management program to this pest.

D. Efficacy based on number of fruit borer, H. armigera

Five days after spray, lowest fruit borer larval population per plant was noticed in chlorantraniliprole 18.5 % SC @ 0.15 ml/l (1.10/ plant) treatment and was on par with chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by spiromesifen 22.9 % SC @ 0.5 ml/l (1.12/ plant) and untreated check recorded highest number of fruit borer larvae (2.19/ plant) (Table 3). Sapkal *et al*.

(2018) results showed that treatments Chlorantraniliprole 18.5% SC, Flubendiamide 39.35% SG, Emamectin benzoate 5% SG, Indoxacarb 14.5% SC and Spinatoram 11.7 SC% was significantly at par with each other. Among them chlorantraniliprole 18.5% SC found most effective than all other treatment. Patil *et al*. (2018) among nine treatments, chlorantraniliprole 18.5 SC (0.055%) was found most effective against fruit borer Kooner *et al*. (2017) results revealed that the lowest mean number of larvae/plant and lowest fruit infestation were recorded in chlorantraniliprole 18.5 SC @ 175 mL/ha (0.25 larva/ plant and 14.17% fruit damage) followed by chlorantraniliprole 18.5 SC @ 150 mL/ha (0.28 larva/plant and 17.25 % fruit damage) which were significantly superior over control.

E. Efficacy based on per cent fruit damage by fruit borer, H. armigera

After five days of spray, least per cent fruit damage was noticed in chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by spiromesifen 22.9 % SC @ 0.5 ml/l (2.06/ plant), and untreated check has highest per cent fruit damage (24.83/ plant) (Table 3). Patel *et al.* (2016) result revealed that chlorantraniliprole 35 WG @ 30 g a.i./ha reduce larval population of *H. armigera* as well as lowest per cent of fruit damage compared to standard checks. Kaur *et al.* (2020) results revealed that significantly lower larval population and fruit infestation was observed in chlorantraniliprole which was on a par with standard check flubendiamide after 3, 7 and 10 days of spray.

F. Efficacy of different treatments against spider mites

After three days of spray, lowest mites population per square inch was recorded in treatment spiromesifen 22.9 % SC @ 0.5 ml/l (1.07/ sq inch) and untreated check recorded highest number of mites (6.29/ sq inch). Fifteen days after spray, significant decrease in mites per squre inch was recorded in chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by spiromesifen 22.9 % SC @ 0.5 ml/l (1.33/ sq inch), chlorantraniliprole 18.5 % SC @ 0.15 ml/l followed by fenazaquin 10 % EC @ 2ml/l (1.46/ sq inch) and untreated check recorded highest number of mites (7.01/ sq inch). Sood *et al.* (2015) reported that, application of spiromesifen 240 SC @ 144 g a.i./ha significantly reduced red spider mite infestation when sprayed at 21 days interval and was most efficacious in reducing mite population. Balikai (2020) results revealed that spiromesifen 240 SC @ 150, 120 and 90 g a.i./ha afforded highest protection against mites over untreated check (Table 4) . Patel and Patel (2017) showed that the efficacy of fenazaquin 0.01% and spiromesifen 0.02% found most effective against red spider mites. Sharma and Sushil (2020) showed the bio-efficacy of different pesticides against red spider mite on tomato. The results revealed that Spiromesifen 22.9 SC 0.028 per cent and Dimethoate 30EC 0.03 per cent remained most effective treatments against this tomato mite.

Table 1: Efficacy of different treatments against tomato pinworm, *Tuta absoluta* (Meyrick).

Treatments	Based on number of larvae/plant*						Based per cent fruit damage/plant[+]					
	1DBS	1DAS	3DAS	5DAS	7DAS	15DAS	1DBS	1DAS	3DAS	5DAS	7DAS	15DAS
T1	7.62 (2.85)	7.79 (2.88)^{a}	7.97 (2.91)^{c}	8.01 (2.92)^{b}	8.14 (2.94)^{b}	8.62 (3.02)^{b}	21.87 (27.92)	22.25 (28.17)^{ab}	22.50 (28.35)^{cd}	23.28 (28.87)^{cd}	24.58 (29.71)^{bc}	25.35 (30.19)^{bc}
T2	7.40 (2.81)	7.62 (2.85)^{a}	7.87 (2.89)^{c}	7.97 (2.91)^{b}	8.08 (2.93)^{b}	8.26 (2.96)^{b}	20.40 (26.82)	22.47 (28.39)^{ab}	21.53 (27.55)^{c}	22.54 (28.24)^{c}	23.01 (28.55)^{b}	23.50 (28.90)^{b}
T3	7.23 (2.78)	7.57 (2.84)^{a}	7.68 (2.86)^{c}	7.79 (2.88)^{b}	8.20 (2.95)^{b}	8.38 (2.98)^{b}	21.66 (28.23)	22.61 (28.79)^{abc}	22.98 (29.03)^{cd}	23.56 (29.41)^{cd}	24.22 (29.85)^{bc}	24.80 (30.21)^{bcd}
T4	7.06 (2.75)	7.23 (2.78)^{a}	7.53 (2.83)^{c}	7.63 (2.85)^{b}	7.87 (2.89)^{b}	8.00 (2.92)^{b}	23.04 (28.14)	24.76 (29.32)^{bc}	25.53 (29.75)^{e}	26.24 (30.20)^{de}	26.96 (30.68)^{c}	27.69 (31.16)^{cd}
T5	8.67 (3.03)	7.13 (2.76)^{a}	3.07 (1.89)^{ab}	1.76 (1.50)^{a}	2.60 (1.76)^{a}	3.50 (2.00)^{a}	23.55 (28.75)	21.98 (27.76)^{ab}	10.04 (18.47)^{a}	2.49 (8.97)^{a}	4.23 (11.83)^{a}	6.64 (14.95)^{a}
T6	8.86 (3.06)	7.27 (2.79)^{a}	3.17 (1.91)^{ab}	1.83 (1.53)^{a}	2.81 (1.82)^{a}	3.58 (2.02)^{a}	23.86 (29.26)	22.01 (27.88)^{ab}	10.95 (19.48)^{ab}	2.83 (9.75)^{ab}	4.89 (12.78)^{a}	6.62 (15.12)^{a}
T7	9.23 (3.12)	7.47 (2.82)^{a}	3.66 (2.04)^{b}	2.07 (1.60)^{a}	2.93 (1.85)^{a}	3.80 (2.07)^{a}	24.42 (29.68)	23.44 (28.99)^{abc}	12.14 (20.50)^{b}	3.35 (10.67)^{b}	5.13 (13.17)^{a}	6.97 (15.23)^{a}
T8	8.33 (2.97)	9.05 (3.09)^{b}	9.36 (3.14)^{d}	9.49 (3.16)^{c}	9.61 (3.18)^{c}	9.68 (3.19)^{c}	25.35 (30.61)	25.49 (30.90)^{c}	26.35 (30.83)^{e}	27.18 (31.53)^{e}	28.12 (32.16)e	29.02 (32.73)^{d}
T9	8.27 (2.96)	7.20 (2.77)^{a}	2.96 (1.86)^{a}	1.90 (1.55)^{a}	2.73 (1.80)^{a}	3.62 (2.03)^{a}	23.71 (28.97)	20.74 (27.11)^{a}	10.32 (18.72)^{ab}	2.02 (8.24)^{a}	4.40 (12.07)^{a}	6.77 (15.11)^{a}
T10	8.73 (3.04)	7.30 (2.79)^{a}	3.10 (1.90)^{ab}	1.81 (1.52)^{a}	2.63 (1.77)^{a}	3.65 (2.04)^{a}	22.60 (28.87)	21.34 (27.33)^{ab}	10.30 (18.70)^{ab}	2.37 (8.91)^{a}	4.57 (12.34)^{a}	6.61 (15.04)^{a}
T11	9.05 (3.09)	7.43 (2.82)^{a}	3.08 (1.89)^{ab}	1.78 (1.51)^{a}	2.56 (1.75)^{a}	3.55 (2.01)^{a}	23.13 (29.11)	20.85 (27.45)^{ab}	10.64 (19.13)^{ab}	2.66 (9.47)^{ab}	4.72 (12.65)^{a}	6.66 (14.96)^{a}
S.Em.±	NS	0.06	0.05	0.06	0.06	0.05	NS	0.78	0.61	0.53	0.50	0.49
C.D.@ 5%		0.18	0.15	0.18	0.17	0.15		2.20	1.80	1.56	1.48	1.43
C.V. (%)		11.41	10.93	13.73	12.94	10.51		14.32	13.33	14.65	12.57	11.29

DBS-Day before spray; DAS-Days after spary; *Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed; +Figures in the parenthesis are arcsine transformed; Mean followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table 2: Efficacy of different treatments against pinworm, *Tuta absoluta* (Meyrick) live mines in tomato.

Treatments	Number of live mines of *T. absoluta* larvae/plant					
	1DBS	1DAS	3DAS	5DAS	7DAS	15DAS
T1	7.40 (2.81)	7.50 (2.83)^{ab}	7.60 (2.85)^{b}	7.71 (2.86)^{b}	7.81 (2.88)^{b}	7.90 (2.90)^{b}
T2	7.57 (2.84)	7.67 (2.86)^{ab}	7.73 (2.87)^{b}	7.83 (2.89)^{b}	7.93 (2.90)^{b}	8.03 (2.92)^{b}
T3	7.43 (2.82)	7.57 (2.84)^{ab}	7.63 (2.85)^{b}	7.73 (2.87)^{b}	7.83 (2.89)^{b}	8.20 (2.95)^{b}
T4	7.60 (2.85)	7.74 (2.87)^{ab}	7.80 (2.88)^{b}	7.90 (2.90)^{b}	8.00 (2.92)^{b}	8.10 (2.93)^{b}
T5	7.43 (2.82)	6.40 (2.63)^{a}	2.83 (1.83)^{a}	1.50 (1.41)^{a}	2.50 (1.73)^{a}	3.58 (2.02)^{a}
T6	7.40 (2.81)	6.43 (2.63)^{a}	2.87 (1.83)^{a}	1.53 (1.43)^{a}	2.60 (1.76)^{a}	3.74 (2.06)^{a}
T7	7.40 (2.81)	6.60 (2.66)^{a}	3.03 (1.88)^{a}	1.70 (1.48)^{a}	2.70 (1.79)^{a}	3.83 (2.08)^{a}
T8	7.23 (2.78)	8.38 (2.98)^{b}	9.11 (3.10)c	9.42 (3.15)^{c}	9.68 (3.19)^{c}	9.74 (3.20)^{c}
T9	7.57 (2.84)	6.45 (2.64)^{a}	2.88 (1.84)^{b}	1.55 (1.43)^{a}	2.55 (1.75)^{a}	3.57 (2.02)^{a}
T10	7.67 (2.86)	6.58 (2.66)^{a}	3.03 (1.88)^{b}	1.57 (1.44)^{a}	2.46 (1.72)^{a}	3.55 (2.01)^{a}
T11	7.79 (2.88)	6.68 (2.68)^{a}	2.93 (1.85)^{a}	1.59 (1.45)^{a}	2.54 (1.74)^{a}	3.66 (2.04)^{a}
S.Em.±	NS	0.07	0.06	0.06	0.06	0.07
C.D.@ 5%		0.21	0.18	0.17	0.18	0.20
C.V. (%)		13.41	13.76	14.76	12.83	14.26

DBS-Day before spray; DAS-Days after spary; *Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed

Table 3: Efficacy of different treatments against tomato fruit borer, *Helicoverpa armigera* Hübner.

Treatments	Based on number of larvae/plant*						Based per cent fruit damage/plant^{+}					
	1DBS	1DAS	3DAS	5DAS	7DAS	15DAS	1DBS	1DAS	3DAS	5DAS	7DAS	15DAS
T1	1.65 (1.47)	1.78 (1.51)^{cba}	1.82 (1.52)^{cde}	1.87 (1.54)^{b}	2.03 (1.59)^{bc}	2.12 (1.62)^{bc}	19.65 (26.31)	20.12 (26.64)^{bc}	20.69 (27.05)^{bc}	21.20 (27.41)^{b}	21.77 (27.80)^{bc}	22.18 (28.09)^{bc}
T2	1.54 (1.43)	1.60 (1.45)^{ba}	1.66 (1.47)^{abcd}	1.71 (1.49)^{b}	1.82 (1.52)^{b}	1.90 (1.55)^{b}	19.34 (26.09)	19.65 (26.31)^{bc}	20.01 (26.57)^{bc}	20.68 (27.05)^{c}	21.20 (27.41)^{b}	21.61 (27.70)^{b}
T3	1.64 (1.46)	1.69 (1.48)^{cba}	1.72 (1.49)^{bcde}	1.81 (1.52)^{b}	1.87 (1.54)^{b}	1.95 (1.56)^{b}	19.19 (25.98)	19.60 (26.27)^{bc}	19.95 (26.53)^{b}	20.41 (26.85)^{c}	21.02 (27.28)^{b}	21.43 (27.57)^{b}
T4	1.79 (1.51)	1.83 (1.53)^{cb}	1.87 (1.54)^{de}	1.91 (1.55)^{bc}	1.94 (1.56)^{bc}	1.98 (1.58)^{b}	21.28 (27.45)	21.97 (27.93)^{cde}	22.43 (28.24)^{bc}	23.16 (28.74)^{d}	24.03 (29.32)^{cd}	24.63 (29.73)^{cd}
T5	1.58 (1.44)	1.48 (1.41)^{a}	1.31 (1.34)^{a}	1.10 (1.26)^{a}	1.24 (1.32)^{a}	1.30 (1.34)^{a}	21.77 (27.81)	19.25 (26.01)^{ab}	11.74 (20.04)^{a}	2.21 (8.54)^{a}	5.13 (13.08)^{a}	10.26 (18.68)^{a}
T6	1.61 (1.45)	1.55 (1.43)^{ba}	1.43 (1.39)^{abc}	1.23 (1.32)^{a}	1.31 (1.35)^{a}	1.42 (1.38)^{a}	21.09 (27.33)	20.04 (26.60)^{bc}	12.22 (20.46)^{ab}	2.46 (9.02)^{ab}	5.48 (13.54)^{a}	11.15 (19.50)^{a}
T7	1.72 (1.49)	1.66 (1.47)^{ba}	1.50 (1.41)^{abcd}	1.33 (1.35)^{a}	1.36 (1.36)^{a}	1.52 (1.42)^{a}	22.23 (28.11)	20.92 (27.20)^{bcd}	12.97 (21.09)^{d}	3.18 (10.25)^{b}	6.07 (14.25)^{a}	11.23 (19.55)^{a}
T8	1.62 (1.46)	2.00 (1.58)^{c}	2.09 (1.61)^{e}	2.19 (1.64)^{c}	2.32 (1.68)^{c}	2.46 (1.72)^{c}	23.18 (28.75)	23.84 (29.20)^{e}	24.34 (29.54)^{d}	24.83 (29.87)^{e}	25.27 (30.16)^{d}	25.66 (30.42)^{d}
T9	1.65 (1.47)	1.58 (1.44)^{ba}	1.35 (1.36)^{ba}	1.12 (1.27)^{a}	1.19 (1.30)^{a}	1.25 (1.32)^{a}	20.03 (26.59)	17.15 (24.46)^{a}	10.73 (19.12)^{a}	2.06 (8.24)^{a}	4.85 (12.71)^{a}	9.73 (18.18)^{a}
T10	1.70 (1.48)	1.51 (1.42)^{a}	1.35 (1.36)^{ba}	1.18 (1.30)^{a}	1.21 (1.31)^{a}	1.28 (1.33)^{a}	19.93 (26.51)	18.52 (25.49)^{ab}	11.04 (19.40)^{a}	2.24 (8.62)^{a}	4.96 (12.86)^{a}	9.93 (18.36)^{a}
T11	1.82 (1.52)	1.54 (1.43)ba	1.39 (1.37)^{ba}	1.16 (1.29)^{a}	1.23 (1.31)^{a}	1.33 (1.35)^{a}	22.16 (28.07)	19.53 (26.20)^{ab}	12.17 (20.40)^{a}	2.23 (8.58)^{a}	5.34 (13.36)^{a}	10.80 (19.17)^{a}
S.Em.±	NS	0.03	0.04	0.03	0.04	0.04	NS	0.67	0.62	0.46	0.56	0.58
C.D.@ 5%		0.10	0.12	0.09	0.11	0.12		1.98	1.83	1.34	1.66	1.70
C.V. (%)		11.90	13.52	11.74	13.19	14.41		13.29	13.85	13.59	14.41	12.97

DBS-Day before spray; DAS-Days after spary; *Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed; $^{+}$Figures in the parenthesis are arcsine transformed; Mean followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table 4: Efficacy of different treatments aganist two spotted spider mite, *Tetranychus urticae* (Koch) in tomato.

Sr. No.	Treatments	Dose g/ml/lit	Number of mites / square inch of leaf area					
			1DBS	1DAS	3DAS	5DAS	7DAS	15DAS
1.	Spiromesifen 22.9 % SC	0.5	5.09 (2.36)	1.93 (1.56)[a]	1.07 (1.25)[a]	1.43 (1.39)[a]	1.81 (1.52)[a]	5.26 (2.40)[cb]
2.	Dicofol 18.5 % EC	2.5	4.84 (2.31)	3.29 (1.95)[c]	1.42 (1.38)[a]	1.79 (1.51)[a]	2.49 (1.73)[b]	5.17 (2.38)[b]
3.	Fenazaquin 10 % EC	2.0	5.16 (2.38)	2.13 (1.62)[ba]	1.22 (1.31)[a]	1.50 (1.41)[a]	2.00 (1.58)[ba]	5.26 (2.40)[cb]
4.	Propergite 57 % EC	3.0	5.36 (2.42)	2.63 (1.77)[b]	1.30 (1.34)[a]	1.63 (1.46)[a]	2.22 (1.65)[ba]	5.29 (2.41)[cb]
5.	Chlorantraniliprole 18.5 % SC	0.15	4.76 (2.29)	5.03 (2.35)[ed]	5.36 (2.42)[b]	6.05 (2.56)[dc]	6.16 (2.58)[c]	6.36 (2.62)[ed]
6.	Flubendiamide 39.35 % SC	0.075	4.90 (2.32)	5.17 (2.38)[ed]	5.20 (2.39)[b]	5.37 (2.42)[cb]	6.05 (2.56)[c]	6.90 (2.72)[ed]
7.	Emamectin benzoate 5 % SG	0.20	5.50 (2.45)	5.36 (2.42)[ed]	5.55 (2.46)[cb]	5.57 (2.46)[cb]	6.36 (2.62)[c]	6.07 (2.56)[dc]
8.	Untreated check	-	5.60 (2.47)	5.83 (2.52)[e]	6.29 (2.61)[c]	6.68 (2.68)[d]	6.84 (2.71)[c]	7.01 (2.74)[e]
9.	Chlorantraniliprole 18.5 % SC followed by spiromesifen 22.9 % SC	0.15 - 0.5	4.77 (2.29)	4.93 (2.33)[d]	5.61 (2.47)[cb]	5.03 (2.35)[b]	6.01 (2.55)c	1.33 (1.35)[a]
10.	Chlorantraniliprole 18.5 % SC followed by fenazaquin 10 % EC	0.15 - 2.0	5.07 (2.36)	5.20 (2.39)[ed]	5.78 (2.51)[cb]	5.27 (2.40)[cb]	6.31 (2.61)[c]	1.46 (1.40)[a]
11.	Chlorantraniliprole 18.5 % SC followed by propergite 57 % EC	0.15 - 3.0	4.70 (2.28)	5.07 (2.36)[ed]	5.22 (2.39)[b]	4.97 (2.34)[b]	5.91 (2.53)[c]	1.60 (1.45)[a]
	S.Em.±		NS	0.05	0.05	0.05	0.06	0.05
	C.D.@ 5%			0.16	0.14	0.15	0.17	0.15
	C.V. (%)			12.81	11.95	12.46	13.89	12.01

DBS-Day before spray, DAS-Days after spary. Figures in the parenthesis are $\sqrt{(x+0.5)}$ transformed values.
Mean followed by similar alphabets in the column do not differ significantly at 0.05 % by DMRT.

Table 5: Effect of different treatments on yield and cost economics in tomato.

Treatments	Yield (t/ha)	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	Increased yield over control (t/ha)	B:C ratio
T1	11.32	90560	54726	35834	4.28	1.65
T2	9.23	73840	54264	19576	2.19	1.36
T3	10.51	84080	54562	29518	3.47	1.54
T4	9.92	79360	54238	25122	2.88	1.46
T5	13.21	105680	54920	50760	6.17	1.92
T6	12.65	101200	54346	46854	5.16	1.86
T7	12.12	96960	54760	42200	5.08	1.77
T8	7.04	56320	53860	2460	-	1.05
T9	19.22	153760	56865	96895	12.2	2.70
T10	18.53	148240	56532	91708	11.49	2.62
T11	18.13	145040	56284	88756	11.09	2.58

Market price: Tomato = Rs.8000/t; Cost of cultivation (Rs.54860) + cost of treatments
Treatment costs: Spiromesifen 22.9 % SC = Rs.484/100 ml, Dicofol 18.5 % EC = Rs.145/250 ml, Fenazaquin 10 % EC= Rs.691/250 ml, Propergite 57 % EC = Rs.175/100ml, Chlorantraniliprole 18.5 % SC = Rs.820/60 ml, Flubendiamide 39.35 % SC= Rs.800/1000 ml, Emamectin benzoate 5 % SG = Rs.980/100 g

CONCLUSIONS

Based on the outcomes of the present investigation, it can be inferred that the combined chemical management approaches towards most destructive pests pinworm, fruit borer and red spider mite was achieved with different insecticides and acaricides with higher yield.

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REFERENCES

Abdel-Baky, N. F., Alhewairini, S. S. & Bakry, M. M. (2019). Emamectin-benzoate against *Tuta absoluta* Meyrick and *Spodoptera littoralis* Boisduval larvae.

Ahmed, K., Qureshi, A. S. & Khalique, F. (2000). Effect of environmental factors on pheromone trap catches of chickpea pod borer, *Helicoverpa armigera* (Huebn.) from 1983 to 1998. *Proceedings-Pakistan Academy of Sciences*, *37*(2), 227-238.

Ahmed, R. A., Mohanny, K. M., Mohamed, G. S. & Allam, R. O. H. (2020). Evaluation of some pesticides against the tomato borer, *Tuta absoluta* (Meyrick)(Lepidoptera: Gelechiidae) under laboratory conditions. *SVU-International Journal of Agricultural Sciences*, *2*(1), 13-20.

Aji, C. S. (2005). Evaluation of selected newer molecules against Tetranychus urticae Koch (Acari: Tetranychidae) infesting tomato (Doctoral dissertation, University of Agricultural Sciences GKVK, Bangalore).

Atwal, A. S. (1976). Agricultural Pests of India and South-East Asia. Kalyani Publishers New Delhi, 528p.

Balikai, R. A. (2020). Bio-efficacy of spiromesifen 240 SC against whitefly and mites in tomato (*Lycopersicon esculentum*). *Farming and Management*, *5*(2), 75-84.

Kaur, A., Chandi, R. S. & Sharma, S. (2020). Field efficacy of green chemistry molecule (Chlorantraniliprole) against tomato fruit borer, *Helicoverpa armigera* (Hubner). *Indian Journal of Extension Education*, *56*(3), pp.149-152.

Kooner, R., Sharma, S., Sandhu, S. S. & Arora, R. (2017). Chlorantraniliprole to manage tomato fruit borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuiidae) in Punjab. *Pesticide Research Journal*, *28*(2), pp.188-193.

Korycinska, A. & Moran, H. (2009). South American tomato moth *Tuta absoluta*. The Food and Environment Research Agency (Fera). www.defra.gov.uk/fera/plants/plantHealth.

Lange, W. H. & Bronson, L. (1981). Insect pests of tomatoes. *Annual Review of Entomolog*y, *26*(2), 345-371.

Lal, O. P. & Lal, S. K. (1996). Failure of control measures against *Heliothis armigera* (Hübner) infesting tomato in heavy pesticidal application areas in Delhi and satellite towns in western Uttar Pradesh and Haryana (India). *Journal of Entomological Research*, *20*(4), 355-364.

Mashtoly, T. A. & Helal, N. A. (2016). Comparative efficiency of new insecticide formulations against tomato leafminer, *Tuta absoluta*, Meyrick (Lepidoptera: Gelechiidae) in Egypt. *Journal of Plant Protection and Pathology*, *7*(3), pp.199-204.

Mwangi, N. V. R. G. M. (2019). Prevalence of *Tuta absoluta* (Meyrick) and Chemical Management in Loitoktok, Kajiado County, Kenya. *Prevalence*, *9*(22).

Patel, N. B. & Patel, C. C. (2017). Relative bio-efficacy of different acaricides against brinjal mite, *Tetranychus urticae* Koch. *Int. J Curr. Microbiol. App. Sci*, *6*(7), 4353-4363.

Patel, R. D., Parmar, V. R. & Patel, N. B. (2016). Bio-efficacy of Chlorantraniliprole 35 wg against *Helicoverpa armigera* (Hübner) Hardwick in Tomato. *Trends in Biosciences*, *9*(15), 793-798.

Patil, P. V., Pawar, S. A., Kadu, R. V. & 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.

Sapkal, S. D., Sonkamble, M. M. & Gaikwad, B. B. (2018). Bioefficacy 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.

Sharma, V. G. & Sushil Kumar (2020). Bio-efficacy of different pesticides against mite (*Tetranychus urticae*) on tomato (*Esculentum* mill). *Journal of Applied Zoological Researches*, *31*(1), 44-48.

Sood, A. K., Sood, S. & Singh, V. (2015). Efficacy evaluation of spiromesifen against red spider mite, Tetranychus urticae Koch on parthenocarpic cucumber under protected environment. *The Bioscan*, *10*(3), 963-966.

Sridhar, V., Onkaranaik, S. & Nitin, K. S. (2016). Efficacy of new molecules of insecticides against South American tomato moth, *Tuta absoluta* (Meyrick)(Lepidoptera: Gelechiidae). *Pest Management in Horticultural Ecosystems*, *22*(2), 137-145.

Srinivasa, N. & Sugeetha, G. (1999). Bioeffectiveness of certain botanicals and synthetic pesticides against okra spider mite Tetranychus macfarlanei. *Journal of Acarology*, *15*(122), pp. 1-5.

Tewari, G. C. & Krishnamoorthy, P. N. (1984). Yield loss in tomato caused by fruit borer. *Indian J. Agricult. Sci.*, *54*, 341-343.

Tomczyk, A. (1985). Effects on the host plant. *Spider mites: their biology, natural enemies, and control*, *1*, pp. 317-329.

Vavilov, N. I. (1951). The origin, variation, immunity and breeding of cultivated plants. *Chronica Botanica*, *4*(6), 364.

Zhang, Z. Q. (2003). Mites of greenhouses: identification, biology and control. CABI Publishing. Wallingford UK. P. 2003, 244.

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