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EVALUATION OF BIO-EFFICACY OF NEWER MOLECULE GPI 1316 (NOVALURON 9.45% + LAMBDA-CYHALOTHRIN 1.9% ZC) AGAINST TOMATO FRUIT BORER AND ITS PHYTOTOXICITY

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ABSTRACT : A field experiment was conducted to evaluate the bio-efficacy and phytotoxicity of GPI 1316 (Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC) against tomato fruit borer during *Rabi*, 2018 and *Rabi*, 2019. The treatments included: T_1- Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 78 g a.i./ha; T_2- Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha; T_3- Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha; T_4- Novaluron 10 % EC @ 75 g a.i./ha; T_5- Lambda-cyhalothrin 5% EC @ 15 g a.i./ha and T_6- Novaluron 5.25% + Indoxacarb 4.5% SC @ 85.32 g a.i./ha, and T_7-Untreated check. Results revealed that, Novaluron 9.45% + Lambda-yhalothrin 1.9% ZC @ 90 g. a.i./ha treatment was found to be the most effective dose in reducing the population of *Helicoverpa armigera* (Hubner) and recorded higher fruit yield and maximum cost benefit ratio. Further, the predatory insect population was statistically on par with all the dosages of Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC and also did not cause any kind of phytotoxicity.

Key words : Bio-efficacy, *Helicoverpa armigera*, natural enemies, phytotoxicity.

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INTRODUCTION

Tomato (*Solanum lycopersicon* L.) is one of the most important and widely grown vegetable crops in the world. It is a self-pollinated crop belonging to the family Solanaceae having chromosome number 2n = 24 (Rick, 1969). It is economically attractive and the area under cultivation is increasing daily (Pattnaik *et al*, 2012). It ranks next to potato in world acreage and first among the processed vegetables (Chaudhary, 1996). It is used directly as raw vegetable and also in the form of various processed products like ketchup, puree, juice whole canned fruits, *etc*. (Bhagta, 2017).

Tomato contributes as a good source of nutrition to the consumer and also a very good source of income for small and marginal farmers (Singh *et al*, 2010). Tomato holds a significant position based on nutritional viewpoint as it contains essential nutrients including Vitamin A, C, and E providing approximately 20 mg of vitamin C per 100 grams (Wilcox *et al*, 2003). Besides these nutrients, it also contains beta carotene, lycopene pigments, water, and niacin, which are essential for metabolism (Olaniyi *et al*, 2010). Due to the presence of lycopene, flavonoids, and antioxidant properties, tomato is universally treated as 'Protective food' (Sepat *et al*, 2013). Tomato and its products are also used as a preventive strategy against major lifestyle diseases, such as cancer and cardiovascular diseases (Canene-Adams *et al*, 2005).

This crop is native to Central and South America (Vavilov, 1951) and perhaps introduced in India by the Portuguese, though there is no definite record of its introduction. Globally, India ranks second in the area as well as in the production of tomatoes with about 7.97 lakh ha area and production of 20.70 million tonnes. Around 11% of the total world production of tomatoes is cultivated in India. Andhra Pradesh still holds a top position in tomato production, even after the creation of Telangana (Anonymous, 2018).

Tomato is a warm-season annual plant that grows with the average optimum temperature range of 25^0C to 29^0C (Ejaz *et al*, 2011). It is generally grown as a winter crop (October-April) in the plains of India, but in Himachal Pradesh, it is cultivated as an off-season crop from April to October. However, like other vegetables, its successful and economic cultivation is consistently threatened by many production constraints. Tomato is more prone to insect pests and diseases mainly due to the tenderness and softness as compared to other crops. The tomato yield in India is considerably lower because of several factors of which the damage caused by insect pests is most important. It is devastated by an array of pests like jassids, aphids, tobacco caterpillars, flea beetles, leaf miners, spider mites, and fruit borers. However, the major economic damage is caused by the fruit borers (Sajjad *et al*, 2011).

Tomato fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) causing yield losses of up to 31.53 per cent (Singh *et al*, 2017) is the most destructive insect pest resulting in considerable losses in quantity as well as the quality of tomato fruits (Singh and Chahal, 1978; Tewari and Moorthy, 1984). It reduces the market value of fruit up to 50 to 80 per cent.

To control the fruit borer, different pesticides are being used in large quantities by farmers except in a few cases where the crop is grown as per Good Agricultural Practices (GAP) for export purposes. Considering the economic importance of the pest and fruit, the present study was conducted to study the bioefficacy and phytotoxicity of combination products of Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC on tomato.

MATERIALS AND METHODS

Bioefficacy studies

The experiment was carried out at the Agricultural Research Station, Kawadimatti, Karnataka during *Rabi*, 2018 and *Rabi*, 2019 in a Randomized Block Design (RBD) with seven treatments, which were replicated thrice in a net experimental area of 5 m x 5 m each. Tomato variety Ruturaj (Kalash) was transplanted at 90 cm x 45 cm spacing. All the agronomic practices were followed during the crop growth period. The details of the treatments are given below.

Treatment details for Bio-efficacy studies

Tr. No.	Treatment	Dosage (g a.i./ha)	Formulation dose (ml/ha)
T_1	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	78	650
T_2	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	90	750
T_3	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	102	850
T_4	Novaluron 10% EC	75	750
T_5	Lambda Cyhalothrin 5% EC	15	300
T_6	Novaluron 5.25% + Indoxacarb 4.5% SC	85.32	875
T_7	Untreated control (water only)	—	—

The observations on fruit borer incidence and their number were recorded one day before spraying as pre-count. Post-treatment count was taken at 3, 7 and 14 days after each spray. For recording the pest population counts, 10 plants were selected randomly and tagged in each plot. The data on mortality was recorded, based on the dead larvae of third, fourth, and fifth instars. All the counts were taken during morning hours. The data on fruit damage was taken on the tenth day from each treatment after each spray by counting the number of healthy and damaged fruits.

Statistical analysis

The percent reduction of larval population in all the treatments over control was calculated by using Hinderson-Tilton's formula (Hinderson and Tilton, 1955) as under:

$$\text{Ca percent reduction in population} = 100\left(1-\frac{T_a}{T_b}\times\frac{C_a}{C_b}\right)$$

Where, T_a = Number of insects after treatment, T_b = Number of insects before treatment, C_a = Number of insects in untreated check after treatment, C_b = Number of insects in untreated check before treatment.

Post-treatment counts were made after 3, 7 and 14 days after insecticidal application. The percent reduction in population was calculated on the different days after sprays. The data obtained were assigned arc sine transformations, analyzed statistically by applying RBD as suggested by Gomez and Gomez (1984).

Total and damaged fruits were also recorded on 10 plants at harvest. The damage percentage was calculated by using the following formula.

$$\text{Percent fruit damage} = \frac{\text{Number of fruits damaged}}{\text{Total number of fruits}}\times 100$$

Impact on natural enemies

Predatory population *viz*., coccinellids and spiders on tagged plants were recorded one day before and 14 days after each spray was averaged and subjected to statistical analysis.

Fruit yield and Economic analysis

Total tomato fruit yield was recorded from each picking and computed on a hectare basis. The yield (fruit) of tomato obtained from each treatment was subjected to statistical analysis. The standard cost of tomato crop cultivation was the same for all the treatments. It was obtained from the recommended agricultural practice of the University of Agricultural Sciences, Raichur, India. The total cost of cultivation was calculated by adding the common cost of cultivation and treatment cost. The gross return per treatment was computed by multiplying the total yield per hectare by the prevailing market price, while net returns for each treatment were realized by subtracting total cost from grass returns. Each treatment's benefit-cost ratio was derived by dividing gross returns from net returns (Shabozoi *et al*, 2011).

Phytotoxicity studies

Five plants were selected at random from each tomato plot and the total number of leaves of those showing phytotoxicity, if any were counted on 1, 3, 5, 7, and 10 days after spray and were recorded on leaf injury on tips and leaf surface, wilting, necrosis, vein clearing, epinasty and hyponasty, *etc.* The data collected are converted into a percentage. The extent of phytotoxicity was recorded based on the following scale (Balikai, 2020).

Phytotoxicity Rating Scale

Scale	% Injury	Scale	% Injury
0	No phytotoxicity	6	51-60%
1	1-10%	7	61-70%
2	11-20%	8	71-80%
3	21-30%	9	81-90%
4	31-40%	10	91-100%
5	41-50%	-	-

Treatment details for phytotoxicity studies

Tr. No.	Treatment	Dosage (g a.i./ha)	Formulation dose (ml/ha)
T_1	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	90	750
T_2	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	180	1500
T_3	Untreated control (water only)	–	–

RESULTS AND DISCUSSION

Reduction of larval population after first spray

Observations recorded at one day before application revealed that the population of fruit borer was uniformly distributed in the field ranging from 14.67 to 17.33 larvae per 10 plants.

Data presented in Table 1 reveals that there was a significant reduction in the population of larvae after the application of different insecticidal treatments. On three days after first spray Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha (T_3) recorded 2.84 larva per 10 plants and it was on par with Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha (T_2), which recorded 3.00 larvae per 10 plants while untreated control recorded 18.00 larvae per 10 plants. On seven days after the first spray the higher dosage of Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha (T_3) recorded 2.17 larva per 10 plants which was at par with Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha (T_2), which recorded 2.50 larva per 10 plants while untreated control (T_7) recorded 19.17 larvae per 10 plants.

Reduction of larval population after second spray

After the second spray, a similar trend was noticed in the reduction of the larval population due to different treatments. On three days after treatment Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha (T_3) recorded 1.34 larva per 10 plants and it was on par with Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha (T_2), which recorded 1.83 larvae per 10 plants while untreated control (T_7) recorded 19.50 larvae per 10 plants. In untreated control (T_7) maximum larval population of 19.67 larvae per 10 plants was noticed at 14 days after second spray while, Novaluron 9.45% + Lambda-cyhalothrin 1.9 ZC @ 102 g a.i./ha (T_3) and @ 90 g a i/ha (T_2) recorded 0.00 larval population with 100 per cent reduction over control (Table 1).

Reduction of fruit damage

The data on fruit damage at the time of harvesting revealed that all the treatments proved superior with less fruit damage compared to the control plot. Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha (T_3) recorded 1.11 per cent fruit damage which was on par with Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha (T_2), which recorded 1.67 per cent fruit damage. Among the chemical treatments lambda-cyhalothrin 5% EC @ 15 g a.i. /ha (T_5) recorded maximum fruit damage of 9.45 per cent. Untreated control (T_7) recorded 18.39 per cent fruit damage (Table 2).

The bioefficacy of novaluron and lambda-cyhalothrin against fruit borer was studied separately and in combination with other insecticides by several workers but very little study has so far been conducted on the combination product of novaluron and lambda-cyhalothrin. So, similar studies conducted to evaluate the bioefficacy of novaluron and lambda-cyhalothrin have been discussed here to support the present study. The results of the present study showed 100.00, 100.00, 84.79, and 75.49 percent reduction in the larval population of fruit borer after two foliar applications of novaluron+lambda cyhalothrin @ 102 g a.i./ha, novaluron+lambda cyhalothrin @ 90 g a.i./ha, novaluron @ 75 g a.i./ha and lambda-cyhalothrin @ 15 g a.i./ha,

Table 1 : Bio-efficacy of GPI 1316 (Novaluron 9.45% +Lambda cyhalothrin 1.9% ZC) against fruit borer (*Helicoverpa armigera*) in Tomato (Mean of two years).

Tr. No.	Treatments	Dose/ha		Number *Helicoverpa armigera* larvae /10 plants							% reduction over control
		g a.i./ha	Formulation ml/ha	1DBS	I Spray			II Spray			
					3 DAT	7 DAT	14 DAT	3 DAT	7 DAT	14 DAT	
T_1	Novaluron 9.45% +Lambda-cyhalothrin 1.9% ZC	78	650	16.67(4.14)	6.00(2.55)*	5.34(2.42)	5.83(2.52)	4.17(2.16)	3.00(1.87)	2.50(1.73)	87.30
T_2	Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC	90	750	17.33(4.22)	3.00(1.90)	2.50(1.73)	3.67(2.04)	1.83(1.52)	0.67(1.07)	0.00(0.71)	100.00
T_3	Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC	102	850	14.67(3.89)	2.84(1.81)	2.17(1.63)	3.34(1.96)	1.34(1.35)	0.34(0.90)	0.00(0.71)	100.00
T_4	Novaluron 10% EC	75	750	16.67(4.14)	7.34(2.80)	6.50(2.64)	8.17(2.95)	6.33(2.61)	4.84(2.30)	3.00(1.87)	84.79
T_5	Lambda-cyhalothrin 5% EC	15	300	15.33(3.98)	8.33(2.97)	8.00(2.92)	9.00(3.08)	7.00(2.74)	5.17(2.38)	4.83(2.31)	75.49
T_6	Novaluron 5.25% + Indoxacarb 4.5% SC	85.32	875	16.00(4.06)	4.84(2.30)	4.17(2.16)	4.84(2.31)	3.00(1.87)	1.84(1.53)	1.50(1.41)	92.40
T_7	Untreated Control	-	-	17.00(4.18)	18.00(4.30)	19.17(4.43)	18.84(4.40)	19.50(4.47)	20.74(4.61)	19.67(4.49)	-
	C.D. at 0.05			NS	0.41	0.38	0.31	0.53	0.41	0.62	-
	S.Em.±			0.16	0.13	0.12	0.10	0.17	0.13	0.20	-
	C. V. (%)			5.23	6.25	5.46	5.88	6.32	5.66	5.10	-

DBS: Days before spray, DAT: Days after treatment, *Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

respectively which is in closer proximity with the findings of Ghosal *et al* (2015), who reported 95.64, 79.82 and 79.49 per cent larval reduction over control in fruit borer population after three application of novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml/ha, novaluron @ 750 ml/ha, and lambda-cyhalothrin 5% EC @ 400 ml/ha, respectively in first season (2011). In second season (2012), reduction in larval population was 96.12, 80.71 and 80.38 % in plots treated with novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml/ha, novaluron @ 750 ml/ha and lambda-cyhalothrin 5% EC @ 400 ml/ha, respectively.

The results of the present investigation are in conformity with the observations of Kumar *et al* (2003) who reported novaluron alone @ 0.75 ml/l providing 90 per cent mortality of diamondback moth larvae while all the combinations at full doses provided the highest (100%) mortality, whereas novaluron + *Bt.k* (0.375 ml + 1 g/l) which is a half doses combination also gave 100 per cent mortality. Saini *et al* (2013) reported that novaluron @ 18.75, 37.50 and 75 g a.i./ha was found significantly superior against *H. armigera* as compared to the standard check, quinalphos (525 g a.i/ha) with respect to pod damage and grain yield in chickpea. Novaluron 10 EC @ 200 g a.i/ha reduced the population of spotted pod borer, *Maruca vitrata* up to 70 per cent with less than 17 per cent pod damage (Mahalakshmi *et al*, 2013).

The present experimental findings are also supported by the results of Yogeeswarudu and Venkata (2014), who reported 87.12 to 94.38 and 87.12 to 90.83 per cent reduction over control in a larval population of gram pod borer, *H. armigera* in chickpea after two applications of novaluron 10 EC @ 1.5 ml/l and lambda-cyhalothrin 5 EC 1 ml/l, respectively. Lal and Jat (2016) reported minimum (7.3%) pod damage in chickpea following application of novaluron 10 EC @ 375 ml/ha plus 2 per cent urea. Vinit Kumar (2019) also reported similar findings.

Impact on natural enemies

In the field, the population of natural enemies like predatory spiders and coccinellids was comparatively low in all the

Table 2 : Bio-efficacy of GPI 1316 (Novaluron 9.45% +Lambda cyhalothrin 1.9% ZC) against fruit borer of tomato (Mean of two years).

Tr. No.	Treatments	Dose/ha		Percent fruit damage	% Reduction in fruit damage	Yield Tonnes/ha	% increase in yield over control
		Doseg a.i./ha	Formulation ml/ha				
1	Novaluron 9.45% +Lambda cyhalothrin 1.9% ZC	78	650	7.23(15.58)*	60.58	37.67	29.87
2	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	90	750	1.67(7.31)	90.83	49.44	70.50
3	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	102	850	1.11(6.05)	93.95	49.54	70.83
4	Novaluron 10% EC	75	750	8.34(16.77)	54.53	38.83	33.88
5	Lambda Cyhalothrin 5% EC	15	300	9.45(17.89)	48.49	38.61	33.10
6	Novaluron 5.25% +Indoxacarb 4.5% SC	85.32	875	5.00(12.90)	72.68	46.40	59.97
7	Untreated Control	-	-	18.39(25.39)	0.00	29.00	0.00
C.D. at 0.05				5.07		1.69	
S.Em.±				1.65		0.55	
C. V. (%)				5.98		6.44	

* Figures in parentheses are arcsine transformed values.

Table 3 : Effect of GPI 1316 (Novaluron 9.45% +Lambda Cyhalothrin 1.9% ZC) on predatory population in tomato ecosystem (Mean of two years).

Tr. No.	Treatments	Dosage (g.a.i./ha)	Coccinellids/Plant		Spiders/Plant	
			1 DBS	14 DAS	1 DBS	14 DAS
1	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	78	1.79(1.34)*	1.13(1.06)	1.60(1.26)	1.03(1.01)
2	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	90	1.68(1.30)	0.95(0.97)	1.55(1.24)	0.93(0.96)
3	Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	102	1.68(1.29)	0.91(0.95)	1.64(1.28)	0.83(0.91)
4	Novaluron 10% EC	75	1.65(1.29)	1.30(1.14)	1.40(1.18)	1.03(1.01)
5	Lambda Cyhalothrin 5% EC	15	1.63(1.28)	1.00(1.00)	1.66(1.29)	0.90(0.95)
6	Novaluron 5.25% + Indoxacarb 4.5% SC	85.32	1.68(1.29)	0.90(0.95)	1.60(1.27)	0.89(0.94)
7	Untreated control	—	1.63(1.27)	1.71(1.31)	1.57(1.25)	1.48(1.19)
S.Em.±			0.08	0.12	0.10	0.09
C.D. at 5 %			NS	NS	NS	NS

DBS: Days before spray; DAS: Days after spray; *Figures in parentheses are $\sqrt{x+0.5}$ transformed values, NS: Non-significant.

Table 4 : Phytotoxic effect due to GPI 1316 (Novaluron 9.45% +Lambda Cyhalothrin 1.9% ZC) on tomato crop at 1, 3, 5, 7 and 10 days after spray.

Tr. No.	Treatments	Dose/ha		Phytotoxicity Symptoms					
		g a.i.	Formulation (ml/ha)	Leaf injury	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
a.	**Before spray**								
1	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	90	750	0	0	0	0	0	0
2	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	180	1500	0	0	0	0	0	0
3	Untreated check (Water spray)	-		0	0	0	0	0	0
b.	**1 Day after spray**								
1	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	90	750	0	0	0	0	0	0
2	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	180	1500	0	0	0	0	0	0
3	Untreated check (Water spray)	-	-	0	0	0	0	0	0
c.	**3 Days after spray**								
1	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	90	750	0	0	0	0	0	0
2	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	180	1500	0	0	0	0	0	0
3	Untreated check (Water spray)	-	-	0	0	0	0	0	0
d.	**5 Days after spray**								
1	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	90	750	0	0	0	0	0	0
2	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	180	1500	0	0	0	0	0	0
3	Untreated check (Water spray)	-	-	0	0	0	0	0	0
e.	**7 Days after spray**								
1	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	90	750	0	0	0	0	0	0
2	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	180	1500	0	0	0	0	0	0
3	Untreated check (Water spray)	-	-	0	0	0	0	0	0
f.	**10 Days after spray**								
1	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	90	750	0	0	0	0	0	0
2	Novaluron 9.45% + Lambda Cyhalothrin 1.9% ZC	180	1500	0	0	0	0	0	0
3	Untreated check (Water spray)	-	-	0	0	0	0	0	0

insecticidal treatments *viz*., Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ at 78, 90, and 102 g a.i./ha, Novaluron 75 g a.i./ha, Lambda-cyhalothrin 15 g a.i./ha and Novaluron 5.25% +Indoxacarb 4.5 SC @ 85.32 g a.i./ha when compared with untreated check, however, the difference was statistically non-significant (Table 3). Similar observations were made by Balikai and Mallapur (2015) in gherkins; Natikar *et al* (2016) and Kambrekar *et al* (2017) in soybean and Balikai and Mallapur (2021) in black gram with respect to the safety of newer molecules against coccinellids. Venkanna and Balikai (2016) reported that a significantly higher coccinellid and spider population were recorded in emamectin benzoate 5 SG (0.25 g/l) and spinosad 45 SC (0.2 ml/l) followed by

Table 5 : Cost economics of GPI 1316 (Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC) in tomato.

Treatments	Dose ml/ha	Market price of product (Rs/kg or lit)	Cost of cultivation (Rs/ha)	Cost of treatment application + cost of cultivation (Total cost)	Tomato yield (q/ha)	Increase in yield over control (q/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Cost: Benefit ratio
Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	650	975	25000	31268	37.67	8.67	69320	38053	1:1.22
Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	750	975	25000	31463	49.44	20.44	163520	132058	1:4.20
Novaluron 9.45% + Lambda cyhalothrin 1.9% ZC	850	975	25000	31658	49.54	20.54	164280	132623	1:4.19
Novaluron 10% EC	750	2250	25000	33375	38.83	9.83	78640	45265	1:1.36
Lambda Cyhalothrin 5% EC	300	770	25000	30462	38.61	9.61	76880	46418	1:1.52
Novaluron 5.25% + Indoxacarb 4.5% SC	875	2200	25000	33850	46.40	17.39	139160	105310	1:3.11
Untreated Control	-	-	25000	12500	29.00	-	-	-	-

Note: GPI 1316: Rs. 975/liter; Novaluron 10% EC: Rs. 2250/liter; Lambda Cyhalothrin 5% EC: Rs. 770/liter; Novaluron 5.25 %+Indoxacarb 4.5% SC: Rs. 2200/liter; Tomato price: Rs. 8000 per ton; Labour charges: Rs. 5000; Cost of cultivation: Rs. 25000 /ha

rynaxypyr 20 SC (0.3 ml/l), flubendiamide 480 SC (0.1 ml/), indoxacarb 14.5 SC (0.5 ml/l) and novaluron 10 EC (1.0 ml/l).

Fruit yield and economic analysis

Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha recorded 49.54 t/ha fruit yield and it was on par with Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha, which recorded 49.44 t/ha fruit yield. Lambda-cyhalothrin 5% EC @ 15 g. a.i./ha recorded 38.61 t/ha fruit yield. Untreated control recorded lowest fruit yield of 29.00 t/ha. GPI 1316 evaluated at different dosages (650, 750 and 850 ml/ha) did not show significant difference among the doses. The treatment Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i/ha was sufficient for management of tomato fruit borer. Further, the treatment Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i/ha recorded maximum cost: benefit ratio (1:4.20) followed by Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 102 g a.i./ha (1:4.19) (Table 5). Manu *et al* (2014) reported that highest benefit cost ratio was obtained from lambda-cyhalothrin 5 EC @ 0.5 ml/l (4.95) followed by indoxacarb 14.5 SC @ 0.5 ml/l (4.26).

Phytotoxicity

The data on phytotoxicity symptoms revealed that GPI 1316 (Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC) @ at 90 and 180 g a.i./ha did not cause phytotoxicity in any form (yellowing, necrosis, leaf injury, epinasty, hyponasty and vein clearing) (Table 4). Balikai and Mallapur (2014-15) reported that none of the insecticidal treatments showed any type of phytotoxic symptoms on soybean plants at 1, 3, 7 and 10 days after spray at the dosages tried *viz*., lambda-cyhalothrin 2.5 EC @ 0.50, 0.75, 1.00, 1.50, 2.00 and 2.50 ml/l.

CONCLUSION

Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ 90 g a.i./ha treatment was found to be the most effective dose in reducing the population of *H. armigera* and recorded higher fruit yield and maximum cost-benefit ratio. The predatory insect population was statistically on par with all the dosages of Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC. There were no phytotoxicity symptoms on tomato plants treated with various dosages of Novaluron 9.45% + Lambda-cyhalothrin 1.9% ZC @ at 90 and 180 g a.i./ha.

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