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Bioefficacy of Certain Combination Insecticides against Insect Pests in Tomato

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ABSTRACT

Tomato fruits are considerably affected by array of insect pests infesting at different stages of crop growth. Among the factors responsible for low yield of tomato, insect pests are major one. The present experiments entitled was carried out at Students' Instructional Farm, Acharya Deva University of Agriculture and Technology, Kumarganj, Ayodhya (UP) during *rabi* season 2020-21 to test the efficacy of certain combination insecticides against major insect pests. Among the efficacy of certain combination insecticides, the treatment Betacyfluthrin 8.49% + Imidacloprid 19.81% OD 400ml/ha was observed most effective against whitefly, Jassid and serpentine leaf miner, whereas Chlorpyriphos 50%+ Cypermethrin 5% EC 1000 ml/ha was least effective against whitefly, Profenofos 40%+Cypermethrin 4% EC 1250 ml/ha was found least effective against Jassid and Triazophos 35%+ Deltamethrin 1% EC 1000ml/ha was least effective against serpentine leaf miner. Chlorantraniliprole 10%+Lambda cyhalothrin 5% ZC 250 ml/ha was most effective and found Triazophos 35%+ Deltamehtrin 1% EC 100ml/ha least effective against larval population of *H. armigera* followed by Imidacloprid 40%+Fipronil 40% WG 500 g/ha, Imidacloprid 40%+Ethiprole 40% WG 500 g/ha. The maximum yield (203.41 q/ha) was recorded in Betacyfluthrin 8.49% +Imidacloprid 19.81% OD 400ml/ha and minimum yield was recorded in Triazophos 35%+ Deltramethrin 1% EC 1000ml/ha (163.17 q/ha). The benefit cost- ratio 1:19.31 was recorded highest in Betacyfluthrin 8.49%+Imidacloprid 19.81% OD 400 ml/ha and lowest 1:3.12 in Imidacloprid 40%+Ethiprole 40% WG 500 g/ha. In comparison to traditional pesticides, these combination insecticides are a newer more efficient against the major pest of tomato at lower doses.

Keywords Efficacy, Economics, Combination insecticides, Insect pests, Tomato.

INTRODUCTION

Tomato *Lycopersicon esculentum* (Miller) is an herbaceous, annual, prostrate and sexually propagated crop plant with hermaphrodite flowers. The

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genus *Lycopersicon* consists of short lived perennial herbaceous plants belong to family Solanaceae and chromosome No. 2n=14. The species of tomato are native to Peru (South America) (Rick *et al.* 1976). In India, productivity of tomato is very low as compare to its production potential of the developed countries. The production and quality of tomato fruits are considerably affected by array of insect pests infesting at different stages of crop growth. Among the factors responsible for low yield of tomato, insect pests viz., the fruit borer, *Helicoverpaa armigera* (Hȗbner) and sucking insect pests viz. whitefly, *Bemesia tabaci* (Gen), Jassids, *Amrasca biguttulla biguttulla* (Ishida), aphid *Myzus persicae* (Thomas) and *Aphis gossypi* (Glover), thrips, *Thrips tabaci* (Lind), Serpentine leaf miner, *Liriomyza trifolii* (Burgess), tobacco caterpillar (*Spodoptera litura*) and hadda beetle, *Epilachana dodecastigma* (Widemann) are highly destructive causing serious damage and are responsible for lowering the yield of tomato crop (Sam *et al.* 2014, Meena and Bairwa 2014, Lal *et al.* 2008, Jones 2003, De Barro 1995). Farmers mostly rely on insecticides for their management. However, indiscriminate use of insecticides has led to problems like elimination of natural predators, environmental pollution, resistance and resurgence. Continuous use of one group of insecticides resulting in high selection pressure has led to development of resistance to insecticides. However, there is a need to explore the possibility of utilizing effective eco-friendly insecticides, particularly combination of those with different novel mode of action which can fit in IPM program. Considering above facts, study of population incidence and efficacy of combination products were evaluated to find out economically feasible option of pest complex management in tomato.

MATERIALS AND METHODS

The present experiments entitled was carried out at Students' Instructional Farm, Acharya Deva University of Agriculture and Technology, Kumarganj, Ayodhya (UP) during *rabi* season 2020-21. The plot size 3.0×2.40 m and spacing 60×45 cm and variety ND-7 was grown in Randomized Block Design with 3 replications and 8 treatments viz.,T_1-Betacyfluthrin 8.49% + Imidacloprid 19.81% OD @ 400 mL, T_2-Chlorantraniliprole 10% + Lambda Cyhalothrin 5% ZC @ 250 mL/ha,T_3-Chlorpyriphos 50%+ Cypermethrin 5% EC @1000 mL/ha, T_4-Profenofos 40%+Cypermethrin 4% EC @ 1250 mL,T_5-Imidacloprid 40%+ Fipronil 40% WG @ 500 g, T_6-Imidacloprid 40% + Ethiprole 40% WG @ 500 g,T_7-Imidacloprid 40%+ Ethiprole 40% WG @ 500 g and T_8-Control (Water spray) @ 500 L against insect pest complex. Tomato crop monitored regularly and 5 plants were randomly selected for occurrence of insect pest complex. Pre-treatment and post–treatment observations on incidence of insect pest complex were recorded. Spraying of insecticides was done at 75 days after transplanting (first spray) and second spray was done 25 days after first spray. Observations were taken on a day before spray and 3^{rd},7^{th} and 15^{th} day after spraying. The benefit-cost ratio worked out for each treatment on the basis of additional return over control and cost of insecticidal spray in each treatment. The data obtained were analyzed statistically to compare the treatments effect for Randomized Block Design (Panse and Sukhatme 1961).

RESULTS AND DISCUSSION

Whitefly (*B. tabaci*)

The pre-treatment whitefly population was distributed non-significantly a day before first spray. The whitefly population ranged between 5.20-6.07 whitefly per 3 leaves (Table 1).The mean population of whitefly recorded at 3,7 and 15 day after first spray revealed that treatment T_1-Betacyfluthrin 8.49% + Imidacloprid 19.81% OD @ 400 mL (2.11 whitefly per 3 leaves) was most effective followed by T_5-Imidacloprid 40%+ Fipronil 40% WG @ 500 g (2.60 whitefly per 3 leaves), while least effective treatments were T_3-Chlorpyriphos 50% + Cypermethrin 5% EC @ 1000 ml/ha and T_4-Profenofos 40%+Cypermethrin 4% EC @1250 mL/ha (4.02 whitefly/3 leaves). The mean population in control was 6.81 whitefly per 3 leaves after first spray.

The population of whitefly noted a day before second spray was also distributed uniformly and varied from between 3.93-4.33 whitefly per 3 leaves (Table 1). The data after second spray revealed that the minimum mean population of whitefly was seen in the treatment T_1-Betacyfluthrin 8.49% + Imidaclo-

Table 1. Efficacy of certain combination insecticides against whitefly, *B. tabaci* infesting tomato during *rabi* 2020-21. Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values, DBS= Day before spray, DAS= Days after spray, *Mean of three replications.

Sl. No.	Treatments	Dose/ha	*Whitefly per 3 leaves									
			First spray					Second spray				
			DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean
T_1	Betacyfluthrin 8.49%+Imidacloprid 19.81% OD	400 mL	5.47 (2.44)	3.27 (1.94)	1.27 (1.33)	1.80 (1.52)	2.11 (1.62)	4.33 (2.20)	2.47 (1.74)	0.80 (1.14)	1.47 (1.40)	1.58 (1.44)
T_2	Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC	250 mL	6.07 (2.56)	4.53 (2.24)	2.47 (1.72)	3.07 (1.89)	3.36 (1.96)	4.07 (2.14)	3.47 (1.99)	1.80 (1.52)	2.93 (1.85)	2.73 (1.80)
T_3	Chlorpyriphos 50%+Cypermethrin 5% EC	1000 mL	5.73 (2.50)	5.00 (2.35)	3.20 (1.92)	3.87 (2.09)	4.02 (2.13)	4.20 (2.17)	3.53 (2.02)	2.40 (1.70)	3.47 (1.99)	3.13 (1.91)
T_4	Profenofos 40%+Cypermethrin 4% EC	1250 mL	5.20 (2.39)	4.80 (2.30)	3.27 (1.94)	4.00 (2.12)	4.02 (2.13)	4.00 (2.12)	3.93 (2.11)	2.00 (1.58)	3.33 (1.96)	3.09 (1.89)
T_5	Imidacloprid 40%+ Fipronil 40% WG	500 g	5.93 (2.54)	3.87 (2.09)	1.60 (1.45)	2.33 (1.68)	2.60 (1.76)	4.13 (2.15)	2.87 (1.83)	1.13 (1.28)	1.80 (1.52)	1.93 (1.56)
T_6	Imidacloprid 40%+ Ethiprole 40% WG	500 g	5.80 (2.51)	4.00 (2.12)	1.93 (1.56)	2.93 (1.85)	2.96 (1.86)	3.93 (2.11)	3.20 (1.92)	1.40 (1.38)	2.40 (1.70)	2.33 (1.68)
T_7	Triazophos 35% + Deltamethrin 1% EC	1000 mL	5.73 (2.51)	4.47 (2.23)	2.93 (1.85)	3.40 (1.97)	3.60 (2.02)	4.13 (2.15)	3.73 (2.06)	2.07 (1.60)	3.13 (1.90)	2.98 (1.86)
T_8	Control (Water spray)	-	6.00 (2.55)	6.53 (2.65)	6.73 (2.69)	7.17 (2.77)	6.81 (2.70)	4.27 (2.18)	5.73 (2.49)	6.33 (2.61)	7.00 (2.74)	6.36 (2.62)
	SEm±		-	**(0.03)**	**(0.05)**	**(0.05)**	**(0.02)**	-	**(0.04)**	**(0.05)**	**(0.05)**	**(0.03)**
	CD at 5%		**(NS)**	**(0.10)**	**(0.16)**	**(0.14)**	**(0.06)**	**(NS)**	**(0.11)**	**(0.15)**	**(0.16)**	**(0.09)**

prid 19.81 % OD 400 ml/ha (1.58 whitefly /3 leaves) followed by T_5-Imidacloprid 40%+ Fipronil 40% WG 500 g/ha (1.93 whitefly /3 leaves) and T_6-Imidacloprid 40% + Ethiprole 40% WG 500 g/ha (2.33 whitefly/ 3 leaves). The maximum population after second spray was recorded T_3-chlorpyriphos 50% + Cypermethrin 5% EC @1000 ml/ha (3.13 whitefly/ 3 leaves) followed by T_4- Profenofos 40%+ Cypermethrin 4%

Table 2. Efficacy of certain combination insecticides against jassid, *A. biguttulla biguttulla* infesting tomato during *rabi* 2020-21. Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values, DBS= Days before spray, DAS= Days after spray, *Mean of three replications.

Sl. No.	Treatments	Dose/ha	*Jassid per 3 leaves									
			First spray					Second spray				
			DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean
T_1	Betacyfluthrin 8.49%+ Imidacloprid 19.81% OD	400 mL	5.00 (2.34)	2.67 (1.78)	0.67 (1.08)	1.00 (1.22)	1.44 (1.39)	3.00 (1.87)	1.60 (1.45)	0.53 (1.02)	1.07 (1.25)	1.07 (1.25)
T_2	Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC	250 mL	5.53 (2.46)	4.07 (2.14)	1.93 (1.56)	2.33 (1.68)	2.78 (1.81)	3.53 (2.01)	2.33 (1.68)	1.47 (1.40)	2.20 (1.64)	2.00 (1.58)
T_3	Chlorpyriphos 50%+Cypermethrin 5% EC	1000 mL	5.13 (2.37)	4.27 (2.18)	2.40 (1.70)	2.93 (1.85)	3.20 (1.92)	3.33 (1.96)	2.93 (1.85)	1.93 (1.56)	3.00 (1.87)	2.62 (1.77)
T_4	Profenofos 40%+Cypermethrin 4% EC	1250 mL	4.93 (2.33)	4.47 (2.23)	2.53 (1.74)	2.80 (1.82)	3.27 (1.94)	3.53 (2.01)	2.87 (1.83)	2.13 (1.62)	3.13 (1.91)	2.71 (1.79)
T_5	Imidacloprid 40%+ Fipronil 40% WG	500 g	5.27 (2.40)	2.80 (1.82)	0.93 (1.20)	1.47 (1.40)	1.73 (1.49)	3.93 (2.11)	2.00 (1.58)	0.80 (1.14)	1.27 (1.33)	1.36 (1.36)
T_6	Imidacloprid 40%+ Ethiprole 40% WG	500 g	5.67 (2.48)	3.13 (1.91)	1.33 (1.35)	1.87 (1.54)	2.11 (1.62)	3.33 (1.96)	1.87 (1.54)	1.07 (1.25)	1.60 (1.45)	1.51 (1.42)
T_7	Triazophos 35% + Deltamethrin 1% EC	1000 mL	5.20 (2.39)	4.00 (2.12)	2.27 (1.66)	2.60 (1.76)	2.96 (1.86)	3.47 (1.99)	2.73 (1.80)	1.73 (1.49)	2.40 (1.70)	2.29 (1.67)
T_8	Control (Water spray)	500 L	5.07 (2.36)	5.87 (2.52)	7.33 (2.80)	8.27 (2.96)	7.16 (2.77)	3.20 (1.92)	4.00 (2.12)	4.93 (2.33)	5.47 (2.44)	4.80 (2.30)
SEm±			-	**(0.04)**	**(0.05)**	**(0.04)**	**(0.02)**	-	**(0.06)**	**(0.04)**	**(0.04)**	**(0.01)**
CD at 5%			**(NS)**	**(0.13)**	**(0.16)**	**(0.12)**	**(0.06)**	**(NS)**	**(0.17)**	**(0.11)**	**(0.12)**	**(0.04)**

Table 3. Efficacy of certain combination insecticides against serpentine leaf miner, *L. trifolii* infesting tomato during *rabi* 2020-21. Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values, DBS= Days before spray, DAS= Days after spray, *Mean of three replications.

Sl. No.	Treatments	Dose/ha	*Number of mined leaves per plant									
			First spray					Second spray				
			DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean
T_1	Betacyfluthrin8.49%+Imidacloprid 19.81% OD	400 mL	6.47 (2.63)	3.40 (1.97)	1.00 (1.22)	1.73 (1.49)	2.04 (1.59)	3.20 (1.92)	1.47 (1.40)	0.87 (1.16)	1.00 (1.22)	1.11 (1.27)
T_2	Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC	250 mL	6.67 (2.67)	4.00 (2.12)	1.53 (1.42)	2.60 (1.76)	2.71 (1.79)	3.47 (1.99)	1.93 (1.56)	1.20 (1.30)	1.53 (1.43)	1.56 (1.43)
T_3	Chlorpyriphos 50%+Cypermethrin 5% EC	1000 mL	6.40 (2.63)	4.20 (2.17)	1.80 (1.51)	2.73 (1.79)	2.91 (1.84)	3.60 (2.02)	2.13 (1.62)	1.47 (1.40)	1.67 (1.47)	1.76 (1.50)
T_4	Profenofos 40%+Cypermethrin 4% EC	1250 mL	6.73 (2.69)	4.27 (2.18)	2.00 (1.58)	3.00 (1.87)	3.09 (1.89)	3.53 (2.00)	2.33 (1.68)	1.67 (1.47)	1.87 (1.53)	1.96 (1.57)
T_5	Imidacloprid 40%+Fipronil 40% WG	500 g	6.33 (2.61)	3.67 (2.04)	1.27 (1.32)	2.13 (1.62)	2.36 (1.69)	3.47 (1.99)	1.67 (1.47)	0.93 (1.20)	1.27 (1.32)	1.29 (1.34)
T_6	Imidacloprid 40%+ Ethiprole 40% WG	500 g	6.20 (2.59)	3.80 (2.07)	1.40 (1.37)	2.40 (1.70)	2.53 (1.74)	3.40 (1.97)	1.80 (1.52)	1.00 (1.22)	1.47 (1.40)	1.42 (1.39)
T_7	Triazophos 35% + Deltamethrin 1% EC	1000 mL	6.53 (2.65)	4.47 (2.23)	2.27 (1.66)	3.60 (2.02)	3.44 (1.98)	3.33 (1.96)	2.53 (1.74)	1.73 (1.49)	2.13 (1.62)	2.13 (1.62)
T_8	Control (Water spray)	500 L	6.73 (2.69)	7.07 (2.75)	7.93 (2.90)	8.27 (2.96)	7.76 (2.87)	3.40 (1.97)	4.07 (2.14)	4.73 (2.28)	5.53 (2.46)	4.78 (2.30)
	SEm±		-	**(0.05)**	**(0.08)**	**(0.09)**	**(0.04)**	-	**(0.04)**	**(0.06)**	**(0.06)**	**(0.03)**
	CD at 5%		**(NS)**	**(0.15)**	**(0.23)**	**(0.27)**	**(0.12)**	**(NS)**	**(0.13)**	**(0.19)**	**(0.20)**	**(0.09)**

EC @ 1250 ml/ha (3.09 whitefly per 3 leaves). The mean population in T_8 (Control) was 6.36 whitefly per 3 leaves after first spray. The present findings are also in conformity with Zote *et al.* (2018) who found that among the different doses of Solomon tested against cashew tea mosquito bug and thrips, the treatment T_2 Solomon 300 OD (Betacyfluthrin 90% + Imidacloprid 210%) @ 1.5 ml/10 liter was most effective for management of tea mosquito bug and thrips. Jat (2016) also reported the combination insecticides found effective against sucking than other single insecticides.

Table 4. Efficacy of certain combination insecticides against tomato fruit borer, *H. armigera* infesting tomato during *rabi* 2020-21. Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values, DBS= Days before spray, DAS= Days after spray, *Mean of three replications.

Tr. No.	Treatments	Dose/ha	*Tomato fruit borer larvae per plant									
			First spray					Second spray				
			DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean
T_1	Betacyfluthrin 8.49%+ Imidacloprid 19.81% OD	400 mL	2.60 (1.76)	1.80 (1.52)	0.80 (1.14)	1.40 (1.38)	1.33 (1.35)	2.40 (1.70)	1.20 (1.30)	0.67 (1.08)	0.93 (1.20)	0.93 (1.20)
T_2	Chlorantraniliprole 10%+ Lambda cyhalothrin 5% ZC	250 mL	2.93 (1.85)	1.47 (1.40)	0.40 (0.95)	0.93 (1.20)	0.93 (1.20)	2.47 (1.72)	0.93 (1.20)	0.33 (0.91)	0.67 (1.08)	0.64 (1.07)
T_3	Chlorpyriphos 50%+Cypermethrin 5% EC	1000 mL	2.53 (1.74)	2.13 (1.62)	1.40 (1.38)	2.13 (1.62)	1.89 (1.55)	2.27 (1.66)	1.53 (1.43)	1.20 (1.30)	1.33 (1.35)	1.36 (1.36)
T_4	Profenofos 40%+Cypermethrin 4% EC	1250 mL	2.73 (1.80)	2.20 (1.64)	1.47 (1.40)	2.27 (1.66)	1.98 (1.57)	2.60 (1.76)	1.67 (1.47)	1.27 (1.33)	1.40 (1.38)	1.44 (1.39)
T_5	Imidacloprid 40% + Fipronil 40% WG	500 g	2.87 (1.83)	1.93 (1.56)	1.20 (1.30)	1.67 (1.47)	1.60 (1.45)	2.67 (1.78)	1.33 (1.35)	0.80 (1.14)	1.20 (1.30)	1.11 (1.27)
T_6	Imidacloprid 40%+ Ethiprole 40% WG	500 g	3.00 (1.87)	2.07 (1.60)	1.33 (1.35)	1.93 (1.56)	1.78 (1.51)	2.53 (1.74)	1.40 (1.38)	1.00 (1.22)	1.27 (1.33)	1.22 (1.31)
T_7	Triazophos 35% + Deltamethrin 1% EC	1000 mL	2.60 (1.76)	2.40 (1.70)	1.60 (1.45)	2.33 (1.68)	2.11 (1.62)	2.47 (1.72)	1.80 (1.52)	1.33 (1.35)	1.53 (1.43)	1.56 (1.43)
T_8	Control (Water spray)	500 L	2.47 (1.72)	3.13 (1.91)	3.80 (2.07)	4.00 (2.12)	3.64 (2.04)	2.73 (1.80)	3.13 (1.91)	3.27 (1.94)	3.60 (2.02)	3.33 (1.96)
	SEm±		-	**(0.05)**	**(0.06)**	**(0.05)**	**(0.03)**	-	**(0.04)**	**(0.03)**	**(0.05)**	**(0.02)**
	CD at 5%		**(NS)**	**(0.16)**	**(0.18)**	**(0.14)**	**(0.08)**	**(NS)**	**(0.13)**	**(0.11)**	**(0.17)**	**(0.07)**

Table 5. Impact of different combination insecticide on yield of tomato during *rabi* season 2020–2021.

Sl. No.	Treatments	Dose/ ha	Yield (q/ha)
T_1	Betacyfluthrin 8.49% + Imidacloprid 19.81% OD	400 mL	203.41
T_2	Chlorantraniliprole10% + Lamda cyhalothrin 5% ZC	250 mL	193.97
T_3	Chlorpyriphos 50 %+ Cypermethrin 5 % EC	1000 mL	170.67
T_4	Profenophos 40%+Cypermethrin 4% EC	1250 mL	169.15
T_5	Imidacloprid 40%+ Fipronil 40% WG	500g	199.18
T_6	Imidacloprid 40%+ Ethiprole 40% WG	500g	186.58
T_7	Trazophos 35% EC + Deltamethrin 1% EC	1000 mL	163.17
T_8	Control (Water spray)	500 L	150.60
	SEm±		**3.18**
	CD at 5%		**9.77**

Jassid *(A. biguttulabiguttula)*

The pre-treatment data of Jassid recorded a day before first spray depicted that population was non-significantly distributed and ranged between 4.93-5.67 Jassid per 3 leaves(Table 2).The mean of Jassidpopulation recorded at 3,7and 15 day after first spray showed that treatment T_1-(Betacyfluthrin 8.49%+ Imidacloprid 19.81%) OD 400mL (1.44Jassid per 3 leaves) was most effective treatment followed by T_5-Imidacloprid 40 %+ Fipronil 40% WG 500g/ha (1.73 Jassid/ 3 leaves) and treatment T_4-Profenophos 40%+ Cypermethrin 4% EC @ 1250ml/ha (3.27 Jassid per 3 leaves) was least effective followed by T_3-Chlorpyriphos 50% + Cypermethrin 5% EC 1000ml/ha (3.20 Jassid per 3 leaves). The mean population in T_8-(control) was 7.16 Jassid per 3 leaves after first spray.

The pertaining second spray population a day before spray was varied in range 3.00-3.93 jassid per 3 leaves (Table 2). The mean of population recorded at 3,7and 15 day after second spray revealed that minimum population was observed in treatment T_1-Betacyfluthrin 8.49%+ Imidacloprid 19.81% OD. Jat (2016) reported the combination insecticides found effective against sucking than other single insecticides.

Table 6. Economics of certain combination insecticides against insect pest complex in tomato during Rabi 2020-21. BCR= Benefit cost ratio, Prevailing market price of tomato during 2020-21 = 15/kg, Labour charge = ₹300/day/labour, Sprayer charge: ₹ 50/day.

Sl. No.	Treatments	Dose/ha	Cost of one Spray (labour+ Sprayer+ insecticide) /ha)	No. of sprays	Total cost of spraying /ha	Yield (q/ha)	Additional yield over control (q/ha)	Total return /ha	Net return /ha	B:C ratio	Rank
T_1	Betacyfluthrin8.49% +Imidacloprid 19.81% OD	400mL	1950	2	3900	203.41	52.81	79215	75315	19.31	I
T_2	Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC	250 mL	3140	2	6280	193.97	43.37	65050	58770	9.36	IV
T_3	Chlorpyriphos 50% +Cypermethrin 5% EC	1000mL	1025	2	2050	170.67	20.07	30100	28050	13.68	III
T_4	Profenofos 40% +Cypermethrin 4% EC	1250 mL	915	2	1830	169.15	18.55	27825	25995	14.20	II
T_5	Imidacloprid 40%+ Fipronil 40% WG	500g	8150	2	16300	199.18	48.58	72875	56575	3.47	VI
T_6	Imidacloprid 40%+ Ethiprole 40% WG	500g	6550	2	13100	186.58	35.98	53975	40875	3.12	VII
T_7	Triazophos 35% EC + Deltamethrin 1% EC	1000 mL	1450	2	2900	163.17	12.57	18850	15950	5.50	V
T_8	Control (Water spray)	500 L	-	2	-	150.60	-	-	-	-	-

Serpentine leaf miner (*L. trifolii*)

The data pertaining to the damage of Serpentine leaf miner was recorded a day before first spray indicates that the Serpentine leaf miner damage was distributed uniformly in all treatments and varied in the range of 6.20-6.73 mined leaves per plant (Table 3). The mean of Serpentine leaf miner damage recorded at 3,7 and 15 days after first spray depicted that -minimum damage was found in T_1-(Betacyfluthrin 8.49%+ Imidacloprid 19.81%) OD @ 400ml/ha (1.73 mined leaves per plant) followed by T_5-Imidacloprid 40 %+ Fipronil 40% WG 500 g/ha (2.36 mined leaves per plant) and maximum damage was found in the treatment T_7-Triazophos 35%+ Deltamethrin1% EC 1000 ml/ha (3.44 mined leaves per plant) followed by T_4-Profenophos 40% + Cypermethrin 4% EC 1250 ml/ha (3.09 mined leaves per plant). Whereas, the damage in T_8-Control was 7.76 mined leaves per plant.

The damage of Serpentine leaf miner noted a day before second spray was also distributed uniformly and varied from between 3.20-3.60 mined leaves per plant (Table 3). After second spray lowest damage was recorded inT_1-Cyfluthrin 8.49% + Imidacloprid 19.81% OD 400 ml/ha (1.11 mined leaves per plant) followed by T_5-Imidacloprid 40% + Fipronil 40% WG 500g/ha (1.29 mined leaves per plant), Imidacloprid 40 5+ Ethiprole 40% WG 500 g/ha (1.42 mined leaves per plant), while the highest damage was observed in treatment T_7-Triazophos 35% + Deltamethrin 1%EC 1000 ml/ha (2.13 mined leaves per plant). However, the damage in T_8-Control was 4.78 mined leaves per plant. The present findings are also similar to Kotak *et al.* (2020) who observed that Profenophos + Cypermethrin 44 EC (0.044%) was found to be more effective for the control of leaf miner (*Liriomyza trifolii*).

Tomato fruit borer (*H. armigera*)

The data concerning the larval population of H. *armigera* recorded at a day before first spray of was ranged from 2.47-3.00 larvae per plant (Table 4). The larval population of *H. armigera* recorded at 3, 7 and 15 days after first spray revealed that minimum population T_2-Chlorantraniliprole 10%+ Lambda cyhalothrin 5% ZC 250 mL/ha (0.93 larvae per plant) followed by T_1-Betacyfluthrin 8.49%+ Imidacloprid 19.81% OD 400mL/ha (1.33 larvae per plant) and T_7-Triazophos 35%+ Deltamethrin 1% EC 1000ml/ha (2.11 larvae per plant) followed by T_4-Profenofos 40%+Cypermethrin 4% EC 1250 (1.98 larvae per plant). T_8-Control recorded 3.64 larvae per plant after first spray.

The data were recorded a day before second spray revealed that population varied non-significantly a day before spray ranged from 2.27 to 2.73 larvae per plant (Table 4). Post treatment data revealed that larval population of *H. armigera* recorded at 3, 7 and 15 days after second spray was found minimum in T_2-Chlorantraniliprole 10%+ Lambda cyhalothrin 5% ZC 250 mL/ha (0.64 larvae per plant) followed by T_1-Betacyfluthrin 8.49%+ Imidacloprid 19.81% OD 400ml/ha (0.93 larvae per plant) and maximum population was recorded in T_7-Triazophos 35%+ Deltamethrin 1% EC 1000 ml/ha (1.56 larvae per plant) followed by T_4-Profenofos 40% + Cypermethrin 4% EC 1250 (1.44 larvae per plant). Whereas, mean population in T_8-Control was 3.33 larvae per plant after second spray. The present findings are also in strong agreement with Reddy and Hampaiah (2018) who found that Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 0.50 mL L^{-1} is superior to control larval population of *Maruca vitrata* in cowpea.

Impact of different combination insecticide on yield of tomato

The data revealed that the significantly highest yield was recorded in T_1-Betacyfluthrin 8.49% + Imidacloprid 19.81% OD 400 ml/ha (203.41 q/ha) fallowed by T_5- Imidacloprid 40% + Fipronil 40 % WG 500 g/ha (199.18 q/ha), T_2-Chlorantraniliprole 10% + Lambda cyhalothrin 5% 250 ml/ha (193.97 q/ha), whereas the lowest yield was recorded in T_7-Triazophos 35%+Deltamethrin 1% EC 1000 ml/ha (163.17 q/ha) (Table 5). These findings are also conformity with Zote *et al.* (2018) who found that Solomon 300 OD (Betacyfluthrin 90% + Imidacloprid 210%) 1.5 mL/10 liter most effective for management of tea mosquito bug, thrips and also produced highest yield.

Economics of certain combination insecticides against insect pest complex of tomato

The data of economics depicted that the highest net profit of Rs 75315 per hectare was attained in T_1-Betacyfluthrin 8.49 +Imidacloprid 19.81 OD 400 ml/ha followed by T_2-Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC 250 ml/ha with Rs 58770, T_5-Imidacloprid 40% + Fipronil 40% WG 500 g/ha with Rs 56575 and T_6-Imidacloprid 40% + Ethiprole 40% WG 500g/ha with Rs 40875. The minimum net profit in T_3-Chlorpyriphos 50% + Cypermehtrin 5% EC 1000 ml/ha with Rs 28050 followed by T_4-Profenofos 40% + Cypermethrin 4% EC @ 1250ml/ha with Rs 25995, T_7-Triazophos 35% + Deltamethrin1% EC @ 1000ml/ha with Rs 15950. The cost benefit ratio was workout the best and economical treatment was T_1-Betacyfluthrin 8.49% + Imidacloprid 19.81% OD with B:C ratio 1:19.31 followed by T_4-Profenofos 40% + Cypermethrin 4% EC with 1:14.20, T_3-Chlorpyriphos 50% + Cypermethrin 5% EC with 1:13.68 (Table 6).

One of the most frequent practises in managing insect pests in agricultural ecosystems is the application of pesticides since they offer effective control of insects in a short amount of time. The most effective insecticides against whitefly, Jassid and Serpentine leaf miner was Betacyfluthrin 8.49% +Imidacloprid 19.81% OD 400 ml/ha with the lowest population, whereas Chlorantraniliprole 10%+Lambda cyhalothrin 5% ZC 250 ml/ha was most effective against *H. armigera*. The maximum yield per hectare was seen in foliar sprays of Betacyfluthrin 8.49% +Imidacloprid 19.81% OD 400 ml/ha. The most profitable treatment, with the highest benefit-cost ratio was Betacyfluthrin 8.49%+Imidacloprid 19.81% OD 400 ml/ha. In comparison to traditional pesticides, these combination insecticides are a newer more efficient against the major pest of tomato at lower doses. The knowledge gained from the current study can be effectively implemented into managerial methods.

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