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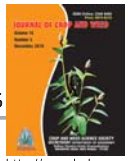

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Efficacy of spirotetramat 11.01 + imidacloprid 11.01 SC against jassids, red mites and general predators in tomato

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ABSTRACT

Three different formulated doses (375, 500 and 625 ml ha^{-1}) of spirotetramat + imidacloprid against jassids (Amrasca biguttula biguttula), red mites (Tetranychus urticae) and insect predators (coccinellids and spider) of tomato were tested in field condition during rabi summer seasons of 2017 and 2018. The other treatments were spirotetramat (500 ml ha^{-1}), imidacloprid (375 ml ha^{-1}), fenazaquin (1250 ml ha^{-1}) and acephate (390 g ha^{-1}). The statistically at par maximum efficacy (against jassids and mites) and yield were observed in spirotetramat + imidacloprid at 500 and 625 ml ha^{-}1. Even the lowest dose (375 ml ha^{-1}) was also better responsive as compared to other treatments. Except acephate and fenazaquin, no harmful effect was recorded against above mentioned general insect predators. But considering economics, spirotetramat + imidacloprid at 375 - 500 ml ha^{-1} could be recommended in farmers' field for managing jassids and mites in tomato.

Keywords: Imidacloprid, jassid, predators, red mite, spirotetramat and tomato

India ranks second in both for production and area of tomato in the world. There was a production of about 196.97 lakh metric tonnes from 8.09 lakh ha area during 2016-17 in India (Anon., 2017). Several problems are faced by the farmers to grow tomato (Phukan, 2017; Bugti, 2016). Among these, the loss caused by different insect and non-insect pests on tomato is quite regular. The low yield in tomato is caused by heavy infestation of sucking pests including mites and jassids (Solangi *et al.*, 2017). The Economic Threshold Level (ETL) of jassids in potato is 1-1.5 leaf^{-1} (Akbar *et al*., 2012) and for red mites in tomato, it is 1-2 leaflet $^{-1}$ (Meck, 2010). Chemical is still practical consideration as the first line of defence against different crop pests. The combined formulation of Spirotetramat (the insecticide which has mobility through both of phloem and xylem) and Imidacloprid (a widely used systemic insecticide) is very effective against sucking pests of brinjal (Sen *et al*., 2017). Now it is imperative to check the comparative performance of such premix insecticide with other existing insecticides apropos bioefficacy, safety, yield and economics. So, the experiment was conducted to study the effect of Spirotetramat 11.01% + Imidacloprid 11.01% SC against jassid (*Amrasca biguttula biguttula)*, red mite (*Tetranychus* spp.) and insect predators like coccinellids and spiders in tomato.

MATERIALS AND METHODS

The present experiment was carried out at the Instructional Farm of College of Agriculture, BCKV, Farm Gate 1, Kalna Road, Burdwan, West Bengal, India during two consecutive rabi-summer seasons of 2017 and 2018. Randomized Block Design with 3 replications of 8 treatments *viz*., i) Spirotetramat 11.01 + Imidacloprid 11.01 SC (375 ml ha^{-1}) ii) Spirotetramat 11.01 + Imidacloprid 11.01 SC (500 ml ha^{-1}) iii) Spirotetramat 11.01 + Imidacloprid 11.01 SC (625 ml ha^{-1}) iv) Spirotetramat 15.94 OD (500 ml ha^{-1}) v) Imidacloprid 17.8 SL (375 ml ha^{-1}) vi) Fenazaquin 10 % EC (1250 ml ha^{-1}) vii) Acephate 75 % WP (390 g ha^{-1}) and viii) untreated control was followed. The crop variety 'Bisakha' was grown at a spacing of about 2 × 2 ft in each plot size of about 5 × 5m. The recommended fertilizer doses and other intercultural operations were followed to raise the crop. The crop was sprayed using knapsack sprayer. Two sprays were given at 10 days interval starting from 45 days after transplanting of tomato. The spray volumes per hectare were 400 and 450 litre, respectively for the1st and 2nd spray in both the years.

To record the population of jassids and red mites, five randomly selected plants per replication were observed. Populations were counted as pre-treatment (one day before treatment) and at the interval of 3, 5 and 7 days after each of two rounds spray. For jassid, the average numbers of nymph and adult was considered on the basis of data taken from five leaves (3 from top and 2 from middle) plant^{-1}. Same procedure was adopted to count the mite population leaf^{-1}. Mean population of natural enemies (predatory coccinellids and spiders) were also estimated by counting their total numbers from same selected 5 plants plot^{-1} before and after treatment as specified earlier for the pests' population count. The record on plot wise total yield of marketable ripe fruits of tomato was also taken. The yield data thus obtained were expressed in q ha^{-1} and also used to calculate benefit

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cost ratio. All these data were compiled and analyzed statistically in MSTAT C after making suitable conversion.

RESULTS AND DISCUSSION

The bio-efficacy of three doses of pre-mix formulation of Spirotetramat 11.01 + Imidacloprid 11.01 SC was evaluated against jassids and red mites of tomato along with other treatments.

Bioefficacy against Jassids

Before first spray, the population of jassids (Table 1) was more or less uniform and no outstanding difference was observed among the treatments during the year 2017 and 2018. All treatments were significantly superior over control at 3rd, 5th and 7th day after each of two sprays for both years. Here, the maximum reduction in jassid population was noticed at 7th day after each spray. The significant maximum reduction with 81.58 and 81.58; 80.75 and 81.52 per cent was recorded in Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 625 ml ha^{-1} at 7th day after first and second spray during the year 2017 and 2018, respectively. This was statistically at par with 81.81 and 81.54; 80.27 and 81.48 per cent reduction in Spirotetramat + Imidacloprid @ 500 ml ha^{-1}. The next best treatment was Spirotetramat + Imidacloprid @ 375 ml ha^{-1} followed by Imidacloprid 17.8 SL (375 ml ha^{-1}) and Acephate 75 WP (390 g ha^{-1}) which were at par with each other. Whereas, minimum percent reduction in jassid population by 22.41 and 33.90; 33.12 and 28.00 were recorded in Fenazaquin 10 % EC (1250 ml ha^{-1}) at 7th day after first and second spray during the year 2017 and 2018, respectively followed by 72.11 and 69.37; 69.37 and 64.23 in Spirotetramat 15.94 OD (500 ml ha^{-1}).

Spirotetramat targets juvenile stages of sucking insects such as aphids, psyllids, mealybugs and whiteflies (Lopez *et al*., 2017). Bio-efficacy of premix formulation of Spirotetramat + Imidacloprid has already been reported against sucking pest management in brinjal, okra and cotton. But, it might be the first efficacy report against jassid in tomato by the present author. Rizvi *et al*. (2015) mentioned 92.96% mortality of mealy bug in cotton by application of this. The considerable mortality (70.11%) of adult whitefly by Spirotetramat in cotton was also reported by Babar *et al.*, 2013. Imidacloprid was found to be effective by Bambhaniya *et al.* (2018) against jassid and thrips in tomato. The reduction of jassid by Imidacloprid was 80.25 % in groundnut as noticed by Biswas (2015). All these earlier evidences support the present result obtained in Spirotetramat + Imidacloprid.

Bioefficacy against red mites

In case of mites also, the pre-spray population was quite uniform during both the years. As data shown (Table 2), it ranged from 5.40 to 7.00 and 7.90 to 8.50 $leaf^{-1}$ for the year 2017 and 2018, respectively. All the treatments significantly checked mite population over control at 3rd, 5th and 7th day after each of two sprays for each year. Except control, the reduction in mite population in each treatment was found highest at 7th day after each spray of both years. The data pertaining to 1st spray revealed statistically at par maximum percent reduction from 85.82 – 86.09 and 82.50 – 83.00 in 2017 and 2018, respectively for the treatments, Spirotetramat + Imidacloprid @ 500 and 625 ml ha^{-1}. This was followed by Spirotetramat + Imidacloprid @ 375 ml ha^{-1} [76.60 % (2017); 78.20 % (2018)], Spirotetramat [75.80 % (2017); 77.60 % (2018)] and Fenazaquin [75.34 % (2017); 77.60 % (2018)], which were at par with each other. Whereas, Imidacloprid [68.03 % (2017); 69.10 % (2018)] showed least effectiveness.

After second spray, the trend was similar as that of first spray. On 7th day after spray, the significantly at par highest percent mortality in red mites with 87.44 and 87.43 in 2017; 83.10 and 83.00 in 2018 was noted in Spirotetramat + Imidacloprid @ 625 and 500 ml ha^{-1}, respectively which was followed by Spirotetramat + Imidacloprid @ 375 ml ha^{-1}, Spirotetramat and Fenazaquin with percent mortality of 77.60, 76.90 and 76.44; 78.20, 77.60 and 76.40 during 2017 and 2018, respectively. But these were remarkably at par to each other. Whereas, the lowest percent reduction in mite population with 65.38 and 70.50 was recorded in Imidacloprid followed by 72.96 and 73.40 in Acephate during 2017 and 2018, respectively.

£abanowska *et al*. (2017) recorded remarkable efficacy of Spirotetramat (0.75 l ha^{-1}) against *T. urticae* in black current plantation (99.0 %) and raspberry (100 %). *Marcic et al.* (2011) also reported that there is a significant negative effect of Spirotetramat on fertility and longevity of female *T. urticae*. Pokle and Shukla (2015) reported that the mobile stages of *T. Urticae* can effectively be controlled (53.82 %) by Fenazaquin10 EC in poly house tomato. Naga *et al.* (2017) reported 60.52 and 59.31 % respective reduction of mite in okra after treatment with Imidacloprid and Acephate. In contrary, around 40 % mortality of *Tetranychus urticae* was observed on rose under polyhouse conditions treated with Imidacloprid (Singh *et al*., 2017). All these earlier works on *T. urticae* are in more or less agreement with the present related findings.

Effect of treatments on predators

The distribution of coccinellids before 1st spray was uniform and did not vary significantly among the treatments (Table 3) during 2017 (9.33 to 11.00 $plants^{-5)}$ and 2018 (10.33-11.67 $plants^{-5}$). On 3rd, 5th and 7th days

Table 1: Effect of some chemicals against jassids (*A. biguttula biguttula*) in *rabi*-summer tomato during 2017 and 2018

Insecticides	2017							2018						
	Pre-treatment population leaf^{-1}	First spray: Percent reduction in population at differentdays after spray (DAS)			Second spray: Percent reduction in population at different days after spray (DAS)			Pre-treatment population leaf^{-1}	First spray: Percent reduction in population at different days after spray (DAS)			Second spray: Percent reduction in population at different days after spray (DAS)		
		3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS		3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS
T_1 : Untreated control	3.37	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	5.40	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)
T_2 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 375 ml ha^{-1}	3.70	69.37 (56.65)	74.77 (60.19)	75.68 (60.82)	72.46 (58.76)	76.81 (61.81)	76.81 (61.68)	5.53	71.08 (57.79)	73.49 (59.32)	75.90 (60.97)	69.88 (57.07)	72.29 (58.52)	74.70 (60.35)
T_3 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 500 ml ha^{-1}	3.80	75.44 (60.70)	80.67 (64.27)	81.51 (64.97)	76.32 (61.12)	81.54 (65.10)	81.54 (65.07)	4.90	75.51 (60.65)	79.50 (63.45)	80.27 (64.02)	74.07 (59.69)	76.54 (61.40)	81.48 (64.87)
T_4 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 625 ml ha^{-1}	3.97	76.47 (61.29)	80.70 (64.22)	81.58 (64.98)	76.92 (61.72)	81.58 (64.85)	81.58 (64.97)	5.37	75.78 (60.72)	79.59 (63.54)	80.75 (64.22)	73.56 (59.23)	77.01 (61.82)	81.52 (64.90)
T_5 : Spirotetramat 15.94 OD @ 500 ml ha^{-1}	3.63	68.44 (56.13)	71.19 (57.85)	72.11 (58.44)	64.23 (53.57)	68.83 (56.37)	69.37 (56.65)	5.13	66.10 (54.59)	69.03 (56.32)	69.37 (56.65)	61.06 (51.69)	63.95 (53.20)	64.23 (53.57)
T_6 : Imidacloprid 17.8 SL @ 375 ml ha^{-1}	3.77	69.03 (56.32)	71.68 (58.05)	74.34 (59.78)	70.83 (57.32)	73.61 (59.20)	73.61 (59.20)	5.27	70.25 (57.08)	72.15 (58.33)	72.15 (58.23)	68.69 (56.23)	71.72 (58.14)	73.74 (59.61)
T_7 : Fenazaquin 10 EC@ 1250 ml ha^{-1}	3.87	19.83 (26.63)	21.55 (27.90)	22.41 (28.59)	23.73 (29.33)	22.88 (28.77)	33.90 (35.80)	5.27	24.68 (29.84)	31.65 (34.19)	33.12 (35.44)	23.98 (29.62)	30.99 (33.95)	28.00 (31.90)
T_8 : Acephate 75 WP@ 390 g ha^{-1}	3.93	66.10 (54.59)	70.34 (57.61)	72.88 (58.85)	70.21 (57.10)	73.40 (59.17)	73.40 (59.37)	5.20	69.87 (56.95)	70.51 (57.49)	71.15 (57.62)	68.18 (55.97)	70.91 (57.71)	73.64 (59.41)
SEm (±)	**-**	**1.32**	**1.46**	**1.00**	**2.20**	**1.41**	**1.39**	**-**	**1.12**	**1.19**	**1.28**	**1.15**	**2.00**	**1.24**
LSD(0.05)	**NS**	**3.94**	**4.39**	**3.00**	**6.59**	**4.24**	**4.18**	**NS**	**3.37**	**3.57**	**3.82**	**3.44**	**5.99**	**3.72**

Note : Figures in parentheses are angular transformed value.

Table 2: Effect of some chemicals against red mites (*Tetranychus spp.*) in *rabi*-summer tomato during 2017 and 2018

Insecticides	2017							2018						
	Pre-treatment population leaf^{-1}	First spray: Percent reduction in population at differentdays after spray (DAS)			Second spray: Percent reduction in population at different days after spray (DAS)			Pre-treatment population leaf^{-1}	First spray: Percent reduction in population at different days after spray (DAS)			Second spray: Percent reduction in population at different days after spray (DAS)		
		3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS		3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS
T_1 : Untreated control	7.00	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	8.33	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)	0 (4.05)
T_2 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 375 ml ha^{-1}	6.60	73.40 (59.00)	75.70 (60.50)	76.70 (63.20)	72.30 (58.20)	74.70 (59.80)	77.60 (61.80)	8.50	73.40 (59.00)	75.80 (60.50)	78.20 (62.20)	71.90 (58.00)	75.80 (64.80)	78.20 (62.20)
T_3 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 500 ml ha^{-1}	5.40	81.46 (64.85)	85.11 (67.23)	85.82 (67.87)	80.63 (64.13)	85.86 (68.18)	87.43 (69.53)	7.90	76.90 (61.30)	79.40 (63.00)	82.50 (65.30)	75.70 (60.50)	80.50 (63.70)	83.00 (65.70)
T_4 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 625 ml ha^{-1}	6.30	81.56 (64.48)	85.43 (67.96)	86.09 (68.55)	80.90 (64.47)	85.93 (68.38)	87.44 (69.65)	8.33	77.60 (61.80)	80.50 (63.70)	83.00 (65.70)	76.40 (60.90)	81.50 (64.50)	83.10 (65.73)
T_5 : Spirotetramat 15.94 OD @ 500 ml ha^{-1}	5.90	71.40 (59.90)	73.40 (59.00)	75.80 (60.50)	71.90 (58.00)	74.00 (59.30)	76.90 (61.30)	8.50	72.50 (58.37)	75.40 (60.28)	77.60 (61.80)	70.70 (57.23)	74.30 (59.60)	77.60 (61.80)
T_6 : Imidacloprid 17.8 SL@ 375 ml ha^{-1}	6.80	63.95 (53.20)	65.31 (53.90)	68.03 (55.53)	61.06 (51.69)	64.90 (53.97)	65.38 (54.28)	8.50	62.00 (51.90)	64.80 (53.60)	69.10 (56.23)	63.10 (52.50)	64.80 (53.60)	70.50 (57.10)
T_7 : Fenazaquin 10 EC@ 1250 ml ha^{-1}	6.20	71.92 (58.31)	74.66 (60.15)	75.34 (60.55)	74.35 (59.89)	75.92 (60.84)	76.44 (61.23)	8.07	71.40 (59.90)	76.90 (61.30)	77.60 (61.80)	73.40 (59.00)	77.60 (61.80)	76.40 (60.90)
T_8 : Acephate 75 WP@ 390 g ha^{-1}	6.50	70.34 (57.18)	72.41 (58.56)	73.10 (59.21)	70.92 (57.69)	72.45 (58.66)	72.96 (58.99)	8.37	67.30 (55.20)	71.90 (58.00)	73.40 (59.00)	71.90 (58.00)	72.30 (58.20)	73.40 (59.00)
SEm (±)	**-**	**1.36**	**1.36**	**1.13**	**0.87**	**0.94**	**1.15**	**-**	**1.30**	**1.10**	**1.25**	**1.00**	**1.05**	**1.10**
LSD(0.05)	**NS**	**4.09**	**4.09**	**3.38**	**2.61**	**2.81**	**3.44**	**NS**	**3.70**	**3.28**	**3.74**	**2.99**	**3.14**	**3.14**

Note : Figures in parentheses are angular transformed value.

Table 3: Effect of some chemicals against lady bird beetles in *rabi*-summer tomato during 2017 and 2018

Insecticides	Population of coccinellids per 5 plants at pre-treatment (PT) and different days after spray (DAS)															
	2017								2018							
	First spray				Second spray				First spray				Second spray			
	PT	3 DAS	5 DAS	7 DAS	PT	3 DAS	5 DAS	7 DAS	PT	3 DAS	5 DAS	7 DAS	PT	3 DAS	5 DAS	7 DAS
T_1 : Untreated control	10.33	10.33	10.33	10.67	11.33	11.33	11.00	11.00	10.67	10.67	10.33	10.33	11.33	11.00	11.00	10.67
T_2 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 375 ml ha^{-1}	11.00	11.00	10.33	10.33	11.33	10.67	10.33	10.00	11.33	11.00	10.67	10.33	11.33	11.33	11.00	11.00
T_3 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 500 ml ha^{-1}	10.33	9.67	9.33	9.33	10.67	10.67	9.67	9.67	11.00	11.00	10.33	10.33	10.67	10.33	10.33	10.00
T_4 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 625 ml ha^{-1}	10.00	9.33	9.00	9.00	10.33	10.00	10.00	9.67	11.33	10.67	10.33	10.00	10.33	10.00	9.67	9.67
T_5 : Spirotetramat 15.94 OD @ 500 ml ha^{-1}	9.67	9.33	9.33	9.00	10.00	9.67	9.67	9.67	11.67	10.67	10.00	9.67	11.00	10.33	9.67	9.67
T_6 : Imidacloprid 17.8 SL @ 375 ml ha^{-1}	10.67	9.33	9.33	9.00	10.33	10.33	10.00	10.00	10.00	10.00	10.33	10.00	11.00	10.67	10.33	10.00
T_7 : Fenazaquin 10 EC@ 1250 ml ha^{-1}	9.33	4.33	3.67	2.33	3.33	1.33	1.00	0.67	10.33	2.00	1.33	1.00	2.67	2.33	1.67	1.33
T_8 : Acephate 75 WP@ 390 g ha^{-1}	9.67	2.67	2.33	2.00	2.67	2.00	1.67	1.00	11.33	1.67	1.33	1.00	2.33	1.67	1.00	0.67
SEm (±)	**0.60**	**0.73**	**0.72**	**0.82**	**0.77**	**0.48**	**0.72**	**0.45**	**0.87**	**0.46**	**0.53**	**0.66**	**0.61**	**0.75**	**0.58**	**0.54**
LSD(0.05)	**1.80**	**2.19**	**2.16**	**2.46**	**2.30**	**1.44**	**2.15**	**1.35**	**2.61**	**1.38**	**1.60**	**1.98**	**1.84**	**2.26**	**1.73**	**1.61**

Table 4: Effect of some chemicals against spiders in summer tomato during 2017 and 2018

Insecticides	Population of coccinellids per 5 plants at pre-treatment (PT) and different days after spray (DAS)															
	2017								2018							
	First spray				Second spray				First spray				Second spray			
	PT	3 DAS	5 DAS	7 DAS	PT	3 DAS	5 DAS	7 DAS	PT	3 DAS	5 DAS	7 DAS	PT	3 DAS	5 DAS	7 DAS
T_1 : Untreated control	9.67	9.67	9.33	9.33	10.33	10.00	10.00	10.00	10.67	10.67	10.33	10.33	11.00	11.00	10.67	10.67
T_2 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 375 ml ha^{-1}	9.33	9.00	8.67	8.67	9.67	9.33	9.33	9.00	10.00	9.67	9.33	9.33	10.67	10.00	9.00	8.67
T_3 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 500 ml ha^{-1}	9.67	9.00	8.67	8.33	9.67	9.00	9.00	8.67	9.33	9.00	9.00	9.00	11.00	10.00	9.67	9.33
T_4 : Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 625 ml ha^{-1}	9.00	8.67	8.67	8.33	9.67	9.00	8.67	8.67	9.67	9.00	8.67	8.33	10.33	10.00	9.33	9.33
T_5 : Spirotetramat 15.94 OD @ 500 ml ha^{-1}	10.00	9.33	9.00	8.67	9.67	9.33	9.00	8.67	9.67	9.33	9.00	9.00	11.00	10.67	10.33	10.00
T_6 : Imidacloprid 17.8 SL @ 375 ml ha^{-1}	9.67	9.33	9.00	9.00	9.33	9.00	9.00	8.67	9.33	9.00	8.67	8.67	10.67	10.00	9.67	9.33
T_7 : Fenazaquin 10 EC @ 1250 ml ha^{-1}	9.33	3.67	2.67	2.00	3.00	1.67	1.67	1.33	10.67	5.00	4.00	3.00	3.00	1.33	1.00	0.67
T_8 : Acephate 75 WP @ 390 g ha^{-1}	9.67	4.00	2.33	1.33	2.33	1.33	1.00	0.67	11.00	3.67	2.33	3.00	2.67	1.00	0.67	0.33
SEm (±)	**0.69**	**0.75**	**0.63**	**0.71**	**0.74**	**0.59**	**0.63**	**0.60**	**0.77**	**0.48**	**0.72**	**0.45**	**0.61**	**0.75**	**0.58**	**0.54**
LSD(0.05)	**2.07**	**2.26**	**1.88**	**2.13**	**2.21**	**1.76**	**1.89**	**1.79**	**2.30**	**1.44**	**2.15**	**1.35**	**1.84**	**2.26**	**1.73**	**1.61**

Table 5: Cost effectiveness of different treatments against jassids and red mites in tomato during *rabi*-summer of 2017 and 2018.

Treatments	Marketable yield ($q\ ha^{-1}$)		Increased yield over control ($q\ ha^{-1}$)		Added benefit over control ($Rs.\ ha^{-1}$)		Cost of treatment ($Rs.\ ha^{-1}$)		Net profit ($Rs.\ ha^{-1}$)		BCR (Benefit Cost Ratio)	
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
T_1 : Untreated control	126.67	132.33	-	-	-	-	-	-	-	-	-	-
T_2 : Spirotetramat 11.01 + Imidacloprid 11.01 SC@ 375 ml ha^{-1}	142.67	145.67	16	13.34	24000	21344	2250	2250	21750	19094	9.67	8.49
T_3 : Spirotetramat 11.01 + Imidacloprid 11.01 SC@ 500 ml ha^{-1}	146.00	148.33	19.33	16	28995	25600	2750	2750	26245	22850	9.54	8.31
T_4 : Spirotetramat 11.01 + Imidacloprid 11.01 SC@ 625 ml ha^{-1}	146.67	149.33	20	17	30000	27200	3250	3250	26750	23950	8.23	7.37
T_5 : Spirotetramat 15.94 OD@ 500 ml ha^{-1}	139.00	142.00	12.33	9.67	18495	15472	2250	2250	16245	13222	7.22	5.88
T_6 : Imidacloprid 17.8 SL@ 375 ml ha^{-1}	137.33	142.33	10.66	10	15990	16000	2175	2175	13815	13825	6.35	6.36
T_7 : Fenazaquin 10 EC@ 1250 ml ha^{-1}	136.67	138.67	10	6.34	15000	10144	3250	3250	11750	6894	3.62	2.12
T_8 : Acephate 75 WP@ 390 g ha^{-1}	137.67	139.00	11	6.67	16500	10672	2000	2000	14500	8672	7.25	4.34
SEm (±)	**0.84**	**0.78**	-	-	-	-	-	-	-	-	-	-
LSD(0.05)	**2.55**	**2.33**	-	-	-	-	-	-	-	-	-	-

Note : i) Selling price of tomato during 2017 – Rs. 1500 per quintal   ii) Selling price of tomato during 2018 – Rs. 1600 per quintal after spray, the predatory coccinellids population did not differ significantly in most of the treatments from that of control indicating their safeties except Fenazaquin and Acephate to the predators during both the years. Here, the mean population per 5 plants was reduced from 9.67 to 2.00 and 11.33 to 1.00 in Acephate followed by 9.33 to 2.33 and 10.33 to 1.00 in Fenazaquin during 2017 and 2018, respectively. Due to lethal effect, pre-treatment population per 5 plants for 2nd spray was lowest as 2.67 (2017) and 2.33 (2018) in Acephate followed by 3.33 (2017) and 2.67 (2018) in Fenazaquin. No statistical variation in pre-treatment population of coccinellids per plants (10.00 to 11.33 in 2017 and 10.33 to 11.33 in 2018) for 2nd spray was recorded in all other treatments including control. Like 1st spray, similar trend in safety of coccinellids on 3rd, 5th and 7th days after 2nd spray was noticed in Spirotetramat + Imidacloprid (375 – 625 ml ha^{-1}), Spirotetramat (500 ml ha^{-1}) and Imidacloprid (375 ml ha^{-1}). The coccinellids population for all these treatments was statistically uniform with that of control at different days after 2nd spray for both the years of experiment.

The data presented in table 4 also reveals the safety of Spirotetramat + Imidacloprid (375 – 625 ml ha^{-1}), Spirotetramat (500 ml ha^{-1}) and Imidacloprid (375 ml ha^{-1}) to the adults of spiders as population was significantly at par with control at pre and different days (3rd, 5th and 7th) of post treatment for each of 1st and 2nd spray during 2017 and 2018. However, Acephate and Fenazaquin showed detrimental effect on population of spiders.

The present safety report of Spirotetramat + Imidacloprid against lady beetles and spiders in tomato is in conformity with the earlier work done by Patel *et al*. (2010) on cotton ecosystem. The positive compatibility of Spirotetramat with coccinellid *M. sexmaculatus* was concluded by Azod *et al.* (2016). The safety of Imidacloprid against natural enemies in soyabean had also reported by Varenhorst and O'neal (2012). All these safety results may be due to selective, systemic, non contact and translaminar nature of Spirotetramat and Imidacloprid.

Effect of treatments on yield and economics

The marketable yield (q ha^{-1}) of tomato during 2017 was recorded maximum in Spirotetramat + Imidacloprid @ 625 ml ha^{-1} (146.67) followed by Spirotetramat + Imidacloprid @ 500 ml ha^{-1} (146.00), Spirotetramat + Imidacloprid @ 375 ml ha^{-1} (142.67), Spirotetramat (139.00), Acephate (137.67), Fenazaquin (136.67), Imidacloprid (137.33) and untreated control (126.67) (Table 5). Hence, Spirotetramat + Imidacloprid @ 625 ml ha^{-1} obtained highest net profit (Rs. 26750 ha^{-1}) over control, but it was succeeded by Spirotetramat + Imidacloprid @ 500 ml ha^{-1} (Rs. 26245 ha^{-1}), Spirotetramat + Imidacloprid @ 375 ml ha^{-1} (Rs. 21750 ha^{-1}), Spirotetramat (Rs. 16245 ha^{-1}), Acephate (Rs. 14500 ha^{-1}), Imidacloprid (Rs. 13815 ha^{-1}) and Fenazaquin (Rs. 11750 ha^{-1}). But the benefit cost ratio (BCR) was found highest in Spirotetramat + Imidacloprid @ 375 ml ha^{-1} (9.67) and then in Spirotetramat + Imidacloprid @ 500 ml ha^{-1} (9.54), Spirotetramat + Imidacloprid @ 625 ml ha^{-1} (8.23), Acephate (7.25), Spirotetramat (7.22), Imidacloprid (6.35) and Fenazaquin (3.62).

During 2018, the marketable fruit yield (q ha^{-1}) of tomato was obtained highest in Spirotetramat + Imidacloprid @ 625 ml ha^{-1} (149.33), which was succeeded by Spirotetramat + Imidacloprid @ 500 ml ha^{-1} (148.33), Spirotetramat + Imidacloprid @ 375 ml ha^{-1} (145.67), Imidacloprid (142.33), Spirotetramat (142.00), Acephate (139.00), Fenazaquin (138.67) and untreated control (132.33). The per hectare maximum net profit over control was recorded from Spirotetramat + Imidacloprid @ 625 ml ha^{-1} (Rs. 23950) and then from Spirotetramat + Imidacloprid @ 500 ml ha^{-1} (Rs. 22850), Spirotetramat + Imidacloprid @ 375 ml ha^{-1} (Rs. 19094), Imidacloprid (Rs. 13825), Spirotetramat (Rs.13222), Acephate (Rs. 8672) and Fenazaquin (Rs. 6894). Therefore, Spirotetramat + Imidacloprid @ 375 ml ha^{-1} achieved maximum BCR (8.49) over control and then in order were Spirotetramat + Imidacloprid @ 500 ml ha^{-1} (8.31), Spirotetramat + Imidacloprid @ 625 ml ha^{-1} (7.37), Imidacloprid (6.36), Spirotetramat (5.88), Acephate (4.34) and Fenazaquin (2.12).

From this experiment, it was revealed that Spirotetramat 11.01 + Imidacloprid 11.01 SC @ 500 and 625 ml ha^{-1} were almost equally effective to reduce the jassids and red mites of tomato. Its lowest dose (375 ml ha^{-1}) was also responsive as compared to other treatments. Now considering efficacy against jassids an mites, safety for natural enemies, crop yield and economics; the said chemical at 375 - 500 ml ha^{-1} could be recommended in farmers' field for managing jassids and mites in tomato. The negligible detrimental effect of lady beetles and spiders indicates the product as comparatively eco-friendly to use in tomato.

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