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Efficacy of different synthetic insecticides against citrus leaf miner, *Phyllocnistis citrella* on acid lime

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Abstract
The present field experiment was conducted at All India Co-ordinated Research Project on fruit crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2018 and 2019 on acid lime. The data reveals that the observations pertaining to the six spray applications at all the four dates of observations wherein, more or less similar trend was exhibited. Amongst the seven test synthetic insecticides, Spinetoram appears to be equally promising with that of the standard check, Ethion 40% plus Cypermethrin followed by Cypermethrin, Cyantraniliprole, Abamectin, Spinosad and Imidacloprid in the descending order of the bio-efficacy.

Keywords: Acid lime, citrus leaf miner, synthetic insecticides, Maharashtra

1. Introduction
Citrus is a globally cultivated important fruit crop, which includes orange, sweet orange, acid lime, pomelo, grape fruit and other related species of citrus. Citrus species are native of tropical and sub-tropical regions of south-east Asia and Malayan Archipelago (Webber, 1967) [17] and acid lime (*Citrus aurantifolia*) belongs to family Rutaceae, originated in India and it is the third most important citrus species, after Mandarin and Sweet orange (Yadlod *et al*., 2018) [18]. Citriculture is the third largest fruit industry after mango and banana in India. Citrus belongs to family Rutaceae. Citrus is not only delicious and refreshing fruit to eat, but also it provides vitamins, minerals and many other essential elements which are essential for human health. Citrus is the main source of vitamin "C" (citric acid). Citrus fruits also have sufficient amounts of vitamins and minerals that your body needs to function properly, including B vitamins, phosphorous, potassium, magnesium and copper. Also, they are rich in plant compounds that have various health benefits, including anti-inflammatory and antioxidant effects. Their wholesome nature, various nutritional and medicinal values have made them so important for humans. The fruit has valued not only for its nutritional and medicinal uses but also extensively used for the preparation of value added products, like squashes, syrup, cordials, pickles, manufacture of citric acid and for culinary uses in the daily diet of Indians (Tetens, 2013) [16].

India is the world's largest producer of lemons and limes. In case of India, leading kagzi lime producing states are Andhra Pradesh, Gujarat, Tamil Nadu, Karnataka, Maharashtra, Assam and Rajasthan. In India, acid lime covers about 2.83 lac hectares area and about 32.21 lac metric tonnes production during 2018-19. In Maharashtra Nagpur, Akola, Amravati and Wardha are the major citrus growing districts which cover about 27.27 thousands hectares area of acid lime with 2.50 lac metric tonnes production during 2018-19 (Anonymous, 2018) [1].

About 250 different species of insects and mites have been found in India which are infesting different species of citrus crop (Butani, 1979) [4]. In Maharashtra state, 14 species are reported out of these 8 species have most significant importance (Lad *et al*., 2010) [7]. Citrus leaf miner is the most destructive pest and mostly attacks nurseries, tender flushes and young plantations which completed about 16 overlapping generations in a year (Sandhu, 1964) [13]. Kalidas and Shivankar (1994) [6] stated that, more than 80 per cent citrus nurseries were infested by this destructive pest in India. The total damage caused by the various pest of citrus, 30 per cent damae caudes by *P. citrella* alone. The average infestation rate caused by citrus leaf miner varied from 17 to 57 per cent (Boughdad *et al.*, 1999) [3]. Keeping in view the great commercial importance of citrus fruit and importance of this pest in Maharashtra the present study was conducted with the view to determine the efficacy of synthetic insecticides against citrus leaf miner, *Phyllocnistis citrella* on acid lime.

2. Materials and Methods

The present investigation was conducted at All India Co-ordinated Research Project on fruit crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2018 and 2019 on acid lime plant. The experiment was conducted with Randomized Block Design with three replications and eight treatments. The acid lime trees having uniform size, growth and age with a spacing of 6 m between two trees were selected to conduct the field experiment. Each selected synthetic insecticide sprayed on randomly selected and tagged plants on which *P. Citrella* damage crossed 10 per cent. One plant considered as one replication. Water spray made in control plants. The spray suspension of respective treatment made as per required concentration. The application of suspension @ 5 litres / tree made with the help of the knapsack sprayer through triple action nozzle. For recording observations, the *P. Citrella* infested and total leaves also recorded from each randomly selected twig before application as well as 3, 7, 10 and 15 days after each application. Data, thus obtained subjected to ANOVA after following arcsine transformation of *P. citrella* damaged leaves, respectively.

3. Results and Discussion

Newly developed and introduced insecticides *viz*., Cyantraniliprole 10.26 OD, Imidacloprid 17.8 SL, Spinosad 45 SC, Spinetoram 17.7 SC, Ethion 40% + Cypermethrin 5% 45 SC, Abamectin 1.9 EC and Cypermethrin 25 EC evaluated against *P. citrella* on acid lime during 2018-2019 at All India Co-ordinated Research Project on fruit crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. Each insecticidal treatment was consisting of three sprays applied at *Ambia, Mrig* and *Hasta bahar* during 2018-2019. Pre-count data on per cent leaf infestation under the study were recorded one day prior to spray which was observed to be statistically non-significant and homogenous in the field.

3.1 Overall performance of the test synthetic insecticides (2018)

The data have been presented in Table 1 and Fig. 1 wherein, the trends of the results obtained for each of the dates of observation are indicated below.

At 3 DAS: The standard check, Ethion 40% plus Cypermethrin 5% was found prominent treatment and was at par with Spinetoram and Cyantraniliprole followed by rest of the treatments under the studies.

At 7 DAS: Spinetoram was observerd to be the most promising treatment and was on par with Ethion 40% plus Cypermethrin followed by Cypermethrin, Cyantraniliprole and Abamectin which, were on par with each other followed by rest of the treatments.

At 10 DAS: Ethion 40% plus Cypermethrin 5% was found prominent treatment and was at par with Spinetoram followed by rest of the treatments.

At 15 DAS: Ethion 40% plus Cypermethrin 5% was found to be promising which however was on par with Spinetoram and Cyantraniliprole followed by rest of the treatments.

Table 1: Overall performance of test synthetic insecticides (2018)

S. No.	Treatment	Formul-ation	Dose (ml/l)	% leaf infestation			
				3 DAS	7 DAS	10 DAS	15 DAS
T_1	Cyantraniliprole	10.26 OD	1.8 ml	16.58 (24.03)	15.68 (23.33)	9.87 (18.31)	11.02 (19.39)
T_2	Imidacloprid	17.8 SL	0.28 ml	21.97 (27.95)	19.00 (25.84)	14.60 (22.46)	16.85 (24.23)
T_3	Spinosad	45 SC	0.04 ml	20.96 (27.25)	18.47 (25.45)	13.85 (21.85)	15.46 (23.15)
T_4	Spinetoram	11.7 SC	0.9 ml	16.19 (23.72)	11.47 (19.80)	7.74 (16.16)	10.75 (19.14)
T_5	Abamectin	1.9 EC	0.37 ml	20.42 (26.86)	17.31 (24.59)	11.37 (19.71)	13.07 (21.20)
T_6	Cypermethrin	25 EC	0.5 ml	19.72 (26.37)	15.52 (23.20)	11.20 (19.55)	12.06 (20.32)
T_7	Ethion 40% + Cypermethrin 5% (Treated check)	45 SC	2 ml	15.37 (23.08)	11.67 (19.97)	7.37 (15.75)	9.31 (17.76)
T_8	Untreated check	-	-	28.58 (32.32)	28.73 (32.41)	25.83 (30.55)	26.13 (30.74)
	F test			Sig	Sig	Sig	Sig
	S.Em±			0.72	0.69	0.56	0.77
	CD (5%)			2.19	2.11	1.7	2.36

*Figures in parenthesis are arc sin transformation
DAS – Days after Spray

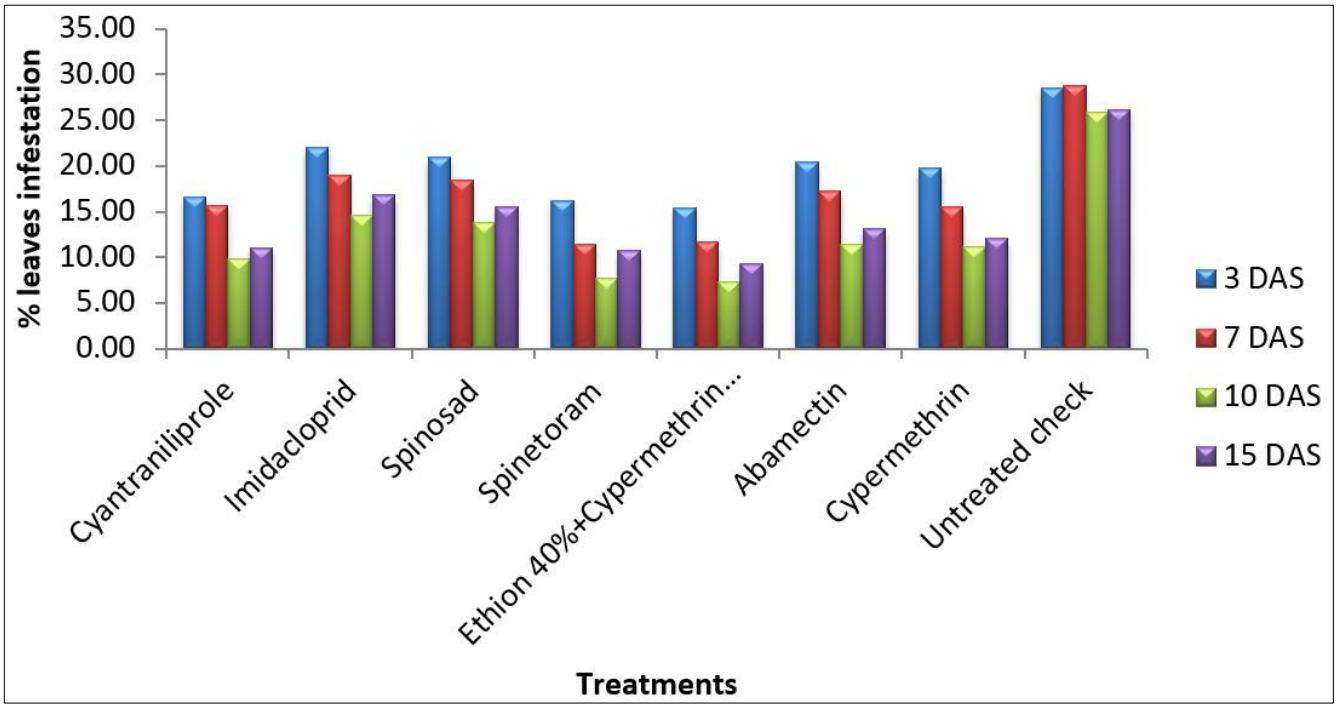

Fig 1: Overall bio-efficacy of test synthetic insecticides against *P. citrella* on acid lime (2018)

3.2 Overall performance of the test synthetic insecticides (2019)

The data have been presented in Table 2 and Fig. 2. Wherein, trends of the results obtained for each of the dates of observation are indicated below.

At 3 DAS: Spinetoram was observed to be the most promising treatment and was on par with the treated check, Ethion 40% plus Cypermethrin followed by Cyantraniliprole, Cypermethrin and Abamectin were on par with each other followed by rest of the treatments.

At 7 DAS: Ethion 40% plus Cypermethrin was observed to be the most promising treatment and was on par with Spinetoram followed by Cypermethrin, Cyantraniliprole and Abamectin which, were on par with each.

At 10 DAS: Ethion 40% plus Cypermethrin 5% was found prominent treatment and was at par with Spinetoram and Cyantraniliprole followed by rest of the treatments.

At 15 DAS: Ethion 40% plus Cypermethrin 5% was found to be effective which however was on par with Spinetoram and Cyantraniliprole followed by rest of the treatments.

Table 2: Overall performance of test synthetic insecticides (2019)

S. No.	Treatment	Formul-ation	Dose (ml/l)	% leaf infestation			
				3 DAS	7 DAS	10 DAS	15 DAS
T_1	Cyantraniliprole	10.26 OD	1.8 ml	21.30 (27.49)	15.96 (23.55)	11.28 (19.63)	13.69 (21.72)
T_2	Imidacloprid	17.8 SL	0.28 ml	26.50 (30.99)	21.76 (27.81)	17.96 (25.07)	19.64 (26.31)
T_3	Spinosad	45 SC	0.04 ml	25.49 (30.33)	20.65 (27.03)	17.22 (24.52)	19.03 (25.87)
T_4	Spinetoram	11.7 SC	0.9 ml	17.96 (25.08)	13.87 (21.87)	10.81 (19.20)	12.35 (20.58)
T_5	Abamectin	1.9 EC	0.37 ml	24.59 (29.73)	18.83 (25.72)	16.07 (23.64)	17.52 (24.75)
T_6	Cypermethrin	25 EC	0.5 ml	24.15 (29.44)	18.29 (25.32)	15.45 (23.15)	18.16 (25.23)
T_7	Ethion 40% + Cypermethrin 5% (Treated check)	45 SC	2 ml	18.81 (25.71)	13.01 (21.14)	9.92 (18.36)	11.90 (20.19)
T_8	Untreated check	-	-	33.82 (35.56)	33.35 (35.28)	32.13 (34.53)	33.55 (35.40)
	F test			Sig	Sig	Sig	Sig
	S.Em±			0.79	0.73	0.64	0.58
	CD (5%)			2.39	2.21	1.95	1.77

*Figures in parenthesis are arc sin transformation
DAS – Days After Spray

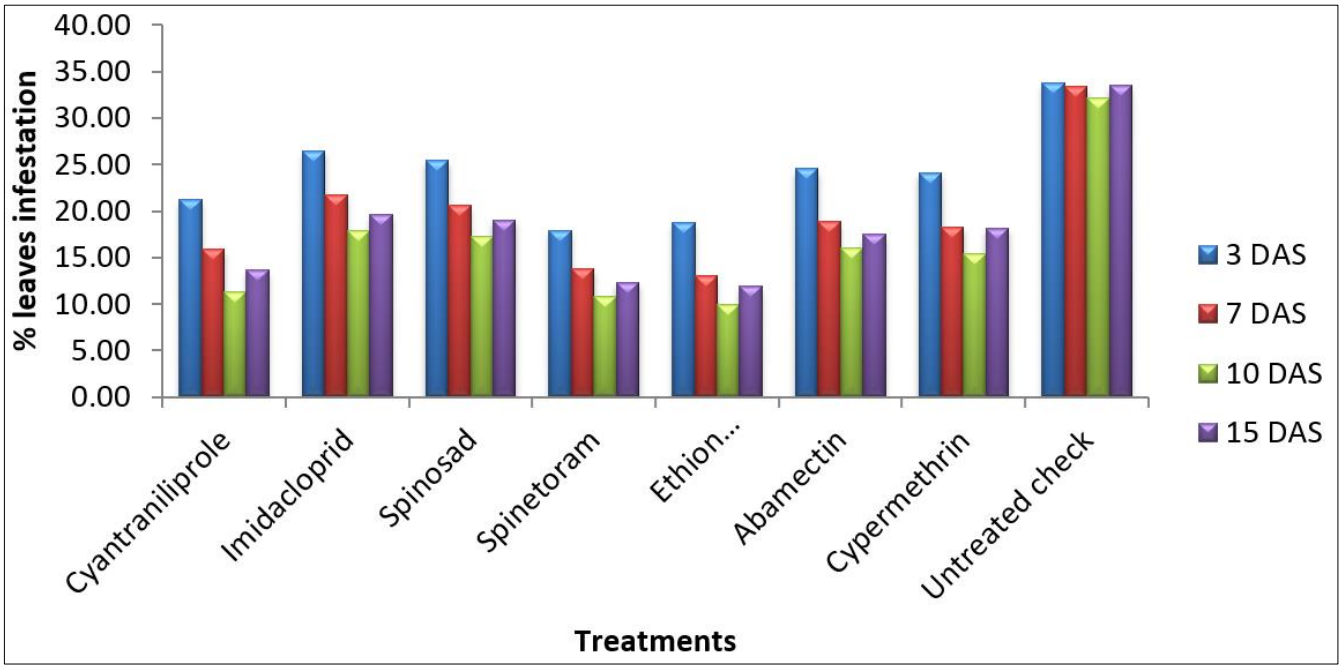

Fig 2: Overall bio-efficacy of test synthetic insecticides against *P. citrella* on acid lime (2019)

3.3 Cumulative performance of the test synthetic insecticides (2018- 2019)

The cumulative bio-efficacy of the test synthetic insecticides have been presented in Table 3 and Fig. 3. The data reveals that the observations pertaining to the six spray applications at all the four dates of observations wherein, more or less similar trend was exhibited. Amongst the seven test synthetic insecticides, Spinetoram appears to be equally promising with that of the standard check, Ethion 40% plus Cypermethrin followed by Cypermethrin, Cyantraniliprole, Abamectin, Spinosad and Imidacloprid in the descending order of the bio-efficacy.

Bio-efficacy of the standard check, Ethion 40% plus Cypermethrin has been advocated by Rukesh *et al.* (2019) [12] on vegetable crops against *Liriomyza trifolii* under laboratory conditions. Spinetoram has been reported to be promising by Hanafy and Walaa El-Sayed (2013) [5], Sridhar *et al*. (2016) [15] and Sapkal *et al*. (2018) [14] against *Tuta absoluta* on tomato. Cyantraniliprole has been advocated by Sridhar *et al*. (2016) [15] on tomato against *Tuta absoluta*. The field bio-efficacy of Abamectin was reported to be effective against *P. citrella* on acid lime by Patil (2013) [10] and Mane *et al.* (2016) [8]. Spinosad has been reported to be effective by Patil (2013) [10], Mohamed and Abdalla (2015) [9], Rathod *et al.* (2018) and Bhut and Jethva (2019) [2] against *P. citrella* on acid lime. Lad *et al.* (2010) [7] reported that Imdicloprid was effective against *P.citrella* on acid lime. Amongst the aforesaid reported findings, none of the workers have evaluated the field bio-efficacy of Ethion 40% plus Cypermethrin, Spinoteram, Cypermethrin and Cyantraniliprole against *P. citrella* on acid lime.

Table 3: Cumulative performance of test synthetic insecticides (2018-2019)

S. No.	Treatment	Formul-ation	Dose (ml/l)	% leaf infestation			
				3 DAS	7 DAS	10 DAS	15 DAS
T_1	Cyantraniliprole	10.26 OD	1.8 ml	18.94 (24.11)	15.82 (23.44)	10.58 (18.98)	12.36 (20.58)
T_2	Imidacloprid	17.8 SL	0.28 ml	24.24 (29.42)	20.38 (26.84)	16.28 (23.79)	18.25 (25.29)
T_3	Spinosad	45 SC	0.04 ml	23.23 (26.80)	19.56 (26.25)	15.54 (23.21)	17.25 (24.54)
T_4	Spinetoram	11.7 SC	0.9 ml	17.07 (22.42)	12.68 (20.86)	9.28 (17.73)	11.55 (19.87)
T_5	Abamectin	1.9 EC	0.37 ml	22.51 (25.79)	18.07 (25.16)	13.72 (21.74)	15.30 (23.02)
T_6	Cypermethrin	25 EC	0.5 ml	21.94 (27.42)	16.91 (24.28)	13.33 (21.41)	15.12 (22.88)
T_7	Ethion 40% + Cypermethrin 5% (Treated check)	45 SC	2 ml	17.09 (24.92)	12.34 (20.56)	8.64 (17.10)	10.61 (19.01)
T_8	Untreated check	-	-	31.20 (32.79)	31.04 (33.86)	28.99 (32.57)	29.85 (33.11)
	F test			Sig	Sig	Sig	Sig
	S.Em±			0.58	0.57	0.45	0.44
	CD (5%)			1.76	1.73	1.39	1.36

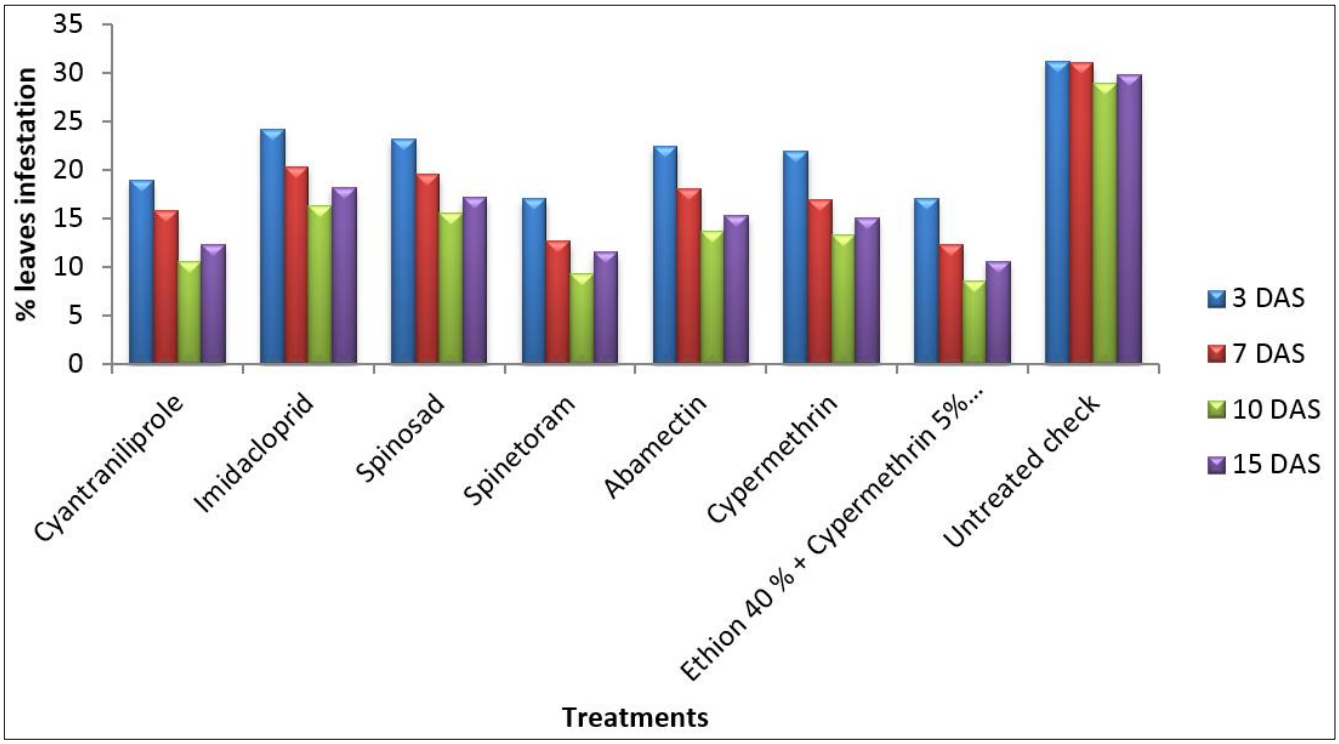

Fig 3: Cumulative performance of test synthetic insecticides (2018-2019)

4. Conclusion

From the above findings of present investigation following conclusions could be drawn. Infestation of citrus leaf miner was more in newly sprouted leaves than older one. The field bio-efficacy of Spinetoram and Cyantraniliprole exhibited promising performance with that of Ethion 40% plus Cypermethrin 5% (standard check) and proved to be most suitable for minimizing citrus leaf miner *P. citrella* infestation on acid lime crop and can be encouraged in IPM programme.

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