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Bio-efficacy of biorational 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 test biorational insecticides, NSE was equally promising with standard check, Azadirachtin followed by Pongamia oil, Tobacco leaf extract, *Metarhizium* anisopliae, Beauveria *bassiana* and Parthenium leaf extract in descending order.

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

1. Introduction

Citrus fruits belong to family Rutaceae. These are globally cultivated important fruit crops, 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) [16].

Genus citrus have a different species *viz.*, Kagzi lime (*Citrus aurantifolia* Swingle), Citron (*Citrus medica* Linnaeus), Pomelo/Shaddock (*Citrus maxima* Merrill), Mandarin orange (*Citrus reticulata* Blanco) *etc*. Within Rutaceae family, Acid lime is the most widely planted citrus cultivars. Acid lime (*Citrus aurantifolia*) belongs to family Rutaceae, originated in India is the third most important citrus species, after Mandarin and Sweet orange (Yadlod *et al*., 2018) [17]. It is a very famous citrus plant known for its delicious juicy fruit. Environmental and soil conditions are ideal for acid lime in Maharashtra State. Citrus is one of the foremost fruit of India in stipulations of area, yield and export. Although citrus crop is kept in great esteem, yet present status is defenseless by a number of factors, which impede the fruit yield and quality (Atiq, 2008) [3].

Maharashtra gets second rank with 15.79 per cent of total citrus fruit production. The area under citrus fruit crop is 275.0 thousand hectare, from which 1761.0 thousand MT citrus fruit produced. The productivity of citrus in Maharashtra is 5.57 MT/ha, while India's productivity is 12.52 MT/ha. In Maharashtra especially Nagpur, Amravati, Akola, and Wardha districts of Vidarbha are leading in citrus production. Citrus is the third important fruit crop in India. It occupies about 9 per cent of the total area of fruit crop. Out of total area under citrus cultivation in Maharashtra, about 60 per cent is found under acid lime production.

However, citrus crop in Maharashtra (India) is attacked by many diseases and insect pests which are deleterious for citrus industry. Among this pests citrus leaf miner *Phyllocnistis citrella* (Stainton) causes a huge loss of quality citrus fruits (Khair, 2004) [10]. According to Ujiye (2000) [14], citrus leaf miner is a destructive pest of citrus crops. The citrus leaf miner, *Phyllocnistis citrella* Stainton is an important pest of citrus and related rutaceae and ornamental plants almost worldwide (Achor *et al*., 1997) [1]. Leaf miner existence observed on the growing citrus trees and from last two decade it became a serious pest of citrus in Maharashtra. Leaf miner, *Phyllocnistis citrella*, larvae cause damage in the form of mine on immature foliage. Twisted and curled leaves are generally the first symptoms noticed. When larvae cause damages on leaf it become the severe infestation, ultimately the plant can retard the growth and yield, but their effect on mature trees is less serious than nursery, such infestations usually occur in late summer.

They rarely occur in spring because the production of new growth is prolific and synchronized and quickly becomes immune to attack. Generally one leaf has one mine, but in the case of heavy infestation two to three mines could be found per leaf. It mines leaves, surface tissue of young shoots and stems and less frequently the fruit (Sponagel and Diaz, 1994) [13]. *Phyllocnistis citrella* not only causes direct injure to the new sprouts of leaves, but also brutally infect the twigs and fruits and it is also a vector of citrus canker outbreak which is cause by *Xanthomonas axonopodis* pv. citri. It exacerbates citrus canker disease by exposing leaf mesophyll cells during its feeding and allowing direct penetration of bacterium. (Chagas *et al.*, 2001, Urbaneja *et al.*, 2003; Graham *et al*., 2004 and Khair, 2004) [5, 15, 6, 10]. In cases of enormous infestation, citrus leaf miner defect even young fruits (Heppner, 1995) [7]. In view of the aforesaid considerations the present investigations were undertaken to study the bio-efficacy of new biorational insecticides against citrus leaf miner, *P. citrella* on acid lime.

2. Materials and Methods

The present investigations were conducted at AICRP on fruit crops, Department of Horticulture, MPKV, Rahuri during 2018 and 2019. The experiments were conducted in randomized block design with three replications. 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 biorational 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 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

Biorational insecticides *viz*., Azadirachtin (10000 ppm), NSE (5%), Pongamia oil (0.50%), Tobacco leaf extract (5%), *Metarhizium anisopliae* (1 × 10^8 CFU/g), Parthenium leaf extract (5%), *Beauveria bassiana* (1 × 10^8 CFU/g) 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 biorational 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.

3.1.1 At 3 DAS: NSE was observerd to be the most promising treatment and was on par with the treated check, Azadirachtin followed by Pongamia oil, Tobacco leaf extract, *Metarhizium anisopliae*, *Beauveria bassiana*, Parthenium leaf extract and were on par.

3.1.2 At 7 DAS: Azadirachtin was observerd to be the most promising treatment and was on par with NSE. Pongamia oil was next in order of reference followed by rest of treatments which, were on par with each.

3.1.3 At 10 DAS: Azadirachtin was found prominent treatment and was at par with NSE. Next best treatment was pongamia oil that was on par with Tobacco leaf extract followed by rest of the treatments.

3.1.4 At 15 DAS: Azadirachtin was found to be effective which however was on par with NSE followed by rest of the treatments.

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

S N	Treatment	Formulation/ Concentration	Dose (ml or g/ l)	% leaf infestation			
				3 DAS	7 DAS	10 DAS	15 DAS
T_1	NSE	5%	50 g	18.98 (25.83)	14.92 (22.73)	12.02 (20.29)	12.97 (21.12)
T_2	Pongamia oil	0.50%	5 ml	25.11 (30.08)	18.05 (25.14)	15.24 (22.98)	16.43 (23.92)
T_3	Parthenium leaf extract	5%	50 g	27.92 (31.90)	26.36 (30.89)	22.53 (28.34)	24.38 (29.59)
T_4	Tobacco leaf extract	5%	50 g	25.52 (30.35)	21.27 (27.47)	17.47 (24.71)	17.93 (25.06)
T_5	*Beauveria bassiana*	1 × 10^8 CFU/g	5 g	27.69 (31.75)	23.20 (28.80)	19.40 (26.13)	19.96 (26.54)
T_6	*Metarhizium anisopliae*	1 × 10^8 CFU/g	5 g	27.46 (31.60)	22.04 (28.01)	19.43 (26.16)	20.74 (27.09)
T_7	Azadirachtin (Treated check)	10000 ppm	2 ml	19.86 (26.47)	14.31 (22.23)	10.97 (19.35)	12.49 (20.70)
T_8	Untreated check	-	-	29.29 (32.77)	28.97 (32.56)	28.49 (32.26)	28.25 (32.11)
	F test			Sig	Sig	Sig	Sig
	S.Em±			0.9	0.74	0.67	0.92
	CD (5%)			2.87	2.26	2.04	2.79

*Figures in parenthesis are the arc sin transformed values
DAS - Days After Spray

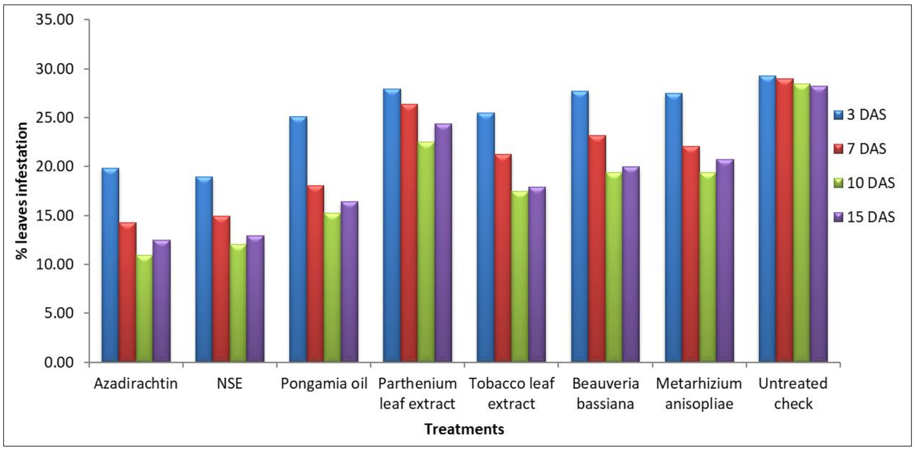

Fig 1: Overall bio-efficacy of test biorational insecticides against *P. citrella* on acid lime (2018)

3.2 Overall performance of the test biorational insecticides (2019)

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

3.2.1 At 3 DAS: NSE was observerd to be the most promising treatment and was on par with the treated check, Azadirachtin followed by Pongamia oil, Tobacco leaf extract, *Beauveria bassiana*, *Metarhizium anisopliae*, Parthenium leaf extract and were on par.

3.2.2 At 7 DAS: Azadirachtin was observerd to be the most promising treatment and was on par with NSE. Pongamia oil was next in order of reference that was at par with Tobacco leaf extract followed by rest of treatments which, were on par with each.

3.2.3 At 10 DAS: Azadirachtin was found prominent treatment and was at par with NSE. Next best treatment was pongamia oil that was on par with Tobacco leaf extract followed by rest of the treatments.

3.2.4 At 15 DAS: Azadirachtin was found to be effective which however was on par with NSE. Next best treatment was pongamia oil that was on par with Tobacco leaf extract followed by rest of the treatments.

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

S N	Treatment	Formulation/ Concentration	Dose (ml or g/ l)	% leaf infestation			
				3 DAS	7 DAS	10 DAS	15 DAS
T_1	NSE	5%	50 g	21.07 (27.32)	15.04 (22.82)	11.18 (19.54)	13.29 (21.38)
T_2	Pongamia oil	0.50%	5 ml	26.60 (31.05)	19.56 (26.25)	14.95 (22.75)	17.02 (24.37)
T_3	Parthenium leaf extract	5%	50 g	30.33 (33.42)	28.66 (32.37)	25.98 (30.65)	27.73 (31.78)
T_4	Tobacco leaf extract	5%	50 g	27.31 (31.51)	20.98 (27.26)	17.96 (25.08)	20.12 (26.65)
T_5	*Beauveria bassiana*	1×10^8 CFU/g	5 g	29.05 (32.62)	23.89 (29.26)	21.97 (27.95)	24.01 (29.35)
T_6	*Metarhizium anisopliae*	1×10^8 CFU/g	5 g	29.78 (33.08)	25.21 (30.14)	22.43 (28.27)	24.53 (29.69)
T_7	Azadirachtin (Treated check)	10000 ppm	2 ml	21.80 (27.84)	13.89 (21.89)	9.87 (18.31)	12.11 (20.37)
T_8	Untreated check	-	-	32.16 (34.55)	31.23 (33.98)	30.70 (33.65)	30.29 (33.39)
	F test			Sig	Sig	Sig	Sig
	S.Em±			0.64	0.66	0.78	0.79
	CD (5%)			1.95	2.03	2.37	2.39

*Figures in parenthesis are the arc sin transformed values
DAS - Days after Spray

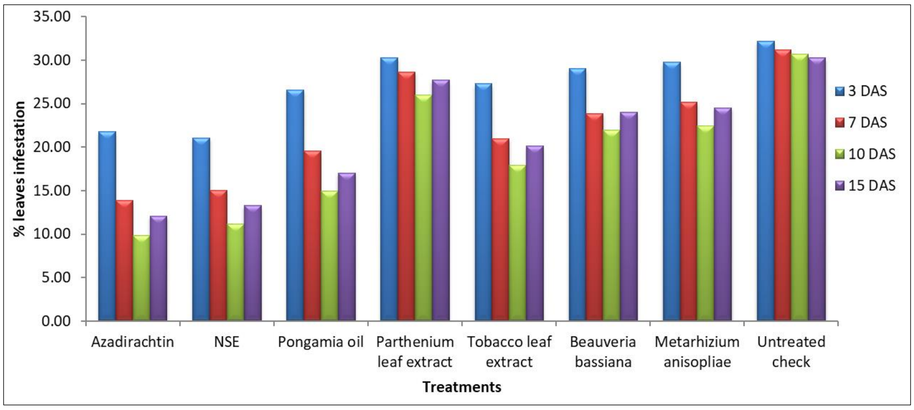

Fig 2: Overall bio-efficacy of test biorational insecticides against *P. citrella* on acid lime (2019)

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

The cumulative bio-efficacy of the test biorational 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 exhibited similar trend. Amongst the seven test biorational insecticides, NSE appears to be equally promising with that of the standard check, Azadirachtin followed by Pongamia oil and Tobacco leaf extract in the descending order of bio-efficacy, whereas *Beauveria bassiana*, *Metarhizium anisopliae* and Parthenium leaf extract were found to be relatively less effective.

Bio-efficacy of the standard check, Azadirachtin and NSE was reported to be effective against *P. citrella* on acid lime by Jayanthi and Verghese (2004) [8], Saravanan and Savithri (2005) [12] and Arshad *et al*. (2019) [2]. Similar findings have been reported by Rao *et al*. (2015) [11] on sweet orange. Pongamia oil has been reported to be moderately effective against *P. citrella* on mandarin and sweet orange, respectively (Jothi *et al*., 1993 and Rao *et al*., 2015) [9, 11]. Tobacco leaf extract has been reported (Rao *et al*. (2015)) [11] moderately effective against *P. citrella* on sweet orange. The efficacy of *Beauveria bassiana* has been reported by Bhut (2012) [4] to be relatively less effective against *P. citrella* on acid lime. Present findings are in agreement with the findings reported by the earlier workers.

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

S N	Treatment	Formulation	Dose (ml or g /l)	% leaf infestation			
				3 DAS	7 DAS	10 DAS	15 DAS
T_1	NSE	5%	50 g	20.03 (26.58)	14.98 (22.77)	11.61 (19.92)	12.66 (20.84)
T_2	Pongamia oil	0.50%	5 ml	25.86 (30.57)	18.81 (25.70)	15.10 (22.86)	16.13 (23.68)
T_3	Parthenium leaf extract	5%	50 g	29.13 (32.66)	27.51 (31.64)	24.26 (29.51)	25.14 (30.09)
T_4	Tobacco leaf extract	5%	50 g	26.42 (30.93)	21.13 (27.37)	17.72 (24.89)	18.80 (25.69)
T_5	*Beauveria bassiana*	1×10^8 CFU/g	5 g	28.38 (32.19)	23.55 (29.03)	20.69 (27.05)	21.71 (27.77)
T_6	*Metarhizium anisopliae*	1×10^8 CFU/g	5 g	28.63 (32.35)	23.63 (29.09)	20.94 (27.23)	21.99 (27.96)
T_7	Azadirachtin (Treated check)	10000 ppm	2 ml	20.84 (27.16)	14.11 (22.06)	10.43 (18.84)	11.54 (19.86)
T_8	Untreated check	-	-	30.73 (33.66)	30.11 (32.28)	29.60 (32.96)	29.39 (32.83)
	F test			Sig	Sig	Sig	Sig
	S.Em±			0.47	0.47	0.56	0.46
	C.D. at 5%			1.42	1.43	1.72	1.42

*Figures in parenthesis are the arc sin transformed values
DAS - Days After Spray

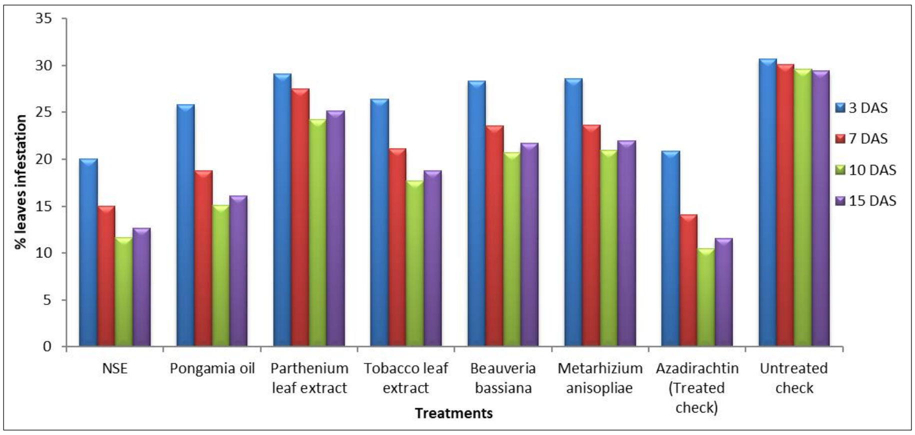

Fig 3: Cumulative performance of test biorational insecticides (2018-2019)

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. In suppressing the field prevailing larval population, NSE appeared to be equally promising with the standard check, Azadirachtin and may be recommended.

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