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Evaluation of biopesticides and chemicals for the management of sucking pests of curry leaf in Thiruvananthapuram, Kerala

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ABSTRACT: A field investigation was carried out to evaluate the efficacy of certain biopesticides and chemical insecticides against the major sucking pests of curry leaf, *Murraya koenigii* (L.) Spreng. in the Neyyattinkara region of Thiruvananthapuram district in Kerala, India during September 2022. Among the treatments evaluated, neem garlic soap formulation- KAU Raksha and talc-based formulation of *Lecanicilium lecanii* were proved effective in reducing the psyllids, *Diaphorina citri* population by 65 and 58.17 per cent. Further, Horticultural Mineral Oil and talc-based formulations of *L. lecanii* were effective in reducing the mite *Schizotetranychus baltazari* population by 39.18 and 33.44 per cent, respectively. Whitefly, *Aleuroclava complex* was effectively managed by talc-based formulation of *L. lecanii* with a per cent efficacy of 75.23, which was on par with chemical management. Among the chemical insecticides, chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC reduced psyllid, mite and whitefly populations by 89.91, 49.76 and 76.63 per cent, respectively, over untreated control. The study highlighted the effectiveness of some biopesticides, which can be utilized for the organic pest management of sucking pests of curry leaf.

Keywords: Biopesticides, curry leaf, mite, *Murraya koenigii*, psyllid, whitefly

INTRODUCTION

Curry leaf, *Murraya koenigii* (L.) Spreng. is a native of India and is utilized for medicinal and culinary purposes. The major cultivators of curry leaves in India are Tamil Nadu, Karnataka and Andhra Pradesh. It is also a highly export-oriented crop, India being its largest exporter globally, followed by Sri Lanka and Kenya (Volza's India Export Data, 2023). In recent years, the curry leaf has progressed from an underexploited crop to a commercial commodity in the country. However, the infestation of pests and pathogens is a major constraint to the successful production of healthy curry leaves. Tara and Sharma (2010) have reported that despite curry leaves possessing insecticidal properties, they are attacked by several insect pests, which decreases the plant's economic value. They also observed that the plants are attacked mainly by insects from the order Hemiptera, followed by Lepidoptera and Coleoptera. Significant variations in weather parameters have also caused exotic pest invasion in curry leaves. These problems have resulted in commercial curry leaf farmers taking up pesticide sprays to obtain a remunerative price and increased yield, thus deteriorating the quality of the leaves (Mathrubhumi, 2020). Approximately twenty pests attacking curry leaves were recorded in a one-year survey conducted at twenty homesteads in Thiruvananthapuram district, with the major ones being lemon butterflies (*Papilio demoleus* L. and *P. polytes* L.), citrus psyllid (*Diaphorina citri* Kuwayama), citrus green mite (*Schizotetranychus baltazari* Rimando), curry leaf tortoise beetle (*Silana farinosa* (Boheman)), citrus leaf roller (*Psorosticha zizyphi* (Stainton)), scale insects (*Pinnaspis strachani* (Cooley) and *Icerya aegyptiaca* (Douglas), blackflies (*Aleurocanthus terminaliae* Dubey & Sundararaj, *Aleurolobus orientalis* David & Jesudasan) and whiteflies (*Aleuroclava complex* Singh). Sucking pests were the major insect pests, with the predominant ones being *D. citri, S. baltazari* and *A. complex*. They sucked the vital fluids from the leaves and tender parts of the plant and caused drying and wilting of the growing points and a sick appearance of the leaves. The damage caused by these pests on curry leaves was so evident that it led to a decrease in the value of this crop in the markets. Therefore, a study was conducted in a farmer's field using some selected biopesticides and chemicals to evaluate their performance in controlling these sucking pests that damaged curry leaves.

MATERIALS AND METHODS

Evaluation of bipesticides, botanicals, mineral oils

Table 1: Effect of treatments on the population and extent of damage by psyllids

Treatments	Mean number of psyllids per five cm apical twig					Damage (%)	
	Pre-count	3 DAS*	5 DAS	7 DAS	14 DAS	Pre count	14 DAS
Talc based formulation of *B. bassiana* NBAIR Bb 5 @ 20 g L^{-1}	14.58 (3.82)	12.00 (3.46)^{dc}	5.78 (2.40)^{bc}	6.06 (2.46)^{bc}	8.17 (2.86)^{d}	30.06 (33.15)	20.00 (26.43)^{c}
Talc based formulation of *L. lecanii* NBAIR Vl 8 @ 20 g L^{-1}	12.36 (3.51)	11.28 (3.36)^{bcd}	5.25 (2.29)^{ab}	5.42 (2.33)^{bc}	5.89 (2.43)^{c}	31.12 (33.88)	18.89 (25.54)^{bc}
Talc 2% @ 20 g L^{-1}	13.03 (3.61)	12.53 (3.54)^{de}	10.33 (3.21)^{e}	9.50 (3.08)^{d}	10.64 (3.26)^{e}	35.19 (36.24)	34.31 (35.82)^{d}
Neem garlic soap formulation-KAU Raksha @ 10 g L^{-1}	11.33 (3.37)	10.61 (3.26)^{bc}	6.56 (2.55)^{cd}	5.19 (2.25)^{b}	4.92 (2.21)^{c}	31.88 (34.32)	23.22 (28.78)^{cd}
Horticultural Mineral Oil HMO @ 25 mL L^{-1}	13.61 (3.68)	10.06 (3.17)^{b}	7.19 (2.68)^{d}	7.33 (2.71)^{cd}	8.22 (2.87)^{d}	31.86 (34.30)	24.53 (29.37)^{cd}
Chlorantraniliprole 8.8 % w/w+ Thiamethoxam 17.5 % w/w SC @ 150 g a.i ha^{-1}	13.89 (3.72)	6.47 (2.54)^{a}	4.61 (2.14)^{a}	1.97 (1.39)^{a}	1.42 (1.19)^{a}	30.01 (33.14)	10.01 (17.79)^{a}
Quinalphos 25 EC @ 250 g a.i ha^{-1}	12.81 (3.58)	6.97 (2.64)^{a}	4.50 (2.12)^{a}	2.22 (1.47)^{a}	2.53 (1.58)^{b}	33.88 (35.49)	9.99 (18.30)^{ab}
Untreated	14.33 (3.78)	14.25 (3.77)^{e}	15.06 (3.88)^{f}	13.08 (3.62)^{e}	14.08 (3.75)^{f}	32.95 (34.99)	47.86 (43.77)^{e}
CD (0.05)	(NS)	(0.239)	(0.249)	(0.398)	(0.232)	(NS)	(7.720)

Mean of three replications; * DAS – Days After Spraying; Value in the parenthesis – Square root transformed values (Population); Arcsine transformed values (Percent damage)

Table 2: Effect of treatments on the population and extent of damage by mites

Treatments	Mean number of mites per leaf					Damage (%)	
	Pre-count	3 DAS	5 DAS	7 DAS	14 DAS	Pre count	14 DAS
Talc based formulation of B. *bassiana* NBAIR Bb 5 @ 20 g L^{-1}	80.61 (8.98)	74.85 (8.65)^{cd}	73.65 (8.58)^{d}	70.45 (8.39)^{d}	70.27 (8.38)^{d}	34.45 (35.86)	25.91 (30.57)^{cd}
Talc based formulation of *L. lecanii* NBAIR Vl 8 @ 20 g L^{-1}	82.92 (9.11)	71.45 (8.45)^{bcd}	62.92 (7.93)^{c}	60.39 (7.77)^{c}	56.01 (7.48)^{c}	31.12 (33.72)	19.06 (25.84)^{abc}
Talc 2% @ 20 g L^{-1}	82.69 (9.09)	78.70 (8.87)^{de}	77.35 (8.80)^{d}	76.16 (8.73)^{e}	76.91 (8.77)^{e}	35.01 (36.20)	32.25 (34.59)^{d}
Neem garlic soap formulation-KAU Raksha @ 10 g L^{-1}	82.33 (9.07)	70.74 (8.41)^{bc}	64.77 (8.05)^{c}	61.45 (7.84)^{c}	54.08 (7.35)^{bc}	28.89 (32.46)	25.42 (30.17)^{cd}
Horticultural Mineral Oil HMO @ 25 mL L^{-1}	83.19 (9.12)	68.90 (8.30)^{bc}	60.68 (7.79)^{c}	55.42 (7.44)^{b}	51.18 (7.15)^{b}	33.82 (35.48)	21.45 (27.36)^{bc}
Chlorantraniliprole 8.8 % w/w+ Thiamethoxam 17.5 % w/w SC @ 150 g a.i ha^{-1}	81.13 (9.01)	64.75 (8.03)^{ab}	49.46 (7.03)^{b}	47.85 (6.92)^{a}	42.28 (6.50)^{a}	27.78 (31.75)	14.83 (22.61)^{ab}
Quinalphos 25 % EC @ 250 g a.i ha^{-1}	80.74 (8.99)	58.96 (7.68)^{a}	43.33 (6.58)^{a}	47.46 (6.89)^{a}	41.06 (6.41)^{a}	27.78 (31.77)	14.09 (21.92)^{a}
Untreated	82.44 (9.08)	85.11 (9.23)^{e}	82.75 (9.10)^{e}	81.31 (9.02)^{f}	84.15 (9.17)^{f}	30.56 (33.55)	33.38 (35.27)^{d}
CD (0.05)	(NS)	(0.423)	(0.258)	(0.271)	(0.246)	(NS)	(5.420)

Mean of three replications; * DAS – Days After Spraying; Value in the parenthesis – Square root transformed values (Population); Arcsine transformed values (Percent damage)

and new molecules of insecticides was carried out at a farmer's field in Neyyattinkara (8.3999° N, 77.1061° E) of Thiruvananthapuram district, Kerala, against the pests *D. citri, S. baltazari* and *A. complex*. Curative treatments were given when the plants had a 10% pest incidence. There were eight gtreaments including a control (Table 1) in a RBD with three replications. The pre-count was taken one day before spraying. The number of pests in each treatment was counted by appropriate methods, and the mean population was calculated. Psyllids were counted visually by tagging tender twigs, and the mean number of psyllids in a 5 cm apical twig was recorded from tagged branches on four sides of each tree. Mites and whiteflies were counted visually from the undersurface of leaves, and the mean was calculated. The percentage damage of each treatment was also worked out by recording the number of leaves damaged out of twenty randomly selected leaves from each replication. Post-treatment counts were made on the 3rd, 5th, 7th and 14th days after spraying.

Statistical analysis

Data obtained from each experiment were transformed as required and subjected to analysis of variance using WASP 2.0 software (Jangam and Wadekar, 2019).

RESULTS AND DISCUSSION

Effect of treatments on the population and extent of damage by psyllids, *D. citri*

The observations recorded on psyllids three days after spraying indicated that treatments chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC and quinalphos'25 % EC were statistically at par, with a mean population of 6.47 and 6.97 psyllids per five cm twig, respectively (Table 1). Among the non-insecticidal treatments, the treatment Horticultural Mineral Oil which recorded a mean population of 10.06, was found on par with the treatments neem garlic soap formulation-KAU Raksha (10.61) and talc based formulation of *L. lecanii* NBAIR Vl 8 (11.28). Sharma (2008) also tested the bio-efficacy of different insecticides where thiamethoxam (0.008%) and quinalphos (0.075%) showed significantly high reduction (91 to 100 per cent) of citrus psylla nymphs. The greater residual effect of thiamethoxam was reported by Arora and Sharma (2011) compared to imidacloprid and acetamiprid against psyllids in kinnow. Seven days after spraying, the treatments quinalphos;25 % EC (2.22) and chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC (1.97) were found on par with each other, and both these treatments were found superior to the treatment talc formulation of *L. lecanii* NBAIR Vl 8 (5.42). After fourteen days of spraying, observations indicated that the treatment chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC was the best in reducing the psyllid population (1.42 /plant). Among the biopesticides, neem garlic soap formulation-KAU Raksha (4.92/ plant) and talc based formulation of *L. lecanii* NBAIR Vl 8 (5.89/ plant) were also on par. Rao and Shivankar (2011) have a different account where they found neem soap @ five gL^{-1}, Pongamia soap @ five gL^{-1}, neem oil @ 6.76 ml L-1 and azadirachtin (10000 ppm) @ 3.65 ml L-1 as most effective than *B. thuringiensis*, *V. lecanii* and sweet flag against second instar nymphs of *D. citri* at 15 days after application.

Effect of treatments on the population and extent of damage by *S. baltazari*

The effect of various treatments on the population of *S. baltazari,* 3 days after spraying, revealed that the statistically superior treatment was quinalphos 25 % EC which recorded a mean population of 58.96 mites/leaf followed by the treatment chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC which recorded a mean of 64.75 mites/leaf (Table 2). After five days of spraying, the lowest population of mites was recorded on plants treated with treatment quinalphos 25 % EC (43.33) followed by on plants sprayed with chlorantraniliprole.8.8 % w/w + thiamethoxam 17.5 % w/w SC (49.46). Seven days after spraying, among the rational treatments, the effective one was Horticultural Mineral Oil (55.42 mites/leaf). Still, it was found inferior to the treatments quinalphos 25 % EC (47.46 mites/leaf) and chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC (47.85 mites/ leaf). Ramanna (2009) reported that, among organic insecticides evaluated, the minimum number of mites (0.83 mites/leaf) was recorded in *V. lecanii* (2 g L-1). Still, it was found inferior to the ashwagandha insecticide dicofol (2.5 ml L-1). Observations after fourteen days of spraying indicated that the treatments quinalphos 25 % EC and chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC were effective and on par in reducing the mite population with a mean count of 41.06 and 42.28, respectively followed by treatment Horticultural Mineral Oil (51.18) and neem garlic soap formulation-KAU Raksha (54.08) among the biorational treatments. Yadav (2018) also stated that in okra, HMO at 2.5% (84.00 per

Table 3: Effect of treatments on the population and extent of damage by whiteflies

Treatments	Mean number of whiteflies per leaf					Damage (%)	
	Pre-count	3 DAS	5 DAS	7 DAS	14 DAS	Pre count	14 DAS
Talc based formulation of *B. bassiana* NBAIR Bb 5 @ 20 g L^{-1}	2.67 (1.63)	1.64 (1.27)^{c}	1.06 (1.01)^{b}	1.11 (1.05)^{c}	1.03 (1.01)^{c}	34.81 (36.15)	16.67 (23.39)^{ab}
Talc based formulation of *L. lecanii* NBAIR Vl 8 @ 20 g L^{-1}	2.22 (1.49)	1.39 (1.18)^{bc}	0.58 (0.76)^{a}	0.50 (0.70)^{ab}	0.53 (0.72)^{ab}	31.67 (34.14)	17.23 (24.01)^{ab}
Talc 2% @ 20 g L^{-1}	2.06 (1.43)	1.72 (1.30)^{c}	1.72 (1.31)^{cd}	1.69 (1.30)^{d}	1.14 (1.06)^{c}	31.15 (33.83)	30.56 (33.37)^{c}
Neem garlic soap formulation-KAU Raksha @ 10 g L^{-1}	2.89 (1.69)	1.08 (1.04)^{b}	0.53 (0.72)^{a}	0.72 (0.84)^{b}	0.97 (0.98)^{c}	32.31 (34.51)	25.56 (30.17)^{bc}
Horticultural Mineral Oil HMO @ 25 mL L^{-1}	2.61 (1.61)	1.19 (1.09)^{bc}	1.28 (1.12)^{bc}	1.14 (1.06)^{c}	1.19 (1.09)^{c}	29.60 (32.76)	18.39 (25.35)^{b}
Chlorantraniliprole 8.8 % w/w+ Thiamethoxam 17.5 % w/w SC @ 150 g a.i ha^{-1}	2.78 (1.67)	0.61 (0.77)^{a}	0.31 (0.55)^{a}	0.50 (0.71)^{ab}	0.50 (0.69)^{a}	27.75 (31.73)	8.89 (16.53)^{a}
Quinalphos 25 EC @ 250 g a.i ha^{-1}	2.25 (1.50)	0.44 (0.66)^{a}	0.53 (0.72)^{a}	0.42 (0.64)^{a}	0.92 (0.94)^{bc}	27.78 (31.77)	9.53 (17.44)^{a}
Untreated	2.56 (1.60)	2.72 (1.65)^{d}	2.39 (1.54)^{d}	2.22 (1.49)^{e}	2.14 (1.46)^{d}	36.29 (36.98)	46.89 (43.21)^{d}
CD (0.05)	(NS)	(0.212)	(0.244)	(0.145)	(0.240)	(NS)	(7.600)

Mean of three replications; * DAS – Days After Spraying; Value in the parenthesis – Square root transformed values (Population); Arcsine transformed values (Percent damage)

Table 4: Percentage reduction in population and damage of pests over untreated control, 14 DAS

Treatments	Psyllids		Mites		Whiteflies	
	Population	Damage	Population	Damage	Population	Damage
Talc based formulation of *B. bassiana* NBAIR Bb 5 @ 20 g L^{-1}	41.97	58.21	16.49	22.38	51.87	64.44
Talc based formulation of *L. lecanii* NBAIR Vl 8 @ 20 g L^{-1}	58.17	60.53	33.44	42.37	75.23	63.23
Talc 2% @ 20 g L^{-1}	24.43	28.31	8.60	3.34	46.73	34.83
Neem garlic soap formulation-KAU Raksha @ 10 g L^{-1}	65.06	51.48	35.73	23.85	54.67	45.49
Horticultural Mineral Oil HMO @ 25 mL L^{-1}	41.62	48.75	39.18	35.74	44.39	60.78
Chlorantraniliprole 8.8 % w/w+ Thiamethoxam 17.5 % w/w SC @ 150 g a.i ha^{-1}	89.91	79.08	49.76	55.57	76.63	81.04
Quinalphos 25 EC @ 250 g a.i ha^{-1}	82.03	79.12	51.20	57.79	57.00	79.68

cent) and neem oil at 2.0 % (81.33 per cent) were on par with each other in mite mortality, but the superior treatment was HMO at 3.0% (92.00 per cent).

Effect of treatments on the population and extent of damage by *A. complex*

Three days after spraying, treatments quinalphos 25 % EC and chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC were on par in reducing the population of *A. complex* with a mean population of 0.44 and 0.61 whiteflies/leaf (Table 3). Patil (2016) obtained similar results using another neonicotinoid, imidacloprid (0.005%), against *A. woglumi*, demonstrating that it was the most effective in reducing the blackfly population by up to 76.77% 14 days after spraying. Jadhav *et al.* (2018) also reported that thiamethoxam 25 WG @ 25 g a.i ha-1 was the most effective treatment (6.31 whitefly/plant) at 14 DAS against whitefly in brinjal. After five days of spraying, lowest population of whiteflies was recorded on plants treated with chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC (0.31), which was also on par with treatments quinalphos 25 % EC (0.53), neem garlic soap formulation- KAU Raksha (0.53) and talc based formulation of *L. lecanii* NBAIR Vl 8 (0.58). Fourteen days after spraying, chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC recorded a minimum number of whiteflies (0.50 /leaf), which was followed by talc based formulation of *L. lecanii* NBAIR Vl 8 (0.53), superior among the rationals.

All biorational treatments *viz.*, talc based formulation of *B. bassiana* NBAIR Bb 5, talc based formulation of *L. lecanii* NBAIR Vl 8, talc 2%, neem garlic soap formulation-KAU Raksha, and Horticultural Mineral Oil displayed a significant reduction in the population and extent of damage caused by the above mentioned pests over untreated control. Against *D. citri*, treatments of neem garlic soap formulation-KAU Raksha and *L. lecanii* NBAIR Vl 8 showed 65.06 and 58.17% reduction in population and 51.48 and 60.53% reduction in damage after 14 days of spray (Table 4). Against spider mites, effective ones were Horticultural Mineral Oil and neem garlic soap formulation-KAU Raksha, which showed 39.18 and 35.73 per cent reductions in mite population at the end of the observation schedule. At the same time, in reducing the extent of damage, the talc-based formulation of *L. lecanii* NBAIR Vl 8 and Horticultural Mineral Oil was superior, with 42.37 and 35.74 per cent reduction, respectively. Treatments effectively controlled whitefly, A. complex chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC and talc based formulation of *L. lecanii* NBAIR Vl 8, which reduced the population and extent of damage caused by whiteflies by 76.63, 75.23 and 81.04 and 63.23 per cent, respectively. They were also comparable with each other in reducing the whitefly population. Since synthetic pesticides are not an option in curry leaves, this result seems promising as an advantage over chemicals in reducing whiteflies in curry leaves. Also, when comparing the percentage reduction in the population of whiteflies from 3 to 14 DAS, talc based formulation of *L. lecanii* NBAIR Vl 8 caused a reduction of 61.87 per cent with respect to chlorantraniliprole 8.8 % w/w + thiamethoxam 17.5 % w/w SC which only caused 18.03 per cent reduction. This sheds light on the sustainability of mycoinsecticides compared to chemical insecticides in pest management.

Based on our evaluation results, it can be concluded that for managing sucking pests infesting curry leaves, talc based formulation of *L. lecanii* NBAIR Vl 8 @ 20 g L-1, neem garlic soap formulation-KAU Raksha @ 10 g L-1 or Horticultural Mineral Oil HMO @ 25 mL L-1 can be recommended as non-chemical, eco-friendly, and safe options for farmers.

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