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Evaluation of pongamia oil soap against red spider mites, *Tetranychus urticae* Koch and its effect on mite predators in brinjal ecosystem

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ABSTRACT: The efficacy of pongamia oil soap was tested on red spider mites and on its predators (rove beetle, *Oligota* sp. and predatory gall midge, *Feltiella acarisuga* Vallot). Pongamia oil soap at 0.6, 1, 2 and 3 per cent along with neem oil 0.6 per cent, soap solution 0.5 per cent and thiamethoxam 25 WG were investigated and observations were recorded on, a day prior to and, 1, 3, 5, 7 and 14 days after spray application. The results revealed that pongamia oil soap @ 3, 2 and 1 per cent shown mite population reduction up to 86.50, 84.57 and 79.27 per cent respectively. Richness of mite predators didn't vary significantly at one day after spray and the maximum population was observed in soap solution (4.33/5 plants). Population of mite predators was relatively high at 14 days after spray with soap solution (35.67 per five plants) which was at par with pongamia oil soap @ 0.6, 1 and 2 per cent.

KEY WORDS: Rove beetle, predatory gall midge, thiamethoxam, neem oil, soap solution

INTRODUCTION

Brinjal is one of the major vegetables crops in India which positions second in brinjal (*Solanum melongena* L.) production with 12.80 MT of production (National Horticulture Board, 2018). There are 140 different types of insect and non-insect pests have a history of damaging the crop. The destructive pest of brinjal is fruit and shoot borer (BFSB), *Leucinodes orbonalis* Guenee (Lepidoptera, Crambidae) which causes enormous yield loss of as high as 70-92 per cent (Rosaiah, 2001). When infestation levels are high, sucking pests like red spider mites; *Tetranychus urticae* Koch (Tetranychidae, Acari) dramatically lower crop output and inflict damage.

Millettia pinnata (L.) Pierre, often known as "pongam," "Indian beech," or "karanj," is a multifunctional tree that is especially prized for the oil that is extracted from its seeds (27–40% oil). The primary furanoflavones responsible for karanj oil's insecticidal effects on pests, are karanjin, pongapin, kanjone, and diketone pongamol (Bringi, 1987). Different pongamia extracts shown antifeedant and oviposition-deterrent efficacy against various agricultural pests (Kumar *et al*., 2006). A field experiment was conducted to

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evaluate the efficacy of four different concentrations of soap formulation of pungam (Milletia/Pongamia) oil against the red spider mite, *Tetranychus urticae* Koch and its effects against its natural enemies, (rove beetle, *Oligota* sp. and a predatory gall midge, *Feltiella acarisuga* Vallot population), in an eggplant ecosystem.

MATERIALS AND METHODS

Pungam oil soap made based on the technology used in "Ready to use Neem Oil Garlic Soap", the biocide approved by Kerala Agricultural University (Varma, 2018). Pongamia oil was obtained from Tamil Nadu Agricultural University, Coimbatore to make pongamia oil soap required for the experiment. To prepare pongamia oil soap, 55g of caustic soda was mixed with 100ml of distilled water and left undisturbed for 4 hours. The solution blended scrupulously into the solution made up of 55g of soap stone power and one litre of pongamia oil. The final pongamia oil soap solution kept for solidification. The pongamia oil soap solution pH was determined (10.5) in Soil Science and Agricultural Chemistry lab, College of Agriculture, Padannakkad and saponification value was 194mg KOH/g of oil. Neem oil soap 0.6 per cent and standard check (Thiamethoxam) were also included as treatments to compare the results of pongamia oil soap.

Experiments were performed with the KAU released brinjal variety "Surya" under Randomized Block Design with 8 treatments (Table 1) and three replicates at Instructional Farm II, Karuvachery, College of Agriculture, Padannakkad. Eggplant seeds were sown in pro trays and 30 days old seedlings transplanted in a plot of size 3.4 X 2.8m^2 each with the spacing of 60 X 60cm. Pongamia oil soap 3, 2, 1 and 0.6 per cent spray solution were prepared by using pongamia oil soap 30, 20, 10 and 6g pongamia oil soap respectively and knapsack sprayer was used for spraying. Five representative plants among 12 plants were selected and tagged for recording observations. The observations were documented one day before, 1, 3, 5, 7 and 14 days after treatment application. The nymphs and adult red spider mites (RSM) and its natural enemies (predatory gall midge and rove beetle) were counted from the 2 cm^2 leaf area of three leaves (one each from top, middle and lower) from represented plants. To calculate the per cent reduction in red spider mite population, Henderson and Tilton formula was used (Herderson and Tilton, 1955).

$$\text{Per cent reduction} = \{1 - \left(\frac{\text{n in C before treatment x n in T after treatment}}{\text{n in C after treatment x n in T before treatment}}\right)\} \times 100$$

The data on mites and its natural enemy's population count were analyzed after square root transformation by analysis of variance (ANOVA). Web Agri Stat Package (WASP) software was used to analyze the data on population count of mites and its enemies.

RESULTS AND DISCUSSION

Red spider mite population:

RSM population, ranging from 43.67 to 54.53 per 3 leaves recorded one day before the treatments, showed no significant difference among treatments. Pongamia oil soap 3per cent had significantly lower mites (5.53 RSM/3 leaves), comparable to 2 per cent pongamia oil soap on a day after spray application. The soap solution recorded the maximum mite population (91.40 RSM/3 leaves), comparable to the control plot (48.53 RSM/3 leaves). Pongamia oil soap at 1 and 0.6 per cent showed statistically equivalent results in reducing - mite populations (11.53 and 12.67 RSM/3 leaves respectively). Neem oil soap at 0.6 per cent (20.20 RSM/3 sheets) were found to be equivalent to thiamethoxam 25 WG (33.73 RSM/3 sheets) and both were comparable to pongamia soap at 0.6 and 1 percent.

Three days after spray, pongamia oil soap (3%) had the lowest mite population – (16.33 RSM/3 leaves), followed by pongamia oil soap at 2, 1, 0.6 per cent and neem oil soap (20.47, 21.07, 21.93 and 27.27 RSM/3 leaves respectively) and they were on par with each other. The 0.5 per cent soap solution recorded the highest mite count (55.07 RSM/3 leaves), comparable to the control (50.73

Table 1. Average population density of red spider mites, *Tetranychus urticae*

Treatments	Number of mites per 3 cm^2 area of three leaves *					
	Second application					
	1 DBS	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS
Thiamethoxam 25 WG 2g $10L^{-1}$	54.53 (6.93)	33.73 (5.74)^{bc}	35.13 (5.69)^{ab}	61.53 (7.83)^{a}	74.47 (8.61)^{ab}	85.33 (9.22)^{a}
Pongamia oil soap 3%	43.67 (6.59)	5.53 (2.23)^{d}	16.33 (4.02)^{b}	24.40 (4.93)^{c}	35.13 (5.92)^{f}	47.67 (6.92)^{d}
Pongamia oil soap 2%	50.47 (7.09)	7.87 (2.78)^{d}	20.47 (4.50)^{b}	34.87 (5.89)^{bc}	36.60 (6.03)^{ef}	55.73 (7.43)^{cd}
Pongamia oil soap 1%	46.20 (6.70)	11.53 (3.34)^{cd}	21.07 (4.55)^{b}	35.67 (5.96)^{b}	41.67 (6.43)^{def}	62.47 (7.93)^{bcd}
Pongamia oil soap 0.6%	51.00 (7.11)	12.67 (3.45)^{cd}	21.93 (4.63)^{b}	38.93 (6.22)^{b}	50.60 (7.10)^{cde}	64.93 (8.07)^{abcd}
Neem oil soap 0.6%	47.13 (6.85)	20.20 (4.37)^{bcd}	27.27 (5.16)^{b}	37.93 (6.13)^{b}	53.93 (7.33)^{cd}	65.47 (8.09)^{abc}
Soap solution 0.5%	67.00 (7.70)	91.40 (9.10)^{a}	55.07 (7.30)^{a}	76.67 (8.74)^{a}	85.13 (9.18)^{a}	73.20 (8.58)^{ab}
Control	47.47 (6.89)	48.53 (6.96)^{ab}	50.73 (7.09)^{a}	64.73 (8.02)^{a}	59.40 (7.70)^{bc}	74.73 (8.67)^{ab}
C.D. (P=0.05)	NS	2.60	1.86	1.03	1.17	1.16

* Mean of five observations; Means followed by similar alphabets don't differ significantly by DMRT at 5%; Figures in parentheses denotes square root transformed values

RSM/3 leaves). Plants treated with thiamethoxam 25 WG (35.13 RSM/3 leaves) were comparable to all other treatments tested. Observations made 5 days after treatment pongamia soap (3%) showed least 24.40 RSM/3 leaves, followed by pongamia soap (2 and 1%), neem oil soap and pongamia soap (0.6%) with 34.87, 35.67, 37.93 and 38.93 RSM/3 leaves respectively. The soap solution (0.5%) recorded the highest mite count of 76.67 RSM/3 leaves. This was comparable to controls (64.73 RSM/3 leaves) and thiamethoxam 25 WG (61.53 RSM/3 leaves).

Mite populations were lowest on plants treated with pongamia soap @ 3 per cent (35.13 RSM/3 leaves) on day 7 after treatment, compared to pongamia soap @ 2 and 1 percent with 36.60 and 41.67 RSM respectively. It was 50.60 RSM/3 leaves in pongamia soap (0.6%) which was on par with neem oil soap 0.6 per cent (53.93 RSM/3 leaves), and pongamia soap 1 and 2 per cent. The maximum population was observed in 0.5 per cent soap solution (85.13 RSM/3 leaves), followed by thiamethoxam 25 WG (74.47 RSM/3 leaves), and the control (59.40 RSM/3 leaves).

Increased mite populations were observed for all treatments. Pongamia soap (3%) recorded 47.67 RSM/3 leaves after 14 days of spraying - followed by pongamia oil soap 2 per cent (55.73 RSM/3

leaves), 1 per cent (62.47 RSM/3 leaves) and 0.6 per cent (64.93 RSM/3 cards) pongamia soap. Neem oil soap 0.6 per cent (65.47 RSM/3 leaves) was comparable to soap solution 0.5 per cent (73.20 RSM/3 leaves), pongamia oil soap 0.6 and 1 per cent, control (74.73 RSM/3 leaves) and thiamethoxam treated plot showed maximum mite population (Table 1).

Percentage reduction in spider mite population:

Pongamia oil soap 3, 2, and 1 percent were statistically equivalent, reducing mite populations by 86.50, 84.57, and 79.27 per cent, respectively whereas soap solution 0.5 per cent (0.17%) and the insecticide thiamethoxam 25 WG (19.60%) were comparable with control (0.00%) in population decline. Pongamia oil soap 0.6 per cent with a population reduction of 76.40 per cent was equivalent to 1, 2, and 3 per cent pongamia oil soap at 1 day post-treatment. Three days after spray application, a maximum population reduction was recorded in pongamia soap 3 per cent which was on par with pongamia oil soap 2, 1 and 0.6 per cent with 61.17, 57.90, 55.10 and 53.93 per cent decrease in population of mites respectively. At 0.5 per cent soap solution, it was comparable to the control (0.00%) and thiamethoxam 25 WG (32.43%) with only a 16.00 per cent reduction. Neem oil soap 0.6 per cent reduced the population by 45.73 per cent among botanicals, comparable with pongamia soap at 3, 2, 1 and 0.6 per cent.

The pongamia oil soap 3 per cent was the highest among all treatments in population reduction (55.67%), while the soap solution increased mite populations with a negative sign (-23.3%). This was consistent with thiamethoxam 25 WG (5.33%) and comparable to the control (0.00%) at 5 days of application. Pongamia soap @ 2 and 1 per cent, and neem oil soap 0.6 per cent were statistically similar in population decline, recording 44.00, 41.40, and 38.00 3 per cent respectively. After 7 days of application, pongamia soap @ 3 and 2 per cent showed reduction in mite population (42.00 and 40.33%, respectively). Pongamia oil soap @ 1 and 0.6 per cent showed statistically similar results in reducing mite population (18.00 and 17.02% respectively). However, the soap solution, thiamethoxam, and untreated plots showed no reduction in population and recorded negative results (of -47.00, -35.00, and 0.00%, respectively).

On the 14th day of application, population reduction was statistically non-significant among pongamia soap 3, 2, 1, 0.6 per cent and neem oil soap 0.6 per cent treated plots (31.33, 19.00, 18.67, 17.67 and 16.33% respectively). However, thiamethoxam 25 WG and soap solution 0.5% failed to reduce mite numbers, indicated by negative signs of -32 and -4.3 per cent, both comparable to the control plot (Table 2).

Relative abundance of mite predators:

Data on a day before spray application revealed that the mite predator's numbers didn't differ significantly among different treatments and it was at a range of 1.33 to 4.00/5 plants. Mite predator's abundance did not change significantly 1 day after spray application it was at a range of 1.33 to 4.33/ 5 plants. Three days after spray, predator populations were statistically non-significant and evenly distributed (1.67 to 5.67). After 5 days of spray also, there was no significant difference in – predator (1.67 to 7.67/ 5 plants). Observations on 7 DAS revealed that the 0.5 per cent soap solution treatment recorded more predator population of 11.00/5 plants, and significantly different from the other treatments. Pongamia oilseed soap 0.6 per cent recorded 9.33/5 plants and was statistically equivalent to 0.5 per cent soap solution. Pongamia soap 2 per cent and 0.6 per cent neem soap treatments were statistically similar with comparable results to control - (4.00, 4.00 and 4.33/ 5 plants, respectively), but the standard test and 3 per cent pongamia soap showed the lowest population- (0.33 and 2.33/5 plants respectively).

Abundance of mite predators was relatively high in all treatments on 14 DAS. Soap solution (0.5%) recorded highest at 35.67/5 plants which was comparable to pongamia oil soap at 0.6, 1 and 2 per cent with mite predator populations of 20.00,

Table 2. Percentage reduction in red spider mite's population during field evaluation

Treatments	Percentage reduction in mites *				
	Second application				
	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS
Thiamethoxam 25 WG 2g $10L^{-1}$	19.60 ^{c}	32.43 ^{bc}	5.33 ^{c}	-35 ^{c}	-32 ^{b}
Pongamia oil soap 3%	86.50 ^{a}	61.17 ^{a}	55.67 ^{a}	42.00 ^{a}	31.33 ^{a}
Pongamia oil soap 2%	84.57 ^{a}	57.90 ^{a}	44.00 ^{ab}	40.33 ^{a}	19.00 ^{a}
Pongamia oil soap 1%	79.27 ^{a}	55.10 ^{a}	41.40 ^{ab}	18.00 ^{b}	18.67 ^{a}
Pongamia oil soap 0.6%	76.40 ^{ab}	53.93 ^{a}	37.07 ^{b}	17.02 ^{b}	17.67 ^{a}
Neem oil soap 0.6%	57.13 ^{b}	45.73 ^{ab}	38.00 ^{ab}	6.33 ^{bc}	16.33 ^{a}
Soap solution 0.5%	0.17 ^{c}	16.00 ^{cd}	-23.3 ^{c}	-47.00 ^{c}	-4.3 ^{b}
Control	0.00 ^{c}	0.00 ^{d}	0.00 ^{c}	0.00 ^{c}	0.00 ^{b}
C.D. (P=0.05)	21.03	21.04	17.78	13.14	15.96

* Mean of observations of five plants; Means followed by similar letters are not significantly different by DMRT at 5%; DAS- Days After Spray; NS – Non-Significant

19.67 and 18.00/5 plants respectively. All remaining treatments were comparable to control plots (9.33/ 5 plants) containing neem oil soap @ 0.6 per cent, pongamia oil soap @ 3 per cent, and standard checks, each with a mite predator population of 12.33, 11.33, and 8.00/ 5 plants (Table 3).

Overall, pongamia soap solutions (@ 0.6, 1, 2, and 3%) were superior to control in reducing the RSM population. The greatest reduction was observed immediate day after spraying, and all treatments except soap solution remained effective up to 5 days after spraying, after which they declined. This observation is consistent with the acaricidal effect of pongamia oil against the horseshoe mite (*Tetranychus ludeni*). Among the various sprayed chemical treatments, 0.6ml l^{-1} Abamectin 1.8 EC showed the greatest reduction in mite population (70.32%) on 14th day of spraying, followed by spiromesifen and fenpyroximate while pongamia oil at 2 ml/l decreased by 49.58% on the fourteenth day (Raina, 2016). Among botanicals, tulsi leaf extract (5 and 10%), neem oil (3 and 5%) and notchi leaf extract (5 and 10%) recorded superior results followed by 63.53 and 62.98 per cent egg reduction were recorded by pongamia oil soap at 3 and 5 per cent respectively (Raghavendra *et al*., 2017).

The results obtained in the current study show that the miticidal effect of pongamia soap 0.6 per cent is better than that of 0.6 per cent neem oil soap. This result is in consistent with the study reporting, among the plants evaluated, pongamia oil was clearly the superior treatment, showing high mortality with a low LC_{50} value of 0.008 per cent whereas neem oil recorded higher LC_{50} value of 0.230 per cent at 24 h after treatment (Islam *et al*., 2017). In a another study same results was found with abamectin reducing the population of red spider mite (*Tetranychus urticae*) on okra by 74.64 per cent, recording the highest efficacy (Singh *et al*., 2018).

The nirgundi and pongamia oils were given better remedies than neem oil as evidenced by the minimum LC values of 78.40 and 194.20ppm respectively, and neem oil was 1469.88ppm against tea mite *Oligonychus coffeae* (Handique *et al*.,

2018). A reduction of up to 32.43 per cent was recorded on the third day after spraying, and from the fifth day onwards the effect began to decline, indicating an increase in the number of mites on the seventh and fourteenth day. In a study, thiamethoxam, clothianidin, and imidacloprid on cotton, corn, and tomatoes each showed increases in spider mite populations, and noted a 30 per cent increase in spider mite populations on cotton plants treated with thiamethoxam at the end of the study while in the current study are 32 per cent more mite numbers at 14DAS (Szczepaniec *et al*., 2013).

Data on rove beetle, *Oligota* and predatory gall midge, *Feltiella acarisuga* show that pongamia oil soap treated plants recorded higher population compared to even control plot. Soap solution 0.5 per cent recorded highest of 35.67/5 plants, followed by pongamia oil soap 0.6, 1 and 2 per cent. All remaining treatments were comparable to control plots (9.33/5 plants) containing neem oil soap @ 0.6 per cent, pongamia oil soap @ 3 per cent, and standard checks, each with a mite predator population of 12.33, 11.33, and 8.00/5 plants on 14th day after spray. As no previous studies on the

Table 3. Relative abundance of mite predators during field evaluation

Treatments	Number of mite predators per 3 cm^2 area of three leaves*					
	Second application					
	1 DBS	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS
Thiamethoxam 25 WG 2g 10L^{-1}	1.67 (1.46)	1.67 (1.24)	1.67 (1.35)	1.67 (1.39)	0.33 (1.68) ^{d}	8.00 (2.67) ^{b}
Pongamia oil soap 3%	1.67 (1.46)	2.00 (1.41)	1.67 (1.46)	2.67 (1.76)	2.33 (1.68) ^{cd}	11.33 (3.09) ^{b}
Pongamia oil soap 2%	2.33 (1.68)	2.33 (1.52)	2.00 (1.56)	2.67 (1.77)	4.00 (2.12) ^{c}	18.00 (4.15) ^{ab}
Pongamia oil soap 1%	2.00 (1.56)	2.67 (1.63)	3.00 (1.86)	4.67 (2.13)	8.33 (2.96) ^{b}	19.67 (4.32) ^{ab}
Pongamia oil soap 0.6%	2.00 (1.56)	3.00 (1.71)	3.33 (1.95)	6.67 (2.64)	9.33 (3.13) ^{ab}	20.00 (4.42) ^{ab}
Neem oil soap 0.6%	1.33 (1.27)	1.33 (1.14)	2.33 (1.68)	1.67 (1.25)	4.00 (2.09) ^{c}	12.33 (3.50) ^{b}
Soap solution 0.5%	4.00 (2.03)	4.33 (1.94)	5.67 (2.43)	7.67 (2.81)	11.00 (3.38) ^{a}	35.67 (5.92) ^{a}
Control	4.00 (2.09)	2.67 (1.61)	2.67 (1.74)	6.00 (2.41)	4.33 (2.18) ^{c}	9.33 (3.05) ^{b}
C.D. (P=0.05)	NS	NS	NS	NS	0.50	1.89

• Means followed by similar alphabets do not differ significantly @ 0.05 DMRT; Figures in parentheses denotes square root transformed values; DAS- Days After Spray; NS – Non-Significant

effects of pongamia treatment on predatory mites were available in the literature, the results on predatory mite populations are compared with neem products. Adverse effects of applying phytopesticides to the predatory mite *Amblyseius andersoni* were reported (Castagnoli *et al*., 2002). Eggs were unaffected by Biopyrene Plus (Pyrethrin 8 EC) (92.31% hatching) and Neemazal 10 EC (98.73% hatching) after treatment. Only 14.01 per cent toxicity was recorded on females by neemazal treatment whereas others showed 100 per cent toxicity. Survival percentage of protonymphs by neemazal treatment was 51.33 per cent and death was Zero.

It's been observed that the overall toxic effects of thiamethoxam were more than 90 per cent to *Phytoseiurus persimilis* by all different routes of exposure. However, the local exposure could result in low mortality and residual exposure (Pozzebon *et al*., 2011). The present study is in accordance with the findings in which the neonicotinoids are mildly toxic to *Neoseiulus fallacis* (Jamil *et al*., 2016), and neonicotinoids are moderately to highly toxic to *Galendromus occidentalis* and *G. fallacis* (Bostanian *et al*., 2009). It may be concluded pongamia oil soap showed fair control effect on red spider mites, in brinjal better than neonicotinoid thiamethoxam. At the same time, pongamia soap at different concentration showed no negative effects on mite predators hence it is absolutely safe to use against brinjal pests.

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