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**Rajesh Illathur**

Research Associate, KVK,  
Kalyandurg, Department of  
Agricultural Entomology, Tamil  
Nadu Agricultural University,  
Coimbatore, Tamil Nadu, India

**R Philip Sridhar**

Research Associate, KVK,  
Kalyandurg, Department of  
Agricultural Entomology, Tamil  
Nadu Agricultural University,  
Coimbatore, Tamil Nadu, India

**JS Kennedy**

Research Associate, KVK,  
Kalyandurg, Department of  
Agricultural Entomology, Tamil  
Nadu Agricultural University,  
Coimbatore, Tamil Nadu, India

## Evaluation of synergism / antagonism in the efficacy of entomopathogenic fungi against selected mealybugs through co-administration with some adjuvants under both laboratory and pot conditions

**Rajesh Illathur, R Philip Sridhar and JS Kennedy**

**Abstract**

Mealybugs (Hemiptera: Pseudococcidae) are important insect pests in worldwide. Forty one different treatments were tested against *Phenacoccus solenopsis* in laboratory. Among the treatments, lemongrass oil in combination with *Lecanicillium lecanii* (Zimm.) Zare & W. Gams (LIMO2) recorded the highest mortality of 93.10 per cent at 7 DAT, followed by citronella oil in combination with *L. lecanii* (LIMO2) showed the mortality of 89.65 per cent at 7 DAT. As per the results obtained, lemongrass oil, citronella oil, neem oil, pungam oil, mustard oil, sweet flag oil and castor soap shows synergistic effect with *L. lecanii* against mealybugs.

**Keywords:** *Phenacoccus*, *Lecanicillium*, lemongrass oil, citronell oil

**1. Introduction**

Mealybugs are small, soft-bodied, plant sucking insects, which embrace the second largest family of scale insects (Pseudococcidae) with approximately 2000 species belonging to 300 genera and common name is due to the waxy material which covers the bodies of adult females (Miller and Williams 1997; Downie and Gullan 2004). The mealy bug, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) has been observed, damaging cotton crop very seriously from 2004-05 in Gujarat (Jhala *et al.*, 2008). Chemical pesticides are generally used to protect crops and to kill pests. Use of synthetic pesticides causes some unfortunate consequences like environmental pollution, pest resistance and toxicity to other non-target organisms. Microbial control is a powerful pest management tactic, which involves the purposeful manipulation of pathogenic microorganisms to ensure a reduction in pestilence of a pest. This approach is a part of applied biological control in which the role of human agency is quite imperative. *Lecanicillium lecanii* (= *Verticillium lecanii*) (Zimm.) Zare & W. Gams is one of the most promising fungal species for control of whiteflies, aphids and other insect pests.

**2. Materials and methods****2.1 Bioefficacy of effective wax dissolving agents and its combination with Entomopathogenic fungi against different species of Mealybugs.**

Experiment was conducted to evaluate the bioefficacy of effective wax dissolving agents *viz.*, lemongrass oil (*Cymbopogon citratus* L.), citronella oil (*Cymbopogon nardus* L. Rendle), castor soap (*Ricinus communis* L.), neem oil (*Azadirachta indica* L.), mustard oil (*Brassica niger* L.), pungam oil (*Pongamia pinnata* L.), Sweet flag (*Acarus calamus*) oil *viz.*, *L. lecanii* (LIMO2) against *P. solenopsis* on cotton during 2015-2016. The cotton (var. surabhi) was raised in mud pots (30 cm height and 15 cm dia.). In each host plant three plants were maintained. Each treatment was applied to three replicate pots arranged in a complete randomized design (CRD). Pre-treatment observations on *P. solenopsis* population were taken before spraying, while post-treatment observations were taken 3, 7, 10, 15 days after treatment (DAT) in three leaves per plot. Two rounds of application of the treatments were made at 15 days interval. The treatment details are as follows:

All the treatments were imposed @ 20 gm per ml of adjuvant and 10 ml of fungal preparation.

**Correspondence****Rajesh Illathur**

Research Associate, KVK,  
Kalyandurg, Department of  
Agricultural Entomology, Tamil  
Nadu Agricultural University,  
Coimbatore, Tamil Nadu, India

All applications were made using hand sprayer during early morning to take advantage of cool and calm conditions. The

per cent mortality of *P. solenopsis* was corrected with that in control as suggested by Henderson and Tilt (1955).

**Table 1:** Effect of different solvents, oils, medicinal plant powders and their combinations with *Lecanicillium lecanii* (LIMO2) against *Phenacoccus solenopsis* in laboratory.

Treatment	Per cent corrected Cumulative data of 7 Days after treatment*										
	T1 Clove oil + <i>L. lecanii</i>	T2 Sheekai + <i>L. lecanii</i>	T3 Lemongrass oil+ <i>L. lecanii</i>	T4 Surf powder + <i>L. lecanii</i>	T5 Citronella oil + <i>L. lecanii</i>	T6 Castor oil + <i>L. lecanii</i>	T7 Neem oil + <i>L. lecanii</i>	T8 Eucalyptus oil + <i>L. lecanii</i>	T9 Chloroform + <i>L. lecanii</i>	T10 Acetone + <i>L. lecanii</i>	
Percent corrected mortality of <i>Phenacoccus solenopsis</i> *	55.17 <sup>k</sup> (48.26)	68.96 <sup>e</sup> (56.46)	93.10 <sup>a</sup> (75.66)	72.41 <sup>f</sup> (58.63)	89.65 <sup>b</sup> (71.71)	62.06 <sup>i</sup> (52.28)	86.20 <sup>c</sup> (68.69)	62.06 <sup>i</sup> (52.28)	51.72 <sup>l</sup> (46.27)	65.51 <sup>h</sup> (54.35)	
Percent corrected mortality of <i>Phenacoccus solenopsis</i> *	58.62 <sup>j</sup> (50.25)	75.86 <sup>e</sup> (60.92)	79.31 <sup>d</sup> (63.30)	41.37 <sup>o</sup> (40.32)	62.06 <sup>i</sup> (52.28)	44.82 <sup>n</sup> (42.31)	65.51 <sup>h</sup> (54.34)	48.27 <sup>m</sup> (44.29)	44.82 <sup>n</sup> (42.31)	31.03 <sup>a</sup> (34.16)	
Percent corrected mortality of <i>Phenacoccus solenopsis</i> *	55.17 <sup>k</sup> (48.25)	62.06 <sup>i</sup> (52.28)	51.72 <sup>l</sup> (46.27)	44.82 <sup>n</sup> (42.31)	55.17 <sup>k</sup> (48.25)	44.82 <sup>n</sup> (42.31)	41.37 <sup>o</sup> (40.32)	75.86 <sup>e</sup> (60.93)	65.51 <sup>h</sup> (54.34)	62.06 <sup>i</sup> (52.28)	
Percent corrected mortality of <i>Phenacoccus solenopsis</i> *	41.37 <sup>o</sup> (40.32)	48.27 <sup>m</sup> (44.29)	86.20 <sup>c</sup> (68.66)	62.06 <sup>i</sup> (52.28)	62.06 <sup>i</sup> (52.28)	51.72 <sup>l</sup> (46.27)	58.62 <sup>j</sup> (50.25)	37.93 <sup>p</sup> (38.31)	41.37 <sup>o</sup> (40.32)	44.82 <sup>n</sup> (42.32)	0.00 <sup>f</sup> (4.05)
	SEd					CD (P = 0.05)					
	0.9148					1.8198					

\*Mean of three replications; significant at 1%; figures in parentheses are arc sin transformed value; in a column, means followed by a common letter(s) are not significant different by DMRT (P=0.05)

**Table 2:** Effect of wax dissolving agents and their combinations with *Lecanicillium lecanii* (LIMO2) against *Phenacoccus solenopsis* in pot culture.

Treatment	Dose (g or ml per litre)	PTC	Percent corrected mortality of <i>Phenacoccus solenopsis</i> *							
			First spray				Second spray			
			Days after treatment				Days after treatment			
			3	7	10	15	3	7	10	15
Lemongrass oil + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores per ml)	20 + 10	10.13	45.39 <sup>a</sup> (42.64)	69.07 <sup>a</sup> (56.52)	86.84 <sup>a</sup> (69.16)	85.33 <sup>a</sup> (67.94)	44.07 <sup>a</sup> (41.88)	67.76 <sup>a</sup> (55.72)	86.18 <sup>a</sup> (68.61)	88.08 <sup>a</sup> (70.29)
Citronella oil + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores per ml)	20 + 10	12.66	40.52 <sup>b</sup> (39.83)	66.31 <sup>a</sup> (54.83)	84.73 <sup>a</sup> (67.42)	83.47 <sup>a</sup> (66.47)	38.42 <sup>b</sup> (38.59)	64.73 <sup>b</sup> (53.87)	85.78 <sup>a</sup> (68.30)	86.75 <sup>a</sup> (69.09)
Castor soap + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores per ml)	20 + 10	11.06	37.95 <sup>c</sup> (38.32)	62.04 <sup>b</sup> (52.27)	79.51 <sup>b</sup> (63.46)	79.25 <sup>b</sup> (63.28)	35.54 <sup>c</sup> (36.89)	61.44 <sup>c</sup> (51.91)	78.31 <sup>bc</sup> (62.59)	80.59 <sup>b</sup> (64.25)
Neem oil + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores per ml)	20 + 10	10.53	36.70 <sup>c</sup> (37.58)	63.29 <sup>b</sup> (53.01)	80.37 <sup>b</sup> (64.08)	79.48 <sup>b</sup> (63.45)	35.44 <sup>c</sup> (36.83)	62.02 <sup>c</sup> (52.25)	79.74 <sup>b</sup> (63.62)	80.25 <sup>bc</sup> (63.98)
Mustard oil + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores per ml)	20 + 10	9.73	34.24 <sup>d</sup> (36.12)	59.58 <sup>c</sup> (50.82)	75.34 <sup>c</sup> (60.59)	75.71 <sup>b</sup> (60.84)	33.56 <sup>d</sup> (35.70)	58.90 <sup>d</sup> (50.42)	76.71 <sup>cd</sup> (61.49)	77.94 <sup>cd</sup> (62.33)
Pungam oil + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores per ml)	20 + 10	9.26	32.37 <sup>d</sup> (34.98)	54.67 <sup>d</sup> (47.97)	72.66 <sup>c</sup> (58.80)	69.39 <sup>c</sup> (56.73)	31.65 <sup>e</sup> (34.54)	53.95 <sup>e</sup> (47.55)	74.10 <sup>d</sup> (59.75)	75.38 <sup>c</sup> (60.59)
Acarus calamus oil + <i>L. lecanii</i> (1 x 10 <sup>8</sup> spores/ml)	20 + 10	8.46	31.49 <sup>e</sup> (34.45)	55.90 <sup>d</sup> (48.68)	73.22 <sup>c</sup> (59.17)	69.69 <sup>c</sup> (56.92)	30.70 <sup>e</sup> (33.96)	55.11 <sup>e</sup> (48.22)	74.80 <sup>d</sup> (60.21)	75.73 <sup>de</sup> (60.82)
Control		10.46	0.00 <sup>f</sup> (0.00)	0.00 <sup>e</sup> (0.00)	0.00 <sup>d</sup> (0.00)	0.00 <sup>d</sup> (0.00)	0.00 <sup>f</sup> (0.00)	0.00 <sup>f</sup> (0.00)	0.00 <sup>e</sup> (0.00)	0.00 <sup>f</sup> (0.00)
SEd±			0.5334	0.8378	1.0263	1.3746	0.5122	0.5511	0.960	0.7961
CD (P = 0.05)			1.1441	1.7971	2.2014	2.9485	1.0988	1.1820	1.9435	1.7076

Dose: 1 x 10<sup>8</sup> conidia per ml; PTC: Pre Treatment Count (Mean of *P. solenopsis* per 5 cm twig); \*Mean of three replications; significant at 1% level; figures in parentheses are arc

**Table 3:** Assess the synergistic or antagonistic effect of wax dissolving agents on the efficacy of *Lecanicillium lecanii* in laboratory conditions

Treatment	Regression equation	Calculated $\chi^2$	LT <sub>50</sub> (Hours)	Fiducial limits		LT <sub>95</sub> (Hours)	Fiducial limits	
				Lower limit	Upper limit		Lower limit	Upper limit
Clove oil + <i>L. lecanii</i>	y = 1.65x + 1.52	0.3457	153.61	122.53	192.57	406.40	208.07	793.77
Sheekai + <i>L. lecanii</i>	y = 1.85x + 1.37	0.1404	126.28	104.60	152.45	345.40	187.97	634.06
Lemongrass oil+ <i>L. lecanii</i>	y = 3.53x - 1.05	0.3290	80.92	63.24	103.54	200.67	147.43	273.12
Surf powder + <i>L. lecanii</i>	y = 2.16x + 0.82	0.3368	114.36	96.47	135.58	288.41	179..35	463.81
Citronella oil + <i>L. lecanii</i>	y = 2.99x - 0.41	0.1494	82.56	63.80	106.85	219.55	151.28	318.62
Castor oil + <i>L. lecanii</i>	y = 1.57x + 1.79	0.0318	140.87	113.34	175.08	402.39	196.48	824.06
Neem oil + <i>L. lecanii</i>	y = 2.80x - 0.11	0.5920	87.74	69.88	110.18	225.40	155.54	326.63
Eucalyptus oil + <i>L. lecanii</i>	y = 1.55x + 1.83	0.3164	144.82	115.52	181.56	415.66	198.77	869.21
Chloroform + <i>L. lecanii</i>	y = 1.38x + 1.99	0.0003	170.32	128.01	226.61	490.79	213.65	1127.39
Acetone + <i>L. lecanii</i>	y = 1.80x + 1.36	0.1410	135.76	111.18	164.74	359.45	195.59	660.57
Soap oil + <i>L. lecanii</i>	y = 1.61x + 1.67	0.0419	147.34	118.07	183.87	404.46	202.39	808.25
Pungam oil + <i>L. lecanii</i>	y = 2.05x + 1.26	0.1567	93.14	72.85	119.09	281.99	161.65	491.93
Mustard oil + <i>L. lecanii</i>	y = 2.37x + 0.66	0.0395	92.46	73.51	116.30	257.31	161.17	410.80

Mahua oil + <i>L. lecanii</i>	$y = 1.21x + 2.11$	0.0295	212.87	143.71	315.29	621.90	234.56	1648.86
Gingelly oil + <i>L. lecanii</i>	$y = 1.61x + 1.76$	0.0423	137.05	111.12	169.03	389.65	194.21	781.18
Rose water + <i>L. lecanii</i>	$y = 1.17x + 2.29$	0.0292	199.79	137.29	290.74	607.28	224.02	1646.17
Sunflower oil + <i>L. lecanii</i>	$y = 1.59x + 1.86$	0.0316	130.43	105.91	160.63	386.99	188.20	795.76
<i>Solanum trilobatum</i> + <i>L. lecanii</i>	$y = 1.41x + 1.85$	0.0003	181.92	134.33	246.38	505.70	222.88	1147.41
Hibiscus powder + <i>L. lecanii</i>	$y = 1.45x + 1.67$	0.0002	193.47	140.55	266.32	520.09	232.08	1165.27
Amla powder + <i>L. lecanii</i>	$y = 1.11x + 2.10$	0.0006	259.34	157.56	426.89	764.62	254.35	2298.54
<i>Cynodon dactylon</i> powder + <i>L. lecanii</i>	$y = 1.11x + 2.66$	0.0284	160.04	117.60	217.78	558.76	192.22	1624.27

### 3. Results and discussions

#### 3 Evaluation of synergism / antagonism in the efficacy of entomopathogenic fungi against selected mealybugs through co-administration with some adjuvants under both laboratory and pot conditions

##### 3.1.1 Effect of different solvents, oils, medicinal plant powders and their combination with *Lecanicillium lecanii* (LIMO2) for the control of *Phenacoccus solenopsis* in lab conditions.

Forty one different treatments were tested against *P. solenopsis*. Among the treatments, lemongrass oil in combination with *L. lecanii* (LIMO2) recorded the highest mortality of 93.10 per cent at 7 DAT, followed by citronella oil in combination with *L. lecanii* (LIMO2) showed the mortality of 89.65 per cent at 7 DAT and neem oil in combination with *L. lecanii* (LIMO2) and castor soap in combination with *L. lecanii* (LIMO2) recorded the mortality of 86.20 per cent at 7 DAT. Mustard oil with *L. lecanii* (LIMO2) recorded a mortality of 79.31 per cent and both pungam oil with *L. lecanii* (LIMO2) and sweet flag (*Acarus calamus*) oil with *L. lecanii* (LIMO2) recorded the mortality of 75.86 per cent at 7 DAT (Table 1).

##### 3.2 Effect of wax dissolving agents and their combination with *Lecanicillium lecanii* (LIMO2) for the control of *Phenacoccus solenopsis* in pot conditions.

Based on the above results, treatments were designed to carry out the pot experiment (Location: Insectary, Crop: Cotton) to assess the efficacy of oils in combination with entomopathogenic fungi.

##### 3.2.1 Lemongrass oil + *L. lecanii* ( $1 \times 10^8$ spores per ml)

In the lemongrass oil + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and

15 days of first spraying, mortalities of 45.39 per cent, 69.07 per cent, 86.84 per cent and 85.33 per cent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 44.07 per cent, 67.76 per cent, 86.18 per cent and 88.08 per cent were recorded, respectively (Table 2) (Plate 1).

##### 3.2.2 Citronella oil + *L. lecanii* ( $1 \times 10^8$ spores per ml)

In the citronella oil + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and

15 days of first spraying, mortalities of 40.52 per cent, 66.31 per cent, 84.73 per cent and 83.47 percent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 38.42 per cent, 64.73 per cent, 85.78 per cent and 86.75 per cent were recorded, respectively (Table 2) (Plate 1).

##### 3.2.3 Neem oil + *L. lecanii* ( $1 \times 10^8$ spores per ml)

In the neem oil + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and 15 days of first spraying, mortalities of 36.70 per

cent, 63.29 per cent, 80.37 per cent and 79.48 percent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 35.44 per cent, 62.02 per cent, 79.74 per cent and 80.25 per cent were recorded, respectively (Table 2) (Plate 1).

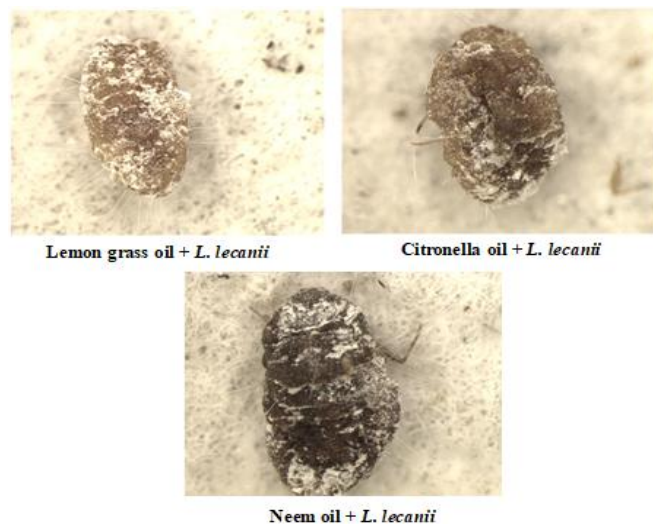


Plate 1: Mealy bug affected due to combination of oil with *L. lecanii*

##### 3.2.4 Mustard oil + *L. lecanii* ( $1 \times 10^8$ spores per ml)

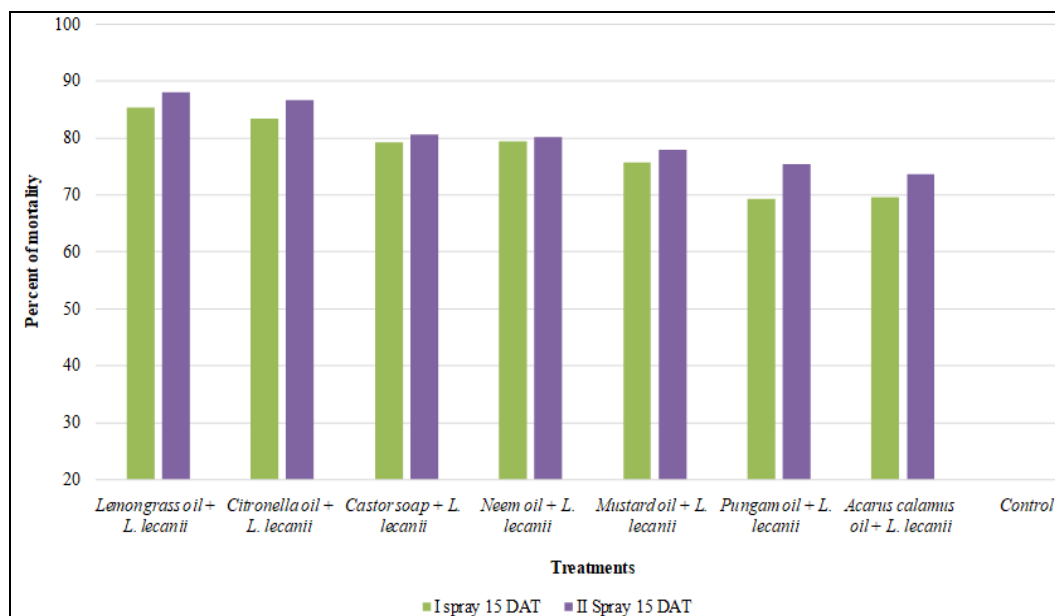
In the mustard oil + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and 15 days of first spraying, mortalities of 34.24 per cent, 59.58 per cent, 75.34 per cent and 75.71 percent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 33.56 per cent, 58.90 per cent, 76.71 per cent and 77.94 per cent were recorded, respectively (Table 2).

##### 3.2.5 Pungam oil + *L. lecanii* ( $1 \times 10^8$ spores per ml)

In the pungam oil + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and 15 days of first spraying, mortalities of 32.37 per cent, 54.67 per cent, 72.66 per cent and 69.39 percent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 31.65 per cent, 53.95 per cent, 74.10 per cent and 75.38 per cent were recorded, respectively (Table 2).

##### 3.2.6 Sweetflag oil + *L. lecanii* ( $1 \times 10^8$ spores per ml)

In the Sweetflag (*Acarus calamus*) + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and 15 days of first spraying, mortalities of 31.49 per cent, 55.90 per cent, 73.22 per cent and 69.69 percent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 30.70 per cent, 55.11 per cent, 74.80 per cent and 75.73 per cent were recorded, respectively (Table 2).



**Fig 1:** Effect of wax dissolving agents and their combinations with *Lecanicillium lecanii* (LIMO2) against *P. solenopsis* in pot culture

### 3.2.7 Castor soap + *L. lecanii* ( $1 \times 10^8$ spores per ml)

In the castor soap + *L. lecanii* treated pots, after 3 days, 7 days, 10 days and 15 days of first spraying, mortalities of 37.95 per cent, 62.04 per cent, 79.51 per cent and 79.25 per cent were recorded, respectively. After 3 days, 7 days, 10 days and 15 days of second spraying, mortalities of 35.54 per cent, 61.44 per cent, 78.31 per cent and 80.59 per cent were recorded, respectively (Table 2).

As per the results obtained, lemongrass oil, citronella oil, neem oil, pungam oil, mustard oil, sweet flag oil and castor soap shows synergistic effect with *Lecanicillium lecanii* against mealybugs. (Table 3).

### References:

1. Hamon AB, Lambdin PL, Kosztarab M. Eggs and wax secretion of *Kermes kingi*. Ann. entomol. Soc. Am. 1975; 68:1077-1078.
2. Hollingsworth RG, Hamnett RM. Using Food-Safe Ingredients to optimize the efficacy of Oil-in-Water Emulsions of Essential Oils for Control of Waxy Insects. Acta Hort, 2010, 880.