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Efficacy of insecticides against papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae)

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ABSTRACT

An investigation was conducted on efficacy of insecticides against papaya mealybug, *Paracoccus marginatus* at Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. Three kinds of insecticides were evaluated for efficacy under glasshouse conditions *viz*., chemical insecticides, physical agents and botanicals and combination of physical agents and botanicals with the least effective chemical insecticide (dichlorvos). Acephate 75 SP (0.075%) and profenophos 50 EC (0.05%) recorded the highest pest mortality of 90.24% and 84.69%, respectively 7 days after spray. Among the physical and botanical agents, lastraw TM (5 ml/l) and neem oil 300 ppm (0.5ml/l) were found promising in suppressing the mealybug population. The combinations of physical and botanical agents with least effective chemical insecticide revealed that lastraw + dichlorvos recorded the highest pest mortality (93.83%).

KEY WORDS: Botanicals**,** insecticides, lastraw, Papaya mealybug, management

INTRODUCTION

Mealybugs, are small, soft-bodied plant sap-sucking insects that constitute the second largest family of scale insects (Hemiptera: Coccoidea), and are considered as “Hard to kill pests” with more than 2,000 described species (Downie and Gullan, 2004). The name "mealybug" is derived from the mealy or waxy secretions that cover the bodies of these insects (Borror *et al*., 1992). These are important herbivores worldwide more soin the tropics. In the current decade, upward trend in the build-up of several mealybug species on crop plants and on wild hosts mainly due to certain abiotic changes in climate and environment (Tanwar *et al*., 2007).Usually mealybugs are not severe pests in countries of origin due to their suppression by indigenous, well adapted natural enemies. The most serious outbreaks occur when mealybugs are accidentally introduced to new countries without their natural enemies. The introduction of pests from infested plant material from one country to another has unfortunately become fairly common mainly due to increase in trade and travel. One such devastating mealybug species recently introduced to India is the papaya mealybug,

Paracoccus marginatus Williams and Granara de Willink (Hemiptera: Pseudococcidae), threatening major agricultural and horticultural crops, incurring severe economic losses, affecting the ecology of the cultivated ecosystems, tradeand commerce.

Papaya mealybug (PMB) is a native of Mexico and/or CentralAmerica (Miller *et al.,* 1999), first reported in 1992 by Williams and Granara de Willink. In India its incidence was first recognized inTamil Nadu Agricultural University (TNAU),Coimbatore on July 10, 2008 (Muniappan *et al.,* 2008). This was the first report of the papaya mealybug in India andSouth Asia. It has spread to Karnataka, Maharashtra, Kerala andTripura presumably due to the movement of fruits. Soon it attained thestatus of a major pest in 2009 (Shylesha *et al.,* 2010). Now it has become a major pest of mulberry, papaya and other economically important crops in Karnataka like Chamarajanagara, Mysore Chickaballapur,Bengaluru and Mandya. Because of failure to contain this pest few farmers were forced to uproot papaya and mulberry crops.

MATERIAL AND METHODS

Test Insect

The mealybugs were first collected from the Papaya and other alternativehosts *viz.,* mulberry (*Morus alba* L.) and parthenium (*Parthenium hysterophorus* L.). The mealybug samples were put in vials containing 70per cent ethyl alcohol for identification and they were submitted to Dr.Sunil Joshi, Principal Scientist, National Bureau of Agriculturally Important Insects (NBAII), Bengaluru for identification. The field collected mealybugs were released on to the potato sprouts, *Parthenium* /Mestha (*Hibiscus cannabinus* L.)/ Sunflower (*Helianthus annuus* L.) for the establishment. The plants were raised in earthen pots (dia 0.3 m) under glass house conditions.

Efficacy of insecticides

Preliminary efforts in maintaining the test insects under glasshouse conditions indicated that Mestha (*Hibiscus cannabinus* L.) and *Parthenium* are suitable in sustaining the mealybug population for sufficiently long time. So, mestha seedlings were raised in earthen pots (dia 0.3 m) under glasshouse conditions with sides having brick wall and glass panes covered with fibre sheets on the top. Twenty days after sowing, only three seedlings were retained in each pot and labelled appropriately. They were artificially infested with 50mealybugs (2nd and 3rd instar nymphs). Three such pots were maintained per treatment, each pot was considered as one replication. These pots were kept away from each other in order to avoid insecticidal drift while spraying. The initial population of *P. marginatus* adults on apical 10 cm shoot length of the three labelled plants was recorded. Commonly used insecticides were evaluated against PMB under three different set of experiments, the details of which are as furnished below. The required insecticidal

spray solution at the desired concentration was prepared and1 ml of sticker was added to each litre of the suspension. The treatments were imposed using a Ganesh hand sprayer (vol. = 1ltr). The sprayer was thoroughly washed and rinsed with soap water before and after imposing each of the individual treatments. Observations regarding the *P. marginatus* population at first, third and seventh days after sprayingwere recorded from apical 10cm long shoot.

Three different sets of experiments were conducted to determine the efficacy of insecticides against *P. marginatus* under glasshouse conditions. The experimental set up comprised of three different types of insecticidal formulations evaluated as follows:

i) Chemical insecticides

ii) Physical and botanical agents

iii) Combination of physical and botanical agents with the least effective chemical (this was done to explore the possibility of enhancing the effectiveness of least effective chemical insecticide).

Observations on the efficacy of the above said formulations on mealybug population were recorded one day before and one, three and seven days after imposition of the treatments. The data were subjected to statistical analysis (ANOVA) under Completely Randomized Design(CRD).

Efficacy of chemical insecticides

Under the first set of experiments, eight most commonly used chemical insecticides were evaluated for efficacy against PMB under glasshouse conditions (Table 1). Once the mealybugs established on mestha, the following chemical insecticides were applied with control (water spray).

Table 1: Insecticides evaluated against PMB under glasshouse conditions

Treatment	**Treatment details**	**Dosage (%)**
T1	Thiamethoxam 25 WDG	0.0125
T2	Imidacloprid 200SL	0.10
T3	Buprofezin 25 SC	0.025
T4	Dimethoate 30EC	0.06
T5	Profenophos 50EC	0.05
T6	Dichlorvos (DDVP) 76WSC	0.15
T7	Acephate 75SP	0.075
T8	Control	

Efficacy of physical and botanical agents

In the second set of experiments, five physical and botanical agents were evaluated (Table 2) against PMB after ensuring sufficient mealybug infestation on mestha seedlings under glasshouse conditions.

Table 2: Physical and botanical agents evaluated against PMB under glasshouse conditions

Treatment	Treatment details	Dosage
T1	Wood ash	10g/l
T2	Lastraw™	5ml/l
T3	Kaolinite clay	5g/l
T4	Neem oil 300ppm	0.5ml/l
T5	Pongamia soap	5g/l
T6	Fish oil Rosin Soap	20g/l
T7	Untreated Control	

N.B: Lastraw™– A specially formulated water soluble organic salt of fatty acids of vegetable oil origin developed for the management of soft bodied sucking pests on contact. It has been formulated and marketed by M/s Bio control Research Laboratory (BCRL), Pest Control (India) Pvt. Ltd., Rajanukunte, Bangalore.

Effect of combination of physical agents and least effective insecticide (LEC)

Under the third set of experiments, the effect of combination of physical agents and least effective insecticide (Table 3) were evaluated for efficacy against PMB.

Table 3: Combination of physical agents and least effective chemical insecticide treatments evaluated against PMB under glasshouse conditions

Treatment	Treatment details
T1	Pongamia soap+ LEC
T2	Wood ash + LEC
T3	Lastraw + LEC
T4	Kaolinite + LEC
T5	Untreated control

N.B: LEC: Least Effective Chemical Insecticide

RESULTS AND DISCUSSION

Efficacy of insecticides

The bio-efficacy of the seven chemical insecticides were evaluated against *P. marginatus.* The mealybug host used for this study was mestha and investigations were made under glasshouse conditions.

Pre-treatment count: The pre-treatment population of the mealybug had a range from38.33 to 41.33 per 10 cm shoot length. Differences in the mealybug population between the treatments were not statistically significant one day before imposition of the treatments (Table 4).The chemical insecticides were evaluated based on number of surviving individuals and the same data was also expressed as per cent mortality.

One day after spray

At one day after spray significant differences were observed between the treatments. The lowest mealybug population of 24.00 /10 cm shoot length was recorded in acephate @ 0.075% which was significantlysuperior over rest of the treatments. This was followed by dimethoate @0.06% (29.00) and profenophos @ 0.05% (32.33). The maximum mealybug population was observed in control (41.33), followed by imidacloprid @ 0.10% (35.67) and dichlorvos @ 0.15% (35.33). The insecticides in the decreasing order of efficacy were acephate (0.075%) >dimethoate (0.06%) > profenophos (0.05%) > buprofezin (0.025%) >thiamethoxam (0.0125%) > dichlorvos (0.15%) > imidacloprid (0.10%)(Table 4).

Three days after spray

Similarly, at three days after spray significant differences were observed between the treatments, the lowest mealybug population of10.67/10 cm shoot was recorded in acephate significantly superior over rest of the treatments; this was followed by profenophos (15.00) and dimethoate (17.33). The maximum population was observed in control (42.00) followed by imidacloprid (29.00), dichlorvos (27.00),thiamethoxam (26.00). The insecticides in the decreasing order of efficacy were acephate > profenophos > dimethoate > buprofezin> thiamethoxam> dichlorvos > imidacloprid (Table 4).

Seven days after spray

At seven days after spray, significant differences were observed between the treatments. The lowest population of 4.33 mealybugs/10 cm shoot was recorded in acephate, significantly superior over rest of the treatments. This was followed by profenophos (6.33) and thiamethoxam (8.67). The maximum mealybug population was observed in control (43.33), followed by dichlorvos (19.00) and imidacloprid (13.67). The insecticides in the decreasing order of efficacy were acephate> profenophos > thiamethoxam > dimethoate > buprofezin > imidacloprid> dichlorvos (Table 4).

Reduction in mealybug population

The data on survival of individuals was transformed to mortality and thus the efficacy of insecticide was assessed based on mealybug mortality. The present investigation explicitly pointed out that acephate 75SP (0.075%) and profenophos 50 EC (0.05%) were significantly superior in suppressing PMB population under glasshouse conditions. The same conclusion was drawn from several workers both in India and abroad as evidenced from field and laboratory studies. Therefore, acephate can be the best option and in its absence, profenophos can be an alternative for the management of PMB.

Acephate and profenophos recorded the least incidence of mealybugs 7th day after spraying and recorded the highest mortality of90.24 and 84.69 per cent, respectively. The above mentioned two insecticides were significantly superior over rest of the chemical insecticides at the end of the 7th day. On the contrary, dichlorvos (56.14%) and imidacloprid (65.76%) recorded the lowest per cent mortality of mealybug at 7 days after spray. However, all the insecticidal treatments were significantly superior over control.

Effectiveness of profenophos 50 EC was also in conformity with the results of Suresh *et al*. (2010a) who reported that spot application of insecticides like buprofezin, chlorpyriphos and profenophos against PMB was highly successful at various places of Tamil Nadu and the same workers also recorded that profenophos 50 EC recorded the highest percentage reduction of *P. solenopsis* (95.99), followed by endosulfan and thiomethoxam. Similarly, Walker *et al*. (2003) reported that number of chemical insecticide options is available to reduce mealybug population, although none are currently registered specifically for control of PMB. Active ingredients in registered pesticide formulations include acephate, carbaryl, chlorpyrifos, diazinon, dimethoate, malathion and white mineral oils.

Efficacy of physical and botanical agents

Pre-treatment count: The pre-treatment population of the mealybug ranged from 30.67to 34.33 per 10 cm length shoot. Differences in the mealybug population between the treatments were not statistically significant, one day before imposition (Table 6).

One day after spray

There was no significant difference between the treatments. The lowest mealybug population of 26.33 /10 cm length apical shoot was recorded in wood ash. This was followed by FORS (26.67) and neem oil (28.00). Maximum population was observed in control (30.67).The insecticides in the decreasing order of efficacy were wood ash >FORS > neem oil > lastraw >Pongamia soap > kaolinite clay (Table 6).

Three days after spray

The lowest mealybug population of 15.67/10 cm apical shoot was recorded in Lastraw statistically significant over rest of the treatments. This was followed by neem oil (18.67) and FORS (21.33).Maximum pest population was recorded in control (31.33) followed by kaolinite clay (24.33)

and Pongamia soap (22.67). The insecticides in the decreasing order of efficacy were lastraw > neem oil > FORS > wood ash>Pongamia soap > kaolinite clay (Table 6).

Seven days after spray

The lowest population of 7.67 mealybugs/10 cm apical shoot was recorded in Lastraw^{TM} on par with neem oil (8.67), this was followed by FORS (12.67) and Pongamia soap (16.00). The maximum mealybug population was recorded control (32.33), followed by kaolinite clay(19.00) on par with wood ash (17.33). The insecticides in the decreasing order of efficacy were lastraw > neem oil > FORS > Pongamiasoap > wood ash > kaolinite clay (Table 6).

Reduction in the mealybug population

The data on survival of individuals was transformed to mortality and thus the efficacy of insecticide was assessed based on mealybug mortality. Lastraw^{TM}(5ml/l) and Neem oil 300 ppm were significantly superior in reducing the population of mealybug on Mestha under glasshouse conditions. Lastraw and neemoil recorded the least incidence of mealybugs 7 days after spraying and recorded the highest mortality of 78.74 and 76.19 per cent, respectively. The above mentioned two physical and botanical agents were significantly superior over rest of the treatments at the end of 7th day. On the contrary, wood ash (46.77) and kaolinite clay (46.74) recorded the lowest per cent mortality of mealybug 7 days after spray. However, all the treatments were significantly superior over control.

Superiority of physical agent *i.e.* Lastraw TM in this study is in line with report of Prabhakara and Ghosh (2011) who evaluated Lastraw TM against major sucking insect pest, white flies *Aleurodicus disperses* Russell and *Bemisia tabaci* Genn. on guava and gerbera respectively. Lastraw TM @ 5ml/l was on par with imidachloprid @ 0.5ml/l after7 days after first spray on Gerbera and after 7 days of second spray on guava in bringing down the white flies population. The higher efficacy of Lastraw in the present study is in line with report of Pena and Johnson(1993) who reported that potassium salts of fatty acids (Safer SoapR) have given satisfactory control against PMB in Florida.

Combined effect of physical and botanical agents with least effective chemical insecticide (LEC) - dichlorvos

Pre-treatment count

The pre-treatment population of the mealybug ranged from 37.75to 39.5 per 10 cm shoot length. Differences in the mealybug population between the treatments were not statistically significant, one day before imposition of the treatments (Table 8 and Fig. 5) thus indicating a uniform pest population.

One day after spray

Significant differences existed between the treatments. The lowest

mealybug population of 30.25 /10 cm shoot length was recorded in lastraw + LEC significantly superior over rest of the treatments. This was followed by Pongamia soap + LEC (32.5). Maximum population was observed in control (39.5). The combination of physical agents and insecticide in the decreasing order of efficacy were Lastraw + LEC > Pongamia soap + LEC > wood ash + LEC > kaolinite clay+ LEC (Table 8).

Three days after spray

The lowest mealybug population of 21/10 cm shoot length was recorded in woodash + LEC, significantly superior over rest of the treatments. This was followed by Lastraw + LEC (23.00). Maximum pest population was recorded in control (39.25). The insecticides in the decreasing order of efficacy were wood ash +LEC, lastraw + LEC > Pongamia soap + LEC >kaolinite clay + LEC (Table 8).

Seven days after spray

The lowest population of 2.50 mealybugs/10 cm shoot length was recorded in lastraw + LEC, statistically significant over rest of the treatments, followed by Pongamia soap + LEC (6.00) and Pongamia soap (16.00). The maximum mealybug population was recorded in case of control (40.25). The insecticides in the decreasing order of efficacy were Lastraw + LEC > Pongamia soap + LEC > kaolinite clay + LEC > wood ash+ LEC (Table 8).

Reduction in the mealybugs

The data on survival of individuals was transformed to mortality and thus the efficacy of insecticide was assessed based on mealybug mortality. Among the physical agents and botanicals tested in combination with the least effective chemical insecticide *i.e*. dichlorvos for their efficacy against PMB under glass house conditions indicated that there was no significant difference between the treatment combinations at one day after spray. However, at three days and seven days after imposition of spray lastraw + LEC recorded significantly highest pest mortality of63.69 and 93.83%, respectively and were significantly superior over rest of the treatments. The rest of the combinations *viz.*, pongamia soap + LEC, wood ash + LEC and kaolinite + LEC which were found on par with each other both at 3 DAS and 7 DAS were inferior to lastraw +LEC.

Irulandi *et al.* (2001) reported that combination spray of azadirachtin 10 ml +quinolphos 0.75 ml recorded maximum reduction of86.82% against coffee mealybug (*P. citri*). Findings of Anonymous (2010) have indicated that for the management of PMB, neem oil (20ml/ltr) or Nimbicidine 10000ppm 2ml/ltr can also be combined with profenophos or dimethoate. Mahalingam *et al*. (2010) reported that 15 days after pruning of mulberry spray applications of dichlorvos @ 2 ml/l along with azadirachtiin (10000 ppm) @ 1 ml /l reduced PMB infestation on mulberry under field conditions.

CONCLUSION

Acephate 75 SP (0.075%) and profenophos 50 EC (0.05%) were the most effective in suppressing mealybug incidence on Mestha under glasshouse conditions. Acephate and profenophos recorded the least incidence of mealybugs 7 days after spray and also recorded highest pest mortality of 90.24% and84.69%, respectively. On the contrary, dichlorvos (56.14) and imidachloprid (65.76%) recorded the lowest mortality of mealybug at 7DAS. Among the different physical and botanical agents evaluated against PMB Lastraw TM (5 ml/l) and neem oil 300 ppm (0.5ml/l) were found promising in suppressing the mealybug population. Lastraw TM and neem oil have recorded maximum reduction in mealybug population of78.74% and 76.19%, respectively. The lowest reduction of mealybug population was recorded in kaolinite clay (46.74%) and wood ash (46.77%), respectively. When a physical and botanical agent that were tested in combination with the least effective chemical (dichlorvos) combination of dichlorvos with lastraw recorded highest pest mortality (93.83%) and the next best combination was pongamia soap combined with dichlorvos has recorded 85.05% mortality. The lowest mortality (79.02%) was recorded in the wood ash + dichlorvos combination.

Table 4: Efficacy of chemical insecticides against *P. marginatus* under glass house conditions

Treatment	No. of Mealybugs / 10cm shoot length			
	DBS	1st DAS	3rd DAS	7th DAS
Thiamethoxam 25 WDG (0.0125%)	40.67 (6.33)	34.33 (5.90)^{abc}	26.00 (5.15)^{bc}	8.67 (3.02)^{abc}
Imidacloprid 200SL (0.10%)	38.33 (6.22)	35.67 (6.00)^{bc}	29.00 (5.43)^{c}	13.67 (3.76)^{de}
Buprofezin 25 SC (0.025%)	38.67 (6.26)	32.67 (5.76)^{abc}	24.33 (4.98)^{bc}	12.00 (3.53)^{cd}
Dimethoate 30EC (0.06%)	38.33 (6.23)	29.00 (5.43)^{ab}	17.33 (4.22)^{ab}	10.67 (3.34)^{bcd}
Profenophos 50EC (0.05%)	39.33 (6.30)	32.33 (5.72)^{abc}	15.00 (3.89)^{a}	6.33 (2.61)^{ab}
Dichlorvos (DDVP) 76WSC (0.15%)	41.33 (6.47)	35.33 (5.98)^{bc}	27.00 (5.24)^{bc}	19.00 (4.41)^{e}
Acephate 75SP (0.075)	40.67 (6.40)	24.00 (4.94)^{a}	10.67 (3.32)^{a}	4.33 (2.16)^{a}
Control	41.00 (6.44)	41.33 (6.47)^{c}	42.00 (6.52)^{d}	43.33 (6.62)^{f}
F test	-	(*)	(*)	(*)
SE.m (±)	-	(0.18)	(0.21)	(0.16)
CD (p = 0.05)	-	(0.54)	(0.62)	(0.49)

DBS: Day before spray; DAS: Days after spray; Means followed by same letter in the column do not differ significantly by Tukey's HSD test Figures in the parentheses are square root transformed value.

Table 5: Reduction of PMB due to chemical insecticides under glass house conditions

Treatment	Per cent reduction of mealybugs		
	1st DAS	3rd DAS	7th DAS
Thiamethoxam 25 WDG (0.0125%)	13.38 (21.12)^{bc}	35.56 (36.55)^{cd}	79.05 (62.88)^{abc}
Imidacloprid 200SL (0.10%)	7.44 (15.72)^{c}	25.88 (30.54)^{d}	65.76 (54.23)^{cd}
Buprofezin 25 SC (0.025%)	15.81 (23.39)^{bc}	38.49 (38.31)^{cd}	70.69 (57.20)^{cd}
Dimethoate 30EC (0.06%)	24.71 (29.77)^{ab}	55.66 (48.24)^{bc}	73.67 (59.13)^{bc}
Profenophos 50EC (0.05%)	18.07 (24.63)^{bc}	63.66 (53.04)^{ab}	84.69 (66.95)^{ab}
Dichlorvos (DDVP) 76WSC (0.15%)	14.94 (22.63)^{bc}	35.98 (36.77)^{d}	56.14 (48.55)^{d}
Acephate 75SP (0.075)	40.87 (39.72)^{a}	74.74 (59.85)^{a}	90.24 (72.00)^{a}
F test	(*)	(*)	(*)
SE.m (±)	(2.24)	(2.20)	(2.02)
CD (p = 0.05)	(6.80)	(6.70)	(6.15)

DAS: Days after spray; Figures in the parentheses indicate arc sine transformed value.
Means followed by same letter in the column do not differ significantly by Tukey's HSD test

Table 6: Efficacy of different physical and botanical agents on *P. marginatus* under glass house conditions

Treatment	No. of Mealybugs / 10cm shoot length			
	DBS	1st DAS	3rd DAS	7th DAS
Wood ash (10g/l)	31.33 (5.64)	26.33 (5.18)	21.67 (4.71)^{bc}	17.33 (4.20)^{c}
Lastraw (5ml/l)	34.00 (5.87)	28.33 (5.37)	15.67 (4.01)^{a}	7.67 (2.85)^{a}
Kaolinite clay (5g/l)	34.33 (5.90)	30.33 (5.55)	24.33 (4.98)^{c}	19.00 (4.41)^{c}
Fish Oil Rosin Soap (20g/l)	31.33 (5.64)	26.67 (5.21)	21.33 (4.67)^{bc}	12.67 (3.62)^{b}
Neem oil 300ppm (0.5ml/l)	34.33 (5.90)	28.00 (5.34)	18.67 (4.38)^{ab}	8.67 (3.02)^{a}
Pongamia soap (5g/l)	32.67 (5.76)	28.33 (5.37)	22.67 (4.81)^{bc}	16.00 (4.06)^{bc}

Untreated Control	30.67 (5.58)	30.67 (5.58)	31.33 (5.64)^{d}	32.33 (5.73)^{d}
F test	(NS)	(NS)	(*)	(*)
SE.m (±)	-	-	(0.14)	(0.17)
CD (p = 0.05)	-	-	(0.43)	(0.51)

DBS: Day before spray; DAS: Day after spray
Means followed by same letter in the column do not differ significantly Tukey's HSD test
Figures in parentheses are square root transformed values

Table 7: Reduction of PMB due to physical and botanical agents under glass house conditions

Treatment	**Per cent reduction of mealybugs**		
	1st DAS	**3rd DAS**	**7th DAS**
Wood ash (10g/l)	10.70 (18.89)	21.95 (27.85)^{c}	46.77 (42.96)^{c}
Lastraw (5ml/l)	16.73 (24.06)	55.34 (48.05)^{a}	78.74 (62.57)^{a}
Kaolinite clay (5g/l)	11.49 (19.50)	30.12 (32.90)^{bc}	46.74 (43.03)^{c}
Fish Oil Rosin Soap (20g/l)	15.20 (22.73)	38.94 (38.54)^{abc}	61.87 (51.85)^{abc}
Neem oil 300ppm (0.5ml/l)	18.38 (25.19)	46.94 (43.23)^{ab}	76.19 (60.81)^{ab}
Pongamia soap (5g/l)	12.96 (20.43)	32.30 (34.61)^{bc}	53.65 (47.08)^{bc}
F test	(NS)	(*)	(*)
SE.m (±)	-	(3.79)	(3.25)
CD (p = 0.05)	-	(11.70)	(10.04)

DAS: Day after spray; Means followed by same letter in the column do not differ significantly by Tukey's HSD test
Figures in parentheses indicate arc sin transformed values

Table 8: Efficacy of combination of physical agents and least effective chemical insecticide (LEC) against PMB under glass house conditions

Treatment	**No. of Mealybugs / 10cm shoot length**			
	DBS	**1st DAS**	**3rd DAS**	**7th DAS**
Pongamia soap + LEC	39.5 (6.32)	32.5 (5.74)^{bc}	24.75 (5.02)^{bc}	6.00 (2.55)^{b}
Wood ash + LEC	37.75 (6.18)	32.75 (5.76)^{bc}	21.00 (4.63)^{c}	8.00 (2.91)^{b}

Lastraw + LEC	39.75 (6.34)	30.25 (5.54)^{c}	23.00 (4.85)^{bc}	2.50 (1.73)^{c}
Kaolinite + LEC	38.5 (6.24)	34.75 (5.94)^{b}	27.00 (5.24)^{b}	7.00 (2.74)^{b}
Untreated control	39.5 (6.32)	39.5 (6.32)^{a}	39.25 (6.30)^{a}	40.25 (6.38)^{a}
F test	(NS)	(*)	(*)	(*)
SE.m (±)	-	(0.08)	(0.10)	(0.08)
CD (p = 0.05)	-	(0.24)	(0.30)	(0.25)

DBS: Day before spray; DAS: Day after spray
Figures in parentheses are square root transformed values
Means followed by same letter in the column do not differ significantly by Tukey's HSD test
LEC: Least Effective Chemical insecticide- dichlorvos

Table 9: Reduction of PMB due to combination of physical agents and chemical insecticide under glass house conditions

Treatment	**Per cent reduction of mealybug**		
	1st DAS	3rd DAS	7th DAS
Pongamia soap + LEC	14.71 (22.35)	35.05 (36.27)^{b}	85.05 (67.26)^{b}
Wood ash + LEC	17.35 (22.35)	40.76 (39.64)^{b}	79.02 (62.77)^{b}
Lastraw + LEC	18.81 (23.89)	63.69 (53.03)^{a}	93.83 (75.65)^{a}
Kaolinite + LEC	13.24 (20.45)	27.27 (31.31)^{b}	82.11 (64.98)^{b}
F test	(NS)	(*)	(*)
SE.m (±)	-	(2.20)	(2.02)
CD (p = 0.05)	-	(6.70)	(6.15)

DAS: Day after spray; Figures in parentheses indicate arc sin transformed values
Means followed by same letter in the column do not differ significantly by Tukey's HSD test
LEC: Least Effective Chemical insecticide- dichlorvos

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