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Evaluation of Different Insecticides and Biorationals Against Scale Insect, *Hemilecanium imbricans* (Green) Under Laboratory Condition

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A B S T R A C T

Among 25 insecticides and biorationals evaluated with and without Fish Oil Rosin Soap (5 ml/l) against different instars of scale insect, *Hemilecanium imbricans*, the insecticides *viz.*, buprofezin 25 SC @ 1.25 ml/l, chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l were recorded highest per cent mortality of scales under laboratory conditions. Irrespective of treatments imposed with and without FORS against different stages of scale insect, *H. imbricans* similar effects were produced with respect to mortality percentage with little variation. With respect to instar susceptibility, the first instars (crawlers) and second instars of *H. imbricans* were shown more susceptibility to all combination treatments compared to third and fourth instars under laboratory conditions.

Introduction

Scale insects are most important as agricultural pest of perennial plants and can cause serious damage to nut and fruit trees, woody ornamentals, forest vegetation, greenhouse plants and house plants. Damage is usually caused by removal of plant sap, toxins and the excretion of large quantities of honeydew with resultant growth of sooty mold fungi that cover leaf surfaces and reduce photosynthesis. The waxy covering of many species of scale insects protects them effectively from contact insecticides, which are only effective against crawlers. However, scale insects are often controlled by use of horticultural oils, Fish oil rosin soap (FORS) that dissolves the wax coating and suffocate and kill them or by biological control agents such as parasitiods wasps, green lace wings, and predators like coccinellid beetles.

In Thailand, *Hemilecanium mangiferae* was reported causing serious infestation during April, associated with sooty mold. On some trees, the surface of the twigs and branches was completely covered by the insects. Large amount of sooty mold was growing on the honey dew, blackening the ground just below the infested canopy, and also on the trunk,

branches and twigs. Furthermore, the leaves of the infested trees showed a signs of yellowing (Kondo and Michael, 2005). *Hemilecanium imbricans* (Green) has become an endemic pest for particularly in Navalur, Kelageri, Jogeyellapur and Mugad villages of Dharwad district in North Karnataka. Lack of effective timely management practices, presence of protective shell and prolific breeding habits lead to build up of large population and spreading from one infested garden to another. In this context, the present investigation was undertaken.

Materials and Methods

In vitro bioassay was carried out with 25 treatments and two replications in Completely Randomized Design (CRD) to evaluate the relative efficacy of different insecticides and biorationals with and without fish oil rosin soap (5 ml/l) against all stages of scale insect, *H. imbricans*.

The recommended dosage of insecticides was diluted in water to get the required concentration. Known numbers (100) of first instar crawlers, second, third, and fourth instar stages on mango twig were selected and spraying was done with the help of baby sprayer ensuring equal number of strokes to all the treatments. The mango twigs were provided with cotton vad to maintain the moisture content of the twig. Mortality was recorded at an interval of 24 hours for seven days. Observations were revealed on shrinkage, shriveling, and mortality of scales percentage was worked out.

Results and Discussion

The results on efficacy of various treatments against scale insect, *H. imbricans* on mango twigs recorded in terms of mortality caused at one, three, five and seven days after spray with and without FORS are presented in table 1-7.

First instar

The precount recorded at one day before spray indicated non-significant difference between various treatments.

One day after spray

There was a satisfactory significant reduction in scale insect in all the treatments except untreated control. Buprofezin 25 SC @ 1.25 ml/l was significantly superior to all other treatments recording 91.10 per cent mortality. It was on par with chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l, buprofezin 5.65 SC + deltamethrin 0.72 EC @ 2.5 ml/l and dichlorvos 76 EC @ 1 ml/l. However, application of pongamia oil + tween 80 recorded lowest mortality of 69.51 per cent (Table 1).

Various insecticides when imposed without FORS exhibited effect similar to with FORS. Buprofezin 25 SC @ 1.25 ml/l was superior recording 90.50 per cent mortality and was on par with chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Cotton oil + tween and sunflower oil + tween effected lower mortality (70.00% and 72.50%) (Table 2). Various insecticides used with or without FORS the mortality trend were similar to 1DAS even at 3, 5 and 7 days after spray.

Second instar

One day after spray

Buprofezin 25 SC @ 1.25 ml/l was significantly superior to all other treatments by recording 56.51 per cent mortality. The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-

cyhalothrin 5 EC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l, buprofezin 5.65 SC + deltamethrin 0.72 EC @ 2.5 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality was recorded in *Lecanicillium lecani* + tween 80 treatment (11.51%) (Table 3).

Treatments without FORS also performed results similar to with FORS but lower mortality compared to with FORS treatment. However, buprofezin 25 SC @ 1.25 ml/l was superior by recording 51.50 per cent mortality but was on par with dichlorvos 76 EC @ 1 ml/l. The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l. Least mortality of 10.50 per cent was recorded in sunflower oil + tween 80 treatment (Table 4).

Three days after spray

The chemical buprofezin 25 SC @ 1.25 ml/l was significantly superior over all other treatments by recording 64.51 per cent mortality but was on par with lambda-cyhalothrin 5 EC @ 0.5 ml/l, dichlorvos 76 EC @ 1 ml/l, chlorpyriphos 20 EC @ 2 ml/l and acephate 75 SP @ 1 g/l. Least mortality of 15.00 per cent was recorded in the treatment, pongamia oil + tween 80 (Table 3).

Use of different insecticides without FORS recorded similar results with FORS treatment though per cent mortality was less. Buprofezin 25 SC @ 1.25 ml/l recorded 66.00 per cent mortality but on par with acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l dichlorvos 76 EC @ 1 ml/l and chlorpyriphos 20 EC @ 2 ml/l. Least mortality of 12.00 per cent was recorded in sunflower oil + tween 80 treatment (Table 4).

Five days after spray

The insecticide lambda-cyhalothrin 5 EC @ 0.5 ml/l significantly differed from all other treatments with 91.00 per cent mortality but was on par with acephate 75 SP @ 1 g/l, chlorpyriphos 20 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Cotton oil + tween 80 treatment recorded least mortality of 10.00 per cent (Table 3). Treatments imposed without FORS did not differ in their effects that were imposed with FORS though with lower mortality rate. Buprofezin 25 SC @ 1.25 ml/l was the top most treatment with 86.50 per cent mortality but was on par with dichlorvos 76 EC @ 1 ml/l. This was followed by chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l and. Sunflower oil + tween 80 treatment effected least mortality of 13.00 per cent (Table 4).

Seven days after spray

Buprofezin 25 SC @ 1.25 ml/l was significantly superior to all treatments with 99.00 cent per cent mortality. The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality of 17.00 per cent was recorded in Pongamia oil + tween 80 treatment (Table 3). Insecticides when imposed without FORS did not differ much though they produced less mortality than with FORS treatment. Buprofezin 25 SC @ 1.25 ml/l was significantly superior effecting 95.50 per cent mortality but was on par with lambda-cyhalothrin 5 EC @ 0.5 ml/l, chlorpyriphos 20 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality of 14.00 per cent was recorded in the treatment, sunflower oil + tween 80 (Table 4).

Third instar

One day after spray

Acephate 75 SP @ 1 g/l performed significantly superior to all other treatments by recording 50.50 per cent mortality. This was

on par with chlorpyriphos 20 EC @ 2 ml/l, buprofezin 25 SC @ 1.25 ml/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality (8%) was recorded in cotton seed oil + tween 80 treatment (Table 5). Results related to treatments without FORS on third instar revealed less mortality compared to with FORS treatment. Lambda-cyhalothrin 5 EC @ 0.5 ml/l treatment was significantly superior to other treatments by recording 48.00 per cent mortality but was on par with chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, buprofezin 25 SC @ 1.25 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality (10%) was recorded in the treatment sunflower seed oil + tween 80 (Table 6).

Three days after spray

Dichlorvos 76 EC @ 1 ml/l was superior with 77.50 per cent mortality but was on par with lambda-cyhalothrin 5 EC @ 0.5 ml/l. The next best treatments were buprofezin 25 SC @ 1.25 ml/l, chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l and profenophos 50 EC @ 2 ml/l. Least mortality (9%) was recorded in the treatment sunflower oil + tween 80 (Table 5).

Insecticides treatments without FORS also produced similar results as that of with FORS but with lower mortality.

Dichlorvos 76 EC @ 1 ml/l was superior by recording 70.50 per cent mortality but was on par with lambda-cyhalothrin 5 EC @ 0.5 ml/l, chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, profenophos 50 EC @ 2 ml/l and buprofezin 25 SC @ 1.25 ml/l. Least mortality (12%) was recorded in the treatment pongamia oil + tween 80 (Table 6).

Five days after spray

Lambda-cyhalothrin 5 EC @ 0.5 ml/l was significantly superior to all other treatments with 86.00 per cent mortality but on par with buprofezin 25 SC @ 1.25 ml/l. The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality (10.50%) was recorded in the treatment sunflower oil + tween 80 (Table 5).

Results without FORS exercised similar effects to that of with FORS on per cent mortality. Buprofezin 25 SC @ 1.25 ml/l topped with 79.00 per cent mortality and was on par with dichlorvos 76 EC @ 1 ml/l.

The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l, acephate 75 SP @ 1 g/l and profenophos 50 EC @ 2 ml/l. Least mortality (13.50%) was recorded in the treatment sunflower oil + tween 80 (Table 6).

Seven days after spray

The chemical insecticide buprofezin 25 SC @ 1.25 ml/l was significantly superior to all other treatments with 92.50 per cent mortality. The next best treatments were lambda-cyhalothrin 5 EC @ 0.5 ml/l, acephate 75 SP @ 1 g/l, chlorpyriphos 20 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality (11.00%) was recorded in the treatment sunflower oil + tween 80 (Table 5).

Insecticides imposed without FORS produced similar to those with FORS though with less mortality. Buprofezin 25 SC @ 1.25 ml/l was significantly superior to all other treatments with 88.50 per cent mortality but was on par with chlorpyriphos 20 EC @ 2 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l. The next best treatments were acephate 75 SP @ 1 g/l and dichlorvos 76 EC @ 1 ml/l.

Least mortality (14.50%) was recorded in sunflower oil + tween 80 treatment (Table 6).

Fourth instar

One day after spray

The chemical insecticide dichlorvos 76 EC @ 1 ml/l was significantly superior to all other treatments with 48.00 per cent mortality but on par with acephate 75 SP @ 1 g/l. The next best treatments were buprofezin 25 SC @ 1.25 ml/l, chlorpyriphos 20 EC @ 2 ml/l profenophos 50 EC @ 2 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l. The treatment Neemazal treatment @ 15000 ppm recorded only 6.00 per cent mortality (Table 7).

Trend was similar when insecticides were applied without FORS. Buprofezin 25 SC @ 1.25 ml/l was superior among the various treatments by recording 35.50 per cent mortality and was on par with chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality (9.00%) was recorded in pongamia oil + tween 80 treatment (Table 8).

Three days after spray

The chemical insecticide buprofezin 25 SC @ 1.25 ml/l was significantly superior to all other treatments with 67.50 per cent mortality but was on par with acephate 75 SP @ 1 g/l and dichlorvos 76 EC @ 1 ml/l. The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, profenophos 50 EC @ 2 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l. However, least mortality (8.50%) was recorded in the treatment pongamia oil + tween 80 (Table 7).

Treatments imposed without FORS exercised similar effects to that when treated with FORS. Buprofezin 25 SC @ 1.25 ml/l was superior recording 50.50 per cent mortality but was on par with acephate 75 SP @ 1 g/l, chlorpyriphos 20 EC @ 2 ml/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. The least mortality of 11.50 per cent was recorded in sunflower oil + tween 80 treatment (Table 8).

Five days after spray

Buprofezin 25 SC @ 1.25 ml/l was superior among the various treatments by recording 82.00 per cent mortality of scale insects. The next best treatments were chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, dichlorvos 76 EC @ 1 ml/l, profenophos 50 EC @ 2 ml/ and lambda-cyhalothrin 5 EC @ 0.5 ml/l. The least mortality of 9.00 per cent was recorded in pongamia oil + tween 80 treatment (Table 7).

Trend was similar when insecticides were applied without FORS. Buprofezin 25 SC @ 1.25 ml/l was found superior among the various treatments by recording 71.50 per cent mortality and was on par with chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, profenophos 50 EC @ 2 ml/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l and dichlorvos 76 EC @ 1 ml/l. Least mortality (13.00%) was recorded in sunflower oil + tween 80, cotton oil + tween 80 treatment and sole fish oil rosin soap treatments (Table 8).

Seven days after spray

Profenophos 50 EC @ 2 ml/l and acephate 75 SP @ 1 g/l were superior among the various treatments by recording 86.00 per cent mortality. The next best treatments were buprofezin 25 SC @ 1.25 ml/l, chlorpyriphos 20 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. The least per cent mortality (12.00) was recorded in sunflower oil + tween 80 treatment (Table 7).

Trend was similar when insecticides were applied without FORS.

Table.1 Laboratory evaluation of different insecticides and biorationals with FORS against first instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
T_1	Buprofezin 25 SC	1.25	91.10 (72.56) a	100 (90)	100 (90)	100 (90)
T_2	Thiamethoxam25 WG	0.3	81.00 (64.16) d-f	100 (90)	100 (90)	100 (90)
T_3	Acetamiprid 20 SP	0.2	83.50 (66.05) c-e	100 (90)	100 (90)	100 (90)
T_4	Imidacloprid 17.8 SL	0.3	83.50 (66.05) c-e	100 (90)	100 (90)	100 (90)
T_5	Dimethoate 30 EC	1.7	83.50 (66.05) c-e	100 (90)	100 (90)	100 (90)
T_6	Chlorpyriphos 20 EC	2.0	89.50 (71.09) a	100 (90)	100 (90)	100 (90)
T_7	Acephate 75 SP	1.0	90.01 (71.58) a	100 (90)	100 (90)	100 (90)
T_8	Deltamethrin 2.8 EC	0.5	81.50 (64.52) d-f	100 (90)	100 (90)	100 (90)
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	89.51 (71.13) a	100 (90)	100 (90)	100 (90)
T_{10}	Lambda-cyhalothrin 5 EC	0.5	89.01 (70.64) a	100 (90)	100 (90)	100 (90)
T_{11}	Methomyl 40 SP	0.3	84.52 (66.81) cd	100 (90)	100 (90)	100 (90)
T_{12}	Profenophos 50 EC	2.0	88.53 (70.18) ab	100 (90)	100 (90)	100 (90)
T_{13}	Bifenthrin 10 EC	0.5	86.00 (68.03) bc	100 (90)	100 (90)	100 (90)
T_{14}	Dichlorvos 76 EC	1.0	90.01 (71.58) a	100 (90)	100 (90)	100 (90)
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	76.51 (61.01) g	100 (90)	100 (90)	100 (90)
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	78.57 (62.37) fg	100 (90)	100 (90)	100 (90)
T_{17}	Mealykill	10.00	78.54 (62.37) fg	100 (90)	100 (90)	100 (90)
T_{18}	Neemazal 15000 ppm	5.00	70.00 (56.78) h	100 (90)	100 (90)	100 (90)
T_{19}	Pongamia oil + tween 80	10% + 0.5	69.51 (56.48) h	100 (90)	100 (90)	100 (90)
T_{20}	Cotton seed oil + tween 80	10% + 0.5	70.00 (56.78) h	100 (90)	100 (90)	100 (90)
T_{21}	Sunflower oil + tween 80	10% + 0.5	75.51 (60.33) g	100 (90)	100 (90)	100 (90)
T_{22}	Fish oil rosin soap	5.00	80.51 (63.83) ef	100 (90)	100 (90)	100 (90)
T_{23}	Arka suraksha (IIHR Product)	15.00	80.51 (63.83) ef	100 (90)	100 (90)	100 (90)
T_{24}	Arka rakshak (IIHR Product)	15.00	81.00 (64.16) d-f	100 (90)	100 (90)	100 (90)
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.07	0.00	0.00	0.00
		CD (p=0.01)	4.23	0.00	0.00	0.00

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table.2 Laboratory evaluation of different insecticides and biorationals without FORS against first instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	3 DAS	5 DAS	7 DAS
T_1	Buprofezin 25 SC	1.25	90.50 (72.10) a	100 (90)	100 (90)	100 (90)
T_2	Thiamethoxam25 WG	0.3	80.50 (63.81) b-d	100 (90)	100 (90)	100 (90)
T_3	Acetamiprid 20 SP	0.2	84.00 (66.46) bc	100 (90)	100 (90)	100 (90)
T_4	Imidacloprid 17.8 SL	0.3	84.50 (66.81) b	100 (90)	100 (90)	100 (90)
T_5	Dimethoate 30 EC	1.7	84.00 (66.46) bc	100 (90)	100 (90)	100 (90)
T_6	Chlorpyriphos 20 EC	2.0	90.50 (72.10) a	100 (90)	100 (90)	100 (90)
T_7	Acephate 75 SP	1.0	89.50 (71.13) a	100 (90)	100 (90)	100 (90)
T_8	Deltamethrin 2.8 EC	0.5	81.00 (64.15) b-d	100 (90)	100 (90)	100 (90)
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	80.00 (63.44) b-d	100 (90)	100 (90)	100 (90)
T_{10}	Lambda-cyhalothrin 5 EC	0.5	90.50 (72.05) a	100 (90)	100 (90)	100 (90)
T_{11}	Methomyl 40 SP	0.3	84.50 (66.81) b	100 (90)	100 (90)	100 (90)
T_{12}	Profenophos 50 EC	2.0	90.50 (72.10) a	100 (90)	100 (90)	100 (90)
T_{13}	Bifenthrin 10 EC	0.5	80.50 (63.81) b-d	100 (90)	100 (90)	100 (90)
T_{14}	Dichlorvos 76 EC	1.0	90.00 (71.58) a	100 (90)	100 (90)	100 (90)
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	77.50 (61.68) d	100 (90)	100 (90)	100 (90)
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	79.00 (62.72) d	100 (90)	100 (90)	100 (90)
T_{17}	Mealykill	10.00	78.50 (62.37) d	100 (90)	100 (90)	100 (90)
T_{18}	Neemazal 15000 ppm	5.00	80.00 (63.44) b-d	100 (90)	100 (90)	100 (90)
T_{19}	Pongamia oil + tween 80	10% + 0.5	79.50 (63.08) cd	100 (90)	100 (90)	100 (90)
T_{20}	Cotton seed oil + tween 80	10% + 0.5	70.00 (56.78) e	100 (90)	100 (90)	100 (90)
T_{21}	Sunflower oil + tween 80	10% + 0.5	72.50 (58.37) e	100 (90)	100 (90)	100 (90)
T_{22}	Fish oil rosin soap	5.00	70.00 (56.78) e	100 (90)	100 (90)	100 (90)
T_{23}	Arka suraksha (IIHR Product)	15.00	80.50 (63.81) b-d	100 (90)	100 (90)	100 (90)
T_{24}	Arka rakshak (IIHR Product)	15.00	81.00 (64.16) b-d	100 (90)	100 (90)	100 (90)
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.26	0.00	0.00	0.00
		CD (p=0.01)	4.96	0.00	0.00	0.00

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table.3 Laboratory evaluation of different insecticides and biorationals with FORS against second instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	3 DAS	5 DAS	7 DAS
T_1	Buprofezin 25 SC	1.25	56.51 (48.73) a	64.51 (53.53) a	81.00 (64.15) b	99.00 (84.26) a
T_2	Thiamethoxam25 WG	0.3	35.00 (36.27) de	40.00 (39.20) d-g	49.50 (44.71) c	51.00 (45.57) c-e
T_3	Acetamiprid 20 SP	0.2	35.00 (36.26) de	41.51 (40.08) d-f	49.00 (44.42) c	51.50 (45.85) c-e
T_4	Imidacloprid 17.8 SL	0.3	41.50 (40.10) bc	46.00 (42.69) b-e	54.00 (47.29) c	57.50 (49.31) c
T_5	Dimethoate 30 EC	1.7	37.51 (37.76) c-e	43.00 (40.94) c-e	50.50 (45.28) c	53.00 (46.72) c-e
T_6	Chlorpyriphos 20 EC	2.0	41.51 (40.58) b	57.10 (49.04) a-d	85.00 (67.31) ab	96.50 (79.24) b
T_7	Acephate 75 SP	1.0	41.51 (40.58) b	60.00 (50.92) a-c	90.00 (71.56) a	94.00 (75.82) b
T_8	Deltamethrin 2.8 EC	0.5	33.51 (35.36) e	37.00 (37.42) e-h	47.00 (43.27) c	50.00 (45.00) de
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	40.00 (39.23) cd	45.00 (42.10) b-e	54.51 (47.58) c	55.50 (48.15) cd
T_{10}	Lambda-cyhalothrin 5 EC	0.5	43.00 (40.94) b	61.00 (51.49) ab	91.00 (72.56) a	94.50 (76.56) b
T_{11}	Methomyl 40 SP	0.3	35.01 (36.25) de	37.00 (37.42) e-h	46.10 (42.70) c	48.00 (43.85) e
T_{12}	Profenophos 50 EC	2.0	36.51 (37.15) c-e	39.50 (38.89) d-g	48.12 (43.85) c	50.00 (45.00) de
T_{13}	Bifenthrin 10 EC	0.5	37.12 (37.46) c-e	39.51 (38.93) d-g	48.00 (43.85) c	49.50 (44.71) de
T_{14}	Dichlorvos 76 EC	1.0	43.00 (40.94) b	60.54 (51.15) ab	88.12 (69.73) ab	94.50 (76.56) b
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	11.51 (19.83) i	15.00 (22.78) i	16.51 (23.97) de	19.00 (25.84) ij
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	16.00 (23.57) gh	18.55 (25.51) i	21.50 (27.62) e	22.50 (30.32) f-h
T_{17}	Mealykill	10.00	19.53 (26.22) fg	21.00 (27.27) hi	26.00 (30.65) e	28.50 (32.26) fg
T_{18}	Neemazal 15000 ppm	5.00	18.14 (25.20) f-h	21.00 (27.27) hi	22.00 (27.97) de	24.00 (29.33) f-i
T_{19}	Pongamia oil + tween 80	10% + 0.5	14.52 (22.39) hi	15.00 (22.78) i	16.50 (23.96) e	17.00 (24.35) j
T_{20}	Cotton seed oil + tween 80	10% + 0.5	16.00 (23.57) gh	17.51 (24.73) i	10.00 (18.40) e	20.50 (26.92) h-j
T_{21}	Sunflower oil + tween 80	10% + 0.5	16.00 (23.57) gh	17.51 (24.73) i	19.50 (26.20) de	22.50 (28.31) g-j
T_{22}	Fish oil rosin soap	5.00	18.55 (25.51) fgh	21.50 (27.62) hi	29.00 (32.58) d	30.00 (33.21) f
T_{23}	Arka suraksha (IIHR Product)	15.00	22.52 (28.33) f	25.51 (30.33) f-i	26.00 (30.65) de	28.50 (32.36) fg
T_{24}	Arka rakshak (IIHR Product)	15.00	20.52 (26.93) f	23.52 (29.01) g-i	26.50 (30.32) de	27.00 (31.30) fg
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.57	2.13	2.04	1.73
		CD (p=0.01)	6.18	6.41	6.05	6.84

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table.4 Laboratory evaluation of different insecticides and biorationals without FORS second instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
T_1	Buprofezin 25 SC	1.25	51.50 (45.85) a	66.00 (54.34) a	86.50 (68.44) a	95.50 (78.91) a
T_2	Thiamethoxam25 WG	0.3	32.50 (34.75) e	40.50 (39.52) cd	46.50 (42.99) c-e	48.00 (43.85) c
T_3	Acetamiprid 20 SP	0.2	32.00 (34.43) e	41.50 (40.09) cd	45.00 (42.12) c-e	49.50 (44.71) c
T_4	Imidacloprid 17.8 SL	0.3	39.00 (38.64) c	44.50 (41.82) bc	51.50 (45.86) c	53.50 (47.01) c
T_5	Dimethoate 30 EC	1.7	35.50 (36.57) c-e	42.50 (40.66) b-d	48.00 (43.85) c-e	52.00 (46.14) c
T_6	Chlorpyriphos 20 EC	2.0	41.50 (40.09) b	55.00 (47.87) ab	78.50 (62.44) b	95.00 (77.14) ab
T_7	Acephate 75 SP	1.0	41.50 (40.09) b	58.00 (49.68) a	80.50 (63.81) b	91.00 (72.56) b
T_8	Deltamethrin 2.8 EC	0.5	31.50 (34.13) e	36.00 (36.84) cd	42.00 (40.39) e	47.50 (43.56) c
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	38.00 (38.05) c	43.50 (41.24) bc	50.00 (45.00) cd	53.00 (46.72) c
T_{10}	Lambda-cyhalothrin 5 EC	0.5	42.50 (40.66) b	59.50 (50.56) a	80.50 (63.81) b	92.50 (74.11) ab
T_{11}	Methomyl 40 SP	0.3	33.00 (35.04) de	36.00 (36.84) cd	41.50 (40.09) e	46.50 (42.99) c
T_{12}	Profenophos 50 EC	2.0	35.00 (36.26) c-e	39.00 (38.61) cd	43.50 (41.26) de	49.00 (44.42) c
T_{13}	Bifenthrin 10 EC	0.5	36.50 (37.16) cd	38.50 (38.34) cd	44.00 (41.55) de	50.50 (45.28) c
T_{14}	Dichlorvos 76 EC	1.0	48.50 (44.14) ab	58.50 (49.89) a	80.50 (63.81) b	93.50 (75.23) ab
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	18.00 (25.10) gh	22.00 (27.97) ef	25.50 (28.93) g-i	27.00 (31.30) df
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	15.00 (22.78) ij	19.50 (26.20) ef	22.50 (28.39) g-i	24.00 (29.33) e-g
T_{17}	Mealykill	10.00	19.00 (25.84) g	20.00 (26.56) ef	23.50 (28.99) g-i	28.00 (31.94) de
T_{18}	Neemazal 15000 ppm	5.00	27.00 (31.30) f	30.00 (33.21) de	31.50 (34.14) f	32.50 (34.75) d
T_{19}	Pongamia oil + tween 80	10% + 0.5	12.50 (20.70) j-l	14.00 (21.97) f	16.00 (23.58) jk	19.00 (25.84) gh
T_{20}	Cotton seed oil + tween 80	10% + 0.5	14.00 (21.97) i-k	15.50 (23.18) f	18.50 (25.47) h-j	19.50 (26.26) f-h
T_{21}	Sunflower oil + tween 80	10% + 0.5	10.50 (18.90) l	12.00 (20.26) f	13.00 (21.13) k	14.00 (21.97) h
T_{22}	Fish oil rosin soap	5.00	12.00 (20.26) kl	15.50 (22.78) f	18.00 (25.10) ij	22.50 (28.31) e-g
T_{23}	Arka suraksha (IIHR Product)	15.00	15.50 (23.18) hi	18.50 (25.47) f	24.00 (29.33) gh	26.00 (30.65) d-g
T_{24}	Arka rakshak (IIHR Product)	15.00	19.50 (26.20) g	22.00 (27.97) ef	27.00 (31.30) fg	29.00 (32.58) de
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.19	2.90	1.98	2.04
		CD (p=0.01)	4.68	4.37	4.39	4.03

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table.5 Laboratory evaluation of different insecticides and biorationals with FORS against third instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
T_1	Buprofezin 25 SC	1.25	44.50 (41.84) a	59.50 (50.47) b	82.50 (65.27) ab	92.50 (74.10) a
T_2	Thiamethoxam25 WG	0.3	25.00 (30.00) c	31.50 (34.14) d	35.50 (36.57) e	43.00 (40.97) fg
T_3	Acetamiprid 20 SP	0.2	25.00 (30.00) c	31.50 (34.14) d	35.00 (36.27) e	40.50 (39.52) gh
T_4	Imidacloprid 17.8 SL	0.3	25.00 (30.00) c	33.50 (35.36) d	37.50 (37.75) e	43.00 (40.97) fg
T_5	Dimethoate 30 EC	1.7	30.00 (33.19) bc	35.50 (36.57) d	39.50 (38.93) e	43.00 (40.97) fg
T_6	Chlorpyriphos 20 EC	2.0	47.00 (43.27) a	59.50 (50.47) b	81.00 (64.15) b	85.50 (67.61) d
T_7	Acephate 75 SP	1.0	50.50 (45.28) a	59.50 (50.47) b	81.00 (64.15) b	88.00 (69.73) bc
T_8	Deltamethrin 2.8 EC	0.5	28.50 (32.26) bc	35.00 (36.27) d	39.50 (38.93) e	44.50 (41.84) f
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	34.00 (35.65) b	41.50 (40.10) c	45.00 (42.13) cd	47.50 (43.56) e
T_{10}	Lambda-cyhalothrin 5 EC	0.5	50.00 (45.00) a	75.00 (60.07) ab	86.00 (68.02) a	89.00 (70.63) b
T_{11}	Methomyl 40 SP	0.3	25.50 (30.32) c	31.50 (34.14) dc	36.00 (36.86) e	43.00 (40.97) fg
T_{12}	Profenophos 50 EC	2.0	34.00 (35.65) b	44.00 (41.55) c	47.00 (43.27) c	50.00 (45.00) e
T_{13}	Bifenthrin 10 EC	0.5	30.00 (33.19) bc	34.00 (35.65) d	40.00 (39.23) de	43.50 (41.26) fg
T_{14}	Dichlorvos 76 EC	1.0	50.00 (45.00) a	77.50 (61.69) a	81.00 (64.15) b	86.00 (68.02) cd
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	10.50 (18.90) e	12.50 (20.70) f-h	13.50 (21.55) hi	15.50 (23.18) kl
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	10.00 (18.43) e	14.50 (22.38) e-g	15.50 (23.18) f-h	16.00 (23.57) kl
T_{17}	Mealykill	10.00	10.00 (18.43) e	15.50 (23.18) ef	16.00 (23.57) f-h	17.50 (24.72) k
T_{18}	Neemazal 15000 ppm	5.00	15.50 (23.18) d	17.50 (24.72) e	18.00 (25.10) fg	20.50 (26.92) i
T_{19}	Pongamia oil + tween 80	10% + 0.5	10.00 (18.43) e	10.50 (18.90) hi	11.50 (19.82) i	12.50 (20.70) m
T_{20}	Cotton seed oil + tween 80	10% + 0.5	9.00 (17.45) e	10.50 (18.90) i	11.00 (19.36) i	12.50 (20.70) m
T_{21}	Sunflower oil + tween 80	10% + 0.5	8.00 (16.42) e	9.00 (17.45) i	10.50 (18.90) i	11.00 (19.36) m
T_{22}	Fish oil rosin soap	5.00	11.50 (19.82) de	12.00 (20.26) gh	14.00 (21.97) g-i	15.00 (22.78) l
T_{23}	Arka suraksha (IIHR Product)	15.00	10.00 (18.43) e	15.00 (22.78) e-g	18.00 (25.10) fg	23.00 (28.65) i
T_{24}	Arka rakshak (IIHR Product)	15.00	10.50 (18.90) e	16.50 (23.96) e	19.50 (26.20) f	25.50 (30.32) i
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.73	1.30	0.95	0.99
		CD (p=0.01)	5.60	5.11	3.76	3.92

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table.6 Laboratory evaluation of different insecticides and biorationals without FORS against third instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
T_1	Buprofezin 25 SC	1.25	43.00 (40.97) a	59.50 (50.47) d	79.00 (62.72) a	88.50 (70.18) a
T_2	Thiamethoxam25 WG	0.3	23.50 (28.98) c-f	30.50 (33.51) fg	34.50 (35.96) ef	35.50 (36.57) eh
T_3	Acetamiprid 20 SP	0.2	25.50 (30.30) c-e	30.00 (33.20) g	33.50 (35.36) f	39.50 (38.93) fg
T_4	Imidacloprid 17.8 SL	0.3	25.50 (30.32) c-e	34.00 (35.66) fg	36.00 (36.86) ef	42.50 (40.68) ef
T_5	Dimethoate 30 EC	1.7	29.50 (32.87) bc	34.50 (35.96) f	38.00 (38.05) ef	42.00 (40.39) ef
T_6	Chlorpyriphos 20 EC	2.0	45.00 (42.12) a	64.50 (53.42) bc	64.50 (53.42) b	86.50 (68.44) ab
T_7	Acephate 75 SP	1.0	47.50 (43.56) a	63.00 (52.53) cd	64.50 (53.42) b	73.00 (58.69) c
T_8	Deltamethrin 2.8 EC	0.5	28.00 (31.94) b-d	32.50 (34.75) fg	37.50 (37.75) ef	42.00 (40.39) ef
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	33.50 (35.31) b	39.00 (38.64) e	43.50 (41.26) cd	46.00 (42.70) de
T_{10}	Lambda-cyhalothrin 5 EC	0.5	48.00 (43.85) a	67.50 (55.24) ab	70.00 (56.79) b	86.00 (68.03) ab
T_{11}	Methomyl 40 SP	0.3	24.50 (29.66) c-f	31.00 (33.83) fg	35.50 (36.57) ef	40.00 (39.23) f
T_{12}	Profenophos 50 EC	2.0	33.00 (35.04) b	40.50 (39.52) e	45.50 (42.41) c	49.00 (44.42) d
T_{13}	Bifenthrin 10 EC	0.5	29.50 (32.87) bc	33.00 (35.04) fg	39.50 (38.93) de	42.50 (40.68) ef
T_{14}	Dichlorvos 76 EC	1.0	48.00 (43.85) a	70.50 (57.10) a	78.50 (62.37) a	81.00 (64.15) b
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	20.00 (26.56) e-g	20.50 (26.92) i	22.00 (27.97) hi	24.50 (29.66) jk
T_{16}	*Manisopliae* WP + tween 80	2 + 0.5	18.50 (25.47) f-h	24.00 (29.33) h	25.50 (30.32) gh	27.00 (31.30) j
T_{17}	Mealykill	10.00	17.00 (24.35) g-i	19.50 (26.20) i	24.50 (29.66) gh	26.00 (30.65) j
T_{18}	Neemazal 15000 ppm	5.00	22.00 (27.97) d-g	25.00 (30.00) h	28.50 (32.26) g	31.50 (34.14) hi
T_{19}	Pongamia oil + tween 80	10% + 0.5	10.50 (18.90) j	12.00 (20.26) j	14.50 (21.97) k	15.00 (22.79) l
T_{20}	Cotton seed oil + tween 80	10% + 0.5	12.50 (20.67) ij	13.50 (21.55) j	15.00 (22.79) k	17.50 (24.72) l
T_{21}	Sunflower oil + tween 80	10% + 0.5	10.00 (18.34) j	12.50 (20.67) j	13.50 (21.13) k	14.50 (22.38) l
T_{22}	Fish oil rosin soap	5.00	11.00 (19.20) j	13.00 (21.12) j	16.00 (23.57) jk	17.50 (24.72) l
T_{23}	Arka suraksha (IIHR Product)	15.00	14.50 (22.30) h-j	18.50 (25.47) i	19.50 (26.20) ij	22.00 (27.97) k
T_{24}	Arka rakshak (IIHR Product)	15.00	14.50 (22.30) h-j	19.50 (26.20) I	23.00 (28.65) hi	25.50 (32.26) ij
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.90	1.19	1.48	1.25
		CD (p=0.01)	4.49	4.70	5.83	4.94

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table.7 Laboratory evaluation of different insecticides and biorationals with FORS against fourth instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
T_1	Buprofezin 25 SC	1.25	41.50 (40.10) bc	67.50 (55.24) a	82.00 (64.89) a	85.00 (67.21) bc
T_2	Thiamethoxam25 WG	0.3	21.50 (27.62) e-g	24.50 (29.66) de	27.50 (31.62) de	30.00 (33.21) e-g
T_3	Acetamiprid 20 SP	0.2	19.00 (25.83) g	19.50 (26.18) g	23.50 (28.98) ef	28.50 (32.25) fg
T_4	Imidacloprid 17.8 SL	0.3	18.50 (25.47) g	20.00 (26.56) g	22.50 (28.31) f	25.50 (30.32) g
T_5	Dimethoate 30 EC	1.7	20.50 (26.91) fg	21.50 (27.62) fg	23.00 (28.65) f	27.50 (31.62) fg
T_6	Chlorpyriphos 20 EC	2.0	43.00 (40.97) bc	57.50 (49.31) b	73.50 (59.01) b	82.00 (64.89) c
T_7	Acephate 75 SP	1.0	45.00 (42.12) ab	66.50 (54.63) ab	73.50 (59.01) b	86.00 (68.02) a
T_8	Deltamethrin 2.8 EC	0.5	21.00 (27.27) fg	22.50 (28.31) ef	27.50 (31.62) de	30.50 (33.52) cf
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	20.00 (26.55) fg	22.50 (28.31) ef	30.00 (33.21) cd	33.50 (35.36) e
T_{10}	Lambda-cyhalothrin 5 EC	0.5	30.00 (33.20) d	31.50 (34.13) c	32.50 (34.74) c	38.00 (38.05) d
T_{11}	Methomyl 40 SP	0.3	25.50 (30.32) e	29.50 (32.89) c	31.50 (34.14) cd	39.50 (38.93) d
T_{12}	Profenophos 50 EC	2.0	40.00 (39.23) c	57.50 (49.31) b	75.00 (60.00) b	86.00 (68.02) a
T_{13}	Bifenthrin 10 EC	0.5	24.00 (29.32) cf	25.50 (30.32) d	30.00 (33.20) cd	33.50 (35.36) e
T_{14}	Dichlorvos 76 EC	1.0	48.00 (43.85) a	69.00 (56.17) a	75.00 (60.00) b	82.00 (64.89) c
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	9.50 (17.95) h	10.00 (18.43) jk	11.25 (19.59) h-j	12.00 (20.26) j
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	10.50 (18.90) h	12.00 (20.26) hi	13.00 (21.13) g-i	15.50 (22.78) ij
T_{17}	Mealykill	10.00	9.50 (17.95) h	12.50 (20.70) h	15.50 (23.18) g	17.00 (24.35) hi
T_{18}	Neemazal 15000 ppm	5.00	6.00 (14.17) i	10.50 (18.90) ij	12.50 (20.70) g-i	14.50 (22.38) ij
T_{19}	Pongamia oil + tween 80	10% + 0.5	6.50 (14.77) i	8.50 (16.95) k	9.00 (17.45) j	20.50 (26.92) h
T_{20}	Cotton seed oil + tween 80	10% + 0.5	9.50 (17.95) h	10.00 (18.43) jk	12.50 (20.70) g-i	15.50 (23.18) ij
T_{21}	Sunflower oil + tween 80	10% + 0.5	9.00 (17.45) h	10.00 (18.43) jk	10.50 (18.90) ij	12.00 (20.26) j
T_{22}	Fish oil rosin soap	5.00	10.00 (18.43) h	12.50 (20.70) h	14.50 (22.38) gh	15.00 (22.79) ij
T_{23}	Arka suraksha (IIHR Product)	15.00	10.00 (18.43) h	13.50 (21.55) h	25.50 (30.32) ef	17.50 (24.72) hi
T_{24}	Arka rakshak (IIHR Product)	15.00	10.50 (18.90) h	13.00 (21.13) h	14.00 (21.97) gh	16.00 (25.10) hi
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.11	0.78	1.21	1.17
		CD (p=0.01)	4.37	3.08	4.76	4.01

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05

Table.8 Laboratory evaluation of different insecticides and biorationals without FORS against fourth instar scale, *H. imbricans* (Pooled)

Tr. No.	Treatments	Dosage (g/ml/l)	Per cent mortality			
			1 DAS	**3 DAS**	**5 DAS**	**7 DAS**
T_1	Buprofezin 25 SC	1.25	35.50 (36.57) a	50.50 (45.28) a	71.50 (57.77) a	82.00 (64.92) b
T_2	Thiamethoxam25 WG	0.3	20.00 (26.56) ef	23.00 (28.65) cd	25.50 (30.32) c-e	27.50 (31.62) d-f
T_3	Acetamiprid 20 SP	0.2	18.00 (25.09) f-h	19.00 (25.84) de	22.00 (27.97) e-g	27.50 (31.60) d-f
T_4	Imidacloprid 17.8 SL	0.3	18.00 (25.10) f-h	19.00 (25.83) de	21.00 (27.26) e-g	25.00 (30.00) e-h
T_5	Dimethoate 30 EC	1.7	20.00 (26.56) ef	21.50 (27.62) cd	24.00 (29.33) d-f	26.50 (30.98) d-f
T_6	Chlorpyriphos 20 EC	2.0	32.50 (34.75) ab	50.50 (45.28) a	68.50 (55.86) a	87.00 (68.92) a
T_7	Acephate 75 SP	1.0	30.50 (33.52) a-c	48.50 (44.14) a	68.50 (55.86) a	85.50 (67.64) ab
T_8	Deltamethrin 2.8 EC	0.5	19.50 (26.20) ef	21.00 (27.25) cd	26.50 (30.95) b-e	29.00 (32.56) de
T_9	Buprofezin 5.65 SC + Deltamethrin 0.72 EC	2.5	19.00 (25.84) e-g	21.00 (27.26) cd	29.00 (32.57) b-d	32.50 (34.75) cd
T_{10}	Lambda-cyhalothrin 5 EC	0.5	28.00 (31.91) b-d	29.00 (32.58) b	32.00 (34.44) b	36.50 (37.16) c
T_{11}	Methomyl 40 SP	0.3	24.50 (29.66) c-e	28.50 (32.25) b	30.50 (33.52) bc	38.00 (38.05) c
T_{12}	Profenophos 50 EC	2.0	32.00 (34.44) ab	46.00 (42.70) a	69.00 (56.17) a	85.50 (67.64) ab
T_{13}	Bifenthrin 10 EC	0.5	22.50 (28.28) d-f	25.00 (30.00) bc	29.00 (32.56) b-d	32.50 (34.74) cd
T_{14}	Dichlorvos 76 EC	1.0	34.50 (35.96) ab	49.50 (44.71) a	69.50 (56.48) a	82.00 (64.92) b
T_{15}	*Lecanicillium lecani* WP + tween 80	2 + 0.5	14.00 (21.92) g-i	16.50 (23.96) ef	18.00 (25.09) gh	22.00 (27.97) f-i
T_{16}	*M. anisopliae* WP + tween 80	2 + 0.5	12.50 (20.61) i	14.00 (21.97) fg	18.50 (25.45) f-h	19.00 (25.84) i-k
T_{17}	Mealykill	10.00	14.00 (21.97) g-i	16.50 (23.97) ef	19.50 (26.20) f-h	20.50 (26.92) g-i
T_{18}	Neemazal 15000 ppm	5.00	10.00 (18.43) i	13.50 (21.55) fg	15.00 (22.79) hi	17.50 (24.72) i-k
T_{19}	Pongamia oil + tween 80	10% + 0.5	9.00 (21.12) hi	12.00 (20.26) g	15.00 (22.79) hi	17.00 (24.35) i-k
T_{20}	Cotton seed oil + tween 80	10% + 0.5	10.00 (18.43) i	12.50 (20.70) g	13.00 (21.13) i	14.50 (22.38) k
T_{21}	Sunflower oil + tween 80	10% + 0.5	9.50 (17.95) i	11.50 (19.82) g	13.00 (21.13) i	15.00 (22.78) jk
T_{22}	Fish oil rosin soap	5.00	11.50 (19.60) i	12.00 (20.26) g	13.00 (21.13) i	15.50 (30.32) e-g
T_{23}	Arka suraksha (IIHR Product)	15.00	12.50 (20.61) i	13.50 (21.55) fg	17.00 (24.35) g-i	19.50 (26.20) ij
T_{24}	Arka rakshak (IIHR Product)	15.00	12.00 (20.26) i	14.50 (22.38) fg	19.00 (25.84) f-h	20.00 (26.56) h-j
T_{25}	Untreated control	-	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)	0.00 (0.29)
		S.Em±	1.60	1.51	1.73	1.68
		CD (p=0.01)	5.29	4.97	5.84	4.02

DAS – Day after spray Figures in the parentheses are arc sine transformed values

Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

However, Chlorpyriphos 20 EC @ 2 ml/l found superior among the various treatments by recording 87.00 per cent mortality and was on par with, acephate 75 SP @ 1 g/l and profenophos 50 EC @ 2 ml/l. The next best treatments were buprofezin 25 SC @ 1.25 ml/l, dichlorvos 76 EC @ 1 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l. Least mortality (14.50%) was recorded in cotton oil + tween 80 treatment (Table 8).

Irrespective of treatments whether imposed with or without FORS similar effects were produced with respect to mortality percentage of scales with light variation for third and fourth instars. With respect to instar susceptibility, the first instars (crawlers) of *H. imbricans* were most susceptible compared to second, third and fourth instars under laboratory condition.

Among 25 insecticides and biorationals used for the management of different stages of *H. imbricans* with and without FORS (5 ml/l) insecticides *viz.*, buprofezin 25 SC @ 1.25 ml/l, chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l recorded significantly higher mortality under laboratory conditions. Irrespective of whether imposed with or without FORS effects were similar with slight variation in mortality.

Among the various instars, the first instars (crawlers) and second instars had more mortality to all treatments compared to third and fourth instars. For first instar crawlers pertained significant reduction to all imposed treatments except in untreated control. This clearly indicated that crawlers were most susceptible to all imposed treatments because of their delicate, non mealy/waxy body enabling the insecticides to come in direct contact with the insect.

Hussian *et al.*, (2012) from Pakistan evaluated the different insecticides concentrations on mango mealybug, *Drosicha mangiferae* under laboratory conditions. Profenofos @ 240µl/30ml showed maximum per cent mortality of 93.3 and 86.6 per cent for first and second instar which is in full confirmation with present finding with respect to profenophos. While trizophos @ 1500µl/30 ml proved to be an effective insecticide for the control of fourth instar recording 64.0 and 100 per cent mortality in leaf dip method and foliar application.

Kwaiz (1999) recorded that the pre adult stages of *Klifia acuminata* were highly susceptible to profenofos followed by diazinon, chlorpyrifos-methyl, malathion, KZ and Shekrona oils compared with the adult stage. However, the efficacy of these insecticides is established the present study against all the instars of scale insect.

Present findings are also in line with Bazrafshan *et al.*, (2010) who reported that methoxyfenozide had the least toxic effect (LC_{90} = 30954.77 ppm) and chlorpyrifos had highest toxic effect (LC_{90} = 11636.94 ppm) to the white peach scale, *Pseudaulacaspis pentagona* Targioni in adult stage. Based on the estimated LC_{90}, the toxicities of all insecticides tested was rated in following order chlorpyrifos> diazinon> azinphosmethyl> mineral oil> spinosad> methoxyfenozide as being reported in the present study with respect to chlorpyrifos against *H. imbricans*.

In the present study, Neemazal 15000 ppm, Pongamia oil (10%), Cotton seed oil (10%) and Sunflower oil (10%) were least effective against *H. imbricans* except for first instars. The present findings slightly deviated from the report of Hussian (1996) who reported Neem and pongamia oils at 4 per cent gave good control of various species of scales

(*Orthezia insignis* Browne on crossandra and *Chloropulvinaria psidii* Sulz. on mango). Pongamia (4%) and neem oil (2% and 4%) were found to be highly effective against the red scale on citrus (Anon., 1987). This deviation may be due to difference in scale species studied and morphology of *H.imbricans* in that the scale is hard like a pebble and does not allow the oils to penetrate reducing the efficacy of biorationals used in the present study.

Dhingra (1990) tested insecticidal sprays against mango mealybug, *Drosicha mangiferae* (Green) in the laboratory and found that lindane and malathion were ineffective. But, the LC 50 values for lambda cyhalothrin, alphamethrin, decamethrin, methyl parathion, fenvelerate, monocrotophos and endosulfan were 0.0196, 0.0209, 0.0292, 0.0385, 0.0454, 0.2357 and 0.9303 per cent respectively. These results are in close agreement with present findings with respect to lambda cyhalothrin which was very effective against all four instars of *H.imbricans*.

The systemic insecticide monocrotophos 36 SL @ 0.08 per cent excelled over all other chemicals in managing the *P. nigra* by recording 84.04 per cent mortality, which was then followed by fenvalerate 0.02 per cent (83.45), cypermethrin 0.02 per cent (79.50), phosphamidon 0.08 per cent (79.29), dimethoate 0.08 per cent (77.93), quinalphos 0.08 per cent (76.95), phenthoate 0.08 per cent (75.00), malathion 0.1 per cent (72.30) and chlorpyriphos 0.08 per cent (69.53) (Ghule and Dhumal, 1992). These results are in line with present report with respect to efficacy of dimethoate and chlorpyriphos though species of scale insect studied is different.

Abamectin and teflubenzuron (IGR) significantly reduced the populations of *S. oleae* compared to carbaryl (Sevin 80% WP) (Lampson and Morse, 1992). This confirms the present study with respect to effect of buprofezin. Further, Insect growth regulator (IGR) Insegar (fenoxycarb 25%) @ 7.5 g/lit gave better control of *Saissetia oleae* (Anna and Leonardi 1990) which is also in line with the present study with respect to IGR used.

Imidacloprid 17.8 per cent SL (Confidor 200 SL) at 0.01, 0.05 and 0.1 per cent a.i. on *Saissetia coffeae* was found effective even at 30 days after application (Irulandi *et al.*, 2000). However, in the present study imidacloprid was less effective which may be due to change of morphology of scale species.

Dewer *et al.* (2012) observed that the two compounds mixtures Star oil + Admiral and Star oil + Nimbecidine were the most effective treatments against purple scale insect, *Lepidosaphes beckii* throughout the experiment period. Whereas the reduction percentage for Star oil + Admiral was 99.50% the reduction percentage for Star oil + Nimbecidine was 99.34%, respectively. However, in the present study most of the biorationals used could not kill the different instars of *H. imbricans* which might be the incapability of these biorationals to penetrate the hard waxy/mealy cover.

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