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Field evaluation of new insecticides against, scale insect, *Hemilecanium imbricans* (Coccidae: Homoptera) on mango

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Abstract
The field experiment was conducted during 2013-14 and 2014-15 seasons in Navalur village in Dharwad district in Karnataka, India to know the effective chemical molecules for managing the scale insects. Among insecticides and biorationals tested, 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 the effective insecticides in chronologically in controlling all stages of scale insects under field conditions. But the usage of FORS @ 5 ml/l helped in dissolving the mealy wax coating of scale insects especially second instar onwards enabling effective penetration of the insecticides. Among the various instars, the first instars (crawlers) and second instars had more mortality to all treatments (139.38 per 20 cm length twig in acephate 75 SP @ 1 g/l and 163.25 and 163.88 second instar scales was recorded in dichlorvos 76 EC @ 1 ml/l and profenophos 50 EC @ 2 ml/l.) compared to third and fourth instars. 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.

Keywords: Scale insect, *Hemilecanium*, insecticides, instar, spray etc.

1. 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 parasitiod 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 [1]. 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. Scale insects become serious pests of mango following non-judicious use of insecticides against fruit flies. Again, the severity of scale insects on mango depends upon season, weather factors such as temperature, relative humidity and rainfall etc [2]. Most scale insects are parasites of plants, feeding on sap drawn directly from the plant's vascular system. Scale insects feed on a wide variety of plants, though particular species commonly are specific to particular host plants or plant groups. Scale insects are serious plant pests and because they are small and cryptic, they frequently are not detected until they have caused significant damage.

1.1 Objective of study: to know the effective chemical molecules for managing the Scale insect, *Hemilecanium imbricans* on manago.

2. Material and Methods

2.1 Study Area: This field experiment was conducted during 2013-14 and 2014-15 seasons in Randomized Block Design (RBD) with five treatments and four replications in well established twenty year old mango orchard located at Navalur village in Dharwad district in Karnataka, India.

The experiment was conducted on scale infested mango twigs of Alphanso variety planted at a spacing of 10 x 10 m. All the horticultural practices were followed as per the package of practices for higher yield except plant protection schedule. Based on lab evaluation the highly effective chemical insecticides *viz.*, buprofezin 25 SC @ 1.25 ml/l, chlorpyriphos 20 EC @ 2 ml/l, profenophos 50 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 were selected for bioefficacy under field condition. The spraying was taken with the help foot sprayer at peak incidence of *H. imbricans* on mango tree. The foot spray pump was washed with water thoroughly well before changing the chemical insecticides. Mortality was recorded immediately after spray. Post treatment observations were recorded at one, three, five, seven and ten days after application. With the help of hand lens (10X) the observation on shrinkage, shrivelling, and number of dead scales was recorded and the corrected mortality percentage was worked out.

2.2 Statistical Analysis

Statistical analysis was done by SPSS. Results were expressed as (√x+0.5) transformed values with DMRT (Duncan's Multiple Range Test).

3. Results

Based on the laboratory results the top six effective insecticides were imposed with FORS (5 ml/l) in the field to study the efficacy against different instars and the results are presented in Table 1-5.

3.1 First Instar

Observation on the mean population a day before spraying revealed that all the treatments including untreated check had population ranging from 375.38 to 400.13 per 20 cm length twig and was statistically non-significant indicating uniform distribution of the crawlers in the experimental area. One day after spraying all the insecticides reduced the incidence. Significantly lowest population of 139.38 was recorded in acephate 75 SP @ 1 g/l and was on par with lambda-cyhalothrin 5 EC @ 0.5 ml/l and profenophos 50 EC @ 2 ml/l with population of 140.88 and 150.00 respectively. However, chlorpyriphos 20 EC @ 2 ml/l was the next best recording 152.13 scales per 20 cm length twig whereas, the highest population was recorded in untreated control (419.00 crawlers per 20 cm length twig).

Two day after spraying, significantly lower population of 52.38 per 20 cm length twig was recorded in buprofezin 25 SC @ 1.25 ml/l which did not differ with lambda-cyhalothrin 5 EC @ 0.5 ml/l, dichlorvos 76 EC @ 1 ml/l and acephate 75 SP @ 1 g/l. This was followed by chlorpyriphos 20 EC @ 2 ml/l that recorded 62.50 first instar crawlers per 20 cm length twig. Highest population was recorded in untreated control (413.13 crawlers).

Three day after spraying, significantly the lowest population (3.06 crawlers) was recorded in lambda-cyhalothrin 5 EC @ 0.5 ml/l and was on par with all the treatments except untreated check. Whereas, the highest population was recorded in untreated control (405.00 first instar crawlers). Five days after treatment, all treatments imposed were equally effective recording all most nil population. However, untreated control had 410.00 first instar crawlers.

3.2 Second Instar

Observation on the mean population of scale insects, a day before spraying revealed that all the treatments including untreated check had scale insect population ranging from 315 to 331 scale insects per 20 cm length twig and was statistically non-significant indicating uniform distribution of scale insects in the experimental area.

One day after spraying, significantly lower population of 163.25 and 163.88 second instar scales was recorded in dichlorvos 76 EC @ 1 ml/l and profenophos 50 EC @ 2 ml/l. Chlorpyriphos 20 EC @ 2 ml/l, acephate 75 SP @ 1 g/l, buprofezin 25 SC @ 1.25 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l were the next best treatments with population of 176.75, 187.38, 188.13 and 192.38 respectively whereas, the highest population was recorded in untreated control (327.50).

Three days after spraying, significantly lower population of 54.50 scales was recorded in dichlorvos 76 EC @ 1 ml/l. The next best treatments were profenophos 50 EC @ 2 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l and acephate 75 SP @ 1 g/l registering 62.50, 62.00 and 65.00 scales respectively. Highest population was recorded in untreated control (319.00).

All treatments recorded significantly lower population recorded five days after treatment and ranged from 9.63 to 13.25 scales and were on par with each other. The highest population was recorded in untreated control (327.63). Similar to five days seven days after treatment all the treatments effected least population by exercising similar effects. The population ranged from 0.50 to 1.25. The highest population was recorded in untreated control (330.63).

3.3 Third Instar

One day after spraying, significantly lower population of 305.63 scales was recorded in lambda-cyhalothrin 5 EC @ 0.5 ml/l which was on par with acephate 75 SP @ 1 g/l and buprofezin 25 SC @ 1.25 ml/l and profenophos 50 EC @ 2 ml/l. This was followed by chlorpyriphos 20 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l recording 353.88 and 356.88 scales respectively whereas, the highest population was recorded in untreated control (402.00).

Three days after spraying, significantly lower population of 202.63 scales was recorded in lambda-cyhalothrin 5 EC @ 0.5 ml/l and was on par with profenophos 50 EC @ 2 ml/l chlorpyriphos 20 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l. Acephate 75 SP @ 1 g/l and buprofezin 25 SC @ 1.25 ml/l were the next best treatments with population of 230.25 and 235.38 respectively. Highest population was recorded in untreated control (410.75 scales).

Five days after treatment, all the treatments effected lower population producing similar effect between each other. However, untreated control had 415.50 scales.

Seven days after treatment, the population ranged from 47.75 to 62.13 20 cm length twig. Seven days after spraying, significantly lower population of 47.75 was recorded in dichlorvos 76 EC @ 1 ml/l and was on par with profenophos 50 EC @ 2 ml/l and buprofezin 25 SC @ 1.25 ml/l. Lambda-cyhalothrin 5 EC @ 0.5 ml/l, acephate 75 SP @ 1 g/l and chlorpyriphos 20 EC @ 2 ml/l treatments recorded 58.38, 59.00 and 62.13 scales respectively. However, untreated control had 409.25 scales.

Ten days after treatment, the population ranged from 8.25 to

15.13 per 20 cm length twig. Significantly lower population of 8.38 was recorded in dichlorvos 76 EC @ 1 ml/l, which was on par with acephate 75 SP @ 1 g/l, lambda-cyhalothrin 5 EC @ 0.5 ml/l and chlorpyriphos 20 EC @ 2 ml/l. These were followed by buprofezin 25 SC @ 1.25 ml/l and profenophos 50 EC @ 2 ml/l that recorded 13.38 and 15.13 scales respectively. The highest population was recorded in untreated control (420.25 scales).

3.4 Fourth instar

Observation on the mean population of scale insects, a day before spraying revealed that all the treatments including untreated check had scale population ranging from 324.75 to 339.13 and was statistically non-significant ensuring uniform distribution of scales in the experimental area.

One day after spraying, significantly lower population of 223.13 scales was recorded in chlorpyriphos 20 EC @ 2 ml/l treatment and was on par with all other treatments whereas, the highest population was recorded in untreated (Control 324.50 scales).

Three days after spraying, significantly lower population of 122.38 scales was recorded in lambda-cyhalothrin 5 EC @ 0.5 ml/l treatment which was on par with acephate 75 SP @ 1 g/l and buprofezin 25 SC @ 1.25 ml/l. These treatments were followed by chlorpyriphos 20 EC @ 2 ml/l, profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l that recorded 132.50, 134.13 and 140.88 scales respectively. 325.88 scales were recorded in untreated control

Five days after spraying, buprofezin 25 SC @ 1.25 ml/l recorded significantly lower population of 75.38 scales which was on par with 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. However, dichlorvos 76 EC @ 1 ml/l recorded 91.88 scales. 326.00 scales were recorded in untreated control.

Seven days after spraying, significantly lower population of 45.25 scales was recorded in chlorpyriphos 20 EC @ 2 ml/l, producing similar effect with buprofezin 25 SC @ 1.25 ml/l acephate 75 SP and lambda-cyhalothrin 5 EC @ 0.5 ml/l @ 1 g/l. The next best treatments were profenophos 50 EC @ 2 ml/l and dichlorvos 76 EC @ 1 ml/l that recorded 56.88 and 56.63 scales respectively. 330.25 scales were recorded in untreated control.

Ten days after spraying the population ranged from 36.75 to 40.38 scales. Significantly lower population of 36.75 was recorded in chlorpyriphos 20 EC @ 2 ml/l treatment but was on par with dichlorvos 76 EC @ 1 ml/l and buprofezin 25 SC @ 1.25 ml/l. The next best treatments were acephate 75 SP @ 1 g/l, profenophos 50 EC @ 2 ml/l and lambda-cyhalothrin 5 EC @ 0.5 ml/l, by recording 40.38, 40.00 and 40.00 scales respectively. Whereas, population recorded in untreated control was 327.13 scales.

Twelve days after spraying, significantly lower population of 33.00 scales was recorded in dichlorvos 76 EC @ 1 ml/l treatment and was on par with acephate 75 SP @ 1 g/l, chlorpyriphos 20 EC @ 2 ml/l and profenophos 50 EC @ 2 ml/l. The next best treatments were lambda-cyhalothrin 5 EC @ 0.5 ml/l and buprofezin 25 SC @ 1.25 ml/l that recorded 37.25 and 36.88 scales respectively. 330.13 scales were recorded in untreated control.

With respect to instar susceptibility, the first instars (crawlers) of *H. imbricans* more susceptible to all imposed treatments compared to second, third and fourth instars under field condition. Results obtained during 2013-14 and 2014-15 were followed similar trend as that of pooled results.

Table 1: Field evaluation of few insecticides with FORS against first instar *Hemilecanium imbricans* on mango (Pooled)

S. No	Treatments	Insecticides	Dosage (g/ml/l)	Population of scale insects/20 cm twig				
				1 DBS	1DAS	2 DAS	3 DAS	5 DAS
1	T_1	Buprofezin 25 SC	1.25	375.38 (19.38)	164.50 (12.84) d	52.38 (7.27) a	10.00 (3.24) a	0.13 (0.78) a
2	T_2	Chlorpyriphos 20 EC	2.00	391.75 (19.80)	152.13 (12.34) bc	62.50 (7.93) c	11.13 (3.39) a	0.13 (0.78) a
3	T_3	Acephate 75 SP	1.00	391.88 (19.81)	139.38 (11.83) a	59.50 (7.74) bc	10.25 (3.27) a	0.13 (0.78) a
4	T_4	Lambda-cyhalothrin 5 EC	0.50	400.13 (20.01)	140.88 (11.89) ab	55.25 (7.47) ab	8.88 (3.06) a	0.38 (0.91) bc
5	T_5	Profenophos 50 EC	2.00	380.63 (19.52)	150.00 (12.27) abc	60.00 (7.77) bc	11.00 (3.39) a	0.00 (0.71) a
6	T_6	Dichlorvos 76 EC	1.00	399.00 (19.97)	154.88 (12.46) cd	56.25 (7.53) ab	11.88 (3.51) a	0.75 (1.11) c
7	T_7	Untreated control	-	388.63 (19.73)	419.00 (20.48) e	413.13 (20.34) d	405.00 (20.14) b	410.00 (20.26) d
		S.Em+		0.21	0.16	0.11	0.12	0.07
		C.D (0.05)		NS	0.49	0.33	0.37	0.21

DBS – Day before spray **DAS –** Day after spray **NS –** Non significant
Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table 2: Field evaluation of few insecticides with FORS against second instar *Hemilecanium imbricans* on mango (Pooled)

Sl. No.	Treatments	Insecticides	Dosage (g/ml/l)	Population of scale insects/20 cm twig				
				1 DBS	1DAS	3 DAS	5 DAS	7 DAS
1	T_1	Buprofezin 25 SC	1.25	328.13 (18.13)	188.13 (13.73) bc	70.75 (8.44) c	10.00 (3.23) ab	1.00 (1.17) a
2	T_2	Chlorpyriphos 20 EC	2.00	331.00 (18.21)	176.75 (13.31) b	71.13 (8.46) c	10.75 (3.35) ab	0.50 (0.96) a
3	T_3	Acephate 75 SP	1.00	322.25 (17.96)	187.38 (13.71) bc	65.00 (8.09) bc	9.63 (3.17) a	0.63 (1.00) a
4	T_4	Lambda-cyhalothrin 5 EC	0.50	315.00 (17.76)	192.38 (13.88) c	62.00 (7.90) b	11.00 (3.39) ab	0.75 (1.10) a
5	T_5	Profenophos 50 EC	2.00	317.63 (17.83)	163.88 (12.82) a	62.50 (7.93) b	12.13 (3.55) ab	0.75 (1.06) a
6	T_6	Dichlorvos 76 EC	1.00	316.63 (17.81)	163.25 (12.80) a	54.50 (7.42) a	13.25 (3.70) b	1.25 (1.27) a
7	T_7	Untreated control	-	326.88 (18.09)	327.50 (18.11) d	319.00 (17.87) d	327.63 (18.11) c	330.63 (18.20) b
		S.Em+		0.13	0.16	0.13	0.11	0.16
		C.D (0.05)		NS	0.48	0.38	0.33	0.48

DBS – Day before spray **DAS –** Day after spray **NS –** Non significant
Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table 3: Field evaluation of few insecticides with FORS against third instar *Hemilecanium imbricans* on mango (Pooled)

Sl. No.	Treatments	Insecticides	Dosage (g/ml/l)	Population of scale insects/20 cm twig					
				1 DBS	1DAS	3 DAS	5 DAS	7 DAS	10DAS
1	T_1	Buprofezin 25 SC	1.25	423.00 (20.57)	339.00 (18.40) ab	235.38 (15.36) b	121.00 (11.02) a	54.63 (7.42) ab	13.38 (3.70) bc
2	T_2	Chlorpyriphos 20 EC	2.00	419.13 (20.48)	353.88 (18.82) b	223.13 (14.95) ab	121.00 (11.02) a	62.13 (7.91) b	11.13 (3.38) ab
3	T_3	Acephate 75 SP	1.00	433.75 (20.83)	323.13 (17.97) ab	230.25 (15.18) b	121.75 (11.05) a	59.00 (7.71) b	8.25 (2.95) a
4	T_4	Lambda-cyhalothrin 5 EC	0.50	439.75 (20.98)	305.63 (17.49) a	202.63 (14.25) a	113.88 (10.68) a	58.38 (7.67) b	8.75 (3.04) a
5	T_5	Profenophos 50 EC	2.00	408.50 (20.22)	333.25 (18.26) ab	208.38 (14.45) a	118.75 (10.91) a	51.00 (7.16) a	15.13 (3.94) c
6	T_6	Dichlorvos 76 EC	1.00	416.38 (20.41)	356.88 (18.88) b	220.75 (14.87) ab	120.13 (10.98) a	47.75 (6.94) a	8.38 (2.96) a
7	T_7	Untreated control	-	412.25 (20.31)	402.00 (20.06) c	410.75 (20.28) c	415.50 (20.39) b	409.25 (20.24) c	420.25 (20.51) d
		S.Em+		0.24	0.34	0.20	0.20	0.16	0.16
		C.D (0.05)		NS	1.02	0.60	0.58	0.46	0.46

DBS – Day before spray **DAS –** Day after spray **NS –** Non significant
Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

Table 4: Field evaluation of few insecticides with FORS against fourth instar *Hemilecanium imbricans* on mango (Pooled)

Sl. No.	Treatments	Insecticides	Dosage (g/ml/l)	Population of scale insects/20 cm twig						
				1 DBS	1DAS	3 DAS	5 DAS	7 DAS	10DAS	12 DAS
1	T_1	Buprofezin 25 SC	1.25	339.13 (18.43)	232.25 (15.25) a	126.88 (11.29) ab	75.38 (8.71) a	46.50 (6.85) a	38.25 (6.22) ab	36.88 (6.11) b
2	T_2	Chlorpyriphos 20 EC	2.00	324.75 (18.03)	223.13 (14.95) a	132.50 (11.53) b	77.38 (8.82) a	45.25 (6.76) a	36.75 (6.10) a	35.38 (5.99) ab
3	T_3	Acephate 75 SP	1.00	328.75 (18.14)	231.13 (15.22) a	123.88 (11.15) a	80.75 (9.01) a	48.75 (7.02) a	40.38 (6.39) b	34.25 (5.89) ab
4	T_4	Lambda-cyhalothrin 5 EC	0.50	334.50 (18.30)	237.38 (15.42) a	122.38 (11.08) a	82.88 (9.13) a	51.38 (7.20) ab	40.00 (6.36) b	37.25 (6.14) b
5	T_5	Profenophos 50 EC	2.00	325.75 (18.06)	227.25 (15.09) a	134.13 (11.60) bc	81.13 (9.03) a	56.88 (7.57) b	40.00 (6.36) b	35.13 (5.97) ab
6	T_6	Dichlorvos 76 EC	1.00	339.13 (18.43)	230.75 (15.21) a	140.88 (11.89) c	91.88 (9.61) b	56.63 (7.55) b	37.63 (6.17) ab	33.00 (5.78) a
7	T_7	Untreated control	-	325.38 (18.05)	324.50 (18.03) b	325.88 (18.06) d	326.00 (18.07) c	330.25 (18.19) c	327.13 (18.10) c	330.13 (18.18) c
		S.Em+		0.19	0.14	0.11	0.12	0.13	0.08	0.10
		C.D (0.05)		NS	0.42	0.33	0.37	0.38	0.23	0.29

DBS – Day before spray **DAS –** Day after spray **NS –** Non significant
Figures in the parentheses are ($\sqrt{x+0.5}$) transformed values
Means followed by same alphabet do not differ significantly by DMRT (p=0.05)

4. Discussion

Among insecticides and biorationals tested, 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 the promising insecticides in controlling all stages of scale insects under field conditions. Treatments imposed with and without FORS against different stages of scale insect, *H. imbricans* similar effects were produced with respect to mortality percentage only with little variation. But the usage of FORS @ 5 ml/l helped in dissolving the mealy wax coating of scale insects especially second instar onwards enabling effective penetration of the insecticides. The first instars (crawlers) and second instars of *H. imbricans* were more susceptible effecting higher mortality to all insecticides compared to third and fourth instars under field conditions. The present findings with respect to efficacy of buprofezin are in full agreement with [3] who found that buprofezin reduced nymphs of *A. mangifera*e by 61.96 and 77.6 percent during 2008 and 2009, respectively. The chlorpyrifos-methyl was the most effective treatment against mango soft scale insect, *Kilifia acuminate* after spraying. The mean reduction percentage being 94.10, 91.63 and 92.00 percent while it gave the highest toxic effect after three months, 90.27, 87.84 and 89.73 percent reduction in infestation on pre-adult, adult and gravid female stages, respectively [4] which more or less confirms the present findings with respect to efficacy of chlorpyrifos.

The insecticidal efficacy of seven chemical and natural controlling agents against the Mediterranean black scale, *Saissetia oleae* (Oliver) on olive trees during 2006 and 2007 seasons [5]. In both seasons, the two IGR's (Buprofezin and Pyriproxyfen) gave good reduction rates against all stages of scale insects which is corroboration with the present finding with respect to efficacy of buprofezin both under lab and field condition with respect to with or without FORS against all stages of *H. imbricans*. Similarly the chlorpyrifos had highest toxic effect (LC_{90} = 11636.94 ppm) against white peach scale, *Pseudaulacaspis pentagona* Targioni in adult stage. Based on the estimated LC_{90}, the toxicities of all insecticides tested can be rated in following order chlorpyrifos> diazinon>azinphosmethyl> mineral oil> spinosad> methoxyfenozide [6] and is in corroboration with the present findings with respect to field efficacy of chlorpyrifos.

Irrespective of whether the insecticides were imposed with or without FORS mortality of scale did not vary much. However, with FORS treatments registried higher mortality since the use of FORS @ 5 ml/l dissolved the mealy wax coating of scale insects. The effect of botanicals in combination with entomopathogens with FORS and without FORS on different instars of grape mealy bug, *Maconellicoccus hirsutus* and results revealed that, among the botanicals the NSKE recorded significantly higher percent of mortality (34.79) on first instar mealy bug *M. hirsutus*. Among entomopathogen, *V. lecanii* produced significantly higher mortality (30.76%) [7]. However, *V. lecanii* + FORS along with NSKE resulted in higher percent mortality (47.35) and is in corroboration with the present findings with respect to efficacy of FORS against *H. imbricans.* Oils were preferred for controlling scale insects on citrus. KZ oil was the most effective oil at concentration of 2.0 percent. Nymphs were the most sensitive stage during a period of 1-3 months after application [8]. However, in the present study none of the oils used were effective against *H. imbricans.*

Further, lime sulphur, fenoxycarb and neem significantly reduced the fruit infestation by scale insects at harvest relative to untreated tree but not to the same extent as the organophosphate insecticides, diaznon and chlorpyriphos [9]. This agrees with present study with respect to chlorpyriphos and IGR group chemical fenoxycarb though the IGR used in the present study is buprofezin but neemazol was ineffective. Pyriproxyfen, thiamethoxam and diazinon were most effective against nymphs of *Aspidiotus destructor,* while imidacloprid provided 80 percent nymphal mortality. The most effective insecticide in causing adult mortality was thiamethoxam *i.e.,* 100 percent mortality reached between 47 to 49 ^{0}C exposure to 49 ^{0}C for 7-15 min resulted in 100% nymphal mortality. However, the present study revealed that both imidacloprid and thiamethoxam were ineffective but buprofezin (IGR) was very effective as being reported [10] against *A. destructor.*

Several fungal species showed antagonistic activity both in nature and in laboratory. *Aphanocladium album* (Isolate MX-95) was found infecting scale insects and whiteflies and also perhaps associated with sooty mold in nature. These results are deviating from present study on *H. imbricans* since the fungal species tested were not promising in controlling scale may be due to presence of hard encrustation over its body [11]. Entomopathogenic fungus, *Cephalosporium lecanii*, is an ideal biological agent for management of second instar nymph of *Lepidosaphes gloverii*. However, they reported that, most effective control method was the use of chemicals against the first instar nymphs, which dispersed through the citrus crop [12]. Similar to *L. gloverii* the first instar crawlers of *H. imbricans* are active and dispersed through the mango crop to select suitable place for settlement and hence the insecticides used were more effective than the two entomopathogens *viz., Lecanicillium lecani* and *M. anisopliae* used in the present study.

5. Conclusion

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 the promising insecticides in managing the scale pest under field conditions for different instars of scale insect. 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 and field conditions.

6. References

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