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Efficacy of biorational insecticides for the management of mealybug, *Maconellicoccus hirsutus* (Green) and spiralling whitefly, *Aleurodicus disperses* (Russel) and their safety to coccinellid beetles on guava

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ABSTRACT: Field experiment on effectiveness of different biorational insecticides against mealybug (*Maconellicoccus hirsutus* Green) and spiralling whitefly (*Aleurodicus disperses* Russel) and their safety to natural enemies in guava were carried out at Experimental Farm, Division of Entomology and Nematology, IIHR, Bangalore, India during 2015-16. All the treatments were significantly superior over untreated check. Results indicated that the maximum reduction of mealybug population was recorded in the treatment of organic salt 30 WS @ 5 ml/l (2.32 mealy bugs/three shoots) followed by spinosad 45 SC @ 0.2 ml/l (2.45 mealy bugs/three shoots) after first and second spray respectively. Whereas less population of spiralling whitefly was recorded in spinosad treated plot (2.06 spiralling whiteflies/three leaves). Safety of natural enemy's concern dimethoate 30 EC @1.6 ml/l, azadirachtin 10000 ppm @1 ml/l and Neem soap @ 10 g/l were found to be more harmful to coccinellid beetles and recorded very less beetle population, while Organic salt 30 WS @ 4 ml/l, *L. lecanii* @ 2 g/l and spinosad 45 SC @ 0.2 ml/l were the safest chemicals.

Keywords: Biorational insecticides, guava, *Maconellicoccus hirsutus*, *Aleurodicus disperses*, organic salt

INTRODUCTION

Guava (*Psidium guajava* L) is an important fruit crop of the tropical and subtropical regions of the India. It can be considered as the 'Apple of Tropics' for its high vitamin C and mineral content and also known as 'Poor Man's Fruit'. In India it is cultivated over 2.60 lakh hectare area with an annual production of 38.26 lakh tonnes with an average productivity of 14.75 metric tonnes per hectare (Anon, 2017). About 80 species of insect pests have been recorded on guava, but only few of them had been identified as pest of regular occurrence and causing serious damage. Sucking pests were considered as minor pests in guava but in recent years, they assumed a serious form. The two insect pests familiarized recently in India need special attention, i.e., spiralling white fly, *Aleurodicus dispersus* (Russel) and mealy bug (*Maconellicoccus hirsutus*) in South India.

Spiralling whitefly, *Aleurodicus dispersus* (Russell) (Aleyrodidae: Homoptera) is an introduced polyphagous pest of vegetables, fruit trees, ornamentals and shade trees. It is native of Caribbean islands and Central America (Russell, 1965). In India, it was first recorded in western ghats of Kerala, which might have been accidentally introduced from Maldives through free entry of propagation materials through ports without plant quarantine. In Kerala, this pest was first reported on cassava at Thiruvananthapuram during November 1993 to April 1994 (Palaniswami *et al*., 1995). A steady spread of this pest from Kerala to nearby States like Tamil Nadu and Karnataka was reported (Ranjith *et al*., 1998). A severe incidence of *A. dispersus* on guava was first noticed around Bangalore and Coimbatore in 1996 (Mani and Krishnamoorthy, 1996). Both nymphs and adults suck the sap from their host plants and severe infestation results in weakening of the plant growth, premature leaf fall and subsequently drying of the plant. Yellow speckling, crinkling and curling of the leaves was noted when the infestation by *A. dispersus* was severe (Palaniswami *et al*., 1995). Wen *et al.* (1995) estimated that four-month long infestation could result in 80 per cent fruit yield loss in guava. Since the pest is of ubiquitous nature and covered with white waxy flocculent materials, management through chemicals were found to be impracticable and less effective.

Mealybugs (Pseudococcidae: Homoptera) are highly polyphagous and inflict direct damage to crops by sucking their sap from trunk, cordons, buds, spurs, aerial roots, leaves, shoots, nodes, flower panicles, fruits and roots. Mealybugs once considered as minor pests have assumed the major pest status due to their polyphagous nature coupled with high reproductive capacity with short life cycle which is more favoured due to prolonged drought and quick dispersal through wind, seeds and planting materials (Suresh *et al*., 2010). In recent years number of insect species have become resistant to an increasing number of insecticides (Knight and Norton, 1989). *Maconellicoccus hirsutus* is native to Southern Asia, spread to other parts of the world as; Africa, North America, India, Pakistan and is still extending its range (Rao *et al*., 1993; Gowda *et al*., 1996; Kairo *et al*., 2000; Muralidharan and Badaya, 2000; Rama and Kumar, 2007) throughout the Caribbean region since it was first detected in Grenada and in Southern California, Mexico, and Central America, Hawaii (Beardsley, 1985). Similar to many phloem-feeding insects, *M. hirsutus* produces copious amount of honeydew which reduces the aesthetic value of plants and provides a growing medium for black sooty mold which further reduces value and normal growth and reproduction. (Chong *et al*., 2015) and when fruits infested, those entirely covered with the white waxy coating of the mealybug, if flower blossoms, the fruit sets poorly (Meyerdirk *et al*., 1996). Botanical insecticides have long been pushed as an alternative to synthetic chemical insecticides for pest management (Isman *et al*., 2006). Since they are eco-friendly, economic, target-specific and harmless to natural enemies.

MATERIAL AND METHODS

Field experiments were carried out at Experimental Farm, Division of Entomology, ICAR-IIHR, Bengaluru during 20015-16 to find out the effectiveness of different biorational insecticides against mealy bug, spiralling whitefly and their safety to natural enemies of guava. Experiments were laid out in Randomized Block Design with three replications and eight treatments. The spraying of insecticides was done at morning hours, at initiation of incidence of the pests. The first spray was given when the sucking insect population reached ETL and subsequent sprays were given at 15 days intervals. The number of mealy bug population per shoot was taken from 15 randomly selected and tagged plants. Observations were recorded at a day before spray (DBS), three, seven and 15 days after each spray. In case of spiralling whiteflies both adults and nymphs of spiralling whiteflies were counted from top three leaves on 15 randomly selected and tagged plants. Observations recorded at a day before spray (DBS), three, seven and 15 days after each spray and later pooled mean of two sprays was calculated. The data obtained from the field experiments were subjected to square root transformation and subjected to ANOVA analysis.

RESULTS AND DISCUSSION

Effect of biorational insecticides on mealy bug population

First spray

The results (Table 1) indicated significant differences among all the treatments in the period of study. It is noticeable from data in Table 1 that the before spray the mealy bug population was non-significant showing even distribution. On third day of observation, all the treatments were significantly reduced the population of mealy bugs over untreated control. At three days after first spray, the treatment organic salt 30 WS @ 5 ml/l was found to be effective in reducing the mealy bugs population with 2.35 mealy bugs/three shoots which was on par with spinosad 45 SC @ 0.2 ml/l (2.54 mealy bugs/three shoots). Whereas, maximum population was recorded in untreated control and neem soap @ 10g/l with (14.96 and 3.79 mealy bugs/three shoots), respectively.

After seven days after spraying minimum number of mealy bugs (2.03 mealy bugs/three shoots) was recorded in organic salt 30 WS @ 5 ml/l which was found to be on par with spinosad 45 SC @ 0.2 ml/l (2.18 mealy bugs/three shoots) followed by dimethoate 30 EC @1.6 ml/l, *L. lecanii*@ 2 g/l, azadirachtin 10,000 ppm @1ml/l and organic salt 30 WS@ 4 ml/l (2.18, 2.97, 3.02 and 3.15 mealy bugs/three shoots) and they were on par with each other. After 15 days of spraying significantly minimum number of mealy bugs (2.06 mealy bugs/three shoots) was recorded in spinosad 45 SC @ 0.2 ml/l which was found on par with organic salt 30 WS@ 5 ml/l (2.25 mealy bugs/three shoots).

Second spray: Observations recorded (Table 1) on mealy bug population at three days after spraying indicated significant differences among different treatments. Organic salt 30 WS @ 5 ml/l recorded minimum number of mealy bugs (2.55 mealy bugs/three shoots) which was found to be on par with all the other treatments. Seven days after spraying showed that all the treatments were effective over control in reducing the population of mealy bugs. Significantly minimum number of mealy bugs (2.27 mealy bugs/three shoots) was recorded in organic salt 30 WS@ 5 ml/l which was on par with spinosad 45 SC @ 0.2 ml/l (2.59 mealy bugs/three shoots) Whereas, maximum number of mealy bugs

Table 1: Efficacy of biorationals on *Maconellicoccus hirsutus* population in guava during 2016

Treatment	Mean no. of mealy bugs/three shoots (n=15 plants)										Pooled mean
	I Spray					II Spray					
	DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean	
T1 - Azadirachtin (10,000 ppm) @1ml/l	14.80 (3.91)	3.18 (1.92)	3.02 (1.88)	2.96 (1.86)	3.05	14.46 (3.87)	3.26 (1.94)	3.11 (1.90)	3.28 (1.94)	3.21	3.13
T2 - *Lecanicillium lecanii* @ 2 g/l	15.57 (4.01)	3.32 (1.96)	2.97 (1.86)	3.13 (1.90)	3.14	14.64 (3.89)	3.21 (1.93)	3.03 (1.88)	3.20 (1.92)	3.14	3.14
T3 - Neem soap @10 g/l	15.19 (3.96)	3.79 (2.07)	3.63 (2.03)	3.79 (2.07)	3.73	14.79 (3.91)	3.54 (2.01)	3.32 (1.95)	3.37 (1.97)	3.41	3.57
T4 - Organic salt 30 WS @4 ml/l	15.20 (3.96)	3.48 (1.99)	3.15 (1.91)	3.07 (1.89)	3.23	14.87 (3.92)	3.27 (1.94)	3.16 (1.91)	3.29 (1.95)	3.24	3.24
T5 - Organic salt 30 WS @5 ml/l	15.03 (3.94)	2.35 (1.69)	2.03 (1.59)	2.25 (1.66)	2.21	14.81 (3.91)	2.55 (1.74)	2.27 (1.66)	2.48 (1.72)	2.43	2.32
T6 - Spinosad 45 SC @0.2 ml/l	14.85 (3.92)	2.54 (1.74)	2.18 (1.63)	2.06 (1.60)	2.26	14.54 (3.88)	2.86 (1.82)	2.59 (1.75)	2.49 (1.73)	2.64	2.45
T7 - Dimethoate 30 EC @1.6 ml/l	15.08 (3.95)	2.93 (1.85)	2.63 (1.76)	2.50 (1.73)	2.68	14.84 (3.92)	3.20 (1.92)	3.03 (1.88)	3.09 (1.89)	3.10	2.89
T8 - Untreated control	14.73 (3.90)	14.96 (3.93)	15.15 (3.96)	15.45 (3.99)	15.18	14.89 (3.92)	15.08 (3.95)	15.28 (3.97)	15.47 (4.00)	15.27	15.23
CD at 5%	NS	0.56	0.56	0.20	-	NS	0.86	0.47	0.25	-	-
SEm±	-	0.18	0.18	0.06	-	-	0.28	0.15	0.08	-	-

DBS - Day before spraying, DAS - Days after spraying

Figures in parentheses are $\sqrt{X + 0.5}$ transformed values

Table 2: Evaluation of biorationals on *Aleurodicus disperses* population in guava during 2016

Treatment	Mean no. of spiraling whiteflies/three leaves (n=15 plants)										Pooled mean
	I Spray					II Spray					
	DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean	
T1 - Azadirachtin (10,000 ppm) @ 1ml/l	12.71 (3.63)	3.10 (1.90)	2.86 (1.83)	2.99 (1.87)	2.98	11.78 (3.50)	3.69 (2.05)	3.42 (1.97)	3.73 (2.06)	3.61	3.30
T2 - *Lecanicillium lecanii* @ 2 g/l	12.32 (3.58)	3.44 (1.98)	3.05 (1.88)	3.11 (1.90)	3.20	12.45 (3.60)	3.82 (2.08)	3.76 (2.06)	4.06 (2.14)	3.88	3.54
T3 - Neem soap @ 10 g/l	12.00 (3.54)	3.78 (2.07)	3.67 (2.04)	3.74 (2.06)	3.73	12.04 (3.54)	3.96 (2.11)	3.60 (2.02)	3.87 (2.09)	3.81	3.77
T4 - Organic salt 30 WS @ 4 ml/l	12.28 (3.57)	3.87 (2.09)	3.70 (2.05)	3.85 (2.09)	3.80	11.82 (3.51)	4.32 (2.19)	4.12 (2.15)	4.41 (2.22)	4.28	4.04
T5 - Organic salt 30 WS @ 5 ml/l	12.44 (3.60)	3.29 (1.95)	3.01 (1.87)	3.34 (1.96)	3.24	12.11 (3.55)	3.88 (2.09)	3.66 (2.04)	3.89 (2.09)	3.80	3.52
T6 - Spinosad 45 SC @ 0.2 ml/l	12.26 (3.57)	2.76 (1.80)	1.36 (1.36)	1.03 (1.23)	1.71	12.35 (3.59)	3.11 (1.90)	2.24 (1.65)	1.85 (1.53)	2.40	2.06
T7 - Dimethoate 30 EC @ 1.6 ml/l	12.59 (3.62)	3.03 (1.88)	2.81 (1.82)	2.75 (1.80)	2.86	12.63 (3.62)	3.36 (1.96)	3.13 (1.91)	3.23 (1.93)	3.24	3.05
T8 - Untreated control	12.56 (3.61)	12.68 (3.63)	13.71 (3.77)	14.22 (3.84)	13.53	12.68 (3.63)	12.87 (3.66)	13.18 (3.70)	14.46 (3.87)	13.50	13.52
CD at 5%	NS	0.31	0.41	0.32	-	NS	0.52	0.63	0.44	-	-
SEm±	-	0.10	0.13	0.10	-	-	0.17	0.20	0.14	-	-

DBS - Day before spraying, DAS - Days after spraying

Figures in parentheses are $\sqrt{X + 0.5}$ transformed values

was recorded in neem soap @ 10g/l (3.32 mealy bugs/three shoots). Fifteen days after spraying, organic salt 30 WS @ 5 ml/l was recorded lowest population (2.48 mealy bugs/three shoots) followed by spinosad 45 SC @ 0.2 ml/l, dimethoate 30 EC @1.6 ml/l, *L. lecanii*@ 2 g/l (2.49, 3.09 and 3.20 mealy bugs/three shoots).

The overall mean population differed significantly among treatments with respect to number of mealy bugs per three shoots. Among the different treatments organic salt 30 WS@ 5 ml/l (2.32 mealy bugs/three shoots) was significantly superior than all the other treatments followed by spinosad 45 SC @ 0.2 ml/l (2.45 mealy bugs/three shoots). The least number of mealy bugs were observed in organic salt 30 WS @ 5 ml/l treated plot followed by spinosad 45 SC @ 0.2 ml/l and dimethoate 30 EC@ 1.6 ml/l (2.32, 2.45 and 2.89 mealy bugs/three shoots), respectively. This is an agreement with Gowda *et al.* (2013) who noted that organic salt 30 WS@ 5 ml/l was effective in suppressing the mealy bug population of papaya crop.

Effect of insecticides on spiralling whitefly population

Frist spray

The results (Table 2) revealed that population of spiralling whitefly ranged from 12.00 to 12.59/three leaves at a day before spray (DBS) indicating uniform distribution and it differ non significantly among the different treatments tested. At three days after first spray, the treatment spinosad 45 SC @ 0.2 ml/l was found to be effective in reducing the spiralling whitefly population with 2.76 spiralling whiteflies/three leaves which was on par with dimethoate 30 EC @1.6 ml/l (3.03 spiralling whiteflies/three leaves). Significantly minimum number of spiralling whitefly population (1.36 spiralling whiteflies/three leaves) was recorded in spinosad 45 SC @ 0.2 ml/l. Whereas, seven days after spraying dimethoate 30 EC @1.6 ml/l recorded (2.18 spiralling whiteflies/three leaves) followed by azadirachtin @ 1ml/l, organic salt 30 WS @ 5 ml/l and *L. lecanii* @ 2 g/l (2.86, 3.01 and 3.05 spiralling whiteflies/three leaves) and they were on par with each other. After Fifteen days spraying showed that all the treatments were effective over control in reducing the population of spiralling whitefly. Significantly minimum number of spiralling whiteflies (1.03 spiralling whiteflies/three leaves) was recorded in spinosad 45 SC @ 0.2 ml/l which was followed by dimethoate 30 EC @1.6 ml/l, azadirachtin 10,000 ppm @ 1ml/l and *L. lecanii* @ 2 g/l (2.75, 2.99 and 3.11spiralling whiteflies/three leaves).

Second spray

The data (Table 2) indicated that spiralling whitefly population at three days after spraying significant differences among different treatments. Organic salt 30 WS @ 5 ml/l recorded minimum number of spiralling whitefly population (3.11 spiralling whiteflies/three leaves) which was found to be on par with dimethoate 30 EC @1.6 ml/l (3.36 spiralling whiteflies/three leaves). Whereas, seven days after spraying, spinosad 45 SC @ 0.2 ml/l recorded less population (2.24 spiralling whiteflies/three leaves) followed by dimethoate 30 EC @1.6 ml/l, azadirachtin @ 1ml/l and neem soap @ 10g/l (3.13, 3.42 and 3.60 spiralling whiteflies/three leaves), respectively. After 15 days of spraying same trend was observed that, lower spiralling whiteflies (1.85 spiralling whiteflies/three leaves) was noted in spinosad 45 SC @ 0.2 ml/l followed by dimethoate 30 EC @1.6 ml/l, azadirachtin @1ml/l and neem soap@ 10g/l (3.23, 3.73 and 3.87 spiralling whiteflies/three leaves), respectively. The overall mean population of spiralling whiteflies observed that spinosad 45 SC @ 0.2 ml/l was recorded significantly lower population 2.06 whiteflies/three leaves. Whereas, moderate population was recorded in azadirachtin 10,000 ppm @ 1.0 ml/l, organic salt 30 WS@ 5 ml/l and *L. lecanii* @ 2 g/l (3.30, 3.52 and 3.54 spiralling whiteflies/three leaves), respectively. On the basis of the mean pooled data results revealed that all the treatments were significantly effective over the control in reducing the whitefly population. The present study is in agreement with Pushpalatha and Balikai (2015)) who reported that, spinosad was very effective reducing the spiralling whitefly population. Kambrekar and Awaknavar (2004) reported that dimethoate 30 EC (0.025%) recorded less population of spiralling whitefly. The fungi *L. lecanii* exhibited promising levels of control (> 70% mortality of the *A. dispersus* population) on cassava.

Safety of biorationals to coccinellid beetles

The data (Table 3) shown that among the different treated insecticides, dimethoate 30 EC @1.6 ml/l, azadirachtin 10000 ppm @1 ml/l and Neem soap @ 10 g/l were found more harmful to coccinellid beetles and recorded very less beetle population (1.08, 1.66 and 1.95 beetles / three shoots). Whereas, organic salt, *L. lecanii* and spinosad were the most safest chemicals to the coccinellid beetles. Similar trend was observed in second spray also. The overall mean pool data was revealed that dimethoate was more toxic to coccinellid beetles followed by azadirachtin and neem soap (0.68, 1.49 and 1.81 beetles / three shoots).

Table 3: Safety of different biorational insecticides to coccinellid, C. *septumpunctata* during 2015-16 on guava

Treatment	Mean no. of coccinellids/three shoots (n=15 plants)										Pooled mean
	I Spray					II Spray					
	DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean	
T1 - Azadirachtin (10,000 ppm) @1ml/l	4.39 (2.19)	2.19 (1.48)	1.37 (1.37)	1.43 (1.39)	1.66	3.16 (1.91)	1.41 (1.38)	1.29 (1.34)	1.26 (1.33)	1.32	1.49
T2 - *Lecanicillium lecanii* @ 2 g/l	3.79 (2.07)	2.07 (1.68)	2.67 (1.78)	2.76 (1.81)	2.50	3.63 (2.03)	2.20 (1.64)	2.06 (1.60)	2.12 (1.62)	2.13	2.34
T3 - Neem soap @10 g/l	3.90 (2.10)	2.10 (1.59)	1.82 (1.51)	1.94 (1.56)	1.95	3.23 (1.93)	1.70 (1.48)	1.55 (1.43)	1.77 (1.50)	1.67	1.81
T4 - Organic salt 30 WS @4 ml/l	4.16 (2.16)	2.16 (1.77)	2.42 (1.71)	2.52 (1.74)	2.37	3.59 (2.02)	2.72 (1.80)	2.54 (1.74)	2.58 (1.75)	2.61	2.49
T5 - Organic salt 30 WS @5 ml/l	3.84 (2.08)	2.08 (1.71)	2.25 (1.66)	2.35 (1.69)	2.23	3.29 (1.95)	2.54 (1.74)	2.25 (1.66)	2.36 (1.69)	2.38	2.31
T6 - Spinosad 45 SC @0.2 ml/l	4.25 (2.18)	2.18 (1.70)	2.17 (1.63)	2.15 (1.63)	2.17	3.34 (1.96)	2.50 (1.73)	2.27 (1.67)	2.38 (1.70)	2.42	2.28
T7 - Dimethoate 30 EC @1.6 ml/l	4.26 (2.18)	2.18 (1.24)	0.44 (0.95)	0.61 (1.04)	1.08	3.44 (1.99)	0.75 (1.10)	0.10 (0.77)	0.00 (0.71)	0.28	0.68
T8 - Untreated control	3.76 (2.06)	2.06 (2.09)	4.01 (2.12)	4.23 (2.17)	3.43	3.41 (1.98)	3.46 (1.99)	3.59 (2.02)	3.59 (2.02)	3.55	3.49
CD at 5%	NS	0.18	0.61	0.23	-	NS	0.57	0.25	0.40	-	
SEm±	-	0.06	0.20	0.07	-	-	0.18	0.08	0.13	-	-

DBS - Day before spraying, DAS - Days after spraying

Figures in parentheses are $\sqrt{X + 0.5}$ transformed values

CONCLUSION

The present study revealed the effectiveness of various biorational insecticides against mealybug, spiralling white fly and their safety to natural enemies (coccinellid beetle). Spinosad 45 SC @ 0.2 ml/l proved to be the highly effective treatment among all the treatments tested for the control of spiralling white fly and for mealybug organic salt 30 WS @ 5 ml/l was more effective in the field study. In case of natural enemies, organic salt 30 WS @ 4 and 5 ml/l, *L. lecanii* @ 2 g/l and spinosad 45 SC @ 0.2 ml/l were proved to be safe to the coccinellid beetes.

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