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Evaluation of insecticides against gall midge, *Procontarinia matteiana* Kieffer & Cecconi infesting mango

MB Zala and TM Bharpoda

Abstract
The field experiments were conducted at Horticulture farm, B. A. College of Agriculture, Anand Agricultural University, Anand during September, 2014 and 2015 to evaluate the efficacy of different insecticides against gall midge, *Procontarinia matteiana* Kieffer & Cecconi on mango. Among the different ten insecticides evaluated, imidacloprid 35 SC 0.02% found as best by recording lower infestation of *P. matteiana* (1.11 leaf damage index) and did not have any significant effect on the spiders and coccinellids population on the mango.

Keywords: Mango, bio-efficacy, insecticides, imidacloprid 35 SC, gall midge, *Procontarinia matteiana*, spiders, coccinellids

Introduction
India has achieved self-sufficiency in food grain production and now the focus has been shifted from Agriculture to Horticulture which besides imparting nutritional security, offers a great potential for efficient input use, higher returns per unit area, crop diversification, foreign exchange earnings and greater employment generation through post harvest processing in agro industries. Fruits cultivation in India is one such major commercial and business sectors for exporting merchandise and shipping from which much of the international revenue is incurred. India proudly ranks first in the world with respect to production of fruits *viz*., banana, mango and papaya (Anon., 2016) [2]. There are almost 180 families of fruits being cultivated all over the world. Mango, banana, citrus, apple, guava, papaya, pineapple and grape are major fruit crops being cultivated in India (Jadav, 2009) [7].

Mango (*Mangifera indica* Linnaeus) is national fruit of India and known as "King of fruits" due to its wide adaptability, excellent taste, exotic flavour, exemplary nutritive value, richness in variety, attractive colour, appearance and popularity among the masses. The major mango producing countries in the world are India, China, Pakistan, Mexico, Thailand, Indonesia, Brazil, Philippines, Nigeria and Viet Nam. India ranks first in production of mango in the world. Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Himachal Pradesh, Maharashtra, Orissa, Tamil Nadu, Gujarat and West Bengal are the major mango producing states. In Gujarat, Valsad, Kheda, Junagadh, Surat and Banaskantha are the known districts for cultivation of mango crop. The popular varieties grown in Gujarat are Kesar, Rajapuri, Langra and Alphonso. The mango tree suffers regularly a colossal loss due to ravages of pests, a serious threat to mango industry. The crop is attacked by about 492 species of insects, 17 species of mites and 26 species of nematodes at the world level. Of these, 188 species of insects have been reported from India (Tandon and Verghese, 1985) [14]. The infestation of mango gall midge, *Procontarinia matteiana* Kieffer & Cecconi (Cecidomyiidae: Diptera) has steadily increased year after years in mango orchards due to changes in environment, cropping system, cultivation of susceptible varieties etc. About 26 species of insects produces galls on various plant parts of mango tree. Most of the mango gall inducing species belong to genus *Procontarinia* (Cecidomyiidae: Diptera) (Boucek, 1986) [5]. Mango gall midge is a common gall midge on mango found in India (Askari and Radjabi, 2003) [3]. In India, the infestation of gall midge found on mango throughout the year, prominently during vegetative and fruit maturity period *i.e.* September and April (Kaushik *et al.*, 2012) [10]. Jadhav *et al.*, (2013_a) [8] observed that the early instar maggot burrows the leaf tissues and forms reddish spot on the leaf tissues and it becomes swollen and soft. The maggot remains inside the leaf tissues and fully developed maggot produce a gall due to continuous feeding on the leaf tissue with the help of cephalopharangeal apparatus. A serious outbreak might be resulted in reduction of fruit yield (Augustyn *et al*., 2013) [4].

Chemical control is still considered as the first line of defense in pest management. Use of insecticides has a positive impact on crop production and insecticides are often highly effective, fast-acting, convenient and economical, making them the most powerful tools in pest management. Farmers, due to inadequate knowledge habitually apply hazardous insecticides in high quantum without any concern to the actual level of field requirement. Such injudicious input, consequences like insecticide resistance, resurgence, secondary pest outbreak, environmental contamination, persistent residual toxicity and reduction in the biodiversity of natural enemies are observed in many cases. Considering above consequences, a study was conducted to assess the efficacy of different insecticides against *P. matteiana* infesting mango.

Materials and Methods

The field experiments were carried out at Horticulture farm, B. A. College of Agriculture, Anand Agricultural University, Anand during September, 2014 and 2015 to study the efficacy of different insecticides against *P. matteiana* infesting mango based on the leaf damage (galling) index (0-5) in Completely Randomized Design with three repetitions (one tree as one repetition). Mango cv. Amrapali had the sown distance of 10 x 10 m. All the standard agronomical practices have been followed. The experiment was laid out by selecting more or less equal age (13 years) trees having similar size and canopy. For recording observations of mango gall midge on each selected and tagged trees, four leaves from terminal twig were selected randomly from each direction before spray as well as 5, 10 and 15 days after each spray. On visual observations, leaf (galling) damage index (0-5) was given. To standardize the scale, 100 leaves were randomly selected and brought to the laboratory. Collected leaves were categorized into the following index looking to the percent leaf area covered based on number of galls counted (Zala and Bharpoda, 2022) [16].

Table 1: Galling Index

Index	Leaf area covered (%)	Average number of gall (s)	Standard deviation (±)
0	No galls (completely free)	0	0
1	20% leaf area covered	6.9	2.02
2	40% leaf area covered	16.6	1.17
3	60% leaf area covered	26.8	3.19
4	80% leaf area covered	47.9	4.38
5	More than 80% leaf area covered	129.6	5.58

The spray applications of different insecticides were given at its respective dose along with sticker *i.e.* detergent powder with the help of foot sprayer with triple action nozzle to the extent of slight run-off. Total two sprays were given to evaluate the efficacy of different insecticides against mango gall midge. First spray was given at initial stage of gall formation while, second spray after 15 days of first spray. The data obtained thus, were subjected to statistical analysis after appropriate transformation to draw valid conclusion as per Steel and Torrie (1980) [13].

Results and Discussion

Based on efficacy of insecticides against *P. matteiana*

The pooled over sprays and years (2014 and 2015) results on bio-efficacy of different insecticides against *P. matteiana* are presented in Table 2. The results Based on pooled over sprays and years results it is revealed that there was no any significant difference in incidence of *P. matteiana* between the various insecticidal treatments before spray and after spray applications, all the insecticides recorded lower incidence (1.11 to 2.78 leaf damage index) than control (3.00). Among the various insecticides evaluated, imidacloprid 35 SC 0.02% found most effective insecticidal treatment by recording significantly the lowest (1.11) incidence of the pest. However, it was at par with thiamethoxam 25 WG 0.0125% (1.22) and dichlorvos 76 EC 0.076% (1.40). Treatments *viz*., cyantraniliprole 10 OD 0.01% (1.52) and flonicamid 50 WDG 0.015% (1.84) were stood as next effective treatments. Clothianidin 50 WDG 0.02%, acetamiprid 20 SP 0.01% and carbosulfan 25 EC 0.04% recorded 2.03 to 2.36 leaf damage index. As such, these treatments proved as less effective. The mango trees treated with spinosad 45 SC 0.0135% recorded maximum (2.78) incidence of *P. matteiana*. Further, it proved inferior insecticide as it was at par with control.

Table 2: Efficacy of different insecticides against gall midge, *P. matteiana* on mango (Pooled over sprays and years)

Treatments		Gall midge incidence (0-5 leaf damage index)			
		Before spray	2014	2015	Pooled over years
Cyantraniliprole 10 OD 0.01%		1.22^{a} (0.99)	1.42^{bc} (1.52)	1.43bc (1.54)	1.42bc (1.52)
Clothianidin 50 WDG 0.02%		1.11^{a} (0.73)	1.66^{de} (2.26)	1.52c (1.81)	1.59de (2.03)
Flonicamid 50 WG 0.015%		1.22^{a} (0.99)	1.57^{de} (1.96)	1.48bc (1.69)	1.53cd (1.84)
Thiamethoxam 25 WG 0.0125%		1.13^{a} (0.78)	1.24^{a} (1.04)	1.39ab (1.43)	1.31ab (1.22)
Acetamiprid 20 SP 0.01%		1.27^{a} (1.11)	1.54^{cd} (1.87)	1.63d (2.16)	1.59de (2.03)
Imidacloprid 35 SC 0.02%		1.15^{a} (0.82)	1.25^{a} (1.06)	1.32a (1.24)	1.27a (1.11)
Spinosad 45 SC 0.0135%		1.15^{a} (0.82)	1.79^{fg} (2.70)	1.82e (2.81)	1.81fg (2.78)
Carbosulfan 25 EC 0.04%		1.22^{a} (0.99)	1.67^{ef} (2.29)	1.71d (2.42)	1.69ef (2.36)
Dichlorvos 76 EC 0.076%		1.22^{a} (0.99)	1.36^{ab} (1.35)	1.41ab (1.49)	1.38ab (1.40)
Untreated Control		1.22^{a} (0.99)	1.83^{g} (2.85)	1.92f (3.19)	1.87g (3.00)
S.Em. ±	Treatment (T)	0.08	0.04	0.03	0.04
	Period (P)	-	0.02	0.02	0.02
	Spray (S)	-	0.02	0.01	0.01
	Year (Y)	0.03	-	-	0.01
	T × P	-	0.08	0.06	0.05
	T × S	-	0.06	0.05	0.04
	T × Y	0.08	-	-	0.04
	P × S	-	0.03	0.02	0.02
	P × Y	-	-	-	0.02
	S × Y	-	-	-	0.02
	T × P × S	-	0.11	0.09	0.07
	T × P × Y	-	-	-	0.07
	T × S × Y	-	-	-	0.06
	P × S × Y	-	-	-	0.03
	T × P × S × Y	-	-	-	0.11
C. V. %		10.70	13.05	10.51	11.82

Note

1. Figures in parentheses are $\sqrt{x+0.5}$ retransformed values; those outside are transformed values.
2. Figures in letter(s) in common are statistically at par as per DNMRT.

Samui and Jha (2012) [12] found significantly lowest number of galls in shoots treated with thiamethoxam 25% WG 0.008% followed by imidacloprid 17.8% SL 0.006%. Augustyn *et al*. (2013) [4] confirmed the efficacy of thiamethoxam 25 WG (250 g/ kg) to curb gall fly infestation in mango orchards at Arcadia (South Africa). Environmentally sustainable chemical control of the gall fly can be successful if the active substance applied is a systemic insecticide, such as thiamethoxam 25 WG (250 g/ kg) (Daneel *et al*., 2000) [6]. Jadhav *et al*. (2013_b) [9] reported imidacloprid 17.8 SL 0.005% as significantly superior over rest of the treatments against *P. matteiana* on mango. Cent percent reduction in the larval population of *Contarinia nasturtii* Kieffer (Diptera: Cecidomyiidae) was recorded when sprayed with imidacloprid in broccoli crop (WU *et al*., 2006) [15]. Patel and Kumar (2020) [11] reported that imidacloprid 0.005% was most effective and economical against leaf gall midge, *P. matteiana* on mango followed by thiamethoxam and dichlorvos. This finding verified that the use of systemic insecticides should currently be retained as an integral part of pest management in the mango orchard. Thus, results obtained in the present investigation are more or less the same that have been reported earlier.

Based on effect on spiders population

Based on pooled over sprays and two consecutive years (2014 and 2015) results on effect of different insecticides on population of spiders, insecticidal application had no any significant impact on spiders as there was no any statistical difference among different insecticidal treatments evaluated which indicates that all the insecticidal treatments found safe to the spiders in mango (Table 3).

Based on effect on coccinellids population

Based on pooled over sprays and two consecutive years (2014 and 2015) results on effect of different insecticides on population of coccinellids (adults), insecticidal application had no any significant impact on coccinellids as there was no any statistical difference among different insecticidal treatments evaluated which indicates that all the insecticidal treatments found safe to the coccinellids in mango (Table 4).

The findings of the present investigations are in close agreement with the findings of Adnan *et al*. (2014) [1] who reported that imidacloprid showed less toxicity to natural enemies in mango.

Table 3: Effect of different insecticides on spiders on mango (Pooled over sprays and years)

Treatments		No. of spiders/ twig			
		Before spray	2014	2015	Pooled over years
Cyantraniliprole 10 OD 0.01%		0.75^a (0.06)	0.76^a (0.08)	0.76^a (0.08)	0.76^a (0.08)
Clothianidin 50 WDG 0.02%		0.75^a (0.06)	0.76^a (0.08)	0.75^a (0.06)	0.76^a (0.08)
Flonicamid 50 WG 0.015%		0.75^a (0.06)	0.76^a (0.08)	0.76^a (0.08)	0.76^a (0.08)
Thiamethoxam 25 WG 0.0125%		0.75^a (0.06)	0.76^a (0.08)	0.76^a (0.08)	0.76^a (0.08)
Acetamiprid 20 SP 0.01%		0.75^a (0.06)	0.76^a (0.08)	0.76^a (0.08)	0.76^a (0.08)
Imidacloprid 35 SC 0.02%		0.77^a (0.09)	0.77^a (0.09)	0.76^a (0.08)	0.77^a (0.09)
Spinosad 45 SC 0.0135%		0.76^a (0.08)	0.77^a (0.09)	0.77^a (0.09)	0.77^a (0.09)
Carbosulfan 25 EC 0.04%		0.75^a (0.06)	0.76^a (0.08)	0.77^a (0.09)	0.77^a (0.09)
Dichlorvos 76 EC 0.076%		0.75^a (0.06)	0.76^a (0.08)	0.76^a (0.08)	0.76^a (0.08)
Untreated Control		0.76^a (0.08)	0.77^a (0.09)	0.78^a (0.11)	0.78^a (0.11)
S. Em. ±	Treatment (T)	0.02	0.01	0.01	0.01
	Period (P)	-	0.01	0.01	0.01
	Spray (S)	-	0.01	0.01	0.01
	Year (Y)	0.01	-	-	0.01
	T × P	-	0.01	0.01	0.02
	T × S	-	0.03	0.02	0.01
	T × Y	0.04	-	-	0.01
	P × S	-	0.02	0.02	0.01
	P × Y	-	-	-	0.01
	S × Y	-	-	-	0.01
	T × P × S	-	0.04	0.03	0.02
	T × P × Y	-	-	-	0.02
	T × S × Y	-	-	-	0.02
	P × S × Y	-	-	-	0.01
	T × P × S × Y	-	-	-	0.03
C. V. %		8.15	8.40	7.96	6.88

Note

1. Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values.
2. Figures in letter(s) in common are statistically at par as per DNMRT.

Table 4: Effect of different insecticides on coccinellids on mango (Pooled over sprays and years)

Treatments	No. of coccinellids (adult)/ twig			
	Before spray	2014	2015	Pooled over years
Cyantraniliprole 10 OD 0.01%	0.77^a (0.09)	0.77^a (0.09)	0.78^a (0.11)	0.78^a (0.11)
Clothianidin 50 WDG 0.02%	0.76^a (0.08)	0.77^a (0.09)	0.78^a (0.11)	0.78^a (0.11)
Flonicamid 50 WG 0.015%	0.76^a (0.08)	0.77^a (0.09)	0.77^a (0.09)	0.77^a (0.09)
Thiamethoxam 25 WG 0.0125%	0.77^a (0.09)	0.77^a (0.09)	0.78^a (0.11)	0.78^a (0.11)
Acetamiprid 20 SP 0.01%	0.76^a (0.08)	0.77^a (0.09)	0.77^a (0.09)	0.77^a (0.09)
Imidacloprid 35 SC 0.02%	0.76^a (0.08)	0.78^a (0.11)	0.78^a (0.11)	0.78a (0.11)
Spinosad 45 SC 0.0135%	0.77^a (0.09)	0.78^a (0.11)	0.78^a (0.11)	0.78^a (0.11)
Carbosulfan 25 EC 0.04%	0.75^a	0.78^a	0.78^a	0.78^a

		(0.05)	(0.11)	(0.11)	(0.11)
Dichlorvos 76 EC 0.076%		0.76[a] (0.08)	0.77[a] (0.09)	0.77[a] (0.09)	0.77[a] (0.09)
Untreated Control		0.76[a] (0.08)	0.79[a] (0.12)	0.80[a] (0.14)	0.80[a] (0.14)
S.Em. ±	Treatment (T)	0.02	0.01	0.01	0.01
	Period (P)	-	0.01	0.01	0.01
	Spray (S)	-	0.01	0.01	0.01
	Year (Y)	0.01	-	-	0.01
	T × P	-	0.01	0.01	0.02
	T × S	-	0.03	0.03	0.01
	T × Y	0.04	-	-	0.01
	P × S	-	0.02	0.02	0.01
	P × Y	-	-	-	0.01
	S × Y	-	-	-	0.01
	T × P × S	-	0.04	0.04	0.02
	T × P × Y	-	-	-	0.02
	T × S × Y	-	-	-	0.02
	P × S × Y	-	-	-	0.01
	T × P × S × Y	-	-	-	0.03
C. V. %		8.00	8.26	8.68	7.13

Note:

1. Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values.
2. Figures in letter(s) in common are statistically at par as per DNMRT.

Conclusion

From the present investigations, it is concluded that two spray applications of imidacloprid 35 SC 0.02% at initiation of gall midge, *P. matteiana* incidence on mango and 2nd at 15 days after 1st spray found most effective and safe to spiders and coccinellids on mango.

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