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Efficacy of flonicamid 50%WG against mango hopper on mango *Mangifera indica* L.

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Abstract
A field experiment was conducted to study the bio-efficacy of some insecticides against mango hopper on mango at B.C.KV, Mohanpur, Nadia, West Bengal, India during 2016 and 2017. In present investigation, seven insecticides (including control) viz. Flonicamid 50%WG @ 15 g a.i. ha^{-1}, Flonicamid 50%WG @ 20 g a.i. ha^{-1}, Flonicamid 50%WG @ 25 g a.i. ha^{-1}, Imidacloprid 17.8 % SL @ 25 g a.i. ha^{-1}, Lambda cyhalothrin 5% EC @ 5 g a.i. ha^{-1} and Dimethoate 30%EC @ 50 g a.i. ha^{-1} were evaluated. Among all the treatments Flonicamid 50%WG @ 25 g a.i. ha^{-1} has found to be best treatment and recorded highest hopper mortality during the experiment. Highest mango yield of 74.4 Q/ha and 80.6 Q/ha were obtained in the treatment of Flonicamid 50% WG @ 25 g a.i. ha^{-1} dosage and the highest cost benefit ratio was also observed in the treatment Flonicamid 50% WG @ 25 g a.i. ha^{-1} in 2016 and 2017. All the doses of Flonicamid 50% WG were found safer to lacewings and spiders in mango ecosystem during the experiments.

Keywords: Mango, mango hopper, flonicamid 50% WG, West Bengal

Introduction
The mango hopper viz. *Amritodus atkinsoni* (Lethierry), *Idioscopus clypealis* (Lethierry) *I. niveosparsus* (Lethierry) and *I. nitidulus* (Walker) are most destructive pests of all the varieties of mango. In fact both the nymphs and adults of the mango hoppers suck the sap from tender shoots, desapped the inflorescences and leaves the crop, at flowering and fruiting stages which causes yield loss up to 100% (Rahman *et al*., 2007; Adnan *et al*., 2014; Karar *et al*., 2018) [9, 1, 8]. The pests damage the crop by secreting honey dew which promotes the development of fungus, *Meliola mangiferae* (Earle) on leaves and affects photosynthesis activity of the leaf (Anonymous, 2012; Gundappa *et al*., 2016) [4, 5].
At present, India is the largest producer and leading exporter of mango with annual production of 18642.53 thousand MT in an area of 2208.56 thousand ha and shares of more than one-third of the world's mango production (Anonymous, 2017) [2]. In West Bengal mango is grown in nearly 97.33 thousand ha area with the production of about 836.07 thousand MT and the area under nursery cultivation of mango is roughly estimated to be thousand hectares (Anonymous, 2018) [3]. If the timely interference is not done, the quality of the fruit is affected and may cause huge yield loss (Rajkumal *et al*., 2013) [11]. In this regard present investigation was undertaken to study on the efficacy of newer and safer insecticides against mango hoppers and their effect on non target organism in mango orchard.

Materials and Methods
The field study was conducted at B.C.KV, Mohanpur, Nadia, West Bengal, India on selected uniform plants (12-15 years old, spaced 10 m apart) of variety Amrapali in randomized block design with three replication of each treatment with an untreated check of water spray. One tree served as one replication. The experiment comprised of seven treatments (including control) *viz*. Flonicamid 50%WG @ 15 g a.i. ha^{-1} , Flonicamid 50%WG @ 20 g a.i. ha^{-1}, Flonicamid 50% WG @ 25 g a.i. ha^{-1}, Imidacloprid 17.8 % SL @ 25 g a.i. ha^{-1}, Lambda cyhalothrin 5% EC @ 5 g a.i. ha^{-1} and Dimethoate 30% EC @ 50 g a.i. ha^{-1}. The quantity of each insecticide required for spraying was calculated on the basis of the active ingredients of their commercial product. During 1st season, the first spray was given at bud stage on 15th February 2016, second spray at pre-anthesis stage on 3rd March 2016. During 2nd season the first spray was given at bud stage on 15th February 2017 and second spray at pre-anthesis stage on 3rd March 2017.

Pre-treatment count (PT) of mango hopper population, both nymphs and adults were taken from three panicles dividing the plant into 4 quadrants. The population was counted at 3, 10 and 15 days after each of the first and second spray. The observations were taken within 7 am to 9 am in the morning. Pest incidence in the study was expressed as pest population count and mortality percentage at different dates after each of the sprays and was subjected to necessary transformation wherever needed. The percentage reduction of mango hoppers population was computed by using Henderson-Tilton's formula.

$$\text{Mortality (\%)} = 1 - (Ta \times Cb)/(Tb \times Ca) \times 100$$

Where: Ta – No. of insects in the treatment after spraying, Tb – No. of insects in the treatment before spraying, Ca – No of insects in the untreated check after spraying, Cb – No. of insects in the untreated check before spraying.

Result and Discussion

Efficacy of insecticides against mango hopper

The pretreatment count of mango hopper varied from 18.33 to 21.75 during first season of 2016 before application of insecticides (Table-1). The results revealed that all the treatments were significantly superior in reducing hopper population as well as increasing yield over the untreated control. The mean result of first spray also followed similar trend with highest mean mortality in the plots treated with Flonicamid 50% WG @ 25 g a.i. ha^{-1} (89.69%) followed by Flonicamid 50% WG 20 @ g a.i. ha^{-1} (82.45%), Flonicamid 50% WG @ 15 g a.i. ha^{-1} (80.07%), Imidacloprid 17.8 % SL @ 25 g a.i. ha^{-1} (35.26%), Lambda cyhalothrin 5% EC @ g a.i. ha^{-1} (32.09%) and Dimethoate 30% EC @ 50 g a.i. ha^{-1} (31.72%). Similarly, the relative efficacy of the insecticides tested in the present investigation after 2nd spray is presented in (Table-1). The mean calculated data of second spray also followed similar trend with highest mean mortality in the plots treated with Flonicamid 50% WG @ 25 g a.i. ha^{-1} (89.48%) followed by followed by Flonicamid 50% WG @ 20 g a.i. ha^{-1} (87.04%), Flonicamid 50% WG @ 15 g a.i. ha^{-1} (82.82%), Imidacloprid 17.8 % SL @ 25 g a.i. ha^{-1} (71.59%), Lambda cyhalothrin 5% EC @ 5 g a.i. ha^{-1} (56.73%) and Dimethoate 30% EC @ 50 g a.i. ha^{-1} (54.49%). The overall efficacy of first season data indicated that all the treatments were found to be significantly effective in controlling mango hopper over untreated control. Flonicamid 50% WG @ 25 g a.i. ha^{-1} proved to be the most effective insecticide with highest overall mortality (89.59%), followed by Flonicamid 50% WG @ 20 g a.i. ha^{-1} (84.75%), Flonicamid 50% WG @ 15 g a.i. ha^{-1} (81.44%), Imidacloprid 17.8 % SL @ 25 g a.i. ha^{-1} (53.43%), Dimethoate 30% EC @ 50 g a.i. ha^{-1} (43.11%) and Lambda cyhalothrin 5% EC @ 5 g a.i. ha^{-1} (42.91%). Whereas, data of second season (Table-2) revealed that all the insecticides tested in the present investigation were found superior in reducing the hopper population over the untreated control. The overall efficacy indicated that the highest percent reduction was registered in Flonicamid 50% WG @ 25 g a.i. ha^{-1}, which gave highest mortality (88.77%) followed by Flonicamid 50% WG @ 20 g a.i. ha^{-1} (82.30%), Flonicamid 50% WG @ 15 g a.i. ha^{-1} (77.79%), Imidacloprid 17.8 % SL @ 25 g a.i. ha^{-1} (48.86%), Dimethoate 30% EC @ 50 g a.i. ha^{-1} (43.6%) and Lambda cyhalothrin 5% EC @ 5 g a.i. ha^{-1} (42.1%). Kangle *et al.* (2019) [5] reported that Flonicamid was moderately effective against mango hoppers. Earlier, Naik *et al.* (2017) [7] stated that the maximum per cent reduction in cotton leafhopper population was recorded in Flonicamid 50% WG@ 50 g a.i. ha^{-1} and was the most effective treatments, which was significantly superior as compared to other treatments. Effective control of major sucking pests were recorded with application of newer molecule flonicamid 50% WG @ 100 g a.i. ha^{-1} on Bt cotton as reported by Nemade *et al*. (2017) [9].

Effect on natural enemy of mango

The insecticides used for efficacy study against mango hoppers were found to be safe against natural enemies like spider and lacewing (Table-3&4). Among the treatments Flonicamid 50% WG @ 25 g a.i. ha^{-1} have shown excellent safety against spider and lacewings. The incidence of spider as recorded (mean data) in Flonicamid 50% WG @ 25 g a.i. ha^{-1} treated plot was 3.99/plant in 2016 and it was and 4.16/plant during 2017. The incidence of lacewing recorded (mean data) in Flonicamid 50% WG @ 25 g a.i. ha^{-1} treated plot was 2.72 per plant in 2016 and 3.52/plant during 2017. Pooled mean data (Table 3 and 4) showed that all the plots treated with Flonicamid 50% WG @ 25 g a.i. ha^{-1} were safe for two important predators recorded in experimental field. Kangle *et al.* (2019) [5] reported that Flonicamid was found safer and showed less impact on natural enemies like lady bird beetel. Effect of Flonicamid 50WG @ 50, 75 and 100 g a.i. ha^{-1} against predatory complex on Bt cotton was studied and flonicamid was found comparatively safer to predatory complex as reported by Chandi *et al.*, 2016 [5].

Effect on yield

From overall observation (Table-5) it can be said that treatment plots have higher yield than untreated control. The highest mango yield of 74.4 Q/ha and 80.6 Q/ha were obtained in the treatment of Flonicamid 50% WG @ 25 g a.i. ha-1 during of 2016 and 2017. Cost benefit ratio for both the seasons revealed that the highest cost benefit ratio was observed in the treatment Flonicamid 50% WG @ 25 g a.i. ha^{-1} (Table-6).

Phytotoxic effect of insecticidal treatments on mango plants

The results of two season experiments were presented in (Table-7&8), which showed that application of Flonicamid 50% WG @ 25 g a.i. ha-1 was non phytotoxic to mango crop as no phytotoxic symptoms like, yellowing, Chlorosis, epinasty, hyponasty, vein clearing, scorching (leaf injury on tips/surface), necrosis and wilting could be observed after 3, 7 and 10 days of each spray.

Table 1: Effect of first and second spray (2016) of insecticides against mango hoppers at B.C.K.V, Mohanpur and West Bengal.

Treatment	Dose (g a. i/ha)	PT	First spray			Mean	PT	Second spray			Mean	Overall Mean
			%mortality at DAS					%mortality at DAS				
			3 DAA	7 DAA	10DAA			3 DAA	7 DAA	10 DAA		
T1-Flonicamid 50% WG	15	23.66	78.74 (62.54)	83.93 (66.37)	77.54 (61.71)	80.07	18.67	81.59 (64.59)	86.79 (68.68)	80.07 (63.48)	82.82	81.44
T2-Flonicamid 50% WG	20	20.33	84.27 (66.63)	83.00 (65.65)	80.08 (63.49)	82.45	17.92	84.56 (66.87)	90.53 (72.08)	86.05 (68.07)	87.04	84.75
T3- Flonicamid 50% WG	25	22.5	90.42 (71.97)	89.67 (71.25)	88.97 (70.60)	89.69	19.33	90.87 (72.42)	88.82 (70.47)	88.76 (70.41)	89.48	89.59
T4-Imidacloprid 17.8 % SL	25	21.08	33.31 (35.25)	44.66 (41.94)	27.80 (31.82)	35.26	19.25	71.87 (57.97)	72.11 (58.12)	70.79 (57.29)	71.59	53.43
T5- Lambda cyhalothrin 5% EC	5	21.75	32.44 (34.72)	39.72 (39.07)	24.13 (29.42)	32.09	18.25	53.57 (47.05)	60.29 (50.94)	56.34 (48.64)	56.73	42.91
T6- Dimethoate 30% EC	50	18.33	33.48 (35.35)	40.28 (39.40)	21.39 (27.55)	31.72	18.42	55.46 (48.13)	54.07 (47.33)	53.95 (47.27)	54.49	43.11
T7-Untreated control		21.16	+17.98 (0.00)	+17.92 (0.00)	+18.10 (0.00)		18.91	+15.49 (0.00)	+24.71 (0.00)	+23.08 (0.00)		
S.Em(±)			2.90	2.30	1.75			1.87	1.76	1.16		
CD at 5%			9.06	7.16	5.44			5.82	5.49	3.61		
CV %			12.39	9.834	8.04			7.66	7.60	4.64		

Figures in parentheses are arcsine transformed value, *DAA: Days after spray, PT: Pretreatment count

Table 2: Effect of first and second spray (2017) of insecticides against mango hoppers at B.C.K.V, Mohanpur and West Bengal

Treatment	Dose (g a. i/ha)	PT*	First spray			Mean	PT	Second spray			Mean	Overall Mean
			%mortality at DAA*					%mortality at DAA				
			3 DAA	7 DAA	10 DAA			3 DAA	7 DAA	10 DAA		
T1-Flonicamid 50% WG	15	22.58	75.68 (60.45)	75.54 (60.36)	79.02 (62.74)	76.75	20.58	73.91 (59.28)	78.66 (62.49)	82.68 (65.40)	78.42	77.79
T2-Flonicamid 50% WG	20	22.17	79.77 (63.27)	82.68 (65.41)	86.74 (68.65)	83.06	19.08	76.89 (61.27)	80.41 (63.73)	87.35 (69.17)	81.55	82.30
T3- Flonicamid 50% WG	25	19.08	86.00 (68.02)	89.54 (71.13)	88.51 (70.19)	88.02	18.92	87.14 (68.99)	91.21 (72.76)	90.19 (71.75)	89.51	88.77
T4-Imidacloprid 17.8 % SL	25	24.75	49.04 (44.43)	53.51 (47.01)	54.59 (47.63)	52.38	21.83	31.46 (34.12)	49.14 (44.51)	55.40 (48.10)	45.33	48.86
T5- Lambda cyhalothrin 5% EC	5	20.25	39.36 (38.86)	40.01 (39.24)	52.31 (46.33)	43.89	18.92	27.89 (31.88)	43.73 (41.40)	49.30 (44.60)	40.31	42.1
T6 Dimethoate 30% EC	50	21.42	42.69 (40.80)	50.11 (45.06)	52.85 (46.63)	48.55	20.92	31.54 (34.17)	41.53 (40.13)	42.88 (40.91)	38.65	43.6
T7-Untreated control		22.42	+26.02 (0.00)	+35.22 (0.00)	+38.30 0.00		20.50	+28.43 (0.00)	+26.08 (0.00)	+25.37 (0.00)	0.00	0.00
S.Em(±)			1.95	2.52	2.02			2.99	2.42	1.50		
CD at 5%			6.07	7.85	6.30			9.33	7.54	4.68		
CV %			8.45	10.64	8.19			13.89	10.30	6.21		

Figures in parentheses are arcsine transformed value, *DAA: Days after spray, PT: Pretreatment count

Table 3: Efficacy of different treatments against natural enemy (Spider) at experimental field during February to April in 2016 and 2017.

Treatment	Dose (g a. i/ha)	PT	Number of spiders			Mean	PT	Number of spiders			Mean
			2016					2017			
			3 DAA	7 DAA	10 DAA			3 DAA	7 DAA	10 DAA	
T1-Flonicamid 50% WG	15	3.16	4.12 (2.03)	3.49 (1.87)	3.85 (1.96)	3.82	3.22	3.66 (1.91)	3.98 (1.99)	3.60 (1.90)	3.75
T2-Flonicamid 50% WG	20	3.05	3.33 (1.82)	3.37 (1.83)	3.39 (1.84)	3.36	3.39	3.84 (1.96)	3.18 (1.78)	3.22 (1.79)	3.41
T3- Flonicamid 50% WG	25	3.39	3.92 (1.98)	4.05 (2.01)	4.01 (2.00)	3.99	3.93	4.22 (2.05)	4.17 (2.04)	4.10 (2.03)	4.16
T4-Imidacloprid 17.8 % SL	25	2.94	3.45 (1.86)	2.81 (1.68)	3.24 (1.80)	3.17	2.27	2.81 (1.68)	2.94 (1.72)	3.20 (1.78)	2.98
T5- Lambda cyhalothrin 5% EC	5	2.87	3.67 (1.92)	2.89 (1.70)	3.18 (1.78)	3.25	3.18	3.68 (1.92)	3.44 (1.85)	3.81 (1.95)	3.64
T6 Dimethoate 30% EC	50	3.03	3.53 (1.88)	3.12 (1.77)	3.22 (1.79)	3.29	3.08	2.52 (1.59)	3.30 (1.82)	3.41 (1.84)	3.08
T7-Untreated control		3.31	3.78 (1.94)	3.46 (1.86)	3.67 (1.91)	3.64	2.96	3.11 (1.76)	3.50 (1.87)	3.86 (1.97)	3.49
			NS	NS	NS			NS	NS	NS	

Values in parentheses represent square root (√X + 1) transformed values for statistical analysis; NS: Non significant.

Table 4: Efficacy of different treatments against natural enemy (Lacewing) at experimental field during the period from February to April in 2016 and 2017.

Treatment	Dose (g a. i/ha)	PT	Number of lacewings 2016			Mean	PT	Number of lacewings 2017			Mean
			3 DAA	7 DAA	10 DAA			3 DAA	7 DAA	10 DAA	
T1-Flonicamid 50% WG	15	2.37	2.54 (1.59)	2.48 (1.58)	2.57 (1.60)	2.53	3.13	3.57 (1.88)	3.39 (1.84)	3.00 (1.73)	3.32
T2-Flonicamid 50% WG	20	1.92	2.17 (1.47)	2.29 (1.51)	2.27 (1.51)	2.24	2.35	2.28 (1.51)	2.41 (1.55)	2.69 (1.64)	2.46
T3- Flonicamid 50% WG	25	2.28	2.58 (1.61)	2.65 (1.63)	2.92 (1.71)	2.72	3.18	3.63 (1.90)	3.66 (1.91)	3.27 (1.80)	3.52
T4-Imidacloprid 17.8 % SL	25	2.12	2.36 (1.54)	2.11 (1.45)	2.45 (1.57)	2.31	2.47	2.93 (1.71)	2.40 (1.54)	2.67 (1.63)	2.67
T5- Lambda cyhalothrin 5% EC	5	2.09	2.09 (1.45)	2.19 (1.48)	2.30 (1.51)	2.19	2.52	2.81 (1.67)	2.79 (1.67)	2.45 (1.56)	2.68
T6 Dimethoate 30% EC	50	1.73	2.03 (1.43)	1.96 (1.40)	2.34 (1.53)	2.11	2.76	3.14 (1.77)	2.94 (1.71)	2.79 (1.67)	2.96
T7-Untreated control		2.07	2.35 (1.53)	2.07 (1.44)	2.12 (1.46)	2.18	2.19	2.52 (1.58)	2.81 (1.68)	2.36 (1.53)	2.56
			NS	NS	NS			NS	NS	NS	

Values in parentheses represent square root (√X + 1) transformed values for statistical analysis; NS: Non significant.

Table 5: Effect of different treatments on yield of mango

Treatments	Dose (g a. i/ha)	Mean fruit yield quintal/ha		Mean
		2016	2017	
TI- Flonicamid 50% WG	15	56.2	57.8	57
T2- Flonicamid 50% WG	20	65.3	66.5	65.9
T3- Flonicamid 50% WG	25	74.4	80.6	77.5
T4-Imidacloprid 17.8 % SL	25	40.4	40.9	40.65
T5- Lambda cyhalothrin 5% EC	5	41.2	39.9	40.55
T6 Dimethoate 30% eC	50	42.8	45.3	44.05
T7- Untreated control		31.7	30.9	31.3
S.Em(±)		3.03	1.87	
CD at 5%		8.93	5.51	

Table 6: Cost benefit ratio

Treatments	Dose (g a. i/ha)	Mean fruit yield quintal/ha	
		2016	2017
TI- Flonicamid 50% WG	15	1: 1.87	1: 1.93
T2- Flonicamid 50% WG	20	1: 1.98	1: 2.01
T3- Flonicamid 50% WG	25	1: 2.38	1: 2.69
T4-Imidacloprid 17.8 % SL	25	1: 1.34	1: 1.36
T5- Lambda cyhalothrin 5% EC	5	1: 1.36	1: 1.33
T6 Dimethoate 30% EC	50	1: 1.43	1: 1.51
T7- Untreated control		1: 1.05	1: 1.03

Table 7: Evaluation of Phytotoxicity due to spraying of Flonicamid 50% WG in mango during 2016 (Season-1)

Treatments	Dose (g a. i/ha)	Days after application (mean of two sprays)																				
		Yellowing			Epinasty			Hyponasty			Necrosis			Wilting			Vein clearing			Scorching		
		3	5	7	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7
Flonicamid 50% WG	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flonicamid 50% WG	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8: Evaluation of Phytotoxicity due to spraying of Flonicamid 50% WG in mango during 2017 (Season-2)

Treatments	Dose(g a. i/ha)	Days after application (mean of two sprays)																				
		Yellowing			Epinasty			Hyponasty			Necrosis			Wilting			Vein clearing			Scorching		
		3	5	7	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7
Flonicamid 50% WG	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flonicamid 50% WG	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Conclusion

From the present study it can be concluded that Flonicamid 50% WG was proved significantly superior over rest of the treatments as it possesses good bio-efficacy against pests as well as had ideal CBR and was eco friendly in nature. Flonicamid 50% WG can be used as insecticides against mango hoppers in mango orchard.

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