International Journal of Entomology Research
ISSN: 2455-4758
Impact Factor: RJIF 5.24
www.entomologyjournals.com
Volume 3; Issue 2; March 2018; Page No. 164-167

Field efficacy of emamectin benzoate 1.9 EC against shoot and fruit borer of okra

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Abstract
Bio-efficacy of various insecticides were evaluated in Okra at two season in Vilacherri, Madurai (I year: August 2015 to December 2015 and II Year: August 2016 to December 2016) of Tamil Nadu. The new formulation of emamectin benzoate 1.9 EC was evaluated at different doses (5.00, 6.75, 8.50 and 11.00 g a.i. ha^{-1}) along with two standard standard checks, pyridalyl 10 EC (50 g a. i. ha^{-1}) and lamda cyhalothrin 5 CS (15 g a.i. ha^{-1}) for comparision and untreated control against shoot and fruit borer in Okra eco-system. The fruit borer infestation was recorded prior to spraying and at 3, 7, 10 and 14 days after each spraying from ten randomly selected plants in each treatment. The lowest mean percent fruit damage was recorded in plots treated with Emamectin Benzoate 1.9 EC at 11.00 g a.i. ha^{-1} followed by emamectin benzoate 1.9 EC at, 8.50 and 6.75 g a.i. ha^{-1}.

Keywords: shoot and fruit borer, *Earias vitella* (Fabricius), emamectin benzoate 1.9 EC, okra

1. Introduction
The major constraint for the low productivity of okra is its more vulnerable to attack of pests. Among all pests, shoot and fruit borer, *Earias vitella* (Fabricius) is the most destructive pest of okra as young larva borers into tender shoots in early vegetative growth of plants. (Dhaker *et al*., 2017) [4]. Grown up larva damages many fruits results in in 54.04% yield loss and also reduces the vitality of the plant (Sivakumar *et al.,* 2003) [16]. The average fruit damage had been estimated to be (35-76%) (Narke and Suryawanshi, 1987) [12]. Indiscriminate use of organo phosphates, carbamates and synthetic pyrethroids had created number of problems such as insect resistance to insecticides (McCaffery *et al.,* 1989) [10], pest resurgence (Hardin *et al.,* 1995) [7] and pesticide residued in consumable produce at harvest (Rolando *et al.,* 1982) [14]. So it was important to adopt or use some newer insecticide molecules with high toxicity even at lower doses and should also be safer to the natural enemies present in the agro eco-system. One such insecticide was emamectin benzoate a semi synthetic derivative of avermectin produced as fermentation metabolites of soil actinomycetes, *Streptomyces avermitilis* Burg (Lasoata and Dybas, 1991) [9]. Hence the present investigation aimed as under taken to evaluate the efficacy of emamectin benzoate1.9 EC against shoot and fruit borer in okra ecosystem.

2. Materials and Methods
Field experiments were conducted, at Vilacherri, Madurai (I year: August 2015 to December 2015) and Vilacherri (II year: August 2016 to December 2016) of Tamil Nadu to evaluate the efficacy of new formulation emamectin benzoate 1.9 EC at different doses (5.00, 6.75, 8.50 and 11.00 g a.i ha^{-1}) along with two standard checks pyridalyl 10 EC and lamda cyhalothrin 5 CS for comparision and untreated control against shoot and fruit borer of okra.
The experiments were conducted in randomized block design (RBD) with seven treatments replicated thrice with a plot size of 4 m × 5 m using the variety NOKH-1013 hybrid obtained from Nuziveedu seeds. During both the years two sprayings were given at 14 days interval starting from 45 days after sowing. Pneumatic knapsack sprayer (Aspee sprayer) using 500 litres of spray fluid per hectare was used to spray various doses of test insecticide. Shoot and fruit borer damage was recorded in all the treatments prior to spraying and at 3, 7, 10 and 14 days after each spraying from 10 randomly selected plants.

3. Statistical Analysis
Data were subjected to analysis of variance (ANOVA). Before analysis, data on population were transformed into square root transformation. In order to know the interaction among treatments, data from field experiment were subjected to factorial RBD analysis (Gomez *et al.,* 1984) [5]

4. Results and Discussion
The results revealed that in the first year, the mean percent fruit damage prior to first spraying was ranged from 24.41 to 27.16 percent per ten plants (Table 1).
On 3rd DAT, the lowest mean damage was recorded in emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} (16.56 per cent) followed by emamectin benzoate. 9 EC at 8.5 g a.i.ha^{-1} (16.67%) were on par with each other. On 7 th DAT emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} was shown better result (14.83%) than other treatments in reducing larval population. The lower dose of emamectin benzoate 1.9 EC at 5.0 and 6.75 g a.i. ha^{-1} recorded 20.67 and 16.07 per cent fruit damage respectively. The standard check pyridalyl 10 EC recorded 19.25 per cent damage followed by lamda cyhalothrin 5 CS (19.74%) at 7th DAT. The same trend was observed at 10th DAT. The slight increase in the fruit damage was noticed at 14th DAT. The overall mean percent damage was lowest in emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} treated plots (14.75%) which showed on par result with emamectin

benzoate 1.9 EC at 8.5 g a.i. ha^{-1} (15.22 %). After first application, the highest reduction in fruit damage over control was recorded in plots treated with emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} (50.71 per cent) followed by emamectin benzoate 1.9 EC at 8.5 g a.i. ha^{-1} (49.13 per cent).

A similar trend was noticed during second spray also (Table 2) in which, emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} recorded a mean damage of 8.48 per cent followed by emamectin benzoate 1.9 EC at 8.5 g a.i. ha^{-1} (8.65%) The lower dose of emamectin benzoate 1.9EC at 5.00 and 6.75 g a.i. ha^{-1} recorded 14.43 and 9.48 per cent damage respectively and standard check, pyridalyl 10 EC at 50 g a.i. ha^{-1} recorded 12.54 per cent damage followed by lamdacyhalothrin (13.36%). Untreated control plot observed highest percent damage of 36.57%. Based on the per cent reduction over untreated check, the order of efficacy of different treatments was as follows: emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1}= emamectin benzoate 1.9 EC at 8.5 g a.i. ha^{-1} = emamectin benzoate 1.9 EC 6.75 g a.i. ha^{-1} > pyridalyl 10 EC > lamdacyhalothrin 5 CS at 5 g a.i.ha^{-1} > emamectin benzoate 1.9 EC @ 5.00 g a.i. ha^{-1} > untreated check. Superiority of emamectin benzoate $^{@}$ 8.5 g a.i. ha ^{1} against shoot and fruit borer in the present investigation is in agreement with Bhemanna *et al*., (2005) [3] who found that emamectin benzoate @8.5 g a.i. ha^{-1} was highly promising against okra fruit borer Kuttalm *et al*., (2008) [8] reported that emamectin 5 EC@ 13 and 15 g a.i. ha^{-1} was effective in suppressing larval population as compared to other insecticides. Bansode *et al.*, (2015) [2] observed that the emamectin benzoate @ 9.5 g a. i. ha^{-1}reduced the percent fruit infestation in bhendi upto 13.62 percent and Aarwe *et al*., (2017) [1] observed that the emamectin benzoate @ 15 g a.i. ha -1 recorded lowest fruit damage (13.61 %) compared to control (39.58 %) in bhendi crop.

The percent damage of fruit borers in the second year, before imposing treatments ranged from 21.91 to 23.32% (Table 3). On 3rd DAT, the lowest mean damage was recorded in emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} (18.76%) followed by emamectin benzoate 1.9 EC at 8.5 g a.i.ha^{-1} (19.69%) which were on par with each other. On 7th DAT emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} was shown better result (15.34 %) than other treatments in reducing larval population. The lower doses of emamectin benzoate 1.9 EC at 5.0 and 6.75 g a.i. ha^{-1} recorded 19.25 % 16.24% damage of fruit respectively. The standard check pyridalyl 10 EC recorded 17.24% damage followed by lamda cyhalothrin 5 CS (18.65%) at 7th DAT. The same trend was observed at 10th DAT. The slight increase in the percent damage was noticed at 14th DAT. The mean percent damage was lowest in emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} treated plots (15.04%) on par result with emamectin benzoate 1.9 EC at 8.5 g a.i. ha^{-1} (15.44 %). Among the insecticidal treatments, the highest fruit damage was recorded in plots treated with emamectin benzoate 1.9 EC at 5 g a.i. ha^{-1} (19.35 per cent). After first application, the highest reduction in fruit damage over control was recorded in plots treated with emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} (42.63 per cent) followed by emamectin benzoate 1.9 EC at 8.5 g a.i. ha^{-1} (41.12 per cent). Sontakke *et al.* (2007) [17] observed that emamectin benzoate 5 SG @8.5 g a.i. ha^{-1}was effective in controlling the fruit borer in okra. Yadav *et al* (2017) [19] observed the minimum percent infestation of shoot and fruit borer at emamectinbenzoate 5 SG @15 g a. i. ha^{-1} treated bhendi crop The results are in accordance with the findings of Govindan *et al., (*2012) [6]. Ememctin benzoate 5 SG @ 200gm per ha recorded comparatively lower fruit and shoot damage and gave higher fruit yield in brinjal (Roy *et al.*, 2016) [15].

A similar trend was noticed during second spray also (Table 4) in which, emamectin benzoate 1.9 EC at 11 g a.i. ha^{-1} recorded a mean damage of 7.85 per cent followed by emamectin benzoate 1.9 EC at 8.5 g a. i. ha^{-1} (8.18 %) The lower doses of emamectin benzoate 1.9EC at 5.00 and 6.75 g a.i. ha^{-1} recorded 13.49 and 8.48 per cent damage respectively and standard check, pyridalyl 10 EC at 50 g a.i. ha^{-1} recorded 10.08 per cent damage followed by lamdacyhalothrin (12.30 %). Untreated control plot observed highest percent damage of 36.10 percent. Prakash and Tomar (2009) [13] stated that the emamectin benzoate 5 SG @11 g a.i. ha^{-1} recorded the lowest boll damage in cotton. Meena *et al*., (2006) [11] found that emamectin benzoate 5 SG @ 11 g a.i. ha^{-1} was effective in reducing pod and grain damage in pigeon pea. The reduced efficacy of insecticide after 10 DAT and the subsequent increase in the larval population might be due to the influence of environmental factors like sun light and temperature which were responsible for the decay of insecticides, as reported by Wilson *et al*. (1986) [18].

Table1: Effect of Emamectin benzoate 1.9 % EC against fruit borer damage in okra after first spray (I year)

Treatments	Dose (g a.i. ha^{-1})	Mean percent fruit damage per ten plants						Percent reduction over control
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	Mean	
Emamectin benzoate 1.9 EC	5.00	24.41 (29.61)	21.88 (27.84)	20.67 (27.00)	18.38 (25.32)	18.91 (25.68)	19.96	33.29
Emamectin benzoate 1.9 EC	6.75	25.02 (30.01)	18.45 (25.40)	16.07 (23.61)	14.65 (22.50)	14.93 (22.96)	16.10	46.19
Emamectin benzoate 1.9 EC	8.50	25.29 (30.19)	16.67 (24.02)	15.52 (23.04)	13.83 (21.68)	14.86 (22.63)	15.22	49.13
Emamectin benzoate 1.9 EC	11.00	25.00 (29.99)	16.56 (23.99)	14.83(22.41)	13.54 (21.54)	14.06 (22.00)	14.75	50.71
Pyridalyl 10 EC	50	27.16 (31.41)	20.48 (26.85)	19.25 (26.02)	15.38 (23.08)	15.90 (23.49)	17.75	40.67
Lamda cyhalothrin 5 CS	15	26.01 (30.67)	21.07 (27.31)	19.74 (26.30)	15.85 (23.45)	16.39 (23.86)	18.26	38.96
Untreated check		26.59 (31.04)	27.01 (31.31)	29.70 (33.02)	30.85 (33.67)	32.13 (34.41)	29.92	
SEd			1.34	2.24	2.13	2.08		
CD(P=0.05)		NS	2.92	4.90	4.64	4.54		

PTC- Pretreatment count; DAT- Days after treatments, * Mean of three replications, Figures in parentheses are arc sin transformed values*;*

Table 2: Effect of Emamectin benzoate 1.9 % EC against fruit borer damage in okra after second spray (I year)

Treatments	Dose (g a.i. ha^{-1})	Mean percent fruit damage per ten plants						Percent reduction over control
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	Mean	
Emamectin benzoate 1.9 EC	5.00	18.91 (25.68)	17.44 (24.67)	12.74 (20.91)	13.68 (21.70)	13.87 (21.86)	14.43	60.53
Emamectin benzoate 1.9 EC	6.75	15.23(22.96)	13.62 (21.65)	10.32 (18.74)	6.86 (15.18)	7.12 (15.48)	9.48	74.07
Emamectin benzoate 1.9 EC	8.50	14.86 (22.63)	13.19 (21.29)	8.18 (16.62)	6.56 (14.83)	6.65 (14.94)	8.65	76.36
Emamectin benzoate 1.9 EC	11.00	14.06 (22.00)	12.94 (21.08)	7.93 (16.36)	6.47 (14.73)	6.56 (14.84)	8.48	76.83
Pyridalyl 10 EC	50	15.90 (23.49)	14.95 (22.75)	12.60 (20.78)	11.22 (19.57)	11.38 (19.72)	12.54	65.72
Lamda cyhalothrin 5 CS	15	16.39 (23.86)	15.43 (23.13)	13.58 (21.61)	12.16 (20.41)	12.28 (20.51)	13.36	63.46
Untreated check		32.13 (34.41)	34.76 (36.13)	34.76 (36.13)	37.62 (37.83)	39.13 (38.72)	36.57	
SEd		2.08	0.48	0.49	0.30	0.47		
CD(P=0.05)		4.54	1.05	1.07	0.66	1.05		

PTC- Pretreatment count; DAT- Days after treatments, * Mean of three replications, Figures in parentheses are arc sin transformed values;

Table 3: Effect of Emamectin benzoate 1.9 % EC against fruit borer in okra after first spray (II Year)

Treatments	Dose (g a.i. ha^{-1})	Mean per cent fruit damage per ten plants						Percent reduction over control
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	Mean	
Emamectin benzoate 1.9 EC	5.00	22.31 (28.16)	21.25 (27.45)	19.25 (26.03)	17.65 (24.84)	19.25 (26.03)	19.35	26.20
Emamectin benzoate 1.9 EC	6.75	22.23 (28.13)	20.64 (27.02)	16.24 (23.77)	13.17 (21.28)	14.52 (22.40)	16.14	38.43
Emamectin benzoate 1.9 EC	8.50	22.88 (28.58)	19.69 (26.34)	15.71 (23.35)	12.57 (20.76)	13.78 (21.79)	15.44	41.12
Emamectin benzoate 1.9 EC	11.00	21.91 (27.89)	18.76 (25.66)	15.34 (23.06)	12.41 (20.63)	13.66 (21.69)	15.04	42.63
Pyridalyl 10 EC	50	22.81 (28.52)	20.72 (27.08)	17.24 (24.53)	16.26 (23.78)	16.82 (24.21)	17.76	32.27
Lamda cyhalothrin 5 CS	15	23.32 (28.87)	21.24 (27.44)	18.65 (25.59)	17.10 (24.43)	18.65 (25.59)	18.91	27.88
Untreated check		22.38 (28.23)	24.48 (29.65)	25.03 (30.02)	26.88 (31.23)	28.50 (32.26)	26.22	
SEd			0.45	0.34	0.17	0.35		
CD(P=0.05)		NS	0.99	0.74	0.37	0.76		

PTC- Pretreatment count; DAT- Days after treatments, * Mean of three replications, Figures in parentheses are arc sin transformed values

Table 4: Effect of Emamectin benzoate 1.9 % EC against fruit borer damage in okra after second spray (II Year)

Treatments	Dose (g a.i. ha^{-1})	Mean percent fruit damage per ten plants						Percent reduction over control
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	Mean	
Emamectin benzoate 1.9 EC	5.00	19.25 (26.03)	16.97 (24.29)	12.27 (20.49)	11.79 (20.08)	12.92 (21.07)	13.49	62.64
Emamectin benzoate 1.9 EC	6.75	14.52 (22.40)	12.73 (20.89)	7.28 (15.64)	6.73 (15.03)	7.17 (15.53)	8.48	76.52
Emamectin benzoate 1.9 EC	8.50	13.78 (21.79)	12.49 (20.68)	6.86 (15.18)	6.36 (14.60)	7.00 (15.32)	8.18	77.35
Emamectin benzoate 1.9 EC	11.00	13.66 (21.69)	11.70 (19.99)	6.56 (14.82)	6.31 (14.53)	6.82 (15.14)	7.85	78.26
Pyridalyl 10 EC	50	16.82 (24.21)	13.18 (21.27)	9.84 (18.26)	8.38 (16.83)	8.90 (17.34)	10.08	72.09
Lamda cyhalothrin 5 CS	15	18.65 (25.59)	15.41 (23.10)	11.17 (19.48)	10.75 (19.13)	11.87 (20.14)	12.30	65.93
Untreated check		28.50 (32.26)	33.81 (35.53)	34.29 (35.84)	36.19 (36.98)	40.10 (39.29)	36.10	
SEd		0.35	1.16	0.82	0.57	0.53		
CD(P=0.05)		0.76	2.54	1.79	1.25	1.16		

PTC- Pretreatment count; DAT- Days after treatments, * Mean of three replications, Figures in parentheses are arc sin transformed values

5. Conclusion

The present study can be concluded that emamectin benzoate 1.9 EC @ 6.5 g a. i. ha-1 could be better option and farmers may be advised to use this insecticide for the effective control of shoot and fruit borer in okra ecosystem.

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