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Evaluation of persistent toxicity of emamectin benzoate 5 SG to *Helicoverpa armigera* (Hubner) on cotton and *Earias vittella* (Fabricius) on okra

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Abstract
A lab experiment was conducted at Tamil Nadu Agricultural University in CRD and replicated thrice to study the persistence of emamectin benzoate in potted cotton and okra plant under glass house condition. The persistent toxicity tests with emamectin benzoate 5 SG (15 g a.i. ha^{-1}) recorded complete mortality of third instar larvae of *Helicoverpa armigera* on cotton and was observed up to 7 DAT, while it was single day for spinosad treated plants. More than 50 percent mortality was observed up to 11 DAT in emamectin benzoate 15 g a.i. ha^{-1} treatment, followed by emamectin benzoate 5 SG at 11 g a.i. ha^{-1} (42.6 percent), Proclaim® (40.1 percent) and spinosad (30.3 percent). Persistent toxicity of emamectin benzoate 5 SG at 11 g a.i. ha^{-1} was observed complete mortality of *Earias vittella* larvae up to 7 DAT indicating no change in the persistent period. However, there was significant variation in mortality at various levels of emamectin benzoate at 8.5 g a.i. ha^{-1} (15 days) and 11 g a.i. ha^{-1} (17 days). In the effective dose of emamectin benzoate at 8.5 g a.i. ha^{-1}, mortality was observed up to 15 DAT, with cent percent mortality only up to 5 DAT. The order of relative efficacy (ORE) of the insecticides based on the persistent toxicity index (PTI) values was emamectin benzoate 5 SG at 15 g a.i. ha^{-1} >emamectin benzoate at 11 g a.i. ha^{-1} >Proclaim®>emamectin benzoate at 9 g a.i. ha^{-1} >emamectin benzoate at 7 g a.i. ha^{-1} >spinosad.

Keywords: Cotton, persistence, emamectin benzoate, *Helicoverpa armigera*

Introduction
The residual toxicity resulting from foliar spray of insecticides could be of great significance in indicating an effective period over which an insecticide could persist in biologically active stage under field conditions. Emamectin benzoate by virtue of its translaminar activity, thereby provided a relatively prolonged residual action. As with abamectin, surface residues were decomposed rapidly in sunlight, resulting in a relatively low toxicity to beneficial insects (McConnell *et al.*, 1989; Jansson *et al.*, 1996) [7, 8]. Abamectin degrades rapidly when exposed to sunlight (Wislocki *et al.*, 1989) [10]. Despite its rapid photodecomposition, abamectin provided residual activity in the field due to its translaminar activity (Wright *et al.*, 1985; Dybas, 1989). Cent percent mortality of *Spodoptera exiqua* was recorded at 17 days after application of emamectin benzoate 5 EC @ 8.4 g a.i ha^{-1} on pepper plants and chick pea plants in glass house (Jansson *et al.*, 1997b) [6]. While emamectin benzoate was susceptible to photodegradation, reservoirs of the compound development in cotton leaf tissue, resulting in long residual activity under field conditions (Dunbar *et al*., 1998) [3]. Brevault *et al.* (2009) [2] reported that the persistence was found to be higher for emamectin benzoate 5 EC @10 g a.i ha^{-1} (10.6 days) followed by spinosad 45 SC @ 36 g a.i ha^{-1} (8.9 days) and persistence was lower for indoxacarb @ 25 g a.i ha^{-1} (3.7 days) and endosulfan @ 750 g a.i ha^{-1} (5.2 days) in cotton plants under simulated rainy condition.

Materials and Methods
Evaluation of persistent toxicity of emamectin benzoate 5 SG to *Helicoverpa armigera* on cotton
Pot culture experiments were conducted in the glass house in order to assess the persistent toxicity of emamectin benzoate as foliar application against third instar larvae of *H. armigera* with the following treatments in a completely randomized block design (CRD) and replicated thrice. Insecticidal solutions were prepared by dissolving 0.14, 0.18, 0.22 and 0.6 g of

emamectin benzoate 5 SG, 0.22 g of emamectin Benzoate (Proclaim® at the recommended dose of 11 g a.i. ha^{-1}), and 0.16 ml of spinosad 45 SC, each in one litre of water which were equivalent to the field doses. Non *Bt* cotton plants (Rasi 2000) grown in pots were sprayed with the insecticides at the respective concentrations at 60 days after sowing at the rate of 15 ml per plant using an atomizer. The leaves and shoot portion bearing flowers of cotton were cut after 1, 3, 7, 9, 11, 13, 15, 17, 19, 21 and 23 days after application and brought to the laboratory (Plate 1). Single third instar larva was released into each plastic cups and 10 tubes made one replication. Observations on larval mortality were recorded from each treatment at 24 h interval. For comparing the relative efficacy of different treatments, index of persistent toxicity values were calculated from mortality data as per the method method given by Pradhan (1967) [9]. Persistent toxicity index (PTI) = Period for which toxicity persisted (P) X Average residual toxicity (T).

Evaluation of persistent toxicity of emamectin benzoate 5 SG to *Earias vittella* on okra

Pot culture experiments were conducted in the glass house (insectary) in order to assess the persistent toxicity of emamectin benzoate against *E. vittella.* Thirty days old potted okra plants (Mahyco 10) were used for the study**.** Insecticidal solutions were prepared by dissolving 0.09, 0.13, 0.17 and 0.22 g of emamectin benzoate 5 SG, 0.17 g of emamectin Benzoate (Proclaim® at the recommended dose of 11 g a.i. ha^{-1}), and 0.16 ml of spinosad 45 SC, each in one litre of water which were equivalent to the field doses. Treated okra fruits were taken from the plants at different time intervals. Single third instar larva was released in to each plastic cup and 10 tubes made one replication.

Observations on larval mortality were recorded from each treatment at 24 h interval.

For comparing the relative efficacy of different treatments, index of persistent toxicity values were calculated from mortality data as per the method given by Pradhan (1967) [9].

Plate 1: Evaluation of persistent toxicity of emamectin benzoate 5 SG in cotton

Plate 2: Evaluation of persistent toxicity of emamectin benzoate 5 SG in cotton

Results and Discussion

The residual toxicity resulting from foliar spray of insecticides could be of great significance in indicating an effective period over which an insecticide could persist in biologically active stage under field conditions. The persistent toxicity tests with emamectin benzoate 5 SG (15 g a.i. ha^{-1}) recorded complete mortality of third instar larvae of *H. armigera* on cotton and *E. vittella* in okra was observed up to 7 DAT, while it was single day for spinosad treated plants.

Plate 3: Evaluation of persistent toxicity in okra fruits

Plate 4: Evaluation of persistent toxicity in cotton bolls

More than 50 percent mortality was observed up to 11 DAT in emamectin benzoate 15 g a.i. ha^{-1} treatment, followed by emamectin benzoate 5 SG at 11 g a.i. ha^{-1} (42.6 percent), Proclaim® (40.1 percent) and spinosad (30.3 percent). In the case of spinosad no mortality was observed at 11 DAT. There was a progressive reduction in the mortality of *H. armigera* larvae as the time increased. The order of relative efficacy (ORE) of the insecticides based on the persistent toxicity index (PTI) values was emamectin benzoate 5 SG at 15 g a.i. ha^{-1} >emamectin benzoate at 11 g a.i. ha^{-1} >Proclaim®>emamectin benzoate at 9 g a.i. ha^{-1} >emamectin benzoate at 7 g a.i. ha^{-1} >spinosad.

The results are in corroboration with the findings of Aiswariya (2010) [1] who reported that persistent toxicity tests with emamectin benzoate 5 WSG (13 g a.i. ha^{-1}) recorded complete mortality of third instar larvae of *H. armigera* on cotton and that was observed up to 7 DAT, while it was single day for Proclaim® and endosulfan treated plants. More than 50 percent mortality was observed up to 13 DAT in emamectin benzoate at 13 g a.i. ha^{-1} treatment, followed by emamectin benzoate at 11 g a.i. ha^{-1} (46.5 percent) while emamectin benzoate at 9 g a.i. ha^{-1} registered cent percent mortality of larvae up to 3 DAT. Govindan (2009) [5] reported that persistent toxicity tests with emamectin benzoate 5 SG (13 g a.i. ha^{-1}) recorded complete mortality of third instar larvae of *H. armigera* on cotton and that was observed up to 9 DAT, while it was single day for spinosad and endosulfan treated plants. More than 50 percent mortality was observed at 15 DAT in emamectin benzoate at 15 g a.i. ha^{-1} treatment, followed by emamectin benzoate at 11 g a.i. ha^{-1} (49.2%)

Table 1: Persistent toxicity of emamectin benzoate 5 SG to *H. armigera* in cotton

Treatments	Percent larval mortality at different exposure periods															
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**P**	**T**	**PTI**	**ORE**
Emamectin benzoate 5 SG @ 7g a.i. ha^{-1}	100	100	94.6	68.4	42.5	12.2	13.8	0	0	0	0	0	13	46.10	829.13	5
Emamectin benzoate 5 SG @ 9 g a.i. ha^{-1}	100	100	90.4	64.3	50.5	36.4	22.7	16.5	0	0	0	0	15	60.10	985.88	3
Emamectin benzoate 5 SG @ 11 g a.i. ha^{-1}	100	100	100	80.7	54.3	42.6	36.5	24.2	0	0	0	0	15	67.28	1071.19	2
Emamectin benzoate 5 SG @ 15 g a.i. ha^{-}	100	100	100	100	74.2	59.1	48.2	25.4	12.3	0	0	0	17	73.61	1251.39	1
Emamectin benzoate 5 SG @ 11g a.i. ha^{-1} (Proclaim®)	100	100	100	77.2	52.1	40.1	33.7	20.4	0	0	0	0	15	51.13	879.94	4
Spinosad 45 SC @ 75 g a.i. ha^{-1}	100	77.6	63.5	58.5	43.2	30.3	0	0	0	0	0	0	11	46.01	634.48	6

P – Period for which toxicity persisted (days), T- Average residual toxicity, PTI- Persistent toxicity index, ORE- Order of relative efficacy

Persistent toxicity of emamectin benzoate 5 SG at 11 g a.i. ha^{-1} was observed complete mortality of *E. vittella* larvae up to 7 DAT indicating no change in the persistent period. However, there was significant variation in mortality at various levels of emamectin benzoate at 8.5 g a.i. ha^{-1} (15 days) and 11 g a.i. ha^{-1} (17 days). In the effective dose of emamectin benzoate at 8.5 g a.i. ha^{-1}, mortality was observed up to 15 DAT, with cent percent mortality only up to 5 DAT. The ORE of the insecticides based on PTI values was emamectin benzoate at 11 g a.i. ha^{-1} > emamectin benzoate at 8.5 g a.i. ha^{-1} >Proclaim®> emamectin benzoate 6.7 g a.i. ha^{-1}> emamectin benzoate at 4.7 g a.i. ha^{-1} >spinosad.

These results were in conformity with that of Aiswariya (2010) [1] who reported that when emamectin benzoate at 9 g a.i. ha^{-1} was applied, there was complete mortality of *E. vittella* larvae up to 7 DAT indicating no change in the persistent period. However, there was significant variation in mortality at various levels of emamectin benzoate at 11 g a.i. ha^{-1} (15 days) and 13 g a.i. ha^{-1} (17 days). In the effective dose of EB at 9 g a.i. ha^{-1}, mortality was observed up to 15 DAT. Govindan (2009) [5] revealed that When EB 5 SG at 13 g a.i. ha^{-1} was applied, there was complete mortality of *E. vittella* larvae up to 9 DAT indicating no change in the persistent period. However, there was significant variation in mortality at various levels of emamectin benzoate 5 SG at 11 g a.i. ha^{-1} (19 days) and 13 g a.i. ha^{-1} (21 days).

Brevault *et al.* (2009) [2] reported that the persistence was found to be higher for emamectin benzoate 5 EC @ 10 g a.i ha^{-1} (10.6 days) followed by spinosad 45 SC @ 36 g a.i ha^{-1} (8.9 days) and indoxacarb @ 25 g a.i ha^{-1} (5.2 days) in cotton plants. Jansson *et al.* (1997b) [6] proved that cent percent mortality of *Spodoptera exigua* (Hubner) was recorded at 17 days after application of emamectin benzoate 5 EC @ 8.4 g a.i ha^{-1} on pepper plants and chickpea plants in glass house. Ishaaya *et al*. (2002) reported that emamectin benzoate at 25 mg a.i.l^{-1} provided 90 percent suppression of *H.armigera* up to 28 days. Translaminar movement of avermectin insecticides is the reason for the prolonged residual efficacy observed in a variety of crops under glass house and field conditions. According to Jansson *et al*. (1996) [7], excellent efficacy of emamectin benzoate was found up to 14-17 days after application when applied at a rate as low as 0.084 g a.i. ha^{-1} under glass house condition. But this could not be expected in the field as it is very susceptible to photodegradation.

Table 2: Persistent toxicity of emamectin benzoate 5 SG to *E. vittella* okra

Treatments	Percent larval mortality at different exposure periods															
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**P**	**T**	**PTI**	**ORE**
Emamectin benzoate 5 SG @ 4.7g a.i. ha^{-1}	100	100	80.2	52.6	36.5	22.6	14.5	0	0	0	0	0	13	55.75	836.25	5
Emamectin benzoate 5 SG @ 6.7 g a.i. ha^{-1}	100	100	89.5	76.1	46.2	37.5	17.6	8.3	0	0	0	0	15	63.03	945.41	3
Emamectin benzoate 5 SG @ 8.5 g a.i. ha^{-1}	100	100	100	78.2	60.1	39.0	19.5	10.6	0	0	0	0	15	68.30	1024.50	2
Emamectin benzoate 5 SG @ 11 g a.i. ha^{-}	100	100	100	100	86.7	68.5	42.3	26.8	8.7	0	0	0	17	70.33	1195.67	1
Emamectin benzoate 5 SG @ 8.5 g a.i. ha^{-1} (Proclaim®)	100	94.2	76.5	60.3	46.6	34.2	18.5	8.8	0	0	0	0	15	54.88	841.95	4
Spinosad 45 SC @ 75 g a.i. ha^{-1}	100	71.2	60.8	40.5	31.7	25.5	9.0	0	0	0	0	0	11	51.12	595.21	6

P – Period for which toxicity persisted (days), T- Average residual toxicity, PTI- Persistent toxicity index, ORE- Order of relative efficacy

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