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Persistent toxicity of newer molecule spinetoram 12 SC W/V (11.7 W/W) against *Helicoverpa armigera* Hubner and *Spodoptera litura* Fabricius on tomato

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Abstract
Pot culture experiments were conducted in the Insectary of AC & RI, Madurai in order to assess the persistent toxicity of spinetoram against *H. armigera* and *S. litura* on tomato fruits and leaves respectively. Insecticidal solutions were prepared by dissolving spinetoram 12 SC 0.6 ml, 0.75 ml and 0.9 ml, indoxacarb 14.5 SC 1.04 ml, novaluron 10 EC 1.5 ml and quinalphos 25 EC 2.0 ml in one liter of water which were equivalent to the field doses. Insecticide solutions treated tomato fruits and leaves were put in a container and released 20 numbers of *H. armigera* and *S. litura* respectively in each container. Observations on larval mortality were recorded from each treatment at 24 h intervals and calculate persistence toxicity. More than 50 per cent mortality of *H. armigera* larva was observed in spinetoram 12 SC at 45 and 54 g a.i./ha and indoxacarb 14.5 SC at 75 g a.i/ha upto 11 DAT where as that was upto 7 DAT for spinetoram 12 SC 36 g a.i/ha and novaluron 10 EC at 75 g a.i/ha. Spinetoram 12 SC was applied at 54 g a.i./ha, cent per cent mortality of third instar of *S. litura* larvae was observed at 1 DAT and 3 DAT, 90.87 at 5 DAT and there was no mortality after 21 DAT. The ORE of the insecticides based on PTI values was spinetoram 54 g a.i./ha > spinetoram 45 g a.i./ha > indoxacarb > novaluron > spinetoram 36 g a.i./ha > quinalphos.

Keywords: Persistence toxicity, Spinetoram 12 SC, *Helicoverpa armigera*, *Spodoptera litura*, tomato, *Saccharopolyspora spinosa*

Introduction
India is the second largest producer of vegetables after China with an average annual production of 87.5 million tonnes from 5.9 million hectares having a share of 14.4 per cent to the world production. Exported vegetables occupy 1.69 per cent of total vegetable production [1]. Among the vegetables, most popular table vegetable is tomato. Tomato (*Lycopersicon esculentum* Mill) is the most popular vegetable crop grown all over the world for fresh use as well as processing. It was cultivated in an area of 5.3 lakh ha and reaping yields to the extent of 9.0 million tonnes per annum in India during 2016 – 17. The average productivity is 17.8 q / ha, which is very low due to the attack of number of diseases and insect pests *viz*., tomato fruit borer (*Helicoverpa armigera* Hubner), tobacco caterpillar (*Spodoptera litura*), whitefly (*Bemisia tabaci* Gennadius) and leafhopper (*Amrasca devastans* Dist.). Among insect pests, fruit borer, *H. armigera* and the leaf feeder, *S. litura* is a potential polyphagous pest which attacks cotton, groundnut, tomato, citrus, cocoa, potato, rubber, castor, millets, sorghum, maize *etc.*, in India and causes extensive economic damage [2]. Synthetic insecticides provide dramatic effect initially, and hence chemical control methods are still largely in use among farmers. Earlier, conventional insecticides like endosulfan [3, 4], malathion and hostothion [5], chlorpyriphos [6] and fenvalerate, methomyl, azinphos methyl, carbaryl and pyrethrin/rotenone [7] were reported in management of pests on tomato.

Recently, some new insecticide molecules offer manifold advantages over earlier ones in terms of greater levels of safety, better performance and reduced environmental impact. One such new insecticide molecule is spinetoram, that has shown outstanding efficacy against codling moth (*Cydia pomonella* L.), oriental fruit moth (*Grapholita molesta* Busck), army worms (*Spodoptera spp*), cabbage looper (*Trichoplusia ni* Hubner), thrips such as western flower thrips (*Frankliniella occidentalis* Pergande) and onion thrips (*Thrips tabaci* Lindeman), leaf leaf miners (*Liriomyza spp*), chilli thrips (*Scirtothrips dorsalis* Hood), fruit borer(*H. armigera*) and many other pests [8]. However, there are no reports on the persistence toxicity of spinetoram 12 SC against the *H. armigera* and *S. litura* on tomato.

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 persistence of insecticides depends on many factors: type of insecticide, insecticides physiochemical properties, dose used, host plant and environmental factors. Therefore, this study was undertaken with the objective to investigate the persistence toxicity of spinosyn, spinetoram 12 SC and other insecticides against *H. armigera* and *S. litura* in the laboratory.

Materials and methods

Pot culture experiments were conducted in the Insectary of AC & RI, Madurai in order to assess the persistent toxicity of spinetoram against *H. armigera* and *S. litura* on tomato fruits and leaves respectively.

Persistence toxicity of spinetoram 12 SC against *H. armigera*: Seventy five days old potted tomato plants were used for the study**.** Insecticidal solutions were prepared by dissolving spinetoram 12 SC 0.6 ml, 0.75 ml and 0.9 ml, indoxacarb 14.5 SC 1.04 ml, novaluron 10 EC 1.5 ml and quinalphos 25 EC 2.0 ml in one liter of water which were equivalent to the field doses and sprayed on potted tomato plants to the point of run-off with the help of hand operated sprayer. Treated tomato fruits were taken from 1, 3, 5, 7, 9, 11, 14 and 21 DAT. Treated fruits were put in a plastic cup and starved laboratory reared third instar larvae of *H. armigera* 20 numbers were released in to each treatment. There were three replications for each treatment [9].

Persistence toxicity of spinetoram 12 SC against *S. litura*: Thirty days old potted tomato plants were used for the study**.** Insecticidal solutions were prepared by dissolving spinetoram 12 SC 0.6 ml, 0.75 ml and 0.9 ml, indoxacarb 14.5 SC 1.04 ml, novaluron 10 EC 1.5 ml and quinalphos 25 EC 2.0 ml in one liter of water which were equivalent to the field doses. Treated tomato leaves were plucked from the plants at different time intervals. 20 starved larvae were released in to each plastic cup which contained treated tomato leaves.

For the above two experiments, observations on larval mortality were recorded from each treatment at 24 h interval. The per cent mortality was calculated and mortality data were corrected by formula [10].

Persistence toxicity = Average residual toxicity x Period for which the toxicity persisted (days)

The number of days for which the toxicity persisted was recorded as 'P'. The average of the mortality percentage constituted the residual toxicity 'T'. The product of 'P' x 'T' was calculated. Based on the 'PT' value the order of relative efficacy (ORE) was worked out. Here, greater the 'PT' value, better was the treatment. The procedures of scientist [11] and elaborated further [12, 13] were adopted to calculate the persistent toxicity.

Results and Discussion

Persistence toxicity of spinetoram 12 SC against *H. armigera*: Spinetoram 12 SC was applied at 54 g a.i./ha and cent per cent mortality of 3rd instar of *H. armigera* larvae was observed at 1 DAT, 97.7 percent at 3 DAT, 93.4 per cent at 5 DAT and there zero per cent mortality after 21 DAT. Spinetoram 12 SC at 45 g a.i/ha recorded 99.0, 94.7 and 90.2 per cent mortality at 1, 3 and 5 DAT respectively (Table 1). More than 50 per cent mortality was observed in spinetoram 12 SC at 45 and 54 g a.i./ha and indoxacarb 14.5 SC at 75 g a.i/ha upto 11 DAT where as that was upto 7 DAT for spinetoram 12 SC 36 g a.i/ha and novaluron 10 EC at 75 g a.i/ha. There was a reduction in the mortality of *H. armigera* larvae as the time increased and there was no mortality after 14 DAT in spinetoram 12 SC 36 g a.i/ha, novaluron 10 EC at 75 g a.i/ha and quinalphos 25 EC at 250 g a.i/ha. Persistence for spinetoram 12 SC 36 g a.i./ha was upto 11 DAT and 14 DAT for 45 and 54 g a.i/ha. The ORE of the insecticides based on PTI values was spinetoram 12 SC 54 g a.i./ha > indoxacarb 14.5 SC at 75 g a.i/ha > spinetoram 12 SC 45 g a.i./ha > novaluron 10 EC at 75 g a.i/ha > spinetoram 12 SC 36 g a.i./ha > quinalphos 25 EC at 250 g a.i/ha (Fig. 1). These results are in accordance with the findings who reported that the persistence was higher for spinosad 45 SC @ 36 g a.i/ha (8.9 days) and persistence was lower for indoxacarb @ 25 g a.i/ha (5.2 days) and endosulfan @ 750 g a.i/ha (2.7 days) in cotton plants against *H. armigera* [14].

Persistence toxicity of spinetoram 12 SC against *S. litura*: Spinetoram 12 SC was applied at 54 g a.i./ha, cent per cent mortality of third instar of *S. litura* larvae was observed at 1 DAT and 3 DAT, 90.87 at 5 DAT and there was no mortality after 21 DAT. Spinetoram at 45 g a.i/ha recorded 100, 93.47 and 81.93 per cent mortality at 1, 3 and 5 DAT respectively (Table 2). More than 50 per cent mortality was observed in spinetoram at 45, 54 g a.i./ha, novaluron and indoxacarb up to 7 DAT where as that was up to 5 DAT for quinalphos. There was a reduction in the mortality of larvae as the time increased and there was no mortality after 14 DAT in spinetoram 36 g a.i/ha, novaluron and quinalphos. The ORE of the insecticides based on PTI values was spinetoram 54 g a.i./ha > spinetoram 45 g a.i./ha > indoxacarb > novaluron > spinetoram 36 g a.i./ha > quinalphos (Fig. 2). According to many scientists [15] spinetoram (Radiant 12 SC) exhibited high mortality in *S. littoralis* (100% and 95.7%) after zero and 1 days respectively then decreased gradually to 58.1 per cent after 7 days of treatment which indicated that there was relatively short residual time of spinetoram.

Table 1: Persistent toxicity of spinetoram 12 SC to *H. armigera* on tomato fruits

Treatments and doses (g a.i/ha)	Corrected per cent mortality at different intervals (days)								P	T	PTI	RE	ORE
	1	3	5	7	9	11	14	21					
Spinetoram12 SC 36 g a.i/ha	90.4	79.7	64.6	49.0	40.6	19.2	0.0	0.0	11	57.3	629.9	1.32	5
Spinetoram12 SC 45 g a.i/ha	99.0	94.7	90.2	80.4	76.6	59.4	11.3	0.0	14	73.1	1023.1	2.15	3
Spinetoram12 SC 54 g a.i/ha	100	97.7	93.4	89.3	86.8	66.6	13.3	0.0	14	78.2	1094.1	2.29	1
Indoxacarb 14.5 SC 75 g a.i/ha	100	95.3	91.3	87.4	84.6	63.3	14.7	0.0	14	76.7	1073.1	2.25	2
Novaluron 10 EC 75 g a.i/ha	94.2	87.6	76.8	54.8	29.5	14.3	0.0	0.0	11	59.6	655.1	1.37	4
Quinalphos 25 EC 250 g a.i/ha	85.3	70.4	60.0	36.7	12.5	0.0	0.0	0.0	9	53.0	476.8	1.00	6

P – Period of toxicity persistence (days)
T – Mean per cent mortality
PTI – Persistent toxicity index
RE – Relative efficacy
ORE – Order of relative efficacy

Table 2: Persistent toxicity of spinetoram 12 SC to *S. litura* on tomato leaves

Treatments (g a.i/ha)	Corrected per cent mortality at intervals (days)								P	T	PTI	RE	ORE
	1	3	5	7	9	11	14	21					
Spinetoram12 SC 36 g a.i/ha	92.28	87.03	70.33	58.97	39.43	21.77	0.00	0.00	11	61.64	678.04	1.19	5
Spinetoram12 SC 45 g a.i/ha	100	93.47	81.93	73.00	42.17	30.00	19.07	0.00	14	62.81	879.34	1.55	2
Spinetoram12 SC 54 g a.i/ha	100	100	90.87	79.33	45.20	32.37	24.93	0.00	14	67.53	945.42	1.66	1
Indoxacarb 14.5 SC 75 g a.i/ha	100	89.37	75.07	60.75	38.53	24.09	17.33	0.00	14	57.88	810.32	1.43	3
Novaluron 10 EC 75 g a.i/ha	63.77	88.95	80.74	69.05	47.27	32.43	0.00	0.00	11	63.70	700.70	1.23	4
Quinalphos 25 EC 250 g a.i/ha	75.33	70.91	62.45	49.13	32.77	19.35	0.00	0.00	11	51.66	568.26	1.00	6

P – Period of toxicity persistence (days)
T – Mean per cent mortality
PTI – Persistent toxicity index
RE – Relative efficacy
ORE – Order of relative efficacy

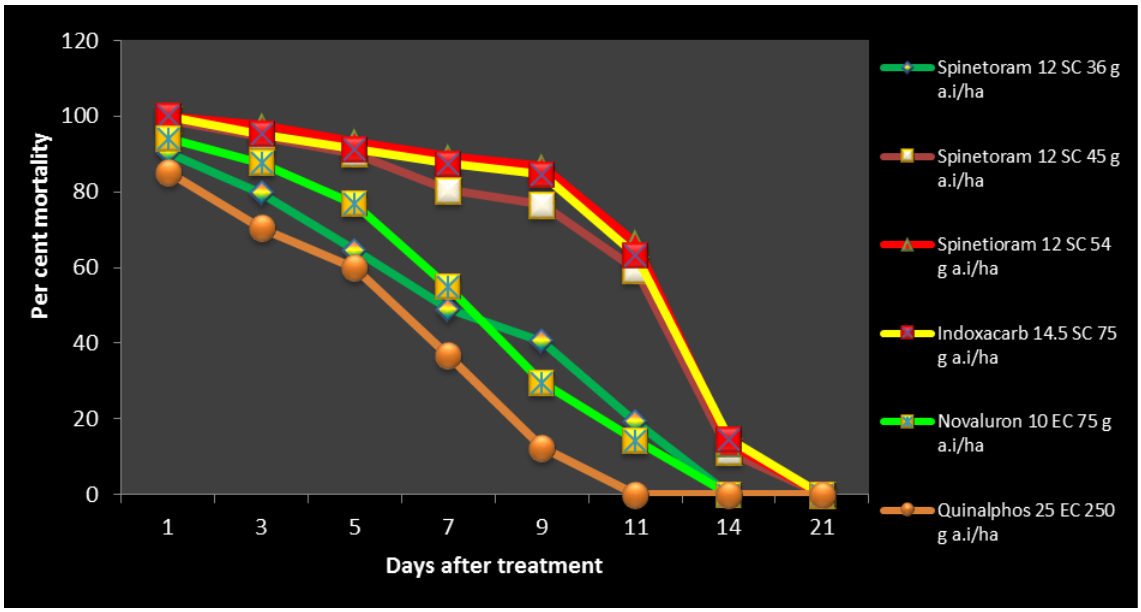

Fig 1: Persistence of spinetoram 12 SC against *H. armigera* on tomato

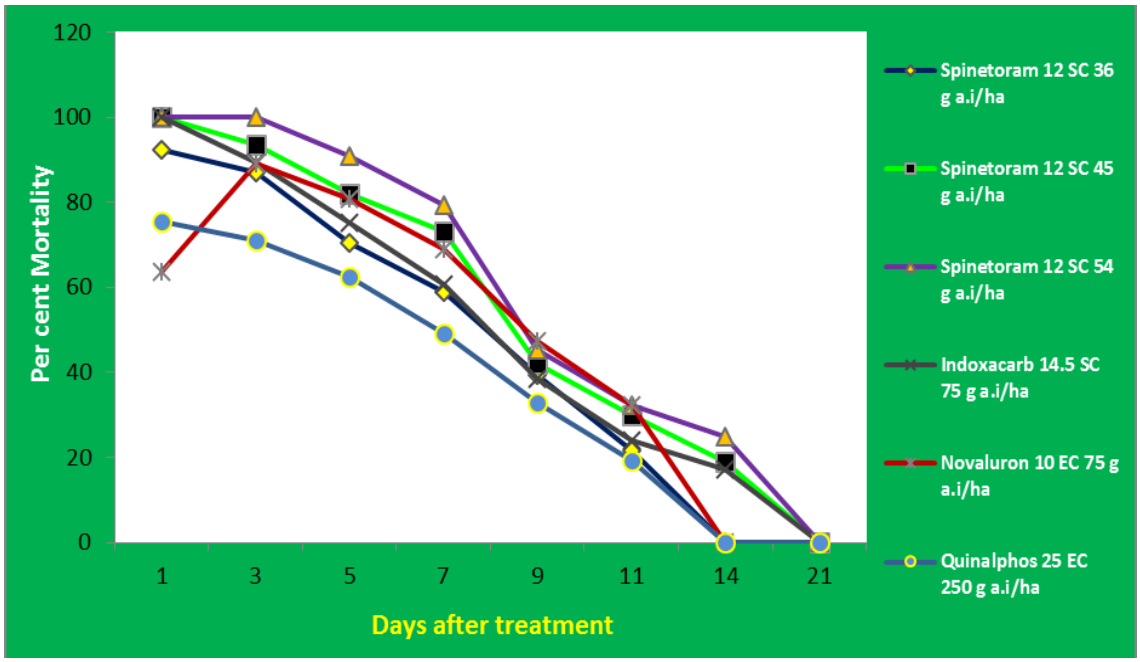

Fig 2: Persistence of spinetoram 12 SC against *S. litura* on tomato

Conclusion

More than 50 per cent mortality of *H. armigera* and *S. litura* larva was observed in spinetoram 12 SC at 45 and 54 g a.i./ha upto 11 DAT where as that was upto 7 DAT for spinetoram 12 SC 36 g a.i/ha. Therefore it is an effective and an excellent tool to be incorporated into integrated pest management for tomato crop to control fruit borer, *H. armigera* and leaf eating caterpillar, *S. litura.*

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