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EFFICACY OF SPINETORAM 10%W/W+ SULFOXAFLOR 30%W/W WG AGAINST *SPODOPTERA LITURA* ON OKRA

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ABSTRACT

Tobacco caterpillar *Spodoptera litura* (F.) is an important defoliator pest of okra causing economic damage both in open field and polyhouse conditions. The combination product spinetoram 10% w/w + sulfoxaflor 30% w/w WG was evaluated against this for two seasons i.e., winter 2015 and summer 2016 at Alagapuri village, Alanganallur Block, Madurai District, Tamil Nadu under field conditions. Three rounds of spray of spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i/ha and spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 120 g a.i/ha from 30 DAT at 15 days interval were effective and superior.

Key words: *Spodoptera litura,* okra, spinetoram, sulfoxaflor, combination product, Tamil Nadu, field efficacy, three sprays, reduction in damage, fruit yield

Tobacco caterpillar *Spodoptera litura* (F.) is a serious polyphagous pest attacking over 120 cultivated plants causing huge losses (Singh and Jalali, 1997). In India, it has extensive host range of around 60 crop plants which includes economically important agricultural and horticultural crops. Okra *Abelmoschus esculentus* (L.) Moench is one of the important vegetable crops grown in both summer and winter seasons (Kalpana et al., 2017). The crop is ravaged by many defoliators and sucking pests. Among the defoliators of okra, *S. litura* is of economic significance and results in complete defoliation. Yield losses in okra are directly associated with higher larval densities and increased defoliation. The control of this pest by various means is known. Some newer chemical molecules are being introduced in the market having novel mode of action and it becomes imperative to evaluate them. Therefore, the present study which evaluates the field efficacy of spinetoram 10% w/w + sulfoxaflor 30% w/w against *S. litura* in okra during winter 2015 and summer 2016.

MATERIALS AND METHODS

Field experiment was conducted at the Alagapuri village, Alanganallur Block, Madurai District during October 2015 to January 2016 (winter 2015) and February to May 2016 (summer 2016) in a randomized block design (RBD). The plot size was 50 m^2 and the treatments include spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 100 g a.i/ha (250 g/ha); 120 g a.i/ha (300 g/ha); 140 g a.i/ha (350 g/ha); spinetoram 12% w/v SC @ 30 g a.i/ha (292 g/ha); sulfoxaflor 24% w/v SC @ 90 g a,i/ha (375 g/ha); thiamethoxam 25% WG @ 25 g a.i/ha (100 g/ha); emamectin benzoate 5% WG @ 8.5 g a.i/ha (170 g/ha); and untreated control.

Spinetoram 12% w/v SC, sulfoxaflor 24% w/v SC, thiamethoxam 25% WG, emamectin benzoate 5% WG were included for comparison. The spray fluid used was 500 to 750 l/ha based on the age of the crop. Insecticides were sprayed to run off point using a high volume hand operated knapsack sprayer with hydraulic cone nozzle. Total three sprays were given 30 days after sowing at 15 days interval for the management of *S. litura*. Population of larva on the leaves, buds and flowers was observed on plant basis on pre treatment and 1, 3, 7 and 10 days after spraying from 10 randomly selected plants in all the treatments. The % reduction over control was worked out. The total yield of marketable fruits was recorded considering all the pickings. The yield/ plot was recorded in kg/ plant/ plot was converted into t/ha. Data thus obtained were analysed statistically.

RESULTS AND DISCUSSION

Winter 2015: Number of larvae of *S. litura* varied from 6.90 to 7.28/ plant before imposing treatments (Table 1). There was significant reduction in the larval population due to treatments at 1,3,7 and 10 DAT (days after treatment) after first spray. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha (2.10, 1.12, 0.85 and 1.32/ plant at 1,3,7 and 10 DAT respectively),

Table 1. Population of S*podoptera litura* on okra, as influenced by spinetoram 10% w/w +sulfoxaflor 30% w/w WG (winter 2015)

Treatments and doses	Pre-count	Population of *S. litura* (no. of larvae/plant) (Days After Treatment)												Mean	% reduction over control	Fruit Yield (t/ha)
		1st spray				2nd spray				3rd spray						
		1	3	7	10	1	3	7	10	1	3	7	10			
Spinetoram 10% w/w +Sulfoxaflor 30% w/w WG @ 100 g a.i./ha.	7.20	3.63 (1.90)^{e}	3.32 (1.82)^{c}	2.03 (1.42)^{c}	2.98 (1.72)^{d}	1.40 (1.18)^{b}	1.21 (1.1)^{bc}	1.00 (1.0)^{a}	1.65 (1.28)^{b}	1.45 (1.20)^{b}	0.98 (0.98)^{bc}	0.88 (0.93)^{b}	1.25 (1.11)^{a}	1.81 (1.34)^{c}	78.83	14.65 (3.82)^{b}
Spinetoram 10% w/w +Sulfoxaflor 30% w/w WG @ 120 g a.i./ha.	7.28	2.83 (1.68)^{b}	1.83 (1.35)^{b}	1.43 (1.19)^{b}	2.32 (1.52)^{c}	1.52 (1.23)^{b}	1.00 (1.0)^{ab}	1.21 (1.1)^{a}	1.93 (1.38)^{b}	1.2 (1.09)^{b}	0.8 (0.89)^{ab}	0.85 (0.92)^{b}	1.0 (1.0)^{a}	1.49 (1.22) ^{bc}	82.57	15.22 (3.90)^{b}
Spinetoram 10% w/w +Sulfoxaflor 30% w/w WG @ 140 g a.i./ha.	6.93	2.10 (1.44)^{a}	1.12 (1.05)^{a}	0.85 (0.92)^{a}	1.32 (1.14)^{a}	0.98 (0.98)^{a}	0.75 (0.86)^{a}	1.02 (1.01)^{a}	1.02 (1.01)^{a}	0.75 (0.86)^{a}	0.56 (0.74)^{a}	0.75 (0.86) ^{ab}	1.38 (1.17)^{bc}	1.05 (1.02)^{a}	87.71	16.72 (4.08)^{a}
Spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ha.	7.15	6.15 (2.47)^{d}	5.10 (2.25)^{d}	5.03 (2.24)^{d}	6.97 (2.64)^{e}	4.56 (2.13)^{d}	2.03 (1.42)^{d}	2.98 (1.72)^{b}	4.32 (2.07)^{c}	2.85 (1.68)^{c}	1.25 (1.11)^{c}	1.04 (1.01)^{b}	1.64 (1.28)^{c}	3.66 (1.91)^{d}	57.19	12.66 (3.55)^{c}
Sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ha.	7.13	6.65 (2.57)^{e}	5.90 (2.42)^{e}	6.10 (2.46)^{e}	7.20 (2.68)^{ef}	6.43 (2.53)^{e}	6.10 (2.46)^{e}	6.08 (2.46)^{c}	7.18 (2.67)^{d}	6.75 (2.59)^{d}	6.05 (2.45)^{d}	7.05 (2.65)^{c}	7.10 (2.66)^{d}	6.54 (2.55)^{e}	23.50	11.34 (3.36)^{d}
Thiamethoxam 25% WG @ 25 g a.i./ha.	6.90	6.73 (2.59)^{e}	5.21 (2.28)^{d}	6.68 (2.58)^{e}	7.18 (2.67)^{ef}	6.78 (2.60)^{e}	6.12 (2.47)^{e}	6.13 (2.47)^{c}	7.13 (2.67)^{d}	7.48 (2.73)^{e}	6.51 (2.55)^{d}	7.63 (2.76)^{c}	7.78 (2.78)^{de}	6.78 (2.60)^{e}	20.70	10.21 (3.19)^{e}
Emamectin Benzoate 5%WG @ 8.5g a.i./ha.	7.18	2.05 (1.43)^{a}	1.18 (1.08)^{a}	1.88 (1.37)^{c}	2.01 (1.41)^{b}	1.98 (1.40)^{c}	1.45 (1.20)^{c}	1.20 (1.09)^{a}	1.75 (1.32)^{b}	1.15 (1.07)^{b}	0.85 (0.92)^{bc}	0.52 (0.72)^{a}	0.98 (0.98)^{a}	1.41 (1.18)^{b}	83.50	15.26 (3.90)^{b}
Untreated check	7.10	7.20 (2.68)^{f}	7.50 (2.70)^{f}	7.53 (2.74)^{f}	7.70 (2.77)^{f}	7.85 (2.80)^{f}	7.98 (2.82)^{f}	7.97 (2.82)^{d}	8.05 (2.82)^{e}	8.25 (2.87)^{e}	8.37 (2.89)^{e}	8.50 (2.91)^{d}	8.60 (2.93)^{e}	8.55 (2.92)^{f}	--	7.07 (2.65)^{f}
SEd	--	0.0342	0.0577	0.0650	0.0479	0.0623	0.0763	0.0705	0.0590	0.0774	0.1023	0.1149	0.0726	0.0607		
CD (0.05)	--	0.0734	0.1238	0.1394	0.1027	0.1336	0.1637	0.1513	0.1265	0.1661	0.2195	0.2465	0.1557	0.1302		

*Mean of three replications; Three rounds of sprays at 10-15 days interval starting from 30 DAS; Figures in table original values and subject to square root transformation for statistical analysis; In a column means followed by same letter(s) not significantly different by DMRT (p= 0.05).

emamectin benzoate 5% @ 8.5 g a.i./ha (2.05, 1.18, 1.88 and 2.01/ plant at 1,3,7 and 10 DAT respectively) and spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 120 g a.i./ha (2.83, 1.83, 1.43 and 2.32/ plant at 1,3,7 and 10 DAT, respectively) significantly superior and registered minimum larval population as against the untreated plot (7.20, 7.50, 7.53 and 7.70/ plant at 1,3,7 and 10 DAT, respectively). Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 100 g a.i./ha (3.63, 3.32, 2.03 and 2.98/ plant at 1,3,7 and 10 DAT, respectively) and sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ ha (6.65, 5.90, 6.10 and 7.20/ plant at 1,3,7 and 10 DAT, respectively) moderately reduced the larval population. The larval population was more in spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ha (6.15, 5.10, 5.03 and 6.97/ plant at 1,3,7 and 10 DAT, respectively) and thiamethoxam 25% WG @ 25 g a.i./ha (6.73, 5.21, 6.68 and 7.18/ plant at 1,3,7 and 10 DAT, respectively).

After second spray, spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha was significantly the most effective and registered minimum larval population of 0.98, 0.75, 1.02 and 1.02/ plant at 1, 3, 7 and 10 DAT, respectively. However, there was continuous reduction in larval population till 10 DAT after third spray. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha was followed by emamectin benzoate 5% WG @ 8.5 g a.i./ha. after second and third spray. Simialr was the case with spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 120 g a.i./ha. The lower dose of spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 100 g a.i./ha recorded 1.40, 1.21, 1.00 and 1.65 larvae/ plant at 1,3,7 and 10 DAT, respectively after second spray and 1.45, 0.98, 0.88 and 1.25 larvae/ plant at 1,3,7 and 10 DAT, respectively after third spray, which was the next best.

Spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ ha registered 4.56, 2.03, 2.98 and 4.32 larvae/ plant at 1,3,7 and 10 DAT, respectively after second spray and 2.85, 1.25, 1.04 and 1.64 larvae/ plant at 1,3,7 and 10 DAT, respectively after third spray; while sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ha recorded 6.43, 6.10, 6.08 and 7.18 larvae/ plant at 1,3,7 and 10 DAT, respectively after second spray and 6.75, 6.05, 7.05 and 7.10 larvae/ plant at 1,3,7 and 10 DAT, respectively after third spray. However, thiamethoxam 25% WG @ 25 g a.i./ha was the least effective.

Mean values revealed that the number of larvae ranged from 1.05 to 8.55/ plant due to treatments. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha and emamectin benzoate 5% WG @ 8.5 g a.i./ha were significantly superior. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 120 g a.i./ha and spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 100 g a.i./ha were also effective. Spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ha and sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ha were moderately effective. However, thiamethoxam 25% WG @ 25 g a.i./ha registered higher larval population 6.78 larvae/ plant with 20.70 per cent reduction over control.

Okra fruit yield ranged from 7.07 to 16.72 t/ha due to treatments. Highest fruit yield was recorded due to spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha (16.72 t/ha) and was followed by emamectin benzoate 5% @ 8.5 a.i./ha (15.26 t/ha). Higher yields in emamectin benzoate treated plots might be due to lesser incidence of fruit borers. Thiamethoxam 25% WG @ 25 g a.i./ha registered fruit yield of (10.21 t/ ha) when compared to untreated plot (7.07 t/ ha).

Summer 2016: Number of larvae of *S. litura* varied from 5.38 to 6.65/ plant before imposing treatments (Table 2). There was significant reduction due to treatments at 1,3,7 and 10 DAT after first spray. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha (2.33, 0.53, 1.66 and 1.90/ plant at 1,3,7 and 10 DAT, respectively), emamectin benzoate 5%WG @ 8.5 g a.i./ha (2.40, 0.88, 1.87 and 2.17/ plant at 1,3,7 and 10 DAT, respectively) and spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 120 g a.i./ha were also significantly superior. With regard to other treatments, the same trend as that of winter season 2015 was reflected after first spraying.

After second spray too, spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha was significantly the most effective and registered minimum larval population of 0.45, 0.10 and 0.17/ plant at 1,3 and 7 DAT, respectively. The *S. litura* population was almost nil after three sprays in this treatment. The treatment sspinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha was followed by emamectin benzoate 5% WG @ 8.5 g a.i./ha after second spray and it was nil at 1,3,7 and 10 DAT after third spray. Similar trend as that of winter 2015 was observed with regard to the other treatments.

Spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ha and sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ha led to moderate reduction; and thiamethoxam 25% WG @ 25 g a.i./ha was the least effective similar to winter 2015 trial. Mean values revealed that the number of

Table 2. Population of *Spodoptera litura* on okra, as influenced by spinetoram 10% w/w +sulfoxaflor 30% w/w WG (summer 2016)

Treatments and doses	Pre-count	Population of *S. litura* (no. of larvae/ plant) (Days After Treatment)												Mean	% reduction over control	Fruit Yield (t/ha)
		1st spray				2nd spray				3rd spray						
		1	3	7	10	1	3	7	10	1	3	7	10			
Spinetoram 10% w/w +Sulfoxaflor 30% w/w WG @ 100 g a.i./ha.	6.65	3.60 (1.89)^{b}	2.40 (1.54)^{d}	3.60 (1.89)^{d}	3.88 (1.96)^{d}	3.35 (1.83)^{bc}	1.63 (1.27)^{b}	1.89 (1.37)^{b}	1.98 (1.40)^{b}	1.05 (1.02)^{b}	0.95 (0.97)^{b}	1.17 (1.08)^{b}	1.18 (1.08)^{b}	2.22 (1.48)^{b}	66.51	15.17 (3.89)^{bc}
Spinetoram 10% w/w +Sulfoxaflor 30% w/w WG @ 120 g a.i./ha.	6.15	3.50 (1.87)^{b}	1.80 (1.34)^{c}	2.84 (1.68)^{c}	3.48 (1.86)^{c}	2.30 (1.51)^{b}	1.53 (1.23)^{b}	1.90 (1.37)^{b}	1.95 (1.39)^{b}	1.03 (1.01)^{b}	0.88 (0.93)^{b}	1.11 (1.05)^{b}	1.13 (1.06)^{b}	1.95 (1.39)^{b}	70.58	15.98 (3.99)^{a}
Spinetoram 10% w/w +Sulfoxaflor 30% w/w WG @ 140 g a.i./ha.	5.65	2.33 (1.52)^{a}	0.53 (0.72)^{a}	1.66 (1.28)^{a}	1.90 (1.37)^{a}	0.45 (0.67)^{a}	0.10 (0.31)^{a}	0.17 (0.41)^{a}	0.18 (0.42)^{a}	0.00 (0.0)^{a}	0.00 (0.0)^{a}	0.00 (0.0)^{a}	0.00 (0.0)^{a}	0.61 (0.78)^{a}	90.79	16.46 (4.05)^{a}
Spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ha.	6.55	4.35 (2.08)^{c}	3.13 (1.76)^{e}	4.11 (2.02)^{e}	4.43 (2.10)^{e}	3.50 (1.87)^{c}	2.83 (1.68)^{c}	3.13 (1.76)^{c}	3.13 (1.76)^{b}	2.15 (1.46)^{c}	1.60 (1.26)^{c}	1.70 (1.30)^{bc}	1.75 (1.32)^{b}	2.98 (1.72)^{c}	55.05	14.79 (3.84)^{c}
Sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ha.	5.50	4.51 (2.12)^{c}	3.20 (1.78)^{e}	4.98 (2.23)^{g}	5.38 (2.31)^{f}	3.88 (1.96)^{c}	3.28 (1.81)^{cd}	4.84 (2.2)^{d}	5.33 (2.30)^{c}	2.60 (1.61)^{c}	2.10 (1.44)^{c}	4.50 (2.12)^{d}	4.60 (2.14)^{c}	4.10 (2.02)^{d}	38.15	13.83 (3.71)^{d}
Thiamethoxam 25% WG @ 25 g a.i./ha.	6.35	6.03 (2.45)^{d}	3.08 (1.75)^{e}	4.59 (2.14)^{f}	6.63 (2.57)^{g}	5.78 (2.40)^{d}	4.75 (2.17)^{de}	5.40 (2.32)^{d}	5.60 (2.36)^{c}	2.38 (1.54)^{c}	1.88 (1.37)^{c}	2.88 (1.69)^{c}	3.20 (1.78)^{c}	4.35 (2.08)^{d}	34.38	12.05 (3.47)^{e}
Emamectin Benzoate 5%WG @ 8.5 g a.i./ha.	5.38	2.40 (1.54)^{a}	0.88 (0.93)^{b}	1.87 (1.36)^{b}	2.10 (1.44)^{b}	0.48 (0.69)^{a}	0.20 (0.44)^{a}	0.23 (0.47)^{a}	0.25 (0.5)^{a}	0.00 (0.0)^{a}	0.00 (0.0)^{a}	0.00 (0.0)^{a}	0.00 (0.0)^{a}	0.70 (0.83)^{a}	89.44	15.79 (3.97)^{ab}
Untreated check	5.63	6.23 (2.49)^{d}	6.25 (2.5)^{f}	6.40 (2.52)^{h}	6.57 (2.56)^{g}	6.35 (2.51)^{d}	6.63 (2.57)^{e}	6.69 (2.58)^{d}	6.70 (2.58)^{c}	6.78 (2.6)^{d}	7.05 (2.65)^{d}	7.33 (2.70)^{e}	6.63 (2.57)^{d}	6.63 (2.57)^{e}	--	9.37 (3.06)^{f}
SEd	--	0.0237	0.0931	0.0335	0.0315	0.1552	0.1856	0.1825	0.1819	0.1889	0.1832	0.1935	0.1939	0.0886		0.0408
CD (0.05)	--	0.0508	0.1997	0.0718	0.0676	0.3330	0.3980	0.3915	0.3901	0.4052	0.3930	0.4150	0.4160	0.1901		0.0875

*Mean of three replications; Three rounds of sprays at 10- 15 days interval starting from 30 DAS; Figures in table original values and subject to square root transformation for statistical analysis; In a column means followed by same letter(s) not significantly different by DMRT (p= 0.05).

larvae ranged from 0.61 to 6.63/ plant due to treatments. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 140 g a.i./ha and emamectin benzoate 5% WG @ 8.5 g a.i./ha were significantly superior. Spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 120 g a.i./ha and spinetoram 10% w/w + sulfoxaflor 30% w/w WG @ 100 g a.i./ha ranked next. Spinetoram 12% SC w/v (11.7% w/w) @ 30 g a.i./ha and sulfoxaflor 24% SC w/v (21.8% w/w) @ 90 g a.i./ha were observed to be having moderate effficacy.

Okra fruit yield ranged from 9.37 to 16.46 t/ha due to treatments. There was significant difference in fruit yield due to spinetoram 10% w/w + sulfoxaflor 30% w/w WG applications. Similar trend as that of winter 2015 season trial was observed in all the treatments.

The effectiveness of newer insecticides against *S. litura* was reported by several workers. Hegde and Gadad (2017) reported that the emamectin benzoate 5 SG was superior in reducing the foliar damage by *S. litura* in groundnut in agreement with present observations. Superiority of emamectin benzoate against *S. litura* is known (Gadhiya et al., 2014). Mutkule et al. (2009) and Suby et al. (2008) with emamectin benzoate reported similar results. Ramesh Babu et al. (2018) also reported the efficacy of chlorantraniliprole, indoxacarb and emamectin benzoate against *S. litura* on soybean.

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