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Bio-Efficacy of Spinetoram 6% W/V (5.66% W/W) + Methoxyfenozide 30% W/V (28.3% W/W) SC against Pod Borers Infesting Greengram [*Vigna radiata* (L.) Wilczek]

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ABSTRACT

Background: Spotted pod borer, *Maruca vitrata* (F.) and blue butterfly, *Lampides boeticus* (L.) are important lepidopteran borers infesting greengram [*Vigna radiata* (L.) Wilczek] throughout India. Therefore, novel insecticide mixture in comparison with other standard synthetic insecticides has been tested for its bio-efficacy against these two borers in greengram.

Methods: A field experiment was conducted at Vagurani, Usilampatti Block, Madurai district, Tamil Nadu during June to August, 2020 in randomized block design (RBD) with eight treatments and three replications. The experimental field was monitored for the population of pests and natural enemies (No./ 10 plants), per cent pod damage, total grain yield and phyto-toxic symptoms. From the data recorded, per cent reduction in population over control was calculated. The per cent pod damage was calculated by randomly picking 100 pods from each plot of each replication. The grain yield from each plot was recorded after each picking and converted into kg/ ha.

Result: Two sprays of spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 144 g a.i/ha and flubendiamide 34.35 SC @ 48 g a.i/ ha from 45 DAS at 15 days interval proved to be most effective and superior in reducing the lepidopteran pod borers like *M. vitrata* and *L. boeticus* and no lethal effect was recorded towards the coccinellid predators, *Menochilus sexmaculatus*, *C. transversalis* and spiders. This combination did not cause any phytotoxic symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty at any day after treatment on stems, leaves, flowers and pods of greengram.

Key words: Bio-efficacy, Greengram, Insecticides, *Lampides boeticus, Maruca vitrata.*

INTRODUCTION

Mung gram or greengram (*Vigna radiata* L.) is a significant legume in South Asia. It is indigenous to India and Central Asia and has been grown in these regions since prehistoric times. Moreover, their role in improving the fertility of the soil, by microbial fixation of atmospheric nitrogen, further enhances their importance and utility. The total area covered by pulses in India was around 30.37 million hectares (Anonymous, 2022) and India is the largest producer of greengram. Pulses occupy a unique position in the Indian economy and being the major source of proteins in diet. It consists of easily digestible high-quality protein (24%), phosphorus (0.32%), iron (0.0073%), carotene (0.00039%), niacin (0.0021%) and energy 334 cal/100 g of greengram (Singh *et al.,* 2009). A number of factors are responsible for less yield, however, losses caused by insect pests are one of the major factors, therefore, appropriate and efficient pest control techniques should be undertaken to reduce these losses. The blue butterfly *(Lampides boeticus* L.) and spotted pod borer (*Maruca vitrata* F.) are the two major pests infesting greengram. Thus, the unique insecticide combination was evaluated to curb insect pests of greengram.

MATERIALS AND METHODS

Field trial was conducted during June to August, 2020 at Vagurani, Usilampatti Block, Madurai district, Tamil Nadu to evaluate the bio-efficacy of spinetoram 6% w/v (5.66% w/w) + methoxyfenozide 30% w/v (28.3% w/w), their safety to natural enemies of target pests and phyto-toxicity effect on the crop. The greengram variety, CO 8 was grown at a spacing of 30 × 10 cm with three replications in randomized block design (RBD) with a total plot size of 150 sq. m. The experimental field was monitored for the pests and natural enemies' population (No./ 10 plants), per cent pod damage, total grain yield and phyto-toxic symptoms. The treatment details are furnished in Table 1. Insecticides were sprayed to run off point using a high volume battery operated knapsack sprayer. The concentration of insecticides required, on the basis of active ingredient, the desired

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amount of each insecticide was measured by an electronic balance and subsequently mixed with spray fluid (500 L ha^{-1}) based on the age of the crop. Based on ETL, two rounds of spraying were given at 15 days interval starting from 45 days after sowing. The per cent pod damage was calculated by randomly picking 100 pods from each plot of each replication. The grain yield from each plot was recorded after each picking and converted into kg/ ha. The phyto-toxic symptoms like leaf injury on tips and leaf surface, wilting, necrosis, vein clearing, epinasty and hyponasty were observed and the extent of phyto-toxicity was recorded based on visual scoring of the European Weed Research Council (EWRC).

Per cent pod damage =

$$\frac{\text{Total number of damaged pods}}{\text{Total number of pods observed}} \times 100$$

Per cent reduction in population over control =

$$100 \times 1 - \left[\frac{Tb \times Cb}{Tb \times Ca}\right]$$

Where,

Ta = Number of insects after treatments.

Tb = Number of insects before treatments.

Ca = Number of insects in untreated check after treatments.

Cb = Number of insects in untreated check before treatments.

RESULTS AND DISCUSSION

Effect of spinetoram 6% w/v + methoxyfenozide 30% w/v SC on borers

Number of *L. boeticus* and *M. vitrata* larvae varied from 6.0 to 7.3 and 3.3 to 4.6 per ten plants, respectively, before imposing treatments. Spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 144 g a.i./ha was significantly superior and registered the lowest larval population of *L. boeticus* (1.42 per ten plants) (85.75% reduction over control) and *M. vitrata* (0.97 per ten plants) (86.97% reduction over control) (Table 1).

Spinetoram 6% w/v + methoxyfenozide 30% w/v SC against pod damage due to pod borers

Flubendiamide 34.35 SC @ 48 g a.i./ha was superior in minimizing the pod damage (5.7%) which was statistically on par with spinetoram 6% w/v + methoxyfenozide 30% w/v @ 144 and 126 g a.i./ha (5.9%) (Table 2).

The present findings are in agreement with Singh and Singh (2019) who found minimum pod and grain damage in green gram by *M. vitrata* due to spinosad 60 g a.i. ha^{-1} (7.17, 2.84%) followed by emamectin benzoate 8 g a.i. ha^{-1} (9.50, 4.88%) and fipronil 100 g a.i. ha^{-1} (11.33, 7.44%). Similar reports were given by Yadav and Singh (2014) and Sonune *et al.* (2010). Similarly, spinosad 45 SC was proved to be effective against *Helicoverpa armigera* Hubner and *M. testulalis* infesting greengram (Meena *et al*., 2022). Selvam *et al.* (2020) stated that flubendiamide 480 SC recorded the lowest larval population of gram blue butterfly, *Euchrysops cnejus* Fab. (1.83 larvae/ plant).

Effect of spinetoram 6% w/v + methoxyfenozide 30% w/v SC on grain yield of greengram

The highest grain yield was recorded for spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 144 g a.i./ha (578.96 kg/ha), which was followed by flubendiamide 34.35 SC @ 48g a.i./ha (555 kg/ha). compared to untreated plot which recorded 287.96 kg/ha grain yield (Table 2).

Similarly, an increase in grain yield (8.86 q/ ha) was obtained in spinosad treated green gram field by Singh and Singh (2019). The present findings are in agreement in Umbarkar and Parsana (2014), Yadav and Singh (2014), Kaushik *et al.* (2016) and Meena *et al.* (2022) who reported the maximum grain yield from spinosad treatment. Singh *et al.* (2020) recorded the highest marketable yield in flubendiamide 20 WG @ 1.0 g/l (9.14 q/ ha) and spinosad 45 SC @ 0.3 ml/l (9.13 q/ ha).

Effect of spinetoram 6% w/v + methoxyfenozide 30% w/v SC on spiders

Data on population of spiders on insecticide treated and control plots are given in Table 3. Mean population after two sprays revealed that spider population was the maximum in untreated check (4.65 per ten plants) followed by spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 126 g a.i./ha (4.45 per ten plants), spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 135 g a.i./ha (4.30 per ten plants) and spinetoram 6% w/v + methoxyfenozide 30% w/ v SC @ 144 g a.i./ha (4.28 per ten plants) treated plots.

Effect of spinetoram 6% w/v + methoxyfenozide 30% SC on coccinellids

Data on population of grubs and adults of coccinellids on insecticide treated and control plots are given in Table 4. Mean population of coccinellids., *Menochilus sexmaculatus* Fab. and *Coccinella transversalis* F. after two sprays revealed that coccinellid population was maximum in untreated check (2.3 per ten plants) followed by spinetoram 6% w/v + methoxyfenozide 30% w/v @ 126 g a.i./ha (2.15 per ten plants), spinetoram 6% w/v + methoxyfenozide 30% w/v @ 135 g a.i./ha (2.11 per ten plants) and spinetoram 6% w/v + methoxyfenozide 30% w/v@ 144 g a.i./ha (1.95 per ten plants) treated plots.

Studies on phytotoxicity of spinetoram 6% w/v + methoxyfenozide 30% w/v SC in greengram

Spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 144 g a.i/ha and spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 288 g a.i/ha did not cause any phytotoxic symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty at any day after treatment on stems, leaves, flowers and pods of greengram.

Table 1: Effect of Spinetoram 6% w/v + Methoxyfenozide 30% w/v SC on pod borers in greengram.

Treatments	Pre-count	Mean of population *L. boeticus*	% reduction over control	Pre-count	Mean of population *M. vitrata*	% reduction over control
T_1: Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 126 g a.i /ha.	7.0	2.07 (1.44)^{c}	79.23	4.3	1.78 (1.33)^{b}	76.10
T_2: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 135 g a.i /ha.	6.6	1.85 (1.36)^{bc}	81.44	4.0	2.01 (1.42)^{bc}	73.02
T_3: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 144 g a.i /ha.	6.3	1.42 (1.19)^{a}	85.75	3.3	0.97 (0.98)^{a}	86.97
T_4: Spinetoram 12% w/v (11.7%w/w) @ 24 g a.i /ha.	7.3	3.33 (1.82)^{d}	66.59	3.6	2.01 (1.42)^{bc}	73.02
T_5: Methoxyfenozide 24% w/v (21.8%w/w) SC @ 124 g a.i /ha.	6.3	3.96 (1.99)^{e}	60.28	4.0	2.16 (1.47)^{bc}	71.00
T_6: Flubendiamide 34.35 SC @ 48 g a.i/ha.	6.6	1.66 (1.29)^{ab}	83.35	4.0	1.01 (1.00)^{a}	86.44
T_7: Thiodicarb 75% WP @ 562.5 g a.i /ha.	6.0	3.33 (1.82)^{d}	66.59	3.6	1.76 (1.33)^{b}	76.37
T_8: Untreated check	7.0	9.97 (3.16)^{f}	-	4.6	7.45 (2.73)^{d}	-
SEd	NS	0.0547	-	NS	0.0493	-
CD (0.05)	NS	0.1173	-	NS	0.1057	-

*Mean of three replications; Two rounds of spraying at 15 days interval starting from 45 DAS. Figures in the parentheses are square root transformed values. In a column means followed by same letter(s) are not significantly different by LSD (P= 0.05).

Table 2: Per cent pod damage by borers and their influence on greengram yield.

Treatments	Pre-count	% Pod damage^{a}	% reduction over control	Grain yield (kg/ha)		Total grain yield (kg/ha)^{b}
				1st picking^{b}	2nd picking^{b}	
T_1: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @126 g a.i /ha.	10.6	6.5 (14.76)^{b}	71.12	326.88 (18.08)^{a}	217.92 (14.76)^{ab}	544.80 (23.34)^{a}
T_2: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 135 g a.i /ha.	11.0	7.05 (15.34)^{bc}	68.68	324.00 (18.00)^{a}	216.00 (14.70)^{abc}	540.00 (23.24)^{a}
T_3: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 144 g a.i /ha.	11.6	5.9 (14.05)^{a}	73.78	347.00 (18.63)^{a}	231.96 (15.23)^{a}	578.96 (24.06)^{a}
T_4: Spinetoram 12% w/v (11.7%w/w) @ 24 g a.i /ha.	12.3	7.7 (16.10)^{bc}	65.79	270.00 (16.43)^{bc}	180.00 (13.42)^{d}	450.00 (21.21)^{b}
T_5: Methoxyfenozide 24% w/v (21.8%w/w) SC @ 124 g a.i /ha.	12.6	8.0 (16.42)^{bc}	64.41	235.44 (15.34)^{c}	189.00 (13.75)^{bcd}	424.44 (20.60)^{b}
T_6: Flubendiamide 34.35 SC @ 48 g a.i /ha.	12.0	5.7 (13.81)^{a}	74.63	333.00 (18.25)^{a}	222.00 (14.90)^{ab}	555.00 (23.56)^{a}
T_7: Thiodicarb 75% WP @ 562.5 g a.i/ha.	10.3	7.8 (16.21)^{b}	64.99	274.50 (16.57)^{b}	183.00 (13.53)^{cd}	457.50 (21.39)^{b}
T_8: Untreated check	13.0	22.51 (28.31)^{d}	-	159.96 (12.65)^{d}	128.00 (11.31)^{e}	287.96 (16.97)^{c}
SEd	NS	0.3617	-	0.5554	0.5587	0.6333
CD (0.05)	NS	0.6331	-	1.1913	1.1984	1.3584

*Mean of three replications; Two rounds of spraying at 15 days interval starting from 45 DAS. Figures in the parentheses are arcsine^{a} and square root^{b} transformed values. In a column means followed by same letter(s) are not significantly different by LSD (P= 0.05).

Table 3: Population of spiders on greengram, as influenced by Spinetoram 6% w/v + Methoxyfenozide 30% w/v SC.

Treatments	Pre-count	Population of spiders (No.of spiders/10 plants)(Days after treatment)								Mean
		1st spray				2nd spray				
		1	3	7	10	1	3	7	10	
T_1: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @126 g a.i /ha	.4.4	4.3 (2.07)^{a}	4.3 (2.07)^{a}	4.2 (2.04)^{a}	4.7 (2.16)^{a}	4.6 (2.14)^{ab}	4.5 (2.12)^{b}	4.4 (2.09)^{b}	4.6 (2.14)^{b}	4.45 (2.11)^{b}
T_2: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 135 g a.i /ha	4.0	3.9 (1.97)^{ab}	3.8 (1.94)^{ab}	4.1 (2.02)^{a}	4.7 (2.16)^{a}	4.6 (2.14)^{ab}	4.4 (2.09)^{b}	4.3 (2.07)^{b}	4.6 (2.14)^{b}	4.30 (2.7)^{c}
T_3: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 144 g a.i /ha	4.4	3.9 (1.97)^{ab}	3.8 (1.94)^{ab}	4.0 (2.00)^{a}	4.6 (2.14)^{a}	4.5 (2.12)^{b}	4.4 (2.09)^{b}	4.4 (2.09)^{b}	4.7 (2.16)^{b}	4.28 (2.07)^{c}
T_4: Spinetoram 12% w/v (11.7%w/w) @ 24 g a.i /ha.	3.9	3.5 (1.87)^{ab}	3.2 (1.78)^{bc}	2.7 (1.64)^{b}	3.1 (1.76)^{b}	2.7 (1.64)^{de}	2.5 (1.58)^{d}	2.6 (1.61)^{d}	2.9 (1.70)^{d}	2.90 (1.70)^{d}
T_5: Methoxyfenozide 24% w/v (21.8%w/w) SC @ 124 g a.i /ha	3.7	3.2 (1.78)^{b}	3.0 (1.73)^{bc}	2.6 (1.61)^{b}	3.0 (1.73)^{b}	2.6 (1.61)^{e}	2.5 (1.58)^{d}	2.6 (1.61)^{d}	2.8 (2.67)^{d}	2.78 (1.67)^{e}
T_6: Flubendiamide 34.35 SC @ 48 g a.i /ha	3.4	3.1 (1.76)^{b}	2.8 (2.67)^{c}	2.6 (1.61)^{b}	3.0 (1.73)^{b}	2.8 (2.67)^{d}	2.5 (1.58)^{d}	2.1 (1.44)^{e}	2.9 (1.70)^{d}	2.72 (1.65)^{e}
T_7: Thiodicarb 75% WP @ 562.5 g a.i /ha	3.7	3.2 (1.78)^{b}	3.0 (1.73)^{bc}	2.7 (1.64)^{b}	3.0 (1.73)^{b}	3.5 (1.87)^{c}	2.8 (2.67)^{c}	2.9 (1.70)^{c}	3.2 (1.78)^{c}	3.03 (1.74)^{d}
T_8: Untreated check	4.2	4.3 (2.07)^{a}	4.3 (2.07)^{a}	4.5 (2.12)^{a}	4.6 (2.14)^{a}	4.7 (2.16)^{a}	4.9 (2.21)^{a}	4.9 (2.21)^{a}	5.0 (2.23)^{a}	4.65 (2.16)^{a}
SEd	-	0.1025	0.1049	0.1074	0.0146	0.0174	0.0205	0.0219	0.0164	0.0507
CD (0.05)	-	0.2198	0.2250	0.2304	0.0314	0.0373	0.0440	0.0469	0.0351	0.1087

*Mean of three replications; Two rounds of spraying at 15 days interval starting from 45 DAS. Figures in the parentheses are square root transformed values.
In a column means followed by same letter(s) are not significantly different by LSD (P= 0.05).

Table 4: Population of coccinellids on greengram as influenced by Spinetoram 10% w/v + Sulfoxaflor 30% w/v SC.

Treatments	Pre-count	Population of spiders (No.of spiders/10 plants)(Days after treatment)								Mean
		1st spray				2nd spray				
		1	3	7	10	1	3	7	10	
T_1: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 126 g a.i /ha	2.2	1.7 (1.30)^{b}	1.8 (1.34)^{b}	1.9 (1.37)^{c}	2.4 (1.54)^{a}	2.2 (1.48)^{a}	2.0 (1.41)^{b}	2. 5 (1.58)^{b}	2.7 (1.64)^{b}	2.15 (1.47)^{b}
T_2: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 135 g a.i /ha	2.4	1.7 (1.30)^{b}	1.8 (1.34)^{b}	1.9 (1.37)^{c}	2.2 (1.48)^{b}	2.2 (1.48)^{a}	2.0 (1.41)^{b}	2.5 (1.58)^{b}	2.6 (1.61)^{bc}	2.11 (1.45)^{c}
T_3: Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC @ 144 g a.i /ha	2.3	1.6 (1.26)^{bc}	1.7 (1.30)^{bc}	1.8 (1.34)^{d}	2.1 (1.44)^{c}	1.8 (1.34)^{c}	1.7 (1.30)^{d}	2.4 (1.54)^{c}	2.5 (1.58)^{cd}	1.95 (1.40)^{d}
T_4: Spinetoram 12% w/v (11.7%w/w) @ 24 g a.i /ha	2.1	1.5 (1.22)^{c}	1.6 (1.26)^{c}	1.7 (1.30)^{e}	2.0 (1.41)^{d}	2.0 (1.41)^{b}	1.8 (1.34)^{c}	2.3 (1.51)^{d}	2.4 (1.54)^{d}	1.91 (1.38
T_5: Methoxyfenozide 24% w/v (21.8%w/w) SC @ 124 g a.i /ha	2.2	1.6 (1.26)^{bc}	1.7 (1.30)^{bc}	1.9 (1.37)^{c}	1.9 (1.37)^{e}	1.8 (1.34)^{c}	1.8 (1.34)^{c}	2.2 (1.48)^{e}	2.4 (1.54)^{d}	1.91 (1.38)^{e}
T_6: Flubendiamide 34.35 SC @ 48 g a.i /ha	2.0	1.1 (1.04)^{d}	1.1 (1.04)^{d}	1.4 (1.18)^{f}	1.5 (1.22)^{f}	1.3 (1.14)^{d}	1.5 (1.22)^{e}	1.8 (1.34)^{f}	2.6 (1.61)^{bc}	1.53 (1.22)^{g}
T_7: Thiodicarb 75% WP@ 562.5 g a.i /ha	2.6 (1.51)^{a}	2.3 (1.48)^{a}	2.2 (1.58)^{a}	2.5 (1.48)^{b}	2.2 (1.41)^{b}	2.0 (1.30)^{d}	1.7 (1.48)^{e}	2.2 (1.26)^{e}	1.6 (1.44)^{f}	2.08
T_8: Untreated check	2.1 (1.44)^{a}	2.1 (1.44)^{a}	2.1 (1.48)^{b}	2.2 (1.48)^{b}	2.2 (1.51)^{a}	2.3 (1.58)^{a}	2.5 (1.64)^{a}	2.7 (1.70)^{a}	2.9 (1.51)^{a}	2.3
SEd	-	0.1551	0.0211	0.0154	0.0129	0.0171	0.0134	0.0101	0.0152	0.0306
CD (0.05)	-	0.3326	0.0453	0.0330	0.0276	0.0368	0.0287	0.0217	0.0327	0.0698

*Mean of three replications; Two rounds of spraying at 15 days interval starting from 45 DAS. Figures in the parentheses are square root transformed values.
In a column means followed by same letter(s) are not significantly different by LSD (P= 0.05).

CONCLUSION

Out of eight treatments evaluated against lepidopteran pod borers *viz., M. vitrata* and *L. boeticus*, two sprays of spinetoram 6% w/v + methoxyfenozide 30% w/v SC @ 144 g a.i/ha and flubendiamide 34.35 SC @ 48 g a.i/ha from 45 DAS at 15 days interval proved to be most effective and no lethal effect was recorded to the coccinellid predators, *M. sexmaculatus*, *C. transversalis* and spiders. They did not cause any phytotoxic symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty at any day after treatment on stems, leaves, flowers and pods of greengram.

Conflict of interest

All authors declared that there is no conflict of interest.

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