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Efficacy of different combination of insecticides against spotted pod borer in cowpea [*Vigna ungiculata* (L.) Walp.]

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Abstract
Different combinations of insecticides were tested on cowpea crop against spotted pod borer (*Maruca vitrata*) during 2012-2014 at different time intervals and revealed that lowest *M. vitrata* population was recorded in the treatment of imidacloprid 17.8 SL in combination with spinosad 45 SC (0.90 larva/plant). The next effective treatments were acetamiprid 20 SP in combination with spinosad 45 SC (0.98 larva/plant) and thiamethoxam 25 WG in combination with spinosad 45 SC (0.98 larva/plant). The highest *M. vitrata* population was observed in control (4.18 larvae/plant). Maximum reduction of larvae was found in the treatments in which spinosad is present followed by the treatments in which novaluron is present. Imidacloprid 17.8 SL in combination with spinosad 45 SC recorded the lowest spotted pod borer damage with 5.61 per cent damage. With respect to BCR, highest BCR (1:8.70) was registered in the treatment imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC which was followed by thiamethoxam 25 WG in combination with indoxacarb 14.5 SC (1:6.52) and acetamiprid 20 SP in combination with indoxacarb 14.5 SC (1:6.43).

Keywords: cowpea, spotted pod borer, *Maruca vitrata*, bio efficacy, spinosad, indoxacarb

Introduction
Cowpea [*Vigna ungiculata* (L.) Walp.] belonging to family leguminaceae is one of the principle pulse crops of the tropics and commonly known as Chala or Choli, Chavli, Lobia, Bobbarlu, southern pea and black – eyed bean. It can be used as fodder, vegetable, green legume as well as green manure crop. In Gujarat, Cowpea is cultivated in about 23,600 ha with an annual production of 19,900 tonnes and on average cowpea occupies area of 6937 hectares with an annual production of 42,432 tonnes (Anonymous, 2003-04) [1]. The losses in grain or foliage of cowpea ranges from 20 to 100 per cent due to field insect pests (Raheja, 1976; Singh and Allen, 1980) [2, 3]. The spotted pod borer is a serious pest of grain legumes in the tropics and subtropics because of its extensive host range, distribution and destructiveness and it is major pest of cowpea (Mahalakshmi *et al.*,2016) [4]. It attacks the crop right from pre-flowering to pod maturing stage (Sravani and Sesha Mahalakshmi, 2016) [5]. The larvae feed on flowers, buds and pods and the entrance hole is plugged with excreta and it is basically hidden pest which completes its larval development inside the web formed by rolling and tying together leaves, flowers, buds and pods.(Sreekanth *et al.*, 2015) [6]. Infested flowers do not develop into pods while the infected pods become malformed. In the present study different combinations of insecticides were tested against spotted pod borer in cowpea.

Materials and Methods
The investigation on chemical control of pest complex of Cowpea [*Vigna ungiculata* (L.) Walp.]" Was carried out at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during 2012-2014. The design used is Randomized block design. The variety used is Pusa Phalguni, the soils are black soils. The spacing followed was 45 cm X 30 cm. Gross plot area was 2.25 X 3.0 m. All the post-sowing agronomical practices were followed.

In order to determine the effectiveness of some insecticides against spotted pod borer (*M. vitrata*), insecticides were sprayed with the initiation of pest and 5 plants were randomly selected from net plot area and tagged. The net plot area was 1.35m X 1.80 m. The details of the insecticide combinations sprayed are given in the table 1. Before spray, pre-treatment counts were made from the tagged plants from net plot area before 24 hours and post-treatment counts were made at 1, 3, 7 and 15 days after spraying. The observations on population of pest were recorded in the morning hours. Pod borer incidence was recorded by counting total number of larvae on each tagged plant at weekly interval from 10 days after sowing. Per cent pod borers damage was also recorded from each treatment at each picking. For this purpose, pods of each treatment were harvested separately from the five selected plants and 100 pods selected at random were observed for the assessment of per cent pod damage. Spraying was done with the help of lever operated knapsack sprayer. Care was taken during spraying to obtain uniform coverage of insecticides on each plot and plant.

Table 1: Details of Insecticidal treatments

Sr. No.	Technical Name	Trade Name
1	Imidacloprid 17.8 SL @ 0.005 % + Novaluron 10 EC @ 0.015%	Confidor, Rimon
2	Imidacloprid 17.8 SL @ 0.005% + Indoxacarb 14.5 SC @ 0.007%	Confidor, Avaunt
3	Imidacloprid 17.8 SL @ 0.005% + Spinosad 45 SC @ 0.014%	Confidor, Tracer
4	Imidacloprid 17.8 SL @ 0.005% + Flubendiamide 480 SC @ 0.144%	Confidor, Fame
5	Thiamethoxam 25 WG @ 0.01% + Novaluron 10 EC @ 0.015%	Actara, Rimon
6	Thiamethoxam 25 WG @ 0.01% + Indoxacarb 14.5 SC @ 0.007%	Actara, Avaunt
7	Thiamethoxam 25 WG @ 0.01% + Spinosad 45 SC @ 0.014%	Actara, Tracer
8	Thiamethoxam 25 WG @ 0.01% + Flubendiamide 480 SC @ 0.144%	Actara, Fame
9	Acetamiprid 20 SP @ 0.006% + Novaluron 10 EC @ 0.015%	Pride , Rimon
10	Acetamiprid 20 SP @ 0.006% + Indoxacarb 14.5 SC @ 0.007%	Pride, Avaunt
11	Acetamiprid 20 SP @ 0.006% + Spinosad 45 SC @ 0.014%	Pride, Tracer
12	Acetamiprid 20 SP @ 0.006% + Flubendiamide 480 SC @ 0.144%	Pride, Fame

Results and Discussion

The differences in population of *M. vitrata* recorded before spraying was found to be non- significant among different treatments which indicated that the infestation of *M. vitrata* was in homogenous condition (Table 2).

The perusal of data (Table 2) recorded on first day after spraying indicated that all the insecticidal treatments recorded lower *M. vitrata* population as compared to control (water spray). Among different insecticidal combinations, imidacloprid 17.8 SL in combination with spinosad 45 SC (1.20 larvae/plant) was found most effective treatment and it was at par with acetamiprid 20 SP in combination with spinosad 45 SC (1.27 larvae/plant) and thiamethoxam 25 WG in combination with spinosad 45 SC (1.26 larvae/plant). Imidacloprid 17.8 SL in combination with novaluron 10 EC (1.73 larvae/plant), imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC, (1.80 larvae/plant), thiamethoxam 25 WG in combination with novaluron 10 EC (1.80 larvae/plant), thiamethoxam 25 WG in combination with indoxacarb 14.5 SC (1.86larvae/plant), acetamiprid 20 SP in combination with novaluron 10 EC(1.86 larvae/plant) and acetamiprid 20 SP in combination with indoxacarb 14.5 SC (1.93 larvae/plant) were the next best treatments. Imidacloprid 17.8 SL in combination with flubendiamide 480 SC, acetamiprid 20 SP in combination with flubendiamide 480 SC and thiamethoxam 25 WG in combination with flubendiamide 480 SC recorded 2.20, 2.26 and 2.46 larvae per plant respectively. The highest *M. vitrata* population was observed in control (3.60 larvae/plant). The perusal of data (Table 2) recorded on third day after spraying indicated the same trend was followed as in case of first day after spray, among different insecticidal combinations, imidacloprid 17.8 SL in combination with spinosad 45 SC (1.00 larva/plant) was found most effective treatment and it was at par with acetamiprid 20 SP in combination with spinosad 45 SC (1.26 larvae/plant) and thiamethoxam 25 WG in combination with spinosad 45 SC (1.06 larvae/plant). Imidacloprid 17.8 SL in combination with novaluron 10 EC (1.53 larvae/plant) was found to next best treatment followed by imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC, (1.60 larvae/plant), thiamethoxam 25 WG in combination with novaluron 10 EC (1.60 larvae/plant), thiamethoxam 25 WG in combination with indoxacarb 14.5 SC (1.66 larvae/plant), acetamiprid 20 SP in combination with novaluron 10 EC (1.60 larvae/plant) and acetamiprid 20 SP in combination with indoxacarb 14.5 SC (1.73 larvae/plant) were the next best treatments. Imidacloprid 17.8 SL in combination with flubendiamide 480 SC, acetamiprid 20 SP in combination with flubendiamide 480 SC and thiamethoxam 25 WG in combination with flubendiamide 480 SC recorded 2.0, 2.06 and 2.26 larvae per plant respectively. The highest *M. vitrata* population was observed in control (3.87 larvae/plant).

The perusal of data (Table 2) recorded on seventh day after spraying indicated imidacloprid 17.8 SL in combination with spinosad 45 SC (0.73 larva/plant) and acetamiprid 20 SP in combination with spinosad 45 SC (0.73 larva/plant) were found most effective treatments and were at par with and thiamethoxam 25 WG in combination with spinosad 45 SC (0.80 larva/plant). Imidacloprid 17.8 SL in combination with novaluron 10 EC (1.26 larvae/plant), imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC (1.33 larvae/plant), thiamethoxam 25 WG in combination with novaluron 10 EC (1.33 larvae/plant) and acetamiprid 20 SP in combination with novaluron 10 EC (1.33 larvae/plant) were next in order and were at par with each other. Thiamethoxam 25 WG in combination with indoxacarb 14.5 SC, acetamiprid 20 SP in combination with indoxacarb 14.5 SC, imidacloprid 17.8 SL in combination with flubendiamide 480 SC, acetamiprid 20 SP in combination with flubendiamide 480 SC and thiamethoxam 25 WG in combination with flubendiamide 480 SC recorded 1.40, 1.46, 1.80, 1.80 and 1.93 larvae per plant respectively. The highest *M. vitrata* population was observed in control (4.33 larvae/plant).The data recorded on fifteenth day after spraying indicated that all the insecticidal treatments recorded lower *M. vitrata* population as compared to control. Among different insecticidal combinations, imidacloprid 17.8 SL in combination with spinosad 45 SC (0.67 larva/plant) was the effective treatment and was at par with acetamiprid 20 SP in combination with spinosad 45 SC (0.87 larva/plant), thiamethoxam 25 WG in combination with spinosad 45 SC (0.87 larva/plant). Acetamiprid 20 SP in combination with indoxacarb 14.5 SC (1.20 larvea/plant) and acetamiprid 20 SP in combination with novaluron 10 EC (1.26 larvae/plant) were next in order. Imidacloprid 17.8 SL in combination with novaluron 10 EC, thiamethoxam 25 WG in combination with novaluron 10 EC, imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC, thiamethoxam 25 WG in combination with indoxacarb 14.5 SC, imidacloprid 17.8 SL in combination with flubendiamide 480 SC, acetamiprid 20 SP in combination with flubendiamide 480 SC and thiamethoxam 25 WG in combination with flubendiamide 480 SC recorded 1.33, 1.33, 1.40, 1.40, 1.80, 1.80 and 1.86 larvae per plant respectively. The highest *M. vitrata* population was observed in control (4.93 larvae/plant).

Pooled data over periods (Table 2) indicated that all the treatments showed significant superiority in controlling the *M. vitrata* population over control. However, significantly lowest *M. vitrata* population was recorded in the treatment of imidacloprid 17.8 SL in combination with spinosad 45 SC (0.90 larva/plant). The next effective treatments were acetamiprid 20 SP in combination with spinosad 45 SC (0.98 larva/plant), thiamethoxam 25 WG in combination with spinosad 45 SC (0.98 larva/plant). Imidacloprid 17.8 SL in combination with novaluron 10 EC (1.46 larvae/plant), thiamethoxam 25 WG in combination with novaluron 10 EC (1.51 larvae/plant), acetamiprid 20 SP in combination with novaluron 10 EC (1.51 larvae/plant) and imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC (1.53 larvae/plant) were the next best treatments. Thiamethoxam 25 WG in combination with indoxacarb 14.5 SC, acetamiprid 20 SP in combination with indoxacarb 14.5 SC, imidacloprid 17.8 SL in combination with flubendiamide 480 SC, acetamiprid 20 SP in combination with flubendiamide 480 SC and thiamethoxam 25 WG in combination with flubendiamide 480 SC and, recorded 1.58, 1.58, 1.95, 1.98 and 2.13 larvae per plant respectively. The highest *M. vitrata* population was observed in control (4.18 larvae/plant).

When Per cent pod damage was calculated for different insecticide combinations none of the treatments were found free from the damage of spotted pod borer, *M. vitrata* (Table 3). However, lowest spotted pod borer damage was recorded in imidacloprid 17.8 SL in combination with spinosad 45 SC (5.61%) and this was at par with thiamethoxam 25 WG in combination with spinosad 45 SC (5.89%) and acetamiprid 20 SP in combination with spinosad 45 SC (6.00%). The next effective treatments were acetamiprid 20 SP in combination with novaluron 10 EC (8.86%), imidacloprid 17.8 SL in combination with novaluron 10 EC (9.08%), thiamethoxam 25 WG in combination with novaluron 10 EC (9.36%). The treatments acetamiprid 20 SP in combination with indoxacarb 14.5 SC, imidacloprid 17.8 SL in combination with indoxacarb 14.5 SC, thiamethoxam 25 WG in combination with indoxacarb 14.5 SC, thiamethoxam 25 WG in combination with flubendiamide 480 SC, acetamiprid 20 SP in combination with flubendiamide 480 SC and imidacloprid 17.8 SL in combination with flubendiamide 480 SC, recorded 10.14, 10.16, 10.26, 10.46, 10.51 and 10.54 per cent pod damage respectively. The highest per cent pod damage was observed in control (28.13 %).

The findings are in line with Shinde (2011) [7], who stated that spinosad 0.09 per cent was the best treatment by recording 90.19, 90.87 and 89.9 per cent death of larvae after 1, 3 and 7 days after spraying against *M. vitrata*. He also found that lowest spotted pod borer damage was seen in the treatment spinosad. According Grigolli *et al.* (2015) [8] the efficacy of flubendiamide ensured good control of *M. vitrata* from 10 days after application when compared to chlorpyrifos, teflubenzuron, and chlorantraniliprole + lambda-cyhalothrin. The results are more or less in acceptance with Umbarkar and Parsana (2014) [9] who stated that indoxacarb 0.0075 per cent recorded the minimum pod damage of 9.58 per cent and was at par with spinosad 0.009 per cent in green gram when compared to the other nine insecticides. The results are more or less in agreement with Yadav and Singh (2014) [10] who found that spinosad 45% SC and indoxacarb 14.5 % SC were the most effective treatments to control *Maruca testulalis* population in cowpea.

From the above investigations it can be inferred that maximum reduction of larvae was found in the treatments with spinosad followed by the treatments in which novaluron is present.

Table 2: Effect of insecticide combinations against *M. vitrata* on cowpea

Sr. No.	Treatment	Mean no. of *M. vitrata*/plant					
		Before spraying	1 DAS	3 DAS	7 DAS	15 DAS	Pooled
1	Imidacloprid 17.8 SL @ 0.005% + Novaluron 10 EC @ 0.005%	1.97(3.40)*	1.49(1.73)*	1.43(1.53)*	1.33(1.26)*	1.35(1.33)*	1.40(1.46)*
2	Imidacloprid 17.8 SL @ 0.005% + Indoxacarb 14.5 SC @ 0.008%	1.85(2.93)	1.51(1.80)	1.44(1.60)	1.35(1.33)	1.38(1.40)	1.42(1.53)
3	Imidacloprid 17.8 SL @ 0.005% + Spinosad 45 SC @ 0.009%	1.97(3.40)	1.30(1.20)	1.22(1.00)	1.11(0.73)	1.08(0.67)	1.18(0.90)
4	Imidacloprid 17.8 SL @ 0.005% + Flubendiamide 48 SC @ 0.005%	1.98(3.47)	1.64(2.20)	1.58(2.00)	1.52(1.80)	1.52(1.80)	1.56(1.95)
5	Thiamethoxam 25 WG @ 0.005% + Novaluron 10 EC @ 0.005%	2.01(3.53)	1.52(1.80)	1.45(1.60)	1.35(1.33)	1.35(1.33)	1.42(1.51)
6	Thiamethoxam 25 WG @ 0.005% + Indoxacarb 14.5 SC @ 0.008%	2.04(3.66)	1.53(1.86)	1.47(1.66)	1.37(1.40)	1.37(1.40)	1.44(1.58)
7	Thiamethoxam 25 WG @ 0.005% + Spinosad 45 SC @ 0.009%	1.94(3.26)	1.33(1.26)	1.25(1.06)	1.14(0.80)	1.14(0.80)	1.21(0.98)
8	Thiamethoxam 25 WG @ 0.005% + Flubendiamide 48SC @ 0.005%	1.94(3.26)	1.72(2.46)	1.66(2.26)	1.56(1.93)	1.54(1.86)	1.62(2.13)
9	Acetamiprid 20 SP @ 0.004% + Novaluron 10 EC @ 0.004%	1.90(3.13)	1.54(1.86)	1.45(1.60)	1.35(1.33)	1.33(1.26)	1.42(1.51)
10	Acetamiprid 20 SP @ 0.004% + Indoxacarb 14.5 SC @ 0.008%	1.95(3.33)	1.55(1.93)	1.48(1.73)	1.39(1.46)	1.29(1.20)	1.43(1.58)
11	Acetamiprid 20 SP @ 0.004% + Spinosad 45 SC @ 0.009%	1.86(3.00)	1.33(1.27)	1.25(1.06)	1.11(0.73)	1.17(0.87)	1.21(0.98)
12	Acetamiprid 20 SP @ 0.004% + Flubendiamide 48 SC @0.005%	1.85(2.93)	1.66(2.26)	1.60(2.06)	1.52(1.80)	1.52(1.80)	1.57(1.98)
13	Control	1.94(3.27)	2.02(3.60)	2.09(3.87)	2.10(4.33)	2.33(4.93)	2.16(4.18)
	S. Em. ±	0.06	0.05	0.06	0.05	0.05	0.05

C. D. at 5%	NS	0.16	0.117	0.15	0.15	0.016
C. V. %	5.90	6.37	7.01	6.69	6.64	6.68
S. Em. ± (P X T)	-	-	-	-	-	0.04
CD at 5 % (P X T)	-	-	-	-	-	0.12

*Figure in parentheses are original values, those outside parentheses are $\sqrt{x+0.5}$ Transformed values DAS: Days After Spraying

Table 3: Effect of insecticide combinations on per cent pod damage caused by *M. vitrata*

Sr. No.	Treatment	1st picking	2nd picking	3rd picking	4th picking	pooled
1	Imidacloprid 17.8 SL @ 0.005 % + Novaluron 10 EC @ 0.015%	16.70(8.27)*	17.31(8.87)*	18.25(9.87)*	17.76(9.33)*	17.50(9.08)*
2	Imidacloprid 17.8 SL @ 0.005% + Indoxacarb 14.5 SC @ 0.007%	17.17(8.73)	18.17(9.73)	19.48(11.13)	19.34(11.00)	18.54(10.14)
3	Imidacloprid 17.8 SL @ 0.005% + Spinosad 45 SC @ 0.014%	12.29(4.53)	13.52(5.47)	15.24(7.00)	13.49(5.47)	13.63(5.61)
4	Imidacloprid 17.8 SL @ 0.005% + Flubendiamide 480 SC @ 0.144%	17.91(9.47)	18.36(9.93)	19.53(11.20)	19.73(11.47)	18.88(10.51)
5	Thiamethoxam 25 WG @ 0.01% + Novaluron 10 EC @ 0.015%	16.76(8.33)	17.71(9.27)	18.71(10.33)	17.97(9.53)	17.79(9.36)
6	Thiamethoxam 25 WG @ 0.01% + Indoxacarb 14.5 SC @ 0.007%	17.45(9.00)	18.10(9.66)	19.76(11.46)	19.21(10.93)	18.65(10.26)
7	Thiamethoxam 25 WG @ 0.01% + Spinosad 45 SC @ 0.014%	12.22(4.49)	13.13(5.33)	15.79(7.46)	14.49(6.27)	13.96(5.89)
8	Thiamethoxam 25 WG @ 0.01% + Flubendiamide 480 SC @ 0.144%	18.17(9.73)	18.49(10.06)	19.56(11.26)	19.45(11.13)	18.92(10.54)
9	Acetamiprid 20 SP @ 0.006% + Novaluron 10 EC @ 0.015%	15.84(7.47)	17.17(8.73)	18.53(10.13)	17.57(9.13)	17.28(8.86)
10	Acetamiprid 20 SP @ 0.006% + Indoxacarb 14.5 SC @ 0.007%	17.85(9.13)	18.20(9.87)	19.55(11.27)	18.71(10.40)	18.56(10.16)
11	Acetamiprid 20 SP @ 0.006% + Spinosad 45 SC @ 0.014%	12.38(4.60)	13.85(5.73)	15.99(7.60)	14.23(6.06)	14.11(6.00)
12	Acetamiprid 20 SP @ 0.006% + Flubendiamide 480 SC @ 0.144%	18.11(9.67)	18.10(9.73)	19.72(11.40)	19.31(11.06)	18.85(10.46)
13	Control	28.54(23.00)	31.82(28.00)	32.12(28.53)	34.96(33.00)	31.86(28.13)
S. Em. ±		0.65	0.78	1.19	0.87	0.44
C. D. at 5%		1.92	2.28	3.48	2.56	1.25
C. V. %		6.70	7.53	10.67	8.02	10.65
S. Em. ± (P X T)		-	-	-	-	0.98
CD at 5 % (P X T)		-	-	-	-	2.95

*Figure in parentheses are retransformed values, those outside parentheses are arcsine transformed value

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