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Original Article

Bioefficacy of Clothianidin 0.5G against Whitefly and Aphid in Okra, *Abelmoschus Csculentus*

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Abstract

Relative bioefficacy of clothianidin 0.5%G @ 30, 40, 50, 60, and 80g a.i. ha^{-1}, carbofuran 3%G @1000g a.i. ha^{-1}, and thiamethoxam 25 WDG @ 25g a.i. ha^{-1} were evaluated against sucking pests (whitefly and aphid) and their natural enemies in okra at Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal for two consecutive seasons of 2011 (*rabi*) and 2012 (pre-*kharif*). Among these, clothianidin @ 60g to 80g a.i. ha^{-1} against whitefly and aphid was found superior over other doses of clothianidin, carbofuran and thiamethoxam. With regard to the fruit yield, clothianidin @60g a.i. ha^{-1} was found statistically superior over others. Also the granular formulation of clothianidin didn't exhibit any adverse harmful effect on predatory natural enemies in okra ecosystem.

Keywords

Carbofuran; Clothianidin; Natural Enemy; Okra; Sucking Pests; Thiamethoxam.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the popular vegetables of common man, cultivated in India for its immature fruits. It is noted for its rich iron content and nutritive value. Though okra finds its origin in South-Africa, India stands top in area and production. The area under this crop is about 0.36 million hectares with an annual production of 3.50 million tonnes and productivity of 9.72 tonnes ha^{-1} in India [1]. There are several factors that lead to the low productivity of okra in India. Among these, one of the major constraints is the pest. Okra is attacked by as many as 45 species of insect-pests belonging to different orders. Among these aphid, *Aphis gossypii* Glover, and whitefly, *Bemisia tabaci* Genn., cause appreciable losses in yield. Use of chemicals forms an important part of pest management strategies as many newer insecticides of different modes of action are available in the market. Evaluation of such chemicals for their bio-efficacy against crop pests is warranted. Keeping in view the about facts the present study was carried out to check the efficacy of clothianidin 0.5G against these pests and its effect on natural enemies.

Materials and Methods

The study was carried out on the effect of clothianidin 0.5%G against whitefly, *Bemisia tabaci* and aphid, *Aphis gossypii* in okra at the Central Research Farm ($22^0 58' 15.08''$ N latitude and $88^0 29' 49.18''$ E longitude with 40 ft elevation) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during two consecutive seasons of 2011 (*rabi*) and 2012 (pre-*kharif*). The experiment was laid out in Randomized Complete Block Design on okra cv. OH-152 for both the seasons. All together eight treatments comprising of clothianidin 0.5%G @ 30, 40, 50, 60, and 80g a.i. ha^{-1}, carbofuran 3%G @1000g a.i. ha^{-1}, and thiamethoxam 25 WDG @ 25g a.i. ha^{-1}were replicated thrice for each treatment. The individual plot size was (5.5m × 3.6m) 19.8 sq. m. Recommended package of practices were adopted to raise okra crop.

Observations on population of whitefly and aphid per leaf, population of predatory coccinellids and spiders per plant, number of fruits $plot^{-1}$, and yield was recorded. Ten plants from each plot leaving border rows were randomly tagged for taking

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observation on these pests and beneficial insects. Top, middle and bottom leaves of each plant were explored for recording the number of insects at weekly interval commencing from their onset and at 0 (pre-treatment), 1, 3, 5, 7 and 10 days after second application of granular insecticides (clothianidin 0.5G and carbofuran 3G) and single foliar spray of thiamethoxam 25WDG. Granular insecticidal application was followed by light watering. Foliar spray of thiamethoxam was made by Knapsack sprayer. Spray volume for foliar spray was 500 litres per hectare.

Reduction of insect pest population after insecticidal treatment was corrected following Henderson and Tilton's formula as mentioned below [2]

Corrected % = (1 -n in Co before treatment * n in T after treatment ÷ n in Co after treatment * n in T before treatment) * 100

Where, n = Insect population, T = treated, Co = control. The data thus recorded during experiment were analyzed statistically according to Duncan's Multiple Range Test at 5% level of probability.

Results

Effect of clothianidin 0.5G on population of whitefly (Bemisia tabaci) of okra during rabi season of 2011-12 and pre-kharif season of 2012

Rabi Season of 2011-12

Initiation of whitefly infestation in *rabi* season okra was first detected on 27th January, 2012 *i.e.* approximately 8 weeks after sowing of the crop. As per the concept of standard meteorological week (SMW), 27th January comes under 4th SMW. Population of whitefly was recorded at regular interval in every SMW after their onset (Table 1). It is clearly revealed here that population of whiteflies recorded at 9th SMW was comparatively lower in

Table 1: Effect of clothianidin on population of whitefly of okra during *rabi* season of 2011-12

Treatments	Population of whitefly/ leaf at weekly interval after their onset					
	4th SMW	5th SMW	6th SMW	7th SMW	8th SMW	9th SMW
T_1: Untreated control	0.38 ^{a}	0.61^{a}	0.37^{a}	0.41^{a}	0.48^{a}	1.80^{a}
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	0.38^{a}	0.50^{a}	0.37^{a}	0.38^{a}	0.40^{a}	1.36^{a}
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	0.38^{a}	0.48^{a}	0.32^{ab}	0.35^{a}	0.34^{abc}	1.28^{bc}
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	0.31^{ab}	0.41^{abc}	0.22^{ab}	0.27^{ab}	0.27^{bc}	1.10^{cd}
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	0.19^{bc}	0.23^{bc}	0.18^{ab}	0.19^{b}	0.26^{bc}	1.10^{cd}
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	0.15^{c}	0.21^{c}	0.13^{b}	0.18^{b}	0.19^{c}	1.00^{d}
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	0.28^{ab}	0.43^{ab}	0.28^{ab}	0.28^{ab}	0.32^{abc}	1.37^{b}
T_8: Thiamethoxam 25 WDG@25 g a.i. ha^{-1}	0.30^{ab}	0.48^{a}	0.37^{a}	0.39^{a}	0.40^{ab}	1.40^{b}
SEm (±)	**0.04**	**0.06**	**0.06**	**0.04**	**0.05**	**0.07**
LSD (0.05)	**0.12**	**0.19**	**0.19**	**0.14**	**0.16**	**0.19**

clothianidin 0.5G application at doses of 50 to 80g a.i. ha^{-1}(T_4, T_5 & T_6) than treated check (carbofuran and thiamethoxam at recommended dose) and untreated control. Blanket application of clothianidin 0.5G in okra @ 50g a.i. ha^{-1}and above doses gave protection from severe whitefly infestation up to 13 weeks after sowing of the crop. The mentioned treatments (T_4, T_5 & T_6) were statistically at par with each other but were significantly superior over application of carbofuran @1000g a.i. ha^{-1} and thiamethoxam @ 25g a.i. ha^{-1} to keep the whitefly population low (Table 1).

The pre-treatment population of whitefly per leaf did not exhibit any significant differences among treated plots (Table 2). Here, reduction in whitefly population against clothianidin application was noted till ten days after application and maximum reduction was observed within 24 hrs of application. Till five days after application of insecticides none of the treatments revealed any significant differences with regard to reduction of whitefly population. Clothianidin 0.5G @ 60g and 80g a.i. ha^{-1} achieved 81.44% and 80.93% reduction of whitefly population, respectively at ten days after application; which were significantly higher over carbofuran, thiamethoxam and lower doses of clothianidin. Mean reduction of *B. tabaci* population after treatment was found maximum with clothianidin 0.5G @ 60g a.i. / ha^{-1}, but it was at par with clothianidin 0.5G @4 0g, 50g, and 80g a.i. ha^{-1}and thiamethoxam 25WDG @ 25g a.i. ha^{-1} while significantly superior over carbofuran 3G @1000g a.i. ha^{-1}(Table 2).

Pre-kharif Season of 2012

Initiation of whitefly infestation in pre-*kharif* season okra was first detected on 19th June, 2012 *i.e.* approximately 7 weeks after sowing of the crop. As per the concept of standard meteorological week (SMW) 19th June comes under 25th SMW. Population of whitefly was recorded at regular interval in every SMW after their onset (Table 3). After onset of whitefly infestation in the pre-*kharif* season okra no significant

Table 2: Efficacy of clothianidin against whitefly population of okra during *rabi* season of 2011-12

Treatments	Pre-treatment population /leaf	% reduction of *B. tabaci* population at days after 2nd application / spraying (DAA) *					Mean
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	8.80_a	4.05_c	4.05_b	4.05_b	4.05_e	4.05_d	4.05_d
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	5.77_b	35.20_b	48.25_a	57.89_a	77.26_{bc}	78.02_{ab}	59.33_{bc}
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	5.51_b	34.77_b	49.17_a	58.38_a	77.37_{bc}	78.36_{ab}	59.61_{abc}
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	4.87_b	35.10_b	52.76_a	60.93_a	78.38_{abc}	79.02_{ab}	61.23_{abc}
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	4.73_b	38.48_b	59.92_a	66.31_a	80.63_a	81.44_a	65.36_a
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	4.50_b	35.19_b	55.69_a	63.07_a	80.13_{ab}	80.93_a	62.99_{ab}
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	5.48_b	31.22_b	51.04_a	58.47_a	70.97_d	72.10_c	56.76_c
T_8: Thiamethoxam 25 WDG@25 g a.i. ha^{-1}	6.10_b	47.28_a	59.22_a	65.05_a	75.29_c	75.65_b	64.49_{ab}
SEm (±)	**0.58**	**2.57**	**3.50**	**2.57**	**0.94**	**1.14**	**1.75**
LSD (0.05)	**1.74**	**7.79**	**10.60**	**7.81**	**2.85**	**3.45**	**5.30**

Note: * Data shown in the table are (x+0.5) angular transformed values
Data marked by common letters are not statistically significant according to DMRT at 5% level of probability.

differences in their population were noted till 27th SMW.

Pre-treatment population of *B. tabci* per leaf did not differ statistically among treated plots in pre-*kharif* season okra. Untreated control plots and plots received foliar application of thiamethoxam having comparatively more population of whitefly than others (Table 4). The maximum per cent reduction of whitefly population in okra was observed after ten days of application of clothianidin 0.5G @ 60g a.i. ha^{-1}. It was significantly better than application of carbofuran 3G @1000g a.i. ha^{-1}and thiamethoxam @25g a.i. ha^{-1} but statistically at par with clothianidin 0.5G@50g and 80g a.i. ha^{-1}regarding reduction of whitefly population in pre-*kharif* season okra (Table 4). Mean reduction of whitefly infestation in okra was maximum in clothianidin 0.5G @80g a.i. ha^{-1}but was at par with its lower dose of 50g and 60g a.i. ha^{-1} (Table 4).

Table 3: Effect of clothaianidin on population of whitefly of okra during *pre-kharif* season of 2012

Treatments	Population of whitefly/ leaf at weekly interval after their onset		
	25th SMW	26th SMW	27th SMW
T_1: Untreated control	0.18^a	0.99^a	1.32^a
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	0.17^a	0.52^b	0.71^b
T_3: Clothianidin 0.5% G @40 g a.i. ha^{-1}	0.13^a	0.51^b	0.68^b
T_4: Clothianidin 0.5% G @50 g a.i. ha^{-1}	0.12^a	0.41^b	0.54^b
T_5: Clothianidin 0.5% G @60 g a.i. ha^{-1}	0.11^a	0.37^b	0.52^b
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	0.11^a	0.37^b	0.49^b
T_7: Carbofuran 3% G @1000 g a.i. ha^{-1}	0.11^a	0.53^b	0.71^b
T_8: Thiamethoxam 25 WDG @25g a.i. ha^{-1}	0.17^a	0.42^b	0.68^b
SEm (±)	**0.03**	**0.09**	**0.11**
LSD (0.05)	**NS**	**0.29**	**0.33**

Table 4: Efficacy of clothianidin against whitefly population of okra during *pre-kharif* season of 2012

Treatments	Pre-treatment population /leaf	% reduction of *B. tabaci* population at days after 2nd application / spraying (DAA) *					Mean
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	7.02^a	4.05^b	4.05^c	4.05^e	4.05^d	4.05^e	4.05^c
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	3.07^b	17.15^a	27.79^b	35.49^d	39.27^c	47.11^d	33.37^b
T_3: Clothianidin 0.5% G @40 g a.i. ha^{-1}	2.93^b	20.25^a	30.94^{ab}	38.54^{cd}	42.91^{bc}	52.39^{cd}	37.01^{ab}
T_4: Clothianidin 0.5% G @50 g a.i. ha^{-1}	2.68^b	20.16^a	33.93^{ab}	42.01^{abc}	46.31^{ab}	57.77^{ab}	40.04^a
T_5: Clothianidin 0.5% G @60 g a.i. ha^{-1}	2.65^b	22.75^a	36.18^a	44.34^{ab}	48.69^{ab}	61.21^a	42.63^a
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	2.47^b	23.30^a	37.16^a	45.41^a	50.09^a	58.56^{ab}	42.90^a
T_7: Carbofuran 3% G @1000 g a.i. ha^{-1}	3.06^b	18.91^a	32.27^{ab}	39.65^{bcd}	45.32^{bc}	49.99^{cd}	36.83^{ab}
T_8: Thiamethoxam 25 WDG @25g a.i. ha^{-1}	3.09^b	20.29^a	33.92^{ab}	41.32^{abc}	45.41^{abc}	54.73^{bc}	39.13^{ab}
SEm (±)	**0.38**	**2.86**	**2.48**	**1.72**	**1.89**	**1.67**	**1.95**
LSD (0.05)	**1.15**	**8.67**	**7.54**	**5.22**	**5.75**	**5.08**	**5.92**

Note: * Data shown in the table are (x+0.5) angular transformed values

Data marked by common letters are not statistically significant according to DMRT at 5% level of probability

Effect of clothianidin 0.5G on population of aphid (Aphis gossypii) of okra during rabi season of 2011-12 and pre-kharif season of 2012.

Rabi Season of 2011-12

Appearance of aphid infestation in *rabi* season okra was first detected on 27th January, 2012 *i.e.* approximately 8 weeks after sowing of the crop. As per the concept of standard meteorological week (SMW) 27th January comes under 4th SMW, population of aphid was recorded at regular interval in every SMW after their onset (Table 5). A slow but steady increase in population of aphid (*A. gossypii*) after their initiation on okra was observed during *rabi* season. Till 9th SMW aphid population was found low in clothianidin @60g and 80g a.i. being 2.70 & 2.53 leaf^{-1}, respectively; but they were at par with lower doses (40g & 50g a.i. ha^{-1}) of clothianidin as well as recommended doses of carbofuran and thiamethoxam (Table 5).

Table 5: Effect of clothianidin on population of aphid of okra during *rabi* season of 2011-12

Treatments	Population of aphid leaf at weekly interval after their onset					
	4th SMW	5th SMW	6th SMW	7th SMW	8th SMW	9th SMW
T_1: Untreated control	0.48 a	1.01 a	1.11 a	1.97 a	1.96 a	9.97 a
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	0.21 b	0.46 b	1.06 a	1.35 b	1.36 bc	4.45 b
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	0.14 bcd	0.43 b	0.76 bc	1.00 cd	1.20 bc	3.37 bc
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	0.11 cde	0.35 b	0.62 bc	0.88 de	1.20 bc	3.32 bc
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	0.05 e	0.34 b	0.63 bc	0.68 e	1.11 c	2.70 c
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	0.07 de	0.26 b	0.52 c	0.61 e	0.61 d	2.53 c
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	0.17 bc	0.38 b	0.81 b	1.22 bc	1.48 b	3.47 bc
T_8: Thiamethoxam 25 WDG@25 g a.i. ha^{-1}	0.07 de	0.34 b	0.62 bc	0.82 de	1.18 c	3.71 bc
SEm (±)	**0.02**	**0.07**	**0.07**	**0.09**	**0.09**	**0.46**
LSD (0.05)	**0.08**	**0.21**	**0.22**	**0.28**	**0.27**	**1.39**

Pre-treatment population of aphid per leaf did not show much of significant variations among treatments. Clothianidin 0.5G at different doses caused 58.71-67.91% reduction of aphid population after ten days of application in *rabi* season okra (Table 6). In contrast, thiamethoxam @25g a.i. ha^{-1} achieved 60.91% reduction of aphid population per leaf at 10 days after spraying. Considering mean reduction of aphid infestation clothianidin @ 80g a.i. ha^{-1} was proven as superior over recommended dose of carbofuran but at par with others dose of clothianidin and recommended doses of thiamethoxam (Table 6).

Pre-kharif Season of 2012

Infestation of aphid in pre-*kharif* season okra was found very scanty and scattered over the plots; though it was first encountered on 19th June, 2012 *i.e.* approximately 7 weeks after sowing of the crop. Thereafter, population of aphid was not detected during the entire crop cycle. Thus data on aphid population is not documented here.

Table 6: Efficacy of clothianidin against aphid population of okra during *rabi* season of 2011-12

Treatments	Pre-treatment population /leaf	% reduction of *A. gossypii* population at days after 2nd application/spraying (DAA) *					Mean
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	16.01 a	4.050 b	4.050 b	4.05 b	4.05 c	4.05 c	4.05 c
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	7.13 bcd	29.63 a	36.53 a	49.91 a	57.25 ab	59.28 ab	46.52 ab
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	6.57 bcd	30.91 a	42.38 a	52.93 a	57.51 ab	58.71 ab	48.49 ab
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	5.10 cd	33.99 a	43.32 a	53.58 a	59.83 ab	61.44 ab	50.43 ab
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	5.06 cd	33.65 a	46.87 a	55.90 a	60.76 ab	62.88 ab	52.01 ab
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	4.72 d	35.01 a	46.23 a	58.66 a	66.85 a	67.91 a	54.93 a
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	7.80 bc	20.28 ab	35.96 a	45.37 a	53.40 b	54.92 b	41.99 b
T_8: Thiamethoxam 25 WDG@ 25g a.i. ha^{-1}	8.63 b	32.64 a	45.66 a	54.03 a	59.79 ab	60.91 ab	50.60 ab
SEm (±)	**0.88**	**6.41**	**4.72**	**4.15**	**2.86**	**2.78**	**3.71**
LSD (0.05)	**2.66**	**19.43**	**14.31**	**12.58**	**8.68**	**8.44**	**11.26**

Note: * Data shown in the table are (x+0.5) angular transformed values
Data marked by common letters are not statistically significant according to DMRT at 5% level of probability

Effect of clothianidin 0.5%G on natural enemies in okra ecosystem

Rabi Season of 2011-12

There was hardly any difference in coccinellid predator population per plant among the treatments including control in *rabi* season okra. Grand mean over the season revealed no significant difference of predatory coccinellid populations among treatments (Table 7).

Pre-kharif Season of 2012

Initially there were no significant variations of coccinellid population among treatments. Later, they varied significantly from each other. Average population of coccinellid predator per plant over the season revealed that untreated control plot had maximum population being, 1.83 plant^{-1} (Table 8). This was closely followed by clothianidin 0.5G @60g and 80g a.i. ha^{-1}.

Rabi Season of 2011-12

Spiders population per plant in *rabi* season okra did not differ significantly due to application of granular clothianidin at varying doses (Table 9).

Pre-kharif Season of 2012

Based on grand mean data of spider population per plant over the season clothianidin at different doses were at par with standard treated check thiamethoxam at recommended dose (Table 10).

Effect of Clothianidin 0.5%G on Yield of Okra

Clothianidin 0.5G @ 60g a.i. ha^{-1} recorded

Table 7: Effect of clothianidin on population of coccinellid predator on okra during *rabi* season of 2011-12

Treatments	Pre-treatment population /plant	Population of cocconellid predator/plant at days after 2nd application/spraying (DAA) *					Grand mean over the season
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	0.77 a	0.75 a	0.75 a	0.79 a	0.82 a	0.82 b	0.80 a
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	0.77 a	0.75 a	0.73 a	0.75 ab	0.75 a	0.75 b	0.77 a
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	0.75 a	0.75 a	0.73 a	0.75 ab	0.75 a	0.75 b	0.78 a
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	0.75 a	0.73 a	0.73 a	0.73 b	0.77 a	0.82 ab	0.77 a
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	0.75 a	0.73 a	0.73 a	0.73 b	0.75 a	0.77 b	0.77 a
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	0.75 a	0.73 a	0.73 a	0.71 b	0.73 a	0.73 c	0.76 b
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	0.75 a	0.71 a	0.71 a	0.71 b	0.73 a	0.73 a	0.75 a
T_8: Thiamethoxam 25 WDG@ 25g a.i. ha^{-1}	0.75 a	0.71 a	0.71 a	0.71 b	0.73 a	0.75 b	0.75 a
SEm (±)	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**
LSD (0.05)	**NS**	**NS**	**NS**	**0.06**	**NS**	**0.06**	**NS**

Note: * Data shown in the table are $\sqrt{(x+0.5)}$ transformed values
Data marked by common letters are not statistically significant according to DMRT at 5% level of robability

Table 8: Effect of clothianidin on population of coccinellid predator on okra during pre-*kharif* season of 2012

Treatments	Pre-treatment population /leaf	Population of coccinellid predator/plant at days after 2nd application/spraying (DAA) *					Grand mean over the season
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	2.29 a	1.96 a	1.98 a	1.44 a	1.45 ab	1.46 a	1.83 a
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	1.57 d	1.23 e	1.25 e	1.22 a	1.23 ab	1.26 b	1.31 d
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	1.83 c	1.50 d	1.50 d	1.35 a	1.34 ab	1.35 ab	1.52 bcd
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	1.81 cd	1.55 cd	1.53 cd	1.31 a	1.33 ab	1.35 ab	1.46 cd
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	1.98 bc	1.87 ab	1.87 ab	1.50 a	1.47 a	1.50 a	1.73 ab
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	2.03 bc	1.63 bcd	1.62 bcd	1.51 a	1.50 a	1.52 a	1.71 ab
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	1.92 bc	1.02 e	1.00 e	1.50 a	1.48 a	1.50 a	1.53 bc
T_8: Thiamethoxam 25 WDG@ 25g a.i. ha^{-1}	2.12 ab	1.79 abc	1.78 abc	1.20 a	1.19 b	1.22 b	1.67 abc
SEm (±)	**0.08**	**0.09**	**0.08**	**0.12**	**0.08**	**0.06**	**0.07**
LSD (0.05)	**0.24**	**0.26**	**0.25**	**NS**	**0.24**	**0.18**	**0.19**

Note: * Data shown in the table are $\sqrt{(x+0.5)}$ transformed values
 # Data marked by common letters are not statistically significant according to DMRT at 5% level of probability

Table 9: Effect of clothianidin on population of spider on okra during *rabi* season of 2011-2012

Treatments	Pre-treatment population /plant	Population of spider/plant at days after 2nd application/spraying (DAA) *					Grand mean over the season
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	0.82 a	0.79 a	0.82 a	0.79 a	0.82 a	0.79 a	0.80 a
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	0.77 a	0.75 a	0.77 a	0.75 a	0.79 ab	0.77 a	0.76 a
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	0.77 a	0.75 a	0.77 a	0.79 a	0.77 ab	0.73 a	0.76 a
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	0.75 a	0.75 a	0.75 a	0.75 a	0.79 ab	0.77 a	0.75 a
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	0.77 a	0.73 a	0.77 a	0.77 a	0.79 ab	0.82 a	0.77 a
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	0.77 a	0.73 a	0.77 a	0.75 a	0.75 b	0.77 a	0.75 a
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	0.77 a	0.71 a	0.73 a	0.75 a	0.75 b	0.73 a	0.75 a
T_8: Thiamethoxam 25 WDG@ 25g a.i. ha^{-1}	0.77 a	0.71 a	0.73 a	0.75 a	0.75 b	0.75 a	0.76 a
SEm (±)	**0.04**	**0.02**	**0.03**	**0.03**	**0.02**	**0.02**	**0.01**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**0.06**	**NS**	**NS**

Note: * Data shown in the table are $\sqrt{(x+0.5)}$ transformed values
 # Data marked by common letters are not statistically significant according to DMRT at 5% level of probability

Table 10: Effect of clothianidin on population of spiders on okra during pre-*kharif* season of 2012

Treatments	Pre-treatment population /leaf	Population of spider/plant at days after 2nd application/spraying (DAA)*					Grand mean over the season
		1 DAA	3 DAA	5 DAA	7 DAA	10 DAA	
T_1: Untreated control	2.02 a	2.04 a	2.10 a	1.91 a	1.87 a	1.91 a	2.00 a
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	1.52 b	1.55 b	1.55 b	1.56 bc	1.86 a	1.86 a	1.67 bc
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	1.88 ab	1.65 b	1.58 b	1.57 bc	1.86 a	1.82 a	1.73 b
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	1.86 ab	1.63 b	1.67 b	1.56 bc	1.62 ab	1.65 abc	1.66 bc
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	2.12 a	1.73 b	1.70 b	1.66 b	1.64 ab	1.68 ab	1.73 b
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	1.78 ab	1.68 b	1.56 b	1.59 bc	1.51 ab	1.50 bc	1.67 bc
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	1.87 ab	1.66 b	1.41 b	1.41 c	1.47 b	1.45 bc	1.49 d
T_8: Thiamethoxam 25 WDG@ 25g a.i. ha^{-1}	1.86 ab	1.70 b	1.40 b	1.37 c	1.32 b	1.37 c	1.59 cd
SEm (±)	**0.11**	**0.08**	**0.10**	**0.07**	**0.11**	**0.09**	**0.04**
LSD (0.05)	**0.33**	**0.23**	**0.30**	**0.20**	**0.33**	**0.27**	**0.12**

Note: *Data shown in the table are √(x+0.5) transformed values

Table 11: Effect of treatments on fruit yield of okra cv. OH-597 during *rabi* and *pre-kharif* season

Treatments	Number of fruits/plot		Yield (q/ha)	
	Rabi (2011-12)	Pre-kharif (2012)	Rabi (2011-12)	Pre-kharif (2012)
T_1: Untreated control	191.3 c	965.7 d	13.58 c	76.33 c
T_2: Clothianidin 0.5% G @30 g a.i. ha^{-1}	207.0 bc	1004.3 cd	17.61 bc	77.82 c
T_3: Clothianidin 0.5% G@40 g a.i. ha^{-1}	254.0 abc	1087.7 bc	18.32 abc	87.71 bc
T_4: Clothianidin 0.5% G@50 g a.i. ha^{-1}	303.3 a	1158.0 b	22.48 ab	92.00 ab
T_5: Clothianidin 0.5% G@60 g a.i. ha^{-1}	348.3 a	1280.0 a	26.30 a	103.71 a
T_6: Clothianidin 0.5% G @80 g a.i. ha^{-1}	340.7 a	1160.3 b	26.01 a	93.37 ab
T_7: Carbofuran 3% G@1000 g a.i. ha^{-1}	264.3 abc	1019.0 cd	20.53 abc	80.25 bc
T_8: Thiamethoxam 25 WDG@ 25g a.i. ha^{-1}	285.3 ab	1141.3 b	21.11 abc	89.76 bc
SEm (±)	**28.03**	**28.54**	**2.40**	**4.14**
LSD (0.05)	**85.04**	**86.57**	**7.29**	**12.55**

Note: #Data marked by common letters are not statistically significant according to DMRT at 5% level of probability

maximum number of fruit (348.3 plot^{-1}) along with maximum yield of 26.3 q ha^{-1} during *rabi* season (Table 11). With regard to number of fruits and yield, clothianidin 0.5G @ 40-80g a.i. ha^{-1} were statistically at par with standard treated check thiamethoxam and carbofuran at recommended dose.

It was observed in pre-*kharif* sown okra that clothianidin 0.5G @60g a.i. ha^{-1} recorded maximum number of fruit (1280 plot^{-1}) along with highest yield of 103.71 q ha^{-1} (Table 11). With respect to the fruit yield of okra clothianidin 0.5G @ 50-80g a.i. ha^{-1} were at par with each other. With regard to the fruit number, clothianidin @ 60g a.i. ha^{-1} was statistically superior over treated check as well as other doses of clothianidin.

Discussion

Maximum mean reduction of *B. tabaci* population after treatment was found with clothianidin 0.5G @ 60g a.i. ha^{-1}, in rabi season (2011-12) and clothianidin 0.5G @80g a.i. ha^{-1} in pre kharif season (2012). Considering mean reduction of aphid infestation clothianidin @ 80g a.i. ha^{-1} was proven as superior over recommended dose of carbofuran but at par with others dose of clothianidin and recommended doses of thiamethoxam. Clothianidin @ 60g to 80g a.i. ha^{-1} has recommendable prospect to control sucking pests population and to achieve maximum pod yield of okra. With respect to the said parameters it was found superior over carbofuran and thiamethoxam at recommended dose. Clothianidin was also observed to be more effective than acetamiprid, dinotefuron and thiamethoxam against whitefly [3]. Seed treatment with chlothianidin (Poncho 600 FS) at 9ml kg^{-1} also afforded protection from the three early season sucking pests (Thrips, Aphids, Jassids) with significantly highest seed cotton yield (11.23 q ha^{-1}) [4]. The whitefly in cluster bean was also found to be control effectively with clothianidin 50 WDG (0.025%) [5]. Two sprays of clothianidin 50% WDG (Dantop) @ 20 and 25 g a.i ha^{-1} rendered very good protection of crop against the early season sucking pests with significantly highest seed cotton yield (11.29 q ha^{1}) from the clothianidin 50% WDG @ 25 g a.i ha^{-1} treated plots [6].

In the present study, granular formulation of clothianidin didn't exhibit any adverse harmful effect on predatory natural enemies in okra ecosystem. The side effects of neonicotinoids against non target

insects especially predators has been demonstrated in the tests under laboratory conditions [7,8]. The results of a field study have also reported less toxicity of these insecticides for a variety of predators [9]. However, Cloyd and Dickinson (2006) reported that spraying of the insecticides acetamiprid, dinotefuran, and clothianidin brings 100% mortality of *Cryptolaemus montrouzieri* adults. It is well known that predatory coccinellid preyed upon small insects and mites but never feed on plant's cell sap. Application of granular insecticides caused toxicity of plant's cell sap which had no direct detrimental effect on natural enemies of crop pest but may exert very little indirect effect on them. Here, granular formulation of clothianidin recorded maximum population of coccinellid predator after control, which indicates it's no harmful effect on these natural enemies in okra crop ecosystem.

Conclusion

Clothianidin 0.5G @ 60g -80g a.i. ha^{-1} was found environmentally safe and effective to manage aphids and whitefly in okra along with simultaneous increase in the yield. It showed superiority over carbofuran 3G @ 1000g a.i. ha^{-1} and thiamethoxam 25 WDG @25g a.i. ha^{-1} in this regard.

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References

1. Anonymous. Meeting demands of markets. The Hindu : Survey of Indian Agriculture. 2006; 40-127.
2. Henderson CF, Tilton EW. Tests with acaricides against the brow wheat mite, Journal of Economic Entomology. 1955; 48: 157-61.
3. Dipak M, Paramita B, Chatterjee ML. Effect of Newer Insecticides against White Fly, *Bemisia tabaci* (Gennadius) and Jassid, *Amrasca biguttula biguttula* (Ishida) on Cotton. Pesticide Research Journal, 2013; 25: 117-22
4. Udikeri SS, Patil SB, Krishna Naik L, Rachappa V, Farook N, Guruprasad GS. Poncho 600 FS – A new seed dressing formulation for sucking pest management in cotton. Karnataka Journal of Agricultural Science. 2007; 20 (1): 51-53.
5. Pachundkar NN, Borad PK, Patil PA. Evaluation of various synthetic insecticides against sucking insect pests of cluster bean. International Journal of Scientific and Research Publications. 2013; 3(8): 1-6.
6. Patil SB, Udikeri SS, Krishna Naik L, Rachappa V, Farook N, Guruprasad GS. DANTOP: A promising new molecule for the management of cotton sap feeding insects. Karnataka Journal of Agricultural Science. 2007; 20(1): 47-50.
7. Mizell RF, Sconyers MC. Toxicity of imidacloprid to selected arthropod predators in the laboratory. Florida Entomologist. 1992; 75: 277-80.
8. Awasthi NS, Barkhade UP, Patil SR, Lande GK. Comparative toxicity of some commonly used insecticides to cotton aphid and their safety to predatory coccinellids. Bioscan. 2013; 8(3): 1007-10.
9. Mensah RK. Development of an integrated pest management programme for cotton. Part 2: Integration of a Lucerne/cotton interplant system, food supplement sprays with biological and synthetic insecticides. International Journal of Pest Management. 2002; 48(2): 95-105.
10. Cloyd RA, Dickinson A. Effect of insecticides on mealybug destroyer (Coleoptera: Coccinellidae) and parasitoid *Leptomastix dactylopii* (Hymenoptera: Encyrtidae), natural enemies of citrus mealybug (Homoptera: Pseudococcidae). Journal of Economic Entomology. 2006; 99(5): 1596-1604.