Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP5: 40-45

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(Special Issue- 5)
Advances in Agriculture and Natural Sciences for Sustainable Agriculture
(October 12 &13, 2018)

Bioefficacy of insecticides against aphids, whitefly and their predators on okra agroecosystem

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Abstract
A field experiment was conducted at Vegetable Research Centre, GBPUA&T, Pantnagarduring *kharif* 2016 to evaluate the efficacy of six insecticides viz. carbofuran 3% CG @ 1000 g a.i./ha, thiamethoxam 25% WG @ 25 g a.i./ha, chlorantraniliprole 18.5% SC @ 25 g a.i./ha, quinalphos 25% EC @ 200 g a.i./ha, buprofezin 25% SC @ 200 g a.i./ ha, cypermethrin 25% SC @ 50 g a.i./ha against aphids, whitefly and their predators in okra agroecosystem. Among all the treatments buprofezin 25% SC @ 200 g a.i./ha was highly effective against whitefly (77.45% and 74.22% reduction over control) after first and second spray, respectively. Thiamethoxam 25% WG@ 25 g a.i./ha, gave the good results against aphids (75.99% and 76.27% reduction over control) after first and second spray, respectively. This was further followed by chlorantraniliprole 18.5% SC @ 25 g a.i./ha and buprofezin 25% SC @ 200 g a.i./ ha. The plots treated with chlorantraniliprole 18.5% SC @ 25 g a.i./ha recorded the maximum population of spiders and *Coccinella*spp. Similarly, chlorantraniliprole 18.5% SC @ 25 g a.i./ha treated plot recorded the maximum yield (10.81 T/ha) followed by thiamethoxam 25%WG @ 25 g a.i./ha (9.63 T/ha).

Keywords: Bioefficacy, insecticides, aphids, okra

Introduction
Vegetables are the affluent and cheaper source of minerals and vitamins. Among the divergent group of the vegetables, okra *Abelmoschusesculentus* L. (Moench) popularly known as bhindi in India is also one of the commonly grown vegetable crop. It is a short duration crop and belongs to family Malvaceae. Okra is one of the major cash crops in the country providing a good source of income and livelihood to the farmers. It accounts for about 60% of the total fresh vegetables export (Pierce, 1987) [8].

Africa is its place of origin but in India itself it is grown in a large area covering about 530.8 thousand hectare area, producing about 6350.3 thousand MT with a productivity about 12 MT/ha (Anonymous, 2013) [2]. The major okra producing states are Andhra Pradesh, Uttar Pradesh, Bihar, Orissa, West Bengal, Karnataka and Assam. Andhra Pradesh is a leading state with an area of 74.25 thousand hectare, production 1113.81 thousand MT and 15 MT/ha productivity thus, accounting for 18% of the total okra production, followed by West Bengal which contributes 14% to the total production (Anonymous, 2013) [2].

Okra can be cultivated all-round the year especially in the Tropical and Sub-Tropical countries. In India, it can be grown throughout the year but summer and *kharif* are generally favorable season for its cultivation. Okra is cultivated for its immature and edible fruits. Immature fruits or pods are generally harvested and are used as vegetable. It is the rich source of vitamins, minerals like Fe, Mn, Zn, Ni.

Okraserves as the house of pest and diseases. Insect-pests infestation is the prime and the most limiting factor in the successful cultivation of okra (Tripathi*et al*., 2011) [11]. The crop is attacked by several insect-pests like *Eariasvittella* Fabricus, *Helicoverpaarmigera* Hubner, *Bemisiatabaci* Gennadius, *Amrascabigutullabigutulla* Ishida, *Aphis gossypii* Glover, *Syleptaderogata*, *Mylabrispustulatus*, *Oxycarenushyalinipennis* and *Tetranychusurticae* etc. Sucking pests lead to maximum yield loss in okra. The recorded yield loss by whitefly is 94.0 per cent and 54.04 per cent by aphids (Meenambigai *et al*., 2017) [7].

The control of pest population by biological agents is an ecofriendly pest management

strategy. Some of the predator population that contributed to the reduction of sucking pests in okra ecosystem is *Encarsia* spp., *Chrysoperla* spp., ants, spiders and coccinellids (Solangi and Lohar, 2007) [10]. However, to bring the pest population instantly below the ETL level insecticidal chemicals are being used. To control sucking pests (aphids, whitefly) many insecticides have been recommended and suggested. Thus, the present study was undertaken to evaluate the efficacy of some insecticides against these major pests and their predators on okra crop.

Materials and Methods

Field experiment was carried out at the Vegetable Research Centre, GBPUA&T, Pantnagar, Udham Singh Nagar (Uttarakhand) during the *kharif* season, 2016.ArkaAnamika variety of okra was sown on 30th July, 2016 in the plots of size 5 × 4 m^2 with a spacing of 60cm X 40cm. Each plot consisted of six rows with eleven plants in each row. All the agronomic practices recommended to raise the okra crop were followed uniformly in each experimental plot. The experiment was laid out in a randomized block design (RBD) with seven treatments and four replications. Seven treatments included carbofuran 3% CG @ 1000 g a.i./ha, thiamethoxam 25% WG @ 25 g a.i./ha, chlorantraniliprole 18.5% SC@ 25 g a.i./ha, quinalphos 25% EC @ 200 g a.i./ha, buprofezin 25% SC @ 200 g a.i./ha, cypermethrin 25% SC @ 50 g a.i./ha and an untreated plot. The population of aphids and whitefly was taken on three leaves *viz.* each from upper, middle, and lower portion of plant on randomly selected five plants excluding the border rows from each plot. However, the population of predator *viz.* coccinellids and spiders was recorded on per plant basis on five randomly selected plants. Each insecticide was sprayed two times in the experimental plot. First insecticidal spray was done when plants had attained 50% flowering while the second spray was imposed 21 days after the first spray. Knapsack sprayer fitted with hollow cone nozzles was used to spray the insecticides. The efficacy of different insecticides at different doses against aphids and whitefly was recorded. Individual insecticidal effect was also observed on predator population. The population of the pest and their predators was recorded 1 day before the application of the insecticides and after 3, 7 and 10 days of spray. Reduction over control was calculated by using the following formula (Maji *et al*., 2015) [6]:

Reduction over control (%) = Population in control plots — Populations in treatment plot / Population in treatment plot x 100

Data collected was transformed to the square root values and analyzed by ANOVA under randomized block design.

Results and Discussion

Aphids: Table 1summarizes the population of aphids on okra crop for individual treatment. It was evident from the results of first spray that all the treatments significantly reduced the aphid population when compared to the untreated plot. The best treatment was thiamethoxam 25%WG @ 25 g a.i./ha with 75.99 percent reduction over control. The next best treatment were chlorantraniliprole 18.5% SC @ 25 g a.i./ha (71.82 % ROC), quinalphos 25%EC @ 200 g a.i./ha (68.77 % ROC), buprofezin 25% SC @ 200 g a.i./ ha (60.43% ROC),cypermethrin 25% EC @ 50 g a.i./ ha (47.67 % ROC). However, the least effective treatment was carbofuran 3% CG @ 1000 g a.i./ha (33.38 % ROC).

Second spray was done 21 days after the first spray. The results from the second spray also revealed the minimum aphid population in thiamethoxam 25%WG @ 25 g a.i./ha with 76.27percent reduction over control. The next best treatment were chlorantraniliprole 18.5% SC @ 25 g a.i./ha (71.34 % ROC), quinalphos 25%EC @ 200 g a.i./ha (68.93% ROC), buprofezin 25% SC @ 200 g a.i./ ha (62.83% ROC),cypermethrin 25% EC @ 50 g a.i./ ha (44.29% ROC). However, the least effective treatment was carbofuran 3% CG @ 1000 g a.i./ha (36.87%ROC).

The data collected after the two insecticidal application showed that thiamethoxam 25%WG @ 25 g a.i./ha and quinalphos 25%EC @ 200 g a.i./ha gave highest reduction in the pest population(fig1).The above results are in accordance with Gaikwad *et al*., 2014[4]who recorded 1.38 overall average survival of aphid population with thiamethoxam 25%WG @ 75 g a.i./ha which was superior to all other treatments. Ghosh *et al*., 2016[5]reported a reduction of 92.95% and 99.47% in the population of aphids after first and second spray with thiamethoxam 25%WG @ 75 g a.i./ha being at par with thiamethoxam 25%WG @ 25 g a.i./ha and thiamethoxam 25%WG @ 50 g a.i./ha.

Whitefly: Table 2 summarizes the population of whitefly on okra crop for individual treatment. The data in the table clearly depicts that all the insecticides were effective in reducing the whitefly population. The results of first and second spray revealed that the highest reduction was observed with buprofezin 25% SC @ 200 g a.i./ ha (77.45% and 79.92% ROC, respectively) followed by thiamethoxam 25%WG @ 25 g a.i./ha (74.38% and 74.22% ROC, respectively) and quinalphos 25%EC @ 200 g a.i./ha (69.24% and 71.00% ROC) (fig 2). The present findings are in collaboration with the findings of Ahmad *et al*., 2014 [1] who reported buprofezin to be quite effective in reducing the whitefly population. The pest population reduced to about 76.37% but it was next to pyriproxyfen, imidacloprid, acetamiprid and difenthiuron. Yadav and Raghuram, 2014 [12] observed the mean reduction in the population of whitefly through buprofezin 25 SC was 46.8%, 46.5% and 40% respectively. This was considered as the best treatment next to MAIBA - 01 @ 1500 g a.i./ha and MAIBA - 01 @ 1250 g a.i./ha.

Predators: Table 3 summarizes the mean population of predators (spiders and coccinellids) after the insecticidal spray. Highest population of predators was found in the untreated plot followed by the plots treated with chlorantraniliprole 18.5% SC @ 25 g a.i./ha. The mean spider and coccinellid population with chlorantraniliprole 18.5% SC @ 25 g a.i./ha after first and second spray was recorded to be2.69, 3.03, 2.06 and 2.93 respectively. However, least population of predators was found in the carbofuran 3% CG @ 1000 g a.i./ha treated plots (Fig 3& 4).

Yield: Chlorantraniliprole 18.5% SC @ 25 g a.i./ha treated plot also gave the highest yield of 10.81 T/ha i.e. 76.91% increase over the control plot which recorded the minimum yield of 5.54 T/ha (Table 4). The second highest yield was observed with thiamethoxam 25%WG @ 25 g a.i./ha (9.63T/ha) followed by carbofuran 3% CG @ 1000 g a.i./ha(8.50T/ha) (Fig 5).The findings of the above study are in accordance to the study of Chakraborti and Sarkar 2011[3]who observedrynaxypyr 20 SC @ 50 g a.i./h to be highly safer to the coccinellids and spider population allowing the substantial number of spiders and coccinellids to survive. Saha *et al*., 2014 [9]who based on three years of observations

also noticed the high safety ofrynaxypyr 20 SC (0.006%) tococcinellids, spider and syrphid fly. It also resulted in the highest marketable yield (347 q ha^{-1}).

Conclusion

From the present study it can be concluded that thiamethoxam and buprofezin are the potent chemicals in reducing the sucking pest population (aphids and whitefly). However, among all the treatments chlorantraniliprole was highly safer to the predator population. Thus, these chemicals can be the potent component in IPM module for okra.

Acknowledgment

The authors are thankful to all the faculty members of Entomology Department, College of Agriculture, GBPUAT, Pantnagar for their support and to the coordinator of Vegetable Research Centre, GBPUAT, Pantnagar for providing field and the necessary facilities during the course of study.

Table 1: Efficacy of insecticides against the population of aphids, *Aphis gossypii* (Golver) on okra after insecticidal spray during *kharif*, 2016

Treatment	Dose (g a.i. ha^{-1})	Population of aphids/ 3 leaf (Ist Spray)					Population of aphids/ 3 leaf (IInd Spray)				
		PTC	3DAS	7DAS	10DAS	% ROC	PTC	3DAS	7DAS	10DAS	% ROC
Carbofuran 3% CG	1000	21.16	14.20 (3.82)	14.21 (3.83)	14.25 (3.84)	33.38	19.36	15.20 (3.96)	15.22 (3.95)	15.25 (3.98)	36.87
Thiamethoxam 25%WG	25	20.96	5.10 (2.36)	5.11 (2.36)	5.17 (2.38)	75.99	8.28	5.71 (2.49)	5.72 (2.48)	5.76 (2.50)	76.27
Chlorantraniliprole 18.5% SC	25	21.13	6.00 (2.54)	6.02 (2.55)	6.06 (2.56)	71.82	10.30	6.89 (2.71)	6.93 (2.72)	6.95 (2.74)	71.34
Quinalphos 25%EC	200	21.01	6.65 (2.67)	6.66 (2.67)	6.70 (2.68)	68.77	11.72	7.47 (2.82)	7.49 (2.82)	7.55 (2.84)	68.93
Buprofezin 25% SC	200	20.98	8.43 (2.98)	8.44 (2.98)	8.46 (2.99)	60.43	13.05	8.91 (3.06)	8.96 (3.05)	9.01 (3.08)	62.83
Cypermethrin 25% EC	50	21.08	11.14 (3.40)	11.16 (3.41)	11.19 (3.42)	47.67	16.14	13.42 (3.73)	13.41 (3.73)	13.48 (3.74)	44.29
Untreated		21.28	21.29 (4.62)	21.35 (4.68)	21.38 (4.69)	-	24.03	24.08 (4.96)	24.13 (4.99)	24.16 (5.01)	-
SEm±		0.287	0.062	0.152	0.114	-	0.151	0.132	0.145	0.143	
CD at 0.05%		NS	0.185	0.452	0.339	-	NS	0.393	0.433	0.425	-

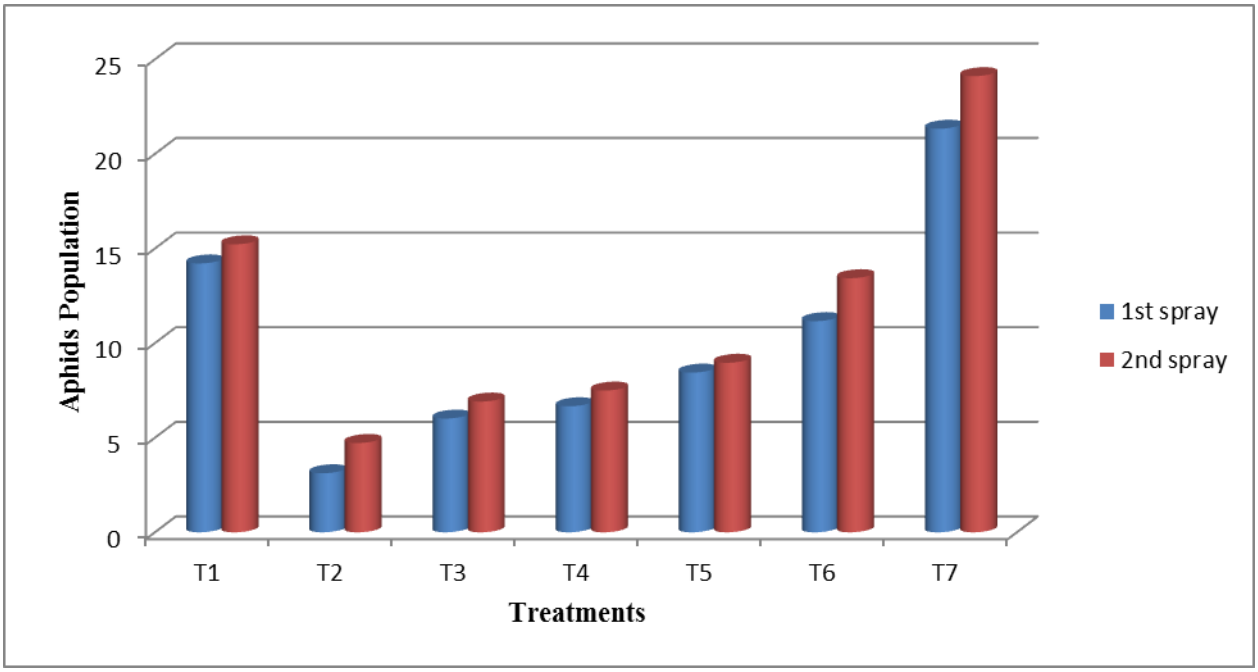

Fig. 1: Efficacy of insecticides against the population of aphids *Aphis gossypii* (Glover) on okra after two insecticidal sprays during *kharif*, 2016

T1: Carbofuran 3% CG @1000 g a.i./ha, T2:Thiamethoxam 25% WG@25 g a.i./ha, T3: Chlorantraniliprole 18.5% SC@25 ml/ha, T4: Quinalphos 25% EC@ 200 ml/ha, T5: Buprofezin 25% SC @ 200 ml/ha, T6: Cypermethrin 25% EC @ 50 ml/ha, T7:Untreated Plot

Table 2: Efficacy of insecticides against the population of whitefly on okra after insecticidal spray during *kharif*, 2016

Treatment	Dose (g a.i. ha^{-1})	Population of whitefly/ 3 leaf (Ist Spray)					Population of whitefly/ 3 leaf (IInd Spray)				
		PTC	3DAS	7DAS	10DAS	% ROC	PTC	3DAS	7DAS	10DAS	% ROC
Carbofuran 3% CG	1000	7.99	4.97 (2.34)	4.98 (2.34)	5.01 (2.35)	38.97	9.26	6.27 (2.59)	6.29 (2.61)	6.32 (2.62)	43.88
Thiamethoxam 25%WG	25	8.01	2.10 (1.61)	2.08 (1.60)	2.12 (1.61)	74.38	3.58	2.87 (1.83)	2.89 (1.84)	2.95 (1.86)	74.22
Chlorantraniliprole 18.5% SC	25	8.00	3.05 (1.88)	3.06 (1.89)	3.09 (1.90)	62.50	5.25	3.56 (2.01)	3.55 (2.01)	3.61 (2.02)	68.24
Quinalphos 25%EC	200	7.85	2.50 (1.73)	2.49 (1.73)	2.53 (1.74)	69.24	4.52	3.25 (1.93)	3.23 (1.94)	3.29 (1.95)	71.00
Buprofezin 25% SC	200	7.79	1.84 (1.52)	1.83 (1.53)	1.85 (1.54)	77.45	3.31	2.22 (1.64)	2.24 (1.65)	2.31 (1.68)	79.92
Cypermethrin 25% EC	50	8.03	3.98 (2.11)	3.97 (2.11)	4.01 (2.12)	51.22	7.29	4.83 (2.30)	4.84 (2.31)	4.87 (2.32)	56.82
Untreated		8.12	8.16 (2.94)	8.13 (2.93)	8.17 (2.94)	-	11.13	11.17 (3.42)	11.23 (3.42)	11.28 (3.43)	-
SEm±		0.563	0.029	0.035	0.043	-	0.052	0.035	0.621	0.057	-
CD at 0.05%		NS	0.221	0.246	0.263	-	NS	0.105	0.184	0.170	-

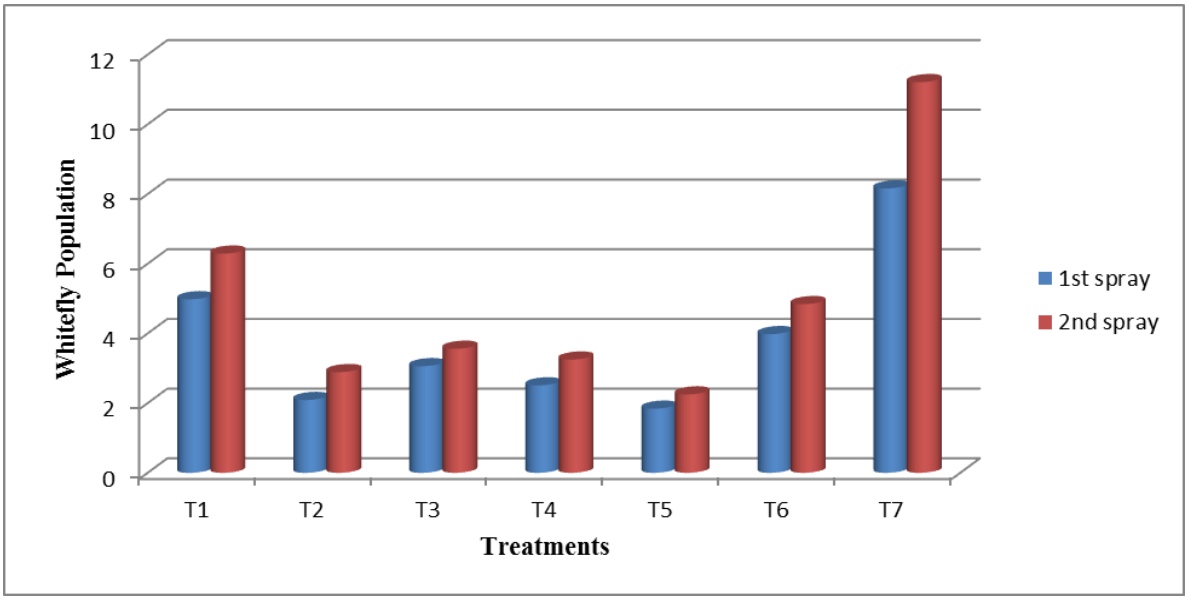

Fig 2: Efficacy of insecticides against the population of whitefly *Bemisiatabaci* (Gennadius) on okra after two insecticidal sprays during *kharif*, 2016

T1: Carbofuran 3% CG @1000 g a.i./ha, T2:Thiamethoxam 25% WG@25 g a.i./ha, T3: Chlorantraniliprole 18.5% SC @ 25 ml/ha, T4: Quinalphos 25% EC@ 200 ml/ha, T5: Buprofezin 25% SC @ 200 ml/ha, T6: Cypermethrin 25% EC @ 50 ml/ha, T7: Untreated Plot

Table 3: Efficacy of insecticides against the Predators population on okra after insecticidal spray during *kharif*, 2016

Treatment	Dose (g a.i. ha^{-1})	Population of spiders/ plant (Ist Spray)					Population of spider/plant (IInd Spray)					Population of Coccinellid/ plant (Ist Spray)					Population of Coccinellid/ plant (IInd Spray)				
		PTC	3DAS	7DAS	10DAS	Mean	PTC	3DAS	7DAS	10DAS	Mean	PTC	3DAS	7DAS	10DAS	Mean	PTC	3DAS	7DAS	10DAS	Mean
Carbofuran 3% CG	1000	2.93	0.97 (1.21)	0.98 (1.22)	1.03 (1.24)	0.99	1.85	1.74 (1.49)	1.72 (1.49)	1.75 (1.50)	1.74	2.14	1.07 (1.25)	1.06 (1.25)	1.10 (1.26)	1.08	2.09	1.19 (1.29)	1.17 (1.29)	1.20 (1.30)	1.19
Thiamethoxam 25%WG	25	2.90	2.30 (1.67)	2.29 (1.67)	2.32 (1.68)	2.30	3.04	2.68 (1.78)	2.69 (1.78)	2.73 (1.80)	2.69	2.30	1.98 (1.57)	1.99 (1.58)	2.01 (1.59)	1.98	3.22	2.75 (1.80)	2.77 (1.81)	2.79 (1.81)	2.78
Chlorantraniliprole 18.5% SC	25	3.00	2.65 (1.77)	2.71 (1.79)	2.75 (1.80)	2.69	3.27	2.97 (1.86)	3.06 (1.86)	3.10 (1.89)	3.03	2.36	2.02 (1.58)	2.09 (1.61)	2.11 (1.62)	2.06	3.01	2.87 (1.83)	2.96 (1.86)	3.01 (1.87)	2.93
Quinalphos 25%EC	200	3.14	1.16 (1.28)	1.15 (1.28)	1.19 (1.30)	1.16	2.90	1.82 (1.52)	1.81 (1.51)	1.83 (1.53)	1.82	2.19	1.66 (1.46)	1.64 (1.46)	1.69 (1.47)	1.66	2.18	1.68 (1.47)	1.66 (1.47)	1.70 (1.48)	1.68
Buprofezin 25% SC	200	2.95	1.97 (1.57)	1.98 (1.57)	2.01 (1.58)	1.98	3.19	2.30 (1.67)	2.29 (1.67)	2.34 (1.68)	2.31	2.27	1.88 (1.54)	1.90 (1.55)	1.93 (1.56)	1.89	2.20	1.89 (1.54)	1.90 (1.54)	1.93 (1.56)	1.90
Cypermethrin 25% EC	50	3.01	1.65 (1.46)	1.67 (1.47)	1.71 (1.49)	1.67	2.94	1.92 (1.55)	1.93 (1.56)	1.97 (1.57)	1.94	2.39	1.42 (1.38)	1.40 (1.37)	1.44 (1.39)	1.42	2.06	1.47 (1.40)	1.46 (1.40)	1.50 (1.41)	1.48
Untreated		2.97	3.02 (1.87)	3.08 (1.89)	3.12 (1.90)	3.05	3.38	3.43 (1.98)	3.48 (1.99)	3.50 (2.00)	3.45	2.20	2.24 (1.65)	2.30 (1.67)	2.32 (1.68)	2.26	3.40	3.44 (1.98)	3.49 (2.00)	3.51 (2.01)	3.46
SEm±		0.017	0.021	0.023	0.015	-	0.022	0.029	0.028	0.018	-	0.016	0.017	0.018	0.019	-	0.022	0.025	0.016	0.013	-
CD at 0.05%		NS	0.062	0.068	0.046	-	NS	0.088	0.085	0.056	-	NS	0.051	0.053	0.058	-	NS	0.074	0.049	0.039	-

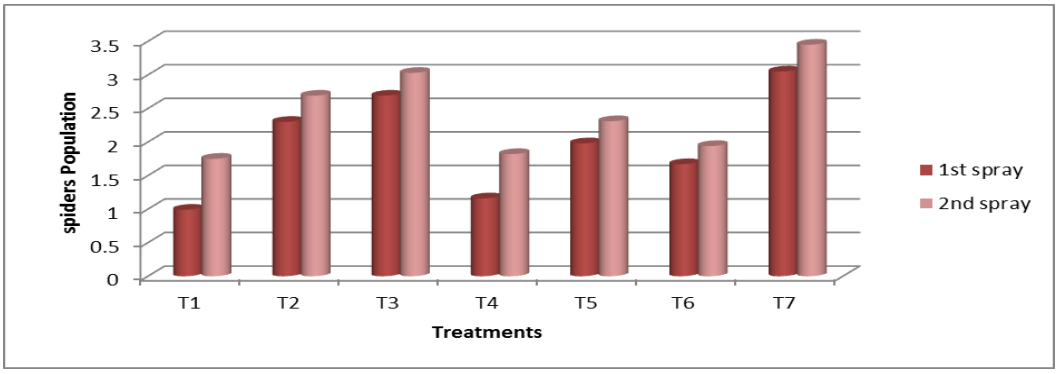

Fig. 3: Efficacy of insecticides against the population of Spiders on okra after two insecticidal sprays during *kharif*, 2016

T1: Carbofuran 3% CG @1000 g a.i./ha, T2:Thiamethoxam 25%WG@25 g a.i./ha, T3: Chlorantraniliprole 18.5% SC@25 ml/ha, T4: Quinalphos 25%EC@ 200 ml/ha, T5: Buprofezin 25% SC @ 200 ml/ha, T6: Cypermethrin 25% EC @ 50 ml/ha, T7:Untreated Plot

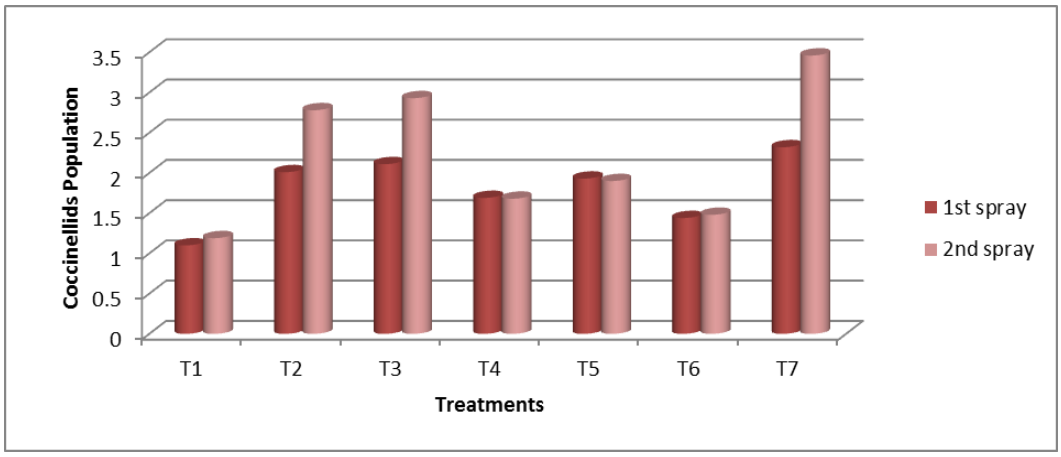

Fig 4: Efficacy of insecticides against the population of Coccinellids on okra after two insecticidal sprays during *kharif*, 2016

T1: Carbofuran 3% CG @1000 g a.i./ha, T2: Thiamethoxam 25%WG@25 g a.i./ha, T3: Chlorantraniliprole 18.5% SC@25 ml/ha, T4: Quinalphos 25%EC@ 200 ml/ha, T5: Buprofezin 25% SC @ 200 ml/ha, T6: Cypermethrin 25% EC @ 50 ml/ha, T7:Untreated Plot

Table 4: Impact of Insecticides on the yield of okra crop at VRC, Pantnagar, during *kharif*, 2016

Treatments	Dose (g a.i./ ha)	Yield of marketable fruits		
		kg/plot	T/ha	% increase over control
Carbofuran 3% CG	1000	17.00	8.50	53.29
Thiomethoxam 25% WG	25	18.01	9.63	62.39
Chlorantraniliprole 18.5% SC	25	19.62	10.81	76.91
Quinalphos 25% EC	200	15.67	7.83	41.29
Buprofezin 25% SC	200	16.05	8.02	44.72
Cypermethrin 25% EC	50	15.88	7.44	43.19
Untreated	_	11.09	5.54	_
Sem±	_	0.200	0.135	_
Cd at 0.05%	_	0.618	0.416	

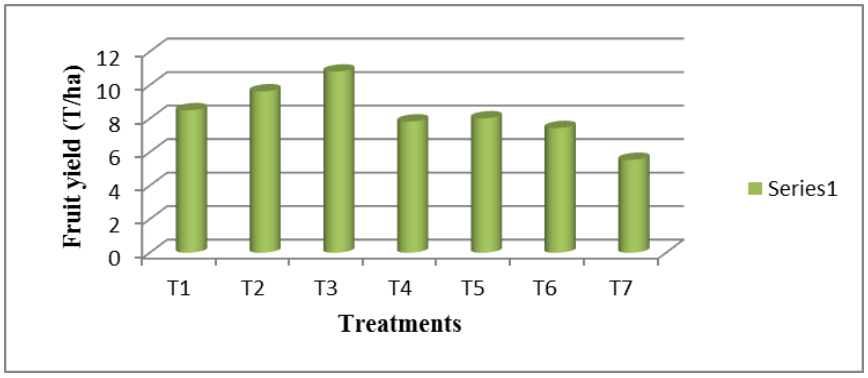

Fig. 5: Impact of Insecticides on yield of okra

T1: Carbofuran 3% CG @1000 g a.i./ha, T2: Thiamethoxam 25%WG@25 g a.i./ha, T3: Chlorantraniliprole 18.5% SC@25 ml/ha, T4: Quinalphos 25%EC@ 200 ml/ha, T5: Buprofezin 25% SC @ 200 ml/ha, T6: Cypermethrin 25% EC @ 50 ml/ha, T7:Untreated Plot

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