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Comparative Studies on the Impact of Insecticides against Aphid, (*Aphis gossypii* Glover) on Okra [*Abelmoschus esculentus* (L.) Moench]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field experiments were conducted to evaluate the efficacy of newer insecticide against aphid on okra during 2018 and 2019. All the treatments were significantly effective over control plots in reducing the aphid population. The aphid population in treated plots ranged from 1.20 to 4.68

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aphids per six leaves as against 6.29 aphids per six leaves in untreated plots. Data computed on per cent reducing in aphid population indicate that 25.7 to 80.9% population may be reduced by spraying of different insecticides. Among the insecticidal treatments, imidacloprid 17.8SL @100 ml/ha (1.20 aphids per six leaves) found most effective followed by thiamethoxam 25WG @100 gm/ha and acetamiprid 20SP @120 gm/ha. Whereas, emamectin benzoate 5SG @200 gm/ha (4.68 aphids/six leaves) found least effective in both the years.

Keywords: Aphid; efficacy; insecticides; okra; yield.

1. INTRODUCTION

"Okra [*Abelmoschus esculentus* (L.) Moench] a common vegetable in India also called 'Lady's Finger' is a popular and most common annual vegetable crop in tropical and subtropical parts of the world" (Sree *et el*., 2019). "India is the largest producer of okra in the world. It occupy nearly 513thousand hectare area with production of 6170thousand matrictonnes and productivity 12.00 matrictonnesha^{-1}. In Madhya Pradesh okra is grown in 0.4012 lakh ha area with production 5.3673 lakh MT and 13.02 tonnes ha^{-1} productivity" (Anonymous, 2018-19).

Okra also suffers from several biotic and abiotic factors, including insect pests. However, insect pests are major production constraints in okra cultivation and the crop is ravaged by numerous insect pests viz*.,* aphids, leafhopper, whiteflies and thrips right from sowing till harvesting. These sucking insect pests cause damage to the crop directly by sucking the sap or indirectly by transmitting a large number of viral diseases. Due to desapping and injection of toxic saliva into plants by sucking pests, leaves turn brownish and may eventually fall down (Rudra & Saikia, 2020). A number of insecticides are sprayed on vegetables as a key component for the management of crop pests. But indiscriminate use of these by the farmers has led to resistance and resurgence of sucking pests and pose environmental pollution. The present study evaluates the efficacy of newer insecticides against aphid in okra (Lal, 2023).

2. MATERIALS AND METHODS

The field experiment was conducted at Entomological Research Farm, Department of Entomology, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, College of Agriculture, Gwalior, Madhya Pradesh in *Kharif*- 2018 and 2019.The experiment were conducted with seven treatments in a Randomized Block Design and replicated thrice with plot size of 3.60×2.40m and spacing 60×45 cm. A the recommended package of practices was adopted for raisingthe crop (Lal, 2023).

First spray was given at time of initiation of insect infestation. The second spray was given at 15 days after first spray. Pretreatment observations on the population of aphid was recorded on six leaves (2 upper, 2 middle and 2 lower leaves of the plant canopy) at one day before treatment. Post treatment observations were recorded on 7 and 14 days after each spray. The population were calculated by applying the following formula – Population (per/leaf) = Total number of insect/number of leaves observed from experimental field were subjected to analysis of variance after transforming into ($\sqrt{x+0.5}$). Economics of different treatments were also worked out (Lal, 2023).

3. RESULTS AND DISCUSSION

The efficacy of insecticidal treatment was assessed on the basis of sucking pest of aphid population. Data recorded on population of aphid different treatments at one day before and 7 and 14 days after are presented in Tables 1, 2 and 3.

3.1 Efficacy of Insecticides against Aphid Population on Okra during 2018

Observations recoded on aphid population at one day before spray ranged from 13.33 to 14.00 aphids per six leaves with statistically at par population in all the plots. Among the insecticidal treatments, imidacloprid (2.00 aphids per six leaves) was found most effective and significantly superior than rest of the treatment except thiamethoxam (2.33 aphids per six leaves). Whereas, emamectin benzoate (10.27 aphids/six leaves) was found least effective. Imidacloprid (2.13 aphids/six leaves) was found most effective and significantly superior than rest of the treatments except thiamethoxam (2.47 aphids/six leaves). Whereas, emamectin benzoate (8.47 aphids/six leaves) was found least effective. All the treatments were found

Table 1. Efficacy of chemical insecticides against aphid, *Aphis gossypii* Glover on okra (*Kharif*- 2018)

Treatments	Dose/ha	Number of Aphid population/6 leaves							
		1 DBS	First spray			Second spray			Mean of four observation
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	
T_1 Imidacloprid 17.8 SL	100 ml	13.47 (3.74)	2.00 (1.58)	2.13 (1.62)	2.07 (1.60)	1.47 (1.40)	1.80 (1.52)	1.63 (1.46)	1.85 (1.53)
T_2 Thiamethoxam 25 WG	100 gm	13.60 (3.75)	2.33 (1.68)	2.47 (1.72)	2.40 (1.70)	1.93 (1.56)	2.07 (1.60)	2.00 (1.58)	2.20 (1.64)
T_3 Acetamiprid 20 SP	120 gm	14.00 (3.81)	2.67 (1.78)	2.73 (1.80)	2.70 (1.79)	2.20 (1.64)	2.27 (1.66)	2.23 (1.65)	2.47 (1.72)
T_4 Cypermethrin 10 EC	250 ml	13.33 (3.72)	3.00 (1.87)	3.33 (1.96)	3.17 (1.91)	2.93 (1.84)	3.13 (1.90)	3.03 (1.87)	3.10 (1.89)
T_5Emamectin benzoate 5 SG	200 gm	13.67 (3.76)	10.27 (3.28)	8.47 (2.99)	9.37 (3.14)	4.40 (2.21)	4.53 (2.24)	4.47 (2.23)	6.92 (2.68)
T_6 Dimethoate 30 EC	200 ml	14.00 (3.81)	3.73 (2.06)	3.53 (2.00)	3.63 (2.03)	2.47 (1.72)	2.73 (1.80)	2.60 (1.76)	3.12 (1.90)
T_7 Spinosad 45 SC	100 ml	13.60 (3.75)	5.27 (2.40)	5.00 (2.34)	5.13 (2.37)	3.13 (1.91)	3.33 (1.96)	3.23 (1.93)	4.18 (2.15)
T_8 Control (untreated)		13.93 (3.80)	16.67 (4.14)	10.60 (3.33)	13.63 (3.74)	5.07 (2.36)	4.47 (2.23)	4.77 (2.29)	9.20 (3.71)
SEm ±		(0.18)	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.02)
CD at 5%		NS	(0.15)	(0.15)	(0.12)	(0.15)	(0.12)	(0.12)	(0.06)

Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant

- *DBS - Day before spray*
- *DAS - Day after spray*

Table 2. Efficacy of chemical insecticides against aphid, *Aphis gossypii* Glover on okra (*Kharif*- 2019)

Treatments	Dose/ha	Number of Aphid population/6 leaves							
		1 DBS	First spray			Second spray			Mean of four observation
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	
T_1 Imidacloprid 17.8 SL	100 ml	5.27 (2.40)	0.80 (1.14)	1.20 (1.30)	1.00 (1.22)	0.13 (0.79)	0.07 (0.75)	0.10 (0.77)	0.55 (1.00)
T_2 Thiamethoxam 25 WG	100 gm	5.00 (2.34)	1.00 (1.22)	1.47 (1.40)	1.23 (1.31)	0.20 (0.84)	0.13 (0.79)	0.17 (0.82)	0.70 (1.06)
T_3 Acetamiprid 20 SP	120 gm	5.13 (2.37)	1.13 (1.28)	1.53 (1.42)	1.33 (1.35)	0.27 (0.87)	0.13 (0.79)	0.20 (0.83)	0.77 (1.09)
T_4 Cypermethrin 10 EC	250 ml	4.93 (2.33)	1.93 (1.56)	2.00 (1.58)	1.97 (1.57)	0.33 (0.91)	0.20 (0.84)	0.27 (0.87)	1.12 (1.22)
T_5Emamectin benzoate 5 SG	200 gm	5.20 (2.39)	4.27 (2.18)	4.67 (2.27)	4.47 (2.23)	0.53 (1.02)	0.27 (0.87)	0.40 (0.94)	2.43 (1.59)
T_6 Dimethoate 30 EC	200 ml	5.20 (2.39)	1.93 (1.56)	2.13 (1.62)	2.03 (1.59)	0.40 (0.94)	0.20 (0.84)	0.30 (0.89)	1.17 (1.24)
T_7 Spinosad 45 SC	100 ml	4.73 (2.29)	2.87 (1.83)	2.07 (1.59)	2.47 (1.71)	0.40 (0.95)	0.20 (0.83)	0.30 (0.89)	1.38 (1.30)
T_8 Control (untreated)		5.07 (2.36)	5.27 (2.40)	7.20 (2.77)	6.23 (2.59)	0.80 (1.14)	0.27 (0.87)	0.53 (1.01)	3.38 (1.80)
SEm ±		(0.04)	(0.03)	(0.07)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)
CD at 5%		NS	(0.09)	(0.21)	(0.11)	(0.12)	(0.09)	(0.08)	(0.06)

Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant

- *DBS - Day before spray*
- *DAS - Day after spray*

significantly effective over control plots (13.63 aphids/six leaves) in reducing the aphid population. Among the insecticidal treatments imidacloprid (2.07 aphids/six leaves) was found most effective and significantly superior than rest of the treatments except thiamethoxam (2.40 aphids/six leaves). Whereas, emamectin benzoate (9.37 aphids/six leaves) was found least effective. All the insecticidal treatments were found significantly effective over control plots (4.47 aphids/six leaves) in reducing the aphid population after second application.

3.2 Population on Okra during – 2019

The pooled data (Table 2) indicates that the aphid population in different insecticides at one day before spray ranged from 4.73 to 5.27aphid/six leaves with statistically at par population in all the plots. Significant reduction in aphid population was noted at 7 and 14 days after spray of insecticides compared to untreated control plot. Average population of aphid per six leaves at seven days after first spray, showed that all the insecticidal treatments were found significantly effective in reducing the population of aphid over control plots (5.27 aphids/six leaves). Among the insecticidal treatments imidacloprid (0.80 aphids/six leaves) was found most effective and significantly superior than rest of the treatments except thiamethoxam and acetamiprid. Whereas, emamectin benzoate (4.27 aphids/six leaves) was found least effective. Average populations of aphid was recorded at fourteen days after first spray, showed that all the insecticidal treatments were found significantly effective over control plots (7.20 aphids/six leaves) in reducing the aphid population. Among the insecticidal treatments imidacloprid (1.20 aphids/six leaves) was found most effective and significantly superior than rest of the treatments except thiamethoxam and acetamiprid. Whereas, emamectin benzoate (4.67 aphids/six leaves) was found least effective. The population of aphid on the basis of average of two observations recorded at 7 and 14 days after first spray, all the treatments were found significantly effective over control plots (6.23 aphids/six leaves) in reducing the aphid population. Among the insecticidal treatments imidacloprid (1.00 aphids/six leaves) was found most effective followed by thiamethoxam, acetamiprid. Whereas, emamectin benzoate (4.47 aphids/six leaves) was found least effective.

The population of aphid recoded at seven days after second spray showed significant differences among different treatments with regards to population of aphid over control plots (0.80 aphids/six leaves) except emamectin benzoate. Among the insecticidal treatments imidacloprid (0.13 aphids/six leaves) was found most effective followed by thiamethoxam (0.20 aphids/six leaves), acetamiprid (0.27 aphids/six leaves) and cypermethrin (0.33 aphids/six leaves). Whereas, emamectin benzoate (0.53 aphids/six leaves) was found significantly least effective. Data recoded at fourteen days after second spray showed significant differences in different treatments with regards to population of aphid over control plots. Minimum population (0.07 aphids/six leaves) was recorded in plots treated with imidacloprid which found significantly less than control and emamectin benzoate but was at par with rest of the imidacloprid treated plots. The average of population of aphid two observations recorded at 7 and 14 days after second spray, showed significant differences among insecticidal treated plots, maximum population (0.40 aphids/six leaves) was recorded in emamectin benzoate which found significantly higher than the population in imidacloprid, thiamethoxam and acetamiprid but was at par with rest of the insecticidal treated plots.Data recorded in *Kharif*- 2019, on the basis of average of four observations recorded at 7 and 14 days after first and second spray, all the treatments were found significantly effective over control plots (3.38 aphids/six leaves/plant) in reducing the aphid population. Among the insecticidal treatments imidacloprid (0.55 aphids/six leaves) was found effective followed by thiamethoxam (0.70 aphids/six leaves), acetamiprid (0.77 aphids/six leaves). Whereas, emamectin benzoate (2.43 aphids/six leaves) was found least effective.

The data observations of the average of two years indicated that all the treatments found significantly effective over control plots in reducing the aphid population. The aphid population in treated plots ranged from 1.20 to 4.68 aphids/six leaves as against 6.29 aphids/six leaves in untreated plots. Data computed on per cent reducing in aphid population indicate that 25.7 to 80.9% population may be reduced by spraying of different insecticides. Among the insecticidal treatments imidacloprid 17.8SL @100 ml/ha (1.20 aphids/six leaves) found most effective followed by thiamethoxam 25WG @100 gm/ha and acetamiprid 20SP @120 gm/ha. Whereas, emamectin benzoate 5SG @200 gm/ha (4.68 aphids/six leaves) found least effective. Similar to the present finding Kumar (2015) also reported imidacloprid 17.8SL to be effective against aphid in okra. Pawar *et al*. (2016) also reported imidacloprid 17.8SL @20 g a.i./ha WG found most effective followed by thiamethoxam 25WG @25 g a.i./ha and acetamiprid 20SP @20g a.i./ha which were at par. Berwa *et al*. (2017) also reported that imidacloprid 17.8SL @35.6 g a.i./ha found to be significantly effective against jassid, aphid and whitefly. Saha (2015) also reported that thiamethoxam 25WG found most effective against aphid population followed by acetamiprid 20SP. Bade *et al.* (2017) and Satyanarayana and Arunakumara (2022) also reported acetamiprid 20SP @15 g a.i./ha and thiamethoxam 25WG @25 g a.i. to be found most effective against aphids four sprays, which corroborate the present findings.

3.3 Fruit Yield under Different Chemical Insecticides

Data recorded in Kharif- 2018, all the chemical insecticides were found significantly effective in registering the higher yield (155.44 to 120.33 q/ha) over control with (99.78 q/ha). Maximum fruit yield (155.44) was recorded in emamectin benzoate 5SG followed by spinosad 45SC (154.44 q/ha) and imidacloprid 17.8 SL (124.22 q/ha). Whereas, minimum fruit yield (120.33 q/ha) was recorded in cypermethrin 10 EC followed by acetamiprid 20 SP and thiamethoxam 25WG. In Kharif- 2019, maximum fruit yield (157.22 q/ha) was recorded in emamectin benzoate 5SG followed by spinosad 45 SC (155.77 q/ha) and imidacloprid 17.8 SL (125.98 q/ha). Whereas, minimum fruit yield (121.78 q/ha) was recorded in cypermethrin 10 EC followed by acetamiprid 20 SP and dimethoate 30 EC. The average of two year observations data, all the insecticides found significantly effective in registering the higher yield (121.06 to 156.33 q/ha) than control plots (101.78 q/ha). Maximum fruit yield (156.33 q/ha) was recorded in plot treated with emamectin benzoate 5SG @200 gm/ha followed by spinosad 45SC @100 ml/ha. Whereas, minimum fruit yield (121.06 q/ha) obtained in plot treated with cypermethrin 10EC @250 ml/ha (Fig. 2).Data computed on per cent avoidable loss in fruit yield caused by shoot and fruit borer indicate that 18.9 to 53.6 % loss in fruit yield may be avoided by the protecting with different insecticides. Maximum fruit yield loss may be avoided by protecting the crop with emamectin benzoate (53.6%) followed by spinosad (Table 4).Similar to the present findings Dhaka *et al*. (2016), Aarwe *et al*. (2017) and Mohanta *et al*. (2020) also reported that highest yield was recorded in emamectin benzoate 5SG as compared to control. Sarkar *et al*. (2015) observed highest marketable fruit yield of okra in spinosad treated plots. Pachole *et al*. (2017) noticed the highest yield in spinosad 45SC @0.05% (197.22 q/ha) followed by imidacloprid 17.8SL @0.3 ml/l (156.25 q/ha).These findings are supported with the study of Gummadidala and Kumar (2018) who also reported highest fruit yield in imidacloprid 17.8SL. Jayarao *et al*. (2016) also reported highest fruit yield in imidacloprid followed by thiamethoxam. Singh and Thakur (2018) reported highest yield in imidacloprid 17.8SL followed by acetamiprid 20SP.

Table 3. Efficacy of chemical insecticides against aphid, *Aphis gossypii* Glover on okra (Pooled- 2018 & 2019)

Treatments	Dose/ha	Number of Aphid population/6 leaves			Reduction in aphid population (%)
		Mean 2018	Mean 2019	Average of two years	
T_1 Imidacloprid 17.8 SL	100 ml	1.85 (1.53)	0.55 (1.00)	1.20 (1.30)	80.9
T_2 Thiamethoxam 25 WG	100 gm	2.20 (1.64)	0.70 (1.06)	1.45 (1.40)	76.9
T_3 Acetamiprid 20 SP	120 gm	2.47 (1.72)	0.77 (1.09)	1.62 (1.45)	74.2
T_4 Cypermethrin 10 EC	250 ml	3.10 (1.89)	1.12 (1.22)	2.11 (1.61)	66.5
T_5Emamectin benzoate 5 SG	200 gm	6.92 (2.68)	2.43 (1.59)	4.68 (2.27)	25.7
T_6 Dimethoate 30 EC	200 ml	3.12 (1.90)	1.17 (1.24)	2.15 (1.62)	65.9
T_7 Spinosad 45 SC	100 ml	4.18 (2.15)	1.38 (1.30)	2.78 (1.81)	55.8
T_8 Control (untreated)		9.20 (3.71)	3.38 (1.80)	6.29 (2.61)	
SEm ±		(0.02)	(0.02)	(0.01)	
CD at 5%		(0.06)	(0.06)	(0.03)	

Figures in the parentheses are transform ($\sqrt{x+0.5}$) values, NS= Non-significant

- *DBS - Day before spray*
- *DAS - Day after spray*

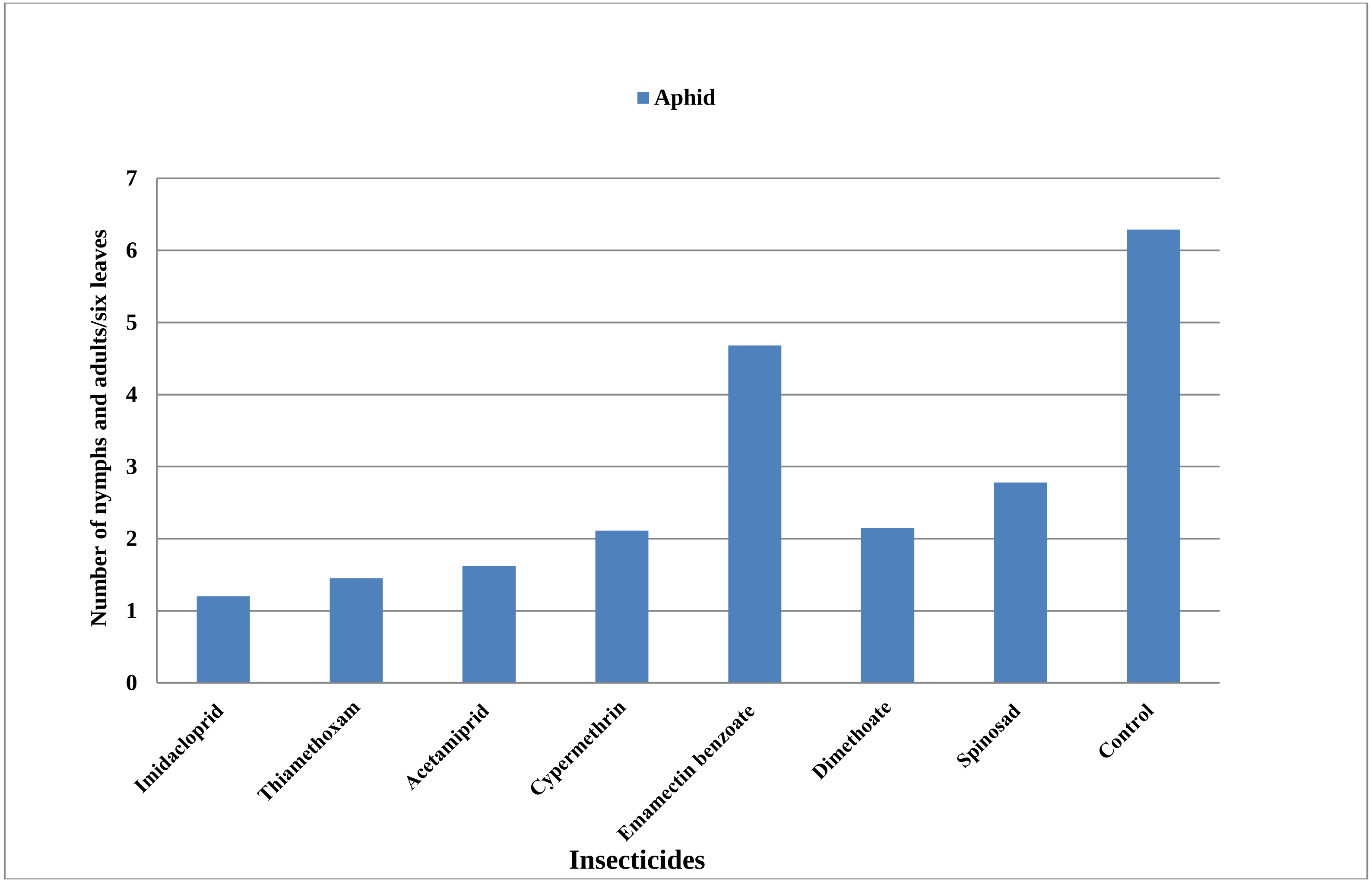

Fig. 1. Population of aphid under different insecticidal treatments

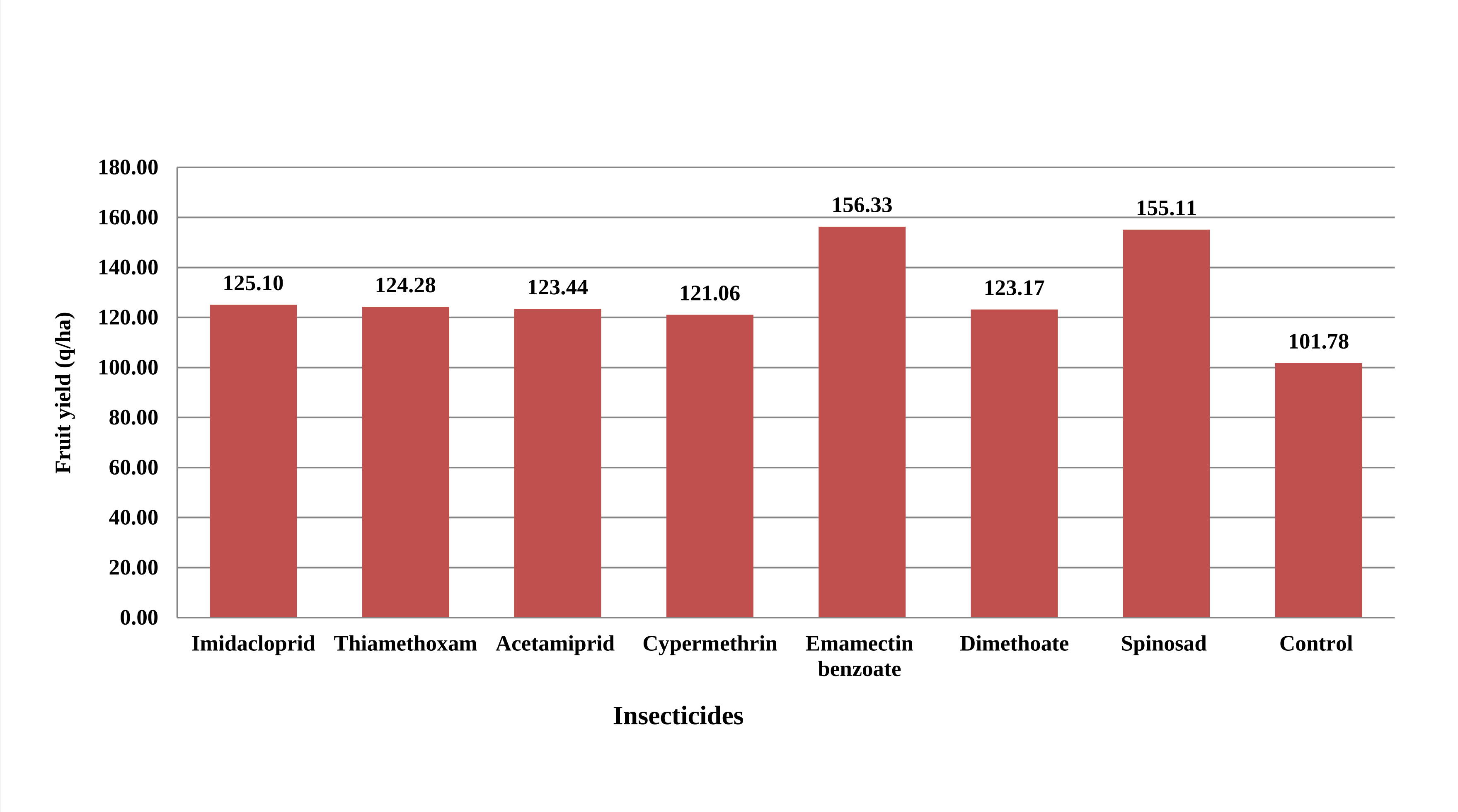

Fig. 2. Fruit yield under different insecticidal treatments

Table 4. Fruit yield under different chemical insecticides

Treatments	Dose/ha	Yield (q/ha)			Per cent Avoidable/ha
		Kharif-2018	*Kharif*- 2019	Average of two years	
T_1 Imidacloprid 17.8 SL	100 ml	124.22	125.98	125.10	22.91
T_2 Thiamethoxam 25 WG	100 gm	123.00	125.55	124.28	22.11
T_3 Acetamiprid 20 SP	120 gm	122.55	124.33	123.44	21.28
T_4 Cypermethrin 10 EC	250 ml	120.33	121.78	121.06	18.94
T_5Emamectin benzoate 5 SG	200 gm	155.44	157.22	156.33	53.59
T_6 Dimethoate 30 EC	200 ml	122.00	124.33	123.17	21.02
T_7 Spinosad 45 SC	100 ml	154.44	155.77	155.11	52.39
T_8 Control (untreated)		99.78	103.78	101.78	
SEm ±		1.72	1.76	1.23	
CD at 5%		5.04	5.16	3.61	

Figures in the parentheses are mean values

Table 5. Economics of different chemical insecticides for the control of major insect pests on okra crop

Treatments	Dose/ha	Yield (q/ha)	Additional yield over control (q/ha)	Additional profit (Rs/ha)	Cost of treatments (Rs/ha)	Net profit (Rs/ha)	C:B ratio
T_1 Imidacloprid 17.8 SL	100 ml	125.10	23.32	34980	1740	33240	1:19.10
T_2 Thiamethoxam 25 WG	100 gm	124.28	22.50	33749	2000	31749	1:15.87
T_3 Acetamiprid 20 SP	120 gm	123.44	21.67	32498	1920	30578	1:15.93
T_4 Cypermethrin 10 EC	250 ml	121.06	19.28	28915	2200	26715	1:12.14
T_5Emamectin benzoate 5 SG	200 gm	156.33	54.55	81825	6800	75025	1:11.03
T_6 Dimethoate 30 EC	200 ml	123.17	21.39	32083	2640	29443	1:11.15
T_7 Spinosad 45 SC	100 ml	155.11	53.33	79993	5040	74953	1:14.87
T_8 Control (untreated)		101.78	-	-	-	-	-

Note:
Selling rate of okra fruit (Rs/q) : 1500
Labour charge for sprays (Rs) : 600 per spray
Rate of insecticides Rs/litre or kg.
Imidacloprid : 2700
Thiamethoxam : 4000
Acetamiprid : 3000
Cypermethrin : 2000
Emamectin benzoate : 14000
Dimethoate : 3600
Spinosad : 19200

3.4 Economics of Different Chemical Insecticides

The data computed on economics of different treatments, revealed that all the insecticidal treatments were economical over control. Maximum net profit was recorded in emamectin benzoate 5SG @200 gm/ha followed by spinosad 45SC @100 ml/ha (74,953 Rs/ha), imidacloprid 17.8SL @100 ml/ha (33,240 R/ha) and thiamethoxam 25WG @100 gm/ha (31,749 Rs/ha). However maximum cost benefit ratio recorded in imidacloprid 17.8 SL @100 ml/ha (1:19.10) followed by acetamiprid 20SP @120 gm/ha (1:15.93), thiamethoxam 25WG @100 gm/ha (1:15.87) and spinosad 45SC @ 100 ml/ha (1:14.87).Similar to the present findings Dhaka *et al*. (2016), Berwa *et al*. (2017) and Sharma and Verma (2019) reported the maximum net returns obtained in emamectin benzoate 5SG followed by spinosad 45SC. Aarwe *et al*. (2017) also report highest net return in emamectin benzoate 5SG.Pachole *et al*. (2017) reported spinosad most economical followed by imidacloprid which is similar to the present finding. Berwa *et al*. (2017) and Gummadidala and Kumar (2018) also report maximum cost benefit ratio record in imidacloprid 17.8 SL.Singh and Thakur (2018) reported higher cost benefit ratio in imidacloprid 17.8SL followed by acetamiprid 20SP, which corroborate the present findings.

4. CONCLUSION

In conclusion, the study affirms the significant efficacy of insecticides imidacloprid 17.8 SL was the most effective for aphid control and thiamethoxam 25 WG and acetamiprid 20 SP in effectively controlling aphid populations on okra crop and economic return, while emamectin benzoate offered the best yield and profit despite lower aphid controlin okra cultivation in Madhya Pradesh in India.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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