



Bio-efficacy of Different Biopesticides against Jassid, (*Amrasca biguttula biguttula* Ishida) Infesting Okra [*Abelmoschus esculentus* (L.) Moench]

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted in the field, Department of Entomology, RVSKVV, College of Agriculture, Gwalior (M.P.) in Kharif- 2018 and 2019. Efficacy of biopesticides against jassid on okra. Experiment was laid out in Randomized Block Design with eight treatments. Biopesticides used in the experiments were *Beauveria bassiana* @ 0.5 kg/ha, *Verticillium lecanii* @ 1.0 kg/ha, Neem oil 5% @ 2.5 litre, Neem leaf extract 5% @ 25 kg/ha, NSKE 5% @ 25 kg/ha, Garlic clove extract 5% @ 25 kg/ha and Panchgavya 3% @ 15 litre/ha. All the biopesticides treatments were found significantly effective in reducing the population of jassid over control (untreated) plots. The biopesticides treatments, NSKE 5% were found most effective in reducing the jassid population followed by neem oil 5%, *V. lecanii*, neem leaf extract 5% and garlic clove extract 5%. Whereas, panchgavya 3% was found least effective in both the years. The highest fruit yield (119.56 q/ha) was recorded in NSKE 5% followed by *B. bassiana* and neem oil 5%. Whereas, minimum fruit yield

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was recorded in panchgavya 3% in both years. The highest net profit (27,128 Rs/ha) was obtained from the plots treated with *B. bassiana* followed by NSKE 5% (25,938 Rs/ha) and maximum benefit ratio in the *B. bassiana* (1:14.13) followed by *V. lecanii* (1:8.36), NSKE 5% (1:8:11) and garlic clove extract 5% (1:6.78).

Keywords: Okra; efficacy; jassid; biopesticides; yield.

1. INTRODUCTION

Okra, [*Abelmoschus esculentus* (L.) Moench] belongs to family Malvaceae a common vegetable in India. Okra locally known as 'Bhindi' also called 'Lady's Finger' is a popular and most common annual vegetable crop in tropical and subtropical parts of the world" [1]. It has good nutritional value, 100 g of edible fruit contains 2 g protein, 0.19 g fat, 7.45 g carbohydrate, 1.48 g of sugars, 0.7 g minerals, 3.2 g fiber, minerals like K (299 mg), Ca (82 mg), Mg (57 mg), Fe (0.62 mg), Zn (0.58 mg) and Vitamins like A, B1, B2, C, E and K" [2]. Okra crop is cultivated for its young tender fruits, which is used as vegetable, tried, in curry and soups. The root and stem are used for clearing cane juice in preparation of jiggery/gur. Seeds are a source of oil, protein and are also used as a coffee substitute, while ground up okra seeds has been used as a substitute for aluminum salts in water purification.

India is the largest producer of okra in the world. It occupy nearly 513thousand hectare area with production of 6170 MT 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" [3].

The pest problem is the main limiting factor in production of okra. As high as, 72 species of insects have been recorded on okra which, the sucking pest viz., aphids (*Aphis gossypii* Glover); leafhopper (*Amrasca biguttula biguttula* Ishida); whitefly (*Bemisia tabaci* Gennadius); shoot and fruit borer (*Earias vittella* Fab.) and mite (*Tetranychus cinnabarinus* Boisduval) causes significant damage to the crop. Okra fruit and shoot borer, *Earias vittella* (Fab.) is a widely distributed insect pest. When the crop is young, larvae bore into tender shoots and tunnel downwards which wither, drop down and growing points are killed. In fruits, the larvae bore inside these and feed on inner tissues which become deformed in shape with no market value. The infested fruits become unfit for human consumption, thus resulting in 35 to 76% decrease in yield and caused severe damage to the crop leading to yield losses to an extent of 35-90 per cent" [4].

Biopesticides are considered to be the best alternative to synthetic pesticides that are highly effective, target specific and reduce environmental risks. These factors lead to their incorporation in pest management programme, instead of chemical pesticides throughout the world. Biopesticides are derived from animals, plants and other natural micro-organisms such as fungi, bacteria, algae, viruses, nematodes, and protozoa. The advanced research and development in the field of biopesticides applications greatly reduces the environmental pollution caused by the chemical synthetic insecticidal residues and promotes sustainable development of agriculture. Since the advent of biopesticides, a large number of products have been registered and released, some of which have played a leading role in the agro-market. The development of biopesticides has incited to replace the chemical pesticide in pest management. The current status and advancement of biopesticides focusing mainly on improving action spectra, replacing chemical pesticides, its role in integrated pest management are the main factors of biopesticides" [5].

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 × 2.40m² each was sown at 60×45 cm spacing. All the recommended package of practices was adopted for raising the crop except plant protection measures.

2.1 Preparation of Different Extract

2.1.1 Neem Seed Kernel Extract (NSKE)

Fifty grams of neem seeds were shade dried, crushed and then soaked overnight in little quantity of water. Later, the mixture was squeezed through the muslin cloth and the

volume was made upto one litre, so as to obtain 5 per cent solution. Soap/Ezee @1 g/litre (1 ml/lit) was added before spraying for better emulsion.

2.1.2 Garlic clove extract

Dried 50 gm garlic were crushed and soaked in 100 ml of water overnight. The content was squeezed and filtered through muslin cloth. The volume was then made up to one litre by adding water to obtain 5% extract and before using added/ml liquid soap (Ezee).

2.1.3 Neem leaf extract

50 gm fresh neem leaf + 500 ml water one litre volume made-up to overnight by adding water to 5%, before spray added liquid soap (Ezee) @1 ml/lit of spray solution.

2.1.4 Panchgavya: Material (Prepared 400 ml)

- Cow dung - 100 ml (juice)
- Cow ghee - 50 gm
- Cow urine - 100 ml
- Cow milk - 50 ml
- Curd - 100 ml

First the cow dung was mixed with ghee and kept for 2 days, later urine and water was added and left for 15 days. Then all ingredients were poured and stirred thoroughly, after 14 days the mixture was ready.

2.2 Observations

Observations on jassid (both adult as well as nymph) were recorded on six leaves at weekly interval during morning hours on five plants. The plants were selected randomly in each plot to record the population from six leaves, each to from top, middle and bottom canopies and mean population per six leaves was worked out.

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 different insect pests were 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 insects/ Number of leaves observed. The data obtained on pest

infestation from experimental field were subjected to analysis of variance after transforming into ($\sqrt{x+0.5}$). Economics of different treatments were also worked out.

3. RESULTS AND DISCUSSION

The efficacy of biopesticides treatments was assessed on the basis of sucking pests of jassid population. Data recorded on population of jassid different treatments at one day before and 7 and 14 days after each spray are presented in Tables 1, 2 and 3.

3.1 Effect of Biopesticides against Jassid, (*Amrasca biguttula biguttula* Ishida) Population on Okra during Kharif – 2018

The polled data indicates that the jassid population in different biopesticides at one day before spray ranged from 15.47 to 16.07 jassid/six leaves with statistically at par population in all the plots. Signification reduction in jassid population was noted at 7 and 14 days after spray of biopesticides compared to untreated control plot. Average population of jassid per six leaves at seven days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (20.60 jassid/six leaves) in reducing the jassid population. Minimum and significantly less population of jassid (9.20 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments. Among the treated plots maximum and significantly higher than rest the treatments population of jassid (13.93 jassid/six leaves) was recorded in panchgavya 3%. Data recorded at fourteen days after first spray showed that all the biopesticides treatments were found significantly effective over control plot (23.53 jassid/six leaves) in reducing the jassid population. Minimum and significantly less population (10.93 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments. Among the biopesticides maximum and significantly higher than rest of the treatments population jassid (13.93 jassid/six leaves) was recorded in panchgavya 3%. The average of two observations recorded at 7 and 14 days after first spray, all the treatments were found significantly effective over control plot (22.07 jassid/six leaves) in reducing the jassid population. Minimum and significantly less population of jassid 5% (10.07 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments except in neem oil 5%. Among the

Table 1. Effect of biopesticides against jassid, *Amrasca biguttula biguttula* (Ishida) on okra (Kharif- 2018)

Treatments	Dose/ha	Number of nymphs and adults of jassid/six leaves							Average of both spray
		First spray				Second spray			
		1 DBS	7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	
T ₁ <i>Beauveria bassiana</i>	0.5 kg	16.00 (4.06)	12.00 (3.54)	14.33 (3.85)	13.17(3.69)	6.00(2.55)	6.67(2.68)	6.33(2.61)	9.75 (3.20)
T ₂ <i>Verticillium lecanii</i>	1.0 kg	15.80 (4.04)	9.80 (3.21)	12.00 (3.54)	10.90(3.37)	6.20(2.59)	6.73(2.69)	6.47(2.64)	8.68 (3.03)
T ₃ Neem oil 5%	2.5 litre	15.47 (3.99)	9.73 (3.20)	11.73 (3.50)	10.73(3.35)	5.73(2.50)	6.00(2.55)	5.87(2.52)	8.30 (2.97)
T ₄ Neem leaf extract 5%	25 kg	15.87 (4.05)	11.87 (3.52)	13.80 (3.78)	12.83(3.65)	5.73(2.50)	6.53(2.65)	6.13(2.57)	9.48 (3.16)
T ₅ NSKE 5%	25 kg	16.20 (4.09)	9.20 (3.11)	10.93 (3.38)	10.07(3.25)	5.00(2.34)	5.40(2.43)	5.20(2.39)	7.63 (2.85)
T ₆ Garlic clove extract 5%	25 kg	15.73 (4.03)	11.53 (3.47)	13.73 (3.77)	12.63(3.62)	5.33(2.41)	6.07(2.56)	5.70(2.49)	9.17 (3.11)
T ₇ Panchgavya 3%	15 litre	16.07 (4.07)	13.93 (3.80)	15.73 (4.03)	14.83(3.91)	7.40(2.81)	6.87(2.71)	7.13(2.76)	10.98 (3.39)
T ₈ Control (untreated)		16.07 (4.07)	20.60 (4.59)	23.53 (4.90)	22.07(4.75)	13.33(3.72)	7.20(2.77)	10.27(3.25)	16.17 (4.08)
SEm ±		(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.01)	(0.02)	(0.03)
CD at 5%		NS	(0.11)	(0.08)	(0.09)	(0.08)	(0.03)	(0.05)	(0.09)

Figures in the parentheses are transformed ($\sqrt{n+0.5}$) values, NS= Non-Significant

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

Table 2. Effect of biopesticides against jassid, *Amrasca biguttula biguttula* (Ishida) on okra (Kharif- 2019)

Treatments	Dose/ha	Number of nymphs and adults of jassid/six leaves							Average of both spray
		1 DBS	First spray		Mean	Second spray		Mean	
			7 DAS	14 DAS		7 DAS	14 DAS		
T ₁ <i>Beauveria bassiana</i>	0.5 kg	9.60(3.18)	5.33(2.41)	9.80 (3.21)	7.57(2.81)	7.73(2.87)	2.53(1.74)	5.13(2.37)	6.35 (2.62)
T ₂ <i>Verticillium lecanii</i>	1.0 kg	9.80(3.21)	5.00(2.33)	7.80 (2.86)	6.40(2.60)	5.67(2.41)	1.93(1.55)	3.80(2.04)	5.10 (2.36)
T ₃ Neem oil 5%	2.5 litre	9.40(3.15)	4.93(2.33)	7.13 (2.75)	6.03(2.54)	5.53(2.45)	1.80(1.52)	3.67(2.04)	4.85 (2.31)
T ₄ Neem leaf extract 5%	25 kg	9.67(3.19)	5.13(2.37)	9.67 (3.16)	7.40(2.76)	7.67(2.82)	2.60(1.76)	5.13(2.37)	6.27 (2.59)
T ₅ NSKE 5%	25 kg	9.73(3.20)	4.87(2.31)	6.40 (2.62)	5.63(2.46)	5.13(2.37)	1.53(1.42)	3.33(1.95)	4.48 (2.23)
T ₆ Garlic clove extract 5%	25 kg	9.67(3.18)	5.00(2.34)	9.13 (3.10)	7.07(2.72)	7.60(2.84)	2.47(1.72)	5.03(2.35)	6.05 (2.56)
T ₇ Panchgavya 3%	15 litre	10.00(3.24)	9.00(3.08)	11.53(3.46)	10.27(3.27)	9.67(3.16)	2.73(1.78)	6.20(2.57)	8.23 (2.95)
T ₈ Control (untreated)		9.93 (3.23)	10.27(3.28)	15.87(4.04)	13.07(3.66)	12.20(3.56)	3.73(2.06)	7.97(2.91)	10.52(3.32)
SEm ±		(0.06)	(0.10)	(0.19)	(0.10)	(0.24)	(0.11)	(0.15)	(0.10)
CD at 5%		NS	(0.29)	(0.56)	(0.30)	(0.72)	(0.31)	(0.46)	(0.30)

Figures in the parentheses remain transformed ($\sqrt{n+0.5}$) values, NS= Non-Significant

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

treated plots maximum and significantly higher than rest of the treatments population of jassid (14.83 jassid/six leaves) was recorded in panchgavya 3%.

Data was recorded at seven days after second spray showed that all the biopesticides treatments were found significantly effective in reducing the jassid population over control plot (13.33 jassid/six leaves). Minimum and significantly less population of jassid (5.00 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments except garlic clove extract 5%. Among the treated plots maximum and significantly higher than the rest of the treatments population of jassid (7.40 jassid/six leaves) was recorded in panchgavya 3%. The average of population of jassid at fourteen days after second spray showed that all the biopesticides treatments were found significantly effective over control (7.20 jassid/six leaves) in reducing the jassid population. Minimum and significantly less population of jassid (5.40 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments. Among the treated plots, maximum and significantly higher than rest of the treatments population (6.87 jassid/six leaves) was recorded in panchgavya 3%. The average populations of two observations recorded at 7 and 14 days after second spray, all the biopesticides treatments were found significantly effective over control plots (10.27 jassid/six leaves) in reducing the jassid population. Minimum and significantly less population (5.20 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments. Among the treated plots, maximum and significantly higher than rest of the treatments population of jassid (7.13 jassid/six leaves) was recorded in panchgavya 3%.

Data recorded in *Kharif*- 2018, on the basis of average of four observations recorded at 7 and 14 days after first and second spray, all the biopesticides treatments were found significantly effective over control plots (16.17 jassid/six leaves) in reducing the jassid population. Minimum and significantly less population of jassid (7.63 jassid/six leaves) was recorded in NSKE 5% than rest of the treatments. Among the treated plots maximum and significantly higher than rest of the treatments population (10.98 jassid/ six leaves) was recorded in panchgavya 3%.

3.2 Effect of Biopesticides against Jassid, (*Amrasca biguttula biguttula* Ishida) Population on Okra during Kharif – 2019

The pooled data (Table 2) indicates that the jassid population in different biopesticides at one day before spray ranged from 9.40 to 10.00 jassid/six leaves with statistically at par population in all the plots. Significant reduction in jassid population was noted at 7 and 14 days after spray of biopesticides compared to untreated control plot. Average population of jassid per six leaves at seven days after first spray, showed that the all the biopesticides treatments were found significant over control plots (10.27 jassid/six leaves) in reducing the population of jassid. Among the biopesticides treatments, NSKE 5% (4.87 jassid/six leaves) was found most effective in reducing jassid population followed by neem oil 5% (4.93 jassid/six leaves) *V. lecanii* (5.00 jassid/six leaves) and garlic clove extract 5% (5.00 jassid/six leaves). Whereas, panchgavya 3% (9.00 jassid/six leaves) was found least effective and statistically at par with control plots. The average populations of jassid were recorded at fourteen days after first spray showed that all the biopesticides treatments were found significantly effective over control plots in reducing the jassid population. Minimum and significantly population less of jassid (6.40 jassid/six leaves) was recorded in plots treated with NSKE 5% than rest of the treatments except neem oil and *V. lecanii*. Among the treated plots maximum and significantly higher population (11.53 jassid/six leaves) was recorded in panchgavya 3% than rest of the treated plots except *B. bassiana* and statistically at par with neem leaf extract and garlic clove extract. The population of jassid on the basis of average of two observations recorded at 7 and 14 days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (13.07 jassid/six leaves). Among the treatments, NSKE 5% (5.63 jassid/six leaves) was found most effective in reducing jassid population followed by neem oil 5% (6.03 jassid/six leaves), *V. lecanii* (6.40 jassid/six leaves) and garlic clove extract 5% (7.07 jassid/six leaves). Whereas, panchgavya 3% (10.27 jassid/six leaves) was found least effective and statistically at par with control plots.

The population of jassid recorded at seven days after second spray showed significant differences

among different treatments. *V. lecanii* and NSKE 5% were found effective significantly over control plots (12.20 jassid/six leaves) in reducing the jassid population except panchgavya and *B. bassiana*. Minimum population (5.13 jassid/six leaves) was recorded in plots treated with NSKE 5% which found significantly less than the plot treated with panchgavya 3% but was at par with rest of the treated plots. Data recorded at fourteen days after second spray showed significant differences among different treatments. NSKE 5% were found effective significantly over control plots (3.73 jassid/six leaves) in reducing the jassid population. Minimum population (1.53 jassid/six leaves) was recorded in plots treated with NSKE 5% which found significantly less than the plot treated with *B. bassiana*, neem leaf extract 5% and panchgavya 3% but was at par with rest of the treated plots. The average population of jassid two observations recorded at 7 and 14 days after second spray showed significant differences among different treatments with regards to population of jassid over control plots (7.97 jassid/six leaves) except panchgavya and *B. bassiana*. Minimum and significantly less population (3.33 jassid/six leaves) was recorded in plots treated with NSKE 5% than rest of the treatments except *V. lecanii*, neem oil, neem leaf extract and garlic clove extract. Among the biopesticides maximum and significantly higher population (6.20 jassid/six leaves) was recorded in panchgavya 3% than rest of the treated plots except *B. bassiana*, neem oil, garlic clove extract and neem leaf extract.

Data recorded in *Kharif*- 2019, on the basis of average of four observations recorded at 7 and 14 days after first and second spray showed significant differences were observed in different treatments with regards to population of jassid over control plots (10.52 jassid/six leaves) except panchgavya. Minimum and significantly less population (4.48 jassid/six leaves) was recorded in plots treated with NSKE 5% than rest of the treatments except *V. lecanii*, neem oil, neem leaf extract and garlic clove extract. Among the biopesticides maximum and significantly higher population (6.20 jassid/six leaves) was recorded in panchgavya 3% than rest of the treated plots except *B. bassiana*, garlic clove extract and neem leaf extract.

The data observations of the average of two years indicated that all the treatments were found significantly effective over control plots (13.35 jassid/six leaves) in reducing the jassid population. Among the biopesticides NSKE

5% jassid population (6.06 jassid/six leaves) was found most effective and significantly superior than rest of treatments except neem oil 5%, *V. lecanii* and garlic clove extract 5%. Whereas, panchgavya 3% (9.61 jassid/six leaves) was found least effective and it at par with *B. bassiana*. Data computed on per cent reduction in jassid population indicate that 28.03 to 54.6 % population may be recorded by spraying of different biopesticides, however, NSKE 5% (54.6%) was found most effective in reducing the jassid population followed by neem oil 5%, *V. lecanii* and garlic clove extract 5%. Similar to the present findings Adilakshmi *et al.* [6], Rudramuni *et al.* [7], Saha [8] and Meena *et al.* [9] reported NSKE 5% to be effective treatment against jassid population. Kalyan *et al.* [10] also reported NSKE 5% comparatively higher per cent reduction in population of jassid in compared to entomopathogenic fungus. Rosaiah [11], Anitha and Nandihalli [12] and Vishwvanath and Singh [13] also reported neem based product to be effective against jassid. Naik *et al.* [14] and Saha [8] reported *V. lecanii* to be effective jassid population. Similar to the present finding Thapa *et al.* [15] reported neem formulation to be effective control for per cent reduction in okra jassid, which corroborate the present findings.

3.3 Fruit Yield under Different Biopesticides

Data recorded in *Kharif*- 2018, all the biopesticides were found significantly effective in registering the higher yield (112.22 to 118.66 q/ha) over control with (98.67 q/ha). Maximum fruit yield (118.66) was recorded in *B. bassiana* followed by NSKE 5% (118.22 q/ha) and neem oil 5% (117.08 q/ha). Whereas, minimum fruit yield (112.22 q/ha) was recorded in panchgavya 3% followed by neem leaf extract 5% and *V. lecanii*. In *Kharif*- 2019, maximum fruit yield (120.89 q/ha) was recorded in NSKE 5% followed by *B. bassiana* (120.33 q/ha) and neem oil 5% (118.42 q/ha). Whereas, minimum fruit yield (113.89 q/ha) was recorded in panchgavya 3% followed by neem leaf extract 5% and garlic clove extract 5%. The average of two year observations data, all the biopesticides found significantly effective in registering the higher yield (113.06 to 119.56 q/ha) over control (100.13 q/ha). Maximum fruit yield (119.56 q/ha) was recorded in NSKE 5% followed by *B. bassiana* (119.50 q/ha) and neem oil 5% (117.75 q/ha). Whereas, minimum fruit yield (113.06 q/ha) was recorded in panchgavya 3%. Data computed on per cent avoidable loss in fruit yield

caused by shoot and fruit borer indicate that 12.9 to 19.4% loss in fruit yield may be avoided by the protecting with different biopesticides. Maximum fruit loss may be avoided by protecting the crop with NSKE 5% (19.4%) followed by *B. bassiana* and neem oil 5% (Table 4). Similar to the present finding Adilakshmi *et al.* [6], Sohail *et al.* [16] and Yeole and Gawande [17] also reported highest fruit yield over control was recorded in neem seed extract. Vishwvanath and Singh [13] also reported that neem formulations protect the crop from the fruit borer infestation and increase the marketable yield of okra.

3.4 Economics of Different Biopesticides

The data computed on economics of different treatments revealed that all the biopesticides treatments were economical over control. Maximum net profit (27,128 Rs/ha) was recorded in *B. bassiana* followed by NSKE 5% (25,938 Rs/ha). However, maximum cost benefit ratio of (1:14.13) was recorded in *B. bassiana* (Table 5). Similar to the present finding Anitha and Nandihalli [12] and Shreedevi [18] also reported that NSKE 5% gave higher net return and coast benefit ratio followed by GCK and panchgavya.

Table 3. Effect of biopesticides against jassid, *Amrasca biguttula biguttula* (Ishida) on okra (Pooled- 2018 & 2019)

Treatments	Dose/ha	Number of nymphs and adults of jassid /six leaves			Reduction in jassid population (%)
		Mean 2018	Mean 2019	Average of two years	
T ₁ <i>Beauveria bassiana</i>	0.5 kg	9.75 (3.20)	6.35 (2.62)	8.05 (2.86)	39.7
T ₂ <i>Verticillium lecanii</i>	1.0 kg	8.68 (3.03)	5.10 (2.36)	6.89 (2.65)	48.4
T ₃ Neem oil 5%	2.5 litre	8.30 (2.97)	4.85 (2.31)	6.58 (2.60)	50.7
T ₄ Neem leaf extract 5%	25 kg	9.48 (3.16)	6.27 (2.59)	7.88 (2.82)	41.0
T ₅ NSKE 5%	25 kg	7.63 (2.85)	4.48 (2.23)	6.06 (2.50)	54.6
T ₆ Garlic clove extract 5%	25 kg	9.17 (3.11)	6.05 (2.56)	7.61 (2.77)	43.0
T ₇ Panchgavya 3%	15 litre	10.98 (3.39)	8.23 (2.95)	9.61 (3.11)	28.0
T ₈ Control (untreated)		16.17 (4.08)	10.52 (3.32)	13.35 (3.72)	
SEm ±		(0.03)	(0.10)	(0.05)	
CD at 5%		(0.09)	(0.30)	(0.15)	

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

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

Table 4. Fruit yield under different biopesticides

Treatments	Dose/ha	Yield (q/ha)			Avoidable losses/ha
		Kharif- 2018	Kharif- 2019	Average	
T ₁ <i>Beauveria bassiana</i>	0.5 kg	118.66	120.33	119.50	19.34
T ₂ <i>Verticillium lecanii</i>	1.0 kg	115.78	117.44	116.61	16.46
T ₃ Neem oil 5%	2.5 litre	117.08	118.42	117.75	17.60
T ₄ Neem leaf extract 5%	25 kg	114.00	115.33	114.66	14.51
T ₅ NSKE 5%	25 kg	118.22	120.89	119.56	19.40
T ₆ Garlic clove extract 5%	25 kg	116.22	117.22	116.72	16.56
T ₇ Panchgavya 3%	15 litre	112.22	113.89	113.06	12.91
T ₈ Control (untreated)		98.67	101.60	100.13	
SEm ±		1.80	1.52	1.18	
CD at 5%		5.30	4.47	3.46	

Figures in the parentheses are mean values

Table 5. Economics of different biopesticides 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 <i>Beauveria bassiana</i>	0.5 kg	119.50	19.37	29055	1920	27128	1:14.13
T ₂ <i>Verticillium lecanii</i>	1.0 kg	116.61	16.48	24720	2640	22078	1:8.36
T ₃ Neem oil 5%	2.5 litre	117.75	17.62	26430	3700	22728	1:6.14
T ₄ Neem leaf extract 5%	25 kg	114.66	14.53	21795	3200	18598	1:5.81
T ₅ NSKE 5%	25 kg	119.56	19.43	29145	3200	25938	1:8.11
T ₆ Garlic clove extract 5%	25 kg	116.72	16.59	24885	3200	21683	1:6.78
T ₇ Panchgavya 3%	15 litre	113.06	12.93	19395	5700	13688	1:2.40
T ₈ Control (untreated)		100.13	-	-	-	-	-

Note:

Selling rate of okra fruit (Rs/q) : 1500
 Labour charge for sprays (Rs) : 600 per spray

Rate of insecticides Rs/litre or kg.

Beauveria bassiana : 720
Verticillium lecanii : 720
 Neem oil : 1000
 Neem leaf extract : 40
 NSKE : 40
 Garlic clove extract : 40
 Panchgavya : 150

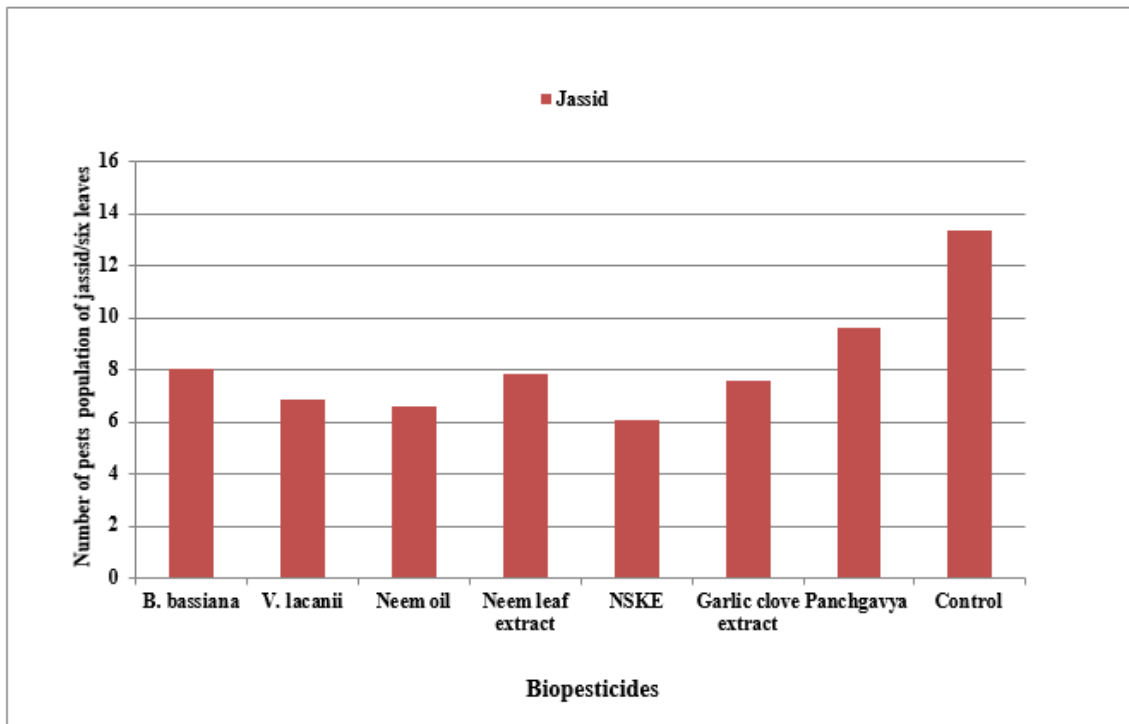


Fig. 1. Population of jassid under different biopesticides

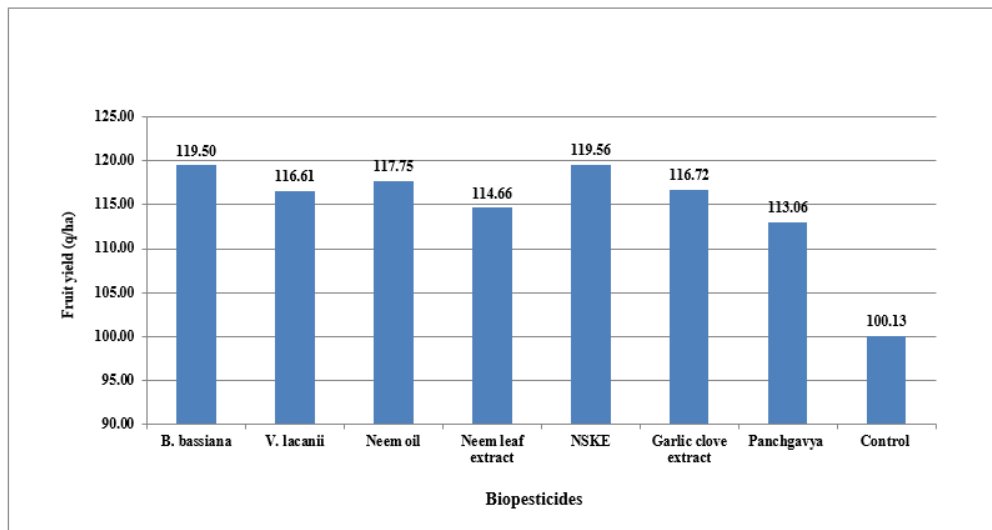


Fig 2. Fruit yield under different biopesticides

4. CONCLUSION

In conclusion, the study affirms the significant efficacy of biopesticides, particularly NSKE 5%, *B. bassiana* and neem oil 5% in effectively controlling jassid populations on okra crops. The varied impact on jassid reduction, fruit yield, net profit and benefit cost ratio highlights the potential of these biopesticides for sustainable pest management in okra cultivation in Madhya Pradesh in India.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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