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Efficacy of biopesticides against sucking pest of aphid, (*Aphis gossypii* Glover) on okra, [*Abelmoschus esculentus* (L.) Moench] in Northern Madhya Pradesh

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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 bio-pesticides against sucking insect pests of 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 lacanii* @ 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 aphid over control (untreated) plots. The treatments *V. lecanii* was found to be significantly effective against aphids population followed by NSKE 5%, garlic clove extract 5% and neem oil 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 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: Aphid, botanical, microbial, biopesticides, okra crop

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 (Sree *et al.*, 2019) [19]. 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 (Patel *et al.*, 2018) [13]. 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 513 thousand hectare area with production of 6170 thousand matric tonnes and productivity 12.00 matric tonnes ha^{-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).
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), leaf hopper (*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% (Koulagi *et al.*, 2009) [6].

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 biopesticide (Nawaz *et al.*, 2016) [11].

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 was conducted with seven treatments in a Randomized Block Design and replicated thrice with plot size of 3.60 × 2.40 m^2 each was sown at 60 × 45 cm spacing. All the recommended package of practices was adopted for raising the crop except plant protection measures.

Observations

Observations on aphids (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 two 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 (x+0.5). Economics of different treatments were also worked out.

Results and Discussion

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

Table 1: Efficacy of biopesticides against aphid, *Aphis gossypii* glover on okra (*Kharif*-2018)

Treatments	Dose/ha	Number of Aphid population/six leaves							Mean of four observation
			First spray			Second spray			
		1 DBS	7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	
T_1*Beauveria bassiana*	0.5 kg	13.53(3.75)	8.40(2.98)	7.53(2.83)	7.97(2.91)	3.20(1.92)	3.27(1.94)	3.23(1.93)	5.60(2.47)
T_2 *Verticillium lacanii*	1.0 kg	14.00(3.81)	6.40(2.63)	6.13(2.58)	6.27(2.60)	2.27(1.66)	2.67(1.78)	2.47(1.72)	4.37(2.40)
T_3 Neem oil 5%	2.5 litre	13.67(3.76)	7.00(2.74)	6.60(2.66)	6.80(2.70)	3.13(1.90)	3.27(1.94)	3.20(1.92)	5.00(2.34)
T_4 Neem leaf extract 5%	25 kg	14.00(3.81)	8.00(2.92)	7.20(2.77)	7.60(2.85)	2.80(1.82)	3.13(1.91)	2.97(1.86)	5.28(2.40)
T_5 NSKE 5%	25 kg	13.93(3.80)	6.80(2.70)	6.27(2.60)	6.53(2.65)	2.47(1.72)	2.67(1.78)	2.57(1.75)	4.55(2.25)
T_6 Garlic clove extract 5%	25 kg	14.20(3.83)	7.33(2.80)	6.47(2.64)	6.90(2.72)	3.13(1.91)	3.27(1.94)	3.20(1.92)	5.05(2.36)
T_7 Panchgavya 3%	15 litre	13.73(3.77)	9.07(3.09)	8.27(2.96)	8.67(3.03)	4.13(2.15)	3.93(2.10)	4.03(2.13)	6.35(2.62)
T_8 Control (untreated)		14.07(3.82)	17.07(4.19)	10.40 (3.30)	13.73(3.75)	5.27 (2.40)	4.73(2.29)	5.00 (2.34)	9.37(3.14)
SEm ±		(0.02)	(0.02)	(0.01)	(0.01)	(0.04)	(0.04)	(0.03)	(0.02)
CD at 5%		NS	(0.05)	(0.03)	(0.04)	(0.13)	(0.11)	(0.10)	(0.06)

Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant
DBS - Day before spray
DAS - Day after spray

Efficacy of biopesticides against aphid, *A. gossypii* (Glover) population on Okra during Kharif-2018

Aphid, *A. gossypii* (Glover) population

The pooled data indicates that the aphid population in different biopesticides at one day before spray ranged from 13.53 to 14.20 aphids/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 biopesticides compared to untreated control plot. Average population of aphids per three leaves at seven days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (17.07 aphids/six leaves) in reducing the population of aphid. Minimum and significantly less population of aphid (6.40 aphids/six leaves) was recorded in *Verticillium lecanii* than rest of the treatments. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (9.07 aphids/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 plots (10.40 aphids/six leaves) in reducing the population of aphid. Minimum and significantly less population of aphid (6.13 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments except NSKE 5%. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (8.27 aphids/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 plots (13.73 aphids/six leaves) in reducing the aphid population. Minimum and significantly less population of aphid (6.27 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (8.47 aphids/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 population of aphid over control plots (5.27 aphids/six leaves). Minimum and significantly less population of aphid (2.27 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments except NSKE 5%. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (4.13 aphids/six leaves) was recorded in panchgavya 3%. The average population of aphid at fourteen days after second spray showed that all the biopesticides treatments were found significantly effective over control plots (4.73 aphids/six leaves) in reducing the population of aphid. Minimum and significantly less population of aphid (2.67 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments except NSKE 5%. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (3.93 aphids/six leaves) was recorded in panchgavya 3%. The average population of two observations recorded at 7 and 14 days after second spray, all the treatments was found significantly effective over control plots (5.00 aphids/six leaves) in reducing the aphid population. Minimum and significantly less population of aphid (2.47 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments except NSKE 5%. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (4.03 aphids/six leaves) was recorded in panchgavya 3%.

Data recoded 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 (9.37 aphids/six leaves) in reducing the population of aphid. Minimum and significantly less population of aphid (4.37 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments except NSKE 5%. Among the treated plots maximum and significantly higher than rest of the treatments population of aphid (6.35 aphids/six leaves) was recorded in panchgavya 3%.

Efficacy of biopesticides against aphid, *A. gossypii* (Glover) population on Okra during Kharif-2019

Aphid, *A. gossypii* (Glover) population

The pooled data (Table 2) indicates that the aphid population in different biopesticides at one day before spray ranged from 4.80 to 5.20 aphids/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 biopesticides compared to untreated control plot. Average population of aphids per three leaves at seven days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (17.07 aphids/six leaves) in reducing the population of aphid. Data recorded at seven days after first spray all the biopesticides treatments were found significantly effective in reducing the population of aphid over control (5.33 aphids/six leaves) except panchgavya. Among the biopesticides treatments, *V. lecanii* (2.33 aphids/six leaves) was found most effective in reducing aphid population followed by NSKE 5% (2.40 aphids/six leaves), garlic clove extract 5% (2.67 aphids/six leaves), *Beauveria bassiana* (3.00 aphids/six leaves) and neem oil 5% (3.07 aphids/six leaves). Whereas, panchgavya 3% (4.93 aphids/six leaves) was found least effective and statistically at par with control plots. The average populations of aphid were recorded at fourteen days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (7.80 aphids/six leaves) in reducing the population of aphid. All the biopesticides were statistically at par in reducing the aphid population except neem leaf extract and panchgavya. Among the biopesticides *V. lecanii* (2.73 aphids/six leaves) was found most effective followed by NSKE 5% (2.80 aphids/six leaves), garlic clove extract 5% (2.87 aphids/six leaves), *B. bassiana* (3.47 aphids/six leaves) and neem oil 5% (3.67 aphids/six leaves). Whereas, panchgavya 3% (4.93 aphids/six leaves) was found least effective. The population of aphid on the basis of mean 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 (6.57 aphids/six leaves) in reducing the population of aphid. All the biopesticides were statistically at par in reducing the aphid population except neem leaf extract and panchgavya. Among the treatments *V. lecanii* (2.53 aphids/six leaves) was found most effective followed by NSKE 5% (2.60 aphids/six leaves), garlic clove extract 5% (2.77 aphids/six leaves), *B. bassiana* (3.23 aphids/six leaves) and neem oil 5% (3.37 aphids/six leaves). Whereas, panchgavya 3% (4.67 aphids/six leaves) was found least effective.

The population of aphid recorded at seven days after second spray. Minimum and significantly less aphid population (0.47 aphids/six leaves) was recorded in *V. lecanii* than rest of the treatments except NSKE 5% and garlic clove extract 5%. Among the biopesticides maximum and significantly higher aphid population (1.33 aphids/six leaves) was recorded in panchgavya 3% than rest of treatments except neem leaf extract 5%, neem oil 5% and *B. bassiana*. Data recorded at fourteen days after spray showed significant differences in different treatments with regards to population of aphid over control plots (0.67 aphids/six leaves) except panchgavya. The aphid population in all the treated plots were statistically similar and ranged from 0.20 aphids/six leaves in (*B. bassiana*) to 0.33 aphids/six leaves in (panchgavya 3%) as against 0.67 aphids/six leaves in untreated control. The average population of aphid two observations recorded at 7 and 14 days after spray, significant differences in different treatments. *V. lecanii* and NSKE 5% were found effective significantly over control plots (1.07 aphids/six leaves) in reducing the aphid population. Minimum population (0.30 aphids/six leaves) was recorded in *V. lecanii* which was found significantly less than plot treated with panchgavya 3% but was at with rest of treated plots.

Data recoded in Kharif-2019, on the basis of average of four observations recorded at 7 and 14 days after first and second spray, significant differences in different treatments with regards to population of aphid over control plots (3.82 aphids/six leaves) except panchgavya. Minimum and significantly less population (1.40 aphids/six leaves) was recorded in *V. lecanii* than rest of treatments except NSKE 5% and garlic clove extract 5%. Among the biopesticides maximum and significantly higher population (2.75 aphids/six leaves) was recorded in panchgavya 3% than rest of the treated plots except neem leaf extract 5%, neem oil and *B. bassiana*.

The data observations of the average of two years, it was observed that all the treatments were found significantly effective over control plots (6.60 aphids/six leaves) in reducing the aphid population. Among the biopesticides *V. lecanii* (2.89 aphids/six leaves) was found most effective followed by NSKE 5%, garlic clove extract 5% and neem oil 5%. Whereas, panchgavya 3% (4.55 aphids/six leaves) was

found least effective and at par with neem leaf extract. Data computed on per cent reduction in aphid population indicate that 31.1 to 56.2% population may be reduced by spraying of different biopesticides. However, *V. lecanii* (56.2%) was found most effective in reducing the aphid population followed by NSKE 5%, garlic clove extract 5% and neem oil 5% (Table 3). Similar to the present findings Khalil *et al.* (1983) [5], Ramarethinam *et al.* (2005) [14], Nirmala *et al.* (2006) [12], Van Hanh *et al.* (2007) [21], Naik and Shekharappa (2009) [9], Naik *et al.* (2012) [10], Saha (2015) [15] and Bade *et al.* (2017) [4] also reported *V. lecanii* to be effective against aphid population on okra. Mishra and Mishra (2002) [8], Anitha and Nandihalli (2008) [2], Adilakshmi *et al.* (2008) [1], Saha (2015) [15] and Meena *et al.* (2020) [7] also reported NSKE 5% to be effective against aphid, which corroborate the present findings. Similar to the present finding Naik *et al.* (2012) [10] also reported neem oil to be effective against aphid.

Table 2: Efficacy of biopesticides against aphid, *Aphis gossypii* Glover on okra (*Kharif*-2019)

Treatments	Dose/ha	Number of Aphid population/six leaves							Mean of four observation
			First spray			Second spray			
		1 DBS	7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean	
T_1 *Beauveria bassiana*	0.5 kg	4.80(2.30)	3.00(1.87)	3.47(1.99)	3.23(1.93)	0.73(1.10)	0.20(0.83)	0.47(0.97)	1.85(1.53)
T_2 *Verticillium lacanii*	1.0 kg	5.13(2.37)	2.33(1.67)	2.73(1.80)	2.53(1.73)	0.47(0.98)	0.07(0.75)	0.27(0.87)	1.40(1.38)
T_3 Neem oil 5%	2.5 litre	5.00(2.34)	3.07(1.89)	3.67(2.04)	3.37(1.96)	0.67(1.05)	0.20(0.84)	0.43(0.95)	1.90(1.55)
T_4 Neem leaf extract 5%	25 kg	4.93(2.33)	4.20(1.67)	4.60(2.25)	4.40(2.21)	1.27(1.33)	0.27(0.87)	0.77(1.10)	2.58(1.75)
T_5 NSKE 5%	25 kg	5.20(2.39)	2.40(1.69)	2.80(1.81)	2.60(1.75)	0.53(0.99)	0.07(0.75)	0.30(0.87)	1.45(1.39)
T_6 Garlic clove extract 5%	25 kg	5.13(2.37)	2.67(1.76)	2.87(1.82)	2.77(1.79)	0.67(1.04)	0.13(0.79)	0.40(0.92)	1.58(1.46)
T_7 Panchgavya 3%	15 litre	5.20(2.39)	4.40(2.21)	4.93(2.33)	4.67(2.27)	1.33(1.35)	0.33(0.90)	0.83(1.13)	2.75(1.80)
T_8 Control (untreated)		5.13(2.37)	5.33(2.41)	7.80(2.88)	6.57(2.65)	1.47(1.40)	0.67(1.08)	1.07(1.24)	3.82(2.08)
SEm ±		(0.04)	(0.11)	(0.10)	(0.09)	(0.10)	(0.06)	(0.06)	(0.07)
CD at 5%		NS	(0.32)	(0.30)	(0.27)	(0.30)	(0.18)	(0.19)	(0.21)

Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant
DBS - Day before spray
DAS - Day after spray

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

Treatments	Dose/ha	Number of Aphid population/six leaves			Reduction in aphid population(%)
		Mean 2018	Mean 2019	Average of two years	
T_1*Beauveria bassiana*	0.5 kg	5.60(2.47)	1.85(1.53)	3.73(1.93)	43.5
T_2 *Verticillium lacanii*	1.0 kg	4.37(2.40)	1.40(1.38)	2.89(1.73)	56.2
T_3 Neem oil 5%	2.5 litre	5.00(2.34)	1.90(1.55)	3.45(1.88)	47.7
T_4 Neem leaf extract 5%	25 kg	5.28(2.40)	2.58(1.75)	3.93(2.00)	40.5
T_5 NSKE 5%	25 kg	4.55(2.25)	1.45(1.39)	3.00(1.75)	54.6
T_6 Garlic clove extract 5%	25 kg	5.05(2.36)	1.58(1.46)	3.32(1.84)	49.7
T_7 Panchgavya 3%	15 litre	6.35(2.62)	2.75(1.80)	4.55(2.14)	31.1
T_8 Control (untreated)		9.37(3.14)	3.82(2.08)	6.60(2.50)	
SEm ±		(0.02)	(0.07)	(0.03)	
CD at 5%		(0.06)	(0.21)	(0.10)	

Figures in the parentheses are transform (√x+0.5) values, NS= Non-significant
DBS - Day before spray
DAS - Day after spray

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) 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 19.3% 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.* (2008) [1], Sohail *et al.* (2015) [17] and Yeole and Gawande (2019) [21] also reported highest fruit yield over control was recorded in neem seed extract. Vishwvanath and Singh (2009) also reported that neem formulations protect the crop from the fruit borer infestation and increase the marketable yield of okra.

Table 4: Fruit yield under different biopesticides

Treatments	Dose/ha	Yield (q/ha)			Avoidable losses/ha
		Kharif-2018	*Kharif*-2019	Average	
T_1*Beauveria bassiana*	0.5 kg	118.66	120.33	119.50	19.34
T_2 *Verticillium lacanii*	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

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 (2008) [2] and Shreedevi (2011) [16] also reported that NSKE 5% gave higher net return and cost benefit ratio followed by GCK and panchgavya.

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*Beauveria bassiana*	0.5 kg	119.50	19.37	29055	1920	27128	1:14.13
T_2 *Verticillium lacanii*	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

Beauveria bassiana : 720

Verticillium lecanii : 720

Neem oil : 1000

Neem leaf extract : 40

NSKE : 40

Garlic clove extract : 40

Panchgavya : 150

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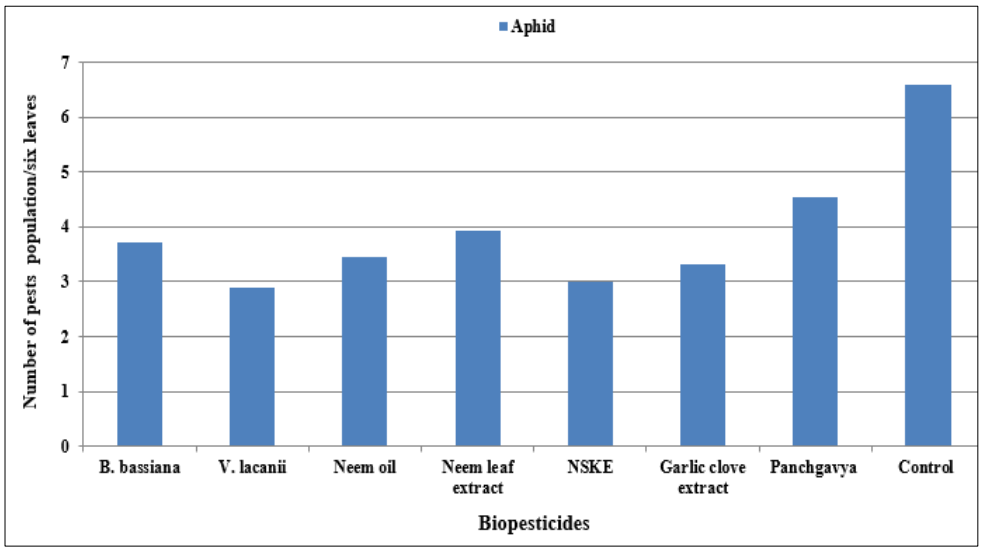

Fig 1: Population of aphid under different biopesticides

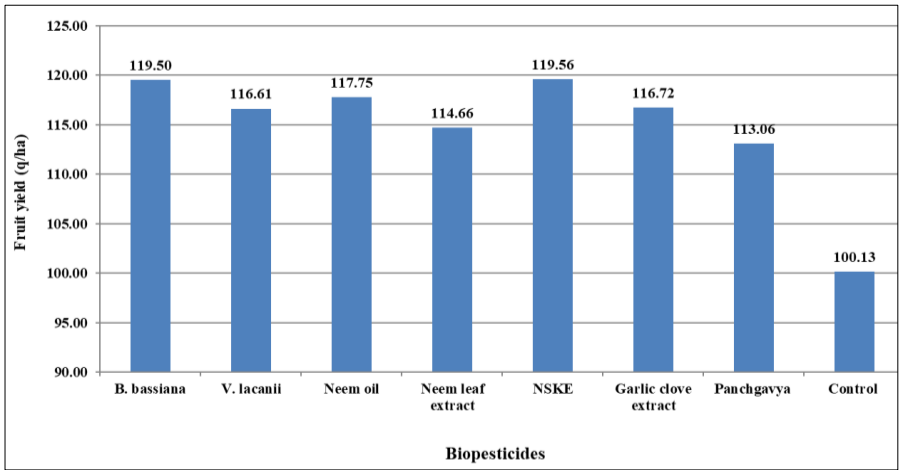

Fig 2: Fruit yield under different biopesticides

Conclusion

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

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