Efficacy of Biopesticides againstWhitefly,(*Bemisiatabaci*Gennadius) on Okra [*Abelmoschus esculentus* (L.) Moench] in Northern Madhya Pradesh, India

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 whitefly 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 whitefly over control untreated plots (11.73 whiteflies/six leaves). Among the biopesticides treatments, NSKE 5% (4.67 whiteflies/six leaves)found most effective in reducing the whitefly population followed by neem oil 5%(4.88 whiteflies/six leaves), *V. lecanii*(5.20 whiteflies/six leaves), neem leaf extract 5% (5.49 whiteflies/six leaves) and garlic clove extract 5%(5.68 whiteflies/six leaves).Whereas, panchgavya 3% (8.59 whiteflies/six leaves) was found least effective in both the years.Data computed on per cent reduction in whitefly population indicate that 26.8 to 60.2% population may be reduced by spraying of different biopesticides.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 the 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: Efficacy, Whitefly, Biopesticides, Okra,Yield

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 el*., 2019).It has good nutritional value, 100 g of edible fruit contains 2 gprotein, 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 and Dhruve, 2018).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 MT 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); leafhopper (*Amrascabiguttulabiguttula* Ishida); whitefly (*Bemisiatabaci* Gennadius); shoot and fruit borer (*Eariasvittella* Fab.) and mite (*Tetranychuscinnabarinus*Boisduval) causes significant damage to the crop. Okra fruit and shoot borer, *Eariasvittella* (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 (Koulagi, 2019).

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 (Nawaz *et al*., 2016).

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

Preparation of different extract:

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. 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).

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.

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.

Economics work of Whitefly on okra:

With a view to ascertain the effect of different chemical insecticides and biopesticides on the yield, the picked fruits of okra were weighted separately from per plot area in each treatment. The fruit yield was then converted on hectare basis. The increase yield over control was calculated by using the following formula:

$$\text{Yield increased over control} = (T - C)$$

Where,

T = Yield of respective treatments (kg/ha)

C = Yield of control plot (kg/ha)

The avoidable losses and increase in yield of fruits over control (untreated) was calculated for each treatment by using following formula (Pradhan, 1964).

$$\textbf{Avoidable loss(\%)} = \frac{\text{Yield in treated plot} - \text{Yield in control}}{\text{Yield in treated plot}} \text{ X100}$$

Cost benefit Ratio (ICBR) was also worked out to compare the economics of different insecticides treatments.

$$\textbf{Cost benefit ratio} = \frac{\text{Net return (Rs ha}^{-1})}{\text{Cost of treatment (Rs ha}^{-1})}$$

Analysis of variance:

The data on pest population was subjected ($\sqrt{x+0.5}$) transformation on per cent and shoots/fruits infested in to rules of arsine transformation should be followed. The transformed data was analyzed for analysis variance as suggested by Fisher and Yates, 1938.

Observations

Observations on whitefly (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 whiteflywasrecorded 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.

RESULTS AND DISCUSSION

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

Efficacy of biopesticides against whitefly, (*Bemisiatabaci*Gennadius)population on Okra during Kharif - 2018

The polled data indicates that the whitefly population in different biopesticides at one day before spray ranged from 15.47 to 16.60whiteflies/six leaves with statistically at par population in all the plots.Among the biopesticides NSKE 5% (10.97 whitefly/six leaves) was found effective and significantly superior than rest of the treatments except neem oil 5%. Whereas, panchgavya 3% (17.27 whitefly/six leaves) was found least effective.Signification reduction in whitefly population was noted at 7 and 14 days after spray of biopesticides compared to untreated control plot. Average population of whitefly per six leaves at seven days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (20.87whiteflies/six leaves) in reducing the whitefly population. Among the biopesticides NSKE 5% (10.97 whiteflies/six leaves) was found effective and significantly superior than rest of the treatments except neem oil 5%. Whereas, panchgavya 3% (17.27 whiteflies/six leaves) was found least effective.Data recorded at fourteen days after first spray showed that all the biopesticides treatments were found significantly effective

over control plot (19.27whiteflies/six leaves) in reducing the whitefly population except panchgavya. Among the biopesticides, NSKE 5% (11.40 whiteflies/six leaves) was found most effective in reducing the whitefly population followed by neem oil 5% (11.67 whiteflies/six leaves), *V.lecanii* (11.87 whiteflies/six leaves) and garlic clove extract 5% (12.60 whiteflies/six leaves). Maximum and significantly higher than rest of the treatments populationwhitefly (17.93whiteflies/six leaves) was recorded in panchgavya 3% and statistically at par with control plots.Theaverage of two observations recorded at 7 and 14 days after first spray, all the treatments were found significantly effective over control plots(20.07 whiteflies/six leaves) in reducing the population of whitefly. Minimum and significantly less population of whitefly(11.18whiteflies/six leaves) was recordedin NSKE 5% followed by neem oil 5% (11.47 whiteflies/six leaves), *V.lecanii* (11.70 whiteflies/six leaves) and *Beauveria bassiana* (12.40 whiteflies/six leaves).Among the treated plots maximum and significantly higher than rest of the treatments population of whitefly(17.60whiteflies/six leaves) was recorded inpanchgavya 3%.

Data was recorded at seven days after second spray showed that all the biopesticides treatment werefoundsignificantlyeffective in reducing the population of whiteflyover control plot (17.40whiteflies/six leaves). Among the biopesticides treatments, NSKE 5% (4.07 whiteflies/six leaves) was found most effective in reducing the whitefly population followed by neem oil 5% (4.27 whiteflies/six leaves), neem leaf extract (4.60 whiteflies/six leaves), *V.lecanii* (4.80 whiteflies/six leaves) and garlic clove extract (4.93 whiteflies/six leaves). Maximum and significantly higher than the rest of the treatments population of whitefly (10.33 whiteflies/six leaves) was recorded in panchgavya 3%.The average of population of whitefly at fourteen days after second spray showed that all the biopesticides treatments were foundsignificantlyeffective over control plots (12.27whiteflies/six leaves) in reducing the population of whitefly. Among the biopesticides treatments, NSKE 5% (3.40 whiteflies/six leaves) was found most effective in reducing the whitefly population followed by neem oil 5% (3.87 whiteflies/six leaves), *V.lecanii* (4.00 whiteflies/six leaves), neem leaf extract (4.07 whiteflies/six leaves) and garlic clove extract (4.27 whiteflies/six leaves). Whereas, maximum and significantly population of whitefly (8.40 whiteflies/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 werefound significantly effective over control plots (16.33whiteflies/six leaves) in reducing the whitefly population. Minimum and significantly less population of whitefly (3.73whiteflies/six leaves) was recorded in NSKE

5% followed by neem oil 5% (4.07 whiteflies/six leaves), neem leaf extract (4.33 whiteflies/six leaves), *V.lecanii* (4.40 whiteflies/six leaves) and garlic clove extract (4.60 whiteflies/six leaves). Among the treated plots, maximum and significantly higher than rest of the treatments population of whitefly (9.37whiteflies/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 (18.20whiteflies/six leaves) in reducing the whitefly population. Minimum and significantly population of whitefly(7.76whiteflies/six leaves) was recorded in NSKE 5% followed by neem oil 5% (7.77 whiteflies/six leaves), *V.lecanii* (8.05 whiteflies/six leaves), neem leaf extract (8.10 whiteflies/six leaves) and garlic clove extract (8.52 whiteflies/six leaves). Among the treated plots maximum and significantly higher than rest of the treatments population of whitefly (13.48whiteflies/six leaves) was recorded in panchgavya 3%.

Effect of biopesticides against whitefly, (*Bemisiatabaci*Gennadius)population on Okra during Kharif - 2019

The pooled data (Table 2) indicates that the whitefly population in different biopesticides at one day before spray ranged from 4.33 to 5.13whiteflies/six leaves with statistically at par population in all the plots.

Significant reduction in whitefly population was noted at 7 and 14 days after spray of biopesticides compared to untreated control plot.Average population of whitefly per six leaves at seven days after first spray, showed that the all the biopesticides treatments were found significant over control plots (7.80whiteflies/six leaves) in reducing the population of whitefly. Minimum and significantly less population of whitefly (2.87 whitefly/six leaves) was recorded in plots treated with NSKE 5% than rest of the treatments except neem oil, *V. lecanii* and garlic clove extract. Among the biopesticides maximum and significantly higher population (5.53 whitefly/six leaves) was recorded in *B. bassiana* than rest of the treated plots except panchgavya 3% and neem leaf extract.The average populations of whiteflywasrecorded at fourteen days after first spray showed that all the biopesticides treatments were found significantly effective over control plots (8.13 whiteflies/six leaves) in reducing the whitefly population. Minimum and significantly population of whitefly(3.07 whiteflies/six leaves) was recorded in plots treated with NSKE 5% followed by neem oil and

V. lecanii. Among the treated plots maximum and significantly higher population of whitefly (6.40 whiteflies/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 whitefly on thebasis of average of two observations recorded at 7 and 14 days after first spray showed that all the biopesticides treatments were found significantlyeffective over control plots (8.13whitefly/six leaves). Among the treatments, NSKE 5% (2.97whiteflies/six leaves) was found most effective in reducing whitefly population followed by neem oil 5%, *V.lacanii*, garlic clove extract 5% and neem leaf extract.Maximum and significantly higher population (5.73 whiteflies/six leaves) was recorded in *B. bassiana* than rest of the treated plots except panchgavya 3%, garlic clove extract and neem leaf extract.The population of whiteflyrecorded at seven days after second spray showed significant differences among different treatmentswith regards to population of whitefly over control plots (3.47 whiteflies/six leaves). Minimum and significantly population (1.40 whiteflies/six leaves) was recorded in plots treated with NSKE 5% followed byneem oil, garlic clove extract, *V. lecanii*, *B. bassiana* and neem leaf extract.Among the biopesticides, maximum and significantly population of whitefly (2.93 whiteflies/six leaves) was recorded in panchgavya 3% followed byneem leaf extract, *B. bassiana,V. lecanii* and garlic clove extract.Data recorded at fourteen days after second spray showed significant differences among different treatments with regards to population of whitefly over control plots (1.60 whiteflies/six leaves). Minimum and significantly less population (0.13 whiteflies/six leaves) was recorded in plots treated with NSKE 5% than rest of the treatments except neem oil, *V. lecanii*, garlic clove extract, neem leaf extractand *B. bassiana*. Among the treated plots maximum and significantly higher population (0.87 whitefly/six leaves) was recorded in panchgavya 3% than rest of the treated plots except *B. bassiana,* neem leaf extract,*V. lecanii,* garlic clove extract and neem oil 5%.The average population of whiteflytwo observations recorded at 7 and 14 days after second spray showed significant differences among different treatments with regards to population of whitefly over control plots (2.53whiteflies/six leaves) were observed. Minimum and significantly less population (0.76 whiteflies/six leaves) was recorded in plots treated with NSKE 5% than rest of the treatments except neem oil, garlic clove extract, *V. lecanii,* neem leaf extract and *B. bassiana*. Among the treated plots maximum and significantly higher population (1.90 whiteflies/six leaves) was recorded in panchgavya 3%, than rest of the treated plots except *B. bassiana,*neem leaf extract, *V. lecanii* and garlic clove extract 5%.

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 whitefly over control plots (5.25 whiteflies/six leaves). Minimum and significantly population of whitefly (1.87 whiteflies/six leaves) was recorded in plots treated with NSKE 5% followed byneem oil, *V. lecanii*, garlic clove extract and neem leaf extract. Among the biopesticides maximum and significantly r population of whitefly (3.70 whiteflies/six leaves) was recorded in panchgavya 3%.

The data observations of the average of two years indicated that all the biopesticides treatments found significantly effective over control plots in reducing the whitefly population. The whitefly population in treated plots ranged from 4.67 to 8.59 whiteflies/six leaves as against 11.73 whiteflies/six leaves in untreated control. Data computed on per cent reduction in whitefly population indicate that 26.8 to 60.2% population may be reduced by spraying of different biopesticides. Among the biopesticides NSKE 5% (4.67 whiteflies/six leaves) found most effective in reducing the whitefly population followed by neem oil 5% (4.88 whiteflies/six leaves), *V. lecanii* (5.20 whiteflies/six leaves), neem leaf extract 5% (5.49 whiteflies/six leaves) and garlic clove extract 5% (5.68 whiteflies/six leaves). Whereas, panchgavya 3% (8.59 whiteflies/six leaves) was found least effective.Similar to the present findings Pun *et al.* (2005), Adilakshmi *et al*. (2008), Naik *et al*. (2012) and Meena *et al*. (2020) also reported NSKE 5% to be effective against whitefly followed by neem oil.Kalyan*et al.* (2017) also reported NSKE 5% comparatively higher per cent reduction in population of whiteflies in compared to entomopathogenic fungus.Ramarethinam*et al*. (2005), Naik and Shekharappa (2009), Naik *et al*. (2012) and Saha (2015) also reported *V. lecanii* to be effective against whitefly population and other homopterous, which corroborate the present findings.

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. lacanii*. 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/ha0 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*. (2008), Sohail *et el*. (2015) and Yeole and Gawande (2019) 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.

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) and Shreedevi (2011) also reported that NSKE 5% gave higher net return and coast benefit ratio followed by GCK and panchgavya.

Conclusion

Inconclusion, the study affirms the significant efficacy of biopesticides, particularly NSKE 5%, *B. bassiana* and neem oil 5% in effectively controlling whitefly populations on okra crops. The varied impact whitefly 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.

Table- 1: Efficacy of biopesticides against whitefly, *Bemisiatabaci*Genn. on okra (*Kharif*- 2018)

Treatments	Dose/ha	Number of nymphs and adults of whitefly/6 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	16.60 (4.14)	12.20 (3.56)	12.60 (3.62)	12.40 (3.59)	5.80 (2.51)	4.40 (2.21)	5.10 (2.36)	8.75 (3.04)
T_2 *Verticillium lacanii*	1.0 kg	16.07 (4.07)	11.53 (3.47)	11.87 (3.52)	11.70 (3.49)	4.80 (2.30)	4.00 (2.12)	4.40 (2.21)	8.05 (2.92)
T_3 Neem oil 5%	2.5 litre	16.20 (4.09)	11.27 (3.43)	11.67 (3.49)	11.47 (3.46)	4.27 (2.18)	3.87 (2.09)	4.07 (2.14)	7.77 (2.88)
T_4 Neem leaf extract 5%	25 kg	16.07 (4.07)	11.73 (3.50)	12.00 (3.54)	11.87 (3.52)	4.60 (2.26)	4.07 (2.14)	4.33 (2.20)	8.10 (2.93)
T_5 NSKE 5%	25 kg	16.00 (4.06)	10.97 (3.39)	11.40 (3.45)	11.18 (3.42)	4.07 (2.14)	3.40 (1.97)	3.73 (2.06)	7.46 (2.82)
T_6 Garlic clove extract 5%	25 kg	15.47 (3.99)	12.27 (3.57)	12.60 (3.62)	11.43 (3.60)	4.93 (2.33)	4.27 (2.18)	4.60 (2.26)	8.52 (3.02)
T_7Panchgavya 3%	15 litre	16.20 (4.0.9)	17.27 (4.21)	17.93 (4.29)	17.60 (4.25)	10.33 (3.28)	8.40 (2.98)	9.37 (3.13)	13.48 (3.74)
T_8 Control (untreated)		16.33 (4.10)	20.87 (4.62)	19.27 (4.43)	20.07 (4.53)	17.40 (4.23)	15.27 (3.96)	16.33 (4.09)	18.20 (4.31)
SEm ±		**(0.04)**	**(0.02)**	**(0.09)**	**(0.05)**	**(0.09)**	**(0.08)**	**(0.06)**	**(0.03)**
CD at 5%		**NS**	**(0.07)**	**(0.27)**	**(0.16)**	**(0.27)**	**(0.28)**	**(0.17)**	**(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: Efficacy of biopesticides against whitefly, *Bemisiatabaci*Genn. on okra (*Kharif*- 2019)

Treatments	Dose/ha	Number of nymphs and adults of whitefly /6 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	4.93 (2.33)	5.53 (2.45)	5.93 (2.52)	5.73 (2.48)	2.13 (1.62)	0.60 (1.04)	1.36 (1.36)	3.54 (1.91)
T_2 *Verticillium lacanii*	1.0 kg	4.40 (2.21)	3.00 (1.86)	3.93 (1.99)	3.47 (1.96)	2.00 (1.58)	0.47 (0.98)	1.23 (1.28)	2.35 (1.61)
T_3 Neem oil 5%	2.5 litre	4.87 (2.32)	2.93 (1.85)	3.20 (1.92)	3.07 (1.88)	1.47 (1.40)	0.33 (0.90)	0.90 (1.15)	1.99 (1.58)
T_4 Neem leaf extract 5%	25 kg	5.13 (2.35)	3.93 (2.10)	4.87 (2.31)	4.40 (2.21)	2.20 (1.64)	0.53 (1.00)	1.36 (1.32)	2.88 (1.77)
T_5 NSKE 5%	25 kg	4.40 (2.21)	2.87 (1.82)	3.07 (1.86)	2.97 (1.84)	1.40 (1.38)	0.13 (0.79)	0.76 (1.08)	1.87 (1.54)
T_6 Garlic clove extract 5%	25 kg	4.57 (2.25)	3.83 (2.07)	5.07 (2.36)	4.45 (2.22)	1.93 (1.56)	0.47 (0.97)	1.20 (1.26)	2.83 (1.82)
T_7Panchgavya 3%	15 litre	4.33 (2.20)	4.60 (2.26)	6.40 (2.62)	5.50 (2.45)	2.93 (1.83)	0.87 (1.16)	1.90 (1.49)	3.70 (1.97)
T_8 Control (untreated)		5.00 (2.31)	7.80 (2.88)	8.13 (2.93)	7.97 (2.91)	3.47 (1.98)	1.60 (1.43)	2.53 (1.71)	5.25 (2.340)
SEm ±		**(0.13)**	**(0.13)**	**(0.20)**	**(0.13)**	**(0.10)**	**(0.11)**	**(0.09)**	**(0.13)**
CD at 5%		**NS**	**(0.38)**	**(0.58)**	**(0.39)**	**(0.30)**	**(0.32)**	**(0.26)**	**(0.39)**

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

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

Table- 3: Efficacy of biopesticides against whitefly, *Bemisiatabaci*Genn. on okra (Pooled- 2018 & 2019)

Treatments	Dose/ha	Number of nymphs and adults of whitefly /6 leaves			Reduction in whitefly population (%)
		Mean 2018	Mean 2019	Average of two years	
T_1*Beauveria bassiana*	0.5 kg	8.75 (2.98)	3.54 (1.91)	6.05 (2.45)	**48.4**
T_2 *Verticillium lacanii*	1.0 kg	8.05 (2.85)	2.35 (1.61)	5.20 (2.23)	**55.7**
T_3 Neem oil 5%	2.5 litre	7.77 (2.80)	1.99 (1.58)	4.88 (2.16)	**58.4**
T_4 Neem leaf extract 5%	25 kg	8.10 (2.86)	2.88 (1.77)	5.49 (2.32)	**53.2**
T_5 NSKE 5%	25 kg	7.46 (2.74)	1.87 (1.54)	4.67 (2.10)	**60.2**
T_6 Garlic clove extract 5%	25 kg	8.52 (2.93)	2.83 (1.82)	5.68 (2.34)	**51.6**
T_7Panchgavya 3%	15 litre	13.48 (3.69)	3.70 (1.97)	8.59 (2.83)	**26.8**
T_8 Control (untreated)		18.20 (4.31)	5.25 (2.340)	11.73 (3.31)	
SEm ±		**(0.03)**	**(0.08)**	**(0.04)**	
CD at 5%		**(0.09)**	**(0.25)**	**(0.13)**	

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*Beauveria bassiana*	0.5 kg	118.66	120.33	119.50	**19.34**
T_2 *Verticillium lecanii*	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_7Panchgavya 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 sucking 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_7Panchgavya 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

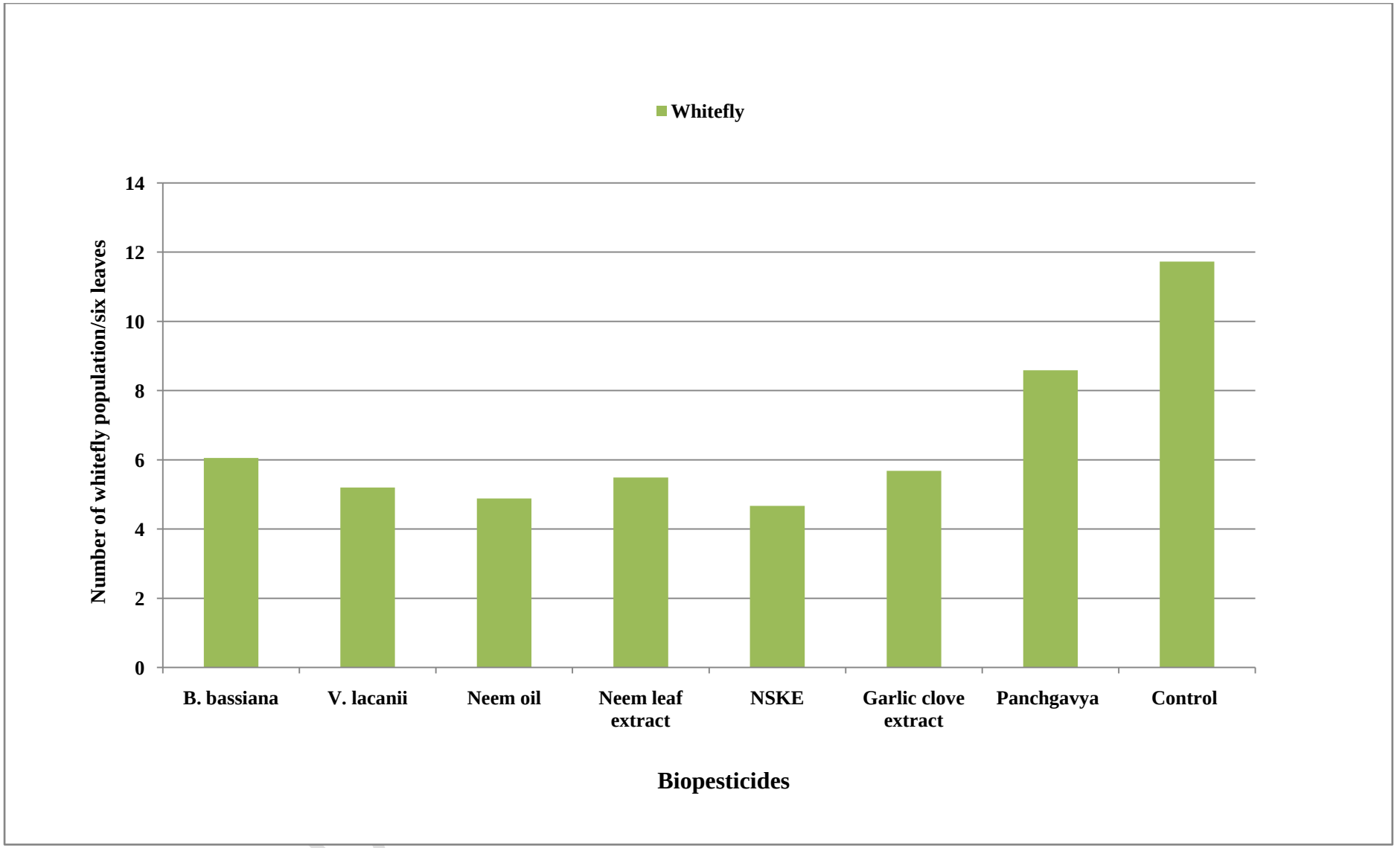

Fig 1:Population of whitefly under different biopesticides

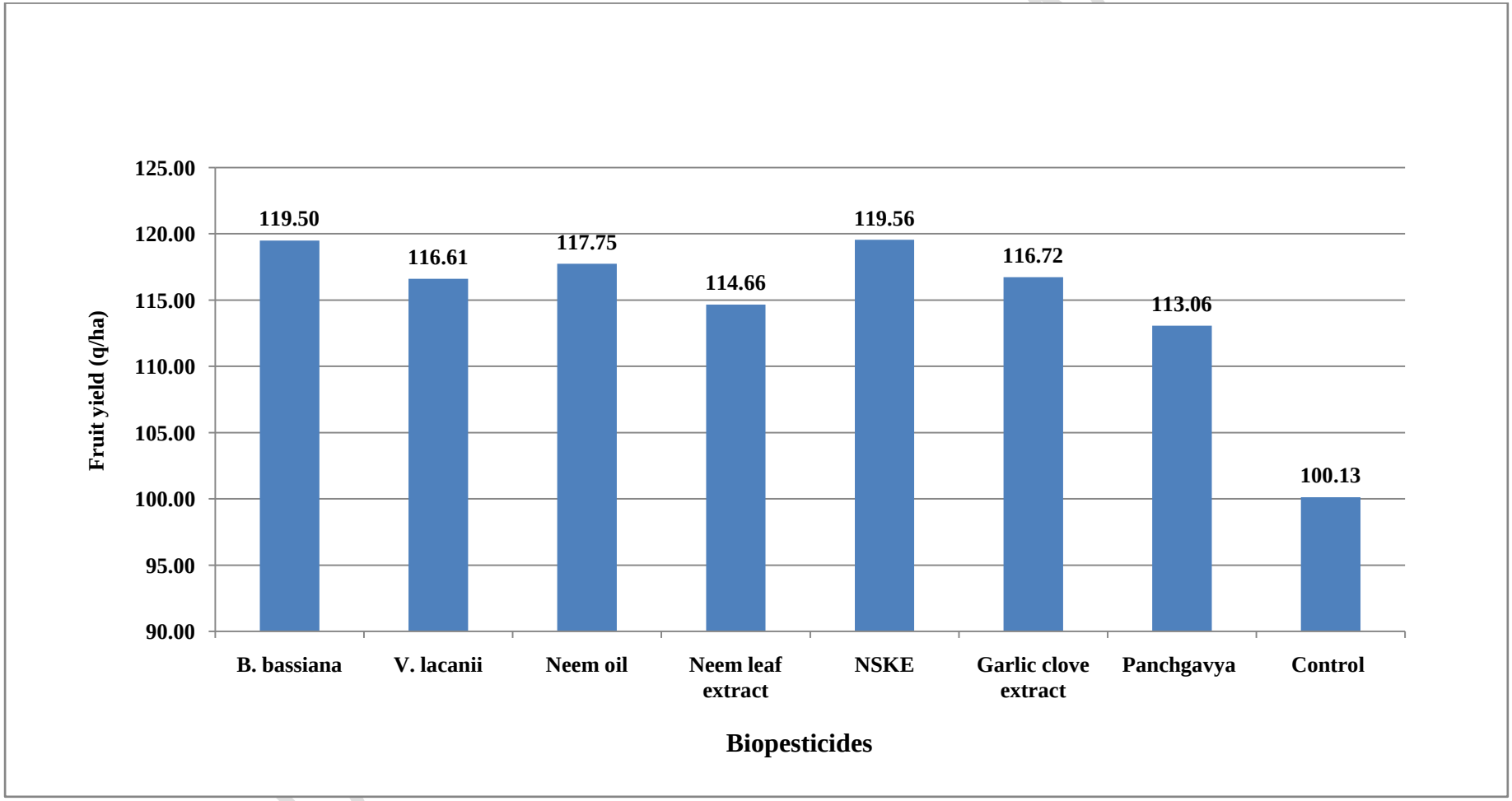

Fig 2:Fruit yield under different biopesticides

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