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Evaluation of different bio-pesticides against aphid on okra

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Abstract

An experiment including both the chemicals, botanicals and biorational-insecticides has been conducted to evaluate their efficacy against aphid on okra. The results revealed that during both the years, most superior treatment for management of aphid on okra was thiamethoxam 25 WG followed by emamectin benzoate 5 SG, NSKE 5%, neem oil 0.2%, Dashparni ark 0.6%, *Verticillium lecanii* 0.4% and *Metarhizium* + *Beauveria bassiana* 0.4%. *Beauveria bassiana* 0.4%, Biomix 0.3%, Karanj oil 0.5% and Eucalyptus oil 0.2% which was statistically at par with each other. The highest aphid population was noticed in untreated plot.

Keywords: Dashparni ark, *Verticillium lecanii*, *Metarhizium* + *Beauveria* and Biomix

Introduction

In India, vegetables have occupied the prime position in human diet, as these are the cheaper source of carbohydrate, minerals, vitamins, proteins, dietary fibers besides having medicinal value and provide nutritional security to a predominately vegetarian population. Among different vegetables, okra, *Abelmoschus esculentus* (L.) Moench belonging to the family Malvaceae is an important annual vegetable, grown for its immature green non-fibrous edible fruits in the tropical and sub-tropical regions of the world [7]. Okra has its own importance, taste, flavor and nutritional values as human food. It has good nutritional value particularly high content of calcium and vitamin C [1]. It is grown extensively in the tropical, subtropical and warm temperature regions of the world especially in India, U.S.A., Africa, Asia, Nigeria, Sudan, Iraq, Pakistan, Turkey, Australia, U.K. and other neighboring countries [6]. India ranks first in area and production in the world. It is a major commercial vegetable cultivated all over India particularly in the states of Andhra Pradesh, West Bengal, Jharkhand, Orissa, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Maharashtra. India occupies an area of 532.66 thousand hectares with a production of 6346.37 thousand tones and productivity of 11.9 MT/ha. [2]. Highest productivity is reported from Egypt (12.5 tons/ha) followed by Saudi Arabia (13.3 tons/ha).

One of the important limiting factors in the cultivation of okra is insect and mite pests. Many of the pests occurring on cotton are found to ravage okra crop. As high as 72 species of insects have been recorded on okra [3] of which, the sucking pests comprising of aphids (*Aphis gossypii* Glover), leafhopper (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius) and mite (*Tetranychus cinnabarinus* Boisduval) [5] causes significant damage to the crop. Krishnaiah (1980) reported about 40 to 56 per cent losses in okra due to leafhopper. There is a reduction of 49.8 and 45.1 per cent in height and number of leaves, respectively due to attack of leafhopper (Rawat and Sahu, 1973). Aphids and leafhoppers are important pests in the early stage of the crop which desap the plants, make them weak and reduce the yield. Failure to control them in the initial stage was reported to cause a yield loss to the tune of 54.04 per cent [4]. Furthermore, there is now evidence suggesting that in areas where insecticide-resistant aphids occur, use of some insecticides may result in increased population densities [8]. Leaves and seeds of neem (*Azadirachata indica* A.) have traditionally been used in India to treat human ailments and control plant pests [9]. *Azadirachta* (a major active ingredient from neem) has anti-feedant action and insect-growth regulatory properties [10]. It is rated as the most potent natural insect feeding deterrent and has been used in management of pests of many crops In Kenya, neem is mainly exploited for medicinal purposes but little has been done to tap its potential for crop pest management. The high susceptibility of crops to pests and diseases in Kenya has necessitated frequent use of chemical pesticides. This has led

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to increased cost of production, as well as a looming chemical residue accumulation in the pods. Farmers are currently faced with the challenge of meeting the permitted maximum residue levels of pesticides in their produce and, keeping the cost of production low enough so as to make profits. This study evaluated effectiveness of synthetic insecticides and neem-based extracts in managing *A. gossypii* infesting okra in Eastern Kenya. The study sought to provide farmers with cheap option for managing the pest that would guarantee lower residue accumulation in their produce ^[11].

Material and Methods

The field experiment on evaluation of different bio-pesticides against major pests of okra using Parbhani OK variety was conducted in a randomized block design with thirteen treatments including untreated control replicated thrice at the farm of Department of Agricultural Entomology, Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani during Kharif season 2017-18 and 2018-19. For recording counts of aphids five plants were selected randomly in each plot and were tagged. From such tagged plants, the pest population on three leaves, one each from top, middle and bottom were recorded. Pre-count was taken at one day before spraying and post counts were recorded on 1, 3, 7 and 15 days after spraying (DAS) ^[12].

Results and Discussion

First spray

The observations of aphid on okra one day before and at 1, 3, 7 and 14, days after first spraying were recorded in Kharif 2017-18 and 2018-19 are presented in Table 1

Pre-count

The pre-count ranged from 18.36 to 21.12 and 18.24 to 20.30/3 leaves, respectively during 2017-18 & 2018-19. The results revealed that there were no significant differences among all treatments indicating the even distribution of population in all treatments during both years.

One day after spray

During 2017-18, the lowest population of aphid was noticed in thiamethoxam 25 WG (10.06/3 leaves). The next effective treatments were emamectin benzoate 5 SG (12.06/3 leaves), NSKE 5% (13.28/3 leaves) and neem oil 0.2% (13.74/3 leaves). These were followed by Dashparni ark 0.6%, Karanj oil 0.5%, LAMIT 0.6%, eucalyptus oil 0.2% and *Metarhizium* + *Beauveria* 0.4%. *Verticillium lecanii* 0.4% and Biomix 0.3% which were at par with each other. *Beauveria bassiana* 0.4%, (16.62/3 leaves) registered higher population among the biopesticide treatments. During 2018-19, Thiamethoxam 25 WG (11.18/3 leaves) was significantly superior to other treatments followed by emamectin benzoate 5 SG, NSKE 5%, neem oil 0.2%, dashparni ark 0.6% with the population of 12.62, 14.30, 15.40 and 16.20/3, leaves respectively. These were followed by *Verticillium lecanii* 0.4%, Biomix 0.3%, LAMIT 0.6%, eucalyptus oil 0.2%, *Beauveria bassiana* 0.4% and Karanj oil 0.5%. *Metarhizium*+ *Beauveria* 0.4% (18.10/3 leaves) noticed maximum aphid as compared to other insecticidal treatments. The untreated control recorded 18.46/3 leaves population of aphid ^[14-18].

Three days after spray

During 2017-18, the lowest population of aphid was registered in the plots sprayed with thiamethoxam 25 WG

(6.52/3 leaves). The next superior treatments were emamectin benzoate 5 SG (7.68/3 leaves), NSKE 5% (9.20/3 leaves), neem oil 0.2% (9.72/3 leaves) and dashparni ark 0.6% (9.90/3 leaves). Karanj oil 0.5%, eucalyptus oil 0.2%, LAMIT 0.6%, *Verticillium lecanii* 0.4%, *Metarhizium* + *Beauveria* 0.4% and *Beauveria bassiana* 0.4% were least effective against aphids. The highest population was observed in the plots sprayed with LAMIT 0.6% (11.55/3 leaves). The untreated control recorded 19.40/3 leaves of aphid population. During 2018-19, thiamethoxam 25 WG (7.12/3 leaves) was most effective insecticide followed by emamectin benzoate 5% SG (8.70/3 leaves), NSKE 5%, neem oil 0.2%, dashparni ark 0.6%, Karanj oil 0.5%, LAMIT 0.6% and eucalyptus oil 0.2%. *Verticillium lecanii* 0.4%, *Metarhizium* + *Beauveria* 0.4% and *Beauveria bassiana* 0.4% were least effective. Biomix 0.3% (16.50/3 leaves) was observed maximum aphid among the bio-pesticides. The highest population was noted in untreated control (18.90/3 leaves) among all treatments ^[19-21].

Seven days after spray

During 2017-18, thiamethoxam 25 WG (3.84/3 leaves) was significantly superior in reducing aphid population over other treatments. The next best treatments were emamectin benzoate 5% SG, NSKE 5%, neem oil 0.2% and dashparni ark 0.6%. These were followed by *Verticillium lecanii* 0.4%, *Metarhizium*+*Beauveria* 0.4% and biomix 0.3%. karanj oil 0.5%, *Beauveria bassiana* 0.4% and euclyptus oil 0.2% were statistically at par with each other. The plots sprayed with LAMIT 0.6% (9.60/3 leaves) found highest population among biopesticides. During 2018-19, the population of aphid ranged from 4.14 to 19.20/3 leaves in different treatments. Thiamethoxam 25 WG (4.14/3 leaves) was the most effective against aphid. It was followed by emamectin benzoate 5 SG (6.38/3 leaves), NSKE 5% (6.56/3 leaves) and neem oil 0.2% (6.82/3 leaves). The next effective bio-pesticides were *Verticillium lecanii* 0.4%, dashparni ark 0.6%, *Metarhizium*+*Beauveria* 0.4%, biomix 0.3%, *Beauveria bassiana* 0.4% and euclyptus oil 0.2%. LAMIT 0.6% observed maximum population followed by karanj oil 0.5%. The higher population of aphids was noticed in untreated control (19.17/3 leaves) among all treatments ^[22-25].

Fifteen days after spray

During 2017-18, LAMIT 0.6% (17.14/3 leaves) was significantly inferior in controlling aphid. Thiamethoxam 25 WG (10.30/3 leaves) treated plots registered less aphid population. NSKE 5%, emamectin benzoate 5 SG, euclyptus oil 0.2% and karanj oil 0.5% were at par with each other. The next superior treatments were neem oil 0.2%, *Verticillium lecanii* 0.4% and dashparni ark 0.6% with the population of 13.60, 13.60 and 13.84/3 leaves, respectively. The least effective treatments were *Metarhizium*+ *Beauveria* 0.4%, biomix 0.3% and *Beauveria bassiana* 0.4%. The highest population was recorded in untreated control (20.45/leaves) among all treatments.

During 2018-19, LAMIT 0.6% (15.90/3 leaves) was significantly least effective bio-pesticide for reducing aphid. The most effective insecticide against aphid was thiamethoxam 25 WG (10.50/3 leaves) followed by emamectin benzoate 5 SG (11.76/3 leaves), *verticillium lecanii* 0.4% (13.04/3 leaves), neem oil 0.2% and biomix 0.3%. NSKE 5%, dashparni ark 0.6% *Metarhizium*+*Beauveria* 0.4%, *Beauveria bassiana* 0.4%, eucalyptus oil 0.2% and karanj oil 0.5% were at par with each other.

Second spray

The data recorded on number of aphids before spraying indicated significant variation of jassid in all the treatments which ranged from 5.24 to 5.64 during 2017-18 and 5.42 to 9.66/3 leaves in 2018-19.

Pre-count

The population of aphid on okra one day before and at 1, 3, 7 and 14, days after second spraying was observed in *Kharif* and these are presented in Table 2

One day after spray

During 2017-18, there were significant differences among the treatments. The untreated control recorded significantly maximum aphid population. However, among all bio-pesticides, the population of aphid was significantly highest in the plots treated with biomix 0.3% (6.88/3 leaves). The lowest population was noticed in thiamethoxam 25 WG (3.60/leaves) followed by emamectin benzoate 5 SG (4.10/3 leaves, NSKE 5% (4.30/3 leaves), neem oil 0.2% (4.50/3 leaves) and dashparni ark 0.6% (4.74/3 leaves). The less effective biopesticides against aphid were *Verticilium lecanii* 0.4%, karanj oil 0.5%, eucalyptus oil 0.2% and *Metarhizium+Beauveria* 0.4%. LAMIT 0.6% and *Beauveria bassiana* 0.4% which were at par with each other. During 2018-19, thiamethoxam 25 WG (3.10/3 leaves) was the most effective treatment followed by emamectin benzoate 5 SG, NSKE 5% and neem oil 0.2%. The next effective treatments against aphid were dashparni ark 0.6%, *Verticilium lecanii* 0.4%, karanj oil 0.5%, eucalyptus oil 0.2%, *Beauveria bassiana* 0.4%, LAMIT 0.6% and *Metarhizium+Beauveria* 0.4%. The plots treated with biomix 0.3% (8.00/3 leaves) recorded maximum population among the all bio-pesticides.

Three days after spray

During 2017-18, thiamethoxam 25 WG (1.74/3 leaves) and NSKE 5% was significantly superior over all treatments. Neem oil 0.2%, emamectin benzoate 5 SG, Karanj oil 0.5%, eucalyptus oil 0.2% and *Beauveria bassiana* 0.4% which were statistically at par with each other. Least effective biopesticide were dashparni ark 0.6%, *Verticilium lecanii* 0.4%, LAMIT 0.6% and *Metarhizium+Beauveria* 0.4%. The plots sprayed with biomix 0.3% (5.80/3 leaves) noticed highest population as compared to other bio-pesticides. The untreated control (9.08/3 leaves) recorded maximum aphid population among all treatments.

The aphid population ranged from 1.90 to 10.28/3 leaves during 2018-19. Biomix 0.3% (6.86/3 leaves) was significantly less effective against aphid. Thiamethoxam 25 WG (1.90/3 leaves), emamectin benzoate 5 SG (2.16/3 leaves), NSKE 5% (2.70/3 leaves), neem oil 0.2% (3.04/3 leaves), dashparni ark 0.6% (3.44/3 leaves) and *Verticilium lecanii* 0.4% (5.02/3 leaves) were proved to be most effective biopesticides. Karanj oil 0.5%, eucalyptus oil 0.2%, *Metarhizium + Beauveria* 0.4% and *Beauveria bassiana* 0.4% which were at par with each other. Biomix 0.3% (6.86/3 leaves) observed higher population and followed by LAMIT 0.6%.

Seven days after spray

During 2017-18, there were significant variation in the efficacy of bio-pesticides against aphid. Thiamethoxam 25 WG (1.20/3 leaves) was the most effective insecticide followed by NSKE 5% (1.54/3 leaves) and neem oil 0.2%

(1.80/3 leaves). These were followed by dashparni ark 0.6%, emamectin benzoate 5 SG, *Metarhizium+ Beauveria* 0.4%, *Beauveria bassiana* 0.4%, karanj oil 0.5%, and eucalyptus oil 0.2% which were at par with each other. The least effective treatment was *Verticilium lecanii* 0.4%, biomix 0.3% and LAMIT 0.6%. The untreated control (7.62/3 leaves) found highest aphid population among all treatments. During 2018-19, the most effective insecticides were thiamethoxam 25 WG (0.92/3 leaves) and emamectin benzoate 5 SG (1.36/3 leaves) followed by NSKE 5%, dashparni ark 0.6%, neem oil 0.2%, *Verticilium lecanii* 0.4% and *Metarhizium+ Beauveria* 0.4%. *Beauveria bassiana* 0.4%, biomix 0.3%, eucalyptus oil 0.2% and karanj oil 0.5% were statistically at par with each other. The plots sprayed with LAMIT 0.6% (4.70/3 leaves) recorded maximum population among insecticide.

Fifteen days after spray

The observations of aphids during 2017-18 revealed that the lowest population was observed in thiamethoxam 25 WG (5.80/3 leaves) followed by emamectin benzoate 5 SG (6.54/3 leaves), NSKE 5% (7.76/3 leaves), neem oil 0.2% (8.02/3 leaves) and *Verticilium lecanii* 0.4% (8.10/3 leaves). *Metarhizium+Beauveria* 0.4%, *Beauveria bassiana* 0.4% and dashparni ark 0.6% were at par with each other. The less effective treatments were biomix 0.3%, eucalyptus oil 0.2% and karanj oil 0.5%. LAMIT 0.6% (9.36/3 leaves) recorded maximum aphid population among biopesticide treatments. During 2018-19 it was found that thiamethoxam 25 WG, emamectin benzoate 5 SG, NSKE 5%, neem oil 0.2%, *Verticilium lecanii* 0.4%, dashparni ark 0.6% with the population of 4.86, 5.52, 6.18, 6.42 6.50 and 6.82/3 leaves, respectively. These were followed by *Beauveria bassiana* 0.4%, *Metarhizium+Beauveria* 0.4% and biomix 0.3%. Karanj oil 0.5% and eucalyptus oil 0.2% were at par with each other. Maximum population was found in LAMIT 0.6% (8.50/3 leaves) among biopesticides.

Third spray

The data on aphid on okra one day before and at 1, 3, 7 and 14, days after third spraying was recorded in *Kharif* and these are presented in Table 3

Pre-count

The aphid population varied from 2.74 to 5.08/3 leaves and 3.02 to 6.18/leaves during 2017-18 and 2018-19, respectively. There were significant differences among treatment during both years.

One day after spray

During 2017-18, thiamethoxam 25 WG (1.20/3 leaves) recorded significantly lowest aphid population over all treatments followed by emamectin benzoate 5 SG (1.68/3 leaves), NSKE 5% (3.02/3 leaves), dashparni ark 0.6% (3.22/leaves), neem oil 0.2% (3.36/leaves) and *Verticilium lecanii* 0.4% (3.60/3 leaves). *Metarhizium+ Beauveria* 0.4%, *Beauveria bassiana* 0.4%, biomix 0.3%, karanj oil 0.5% and eucalyptus oil 0.2% were followed and statistically at par with each other. LAMIT 0.6% noticed highest population among the all biopesticides. The untreated control registered (5.48/3 leaves) maximum population among all treatments. During 2018-19, thiamethoxam 25 WG (1.80/3 leaves) was proved to be most effective insecticide followed by emamectin benzoate 5 SG (2.40/3 leaves), NSKE 5% (2.72/3 leaves), neem oil 0.2% (2.94/3 leaves) dashparni ark 0.6% (3.10/3 leaves) and

Verticillium lecanii 0.4% (3.54/3 leaves). *Metarhizium* + *Beauveria* 0.4%, *Beauveria bassiana* 0.4%, euclyptus oil 0.2% and Karanj oil 0.5% which was at par with each other. The plots treated with LAMIT 0.6% (5.40/3 leaves) was least effective against aphid among biopesticides.

Three days after spray

During 2017-18, thiamethoxam 25 WG, emamectin benzoate 5 SG, NSKE 5%, neem oil 0.2%, dashparni ark 0.6%, *Verticillium lecanii* 0.4% and karanj oil 0.5% were most effective and recording the aphid population of 0.68, 1.02, 2.20, 2.52, 2.80, 3.10 and 3.30/3 leaves, respectively. LAMIT 0.6%, euclyptus oil 0.2%, *Metarhizium*+*Beauveria* 0.4%, *Beauveria bassiana* 0.4% and biomix 0.3% were less effective and at par with each other. The untreated control registered (5.70/3 leaves) highest population among all treatments.

The most effective insecticide during 2018-19 was thiamethoxam 25 WG (0.82/3 leaves) followed by emamectin benzoate 5 SG (1.32/3 leaves), neem oil 0.2%, (2.32/3 leaves), dashparni ark 0.6% (2.50/3 leaves) and NSKE 5% (2.60/3 leaves). The next effective treatments were *Verticillium lecanii* 0.4% and *Metarhizium*+*Beauveria* 0.4%. *Beauveria bassiana* 0.4%, biomix 0.3%, euclyptus oil 0.2% and karanj oil 0.5% were at par with each other. LAMIT 0.6% was recorded maximum population over all biopesticide. The maximum population was recorded in untreated control (6.98/3 leaves) among all treatments.

Seven days after spray

During 2017-18, there were statistically significant differences among treatments. Thiamethoxam 25 WG (0.30/3 leaves) was significantly superior over all treatments. The next best treatments were emamectin benzoate 5 SG and NSKE 5%. Dashparni ark 0.6%, neem oil 0.2%, *Metarhizium*+*Beauveria* 0.4%, biomix 0.3%, karanj oil 0.5% and euclyptus oil 0.2% were statistically at par with each other. Among all bio-pesticides, the maximum aphid population was recorded in LAMIT 0.6%. However, the highest aphid population was noted in untreated control (6.08/3 plant) among all treatments. During 2018-19, the lowest aphid population was observed in thiamethoxam 25 WG (0.50/3 leaves) followed by emamectin benzoate 5 SG (1.04/3 leaves), NSKE 5% (1.50/3 leaves) and neem oil 0.2% (1.64/3 leaves). These were followed by dashparni ark 0.6%, *Verticillium lecanii* 0.4%, *Metarhizium* +*Beauveria* 0.4%, *Beauveria bassiana* 0.4% and biomix 0.3%. Karanj oil 0.5% and euclyptus oil 0.2% were at par with each other.

During 2018-19, the lowest aphid population was observed in thiamethoxam 25 WG (0.50/3 leaves) followed by emamectin benzoate 5 SG (1.04/3 leaves), NSKE 5% (1.50/3 leaves) and neem oil 0.2% (1.64/3 leaves). These were followed by dashparni ark 0.6%, *Verticillium lecanii* 0.4%, *Metarhizium* +*Beauveria* 0.4%, *Beauveria bassiana* 0.4% and biomix 0.3%. Karanj oil 0.5% and euclyptus oil 0.2% were at par with each other. The plots treated with LAMIT 0.6% (3.80/3 leaves) noticed maximum population among biopesticides. The highest aphid population was recorded in untreated control (7.27/3 leaves) among all treatments.

Fifteen days after spray

During 2017-18, the most effective treatments were thiamethoxam 25 WG (1.54/3 leaves), emamectin benzoate 5 SG (2.02/3 leaves), NSKE 5% (3.40/3 leaves) and neem oil

0.2% (3.88/3 leaves). *Verticillium lecanii* 0.4%, dashparni ark 0.6%, *Beauveria bassiana* 0.4%, biomix 0.3%, karanj oil 0.5% and eucalyptus oil 0.2% were at par with each other. The least effective biopesticides were *Metarhizium*+*Beauveria* 0.4% and LAMIT 0.6%. The untreated control recorded highest population (6.70/3 leaves) among all treatments. During 2018-19, the number of aphids ranged from 2.04 to 8.60/3 leaves. Thiamethoxam 25 WG (2.04/3 leaves), was significantly superior insecticide followed by emamectin benzoate 5 SG (3.20/3 leaves). These were followed by NSKE 5%, neem oil 0.2%, *Verticillium lecanii* 0.4%, dashparni ark 0.6% and *Metarhizium*+*Beauveria* 0.4%. *Beauveria bassiana* 0.4%, biomix 0.3%, karanj oil 0.5% and euclyptus oil 0.2% were at par with each other. Among the biopesticides treatments, LAMIT 0.6% (6.48/3 leaves) recorded significantly maximum aphid population. However, the highest population was noticed in untreated control (8.60/3 leaves) among all treatments.

Pooled data (2017-18 and 2018-19)

The observations recorded on number of aphids before one day before spraying and after each spraying were given in Table 4

Pre-count

Before first, second and third spray, it ranged from 18.57 to 20.59, 5.33 to 9.15 and 2.88 to 5.63/3 leaves, respectively. The pooled data of pre-count (first spray) were non-significant.

After spray

The population of aphid in pooled data of two years after first spray ranged from 7.95 to 19.38/leaves. The most effective treatment was thiamethoxam 25 WG (7.95/3 leaves) followed by emamectin benzoate 5 SG, NSKE 5%, neem oil 0.2%, dashparni ark 0.6%, *Verticillium lecanii* 0.4% and karanj oil 0.5%. Eucalyptus oil 0.2% and LAMIT 0.6% were at par with each other. The less effective bio-pesticides against aphid were biomix 0.3% and *Metarhizium* + *Beauveria* 0.4%. The untreated control recorded highest aphid population (19.38/3 leaves) among all treatments.

The pooled data of two years after second spray indicated that thiamethoxam 25 WG (2.88/3 leaves) was most effective followed by emamectin benzoate 5 SG, NSKE 5%, neem oil 0.2%, dashparni ark 0.6% and *Verticillium lecanii* 0.4% with population of 3.47, 3.90, 4.18, 4.50 and 5.33/3 leaves, respectively. These were followed by *Beauveria bassiana* 0.4%, *Metarhizium* + *Beauveria* 0.4% and biomix 0.3%. Karanj oil 0.5%, eucalyptus oil 0.2% were at par with each other. LAMIT 0.6% registered maximum population as compared to other bio-pesticides. ^[26, 27]

The pooled data showed that after third spray, the aphid population ranged between 1.11 to 6.70/3 leaves in various treatments. The most superior treatment for management of aphid on okra was thiamethoxam 25 WG (1.11/3 leaves) followed by emamectin benzoate 5 SG (1.69/3 leaves), NSKE 5% (2.63/3 leaves), neem oil 0.2% (2.85/3 leaves), dashparni ark 0.6% (3.16/3 leaves), *Verticillium lecanii* 0.4% (3.42/3 leaves) and *Metarhizium*+ *Beauveria* 0.4% (4.09/3 leaves). *Beauveria bassiana* 0.4%, biomix 0.3%, karanj oil 0.5% and euclyptus oil 0.2% were less effective and at par with each other. The highest aphid population was noticed in untreated plot (6.70/3 leaves) among all treatments.

Table 1: Efficacy of different bio-pesticides against aphid on okra after first spraying during the years 2017 and 2018

Treatment Name and Number		Dose/mg/g or ml/ha	No. of aphids /3 leaves											
			2017						2018					
			Pre-count	1 DAS	3 DAS	7 DAS	15 DAS	Mean	Pre-count	1 DAS	3 DAS	7 DAS	15 DAS	Mean
T1	NSKE	25 kg	20.40 (4.61)	13.28 (3.77)	9.20 (3.18)	6.34 (2.07)	12.46 (3.66)	10.32 (3.32)	19.02 (4.46)	14.30 (3.90)	10.12 (3.33)	6.56 (2.74)	13.48 (3.80)	11.11 (3.44)
T2	LAMIT	3 lit	20.64 (4.64)	15.40 (4.04)	11.68 (3.55)	9.60 (3.23)	17.14 (4.24)	13.45 (3.76)	19.20 (4.49)	17.32 (4.23)	12.80 (3.71)	10.32 (3.36)	15.90 (4.11)	14.08 (3.85)
T3	Eucalyptus oil	1 lit	20.18 (4.59)	16.10 (4.13)	11.60 (3.53)	9.46 (3.22)	16.68 (4.19)	13.46 (3.76)	18.84 (4.45)	17.56 (4.30)	12.50 (3.67)	10.14 (3.33)	15.72 (4.09)	13.98 (3.84)
T4	Karanj oil	2.5 lit	21.12 (4.69)	15.30 (4.03)	11.52 (3.53)	9.44 (3.21)	16.70 (4.20)	13.24 (3.74)	19.60 (4.53)	17.70 (4.32)	12.10 (3.61)	10.20 (3.34)	15.76 (4.08)	13.94 (3.83)
T5	Neem oil	1 lit	19.50 (4.51)	13.74 (3.83)	9.72 (3.26)	7.02 (2.82)	13.30 (3.77)	10.94 (3.42)	20.10 (4.59)	15.40 (4.04)	10.90 (3.44)	6.82 (2.79)	13.90 (3.86)	11.75 (3.56)
T6	<i>Metarhizium</i> <i>+Beauveria</i>	2 kg	18.46 (4.40)	16.42 (4.16)	13.06 (3.74)	9.14 (3.17)	14.36 (3.90)	13.24 (3.74)	19.22 (4.49)	18.10 (4.35)	15.40 (4.04)	9.42 (3.22)	14.98 (3.99)	14.47 (3.90)
T7	<i>Beauveria bassiana</i>	2 kg	18.36 (4.39)	16.62 (4.19)	13.18 (3.76)	9.46 (3.21)	15.10 (4.00)	13.59 (3.79)	19.70 (4.54)	17.64 (4.31)	16.02 (4.12)	9.78 (3.28)	15.00 (3.99)	14.61 (3.92)
T8	<i>Verticilium lecanii</i>	2 kg	19.40 (4.50)	16.50 (4.17)	12.84 (3.71)	8.40 (3.05)	13.60 (3.81)	12.83 (3.68)	19.52 (4.52)	17.14 (4.25)	15.18 (4.02)	8.60 (3.09)	13.04 (3.74)	13.49 (3.77)
T9	Dashparni ark	3 lit	18.86 (4.45)	14.32 (3.90)	9.90 (3.29)	7.60 (2.92)	13.84 (3.84)	11.41 (3.48)	20.10 (4.58)	16.20 (4.14)	11.38 (3.51)	8.74 (3.12)	13.50 (3.80)	12.45 (3.64)
T10	Biomix	1.5 kg	19.60 (4.52)	16.50 (4.18)	13.30 (3.77)	9.30 (3.20)	14.80 (3.97)	13.47 (3.78)	18.40 (4.50)	17.20 (4.26)	16.50 (4.18)	9.70 (3.26)	14.48 (3.93)	14.47 (3.90)
T11	Thiamthoxam 25 WG	225 g	20.60 (4.64)	10.06 (3.32)	6.52 (2.74)	3.84 (2.19)	10.30 (3.35)	7.68 (2.90)	20.30 (4.61)	11.18 (3.48)	7.12 (2.83)	4.14 (2.26)	10.50 (3.38)	8.23 (2.98)
T12	Emamectin benzoate 5 SG	100 g	21.02 (4.68)	12.06 (3.60)	7.68 (2.94)	5.10 (2.46)	12.50 (3.67)	9.33 (3.16)	20.16 (4.59)	12.62 (3.68)	8.70 (3.11)	6.38 (2.71)	11.76 (3.56)	9.86 (3.26)
T13	Control (water spray)		18.90 (4.45)	19.08 (4.46)	19.40 (4.51)	19.68 (4.54)	20.45 (4.62)	19.65 (4.53)	18.24 (4.38)	18.46 (4.40)	18.90 (4.45)	19.20 (4.49)	19.92 (4.56)	19.12 (4.47)
SE±			0.14	0.12	0.09	0.07	0.11	0.09	0.10	0.12	0.08	0.07	0.09	0.09
C.D. at 5%			NS	0.36	0.27	0.21	0.34	0.29	NS	0.37	0.26	0.22	0.29	0.28
CV			12.57	9.45	11.03	6.61	8.24	8.83	8.08	10.36	9.73	6.13	7.38	8.40

Figures in parentheses are square root transformed values DAS: Days After Spray NS: Non-Significant

Table 2: Efficacy of different bio-pesticides against aphid on okra after second spraying during the years 2017 and 2018

Treatment Name and Number		Dose/mg/g or ml/ha	No. of aphids /3 leaves											
			2017						2018					
			Pre-count	1 DAS	3 DAS	7 DAS	15 DAS	Mean	Pre-count	1 DAS	3 DAS	7 DAS	15 DAS	Mean
T1	NSKE	25 kg	6.12 (2.66)	4.30 (2.30)	2.10 (1.76)	1.54 (1.58)	7.76 (2.95)	3.92 (2.14)	6.70 (2.77)	4.64 (2.37)	2.70 (1.91)	2.04 (1.74)	6.18 (2.67)	3.89 (2.17)
T2	LAMIT	3 lit	8.40 (3.04)	6.62 (2.75)	5.60 (2.56)	4.30 (2.29)	9.36 (3.20)	6.47 (2.70)	9.38 (3.21)	7.86 (2.97)	5.98 (2.63)	4.70 (2.38)	8.50 (3.07)	6.76 (2.76)
T3	Eucalyptus oil	1 lit	8.20 (3.03)	6.40 (2.71)	5.14 (2.47)	4.40 (2.31)	9.10 (3.17)	6.26 (2.66)	9.20 (3.19)	7.70 (2.94)	5.74 (2.58)	4.48 (2.34)	8.34 (3.05)	6.56 (2.72)
T4	Karanj oil	2.5 lit	8.36 (3.05)	6.32 (2.70)	5.10 (2.46)	4.38 (2.31)	9.18 (3.17)	6.24 (2.66)	9.40 (3.22)	7.56 (2.92)	5.70 (2.58)	4.50 (2.34)	8.32 (3.04)	6.52 (2.72)
T5	Neem oil	1 lit	6.72 (2.77)	4.50 (2.34)	2.32 (1.81)	1.80 (1.67)	8.02 (3.00)	4.16 (2.20)	7.02 (2.83)	4.96 (2.43)	3.04 (2.01)	2.42 (1.84)	6.42 (2.71)	4.21 (2.24)
T6	<i>Metarhizium</i> <i>+Beauveria</i>	2 kg	7.40 (2.89)	6.80 (2.78)	5.74 (2.59)	3.10 (2.02)	8.36 (3.05)	6.00 (2.61)	8.14 (3.02)	7.96 (2.98)	6.46 (2.73)	4.08 (2.25)	7.50 (2.91)	6.50 (2.71)
T7	<i>Beauveria bassiana</i>	2 kg	8.20 (3.03)	6.62 (2.75)	5.18 (2.48)	3.12 (2.46)	8.40 (3.06)	5.83 (2.68)	8.20 (3.02)	7.80 (2.96)	6.50 (2.73)	4.26 (2.29)	7.40 (2.89)	6.49 (2.71)
T8	<i>Verticilium lecanii</i>	2 kg	6.68 (2.76)	6.10 (2.66)	4.20 (2.27)	2.10 (1.76)	8.10 (3.01)	5.12 (2.42)	7.42 (2.89)	6.86 (2.80)	5.02 (2.45)	3.82 (2.19)	6.50 (2.73)	5.55 (2.54)
T9	Dashparni ark	3 lit	7.10 (2.84)	4.74 (2.39)	2.60 (1.89)	1.88 (2.42)	8.40 (3.06)	4.40 (2.44)	8.02 (3.00)	5.90 (2.62)	3.44 (2.10)	2.30 (1.81)	6.82 (2.79)	4.61 (2.33)
T10	Biomix	1.5 kg	7.45 (2.90)	6.88 (2.79)	5.80 (2.60)	3.48 (2.11)	9.02 (3.16)	6.29 (2.66)	8.20 (3.03)	8.00 (2.98)	6.86 (2.80)	4.26 (2.29)	7.62 (2.93)	6.68 (2.75)
T11	Thiamthoxam 25 WG	225 g	5.24 (2.49)	3.60 (2.14)	1.74 (1.65)	1.20 (1.48)	5.80 (2.60)	3.08 (1.96)	5.42 (2.53)	3.10 (2.02)	1.90 (1.70)	0.92 (1.38)	4.86 (2.41)	2.69 (1.87)
T12	Emamectin benzoate 5 SG	100 g	5.98 (2.63)	4.10 (2.25)	2.36 (1.83)	1.88 (1.69)	6.54 (2.74)	3.72 (2.12)	6.20 (2.68)	3.86 (2.20)	2.16 (1.77)	1.36 (1.53)	5.52 (2.55)	3.22 (2.01)
T13	Control (water spray)		8.64 (3.09)	8.85 (3.13)	9.08 (3.17)	7.62 (2.93)	10.30 (3.35)	8.96 (3.14)	9.66 (3.20)	8.94 (3.15)	10.28 (3.35)	7.74 (2.95)	9.56 (3.24)	9.13 (3.17)
SE±			0.07	0.08	0.10	0.08	0.12	0.09	0.07	0.12	0.05	0.10	0.09	0.09

C.D. at 5%		0.23	0.24	0.30	0.25	0.36	0.28	0.21	0.21	0.16	0.14	0.24	0.27
CV		5.43	6.15	9.76	7.27	11.37	8.63	8.66	10.03	5.38	9.06	7.06	7.88

*Figures in parentheses are square root transformed values DAS: Days After Spray

Table 3: Efficacy of different bio-pesticides against aphid on okra after third spraying during the years 2017 and 2018

Treatment Name and Number		Dose/mg/g or ml/ha	No. of aphids /3 leaves											
			2017						2018					
			Pre-count	1 DAS	3 DAS	7 DAS	15 DAS	Mean	Pre-count	1 DAS	3 DAS	7 DAS	15 DAS	Mean
T1	NSKE	25 kg	3.80 (2.18)	3.02 (2.00)	2.20 (1.78)	1.36 (1.53)	3.40 (2.08)	2.49 (1.84)	4.68 (2.39)	2.72 (1.92)	2.60 (1.76)	1.50 (1.57)	4.32 (2.30)	2.78 (1.88)
T2	LAMIT	3 lit	4.88 (2.35)	4.20 (2.27)	3.40 (2.09)	2.70 (1.92)	6.10 (2.65)	4.10 (2.23)	6.26 (2.69)	5.40 (2.52)	4.90 (2.42)	3.80 (2.19)	6.48 (2.73)	5.14 (2.46)
T3	Eucalyptus oil	1 lit	4.76 (2.39)	4.12 (2.26)	3.42 (2.10)	2.62 (1.90)	6.00 (2.64)	4.04 (2.22)	6.20 (2.68)	5.28 (2.50)	4.74 (2.39)	3.50 (2.11)	6.36 (2.71)	4.97 (2.42)
T4	Karanj oil	2.5 lit	4.74 (2.39)	4.10 (2.25)	3.30 (2.07)	2.58 (1.89)	6.02 (2.64)	4.00 (2.21)	6.22 (2.68)	5.26 (2.50)	4.78 (2.40)	3.46 (2.11)	6.32 (2.70)	4.95 (2.42)
T5	Neem oil	1 lit	3.98 (2.23)	3.36 (2.08)	2.52 (1.87)	1.64 (1.62)	3.88 (2.20)	2.85 (1.94)	4.94 (2.43)	2.94 (1.98)	2.32 (1.81)	1.64 (1.62)	4.50 (2.34)	2.85 (1.93)
T6	<i>Metarhizium + Beauveria</i>	2 kg	4.20 (2.27)	3.80 (2.18)	3.44 (2.10)	2.20 (1.78)	5.26 (2.50)	3.67 (2.14)	5.34 (2.51)	4.94 (2.43)	4.10 (2.25)	3.06 (2.01)	6.00 (2.64)	4.52 (2.33)
T7	<i>Beauveria bassiana</i>	2 kg	4.36 (2.31)	3.84 (2.19)	3.50 (2.11)	2.52 (1.88)	5.48 (2.54)	3.83 (2.18)	5.40 (2.52)	4.98 (2.44)	4.24 (2.28)	3.16 (2.03)	6.18 (2.67)	4.64 (2.35)
T8	<i>Verticilium lecanii</i>	2 kg	4.00 (2.23)	3.60 (2.14)	3.10 (2.02)	1.90 (1.70)	4.26 (2.29)	3.21 (2.03)	4.92 (2.43)	3.54 (2.12)	3.10 (2.02)	2.50 (1.86)	5.40 (2.52)	3.63 (2.13)
T9	Dashparni ark	3 lit	4.08 (2.25)	3.22 (2.05)	2.80 (1.94)	1.62 (1.61)	4.30 (2.30)	2.98 (1.97)	5.04 (2.45)	3.10 (2.02)	2.50 (1.86)	2.10 (1.76)	5.68 (2.58)	3.34 (2.05)
T10	Biomix	1.5 kg	4.40 (2.47)	3.88 (2.20)	3.52 (2.12)	2.24 (1.80)	5.48 (2.54)	3.78 (2.16)	5.50 (2.54)	5.10 (2.46)	4.30 (2.30)	3.24 (2.05)	6.20 (2.67)	4.71 (2.37)
T11	Thiamthoxam 25 WG	225 g	2.74 (1.93)	1.20 (1.48)	0.68 (1.29)	0.30 (1.13)	1.54 (1.59)	0.93 (1.37)	3.02 (2.00)	1.80 (1.67)	0.82 (1.34)	0.50 (1.22)	2.04 (1.74)	1.29 (1.49)
T12	Emamectin benzoate 5 SG	100 g	3.02 (2.00)	1.68 (1.63)	1.02 (1.42)	0.84 (1.35)	2.02 (1.73)	1.39 (1.53)	3.98 (2.23)	2.40 (1.77)	1.32 (1.52)	1.04 (1.42)	3.20 (2.04)	1.99 (1.68)
T13	Control (water spray)		5.08 (2.46)	5.48 (2.54)	5.70 (2.58)	6.08 (2.65)	6.70 (2.76)	5.99 (2.63)	6.18 (2.67)	6.70 (2.83)	6.98 (2.82)	7.36 (2.88)	8.60 (3.08)	7.41 (2.90)
SE±			0.07	0.05	0.07	0.06	0.08	0.06	0.05	0.04	0.07	0.06	0.09	0.06
C.D. at 5%			0.21	0.17	0.21	0.19	0.23	0.19	0.17	0.12	0.21	0.18	0.27	0.18
CV			5.63	4.79	6.12	8.86	9.87	7.41	7.97	4.09	6.88	5.23	8.27	6.11

*Figures in parentheses are square root transformed values DAS: Days After Spray

Table 4: Efficacy of different bio-pesticides against aphid on okra after different spraying (Pooled data of 2017 & 2018)

Tr No	Name of Treatment and Dose g or ml/ha		Mean number of aphids / 3 leaves					
			Pre-count	After first spray	Pre-count	After second spray	Pre-count	After third spray
T1	NSKE	25 kg	19.71 (4.53)	10.71 (3.38)	6.41 (2.71)	3.90 (2.15)	4.24 (2.28)	2.63 (1.86)
T2	LAMIT	3 lit	19.92 (4.56)	13.76 (3.80)	8.89 (3.12)	6.61 (2.73)	5.57 (2.52)	4.62 (2.39)
T3	Eucalyptus oil	1 lit	19.51 (4.52)	13.72 (3.80)	8.70 (3.11)	6.41 (2.69)	5.48 (2.53)	4.50 (2.32)
T4	Karanj oil	2.5 lit	20.36 (4.61)	13.59 (3.78)	8.88 (3.13)	6.38 (2.69)	5.48 (2.53)	4.47 (2.31)
T5	Neem oil	1 lit	19.80 (4.55)	11.34 (3.47)	6.87 (2.80)	4.18 (2.22)	4.46 (2.33)	2.85 (1.93)
T6	<i>Metarhizium + Beauveria</i>	2 kg	18.84 (4.44)	13.85 (3.82)	7.77 (2.95)	6.25 (2.66)	4.77 (2.39)	4.09 (2.23)
T7	<i>Beauveria bassiana</i>	2 kg	19.03 (4.46)	14.10 (3.85)	8.20 (3.02)	6.16 (2.69)	4.88 (2.41)	4.23 (2.26)
T8	<i>Verticilium lecanii</i>	2 kg	19.46 (4.51)	13.16 (3.72)	7.05 (2.82)	5.33 (2.48)	4.46 (2.33)	3.42 (2.08)
T9	Dashparni ark	3 lit	19.48 (4.51)	11.93 (3.56)	7.56 (2.92)	4.50 (2.38)	4.56 (2.35)	3.16 (2.01)
T10	Biomix	1.5 kg	19.00 (4.42)	13.97 (3.84)	7.82 (2.96)	6.48 (2.70)	4.95 (2.50)	4.24 (2.26)
T11	Thiamthoxam 25 WG	225 g	20.45 (4.62)	7.95 (2.94)	5.33 (2.51)	2.88 (1.91)	2.90 (1.96)	1.11 (1.43)
T12	Emamectin benzoate 5 SG	100 g	20.59 (4.63)	9.59 (3.21)	6.09 (2.65)	3.47 (2.06)	3.50 (2.11)	1.69 (1.60)

T13	Control (water spray)	18.57 (4.41)	19.38 (4.50)	9.15 (3.14)	9.04 (3.13)	5.63 (2.56)	6.70 (2.76)
	SE±	0.12	0.09	0.07	0.09	0.06	0.06
	C.D. at 5%	NS	0.28	0.21	0.27	0.19	0.18
	C.V.	10.32	8.61	7.04	8.25	6.80	6.76

*Figures in parentheses are square root transformed values DAS: Days After Spray

Conclusion

Among all the tested pesticides, botanicals and biorational compounds, tested against okra aphid were found significantly superior over control with different degree of effectiveness. Among them, chemicals were superior over all the botanicals and biorational pesticides. Among the pesticides, thiamethoxam 25 WG followed by emamectin benzoate 5 SG were resulted as superior treatments in the presented experiment. In case of rest pesticides, NSKE 5%, neem oil 0.2%, Dashparni ark 0.6%, *Verticillium lecanii* 0.4% and *Metarhizium + Beauveria bassiana* 0.4%. *Beauveria bassiana* 0.4%, Biomix 0.3%, Karanj oil 0.5% and Eucalyptus oil 0.2% which was statistically at par with each other. The highest aphid population was noticed in untreated plot.

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