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Efficacy of biopesticides against aphids *Aphis craccivora* infesting groundnut (*Arachis hypogaea* L.)

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Abstract

Groundnut holds a significant position in India as an oilseed crop, ranking first in terms of area and second in terms of production compared to soybean; and is subjected to pests' attacks which reduce its yield and profitability of farmers. The field trial was conducted in *kharif* 2021 at Instructional farm, Junagadh agricultural university, Junagadh, Gujarat, India to evaluate 6 biopesticides namely, *Nomuraea rileyi* (Faolow) Samson 1.15 WP, *Beauveria bassiana* 1.15 WP, *Metarhizium anisopliae* 1.15 WP, *Lecanicillium lecanii* 1.15 WP, *Bacillus thuringiensis* 1 WG and Azadirachtin 0.15% W/W. The objective was to determine their efficacy against Aphids *Aphis craccivora*. The overall data revealed that *Lecanicillium lecanii* 1.15 WP was the most effective treatment (51.24% corrected percent mortality) for suppressing the aphid population which was followed by *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP (48.83% corrected percent mortality) and *Metarhizium anisopliae* 1.15 WP (47.78% corrected percent mortality). The Azadirachtin 0.15% W/W (42.51% corrected percent mortality) was moderately effective. The less effective biopesticides were *Bacillus thuringiensis* 1 WG (27.84% corrected percent mortality) and *Nomuraea rileyi* (Faolow) Samson 1.15 WP (15.28% corrected percent mortality).

Keywords: Biopesticides, aphids, *Aphis craccivora*, efficacy, groundnut

1. Introduction

Groundnut (*Arachis hypogaea*) is a leguminous crop belonging to the family Fabaceae, characterized by yellow flowers and geocarpy, where pods develop underground after fertilization (FAO, 2024) [8]. India is one of the largest producers of groundnut globally, followed by China, the United States, and Nigeria. Within India, major producing states include Gujarat, Andhra Pradesh, Tamil Nadu, and Maharashtra, which contribute significantly to total oilseed production (FAO, 2023; Ministry of Agriculture & Farmers Welfare, 2023) [7, 24]. Groundnuts are highly nutritious, rich in protein, healthy fats, vitamins (especially E and B-complex), and minerals such as magnesium, phosphorus, and potassium. They are a staple in many diets and are used in various culinary applications, including cooking oil, snacks, and confectionery (Arya *et al.*, 2016; United States Department of Agriculture, 2024; Food and Agriculture Organization, 2022) [2, 38, 9]. Groundnut cultivation is significantly challenged by insect pests that adversely affect crop yield and quality. Key pests include aphids, which can cause direct damage by feeding on plant sap and indirectly by transmitting viruses such as the groundnut rosette virus, leading to severe crop losses (Meyer *et al.*, 2022) [23]. Additionally, leaf miners can damage foliage, reducing photosynthetic capacity and overall plant vigor. The presence of thrips is another concern, as they can affect flowering and pod development, further exacerbating yield reduction (Ghosh *et al.*, 2023a) [12]. Furthermore, the development of pest resistance to chemical insecticides poses a significant challenge for effective pest management, necessitating the adoption of integrated pest management (IPM) strategies that combine biological controls and resistant varieties (Reddy *et al.*, 2023) [28]. Collectively, these insect pests represent a critical challenge for sustainable groundnut production, highlighting the need for ongoing research and adaptive management practices (Singh *et al.*, 2021) [34]. Aphids, particularly the *Aphis craccivora* (black legume aphid) and *Myzus persicae* (green peach aphid), are among the most destructive pests affecting groundnuts.

These pests feed on the sap of plants, leading to reduced vigor, stunted growth, and wilting. The presence of aphids can also result in the development of sooty Mold, which can hinder photosynthesis. Chemical pesticides are commonly employed in agriculture to manage pests and boost crop productivity, but their use is associated with several negative effects on health and the environment. Prolonged exposure can result in serious health issues, including respiratory illnesses and cancer (Garry *et al.*, 2002) ^[11]. Environmental impacts include soil and water contamination, harming non-target organisms and disrupting ecosystems (Kegley *et al.*, 2013) ^[17]. Additionally, the emergence of pesticide-resistant pests necessitates increased chemical applications, perpetuating this cycle of harm (Gressel, 2002) ^[15]. To mitigate these issues, integrated pest management (IPM) practices can be employed, combining biological, cultural, and chemical strategies to reduce reliance on chemical pesticides (Kumar & Kumar, 2014) ^[20]. Transitioning to organic farming methods also presents a viable solution, promoting biodiversity and soil health while minimizing chemical exposure (Reganold & Wachter, 2016) ^[29]. One of the important methods of Integrated Pest Management (IPM) is the use of biopesticides. Biopesticides are naturally derived substances used to control pests and diseases in agriculture, including microbial, plant-based, and other natural products that target specific pests while minimizing harm to beneficial organisms. One of the primary advantages of biopesticides is their environmental safety, as they tend to break down more rapidly than synthetic chemicals, reducing the risk of soil and water contamination (United States Environmental Protection Agency, 2023; Food and Agriculture Organization, 2021) ^[39]. Additionally, biopesticides generally pose lower health risks to humans and non-target species, making them safer options for farmworkers and consumers (Thompson *et al.*,

2021) ^[37]. They also contribute to resistance management by offering diverse modes of action that pests are less likely to overcome, thus prolonging the effectiveness of pest control strategies (Ghosh *et al.*, 2023b) ^[13]. Furthermore, biopesticides are compatible with integrated pest management (IPM) practices, promoting sustainable agricultural systems by allowing for the integration of various pest control methods.

The present study was undertaken to assess the efficacy of certain biopesticides against Aphids (*Aphis craccivora*) infesting groundnut under field condition and principal aim of the study was to contribute to more sustainable and environment friendly management practices of Aphids (*Aphis craccivora*) in farming communities.

2. Materials and Methods

2.1 Location and experimental layout

The field experiment was conducted at Instructional farm, Junagadh agricultural university, Junagadh in the south saurashtra region of Gujarat, India during *kharif*, 2021. The experiment was laid out in randomized complete block design (RCBD) with seven treatments including untreated check and the treatments were replicated 4 times. Gross plots size was 5 m × 2.7 m and net plot size 4 m × 1.8 m. The groundnut crop was sown with spacing of 45 cm × 10 cm. GG 20 variety was used for the investigation. The plots were differentiated from one another by keeping space of 2 feet between treatments and 1 m between replications. The treatments as presented in Table 1 includes T₁: *Nomuraea rileyi* (Faolow) Samson 1.15 WP @ 2.5 gm/ l, T₂: *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP @ 2.5 gm/ l, T₃: *Metarhizium anisopliae* 1.15 WP @ 2.5 gm/ l, T₄: *Lecanicillium lecanii* 1.15 WP @ 2.5 gm/ l, T₅: *Bacillus thuringiensis* 1 WG @ 2.5 gm/ l, T₆: Azadiractin 0.15% W/W 2.5 ml/ l, T₇: Untreated control.

Table 1: Biopesticides used for efficacy against aphids, *A. craccivora* infesting groundnut during *kharif*-2021

Sr. No.	Treatment	Concentration (%)	Dose /10 lit. water	Trade name	Company
T ₁	<i>Nomuraea rileyi</i> (Faolow) Samson 1.15 WP	0.003	25 g	Nomuraea Riley	Agrilabh Ltd.
T ₂	<i>Beauveria bassiana</i> 1.15 WP	0.003	25 g	Sawaj Beauveria	Biocontrol Lab., Dept. of Entomology, JAU, Junagadh
T ₃	<i>Metarhizium anisopliae</i> 1.15 WP	0.003	25 g	Sawaj Metarhizium	Biocontrol Lab., Dept. of Entomology, JAU, Junagadh
T ₄	<i>Lecanicillium lecanii</i> 1.15 WP	0.003	25 ml	Verticoz	Utkarsh Ltd.
T ₅	<i>Bacillus thuringiensis</i> 1 WG	0.003	25 g	BACILLUS	ABTEC Ltd.
T ₆	Azadiractin 0.15% W/W	0.0003	25 ml	Neemoz	Utkarsh Ltd.
T ₇	Untreated Control	-	-	-	-

2.2 Method of treatment application and agronomic practices

All the bio-pesticides treatments were applied using battery operated knapsack sprayer. When the pest reached its respective ETL level, first spraying was done and the subsequent spray after 15 days when the population rebuilt up. Recommended agronomic practices such as thinning, weeding, pre-emergence weedicide application *etc.* were adopted except plant protection measures to avoid its effects on the pest populations other than the treatments. The sprayer person was secured with protective equipment.

2.3 Method of recording observations

Observations of aphids, *Aphis craccivora* were recorded from randomly selected 10 plants/net plot. The population of aphid was counted from top, middle and lower leaves from each selected plant. The observations were recorded prior to 24 hours before each spray as well as after 3, 5, 7 and 10 days after each spray.

2.4 Statistical analysis

The data was analysed using OPSTAT software (Sheoran *et al.*, 1998) ^[32]. These data were subjected to ANOVA and arc

sine value transformation (Gomez and Gomez, 1984) ^[14] was performed. DMRT test was calculated at a 5% significance level to compare means. Data visualization was done using ggplot2 package (Wickham H, 2016) ^[40] in R version 4.4.1 (R Core Team, 2024) ^[26]. The efficacy of biopesticides treatments were represented by corrected percent mortality by using the formula given by Henderson and Tilton (1955) ^[16].

$$\text{Corrected percent mortality} = 100 \times \left(1 - \frac{T_a \times C_b}{T_b \times C_a}\right)$$

Where,

Tb = Number of insects observed before treatment in treated

plot.

Ta = Number of insects observed after treatment in treated plot.

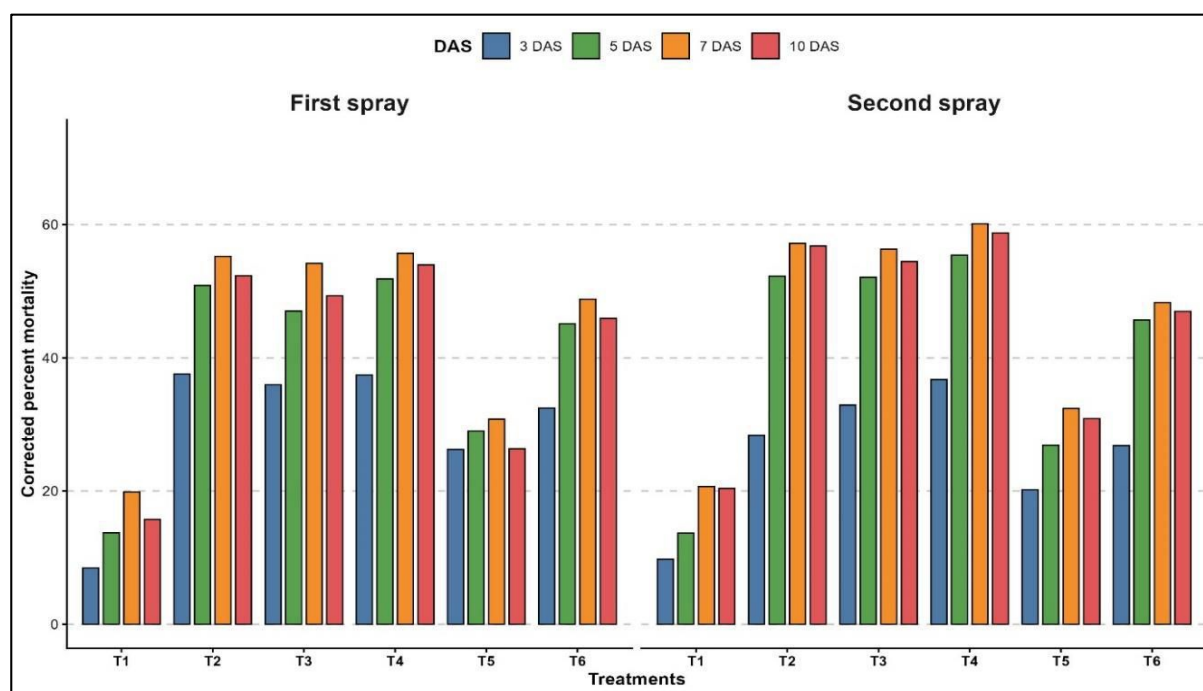
Cb = Number of insects observed before treatment in control plot.

Ca = Number of insects observed after treatment in control plot.

3. Results and Discussion

3.1 Efficacy of biopesticides on aphids, *A. craccivora*

The data on efficacy of biopesticides on aphids infesting groundnut, first spray and second spray are presented in Table 2 and visualized in Figure 1.



T1: *Nomuraea riley* (Faolow) Samson 1.15 WP, T2: *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP, T3: *Metarhizium anisopliae* 1.15WP, T4: *Lecanicillium lecanii* 1.15 WP, T5: *Bacillus thuringiensis* 1 WG, T6: Azardiractin 0.15% W/W, DAS: Days After Spraying.

Fig 1: Efficacy of biopesticides on aphids, *A. craccivora* infesting groundnut during kharif – 2021

Table 2: Efficacy of biopesticides on aphids, *A. craccivora* infesting groundnut during kharif – 2021.

Sr. No.	Treatments	Corrected percent mortality								Overall Mean
		First spray				Second spray				
		3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
1	<i>Nomuraea riley</i> (Faolow) Samson 1.15 WP	16.89 ^c (8.44)	21.74 ^c (13.72)	26.46 ^c (19.85)	23.37 ^c (15.74)	18.22 ^d (9.78)	21.71 ^d (13.68)	27.04 ^d (20.67)	26.84 ^d (20.39)	22.78 ^e (15.28)
2	<i>Beauveria bassiana</i> (Balsamo) Vuilemin 1.15 WP	37.80 ^a (37.57)	45.49 ^a (50.86)	48.02 ^a (55.25)	46.33 ^a (52.32)	32.18 ^b (28.36)	46.31 ^{ab} (52.28)	49.13 ^{ab} (57.18)	48.90 ^{ab} (56.79)	44.27 ^{ab} (48.83)
3	<i>Metarhizium anisopliae</i> 1.15 WP	36.84 ^a (35.95)	43.29 ^a (47.03)	47.40 ^a (54.19)	44.61 ^a (49.31)	35.01 ^{ab} (32.92)	46.20 ^{ab} (52.10)	48.63 ^{ab} (56.32)	47.55 ^{ab} (54.45)	43.69 ^b (47.78)
4	<i>Lecanicillium lecanii</i> 1.15 WP	37.72 ^a (37.43)	46.06 ^a (51.84)	48.27 ^a (55.70)	47.27 ^a (53.95)	37.31 ^a (36.74)	48.11 ^a (55.41)	50.84 ^a (60.11)	50.04 ^a (58.75)	45.70 ^a (51.24)
5	<i>Bacillus thuringiensis</i> 1 WG	30.82 ^b (26.24)	32.58 ^b (28.99)	33.70 ^b (30.78)	30.87 ^b (26.33)	26.71 ^c (20.21)	31.23 ^c (26.88)	34.69 ^c (32.39)	33.75 ^c (30.87)	31.79 ^d (27.84)
6	Azardiractin 0.15% W/W	34.73 ^b (32.45)	42.20 ^b (45.11)	44.32 ^a (48.82)	42.66 ^a (45.93)	31.19 ^b (26.83)	42.53 ^b (45.69)	44.03 ^b (48.31)	43.26 ^b (46.97)	40.62 ^c (42.51)
7	Untreated control	-	-	-	-	-	-	-	-	-
	S.Em ±	1.34	1.62	1.77	1.62	1.31	1.65	1.94	1.85	0.62
	C.D. at 5%	4.07	4.93	5.38	4.94	3.99	5.00	5.89	5.64	1.77
	C.V.%	8.25	8.41	8.55	8.28	8.71	8.36	9.14	8.88	4.56

Note: 1. Figures outside the parentheses are arcsine transformed values and those inside are retransformed values

2. Treatment means followed by the same letter are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% level of significance

3. DAS: Days After Spraying

3.2 First Spray

The population of aphids before first spray was more or less uniform in all the treatments as there was no significant difference among them. All the biopesticides treatments were found significantly superior to control. At 3 DAS, *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP found most effective by recording highest (37.57%) corrected percent mortality of aphids which was at par with *Lecanicillium lecanii* 1.15 WP (37.43%) and *Metarhizium anisopliae* 1.15 WP (35.95%). Azadirachtin 0.15% W/W (32.45%) and *Bacillus thuringiensis* 1 WG (26.24%) were found moderately effective. The least effective treatment was *Nomuraea rileyi* (Faolow) Samson 1.15 WP (8.44%). At 5 DAS, there was a slight change in the treatments trend, as *Lecanicillium lecanii* 1.15 WP was found to be the most effective treatment with 51.84 corrected percent mortality of aphids which was at par with *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP (50.86%) and *Metarhizium anisopliae* 1.15 WP (47.03%). Again, the moderately effective treatments were Azadirachtin 0.15% W/W (45.11%) and *Bacillus thuringiensis* 1 WG (28.99%) which were at par with each other. The least effective treatment was *Nomuraea rileyi* (Faolow) Samson 1.15 WP (13.72%) which is a similar trend as seen on 3 DAS. At 7 DAS, the most efficacious treatment was *Lecanicillium lecanii* 1.15 WP which shown 55.70 corrected percent mortality of aphids which was at par with *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP (55.25%), *Metarhizium anisopliae* 1.15 WP (54.19%) and Azadirachtin 0.15% W/W (48.82%). The moderately efficacious treatment was *Bacillus thuringiensis* 1 WG with 30.78 corrected percent mortality of aphids and the least effective was *Nomuraea rileyi* (Faolow) Samson 1.15 WP (19.85%). More or less same manner of efficacy trend was seen at 10 DAS as seen at 5 DAS.

3.3 Second spray

The population of aphids before second spray was more or less uniform in all the treatments as there was no significant difference among them. At 3 DAS after second spray, *Lecanicillium lecanii* 1.15 WP was reported highest corrected percent mortality (36.74%) of aphids which was at par with *Metarhizium anisopliae* 1.15 WP (32.92%). The *Metarhizium anisopliae* 1.15 WP treatment was also at par with *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP (28.36%) and Azadirachtin 0.15% W/W (26.83%) these both biopesticides were the next effective treatments. The moderately effective biopesticide treatment was *Bacillus thuringiensis* 1 WG which sown 20.21 corrected percent mortality of aphids. The least efficacious treatment was *Nomuraea rileyi* (Faolow) Samson 1.15 WP (9.78%) which sown this repetitive manner as seen on first spray. More or less, similar trend of efficacy of biopesticides on aphid population was observed at 5 DAS and 7 DAS. At 10 DAS, slight decline of corrected percent mortality was observed in all biopesticide treatment with more or less similar trend as 3, 5 and 7 DAS.

4. Overall mean

It was evident from the overall mean data on the percent reduction in the aphid population that *Lecanicillium lecanii* 1.15 WP was significantly superior among the rest of the treatments and recorded 51.24 corrected percent mortality of aphids which was at par with *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP (48.83%). The next efficacious treatment

was *Metarhizium anisopliae* 1.15 WP (47.78%) which was at par with *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP, Azadirachtin 0.15% W/W (42.51%) was subsequent effective treatment after *Metarhizium anisopliae* 1.15 WP. *Bacillus thuringiensis* 1 WG (27.84%) found out to be moderately effective treatment and the *Nomuraea rileyi* (Faolow) Samson 1.15 WP was the least effective treatment with 15.28 corrected percent mortality of aphids.

5. Discussion on Efficacy of biopesticides on aphids, *A. craccivora*

Sahayaraj and Namachivayam (2011) [30] reported that among the tested fungi in lab condition on groundnut pests, *Lecanicillium lecanii* suppressed 62 per cent of *A. craccivora* population at 39 Days after seedling emergence. El-Salam *et al* (2012) [51] studied the effects of certain entomopathogenic fungi on against bean aphids, *A. craccivora* in broad bean crop in field condition and stated that *L. lecanii* was the most effective with 73.3% population reduction and *B. bassiana* caused 45.5% aphid population reduction. El-Gawad *et al* (2008) [4] reported that Highest reduction and yield gain was observed when fungus *L. lecanii* used against cowpea aphid, *A. craccivora* on faba bean in Egypt. Saranya *et al* (2010) [31] studied the efficacy of different entomopathogenic fungi against cowpea aphid, *A. craccivora* in laboratory conditions and concluded that among the five entomopathogenic fungi, *L. lecanii*, *H. thompsonii* and *B. bassiana* were found to be the promising virulent isolates furthermore they stated that by testing their field efficacy, they can be used as potential biocontrol agent for the management of cowpea aphid. Ramanujan *et al* (2017) [27] evaluated the field efficacy of 10 isolates of fungal pathogens against cowpea aphid, *A. craccivora* and they revealed that V1-8 isolate of *L. lecanii*, Ma-6 isolates of *M. anisopliae* and Bb-5a isolate of *B. bassiana* showed 78.01%, 77.42% and 76.91% reduction of aphid population, respectively, over control and were on par with each other. Abdel-Raheem *et al* (2021) [1] studied the pathogenicity of certain entomopathogenic fungi on Fabae bean Aphid, *A. craccivora* in laboratory condition and reported that the concentration (10^9 spores/ml.) gave 100% mortality with *L. lecanii* and *B. bassiana* then *M. anisopliae*. The Lowest LC₅₀ value of 2.1×10^6 spores/ml. was recorded by *V. lecanii*, which showed higher virulence compared to other entomopathogenic fungi. Manushree *et al* (2022) [22] conducted the experiment on efficacy of biorational insecticides against aphids, *A. craccivora* in Amaranthus at Shivamogga, Karnataka, India and reported that the highest per cent reduction of aphid population was recorded in *L. lecanii* 1×10^9 CFU @ 1 g/l (62.87%), followed by NSKE 5% (53.59%). Sujatha and Bharpoda (2016) [35] reported that *B. bassiana* found highly effective for reducing the population of aphid *A. craccivora* being at par with superior treatments viz., Tobacco decoction (Hot water extraction) @ 2% and Tobacco decoction (Cold water extraction) @ 2% in green gram crop sown during summer at Anand, Gujarat, India. Sujatha and Bharpoda (2017) [36] also reported these similar findings in kharif green gram. Baskaran and Rajavel (2013) [3] declared that *B. bassiana* was effective in reducing the population of aphids (*A. craccivora*) on groundnut. Naik and Shekharappa (2009) [25] depicted that oil-based formulation of *L. lecanii* was best and recorded 7.75 aphids/3 leaves followed by *B. bassiana* oil based recorded the 9.75 aphids/3 leaves after second

spray for aphid management in *kharif* okra. Above findings are in agree with present study. Kulkarni (2017) ^[18] studied field evaluation of entomopathogenic fungi for management of aphid, *A. craccivora* in lucerne with combinations and sole concentrations and revealed that sole concentrations of *M. anisopliae* and *N. rileyi* proved least effective which contradict the present findings as *M. anisopliae* was highly effective for reducing the aphid population. However, *N. rileyi* was also less effective in this present study which agrees with above study. Furthermore, the less effectiveness of *N. rileyi* against aphid, *A. craccivora* could happened due to its narrow host range and is mostly limited to lepidopteran larvae (Fronza *et al*, 2017) ^[10].

6. Conclusion

The results from present study indicate that the biopesticides tested were effective against aphids, *A. craccivora* infesting groundnut. Among the biopesticides, *Lecanicillium lecanii* 1.15 WP was highly effective against aphids, *A. craccivora* followed by *Beauveria bassiana* (Balsamo) Vuilemin 1.15 WP and *Metarhizium anisopliae* 1.15 WP. The Azadiractin 0.15% W/W was moderately effective. The less effective biopesticide were *Bacillus thuringiensis* 1 WG and *Nomuraea rileyi* (Faolow) Samson 1.15 WP.

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