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# On-Station Bioefficacy of Neem Seed Extract and *Beauveria bassiana* 115 for Managing Major Insect Pests of Cowpea in the Sahelian Region of Maradi, Niger

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## Abstract

Cowpea, *Vigna unguiculata* L. Walp, is an important food grain legume in Niger facing production losses due to insect pests. This study aims to determine the efficiency of non-chemical methods for managing these pests. A trial was conducted during the 2020 and 2022 cropping seasons at the INRAN station in the Maradi region. A Fischer experimental design with 6 repetitions was used to compare 4 treatments: synthetic chemical pesticide; the entomopathogenic fungus *Beauveria bassiana*; aqueous extracts of neem seeds, and control. Observations were carried out every three days. The cowpea pod-sucking bug, pod borer, and thrips were the main insect pests recorded. In terms of effectiveness, the synthetic pesticide was the best treatment. It reduced insect pest densities by 71.35% to 90.40% in 2020 and by 35.11% to 42.13% in 2022. Grain yields varied between treatments. Neem seed extract followed the synthetic pesticide and significantly reduced insect infestations in both years. The synthetic pesticide and neem seed extract resulted in yields 3 to 5 times higher than the control treatment in 2020. By contrast, *B. bassiana* 115 and neem seed extract produced similar yields in 2022. Therefore, the results of this study showed that *B. bassiana* 115 and neem seed extract have insecticidal potential and could be used as an ecological alternative for managing cowpea insect pests in the Sahel.

## Keywords

*Vigna unguiculata*, Biopesticide, Cowpea, Insect Pest, Niger

# 1. Introduction

Cowpea, *Vigna unguiculata* L. Walpers (Fabaceae), is one of the main food grain legumes cultivated worldwide, particularly in West Africa. It is produced in peri-urban and rural regions of tropical and equatorial zones [1]. This crop helps reduce poverty and improves food security due to its high protein content and socioeconomic importance [2] [3] (Stoilova & Pereira, 2013). In addition, its agronomic benefits help improve the nitrogen content of the soil. West Africa produces around 83% of global production [4].

The crop is grown throughout the southern agricultural belt of Niger. In 2022, production was 2,865,884 tons [5]. Despite the crop's advantages, the yield is less than 400 kg/ha in a farming environment. Abiotic and biotic constraints cause this low productivity. Abiotic constraints include drought, high temperatures, low soil fertility, and soil acidity. Biotic constraints include pathogens and parasitic weeds such as *Striga gesnerioides* [6]. Insects and pathogens are significant pests, causing yield losses ranging from 30% to 100% in extreme cases [7] [8].

The most frequent pests are *Maruca vitrata* Fabricius (Lepidoptera: Crambidae), *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae), *Aphis craccivora* Koch (Homoptera: Aphididae), *Clavigralla tomentosicollis* Stäl (Hemiptera: Coreidae), and *Callosobruchus maculatus* F. (Coleoptera: Chrysomelidae Bruchinae) [9] [10].

To control these insect pests, several methods have been categorized into chemical control, biological control, cultural control, physical or mechanical control, integrated control, and varietal resistance [11]. However, chemicals are expensive, present supply difficulties, contribute to environmental pollution, cause loss of biodiversity, and are not safe for human and animal health [12].

It is necessary to develop alternative methods for cowpea pest management. One ecological alternative is the use of natural biopesticides. Among these, the neem (*Azadirachta indica* A. Juss) biopesticide is widely used and recognized for its insecticidal effect against cowpea insect pests [13]. Neem is a common species in the Sahel and has been quickly adopted as a control method in West Africa [14].

In addition to neem, viruses and fungi are potential biological control agents and important components of integrated insect pest management systems [15]. The effectiveness of viruses against insect pests of agricultural importance has been highlighted by several authors [2] [16]-[20]. Furthermore, other authors have noted the effectiveness of fungi in controlling pests affecting agricultural production [21]-[26]. This study is conducted to evaluate the efficiency of biopesticide spraying on the insect pest population of cowpea crops.

# 2. Materials and Methods

## 2.1. Study Area

The study was conducted in Maradi at the experimental site of the Regional Center for Agronomic Research of Maradi (CERRA/INRAN) during the 2020 and 2022 cropping seasons. The INRAN station of Maradi is located in the southern

Sahelian zone of Maradi city.

## 2.2. Plant Material

During the two experimental years, the cowpea variety IT90K-372-1-2 was used. It is resistant to aphids, sensitive to thrips, but resistant to drought (300 - 600 mm) with a vegetative cycle of 70 to 75 days.

The cowpea plants were naturally infested by insect pests on site, including the pod bug (*C. tomentosicollis*), the cowpea pod borer (*M. vitrata*), and thrips (*M. sjostedti*).

## 2.3. Tested Biopesticides

The neem seed extracts and the entomopathogenic fungus *Beauveria bassiana* 115 were used in trials conducted in 2020 and 2022. The doses per hectare of the products used are presented in Table 1.

Table 1. Biocides tested and recommended doses per hectare.

| Pesticides | Actives ingredients | Doze/ha | References or addresses of companies |
|---|---|---|---|
| Pesticide (PACHA 25 EC) | Acetamipride 10 g/l + Lambda-cyhalothrine 15 g/l | 1 liter (PACHA) + 300 ml water | Savana http://www.savana-france.com/ Distributed by: B.F_PROPHYMO: +22620983940 |
| Neem seeds extracts | Azadirachtine | 12.5 kg (Neem kernel powder) + 250 liters of water | (Jackai *et al.*, 1992) |
| *B. bassiana* 115 | Microbial fungus (souche 115) | 50 g (B.B Powder.) + 5.75 (Soya beam extract) +115 distilled water | IITA-Benin at Abome Calavi. |

## 2.4. Experimental Design

A Fischer block with 4 treatments and 6 repetitions was established. The treatments were randomly assigned to plots. The seeds were sown at a density of 0.75 m × 0.30 m. Each plot consisted of 9 rows and 20 stands per row, totaling 180 stands per plot. The blocks are 3 m apart, with 2 m between plots. The nine rows are arranged for data collection as follows:

The two central rows were kept for grain yield evaluation;

The other two internal rows near the central lines were used for insect pest records. Five randomly selected stands were marked for insect pest data recording. The treatments were as follows: synthetic pesticide, neem seed extracts, *Beauveria bassiana* 115, and a control without pesticide application.

### 2.5. Cultural Practices

Land preparation was done with a tractor before the cropping season, and manure was applied for both the 2020 and 2022 campaigns. Sowing occurred on June 12$^{th}$, 2020, and June 14$^{th}$, 2022. Three weeding were conducted each year. A microdose fertilizer application of NPK 15:15:15 was used. Three phytosanitary treatments were applied in both campaigns. The first spraying occurred at the beginning of the flower buds' emergence, and subsequent treatments were applied weekly. Harvesting involved manually collecting and weighing the pods from the two rows dedicated to yield and other rows.

### 2.6. Data Collection

Observations were conducted on 5 stands selected in each plot every three days. The following parameters were noted: total number of flowers per cowpea stand; for Thrips and larvae of *M. vitrata*, 10 flowers were picked per plot, including 2 flowers at each marked stand (5 stands/plot), and placed in a 90% alcohol solution, then brought to the laboratory and dissected to record the number of insect species; number of pod bug larvae and adults per observation; total number of pods per stand; number of pods damaged by *M. vitrata*; number of pods damaged by pods bugs; number of *M. vitrata* larvae in damaged pods. At crop maturity, the pods were harvested and dried. They were threshed, and the seeds obtained from each plot were weighed. The yield was calculated and extrapolated to a hectare. Data transformation was done using the formula:

$$\text{Tr} = \text{ASIN}\sqrt{\text{Proportion}} \quad (1)$$

The proportion was obtained by dividing the rate by 100 (Rate/100). The pod infestation rate by insect pests was calculated using the following formula:

$$\text{T} = (\text{number of pods damaged} * 100) / \text{Total number of pods}. \quad (2)$$

The yield was calculated based on the following formula:

$$\text{R} = (\text{Weight of seeds harvested in kg}) / \text{surface unit}. \quad (3)$$

### 2.7. Data Analysis

The means and associated standard errors of all variables were calculated using SPSS20 (Statistical Package for Social Science) software. The analysis of variance (ANOVA) for pod infestation rates by insect pests was conducted after the ASIN transformation to compare the average insect and yield. A non-parametric test (Kruskal-Wallis) was used to compare the rates of pod infestations by insect pests.

## 3. Results

### 3.1. Evolution of Insect Population Density per Treatments

Thrips were noted from the 43$^{rd}$ day after sowing (DAS) at the flowering stage during the 2020 cropping season and from the 30$^{th}$ DAS for 2022 campaign. Maximum densities were observed at the 64$^{th}$ DAS for 2020 and at the 52$^{nd}$ DAS for 2022 campaign (**Figure 1**). During these peaks, the density was highest in the control treatment for both years and lowest for the pesticide treatment, followed by the Neem seed treatment.

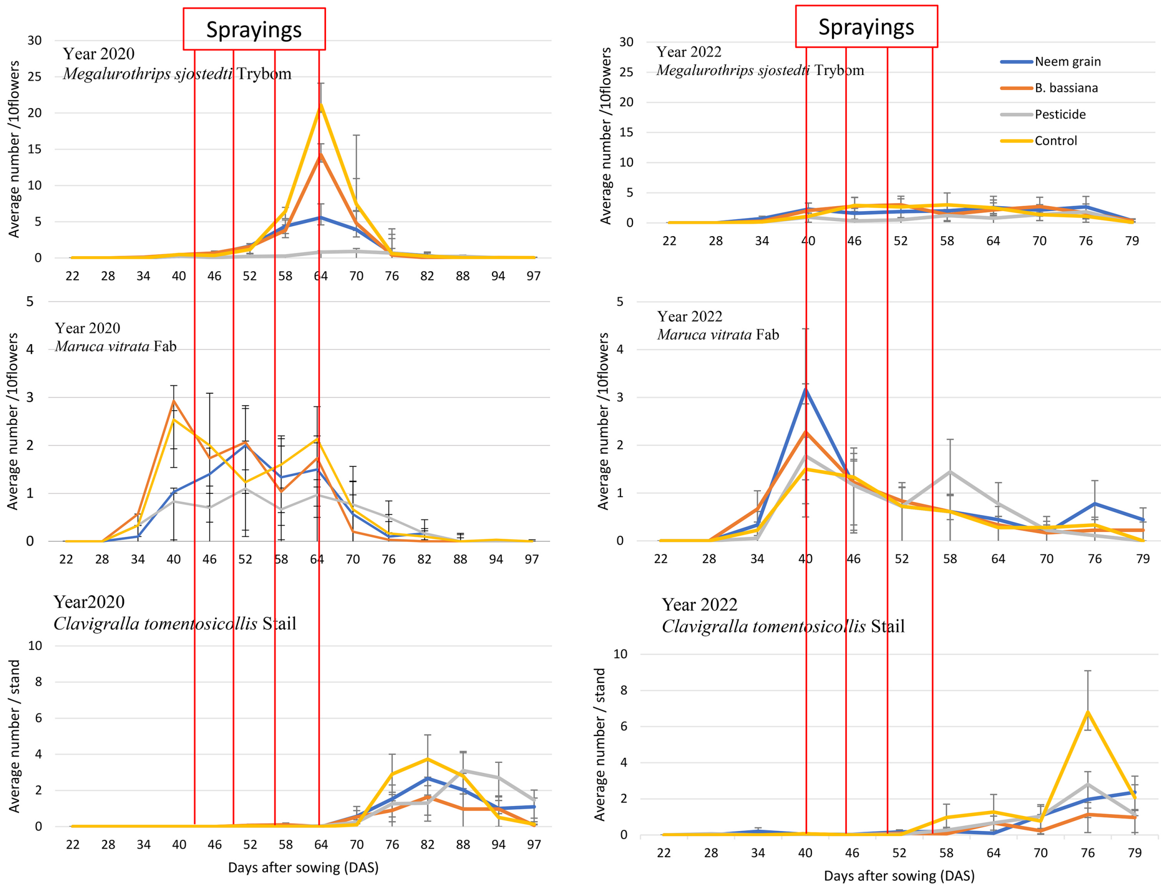


**Figure 1.** Dynamics of the main insect pest pesticide per spraying and treatments.

The larvae of *M. vitrata* were noted from the 28th DAS with the first emerged flowers during 2020 and 2022 agricultural campaigns. The control treatment had the highest density, while the chemical treatment had the lowest population, followed by neem seeds extracts in 2020. In 2022 campaign, the peak of *M. vitrata* was recorded at the 40th DAS for all the treatments.

The Adults and larvae of *C. tomentosicollis* were observed from the 70th and 58th days after sowing (DAS) in 2020 and 2022, respectively, but at low densities. The maximum infestations were noted on the 88th DAS for the pesticide treatment in 2020 campaign and at the 76th DAS in 2022 and the 79th day after sowing for the neem seed extracts. A proliferation of the pod bug was noted during the harvest periods for both years, even after the biocides were sprayed.

### 3.2. Average Number of Insect Pests per Treatment

In the 2020 agricultural campaign, the cumulative average number of thrips observed per 10 flowers varied between the treatments. The highest infestation was recorded in the control plots and those treated with *B. bassiana*. The second group consisted of treatment with neem seed extract, which had moderate infestations. The thrips population was 2.2 times lower compared to the untreated control plot (Table 2).

Table 2. Average number of thrips, *M. vitrata* larvae, and pod-sucking bugs per treatment.

| Treatments | Year 2020 | | | Year 2022 | | |
|---|---|---|---|---|---|---|
| | Thrips/10 flowers | *M. vitrata* /10 flowers | Pod Bug/ cowpea stand | Thrips/10 flowers | *M. vitrata*/10 flowers | Pod bugs/ cowpea stand |
| **Control** | 189.33 ± 27.52c | 54.00 ± 2.61c | 10.23 ± 1.8a | 0.71 ± 0.12b | 2.07 ± 0.16 | 5.7 ± 0.8b |
| ***B. bassiana* 115** | 130.67 ± 11.52ab | 36.50 ± 3.96b | 4.83 ± 1.16b | 0.78 ± 0.12b | 1.76 ± 0.1 | 2.1 ± 0.3a |
| **Neem seeds extract** | 86.33 ± 11.07b | 16.67 ± 1.99a | 4.43 ± 0.62b | 0.77 ± 0.13b | 1.96 ± 0.14 | 3.35 ± 0.5a |
| **Pesticide** | 18.17 ± 4.29a | 9.17 ± 2.02a | 2.93 ± 0.4b | 0.34 ± 0.07a | 1.8 ± 0.14 | 2.55 ± 0.2a |
| **ANoVA** | F = 13.96; P < 0.00 | F = 42.49; P < 0.00 | F = 5.70; P < 0.00 | F =3.53; P = 0.014 | F = 1.07; P = 0.36 | F= 7.23; P < 0.001 |

Means followed by the same letter are not significantly different (LSD, 5%). The same below.

Plots treated with the synthetic chemical pesticide recorded the lowest level of infestation. The density of thrips was 10.4 times lower compared to the control treatment.

In the 2022 agricultural campaign, the density of Thrips was low with chemical treatment and was comparable to the other treatments (Table 2).

For *M. vitrata*, the statistical analyses identified three groups during the 2022 agricultural campaign: The first group consists of the control treatment, where the highest levels of infestation were noted. The second group consists of the *B. bassiana* treatment, which showed a moderate infestation with densities 1.5 times lower compared to control treatments.

The third group consists of neem seed extract and synthetic chemical pesticide treatments. The densities of *M. vitrata* for these treatments ranged from 3.2 to 5.9 times lower compared to the control treatment.

For the 2022 agricultural campaign, all treatments were statistically similar.

For *C. tomentosicollis*, pest density per treatment was higher in the control plots (Table 3). The number of larvae and adults of the pest was 3.5 to 8.1 times lower with the biocide compared to the control. In the 2022 cropping season, all treatments were comparable but differed from the control, where the density was maximal (Table 2).

### 3.3. Damaged Pod Rate

The *C. tomentosicollis* infestations varied depending on the treatments in 2020 and 2022. In 2020, the infestation level in the control plot was the highest, followed by *B. bassiana*, which was slightly lower than the control. The infestation was moderate with neem seed extracts and low with the synthetic pesticide treatment.

In 2022, infestations were higher in the control treatment and similar between the treated plots (Table 3).

**Table 3.** Average rate of pod infestations.

| Treatments | Year 2020 | | Year 2022 | |
|---|---|---|---|---|
| | Pod infestations rate by *M. vitrata* | Pod infestations rate by *C. tomentosicollis* | Pod infestations rate by *M. vitrata* | Pod infestations rate by *C. tomentosicollis* |
| **Control** | 58.54 ± 2.7d | 80 ± 0.86d | 16.12 ± 1.8b | 14.64 ± 1.7b |
| ***B. bassiana*** | 21.11 ± 3a | 76 ± 1.7c | 10.45 ± 1.6a | 11.8 ± 1.5ab |
| **Neem seeds extract** | 50.5 ± 3c | 55.31 ± 3b | 9.7 ± 1.3a | 7.9 ± 0.86a |
| **Pesticide** | 40.6 ± 3.6b | 50 ± 3.3a | 7.4 ± 0.9a | 9.7 ± 1.4a |
| Kruskal W | P < 0.001 | P < 0.001 | P < 0.001 | P = 0.004 |

### 3.4. Cowpea Grain Yield

The seed production of the plots varied between treatments. The yield obtained in plots treated with the entomopathogenic fungus *B. bassiana* was comparable to that obtained in the control treatment. The neem seed extracts recorded a production 3.1 times higher than that obtained in the control plots. The highest production was from plots treated with the synthetic chemical pesticide, with a yield 5.6 times higher than the control plots.

In 2022, the yield of fungus treatment *B. bassiana* was comparable to neem seed extracts and greater than the control. The highest yield was obtained with pesticide treatment, which was 8.6 times higher than the control (Table 4).

**Table 4.** Average grain yield per treatment.

| Treatments | Average yield (kg/ha) | |
|---|---|---|
| | 2020 | 2022 |
| Control | 116.11 ± 20.82a | 251 ± 70a |
| *B.bassiana* 115 | 209.87± 19.32a | 817 ± 91.6b |
| Neem seeds extract | 363.94 ± 46.65b | 941.3 ± 8b |
| Pesticide | 644.56 ± 49.24c | 2161 ± 237.3c |
| ANoVA | F = 45.28; P < 0.001 | F = 222.6; P< 0.001 |

## 4. Discussion

The study determined the effectiveness of the tested biocides on the pest population and their damage to the cowpea crop.

The untreated control plots demonstrated the legume's sensitivity to pest attacks, as noted by several authors [1] [27]. The yield of 116.11 kg/ha obtained in 2020 may be attributed to high attacks by thrips (*M. sjostedti*), the bug *C. tomentosicollis*, and the pod borer *M. vitrata*. These pests were observed from the flowering stage, attacking the flowers and pods. These results confirm the need to develop agro-ecological technologies for pest management.

The synthetic chemical pesticide was significantly more effective in reducing the insect pest's density, followed by neem seed extracts and the entomopathogenic fungus *B. bassiana*. This is due to differences in their active ingredients and modes of action.

In general, synthetic chemicals act quickly and remain active for a relatively long time after application compared to biological products and biopesticides [28], which are characterized by biodegradability due to sunlight. In this study, the pesticide was the most effective treatment, leading to a 90.4% reduction of thrips, 83% reduction of *M. vitrata* larvae, and 71.35% reduction of *C. tomentosicollis* compared to control plots. In Benin, its effectiveness was demonstrated by [2], a study reporting a 76.87% reduction in the population of thrips and *M. vitrata*. This information demonstrates the effectiveness of chemical control due to their action on a wide range of insect pests.

Furthermore, their "knockdown" effect caused significant mortality of insect pests, reducing damage to cowpea pods. The number of pods damaged by the pod bug and *M. vitrata* per cowpea stand experienced reductions of 97.95% and 80.37%, respectively, compared to control plots. These results are similar to those obtained by [29] with pod damage by *M. vitrata* and the rate pf 40% to 85% by the pod bug [30]. Hence, synthetic pesticides have been attractive for their effectiveness in managing insect pests [31]-[33]. However, excessive use of synthetic pesticides leads to insect resistance and poses risks to human health, consumers, animals, and the environment, as well as causing a significant loss of biodiversity [34]-[36]. These reasons highlight the necessity of using biopesticides.

The neem seed extract was the second most effective treatment after the synthetic pesticide, reducing pest populations by 54.4% to 69.12% compared to untreated control plots. These results are similar to [36], a study conducted in Niger, where a reduction of 58.6% to 85.9% in insect populations was recorded. These findings confirm the efficacy of neem seed extracts on a broad spectrum of insect pests as reported by [37]. The performance of neem extracts as a biopesticide is well known, with documented effectiveness on cowpea insect pests such as *C. tomentosicollis*, *M. vitrata*, *Anocplenomis curvipes* and *C. shadabi* [37]-[40]. The use of the biopesticide also reduced pod bug damage compared to control plots, with a reduction in pods attacked by *M. vitrata* of 78.7%, which is close to the 74.5% rate reported by other studies [10].

Treatment with *B. bassiana* led to a population reduction of 52.8% for *C. tomentosicollis* and 32.4% for *M. vitrata*. The infectious effect of beauvericin contributed to affecting the cowpea insect pests.

The synthetic chemical pesticide demonstrates effectiveness, with pod production 5.6 times greater than the control treatment. Furthermore, the 81.98% increase in yield caused by this product proves its effectiveness. These results are similar to those obtained in a study conducted in Niger, where a yield increase of 88.41% was observed with the synthetic chemical pesticide compared to control plots [16].

The yield increase of 68.10% obtained with the aqueous extracts of neem seeds compared to control plots demonstrates the effectiveness of neem seeds. This can be attributed to the insecticidal effect of azadirachtin contained in the neem seeds. The insecticidal properties of neem, due to azadirachtin present in neem tree parts, are responsible for the plant's valorization through its safe use in diverse areas. This biopesticide could be an alternative to synthetic chemical pesticides and could be included in the methods for integrated management of leguminous crops in Sahelian regions. To facilitate the adoption of this technology, animated videos in local languages are available on SAWBO: https://nigercowpeaipm.sawbo-animations.org/video/1767.

## 5. Conclusion

The study compared the effectiveness of biopesticides for controlling the main insect pests of cowpea crops. The results showed that the synthetic chemical pesticide, despite its multiple risks, was the best treatment for all parameters studied, followed by neem seed extracts. Nevertheless, using the entomopathogenic fungus *B. bassiana* reduced the main insect pests' infestations and increased yield compared to the control treatment. The effectiveness of *B. bassiana* was not comparable to synthetic chemical pesticides.

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## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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