



Impact of Commercial *Beauveria bassiana* Application on Cucumber (*Cucumis Sativus* L.) Insect Pests, Pollinator Densities and Some Growth and Fruit Parameters

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Abstract

A field trial was conducted in 2021 and 2022 at the Experimental Farm, Federal University of Agriculture, Abeokuta to establish the bio-efficacy of *Beauveria bassiana* on the abundance of pests, beneficial insects, agronomic characteristics, storability and fruit quality of cucumber. The experiment was designed using a 4 x 3 factorial arrangement in a Randomized Complete Block Design and replicated three times. The treatment comprised four *Beauveria bassiana* (FIXIT-GA™) concentrations (8.00, 6.00, 4.00 and 2.00 kg/ha) applied at three different spray frequencies (spray once a-week, once in two-weeks and once in three-weeks) along with the untreated control. The results indicated that the densities of *Aulacophora hilaris*, *Epilachna chrysomelina*, and *Bactrocera cucurbitae* were significantly reduced in *B. bassiana*-sprayed plots compared to unsprayed ones in both seasons. Higher densities (6.33 and 5.33) of *Apis mellifera* were observed in plots sprayed at 8.00 kg/ha once a week than the unsprayed plots (2.00 and 0.33). The agronomic traits significantly increased when *B. bassiana* was sprayed once a-week at a concentration of 8.00 kg/ha compared to other treatments. At 8.00, 6.00, and 4.00 kg/ha of *B. bassiana* applied once a week, cucumber fruits showed an extended shelf life, lasting between 13 to 15 days before deterioration. In contrast, cucumber fruits sprayed at 2.00 kg/ha and untreated plots deteriorated faster, within 1 to 3 days. Furthermore, the nutritional composition of fruits from the untreated plots was comparable to that of fruits from the treated plots.

Keywords: *Beauveria bassiana*, cucumber, fruit quality insect pests, pollinators.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a cucurbit cultivated in both temperate and tropical regions of the world. It is one of the global top twenty most significant vegetable crops according to FAOSTAT (2008). It is known for its antibacterial, antimicrobial, and antifungal properties, along with exhibiting antioxidant and hypoglycemic activities. According to Randall (2004), cucumber thrives in warm and dry climates, making it susceptible to a diverse array of insect pests throughout its growth stages, starting from the seedling phase

persisting until fruit production. Insect pests pose their greatest threat during the fruiting stage of cucumber causing a substantial yield loss of approximately 60 % (Alalade, 2005). Beyond the direct impact on yield, insect attack also renders cucumber fruits less appealing to consumers. Many insect pests, in addition to causing direct damage, also serve as vectors for a variety of viral diseases (Kuhar and Speese, 2004).

Podagrica uniforma, *Bactrocera cucurbitae*, *Aphis gossypii*, *Bemisia tabaci*, *Bactrocera invadens*, *Epilachna chrysomelina*, *Myzus persicae*, *Aulacophora foveicollis*, *Aulacophora nigripennis*, and *Aulacophora hilaris* are major cucumber insect pests earlier

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reported in southwestern Nigeria (Pitan and Filani, 2013; Adeoti *et al.*, 2023). Adults *P. uniforma* chew small circular holes in leaves resulting in a distinctive sieve-like appearance. *A. gossypii*, *M. persicae*, and *B. tabaci* predominantly inhabit the lower leaf surfaces, where they engage in sap-sucking activities. They also serve as vectors of pathogen particularly cucumber mosaic virus, when present in high populations (Pitan and Filani 2014). Adults and larvae *E. chrysomelina* feed on cucumber leaves, flowers and fruits. Damage by beetles to cucumber fruits is characterized by the presence of grooves, scarification, and patches (Pitan and Filani, 2013). *Dacus* and *Bactrocera* spp. inflict damage to fruits through oviposition, when eggs are laid on the fruits. Maggots that hatch from the eggs develop inside the fruits, feeding on its interior. The feeding activity leads to sunken, discolored patches, distortions, and open cracks on the fruit's surface. These cracks, once formed, can serve as entry points for fungi and bacteria, subsequently causing fruit rot. The distinctive characteristics of this damage not only reduce the quantity of the fruits but also reduce their market value. The larvae (maggots) develop internally, making it a challenge to control this pest, rendering them impervious to external insecticide applications (Pitan and Filani (2014).

Adults of *A. vittatum* feed on flowers, leaves and fruits, but they feed mainly feed on the undersides of developing fruits in warm periods (Hoffmann and Zitter, 1994). Male adult *A. vittatum* attract more individuals into the feeding area by releasing an aggregation pheromone (Boucher, 2003). They also serve as primary vector for bacterial wilt disease in cucurbits (Radin, 1996). *E. chrysomelina* feeds on cucumber leaves creating an irregular pattern on the lower epidermal tissues. They scrap the green chlorophyll component of leaves which results in skeletonization of leaf lamina. (Khan *et al.*, 2000). These damages have a detrimental effect on the host plant's vegetative production, which in turn affects plant growth and yield (Awadalla *et al.*, 2011).

The current approach to insect pest management on cucumber continues to heavily rely on chemical control methods (Jinadu, 2005). However, there is a significant concern associated with the use of conventional insecticides – the development of resistance by insect pests. This phenomenon poses a substantial risk as it greatly affects production economics and insecticide usage. There are also

the real and perceived risks to human health and environment. The negative impact of conventional insecticide, have created a demand for a safe, cheap, eco-friendly and reliable alternative control method (McKinlay, 1992). A biological control that adopts the utilization of an eco-friendly bio-pesticide, *Beauveria bassiana*, remains an interesting alternative method for the control of insect pests on our vegetable crops (Sewify *et al.*, 2009). The entomopathogenic fungus *B. bassiana* manages to regulate insects by initiating contact with the body of an insect host through its microscopic spores. Once in contact, these spores germinate, penetrate the insect's cuticle, and develop internally, ultimately causing the insect's death within a few days. Subsequently, a white mold emerges from the insect carcass, generating fresh spores. The fungus that grows out of the carcass of killed insects kill other insects thus making the fungus to be highly virulent. (Kaoud, 2010). *B. bassiana* isolates differ in their host range while a wide range of insects can be attacked by a typical isolate (Mul *et al.*, 2009).

Beauveria bassiana does not affect human beings or animals thus making it a safe insecticide. Posada and Vega (2006), Ownley *et al.* (2008), Akello *et al.* (2009), Jaber, (2015) and Nwilene *et al.* (2023) documented the effectiveness of *B. bassiana* against insect pests in crops such as cocoa, tomato, grapes, banana and rice. The objective of the study, therefore was to evaluate the bio-efficacy of commercial *B. bassiana* on insect pests, agronomic characteristics, storability, and fruit quality of cucumber production in Nigeria.

MATERIALS AND METHODS

The study was conducted at the experimental farm of the Department of Crop Protection, Federal University of Agriculture, Abeokuta (17°12'54"N-7°19'16"N; 3°20'24"E and 3°27'86"E) during the early growing season of 2021 and late growing season of 2022.

Source of Experimental Materials

A fungus strain, *Beauveria bassiana* CGA IPFBS- 012 under a trade name FIXIT-GA (1.15% WP/ Greenfields Company) and cucumber variety, 'Saira F1' were obtained from a reputable agrochemical company in Abeokuta, Ogun State.

Experimental Design

A Randomized Complete Block Design with a 4 x 3 factors scheme replicated three times was used. The experiment was made up of two factors, *B. bassiana* (FIXIT-GA™)

concentration and *B. bassiana* spray frequency. It comprised four (4) levels of *B. bassiana* (FIXIT-GA™) concentration (8.00, 6.00, 4.00 and 2.00 kg/ha), three (3) spray frequencies of *B. bassiana* (spray once a-week, once in two-weeks and once in three-weeks) and untreated plot (no spray). The entire study area was 530 m² while a dimension of 3 m x 2 m was used for plots with a 2 m border.

Planting Operations and Treatment Application
Cucumber field was established by planting cucumber seeds at the spacing of 1 m × 1 m. After germination, cucumber seedlings were thinned to one seedling per hill at 14 days after planting (14 DAP) cucumber. Weeding of cucumber plots was carried out manually using hoes and cutlasses once in two weeks. Fertilizers and herbicides were not applied to cucumber plants. The fungus strain (1.25 kg) was prepared in 500 litres of water to form a concentration of 2×10^8 CFU/gm min (manufacturer recommendation) and applied two weeks after planting cucumber. The prepared fungus strain was applied between 6.30 -7.30 a.m. (local time) at weekly intervals till fruit maturity with the aid of four (4) litres volume capacity hand-held sprayer.

Data Collection

Assessment of different insect species encountered on cucumber plants and their numbers was carried out at weekly intervals between 7.30 – 9.30 a.m. Sampling by visual counting was on five selected plants within the central rows of each plot. Samples of insects from the cucumber experimental plots were preserved in 70 % ethanol. Sampled insects were air-dried and mounted in insect box at the laboratory. Insect samples were taken to the Insect Museum of the Department of Crop Protection and Environmental Biology (CPEB), University of Ibadan, Ibadan for proper identification by taxonomist.

Harvesting of cucumber fruits began 8 WAP and lasted till 10 WAP. Matured cucumber fruits harvested from 10 selected tagged plants in each plot were sorted into damaged and undamaged fruits. A fruit damaged by *Epilachna* beetles was characterized by the presence of grooves on fruits. Cucumber fruits showing exit holes or tunnels along its length with frass contamination is considered damaged by fruit fly. Data on growth characteristics of cucumber plants viz number of leaves, vine length, number of flowers collected at 5 - 6 WAP cucumber. Undamaged cucumber fruits were counted and weighed for marketable yield evaluation while the damaged

were used for damage estimation.

Proximate Analyses

Proximate analysis of cucumber fruit samples from each treatment was done in the laboratory using Association of Official Analytical Chemists (AOAC) method (2021). The parameters analyzed were; protein, fat, crude fibre, moisture, ash, dry matter, fat and carbohydrate contents of the cucumber fruits.

Data Analysis

Insect population density and percentage values were normalized by use of square root and arcsine transformations respectively. Data on insect population density, yield, damage and growth characteristic were subjected to Analysis of Variance (ANOVA) while Student Newman Keul's (SNK) Test was used for means separation. Cucumber fruits from each treatment were stored at room temperature (20-22°C) and days to deterioration were noted.

RESULTS

Cucumbers subjected to once a-week spray of *Beauveria bassiana* at rates of 8.00, 6.00, 4.00, and 2.00 kg/ha exhibited significantly lower population densities of *Aulacophora hilaris* and *Epilachna chrysomelina* compared with the untreated control had the highest population densities of these insect pests in 2021 and 2022 seasons. In 2021 and 2022 planting seasons, plots sprayed at a rate of 8.00 kg/ha, also recorded higher population densities of *Apis mellifera* compared to the control plots, which had fewer numbers of the insect (Table 1). Number of leaves, vine length, number of flowers and fruits produced were significantly affected by *B. bassiana* application rate and frequency in 2021 late season. The percentage increase in vine length and flower were higher in plots sprayed once a-week at 8.00 kg/ha than other sprayed plots in 2021. Also, the percent increase in fruit was higher ($p < 0.05$) in the plots sprayed once a-week at 8.00, 6.00, 4.00 and 2.00 kg/ha of *B. bassiana* concentrations compared to plots sprayed at other rates once in two-weeks and once in three-weeks (Table 2). Similarly, percent increase in vine length and flower were significantly higher in the plot sprayed at 8.00 kg/ha once a-week compared to the other treated plots in 2022. Also, plots sprayed at 8.00, 6.00, 4.00 and 2.00 kg/ha once a-week had the highest fruit increase relative to plots sprayed once in two-weeks and three-weeks at different rates in 2022 (Table 3). Cucumber fruits sprayed at 2.00 kg/ha once in three-weeks and the untreated plot deteriorated between 1-3 days after harvesting, while fruits

sprayed once a-week with 8.00, 6.00 and 4.00 kg/ha *B. bassiana* concentrations took longer time (between 13-15 days) after harvesting to deteriorate (Table 4). Also, the nutritional compositions of cucumber fruits sprayed at 8.00 and 4.00 kg/ha concentrations of *B. bassiana* once a-week was similar to unsprayed cucumber (Table 5).

late season, 2021 and early season, 2022

Frequency	Rate (kg/ha)	Late season, 2021				Early season, 2022			
		<i>Aulacophora hilaris</i>	<i>Epilachna chrysomelina</i>	<i>Bactrocera cucurbitae</i>	<i>Apis Mellifera</i>	<i>Aulacophora hilaris</i>	<i>Epilachna chrysomelina</i>	<i>Bactrocera cucurbitae</i>	<i>Apis Mellifera</i>
Once	8.00	0.33e	2.10f	0.33c	6.330a	1.33e	3.00f	0.33c	5.33a
a-week	6.00	1.00e	3.02f	0.67bc	5.00a-c	2.00e	4.00f	0.67bc	4.00a-c
	4.00	0.67e	2.33f	1.00bc	5.33ab	1.67e	3.33f	1.00bc	4.33ab
	2.00	1.00e	3.40f	0.67bc	5.00a-c	2.00e	4.00f	0.67bc	4.00a-c
Once-in	8.00	3.00d	7.30de	2.00bc	3.33ab	4.00d	8.00de	2.00bc	2.33a-c
Two-weeks	6.00	4.33cd	6.00e	2.67a-c	4.33a-c	5.33cd	7.00e	2.67a-c	3.33a-c
	4.00	4.33cd	6.02e	2.67a-c	3.33a-c	5.33cd	7.00e	2.67a-c	2.33a-c
	2.00	6.33b	8.67c	3.00a-c	3.67a-c	7.33b	9.67c	3.00a-c	2.67a-c
Once-in	8.00	3.33d	8.03cd	2.67a-c	2.33bc	4.33d	9.00cd	2.67a-c	1.00bc
Three-weeks	6.00	4.67cd	7.40de	1.33bc	2.67a-c	5.67cd	8.00d-e	1.33bc	1.67a-c
	4.00	5.67bc	8.33cd	3.00a-c	2.67a-c	6.67bc	9.33cd	3.00a-c	1.67a-c
	2.00	7.00b	10.33b	3.67ab	3.00a-c	8.00b	11.33b	3.67ab	2.00a-c
Control	0	10.33a	13.10a	5.00a	2.00c	11.33a	14.0a	5.00a	0.33c

Mean values with the same alphabets along the column are not significantly different at 5% probability, using SNK at $p < 0.05$

Table 2: Growth characteristics of cucumber at different application rates and frequencies of *Beauveria bassiana* in the late season, 2021

Frequency	Rate (kg/ha)	Number of Leaves	Increase in Leave (%)	Vine length (cm)	Increase in Vine Length (%)	Number of Flowers	Increase in Flower (%)	Number of Fruits/plant	Fruit Increase (%)	Fruit weight (kg)	Weight Increase (%)
Once	8.00	31.93a	97.10a	92.23a	155.27a	11.93a	258.26a	3.85a	64.52a	0.25a	316.67a
a-week	6.00	29.80ab	83.95ab	73.84b	104.37b	9.60bc	172.7bc	3.60ab	53.85ab	0.21c	250.00c
	4.00	27.87ab	72.04ab	74.37b	105.84b	9.90b	197.30b	3.75a	60.26a	0.22b	266.67b
	2.00	26.93ab	66.24ab	58.60c	62.19c	9.33b-d	180.18b-d	3.66a	56.41a	0.18d	200.00d
Once-in	8.00	24.53a-c	51.42a-c	44.40c	22.89c	9.10b-d	173.27b-d	3.00de	28.21de	0.16ef	166.67ef
Two-weeks	6.00	26.10ab	61.11ab	54.53c	50.93c	7.20c-f	116.22c-f	2.85e	21.79e	0.21d	250.00d
	4.00	23.90a-c	47.53a-c	41.17c	13.95c	8.57b-e	157.36b-e	2.95de	26.06de	0.17e	183.33e
	2.00	21.77b-d	34.38b-d	42.17c	16.72c	6.17ef	85.29ef	3.05de	30.34de	0.12gh	100.00gh
Once-in	8.00	21.77b-d	34.38b-d	41.87c	15.89c	6.68d-f	100.60d-f	3.40bc	45.30bc	0.11f-h	83.33f-h
Three-weeks	6.00	22.10bc	36.42bc	46.33c	28.23c	5.87f	76.28f	3.24cd	38.46cd	0.14e-g	133.33e-g
	4.00	22.70bc	40.12bc	49.00c	35.51c	5.83ef	75.07ef	2.98de	27.35de	0.12gh	100.00gh
	2.00	23.70a-c	46.30a-c	48.87c	25.13c	5.27f	58.26f	2.75e	17.52e	0.11hi	83.33hi
Control	0	16.20c	-	36.13c	-	3.33g	-	2.34f	-	0.06i	-

Mean values with the same alphabets along the column are not significantly different at 5% probability, using SNK at $p < 0.05$

Table 3: Growth characteristics of cucumber at different application rates and frequencies of *Beauveria bassiana* in the early season, 2022

Frequency	Rate (kg/ha)	Number of Leaves	Increase in Leaves (%)	Vine length (cm)	Increase in Vine Length (%)	Number of Flowers	Increase in Flower (%)	Number of Fruits/plant	Fruit Increase (%)	Fruit weight (kg)	Weight Increase (%)
Once	8.00	20.80a	171.27a	62.27a	150.38a	10.93a	238.39a	3.25a	86.75a	0.27a	237.50a
a-week	6.00	18.93ab	146.81ab	54.03b	117.25b	8.33bc	157.89bc	3.05a	75.29a	0.21c	162.50c
	4.00	18.07a-c	135.59a-c	44.37c	78.41c	9.60b	197.21b	3.06ab	75.86ab	0.24b	200.00b
	2.00	17.03b-d	122.03b-d	40.57c-d	63.13c-d	8.33bc	157.89bc	3.00ab	72.41ab	0.18d	125.00d
Once-in	8.00	15.83b-e	106.39b-e	38.47c-e	54.68c-e	8.10bc	150.77bc	2.53c-e	45.40c-e	0.15ef	87.50ef
Two-weeks	6.00	18.10a-c	135.98a-c	31.20ef	25.45ef	6.53cd	102.17cd	2.25e	29.31e	0.23d	187.50d
	4.00	14.83c-e	193.35c-e	29.53f	18.74f	8.23bc	154.80bc	2.46c-e	41.38c-e	0.16e	100.00e
	2.00	15.90b-e	107.20b-e	29.34f	17.97f	6.48c-d	100.62c-d	2.45c-e	40.80c-e	0.11gh	37.50gh
Once-in	8.00	13.93d-e	79.51d-e	33.53d-f	34.82d-f	6.37c-d	97.21c-d	2.8bc	60.92bc	0.09f-h	12.5f-h
Three-weeks	6.00	12.77e	66.49e	27.17f	9.25f	5.87c-d	81.73c-d	2.64cd	51.72cd	0.13e-g	62.5e-g
	4.00	12.10e	57.76d-e	31.93ef	28.39ef	5.67c-d	75.54c-d	2.38de	36.78de	0.11gh	37.50gh
	2.00	13.27d-e	73.01f	28.87f	16.87f	4.83d-e	49.53d-e	2.15e	23.56e	0.10hi	25.00hi
Control	0	7.67f	-	24.87f	-	3.23e	-	1.74f	-	0.08i	-

Mean values with the same alphabets along the column are not significantly different at 5% probability, using SNK at $p < 0.05$

Table 4: Days to deterioration of cucumber fruits grown at different application rates and frequencies of *Beauveria bassiana*

Frequency	Rate (kg/ ha)	Days to Deterioration				
		1-3	4-6	7-9	10-12	13-15
Once a-week	8.00	Nil	Nil	Nil	Nil	Deteriorated
	6.00	Nil	Nil	Nil	Nil	Deteriorated
	4.00	Nil	Nil	Nil	Nil	Deteriorated
	2.00	Nil	Nil	Nil	Deteriorated	**
Once-in Two- weeks	8.00	Nil	Nil	Deteriorated	**	**
	6.00	Nil	Nil	Deteriorated	**	**
	4.00	Nil	Nil	Deteriorated	**	**
	2.00	Nil	Deteriorated	**	**	**
Once-in Three- weeks	8.00	Nil	Deteriorated	**	**	**
	6.00	Nil	Deteriorated	**	**	**
	4.00	Nil	Deteriorated	**	**	**
	2.00	Deteriorated	**	**	**	**
	0	Deteriorated	**	**	**	**

Cucumber fruits stored at normal room temperature (20-22⁰C) and observed daily.

** -Cucumber fruits that have deteriorated in previous days.

Table 5: Proximate composition of cucumber fruits grown at different application rates and frequencies of *Beauveria bassiana*

Nutritional Composition	100% (spray once a-week)	50 % (spray once a-week)	No- Spray	LSD (0.05)	Remarks
Moisture content	97.87	97.59	97.65	1.12	Not significant
Dry matter content	2.13	2.41	2.35	1.01	Not significant
Fat content	0.08	0.08	0.07	0.11	Not significant
Ash content	0.14	0.14	0.15	0.22	Not significant
Crude fiber content	0.57	0.57	0.61	0.31	Not significant
Crude protein content	0.21	0.21	0.25	0.12	Not significant
Carbohydrate content	1.13	1.13	1.29	0.26	Not significant

DISCUSSION

Leaf beetles, *Aulacophora hilaris*, *Epilachna chrysomelina* and melon fruit fly, *Bactrocera cucurbitae* are the major damaging insect pests encountered on cucumber in this study. Studies conducted by Choudhary *et al.* (2012) reveals that melon fruit fly (*B. cucurbitae* Coq.) is a serious pest of cucurbits and Krishna Kumar *et al.* (2006) also attributed 73.83 % damage on cucumber to melon fruit fly (Vinutha and Kotikar, 2018). Khan *et al.* (2012) implicated *A. hilaris* as a serious pest of cucurbits causing up to 70 % damage on leaves and 60 % damage on flowers of cucumber.

As reported by Katoh *et al.* (2014), *E. chrysomelina*, is identified as a damaging pest of considerable economic significance, particularly in the tropics and subtropics. This beetle poses a threat to crops in the Cucurbitaceae and Solanaceae Families. Studies by Ahmad *et al.* (2001) Das *et al.* (2012) and Pitan and Filani (2013) documented its attacks on cucumber, pumpkin, melon, garden egg, potato, and gourd. Both larvae and adults *E. chrysomelina* cause damage by scraping the epidermal tissues of leaves. According to Mondal and Ghatak (2009), feeding behavior of *E. chrysomelina* results in a reduction of leaf area available which adversely affects photosynthetic activities of the host plant.

Adult *Epilachna* also serve as a vector for squash and cucumber mosaic virus, resulting in fruit misshapen, yellowing, and distortions (Aldigail *et al.*, 2012). According to Wioletta and Karol (2016), impact of *Epilachna* attack in cucumber cultivation is substantial, with 80 % yield losses on cucurbits and 70 – 90 % reduction in cucumber yields. (Akinkunmi, 2020). Ahmad *et al.* (2001), Rath (2005), Pitan and Esan (2013), and Pitan and Filani (2013) recognized *Epilachna* beetle as a major biotic stressor of cucumber.

In this study, application of *B. bassiana* at different concentrations and spraying frequencies effectively reduced insect pest infestation on cucumber, particularly *A. hilaris*, *E. chrysomelina*, and *B. cucurbitae*. This highlights the potential of this bio-pesticide for integrated pest management in cucumber production. The effectiveness of this fungus may arise from its ability to attach spores to the insect's body and then penetrate the epicuticle, triggering the development of germ tubes which could result in the colonization of the insect's body, ultimately resulting in the insect's death. This is consistent with a report by Nwilene *et al.* (2023), that application of *B.*

bassiana effectively reduced African rice gall midge tiller infestation in rice fields. Also, the application *B. bassiana* at different rates and frequencies has positive effect on cucumber growth characteristics. This is in conformity with the report of Akello *et al.* (2007) that *B. bassiana* influenced plant height and root length of banana.

Dara *et al.* (2017) demonstrated that the use of biopesticides especially *B. bassiana* positively impacted the survival, growth, length, and dry weight of cabbage. Conversely, Jaber and Enkerli (2017) opined that there is a lack of consistency in the promotion of plant growth when plants are inoculated with entomopathogenic fungi. The notable enhancement in the growth characteristics of cucumber plants, observed in this study with varied rates and frequencies of *B. bassiana* treatment, could be attributed to the findings of Dara (2014). This suggested that insects cause significant nutrient loss to plants through their feeding damage, but plants have developed a mechanism to recover these nutrients, particularly nitrogen, through endophytic interactions with entomopathogenic fungi. Regardless of the presence of insects in the soil, plants may benefit from forming an endophytic or mycorrhiza-like relationship with soil-borne entomopathogens (Dara, 2014). Vega, 2018 opined that entomopathogenic fungi act as endophytes and aid plant growth through enhanced nutrient uptake.

Entomopathogenic fungi have been demonstrated to establish mycorrhiza-like interactions and play a role in the absorption of water and nutrients (Dara, 2019). According to Dara *et al.* (2017), these roles of entomopathogenic fungi are beneficial to plants. The findings of this study are in agreement with the report of Tall and Meyling (2018) that maize sprayed with *B. bassiana* had enhanced plant growth, with longer roots and higher biomass. Additionally, Canassa *et al.* (2019) reported bean seed inoculation with conidial suspensions of *B. bassiana* to improve growth compared to untreated plot.

In addition, Behie *et al.* (2012) disclosed that entomopathogenic fungi can translocate plant nitrogen obtained from insect material. On the other hand, microorganisms, including entomopathogenic fungi, enhances soil structure, fertility, and porosity (Inthama *et al.*, 2021). Also, highest population densities of *Apis mellifera* were obtained in plots sprayed once a-week at 8.00 kg/ha. This implies that *B. bassiana* has no adverse effect on the

abundance of beneficial insect pests. This is in consonance with the findings of Zimmermann (2007) that *B. bassiana* application has no negative effect on honeybees' population. Earlier reports have also established that *B. bassiana* can be used with minimal impact on beneficial organisms. Despite the susceptibility of many hymenopterans to *B. bassiana*, the different application rates of *B. bassiana* used in the study did not adversely affect honey bees. This is in line with the report of Lord (2005). Furthermore, *B. bassiana* does not have negative effect on the fruit nutritional composition and days to deterioration of cucumber fruits in the study. This suggests that *B. bassiana* application as a bio-pesticide is comparatively safe to cucumber plants because it is derived from micro-organisms. Hence, *B. bassiana* can be effectively utilized in the control of cucumber insect pests to reduce their infestations, improve growth characteristics and also to produce a more attractive cucumber fruit with no traces of poisonous substance in it. The use of *B. bassiana* as a control measure in cucumber production to regulate pest population is a promising alternative to conventional insecticides. The effectiveness of this bio-pesticide may be attributed to its unique and novel mode of action.

CONCLUSION

Application of *Beauveria bassiana* as a bio-control agent offers a better alternative for the control of cucumber insect pests. In this study, different application rates and frequencies of *B. bassiana* gave a reduction in the densities of major cucumber insect pests. Notably, the application of *B. bassiana* did not exhibit any adverse effects on the abundance of beneficial insect pests associated with cucumber. Also, *B. bassiana* has a positive effect on the agronomic characteristics, storability and fruit quality of cucumber fruits. of a negative impact by *B. bassiana* on honeybees has been observed in previous work which involved different response variables (Jaronski et al., 2004). A lack of a negative impact by *B. bassiana* on honeybees has been observed in previous work which involved different response variables (Jaronski et al., 2004). A lack of a negative impact by *B. bassiana* on honeybees has been observed in previous work which involved different response variables (JaroChoudhary, J. S., Kumari, A., Das, B., Maurya, S. and Kumar, S. 2012. Diversity and population dynamic of fruit flies species in methyl eugenol based parapheromone traps in Jharkhand region of India. *The Ecoscan*. 1: 57-60.

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