EVALUATION OF ENTOMOPATHOGENIC FUNGI, *BEAUVERIA BASSIANA* FOR THE CONTROL OF INSECT PESTS OF SOYBEAN (*Glycine max* (L.) MERRILL

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Abstract
The study evaluated entomopathogenic fungi, *Beauveria bassiana* for biological control of insect pests of soybean. The experiment was conducted at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta, Ogun State in the early and late planting season of 2015. The experiment was laid out in a split plot arrangement and fitted into Randomized Complete Block Design (RCBD) with three replicates. Synthetic insecticide (Lambda-cyhalothrin) was used as a standard, while water was used as a control. The insect pests that infested the soybean were *Nezara viridula*, *Certoma trifurcata*, *Aspavia armigera*, *Monolepta* spp., *Podagrica* spp. and their diversity varied from season to season. Irrespective of the planting season, pod yield, percentage of damaged leaves, number of leaves per plant, root and shoot dry weight of soybean, stem girth, number of days to 50% flowering and plant height of soybean treated with *B. bassiana*, lambda-cyhalothrin and the untreated ones were not significantly ($p>0.05$) different from each other. Significantly higher percentage of pods were damaged in untreated soybean in both seasons. *Beauvaria bassiana* compared with lambda-cyhalothrin and reduced pod damage by about 11% relative to damage in untreated soybean. To overcome the drawbacks associated with the use of synthetic insecticides, *B. bassiana* could be considered as a myco-insecticide to control insect pests of soybean on the field and reduce damage to pods.
Keywords: *Beauveria bassiana, Glycine max*, Lambda-cyhalothrin, *Podagrica* spp., *Nezara viridula*

Introduction

Soybean [*Glycine max* (L.) Merril] is an important legume bean crop grown in many parts of the world. The crop is a high source of plant protein and edible oil that have significant worldwide economic importance (Leeson and Summers, 2008; Dudje *et al*., 2009;Onwueme and Sinha, 1991). Soybean supply half of the global demand for vegetable oil and protein (Oerke and Dehne, 2004). The crop and its products are excellent source of energy and protein for poultry and swine (Leeson and Summers, 2008). They are widely used in animal feeds and soybean meal is generally regarded as the best of plant protein source in terms of its nutritional value. Also, it has a complementary relationship with cereal grains in supplying the amino acids requirements of farm animals and is the standard to which other plant protein sources are compared (Blair, 2008). Nigeria is Africa's leading producer of soybean and cultivation of the crop is increasingly gaining importance in tropical and sub-tropical Africa. Soybean is a commercial crop of many developed and developing countries of the world and is consumed locally and or used by processing industries (Adegbite *et al*., 2005; Auwal and Auta, 2011).

Insect pests constitute constraints to the production of soybean in areas where it is planted in large scale and their prevalence and damage vary from one year to another and also from one location to the other (Jackai and Singh, 1987; Jackai et al., 1990; Hill *et al.*, 2004). Most of these insect pests are harmful to the crop and yield loss of between 15-20% of total soybean production have been reportedly caused directly and indirectly by insect pests (Hartman *et al.*, 2001; Biswas 2008). Oerke (2006) reported that soybean production could be increased if the problems of insect pest infestation and damage can solved. The insects that caused the greatest potential damage to soybean are the defoliators (Giesler *et al.*, 2002). Other insect pests such as *Spilosoma oblique, Monolepta signata, Nezara viridula, Riptortus dentipes, Aphis* spp. have also been reported to infest and damage soybean worldwide (Imran 1979; Usman *et al.*, 1984; Ali 1988. Insects that cause damage to soybean have been reported to belong to 29 orders, nine of which feed on living green plants and are possible vectors of plant viruses (Alegbejo, 1986, 1996). About 70% of insect vectors belong to order Homoptera and aphids are the most important of these, followed by Aleyrodidae (Whiteflies), Coleoptera (Beetles), Pseudococcidae (Mealy bugs), Cicadellidae (Leafhoppers) and Thysanoptera (Thrips). Other vectors of less importance are Orthoptera (Grasshoppers), Delphacidae (Plant hoppers) and Membracidae (Tree hoppers) (Alegbejo, 1996).

Conventional breeding strategies have not produced insect resistant cultivars accepted by soybean growers because insect resistance has not been introduced into high-yielding cultivars. Both yield and insect resistance are inherited quantitatively, and transferring desired genes into an adapted cultivar has proven difficult (Hulburt *et al.*, 2004). The use of conventional chemical insecticides constitutes the only presently available tool that affords consistent, economical and effective suppression of insect outbreaks on soybean (Turnipseed and Kogan, 1987). However, this primary pest-control method are often abused and used erroneously without consideration for the recommended threshold level (prophylactic control) and the environment (Song and Swinton, 2009). Abuse of insecticide, especially the nonselective ones also kill natural biological agents or reduce their efficacy (Carmo *et al*., 2010). Natural control is an essential component of the ecological basis of IPM, and biological control is among the pest-control tools available to soybean growers.

The use of entomopathogenic fungi as biological control agents for insect species has increased global attention during the last few decades (Ramanujam *et al.,* 2014). The myco-insecticide based on *Beauveria bassiana* (Balsamo) Vaillemin (Babu et al. 2001; Sharma 2004), *Paecilomyces fumosoroseus* (Wize) Brown and Smith (Alter and Vandenberg, 2000; Avery *et al.,* 2004) and *Verticillium lecanii* (Zimm.) are promising myco-insecticide. Fungal pathogens have certain advantages in pest control programmes over other insect pathogens like bacteria and viruses (Ramanujam *et al.,* 2014). Mass production techniques of fungi pathogen are much simpler, easier and cheaper than those used for bacteria or viruses. Also, fungi pathogen infect through insect cuticle unlike bacteria or viruses directly and do not require ingestion for infection and so sucking insects are also infected by entomopathogenic fungi. Entomopathogenic fungi play an important role in the natural pest control in various crops through epizootics. More than 750 sp. of fungi, mostly from hyphomycetes and entomophthorales are pathogenic on insects, many of them offer great potential for pest management. Fungi infect insects of almost all orders, most common on Hemiptera, Diptera, Coleoptera, Lepidoptera, Orthoptera and Hymenoptera. In some insect orders, nymphal or larval stages are more often infected than the adult stages, in others the reverse may be the case. Entomopathogenic fungi are important natural regulators of insect populations and have potential as mycoinsecticide agents against diverse insect pests in agriculture. These fungi infect their hosts by penetrating through the cuticle, gaining access to the hemolymph, producing toxins, and grow by utilizing nutrients present in the haemocoel to avoid insect immune responses (Hajeck and St. Leger, 1994). Entomopathogenic fungi may be applied in the form of conidia or mycelium which sporulates after application. The commercial mycoinsecticide 'Boverin' based on *B. bassiana* with reduced doses of trichlorophon have been used to suppress the second-generation outbreaks of *Cydia pomonella* L. (Ferron 1971).

This study therefore evaluates the efficacy of entomopathogenic fungi, *Beauveria bassiana* for the control of insect pests of soybean (*Glycine max*).

Materials and methods

Experimental site

The experiment was conducted at lowland FADAMA site at the Research Farm of the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria located in latitude 7^0 15^1N and longitude 3^0 25^1E (Altitude 108m) in the derived savannah zone with mean annual rainfall of 1200mm. The study was conducted in the early and late planting season of 2015.

Experimental design and field layout

The experiment was laid-out in a split plot arrangement fitted into Randomized Complete Block Design (RCBD). The main plot treatment consisted of two susceptible soybean varieties TGx1448-2E and TGx1740-2F and the sub treatments consisted of the sprayed regime (*Beauveria bassiana* and Lambda-cyhalothrin) and unsprayed regime. The sub-plots size was 2m by 2m with 1m space between sub-plots. The treatments were replicated three times.

Source of material

The soybean *(Glycine max*) varieties (TGx1448-2E and TGx1740-2F) used for this study was sourced from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State. The synthetic insecticide (Lambda-cyhalothrin) that served as positive check was sourced from Agbeloba agro-chemical store, Abeokuta, Ogun State and a bio-pesticide (Botanigard 22WP (*Beauveria bassiana* strain GHA) was sourced from Lawn and Garden Products, Inc. Fresno, California, USA, an agro-chemical company based in the United State of America.

Planting of soybean seeds and application of treatments

Tillage was done manually using simple implements such as hoe and cutlass. Planting was done one week after tillage at a depth of 3-5cm. Three to four seeds were planted per hole and later thinned to one per hole at two Weeks After Planting (WAP). Weeding was done manually using hoe at 3 and 6 WAP. Lambda-cyhalothrin and Botanigard 22WP-*Beauveria bassiana* strain GHA were separately mixed with water in a hand sprayer according to manufacturer recommendation and applied to the leaves of soybean as from 2 WAP and subsequently at 1 week interval for eight weeks. Fourteen and half milliliters of the powder isolate of Botanigard 22WP-*Beauveria bassiana strain GHA* was mixed with 2.0 liters of water in a knapsack sprayer and applied to the leaves of soybean plants from 2WAP and repeated weekly for 8 weeks. Lambda-cyhalothrin, a synthetic insecticide which serve as positive check was mixed with water in a knapsack sprayer at 0.5ml to 2.0 liters of water at weekly interval for 8 weeks

Collection of data

Agronomic parameters

Data were collected on the following parameters:

(i) **Plant height -** Plant height of soybean at 3, 6, and 9 WAP was taken using meter rule on nine tagged plants from the middle rows on each plot

(ii) **Stem girth per plant -** Stem girth of soybean at 3, 6, and 9 WAP was taken using a venier caliper to measure the stem base, middle and tip of nine tagged plants from the middle rows.

(iii) **Days to 50 percent flowering -** This was determined when 50% of the total population of the plant has flowered.

(iv) **Root and shoot dry weight -** The nine tagged plants were uprooted and dried, thereafter, the shoot and root dry weights were measured using sensitive scale.

Insect counts

Number of insect pests per plant was counted on the upper and lower surfaces of the leaves as from the 2WAP till 8WAP. The insects were visually counted between the hours of 7.00am – 10.00am when the insect are still relatively inactive from nine tagged plants from the middle rows

Damage Assessment

The following damaged assessments were taken;

(i) **Number and weight of damaged pods per plot -** Harvested pods per plot were separated into damaged and undamaged. The weight of damaged and undamaged pods per plant were determined using sensitive weighing scale. Any pod with at least a hole was considered damaged. Percentage pod damage per plant was calculated as:

$$\% \text{ pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Number of damaged leaves per plant

*A*t physiological maturity, the number of damaged and undamaged leaves per plant was counted.

Percentage leaf damage was calculated as:

$$\% \text{ leaf damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Statistical analysis

Data on insect count was transformed using square root transformation method before all data obtained from the experiment were subjected to Analysis of Variance (ANOVA) and significant means (P<0.05) were separated using Least Significant Difference (LSD).

Results

Number of insect pests in Glycine max treated with Beauveria bassiana and Lambda-cyhalothrin

The number and diversity of insects that infested the *Glycine max* treated with *Beauveria bassiana* and Lambda-cyhalothrin is shown in table 1. In the early planting season, the number (2.45) of *Certoma trifurcata* in *Glycine max* plots treated with *B. bassiana* was significantly (p<0.05) lower than the number (2.66) of the insect found in plots treated with lambda-cyhalothrin and the number (3.42) found in untreated plots (Table 1). In the early planting season, the number (0.91) of *Podagrica* spp found in the untreated plots of *G. max* was significantly (p<0.05) higher than the number (0.52) of the insect found in plots of *G. max* treated with BB and the number (0.38) found in soybean treated with lambda-cyhalothrin (Table 1). The number (1.56) of *Nezara viridula* in *G. max* treated with *B. bassiana* was significantly (p<0.05) lower than the number (2.44) found in Lambda-cyhalothrin treated *G. max* and the number (5.50) found in untreated *G. max*. *Aspavia armigera* and *Monolepta* spp were not found in the early planting season, but were found in the late planting season. In the late planting season, a significantly (p<0.05) higher number of *C. trifurcata* (6.22), *Podagrica* spp (4.20), *N. viridula* (8.58), *A. armigera* (6.20) and *Monolepta* spp (3.75) were found in untreated cowpea plots. The number of *Podagrica* spp, *A. armigera* and *Monolepta* spp found in soybean treated with *B. bassiana* and Lambda-cyhalothrin were not significantly (p>0.05) different from each other.

Table 1: Number of insect pests in *Glycine max* treated with *Beauveria bassiana* and Lambda-cyhalothrin

Treatment	*Certoma trifucata*		*Podagrica spp*		*Nezara viridula*		*Aspavia armigera*		*Monolepta spp*	
	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
Beauveria bassiana	2.45	3.44	0.52	3.98	1.56	4.58	0.00	3.72	0.00	1.22
Lamda-cyhalothrin	2.66	3.92	0.38	3.75	2.44	3.22	0.00	3.22	0.00	0.55
Untreated (control)	3.42	6.22	0.91	4.20	5.50	8.58	0.00	6.20	0.00	3.75
LSD (0.05)	0.19	0.41	0.28	0.58	0.52	0.53	0.00	1.22	0.00	1.12

Damage assessment of pods and leaves of Glycine max treated with Beauveria bassiana and Lambda-cyhalothrin

Irrespective of planting season, higher damage was done to the pods of *Glycine max* not treated with entomopathogenic fungi nor synthetic insecticide. In the early and late planting season, significantly ($p<0.05$) higher damage of 26.03% and 27.42% respectively was done to pods harvested from untreated soybean compared to 15.07% and 16.21% pod damage in soybean treated with *B. bassiana* and pods harvested from soybean treated with lambda-cyhalothrin that has pod damage of 16.32% and 17.35% in the early and late planting season respectively (Table 2).

The percentage of damaged leaves in *G. max* from the soybean treated with *B. bassiana*, lambda-cyhalothrin and the untreated ones were not significantly ($p>0.05$) different from each other in both planting seasons (Table 2).

Table 2: Damage assessment of pods and leaves in *Glycine max* treated with *Beauveria bassiana* and Lambda-cyhalothrin

Treatments	% Pod damage		% Damaged leaves	
	Early	**Late**	**Early**	**Late**
Beauveria bassiana	15.07	16.21	2.68	5.29
Lamda-cyhalothrin	16.32	17.35	1.50	3.44
Untreated (control)	26.03	27.42	5.10	10.28
LSD (0.05)	4.94	5.23	6.61	8.25

Pod yield of Glycine max treated with Beauveria bassiana and Lambda-cyhalothrin

In the early planting season, pod yield from the untreated soybean (20.60g) and soybean treated with *B. bassiana* (20.90g) and lambda-cyhalothrin (21.78g) were not significantly ($p>0.05$) different from each other. Similarly, in the late planting season, the pod yield from the untreated soybean (17.90g) and soybean treated with *B. bassiana* (18.80g) and lambda-cyhalothrin (19.22g) were not significantly ($p>0.05$) different from each other (Fig. 1).

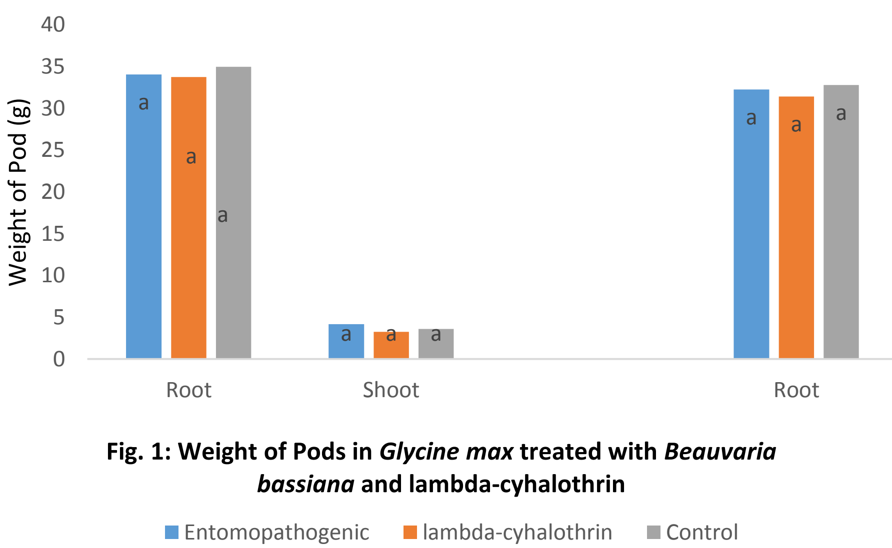

Fig. 1: Weight of Pods in *Glycine max* treated with *Beauvaria bassiana* and lambda-cyhalothrin

Agronomic characters of Glycine max treated with Beauveria bassiana and Lambda cyhalothrin

In the early planting season, the plant height of both treated and untreated soybean plants at 4 WAP and 8 WAP were not significantly (p>0.05) different from each other. In the late planting season, the plant heights were not significantly (p>0.05) different from each other at 4WAP, 6WAP and 8 WAP. Similarly, the stem girths of the cowpea plants at 4WAP, 6WAP and 8WAP were not significantly (p>0.05) different from each other irrespective of the planting season (Table 3). In the early planting season, the number of days to 50% flowering of *G.max* from plots treated with *B. bassiana* (59.17), lambda cyhalothrin (58.00) and untreated plots (58.50) were not significantly (p>0.05) different from each other. The number of days to 50% flowering were also not significantly (p>0.05) different from each other in the late planting season. Similarly, the number of leaves from plots treated with *B. bassiana*, lambda cyhalothrin and the untreated one were not significantly (p>0.05) different from each other in both planting seasons. However, the number (17.72) of flowers on *G.max* plant treated with *B. bassiana* was significantly (p<0.05) higher than the number (12.58) of flowers found in the untreated plots and the number (16.31) found in Lambda cyhalothrin-treated plots in the early planting season. The number of flowers in soybean plants treated with lambda cyhalothrin, *B. bassiana* and untreated ones were not significantly (p>0.05) different from each other in the late planting season (Table 4).

Table 3: Plant height and stem girth of *Glycine max* treated with *Beauveria bassiana* and Lamda-cyhalothrin

Treatment	**Plant height (cm) at weeks after Planting (WAP)**						**Stem girth at weeks after planting (WAP)**					
	4WAP		**6WAP**		**8 WAP**		**4WAP**		**6 WAP**		**8 WAP**	
	Early	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Beauveria bassiana	24.15	22.15	36.80	30.44	56.72	54.52	0.2197	0.2907	0.462	0.412	0.750	0.742
Lamda-cyhalothrin	24.60	21.47	36.93	32.67	59.14	56.90	0.3133	0.3032	0.498	0.433	0.713	0.659
Untreated (control)	23.95	20.99	36.84	33.01	51.35	51.10	0.3017	0.2997	0.510	0.499	0.730	0.710
LSD (0.05)	4.88	3.67	9.26	5.42	10.74	6.25	0.0386	0.0521	0.0755	0.082	0.1493	0.0781

Table 4: Number of leaves, days to 50% flowering and number of flowers in *Glycine max* treated with *Beauveria bassiana* and lamda-cyhalothrin

	Number of leaves		**Number of Days to 50% flowering**		**Number of flower**	
	Early	**Late**	**Early**	**Late**	**Early**	**Late**
Beauveria bassiana	116.3	110.70	59.17	61.44	16.31	15.22
Lamda-cyhalothrin	109.8	108.20	58.00	62.37	17.72	14.13
Untreated (control)	97.6	96.22	58.50	60.55	12.58	13.44
LSD (0.05)	23.51	10.44	3.358	4.49	0.641	3.94

Irrespective of planting season, root and shoot dry weight of *Glycine max* treated with *B. bassiana*, lambda-cyhalothrin and the untreated ones were not significantly (P>0.05) different from each other (Fig.2).

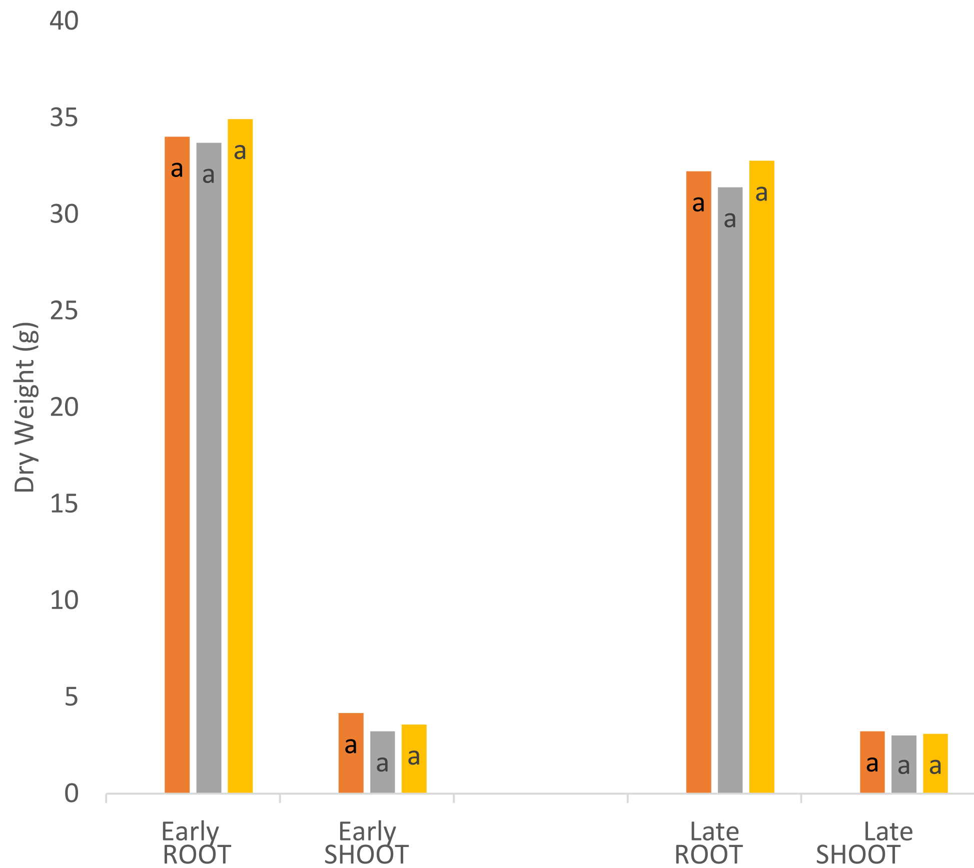

Fig 2: Root and Shoot Dry Weight of Soybean Plants Treated with *Beauvaria bassiana* and lambda-cyhaloth

Discussion

The insect pests encountered in this study are *Nezara viridula* L. (Southern Green Stink Bug) (Hemiptera: Pentatomidae), *Certoma trifurcata* (Bean leaf beetle), (Coleoptera: Chrysomelidae) *Aspavia armigera* L. (Three Spots Shield Bug) (Hemiptera: Pentatomidae), *Monolepta* spp. Chris Reid (Soft Leaf Beetle) (Coleoptera: Chrysomelidae) and *Podagrica* spp. Jac. (Flea Beetle) (Coleoptera: Chrysomelidae). The insects in the family Pentatomidae are pod sucking bugs while the ones in Chrysomelidae are leaf-feeding species. Ndam *et al.* (2012) reported Chrysomelid leaf-eating beetles as dominating among insect species such as *Empoasca dolichi*, *Cicadella nigrifons* and several other species of carabidae that infested soybean plots. Remarkably, the diversity of the insects that infested the soybean varied from one season to the other; three insects namely *C. trifucata*, *Podagrica* spp. and *N. viridula*, infested the crop in the early season, while five, *C. trifucata*, *Podagrica* spp. and *N.viridula*, *A. armigera* and *Monolepta* spp infested the crop in the late season. Ndam et al. (2012) indicated that seasonal variation in pest density and damage of soybean in Markurdi, Plateau State, Nigeria is a rational for insecticide usage in soybean production. Anyim (1996) reported *N. viridula* as a major insect pest of soybean at Umudike, Southeastern Nigeria. In a similar study, Biswas (2013) reported that leaf beetle, *Monolepta signata*, black beetle, *Cyrtozemia cognata*, epilachna beetle, *Epilachna Punctata*, pumkin beetle, *Aulacophorai* sp., black cutworm, *Agrotis ipsilon*, leaf hopper, *Aphannus sordidus*, jassids and *Empoasca* spp were the first insects to infest soybean at the seedling stage and their infestation continued up to pod formation stage of the crop. The author reported that *Helicoverpa armigera*, green stink bug, *N. viridula*, rice bug and other pentatomid bugs infested the soybean as from flowering to maturity of the crop. Jackai *et al.* (1990) and Dudge *et al.* (2009) reported that every stage of soybean is infested by insect pests that attack leaves from vegetative to pod production stages and reduce the rate of photosynthesis process causing yield loss.

In both seasons, the plant height, number of leaves and stem girth of soybean plants treated with *B. bassiana*, lambda-cyhalothrin and untreated ones were comparable. This suggest that the treatments has no negative effects on the growth and other agronomic characters of the soybean plants. This agrees with the report of Ndam *et al.* (2012) which indicated that there was no significant treatment effects in the mean number of leaves per plant in sprayed and unsprayed soybean plots. The leaf damage of soybean caused by foliage-eating insect pests in the treated plot and untreated ones were not significantly different from each other. This is in consonance with the conclusion of Ndam *et al.* (2012) that the impact of phytophagous insect species was not sufficient to show differences in crop damage whether or not insecticidal sprays were applied. NCCES (1994) earlier reported that the ability of soybean plants to sustain defoliation without yield reduction varies with the growth of the plant and younger plants that have not bloom or fill pods can tolerate greater foliage damage than plants which are fruiting.

The pod yield of soybean from plots treated with *B. bassiana*, lambda-cyhalothrin and the untreated plots were not significantly different from each other. Gianessi (2009) reported that soybean tolerate and compensate for injury and has a remarkable capacity to withstand much insect injury without significant yield loss by producing excess leaves and retaining older leaves to maintain high levels of photosynthesis. He accordingly stated that the level of tolerance before yield is significantly impacted varies with the type of damage and the plant developmental stage. Soybean can tolerate 35% defoliation or eight or more feeding larvae per foot of row before flowering begins and after seed pods have filled out, but during flowering and pod development, they can only tolerate 20% defoliation or four or more feeding larvae per foot of row. Foliage loss greater than these threshold amounts has been shown to cause economic yield loss because of the reduction in light interception by the soybean canopy (Gianessi 2009). Adeney *et al.* (2011) evaluated integrated pest management (IPM); prophylactic use of insecticides (PUI), biological control (BC) and untreated soybean plots for insect infestation and yield and reported that although the pest infestation rates in the BC and IPM treatments were higher than that in the PUI treatment, crop productivity, in general, was similar among these treatments and differed only from the control with no pest treatment. The authors concluded prophylactic use of insecticides on soybeans does not result in higher productivity on the field and can impair the sustainability of the soybean crop.

This result suggest that insect pest infestation and damage to the leaves of soybean plant did not affect the yield of the crop. However, significant higher number of pods from the untreated plots were damaged probably by *Nezara viridula* and *Aspavia armigera* compared to pods from plots treated with *B. bassiana* and lambda-cyhalothrin. This is in conformity with the report of Ndam *et al.* (2012) which indicated non-significant differences in soybean yield and yield parameters except for percentage malformed pods and percentage damaged seeds in the sprayed and unsprayed treatments. The reduction in the pod damage of soybean treated with *B. bassiana* reflected the effectiveness of the myco-insecticide in reducing pod damage by pod sucking bugs. In this study, the comparison of the effectiveness of *B. bassiana* and lambda-cyhalothrin at reducing pod damage of soybean is a good development in the search for alternative to the use of synthetic insecticide.

This study concluded that soybean in the study area was infested by foliage feeders and pod sucking bugs that inflicted damage to the leaves and pod of the crop. Treatments of *B. bassina* and lambda-cyhalothrin did not influence pod yield and damage to the leaves of soybean. Higher damage was done to the pods of soybean from untreated soybean plots compared to the pods from plots treated with *B. bassina* and lambda-cyhalothrin. *Beauvaria bassiana* compared with lambda-cyhalothrin and reduced pod damage by about 11% relative to pod damage in untreated soybean. To overcome the drawbacks associated with the use of synthetic insecticides, *B. bassiana* could be considered as a myco-insecticide to control insect pests of soybean on the field and reduce damage to pods.

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Table 1: Number of insect pests in *Glycine max* treated with *Beauveria bassiana* and Lambda- cyhalothrin

Treatment	***Certoma trifucata***		***Podagrica spp***		***Nezara viridula***		***Aspavia armigera***		***Monolepta spp***	
	Early	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Beauveria bassiana	2.45	3.44	0.52	3.98	1.56	4.58	0.00	3.72	0.00	1.22
Lamda-cyhalothrin	2.66	3.92	0.38	3.75	2.44	3.22	0.00	3.22	0.00	0.55
Untreated (control)	3.42	6.22	0.91	4.20	5.50	8.58	0.00	6.20	0.00	3.75
LSD (0.05)	0.19	0.41	0.28	0.58	0.52	0.53	0.00	1.22	0.00	1.12

Table 2: Damage assessment of pods and leaves in *Glycine max* treated with *Beauveria bassiana* and Lambda-cyhalothrin

Treatments	**% Pod damage**		**% Damaged leaves**	
	Early	**Late**	**Early**	**Late**
Beauveria bassiana	15.07	16.21	2.68	5.29
Lamda-cyhalothrin	16.32	17.35	1.50	3.44
Untreated (control)	26.03	27.42	5.10	10.28
LSD (0.05)	4.94	5.23	6.61	8.25

Table 3: Plant height and stem girth of *Glycine max* treated with *Beauveria bassiana* and Lamda-cyhalothrin

Treatment	**Plant height (cm) at weeks after Planting (WAP)**						**Stem girth at weeks after planting (WAP)**					
	4WAP		**6WAP**		**8 WAP**		**4WAP**		**6 WAP**		**8 WAP**	
	Early	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Beauveria bassiana	24.15	22.15	36.80	30.44	56.72	54.52	0.2197	0.2907	0.462	0.412	0.750	0.742
Lamda-cyhalothrin	24.60	21.47	36.93	32.67	59.14	56.90	0.3133	0.3032	0.498	0.433	0.713	0.659
Untreated (control)	23.95	20.99	36.84	33.01	51.35	51.10	0.3017	0.2997	0.510	0.499	0.730	0.710
LSD (0.05)	4.88	3.67	9.26	5.42	10.74	6.25	0.0386	0.0521	0.0755	0.082	0.1493	0.0781

Table 4: Number of leaves, days to 50% flowering and number of flowers in *Glycine max* treated with *Beauveria bassiana* and lamda-cyhalothrin

	Number of leaves		Number of Days to 50% flowering		Number of flower	
	Early	**Late**	**Early**	**Late**	**Early**	**Late**
Beauveria bassiana	116.3	110.70	59.17	61.44	16.31	15.22
Lamda-cyhalothrin	109.8	108.20	58.00	62.37	17.72	14.13
Untreated (control)	97.6	96.22	58.50	60.55	12.58	13.44
LSD (0.05)	23.51	10.44	3.358	4.49	0.641	3.94

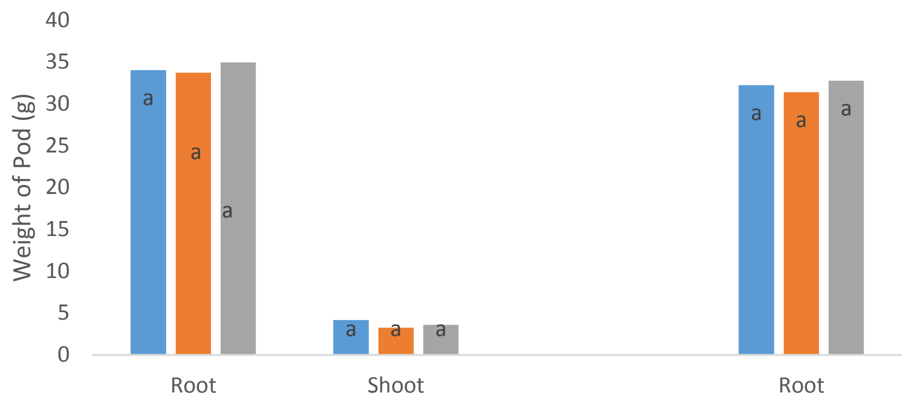

Fig. 1: Weight of Pods in *Glycine max* treated with *Beauvaria bassiana* and lambda-cyhalothrin

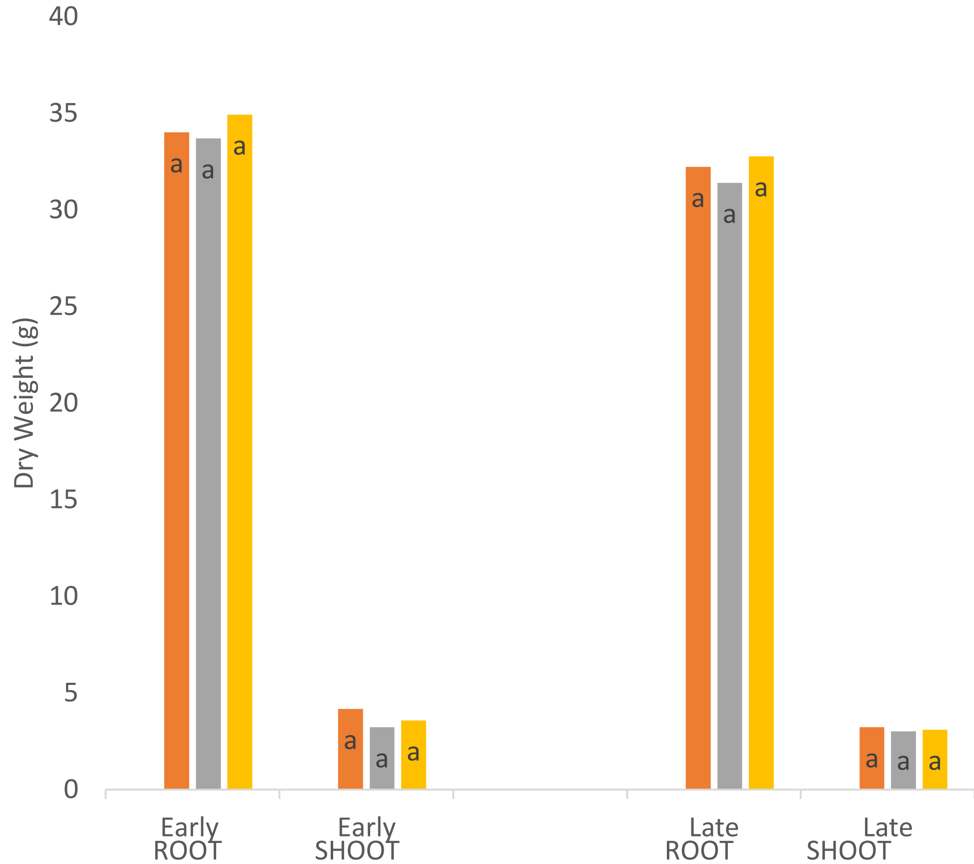

Fig 2: Root and Shoot Dry Weight of Soybean Plants Treated with *Beauvaria bassiana* and lambda-cyhaloth