CONTROL OF FLEA BEETLE *PODAGRICA* SPP. (COLEOPTERA: CHRYSOMELIDAE) WITH ENTOMOPATHOGENIC FUNGUS *BEAUVERIA BASSIANA* (BALSAMO) VUILLEMIN IN OKRA (*ABELMOSCHUS ESCULENTUS)* (L.) MOENCH

Kudemepo C. T.*, Osipitan A. A.*, Popoola R. A.* and Ademolu K. O.**

* Department of Crop Protection, Federal University of Agriculture, P.M.B 2240, Abeokuta, Ogun State, NIGERIA. E-mail: Osipitan1@yahoomail. com

** Department of Pure and Applied Zoology, Federal University of Agriculture, P.M.B 2240, Abeokuta, Ogun State, NIGERIA.

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ABSTRACT: The effectiveness of entomopathogenic fungus, *Beauveria bassiana* at controlling infestation of *Podagrica* spp. in okra field was evaluated at a low-land farm (FADAMA) and University Farms site of Federal University of Agriculture, Abeokuta, Ogun State in 2014 late and 2015 early planting seasons respectively. The experiment was laid out in a split plot arrangement fitted into Randomized Complete Block Design. The main plot consisted of two flea beetle susceptible okra varieties (NH99/DA and LD88/1-8-5-2) and sub-treatment was the spray regime (*B. bassiana* and Lambda-cyhalothrin). The control was the unsprayed okra plots. The isolate of Botanigard 22WP- *Beauveria bassiana* strain GHA was mixed with water in a knapsack sprayer and applied to the leaves of okra plants from 2 WAP at 3.57g/1.5L of water and repeated at weekly interval for 6 weeks. Lambda-cyhalothrin, a synthetic insecticide which served as a check was mixed with water in a knapsack sprayer at 0.5ml/0.96L of water and repeated at weekly interval. The Na, Cu, Ca, Mg, P, Fe, K and proximate composition of *B. bassiana*-treated and untreated okra fruits were determined. Irrespective of season, number of flea beetles per plant, percentage of damaged leaves and pods in *B. bassiana*-treated okra plots were comparable to the ones from okra plants treated with lambda-cyhalothrin. They were however, significantly ($P<0.05$) lower to the ones from untreated okra plots. The fruit yield from plots treated with *B. bassiana* and lambda-cyhalothrin were comparable ($P>0.05$) and significantly ($P<0.05$) higher than the yield from the untreated plots. The proximate composition and minerals evaluated in *B. bassiana*-treated okra fruit were not significantly different ($P>0.05$) from the composition of untreated okra fruits The study concluded that entomopathogenic fungus, *B. bassiana* reduced the number of *Podagrica* spp. in treated okra plants and enhanced yield. The use of the treatment is therefore recommended for the control of *Podagrica* spp. in okra field.

KEY WORDS: Entomopathogenic fungus, *Beauveria bassiana, Podagrica* spp., lambda-cyhalothrin, proximate composition

Okra "*Abelmoschus esculentus*" is an important vegetable crop that supplies carbohydrate, protein, fat, minerals, fibre and other substances that enhance healthy growth of human being (Gopalan et al., 2007). The crop is an economically important vegetable crop grown in tropical and sub-tropical parts of the world as a garden crop as well as on large commercial farms (Thompson & Kelly, 1979). Okra is grown for its pods which are harvested while they are still immature and used in salads and soups, consumed raw, cooked or fried (Moniruzzaman et al., 2007). The crop is used in curing diseases such as genitourinary disorders, spermatorrhoea, chronic dysentery, ulcers and hemorrhoids (Adams, 1975).

Many pests have been reported to attack the crop at different stages of growth (Critchley, 1997; Praveen & Dhandapni, 2001; Dabire-Binso et al., 2009; Echezona et al., 2010). They include species that damage the foliage, shoots, flowers and pods. Hill (1987) identified nine insect species as serious pests of this crop worldwide: *Aphis gossypii* (Glov.), *Empoasca* spp., *Ferrisia virgata* (Ckll.), *Dysdercus* spp., *Oxycarenus hyalipennis* (Costa), *Earias vittella* (Stoll.), *Earias biplaga* (Wlk.), *Earias insulana* (Boisd.) and *Helicoverpa armigera* (Hub.). The crop is also subject to attack by flea beetles, *Podagrica* spp that infest the seedlings and cause damage of economic importance by feeding on the leaves (Praveen & Dhandapani 2001, Seif & Varela 2004). Flea beetle is a general name applied to the small, jumping beetles of the leaf beetle family (Chrysomelidae) (Metcalf & Metcalf, 1993). The adult flea beetle is a very small to moderately sized Chrysomelidae that is difficult to control due to its high mobility ((Metcalf & Metcalf, 1993; Clark, 2005). Flea beetles cause the greatest damage by feeding on cotyledons, stems and foliage. The small round holes caused by an individual flea beetles feeding may coalesce into larger areas of damage under high infestation (Hines & Hutchinson, 1997; George, 2003). This extensive damage to leaves reduces the leaf area available for photosynthesis and the amount of food available for plant use, leading to yield reduction or complete loss in high infestations (Odebiyi, 1980; Ajibola, 1984; Indra & Kamini, 2003).

Koay & Chua (1978) reported that okra yield can be up to 30 t/ha, but could be constrained to 5–10 t/ha in most developing countries as a result of extensive damage by flea beetles. Echezona et al. (2010) reported that *Podagrica uniforma* and *Podagrica sjostedt* are the most destructive in West Africa. The larval and adult stages of the flea beetle have chewing mouthparts, which they use effectively below ground (larvae) and above ground (adults) to cause damage. In addition, scars on fruits and foliage from above-ground feeding may render produce unmarketable (Ambrosino, 2008). Severe damage to above-ground plant parts can kill seedlings, and in older plants can lead to crop stress, reduced growth, stunting, and eventual death (Caldwell et al., 2005). Some species are vector of serious diseases such as okra mosaic virus, potato blight and bacterial wilt of corn (Hill, 1987; Metcalf & Metcalf, 1993; George, 2003).

There are several commercial insecticides recommended to control flea beetles. However, these insecticides have broad-spectrum actions that kill beneficial insects in addition to the targeted pest. This has contributed to the environmental pollution through air or as residues in food. In the last few years, the use of environmentally friendly bio-pesticides that support sustainable crop production is being developed as alternative methods of pest control (Berry, 1998). *Microbial pesticides* consist of a microorganism (e.g., a bacterium, fungus, virus, or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest (Cranshaw & Baxendale, 2005).

Beauveria bassiana is a fungus commonly found in many soils, and it causes a disease in insects known as “white muscadine” (Parker et al., 2012). It grows naturally in the soil throughout the whole world and acts as parasite on various arthropods species causing white muscardine disease. It is being used as a biological insecticide to control a number of pests such as termites, thrips, whiteflies, aphids and different beetles. The specie is named after the Italian entomologist Agostino Bassi, who discovered it in 1835. It was formerly known as *Tritirachium shiotae* while the name *Beauveria bassiana* has long been used to describe a specie complex of morphologically similar and closely related isolates. The fungus, *B. bassiana* was reported to be higly virulent by producing more spores from the fungus that grows out of the cadaver of killed insect thus increasing the chance for other individuals to be killed. When the microscopic spores of the fungus is in contact with the body of an insect host, they germinate, penetrate the cuticle, and grow inside, killing the insect within a matter of days. Afterwards, a white mould emerges from the cadaver and produces new spores. A typical isolate of *B. bassiana* can attack a broad range of insects and various isolates differ in their host range (Mul et al., 2009; Kaoud, 2010).

Beauveria bassiana can be used as a biological insecticide to control a number of pests such as termites, whiteflies, and many other insects. The fungus rarely affects humans or other animals, so it is generally considered safe as an insecticide. This study therefore evaluates the effectiveness of entomopathogenic fungus for the control of flea beetles in okra plots.

MATERIALS AND METHODS

The study was conducted at the at low land and Directorate of University Farm sites of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State in the late 2014 planting season and early 2015 planting season respectively. The areas are located in Latitude $7^0 5^1$N and Longitude $3^0 25^1$E (Altitude 108 m) in the Derived Savannah zone with mean annual rainfall of 1200 mm. The experiment was laid out in a split plot arranged in a Randomized Complete Block Design with three replicates. In both seasons, the main plot was 7 m X 7 m (49 m^2) and 2m space between the plots. There were two okra varieties namely NH 99/DA and LD 88/1-8-5-2. The sub-treatments consisted of sprayed regime (*Beauveria bassiana* (Entomopathogenic fungus) and lambda cyhalothrin (Insecticides) and unsprayed regime which served as control. The sub plot was 2 m X 2 m with 0.5 m space between them.

The isolate of Botanigard 22WP- *Beauveria bassiana strain GHA* in wettable powder was mixed with water in a knapsack sprayer at 3.57g/1.5L of water and applied to the leaves of okra plants from 2WAP. Subsequent spraying was done on weekly basis according to the recommendation of the insecticide's manufacturer. Lambda-cyhalothrin insecticide was mixed with water in a knapsack sprayer at 0.5ml/0.96L of water. Repeated spraying was done on weekly basis.

Data on plant height was taken at 3, 6 and 9 weeks After Planting (WAP). Number of flea beetles per plant was counted on the upper and lower surfaces of the leaves of fifteen tagged okra plants in the middle row as from 4WAP till 8WAP at weekly interval. The counting was done between the hours of 7.00am – 10.00am when the insects were still relatively inactive. The number of leaves per plant was noted at physiological maturity and the percentage leaf damaged was calculated as:

$$\text{Percentage Leaf Damaged} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Data on yield parameters were collected on number of pods per plant, pod weight per plots, number and weight of damage pods. Percentage of damaged pods was calculated as**:**

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

The proximate and mineral composition of okra fruits from plots treated with entomopathogenic fungus *Beauveria bassiana* were determined using the method of AOAC (2000) and compared with the proximate and mineral composition of okra fruits from the untreated plots.

Analysis of data

Data on insect count were transformed using square root transformation method ($\sqrt{}$ ($\varkappa$ + 0.5), where $\varkappa$ was the number of insect counted). Data obtained were subjected to Analysis of Variance (ANOVA) and significant means (P<0.05) were separated using Least Significant Difference (LSD).

RESULTS

Number of *Podagrica* spp. and pod yield of okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin

Table 1 shows the number of flea beetles per plant in both 2014 and 2015 planting seasons. In both seasons, okra plants treated with entomopathogenic fungus *Beauveria bassiana* and lambda-cyhalothrin had significantly (P<0.05) lower number of flea beetles relative to the unsprayed treatment. However, the number of flea beetles from *Beauveria bassian*-treated okra plots were not significantly (P>0.05) different from the number in lambda-cyhalothrin treated okra plots in both years. The number of flea beetles on both okra varieties were not significantly (P>0.05) different from each other irrespective of planting season.

In 2004 planting season, the pod yield in the variety "NH 99/DA" was 517.2 g, 497.1 g and 366.62 g in plots treated with EPF, lambda-cyhalothrin and the untreated plots respectively. In the variety "LD 88/1-8-5-2", it was 517.0 g, 508.2 g and 391.9 g in plots treated with EPF, lambda-cyhalothrin and the untreated plots respectively. Significantly (P<0.05) higher okra pods were obtained from plots treated with *B. bassiana* and lambda-cyhalothrin compared to the ones from plots treated with *B. bassiana* and lambda-cyhalothrin. The pod yield from okra plots treated with *B. bassiana* and lambda-cyhalothrin were comparable (P>0.05) (Table 1).

Number of leaves and percentage of damaged leaves in okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin

There was no significant difference (P>0.05) in the number of leaves per plant in the sprayed (entomopathogenic fungus *B. bassiana* and lambda-cyhalothrin) and the unsprayed okra plants in both 2014 and 2015 planting seasons. Irrespective of planting season, the number of leaves on the two okra varieties were comparable (P>0.05) (Table 2).

The okra plants sprayed with treatments of entomopathogenic fungus *Beauveria bassiana* and lambda-cyhalothrin had significantly (P<0.05) lower percentage of damaged leaves compared to the unsprayed okra plants in both planting seasons. The percentage of damaged leaves in okra plants sprayed with treatments of entomopathogenic fungus *Beauveria bassiana* and lambda-cyhalothrin were however, not significantly (P>0.05) different from each other. The influence of okra variety on damage to the okra leaves was insignificant (P>0.05) (Table 2).

Plant height of okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin

In both 2014 and 2015 planting seasons, there were no significant (P>0.05) difference in plant height of okra at 3, 6 and 9WAP in okra plants treated with *B.*

bassiana, lambda-cyhalothrin and the untreated ones. Varietal influence on plant height of treated and untreated okra plants was also not significant (P>0.05) (Table 3).

Number of pods and percentage of pods damaged in okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin

There were no significant (P>0.05) difference in number of pods per plant on okra plants treated with *B. bassiana*, lambda-cyhalothrin and the untreated ones in 2014 and 2015 planting seasons irrespective of variety (Table 4).

The okra plots treated with *B. bassiana* and lambda-cyhalothrin had a significantly (P<0.05) lower number and percentage of damaged pods compared to the pods from unsprayed plots in 2014 and 2015 planting seasons. However, the number and percentage of damaged pods in *B. bassiana*-treated and lambda-cyhalothrin-treated okra plants were not significantly (P>0.05) different from each other in both planting seasons irrespective of variety (Table 4).

Proximate and mineral composition of okra fruits

The proximate compositions of okra from sprayed plots were not significantly (P>0.05) different from the proximate composition of okra from the unsprayed plots irrespective of the planting season or variety. However, higher dry matter, fiber, ash, crude protein and fat content were noted in okra from plots sprayed *B. bassiana* (Table 5). Similarly, the mineral composition of okra pods from the sprayed plots were not significantly (P>0.05) different from the pods from unsprayed plots irrespective of planting season or variety. However, the Na, Ca, Mg, P, Fe and K content of okra from plots sprayed with *B. bassiana* was lower. (Table 6).

DISCUSSION

In this study, two flea beetle species, *Podagrica uniforma* and *Podagrica sjostedti* were observed as feeding on okra leaves. This result is in consonance with the report of Echezona et al. (2010) which indicated *P. uniforma* and *P. sjostedti* as the most destructive insect pests of okra in West Africa. The presence of these insects in the two okra varieties evaluated in both 2014 and 2015 suggest that the insects are regular insect pest of okra. This agrees with the findings of Pitan and Olatunde (2006) who observed flea beetles *Podagrica* spp. as the most important insect pest of okra in Africa, accounting for as much as 90% of the total pest population found on the crop at vegetative stage.

The average pod damage to the two okra variety in 2014 planting season was 32.49% and 52.66% in 2015 planting season. The ability of the insect to cause damage to infested okra plants has been reported by many authors (Odebiyi, 1980; Parh et al., 1997; Cranshaw, 1998). Koay & Chua (1978) reported that Okra yield can be as high as 30 t/ha, but yield could be constrained to 5–10 t/ha in most developing countries as a result of extensive damage by flea beetles. The economic impact of flea beetles on crop production was reported to vary with population densities and yield losses of about 10% are possible where flea beetles are abundant even when the crop is protected. The average damage to the leaves was 49.31% in 2014 and 46.16% in 2015. This agrees with earlier report which indicated the ability of the insect to cause high damage to insect foliage and stem (Odebiyi 1980; Cranshaw 1998). Parh et al. (1997) reported *P. uniforma* and *P. sjostedti* as major okra defoliators capable of causing heavy defoliations of up to 80% on okra leaves. Cranshaw (1998) reported the ability of adult beetles to make small holes known as 'shot holes' on okra leaves. Odebiyi (1980) and Indra &

Kamini (2003) reported that leaf feeding by the insects reduces the leaf area available for photosynthesis and the amount of food available for plant use, leading to yield reduction or complete loss in high infestations.

In this study, the number of flea beetle in okra plots treated with the entomopathogenic fungus *B. bassiana* was significantly lower than the number of the insect in the untreated plots. This agrees with the reports of Hajek and St. Leger (1994), Inglis et al. (2001) and Wraight et al. (2001) which indicated that *B. bassiana* is widely used to control pests and provides a basis for the production of a large number of mycoinsecticides. Wright (1992), Carruthers et al. (1993), Lewis et al. (1996) and Poprawski et al. (1997) reported that foliar applications of *B. bassiana* have proven to be useful in suppressing population of several economically important insects, including *Bemisia tabaci* (Gennadius) *Leptinotarsa decern/ineata* (Say), *Ostrinia nubilalis* (Htib-ner), and may provide another important option for control of other insect pests. Tefera and Pringle (2003) also tested the entomopathogen efficiency of *B. bassiana* and reported significant reduction in the coleopteran population of *Chilo partellus* in the first four days after treatment with *B. bassiana*. Malarvannan et al. (2010) evaluated *B. bassiana* against the tobacco caterpillar*, Spodoptera litura* and concluded that biopesticides, particularly microbial pesticides can be used as an alternate control method in combating the pest.

There are conflicting reports on the impact of flea beetles on okra yield loss. Several studies reported that insecticide spraying enhance yield increase in okra (Obeng-Ofori & Sackey, 2003; Ahmed et al., 2007; Thul et al., 2009), while other reports showed no systematic evidence of yield enhancement due to control of flea beetle on okra (Odebiyi et al., 1981; Emosairue & Ukeh, 1997). In this study however, yield of okra was enhanced in the plots treated with *B. bassiana* and lambda-cyhalothrin. This is in consonance with the findings of Krishnareddy et al. (1995), Adesina & Idoko (2013) and Adesina & Afolabi (2014) which reported that okra plants treated with biopesticides had higher yield compared to the yield of okra plants in untreated plots. In this study, the comparability of *B. bassiana* with lambda-cyhalothrin in terms of reduction of flea beetle infestation and enhancement of yield is a good development and suggestive that *B. bassiana* could be used as mycoinsecticides that will provide biological alternatives to chemical insecticides as earlier reported by Luangsa-Ard et al. (2005).

The result of this study indicated that proximate composition (moisture, dry matter, fat, ash, crude fiber, crude protein and carbohydrate content and mineral composition (Na, Cu, Ca Mg, P, Fe and K in the pods of sprayed and unsprayed okra plants were comparable. This shows that *B. bassiana* has no negative effect on the pods of the treated okra plants and could be used without any deleterious effect on the nutritional composition of okra pods from treated okra plants. This suggests that okra fruits from treated plots could be consumed without any treatment effect on proximate and major mineral composition of the okra fruit. Moniruzzaman et al. (2007) reported okra as a nutritious vegetable with rich source of vitamins, calcium, potassium and other minerals through its young immature pods which are consumed raw, cooked or fried.

The result of this study reflected the effectiveness of *B. bassiana* at reducing flea beetle infestation of treated plots. Similarly, higher yield of okra fruits was obtained from *B. bassiana*-treated plots. The mineral and proximate composition of *B. bassiana*-treated okra fruits was comparable with the mineral and proximate composition of the untreated okra fruits. The use of the treatment is therefore recommended for the control of *Podagrica* spp. in okra field.

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Table 1. Number of *Podagrica* spp. and yield of okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin.

	Varieties (V)	Spraying (S) 2014				Spraying (S) 2015			
		EPF	L	C	Mean	EPF	L	C	Mean
Number of *Podagrica* spp	NH 99/DA	1.01	1.00	1.62	**1.21**	3.53	3.07	13.53	**6.71**
	LD 88/1-8-5-2	1.03	1.00	1.47	**1.17**	3.20	3.87	12.80	**6.62**
	Mean	**1.02**	**1.00**	**1.55**		**3.37**	**3.47**	**13.17**	
	$LSD_{(0.05)}$	V=NS; S=0.05*; V X S=0.09*				V=NS; S=0.11*; V X S=1.07*			
Weight of pods/plot (g)	NH 99/DA	517.2	497.1	366.6	**460.3**	266.2	275.7	212.8	**251.6**
	LD 88/1-8-5-2	517.0	508.2	391.9	**472.4**	255.3	272.3	207.5	**245.0**
	Mean	**517.1**	**502.7**	**397.3**		**260.8**	**274.0**	**210.2**	
	$LSD_{(0.05)}$	V=NS; S=66.9*; V X S=49.8*				V=NS; S=41.9*; V X S=45.6*			

EPF = Entomopathogenic fungus (*Beauveria bassiana*) sprayed treatment
L = Lambda cyhalothrin sprayed treatment
C = Control (unsprayed treatment)
LSD = Least Significant Difference
* = Significantly Different
NS = Not Significantly Different
S = Sprayed Treatments
V = Varieties (NH 99/DA and LD 88/1-8-5-2)
V X S = Interaction of sprayed treatment and variety

Table 2. Number of leaves and percentage of damaged leaves in okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin.

	Varieties (V)	Spraying (S) 2014				Spraying (S) 2015			
		EPF	L	C	Mean	EPF	L	C	Mean
Number of leaves	NH 99/DA	9.80	10.42	10.47	**10.23**	10.17	11.72	9.49	**10.46**
	LD 88/1-8-5-2	10.09	10.85	9.89	**10.28**	9.35	10.90	9.89	**10.05**
	Mean	**9.95**	**10.64**	**10.18**		**9.76**	**11.31**	**9.69**	
	$LSD_{(0.05)}$	V=NS; S=NS; V X S=NS				V=NS; S=NS; V X S=NS			
Percentage leaf damaged	NH 99/DA	17.37	22.26	49.27	**29.63**	14.42	16.13	46.61	**25.72**
	LD 88/1-8-5-2	20.72	21.29	49.35	**30.45**	14.09	13.46	45.70	**24.42**
	Mean	**19.05**	**21.78**	**49.31**		**14.26**	**14.79**	**46.16**	
	$LSD_{(0.05)}$	V=NS; S=6.05*; V X S=7.23*				V=NS; S=5.02*; V X S=5.65*			

EPF = Entomopathogenic fungus (*Beauveria bassiana*) sprayed treatment
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NS = Not Significantly Different
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V = Varieties (NH 99/DA and LD 88/1-8-5-2)
V X S = Interaction of sprayed treatment and variety

Table 3. Plant height of okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin.

	Varieties (V)	Spraying (S) 2014				Spraying (S) 2015			
		EPF	L	C	Mean	EPF	L	C	Mean
3 WAP	NH 99/DA	19.19	19.75	21.27	**20.07**	10.90	12.40	11.63	**11.64**
	LD 88/1-8-5-2	18.91	19.24	18.19	**18.78**	12.00	13.57	11.53	**12.37**
	Mean	**19.05**	**19.49**	**19.73**		**11.45**	**12.98**	**11.58**	
	$LSD_{(0.05)}$	V=NS; S=NS; V X S=NS				V=NS; S=NS; V X S=NS			
6 WAP	NH 99/DA	31.08	29.38	37.40	**32.62**	20.10	21.67	21.60	**21.12**
	LD 88/1-8-5-2	32.14	30.97	34.52	**32.54**	21.23	23.23	21.47	**21.98**
	Mean	**31.61**	**30.18**	**35.96**		**20.67**	**22.45**	**21.54**	
	$LSD_{(0.05)}$	V=NS; S=NS; V X S=NS				V=NS; S=NS; V X S=NS			
9 WAP	NH 99/DA	61.80	59.50	62.90	**61.40**	42.83	43.07	43.70	**43.20**
	LD 88/1-8-5-2	62.70	61.50	64.70	**62.97**	42.73	41.60	43.20	**42.51**
	Mean	**62.25**	**60.50**	**63.80**		**42.78**	**42.34**	**43.45**	
	$LSD_{(0.05)}$	V=NS; S=NS; V X S=NS				V=NS; S=NS; V X S=NS			

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V X S = Interaction of sprayed treatment and variety

Table 4. Number of pods and percentage of okra pod damaged in okra plants treated with *Beauveria bassiana* and Lambda-cyhalothrin.

	Varieties (V)	Spraying (S) 2014				Spraying (S) 2015			
		EPF	L	C	Mean	EPF	L	C	Mean
Number of pods	NH 99/DA	4.65	4.76	4.60	**4.67**	4.67	4.77	3.53	**4.32**
	LD 88/1-8-5-2	5.49	5.47	5.32	**5.43**	4.73	4.70	3.63	**4.35**
	Mean	**5.07**	**5.12**	**4.96**		**4.70**	**4.74**	**3.58**	
	$LSD_{(0.05)}$	V=NS; S=NS; V X S=NS				V=NS; S=NS; V X S=NS			
Number of damaged pod	NH 99/DA	1.00	1.00	1.58	**1.19**	1.00	1.00	1.87	**1.29**
	LD 88/1-8-5-2	1.04	1.13	1.63	**1.27**	1.00	1.00	1.90	**1.30**
	Mean	**1.02**	**1.07**	**1.61**		**1.00**	**1.00**	**1.89**	
	$LSD_{(0.05)}$	V=NS; S=0.09*; V X S=0.02*				V=NS; S=0.31*; V X S=0.33*			
Percentage pod damaged	NH 99/DA	21.53	21.01	34.34	**25.63**	21.41	20.96	512.97	**31.78**
	LD 88/1-8-5-2	18.94	20.65	30.64	**23.41**	21.14	21.28	52.34	**31.59**
	Mean	**20.24**	**20.83**	**32.49**		**21.28**	**221.12**	**52.66**	
	$LSD_{(0.05)}$	V=NS; S=4.05*; V X S=5.19*				V=NS; S=5.31*; V X S=6.01*			

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S = Sprayed Treatments
V = Varieties (NH 99/DA and LD 88/1-8-5-2)
V X S = Interaction of sprayed treatment and variety

Table 5. Proximate composition (g/100g sample) of okra fruit from okra plant treated with *B. bassiana*.

Treatments (S)	Varieties (V)	EPF	Control	Mean
Moisture content	NH 99/DA	85.76	86.83	**86.29**
	LD 88/1-8-5-2	85.32	86.14	**85.73**
	Mean	**85.54**	**86.49**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Dry matter content	NH 99/DA	12.74	13.16	**12.95**
	LD 88/1-8-5-2	14.86	13.86	**14.36**
	Mean	**13.80**	**13.51**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Crude fat content	NH 99/DA	0.53	0.10	**0.32**
	LD 88/1-8-5-2	0.12	0.12	**0.12**
	Mean	**0.33**	**0.11**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Ash content	NH 99/DA	1.20	1.11	**1.16**
	LD 88/1-8-5-2	1.30	1.23	**1.27**
	Mean	**1.25**	**1.17**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Crude fibre content	NH 99/DA	2.81	2.93	**2.87**
	LD 88/1-8-5-2	3.36	3.19	**3.28**
	Mean	**3.09**	**3.06**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Crude protein content	NH 99/DA	1.96	1.87	**1.92**
	LD 88/1-8-5-2	2.36	2.07	**2.22**
	Mean	**2.16**	**1.97**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Carbohydrate content	NH 99/DA	6.34	7.16	**6.75**
	LD 88/1-8-5-2	7.55	7.26	**7.41**
	Mean	**6.95**	**7.21**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		

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Table 6. Mineral composition (g/100g sample) of okra fruit from okra plant treated with *B. bassiana*.

Treatments (S)	Varieties (V)	EPF	Control	Mean
Sodium (Na)	NH 99/DA	7.94	8.14	**8.04**
	LD 88/1-8-5-2	7.60	8.20	**7.90**
	Mean	**7.77**	**8.17**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Copper (Cu)	NH 99/DA	0.10	0.11	**0.11**
	LD 88/1-8-5-2	0.10	0.10	**0.10**
	Mean	**0.10**	**0.11**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Calcium (Ca)	NH 99/DA	77.34	77.84	**77.60**
	LD 88/1-8-5-2	75.81	78.27	**77.04**
	Mean	**76.58**	**78.06**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Magnesium (Mg)	NH 99/DA	56.60	57.86	**57.23**
	LD 88/1-8-5-2	56.91	58.67	**57.79**
	Mean	**56.76**	**58.27**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Phosphorus (P)	NH 99/DA	63.07	63.86	**63.47**
	LD 88/1-8-5-2	63.86	64.63	**64.25**
	Mean	**63.47**	**64.25**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Iron (Fe)	NH 99/DA	0.79	0.83	**0.81**
	LD 88/1-8-5-2	0.79	0.85	**0.82**
	Mean	**0.79**	**0.84**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		
Potassium (K)	NH 99/DA	291.50	319.00	**305.25**
	LD 88/1-8-5-2	308.50	319.50	**314.00**
	Mean	**300.00**	**319.50**	
	$LSD_{(0.05)}$	V = NS; S = NS; V X S = NS		

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LSD = Least Significant Difference
NS = Not Significantly Different
S = Sprayed Treatment
V = Varieties (NH 99/DA and LD 88/1-8-5-2)
V X S = Interaction of sprayed treatment and variety