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Bio-efficacy of *Beauveria Bassiana* (Balsamo) vuillemin against *Helicoverpa armigera* (hübner) and *Spodoptera litura* (Fabricius) in groundnut under laboratory condition

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Abstract
A laboratory experiment was conducted to determine the bio-efficacy of *B. bassiana* alone and in combination with different insecticides against *Helicoverpa armigera* (Hübner) and *Spodoptera litura* (Fabricius) in groundnut under laboratory condition at bio-control laboratory, Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh during *Kharif* season of 2018. The results indicated that the highest mortality of *H. armigera* was achieved in treatment of chlorantraniliprole 18.5 SC 0.006% as they registered 100% mortality at five days after treatment, whereas *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% (97.33%) and novaluron 10 EC 0.01% (96.33) were found next best treatments. While in case of *S. litura* the highest mortality was recorded in the treatment of chlorantraniliprole 18.5 SC 0.006% as they registered 100% mortality at five days after treatment, whereas novaluron 10 EC 0.01% (97.33%) and *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% were found next best treatments.

Keywords: *Beauveria bassiana* (Balsamo) Vuillemin, Groundnut, *H. armigera, S. litura*

Introduction
Oilseed crops have a specific place in Indian agriculture because edible oils are next to food grains in indian diet. Groundnut (*Arachis hypogaea* Linnaneus) is an important leguminous as well as an oilseed crop. As many as 52 species of insect pests are recorded infesting the groundnut crop in India. (Singh *et al.*, 1990) [4]. Among them *H. armigera* and *S. litura* are important pest infesting the groundnut. Preference of insecticides depends on their easy availability and applicability, but their excessive and indiscriminate use has resulted in the development of insecticidal resistance in the pests and environmental pollution (Phokela *et al.*, 1990) [3]. There is a need to explore alternatives, encompassing available pest control methods and techniques to reduce the sole dependence on insecticides. Among such eco-friendly approaches, entomopathogenic fungi form one of the most important components which are being employed to control noxious insect pest of groundnut ecosystem *viz*., *H. armigera* and *S. litura*. Among several entomopathogenic fungi, *B. bassiana* is the most important entomopathogenic fungus for its control as well as reducing the chances of development of resistance against *H. armigera* and *S. litura*. Looking to the importance of *B. bassiana* as a microbial control agent, and seriousness of *H. armigera* and *S. litura* and hazards of chemical pesticides, it is highly necessity to evaluate the bio-efficacy of *B. bassiana* alone and in combination with different insecticides against this pest infesting groundnut.

Materials and Methods
The laboratory experiment on groundnut (var. GJG-22) was conducted at bio-control laboratory, Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh during 2018. Fresh groundnut leaves were collected from the unsprayed groundnut field were washed properly with clean water and air-dried. The spray of each treatment (Table 1) was applied to leaves of groundnut separately with the help of atomizer. Care was taken to obtain uniform coverage of insecticide. Treated leaves were allowed to dry under the ceiling fan for 15 minutes. Then cotton plug soaked in water was attached to the cut end of the leaf petiole to avoid desiccation and then leaves were placed in plastic vial. The one day starved third instar larvae of *H. armigera* and *S. litura* were kept individually in plastic

vial. Then the treated leaves were provided as food for them. Twenty-five larvae per treatment in each repetition were kept. The larvae were provided with fresh untreated food after 24 hours of feeding on the treated food. Mortality counts were recorded 1, 3 and 5 days after the treatment. Data on mortality were converted into corrected per cent mortality of the pest in each treatment by using the modified formula given by Henderson and Tilton (1955) [1].

Results and Discussion

Data presented in Table 1 revealed that there was a significant difference in percentage larval mortality at every observation days. All the treatments were found significantly superior by giving higher mortality of *H. armigera* larvae to the control. A close perusal of larval mortality data at one day after the treatment indicated that the highest (76.67%) mortality was obtained in the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre and it was at par with combined treatment of *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre (72.33%). The treatments, novaluron 10 EC 0.01% @ 1 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre, quinalphos 25 EC 0.05% @ 2 ml/litre, and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre remained in next order with 67.67%, 62.00%, 61.67% and 53.33% larval mortality, respectively. *B. bassiana* 1.15% WP 0.006% @ 5.0 g/litre was found the poorest (35.00% mortality) among all treatments, as it is initially slow action of fungus against target pest.

The mortality was increased at third day after treatment. The data showed that the highest (92.00%) mortality was obtained in the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre which was followed by the treatment of *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre, novaluron 10 EC 0.01% @ 1 ml/litre, quinalphos 25 EC 0.05% @ 2 ml/litre and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre caused 90.33%, 82.67%, 81.67%, 75.00% and 73.33% larval mortality, respectively. The *B. bassiana* 1.15 WP 0.006% @ 5.0 g/litre showed the lowest (50.00%) per cent mortality.

Perusal of results on mortality of *H. armigera* at 5 days after treatment revealed that chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre gave the highest (100.00%) mortality, which was followed by the treatments of *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre (97.33%). The next better treatments were novaluron 10 EC 0.01% @ 1 ml/litre, quinalphos 25 EC 0.05% @ 2 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre as it exhibited 96.33%, 94.67%, 93.00%, and 88.67% mortality, respectively. The remaining treatment, *B. bassiana* 1.15 WP 0.006% @ 5.0 g/litre was less effective, as it showed 66.67% mortality.

The mean results revealed that the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre found to be the most effective insecticide, as it recorded 100% mortality of this pest and it was at par with *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre followed by novaluron 10 EC 0.01% @ 1 ml/litre, quinalphos 25 EC 0.05% @ 2 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre. *B. bassiana* 1.15% WP @ 5.0 g/litre showed that the toxicity from 1st day of application, increased gradually in subsequent periods and showed up to maximum toxicity at 5th day of application where it was found more or less comparable with chemical insecticides (Plate-1).

Plate 1: Experimental set up for evaluation of *B. bassiana* against *H. armigera* under laboratory condition

Table 1: Bio-efficacy of *B. bassiana* alone and in combination with different insecticides against *H. armigera* in groundnut under laboratory condition

Sr. No.	Treatments	Per cent corrected mortality		
		1 DAS	3 DAS	5 DAS
1.	*B. bassiana* 1.15 WP 0.006% @ 5 g/litre	36.24 (35.00)	45.00 (50.00)	54.75 (66.67)
2.	Quinalphos 25 EC 0.05% @ 2 ml/litre	51.84 (61.67)	60.07 (75.00)	76.66 (94.67)
3.	Novaluron 10 EC 0.01% @ 1 ml/litre	55.36 (67.67)	64.69 (81.67)	78.98 (96.33)
4.	Chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre	61.12 (76.67)	73.59 (92.00)	84.26 (100.00)
5.	*B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre	46.91 (53.33)	58.93 (73.33)	70.44 (88.67)
6	*B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre	51.95 (62.00)	65.43 (82.67)	74.68 (93.00)
7	*B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre	58.28 (72.33)	71.92 (90.33)	80.92 (97.33)
8	Control	5.74 (0.00)	5.74 (0.00)	5.74 (0.00)
	S.Em.±	1.38	1.10	0.97
	C.D. at 5%	4.17	3.33	2.92
	C.V.%	5.19	3.44	2.56

Figures in the parenthesis are original values, while outside values are arcsine transformed. DAS = Days after Spraying Local strain of *B. bassiana* $2x10^6$ cfu/g was used.

Data presented in Table 2 revealed that the larval mortality of *S. litura* at one day after the treatment indicated that the highest (80.33%) mortality was obtained in the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre which was followed by treatment of *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre, novaluron 10 EC 0.01% @ 1 ml/litre, quinalphos 25 EC 0.05% @ 2 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron

10 EC 0.005% @ 2.5 g + 0.5 ml/ litre and *B. bassiana* 1.15 WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre remained in next order with larval mortality 71.00%, 70.00%, 64.33%, 61.00% and 58.33%, respectively. *B. bassiana* 1.15% WP @ 5.0 g/litre was found the poorest (40.00% mortality) among all treatments, as it was initially slow in action against target pest.

The mortality was increased at third day after treatments. The data showed that the highest (95.67%) mortality was obtained in the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre which was followed by the treatment of *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre, novaluron 10 EC 0.01% @ 1 ml/litre, quinalphos 25 EC 0.05% @ 2 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre, and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre caused 90.67%, 87.67%,79.33%, 74.33%, and 65.00% larval mortality, respectively. The *B. bassiana* 1.15 WP 0.006% @ 5.0 g/litre showed the lowest (60.33%) mortality percentage.

Perusal of results on mortality of *S. litura* at 5 days after treatment revealed that chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre gave the highest (100.00%) mortality, which was followed by the treatments of novaluron 10 EC 0.01% @ 1 ml/litre (97.33%). The next better treatments were *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre, quinalphos 25 EC 0.05% @ 2 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/litre and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre as it exhibited 97.00%, 93.33%, 85.67%, and 80.67% mortality, respectively. The remaining treatment, *B. bassiana* 1.15 WP 0.006% @ 5.0 g/litre was less effective, as it showed 69.33% mortality.

Thus, this study convinced that the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre found to be the most effective insecticide, as it recorded 100% mortality of *S. litura* followed by novaluron 10 EC 0.01% @ 1 ml/litre and *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5 g + 0.15 ml/litre followed by quinalphos 25 EC 0.05% @ 2 ml/litre, *B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% @ 2.5 g + 0.5 ml/ litre and *B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% @ 2.5 g + 1 ml/litre. *B. bassiana* 1.15% WP @ 5.0 g/litre showed that the toxicity from 1st day of application, increased gradually in subsequent periods, up to maximum toxicity at 5th day of application and found more or less comparable with chemical insecticides (Plate-2).

Plate 2: Experimental set up for evaluation of B. bassiana against S. litura under laboratory condition

Table 2: Bio-efficacy of *B. bassiana* alone and in combination with different insecticides against *S. litura* in groundnut under laboratory condition

Sr. No.	Treatments	Per cent corrected mortality		
		1 DAS	3 DAS	5 DAS
1.	*B. bassiana* 1.15 WP 0.006% @ 5 g/litre	39.23 (40.00)	50.96 (60.33)	56.38 (69.33)
2.	Quinalphos 25 EC 0.05% @ 2 ml/litre	53.35 (64.33)	62.97 (79.33)	75.24 (93.33)
3.	Novaluron 10 EC 0.01% @ 1 ml/litre	56.84 (70.00)	69.50 (87.67)	80.73 (97.33)
4.	Chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre	63.68 (80.33)	78.00 (95.67)	84.26 (100.00)
5.	*B. bassiana* 1.15WP 0.003% + quinalphos 25 EC 0.025% (2.5 g + 1 ml/litre)	49.83 (58.33)	53.73 (65.00)	63.92 80.67)
6	*B. bassiana* 1.15WP 0.003% + novaluron 10 EC 0.005% (2.5 g + 0.5 ml/litre)	51.36 (61.00)	59.61 (74.33)	67.79 (85.67)
7	*B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% (2.5 g + 0.15 ml/litre)	57.42 (71.00)	72.23 (90.67)	80.12 (97.00)
8	Control	5.74 (0.00)	5.74 (0.00)	5.74 (0.00)
	S.Em.±	1.21	0.81	0.99
	C.D. at 5%	3.67	2.44	2.99
	C.V.%	4.47	2.48	2.68

Figures in the parenthesis are original values, while outside values are arcsine transformed. DAS = Days after Spraying Local strain of *B. bassiana* $2x10^6$ cfu/g was used.

In the present study, chlorantraniliprole caused 100% mortality in *H. armigera* and *S. litura* which in close agreement with the work of Karuppaiah and Chitra (2013) [2] they reported that the LC_{50} obtained by leaf-dip method showed that chlorantraniliprole 18.5 SC 0.0001% was most effective against *S. litura*. Su *et al*. (2012) [5] worked out baseline value of chlorantranilliprole for laboratory strain of *S. litura* reported most susceptible to chlorantranilliprole (LC_{50}: 4.20 µg a.i. /ml). Temple *et al*. (2009) [6] revealed that rynaxypyr (chlorantranilliprole) was highly toxic to bollworm, *Helicoverpa zea* (Boddie), fall armyworm, *Spodoptera frugiperda* (Smith) and tobacco budworm, *Heliothis virescense* (Fabricius) in all the three laboratory bioassay procedures (*viz*., insecticide treated diet, topical application and adult vial test) which is in line with present study. Thus, the present findings conform with findings of earlier workers.

The laboratory study concluded that the treatment of chlorantraniliprole 18.5 SC 0.006% @ 0.3 ml/litre and *B. bassiana* 1.15 WP 0.003% + chlorantraniliprole 18.5 SC 0.003% @ 2.5g + 0.15ml/litre or novaluron 10 EC 0.01% @ 1ml/litre was found as effective as the recommended insecticides for mortality of *H. armigera* and *S. litura* larvae on groundnut.

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