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***Research Article***

# ECO-FRIENDLY MANAGEMENT STRATEGIES AGAINST POD BORER COMPLEX OF COWPEA, *VIGNA UNGUICULATA* VAR. *SESQUIPEDALIS* (L.) VERDCOURT

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## ABSTRACT
Field experiments were conducted at College of Horticulture, Thrissur, to evaluate the efficacy of a botanical *viz.*, azadirachtin (0.005%), bioagents *viz.*, *Beauveria bassiana* (1%), *Metarhizium anisopliae* (1%), *Bacillus thuringiensis* (0.2%) along with their sequential application (azadirachtin followed by *B. bassiana / M. anisopliae / B. thuringiensis*), a safer chemical *viz.*, flubendiamide 480SC (0.008%) and a standard check (quinalphos 0.05%) against pod borer complex of cowpea. Results showed that after three consecutive sprays at fortnightly intervals starting from flowering, flubendiamide was found to be the most effective in managing the larval population of pod borers, viz., *Maruca vitrata* (Fabricius), *Lampides boeticus* (L.). Azadirachtin, *M. anisopliae* and *B. thuringiensis* recorded larval population below economic threshold level (ETL) starting from 14$^{th}$ day after first spraying till the end of cropping period. With respect to per cent pod damage (in terms of number and weight) flubendiamide was found to be significantly superior over control and all other treatments were on par. Though quinalphos recorded the highest total yield both in terms of weight and number, application of flubendiamide resulted in highest number of marketable pods. It also recorded the highest B: C ratio (1.69) followed by quinalphos (1.53) and *B. bassiana* (1.22).

***Keywords:*** *Azadirachtin, Bioagents, Flubendiamide, Pod Borers, Maruca Vitrata, Lampides Boeticus*

## INTRODUCTION
The pod borer complex posing serious threat to cowpea cultivation includes *Maruca vitrata* (Fabricius), *Lampides boeticus* (L.), *Helicoverpa armigera* (Hubner), *Etiella zinckenella* Treitsche, *Adisura atkinsoni* Moore and *Exelastis atomosa* (Walsingham).

Among these pod borers, *M. vitrata* was found to be the predominant species in South India (Kolarath, 2010).

Application of highly toxic chemical insecticides at short intervals against insect pests has resulted in many deleterious effects such as residual toxicity, insecticide resistance, pest resurgence, destruction of natural enemies and environmental pollution.

In this context, the relevance of the use of botanicals, entomopathogenic fungi and green labelled newer chemicals for managing pod borer complex assumes greater significance.

Azadirachtin containing formulations are effective in reducing the larval population of pod borers and contribute to a higher yield (Singh and Yadav, 2006).

Biopesticides like *Beauveria bassiana* and *Metarhizium anisopliae* have been reported to cause pathogenicity to legume pod borers (NBAII, 2010; Kulkarni *et al.*, 2005). The crystal inclusions derived from *Bacillus thuringiensis* var. *kurstaki* is generally lepidopteran specific and its effectiveness against the larvae of *H. armigera* was reported by Dhaliwal and Arora (1996).

Flubendiamide, a novel green labelled insecticide with selective toxicity to lepidopterans is effective for the management of pod borer complex of pigeonpea (Dey *et al.*, 2012).

## MATERIALS AND METHODS

Field experiments were conducted at College of Horticulture during *rabi* season to evaluate the efficacy of the botanical *viz.*, azadirachtin (0.005%), bioagents *viz.*, *Beauveria bassiana* (1%), *Metarhizium anisopliae* (1%), *Bacillus thuringiensis* (0.2%) along with their sequential application (azadirachtin followed by *B. bassiana*, azadirachtin followed by *M. anisopliae*, azadirachtin followed by *B. thuringiensis*), the safer chemical *viz.*, flubendiamide 480SC (0.008%) and a standard check (quinalphos 0.05%) against pod borer complex of cowpea.

The experiment was laid out in Randomized Complete Block Design (RCBD) with ten treatments and three replications.

A short duration bushy vegetable cowpea variety *Bhagyalakshmi* was used for the experiment. Application of treatments was started 48 days after sowing (at 50% flowering stage of the crop) when pod borer incidence was above economic threshold level (1 larva per two plants of pigeonpea for *H. armigera and M. vitrata*) (Pal and Gupta, 1994)). Spraying was repeated at fortnightly intervals.

### *Larval Population*

The larval population was estimated by counting the number of live larvae on pods and flowers on 10 tagged plants in each plot. Observations on larval population were taken one day prior to treatment application and at five, seven and 14 days after treatment (DAT).

Data on larval counts were transformed using square root transformation. Population differences on five, seven and 14 days after each application were first tested by one way ANOVA. Subsequently the transformed data were analyzed by analysis of covariance (ANOCOVA), taking population density prior to treatment application as covariate. The result obtained was subjected to DMRT.

### *Pod Damage*

The matured pods were harvested plot wise and per cent infestation (on number and weight basis) was worked out.

$$\text{Per cent pod infestation} = \frac{\text{Number/ weight of damaged pods}}{\text{Number/ weight of pods}} \times 100$$

Per cent pod damage was subjected to logit transformation and transformed data was analyzed by ANOVA and the means were separated by DMRT.

### *Yield*

The total yield and marketable yield were recorded in terms of pod number and weight and per cent marketable yield was calculated. Benefit cost ratio was worked out to assess the economic feasibility.

## RESULTS AND DISCUSSION

The results obtained after three consecutive sprays showed that flubendiamide consistently recorded the lowest population of pod borer larvae from fifth day after the first spray (Table 1). Hence application of flubendiamide was found to be the best compared to the botanical and bioagents in reducing the larval population of pod borers throughout the growing season of cowpea. In the case of quinalphos, the population of pod borers decreased from 2.35 to 1.30 larvae per plant on seven days after first spraying. Thereafter the population showed an increasing tendency (Table 1).

Similar trend was observed during the second and third spraying also. As quinalphos is a contact insecticide with residual toxicity lasting up to seven days, the new flowers and pods developed on the plants after the application of treatments might not be having the active ingredient deposited on it. So the newly formed flowers and pods get fresh infestation.

Hence repeated application of quinalphos at seven days interval can effectively manage pod borer complex.

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**Table 1: Larval population of pod borer complex in different treatments after first, second and third spraying**

| Tr. No. | Treatments | Number of larvae per plant | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **First spraying** | | | | **Second spraying** | | | | **Third spraying** | | |
| | | † **PTC** | †† **5 DAT** | †† **7 DAT** | †† **14 DAT** | † **PTC** | †† **5 DAT** | †† **7 DAT** | †† **14 DAT** | † **PTC** | †† **5 DAT** | †† **7 DAT** |
| T1 | Azadirachtin 0.005% | 1.70 (1.45)$^{a}$ | 1.90 (1.71)$^{abc}$ | 1.25 (1.46)$^{a}$ | 0.30 (0.92)$^{a}$ | 0.30 (0.878)$^{a}$ | 0.05 (0.74)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.30 (0.89)$^{bc}$ | 0.30 (0.89)$^{cd}$ | 0.10 (0.80)$^{a}$ | 0.10 (0.79)$^{a}$ |
| T2 | *Beauveria bassiana* 1% | 2.95 (1.85)$^{a}$ | 3.05 (1.64)$^{bc}$ | 1.00 (0.95)$^{a}$ | 0.10 (0.72)$^{a}$ | 0.10 (0.772)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.05 (0.75)$^{a}$ | 0.70 (1.08)$^{bc}$ | 0.70 (1.09)$^{bc}$ | 0.60 (1.03)$^{a}$ | 0.40 (0.92)$^{a}$ |
| T3 | *Metarhizium anisopliae* 1% | 2.45 (1.71)$^{a}$ | 2.50 (1.66)$^{abc}$ | 1.20 (1.19)$^{a}$ | 0.50 (0.98)$^{a}$ | 0.50 (1.000)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.00 (0.70)$^{a}$ | 0.45 (0.99)$^{bc}$ | 0.45 (0.97)$^{bcd}$ | 0.30 (0.92)$^{a}$ | 0.25 (0.88)$^{a}$ |
| T4 | *Bacillus thuringiensis* var. *kurstaki* 0.2% | 2.60 (1.76)$^{a}$ | 3.30 (1.82)$^{abc}$ | 1.40 (1.15)$^{a}$ | 0.15 (0.77)$^{a}$ | 0.15 (0.801)$^{a}$ | 0.05 (0.74)$^{a}$ | 0.05 (0.75)$^{a}$ | 0.30 (0.88)$^{bc}$ | 0.30 (0.89)$^{cd}$ | 0.25 (0.91)$^{a}$ | 0.15 (0.83)$^{a}$ |
| T5 | Azadirachtin 0.005% f.b. *B. bassiana* 1% | 1.50 (1.38)$^{a}$ | 2.50 (1.98)$^{ab}$ | 1.10 (1.48)$^{a}$ | 0.30 (0.95)$^{a}$ | 0.30 (0.887)$^{a}$ | 0.10 (0.77)$^{a}$ | 0.10 (0.77)$^{a}$ | 0.60 (1.04)$^{bc}$ | 0.60 (1.04)$^{bcd}$ | 0.45 (0.97)$^{a}$ | 0.35 (0.92)$^{a}$ |
| T6 | Azadirachtin 0.005% f.b. *M. anisopliae* 1% | 1.80 (1.47)$^{a}$ | 2.50 (1.88)$^{ab}$ | 0.50 (1.16)$^{a}$ | 0.20 (0.88)$^{a}$ | 0.20 (0.837)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.05 (0.74)$^{a}$ | 0.50 (0.99)$^{bc}$ | 0.50 (1.00)$^{bcd}$ | 0.55 (1.03)$^{a}$ | 0.45 (0.97)$^{a}$ |
| T7 | Azadirachtin 0.005% f.b. *B. thuringiensis* 0.2% | 1.75 (1.50)$^{a}$ | 3.70 (2.19)$^{a}$ | 1.05 (1.39)$^{a}$ | 0.10 (0.81)$^{a}$ | 0.10 (0.772)$^{a}$ | 0.10 (0.78)$^{a}$ | 0.15 (0.81)$^{a}$ | 0.95 (1.19)$^{ab}$ | 0.95 (1.20)$^{ab}$ | 0.50 (0.95)$^{a}$ | 0.50 (0.97)$^{a}$ |
| T8 | Quinalphos 0.05% | 2.35 (1.69)$^{a}$ | 1.45 (1.40)$^{c}$ | 1.30 (1.26)$^{a}$ | 1.40 (1.25)$^{a}$ | 1.40 (1.262)$^{a}$ | 0.05 (0.73)$^{a}$ | 0.00 (0.69)$^{a}$ | 0.50 (1.04)$^{bc}$ | 0.50 (1.00)$^{bcd}$ | 0.10 (0.79)$^{a}$ | 0.00 (0.72)$^{a}$ |
| T9 | Flubendiamide 0.008% | 3.15 (1.91)$^{a}$ | 0.55 (0.75)$^{d}$ | 0.10 (0.47)$^{a}$ | 0.01 (0.64)$^{a}$ | 0.01 (0.707)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.10 (0.75)$^{c}$ | 0.10 (0.78)$^{d}$ | 0.00 (0.79)$^{a}$ | 0.00 (0.76)$^{a}$ |
| T10 | Control( No treatments) | 2.35 (1.65)$^{a}$ | 2.60 (1.72)$^{abc}$ | 1.60 (1.32)$^{a}$ | 0.60 (1.05)$^{a}$ | 0.60 (1.049)$^{a}$ | 0.20 (0.83)$^{a}$ | 0.25 (0.86)$^{a}$ | 1.65 (1.48)$^{a}$ | 1.65 (1.46)$^{a}$ | 0.60 (0.91)$^{a}$ | 0.45 (0.89)$^{a}$ |

*DAT- Days After Treatment, PTC- Pre Treatment Count, f.b. - followed by*
*In a column mean followed by a common letter are not significantly different by DMRT (P= 0.05)*
*†- Values in the parenthesis are square root transformed values, ††- Values in the parenthesis are adjusted means of square root transformed values based on ANOCOVA*

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**Table 2: Effect of treatments on per cent pod damage (in terms of number and weight), total yield, marketable yield, per cent marketable yield and BC ratio**

| Tr. No. | Treatments | Per cent infestation by number | | | Per cent infestation by weight | | | Total yield | | Marketable yield | | Per cent marketable yield | | Benefit Cost Ratio* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | First Harvest | Second Harvest | Third Harvest | First Harvest | Second Harvest | Third Harvest | Pod number | Pod weight (kg) | Pod number | Pod weight (kg) | Pod number | Pod weight | |
| T1 | Azadirachtin 0.005% | 23.36 (-1.21)$^{a}$ | 11.27 (-2.27)$^{a}$ | 4.01 (-3.18)$^{d}$ | 24.26 (-1.18)$^{a}$ | 10.26 (-2.34)$^{a}$ | 2.83 (-3.55)$^{a}$ | 1081.50$^{a}$ | 3.90$^{a}$ | 909.50$^{bc}$ | 3.20$^{a}$ | 84.13$^{b}$ | 81.92$^{a}$ | 0.97 |
| T2 | *Beauveria bassiana* 1% | 31.98 (-0.76)$^{a}$ | 11.60 (-2.04)$^{a}$ | 8.22 (-2.41)$^{bc}$ | 23.45 (-1.38)$^{a}$ | 18.38 (-1.55)$^{a}$ | 5.52 (-2.87)$^{a}$ | 1426.00$^{a}$ | 4.97$^{a}$ | 1141.00$^{abc}$ | 3.96$^{a}$ | 80.02$^{b}$ | 79.66$^{a}$ | 1.22 |
| T3 | *Metarhizium anisopliae* 1% | 34.31 (-0.68)$^{a}$ | 22.32 (-1.27)$^{a}$ | 4.59 (-3.07)$^{cd}$ | 34.57 (-0.67)$^{a}$ | 14.65 (-1.78)$^{a}$ | 4.97 (-2.95)$^{a}$ | 1145.50$^{a}$ | 4.55$^{a}$ | 886.50$^{bc}$ | 3.56$^{a}$ | 77.37$^{b}$ | 78.13$^{a}$ | 1.09 |
| T4 | *Bacillus thuringiensis* var. *kurstaki* 0.2% | 30.51 (-0.83)$^{a}$ | 25.37 (-1.08)$^{a}$ | 9.13 (-2.31)$^{b}$ | 34.86 (-0.63)$^{a}$ | 18.50 (-1.52)$^{a}$ | 7.01 (-2.67)$^{a}$ | 1307.00$^{a}$ | 5.34$^{a}$ | 976.00$^{bc}$ | 3.92$^{a}$ | 74.92$^{b}$ | 73.48$^{a}$ | 1.20 |
| T5 | Azadirachtin 0.005% f.b. *B. bassiana* 1% | 20.48 (-1.47)$^{a}$ | 16.05 (-1.66)$^{a}$ | 7.26 (-2.57)$^{bcd}$ | 19.22 (-1.57)$^{a}$ | 14.67 (-1.76)$^{a}$ | 6.42 (-2.70)$^{a}$ | 957.00$^{a}$ | 3.67$^{a}$ | 818.00$^{bc}$ | 3.09$^{a}$ | 86.03$^{b}$ | 84.06$^{a}$ | 0.94 |
| T6 | Azadirachtin 0.005% f.b. *M. anisopliae* 1% | 29.98 (-0.90)$^{a}$ | 16.34 (-1.63)$^{a}$ | 5.37 (-2.92)$^{bcd}$ | 29.18 (-0.95)$^{a}$ | 14.04 (-1.81)$^{a}$ | 5.37 (-2.91)$^{a}$ | 993.00$^{a}$ | 3.03$^{a}$ | 778.00$^{c}$ | 2.31$^{a}$ | 78.72$^{b}$ | 76.07$^{a}$ | 0.71 |
| T7 | Azadirachtin 0.005% f.b. *B. thuringiensis* 0.2% | 20.87 (-1.38)$^{a}$ | 13.02 (-1.98)$^{a}$ | 6.30 (-2.76)$^{bcd}$ | 21.53 (-1.34)$^{a}$ | 18.70 (-1.47)$^{a}$ | 6.48 (-2.89)$^{a}$ | 1388.50$^{a}$ | 4.47$^{a}$ | 1178.00$^{ab}$ | 3.66$^{a}$ | 84.36$^{b}$ | 81.97$^{a}$ | 1.12 |
| T8 | Quinalphos 0.05% | 16.41 (-1.69)$^{a}$ | 14.99 (-1.86)$^{a}$ | 9.67 (-2.33)$^{b}$ | 13.73 (-1.88)$^{a}$ | 14.17 (-1.96)$^{a}$ | 8.19 (-2.52)$^{a}$ | 1614.50$^{a}$ | 5.86$^{a}$ | 1371.50$^{a}$ | 4.99$^{a}$ | 85.79$^{b}$ | 85.23$^{a}$ | 1.53 |
| T9 | Flubendiamide 0.008% | 4.62 (-3.03)$^{a}$ | 0.52 (-6.89)$^{b}$ | 5.58 (-2.83)$^{bcd}$ | 3.50 (-3.33)$^{a}$ | 0.40 (-7.03)$^{b}$ | 5.87 (-2.87)$^{a}$ | 1516.50$^{a}$ | 5.71$^{a}$ | 1463.00$^{a}$ | 5.56$^{a}$ | 96.44$^{a}$ | 97.37$^{a}$ | 1.69 |
| T10 | Control( No treatments) | 23.91 (-1.23)$^{a}$ | 14.51 (-1.82)$^{a}$ | 16.93 (-1.59)$^{a}$ | 16.55 (-1.64)$^{a}$ | 14.60 (-1.80)$^{a}$ | 12.12 (-2.01)$^{a}$ | 1013.50$^{a}$ | 3.64$^{a}$ | 813.50$^{bc}$ | 3.05$^{a}$ | 80.76$^{b}$ | 83.79$^{a}$ | 0.99 |

*f.b. – followed by*
*In a column mean followed by a common letter are not significantly different by DMRT (P= 0.05)*
*Values in the parenthesis are logit transformed values*
**The price of the produce is taken as Rs. 40 per kg*

With respect to per cent pod damage (in terms of number and weight), flubendiamide was significantly superior to control and all other treatments were on par. Though quinalphos recorded the highest total yield both in terms of weight and number, application of flubendiamide resulted in the highest number of marketable pods. The total yield recorded in terms of pod weight was higher in *B. thuringiensis* among other bioagents. Azadirachtin followed by *B. thuringiensis* application resulted in high marketable yield among bioagents and botanical, followed by *B. bassiana* and were on par with the two chemical insecticides (Table 2).
Application of flubendiamide gave the highest B: C Ratio (1.69) and it was followed by quinalphos (1.53). Highest return (Rs. 987554.57/ha) obtained from flubendiamide balanced the high cost of the chemical (Rs. 35110.33/ha) needed to spray one hectare area and gave the highest B: C ratio. Among the bioagents, *B. bassiana* (T2) resulted in the highest B: C Ratio (1.22) followed by *B. thuringiensis* (1.20), azadirachtin f.b. *B. thuringiensis* (1.12) and *M. anisopliae* (1.09) (Table 2).

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