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Field efficacy of insecticides against pod borer, *Maruca vitrata* Geyer infesting lablab bean

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Abstract
The present investigation was carried out to study the field efficacy of insecticides against pod borer, *Maruca vitrata* Geyer infesting lablab bean. A statistically designed field experiment was conducted with Randomized Block Design with three replications and nine treatments during *Rabi* season of 2017-18 and 2018-19 at Botany farm, College of Agriculture, Dapoli. The results on pooled data of both of years, the overall mean per cent pod damage five plants^{-1} of all observations revealed that the treatment T_1 (Spinosad 45 SC) was significantly superior over rest of the treatments by recording 4.20 overall mean per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) was at par with T_8 (Emamectin benzoate 5 SG) recorded 5.13 per cent pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) which was at par with treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded 6.90, 8.21 and 8.36 per cent pod damage five plant^{-1}, respectively. Whereas, the next treatments T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which were at par with each other and recorded (11.41%, 12.03% and 12.70%) pod damage five plants^{-1}, respectively. The maximum (33.25%) pod damage five plants^{-1} was recorded in treatment T_9 (Control water spray).

Keywords: pod borer, *maruca vitrata* gayer, efficacy, insecticides

Introduction

Dolichos bean, *Lablab purpureus* (L.) Sweet commonly known as "lablab bean", "hyacinth bean", "field bean", "Indian bean" or "*Wal*" is one of the important vegetable crops grown in different parts of the country. India is recognized as a major contributor of pulses in the world having about 25 per cent share in the global production and 32 per cent of global acreage in the world. The area and production of pulses crops in the Country are 24.31 million hectares and 19.27 million tonnes, respectively with productivity of 631.9 kg ha^{-1} (Anon., 2016) [1]. Maharashtra ranks first in acreage and production of pulses followed by Madhya Pradesh, Uttar Pradesh, Rajasthan, Orissa, Haryana, Gujarat, Karnataka, Tamilnadu and Andra Pradesh. In Maharashtra, the total pulse production was 34.46 lakh tonnes, which was produced from 38.26 lakh ha with an average production of 900 kg ha^{-1} in the year 2015-2016 while in Konkan region total pulse area was 27.2 thousand ha which produced 16.70 thousand tonnes (Anon., 2016) [1]. Govindan (1974) [3] recorded as many as 55 species of insects and one species of mite feeding on the crop from seedling stage till the harvest of the crop in Karnataka. However, only a few of them such as pod borers were considered to be most destructive and they appeared regularly causing economic loss, whereas others were considered as minor pests. The pod borers complex include *Helicoverpa armigera* (Hubner), *Adisura atkinsoni* (Moore), *Maruca testulalis* (Geyer), *Maruca vitrata* (Geyer), *Etiella zinckenella* (Treitschke), *Cydia ptychora* (Meyrick), *Exelastis atomosa* (Walshinghan), Sphenarches caffer (Zeller) and *Lampides boeticus* (Linnaeus). *Boeticus* (Linnaeus).Among the various pests, pod borer complex causing 80 per cent pod damage. The larvae of pod borer, *M. vitrata* to cause considerable damage to lablab bean attacking buds, flowers, pods and seeds. The larva further damages the reproductive parts of flower leading to poor pod setting, pod formation and reduction in grain yield. (Swamy *et al*., 2015)[14]. In view of the importance of lablab bean seriousness of pod borer, *M. vitrata* the present investigation was planned.

Materials and Methods

A statistically designed field experiment with randomized block design was conducted during 2017-18 and 2018-19 at Botany farm, Dr. B.S.K.K.V., Dapoli.

Experimental details

Location	:	Botany farm, Dr. B.S.K.K.V., Dapoli
Design	:	Randomized Block Design (RBD)
Replications	:	Three
Treatments	:	Nine
Season	:	*Rabi* 2017-18, 2018-19
Crop	:	Lablab bean
Variety	:	Konkan *Wal* – 2
Plot Size - Gross Plot	:	3 m x 2.7 m (8.1 m^2)
Net Plot	:	2.7 m x 2.4 m (6.48 m^2)
Spacing	:	30 x 30 cm
Total Experimental Area	:	357.54 m^2 (119.18 m^2 x 3)

Treatment Details

Treatments		**Insecticides**	**Conc. (%)**	**Dose**
T_1	:	Spinosad 45 SC	0.015	0.3 ml l^{-1}
T_2	:	Azadirachtin 10000 ppm (1%)	0.003	3 ml l^{-1}
T_3	:	Deltamethrin 2.8 EC	0.0025	0.9 ml l^{-1}
T_4	:	Malathion 50 EC	0.05	1ml l^{-1}
T_5	:	*Beauveria bassiana* 1.15 WP 1x10^8 cfu g^{-1}	-	5 g l^{-1}
T_6	:	*Verticillium lecanii* 1.15 WP 1x10^8 cfu g^{-1}	-	5 g l^{-1}
T_7	:	*Metarrhizium anisopliae* 1.15 WP 1x10^8 cfu g^{-1}	-	5 g l^{-1}
T_8	:	Emamectin benzoate 5 SG	0.0016	0.32 g l^{-1}
T_9	:	Control (Water spray)	-	-

Method of recording observations

The observations on pod borer were recorded from five randomly selected plants of lablab bean. The per cent pod infestation was worked out on the basis of healthy and damaged pods at 3rd, 7th, 10th and 14th days after spraying. On the basis of this, per cent pod damage was calculated by using following formula;

$$\text{Per cent Pod damage} = \frac{\text{No. of damaged pods}}{\text{Total no. of pods}} \times 100$$

Pre-treatment observation was recorded 24 hrs. before first spray. Spraying was taken as and when pest incidence was observed on lablab bean. Second spraying were done as need base spray. The data thus obtained was subjected to appropriate transformation and analyzed statistically.

Preparation of spray solution and method of application

The actual quantity of spray volume required per treatment per plot was calibrated by using water alone. At the time of preparation of spray solution, the measured quantity of insecticide was mixed in desired quantity of water. The spray solution was thoroughly stirred with the help of wooden stick and then sprayed uniformly on the crop. The 500 liters of spray solution was used per hectare. Spraying was undertaken by using knapsack sprayer. The spraying of insecticide was done after initiation of the pest. Another application was done 15 days after first spray. Care was taken to wash the spray pump with water and soap thoroughly well before using other insecticides.

Result and Discussion

1. To study the efficacy of insecticides on pod borer, *M. vitrata* infesting lablab bean during *Rabi* 2017-18

The data pertaining on the per cent pod damage of lablab bean by pod borer, *M. vitrata* per five plants during *Rabi* 2017-2018 at 3rd, 7th, 10th and 14th days after spraying are presented in Table 1 and depicted in Fig. 1. The per cent pod damage of lablab bean by pod borer, *M. vitrata* five plants^{-1} prior to application of treatments was ranged from 9.65 to 17.95. The difference among the treatments was non-significant, indicating uniform damage.

First spray

The data on per cent pod damage five plants^{-1} on third day after first spray revealed that minimum pod damage (7.91%) recorded in treatment T_1 (Spinosad 45 SC) which was at par with treatments and T_8 (Emamectin benzoate 5 SG) and T_2 (Azadirachtin 10000 ppm) which recorded 10.62 and 10.72 per cent pod damage five plants^{-1}, respectively. The next best treatment T_3 (Deltamethrin 2.8 EC) which was at par with the treatments T_4 (Malathion 50 EC), T_5 (*Beauveria bassiana*) and T_7 (*Metarrhizium anisopliae*) recorded (13.06%, 13.13%, 15.59% and 16.25%) pod damage five plants^{-1}, respectively. The 16.76 per cent pod damage five plants^{-1} was recorded treatment T_6 (*Verticillium lecanii*). The maximum (20.88%) pod damage five plants^{-1} observed in T_9 (Control water spray). The observations recorded on seventh day after first spray revealed that the treatment T_1 (Spinosad 45 SC) which was at par with treatments T_8 (Emamectin benzoate 5 SG) and T_2 (Azadirachtin 10000 ppm) recorded (6.77%, 8.46% and 10.45%) pod damage five plants^{-1}. The treatment T_3 (Deltamethrin 2.8 EC) was found to be next best treatment and recorded 12.18 per cent pod damage five plant^{-1}. The treatments T_4 (Malathion 50 EC), T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) recorded 12.56, 14.55, 15.31 and 15.89 per cent pod damage five plants^{-1}, respectively and were at par with each other and T_3 (Deltamethrin 2.8 EC). The treatment T_9 (Control water spray) was recorded maximum (21.28%) pod damage five plants^{-1}. On tenth day after first spray indicated that the treatment T_1 (Spinosad 45 SC) recorded minimum pod damage (4.56%) which was at par with treatments and T_8 (Emamectin benzoate 5 SG) and T_2 (Azadirachtin 10000 ppm) which recorded (5.81% and 7.46%) pod damage five plants^{-1}, respectively. The treatment T_3 (Deltamethrin 2.8 EC) found to be next best treatment which was at par with the treatments T_4 (Malathion 50 EC), T_5 (*Beauveria bassiana*) and T_7 (Metarrhizium anisopliae) recorded 8.34, 8.34, 12.22 and 13.06 per cent pod damage five plants^{-1}, respectively. Whereas, the treatment T_6 (*Verticillium lecanii*) was recorded

(13.40%) pod damage five plants^{-1}. The highest 27.30 per cent pod damage five plants^{-1} was observed in treatment T_9 (Control water spray). The observations recorded on fourteenth day after first spray revealed that the treatment T_1 (Spinosad 45 SC) found to be significantly superior over rest of the treatments and which was at par with treatment T_8 (Emamectin benzoate 5 SG) and recorded 3.58 and 4.07 per cent pod damage five plants^{-1}. The next best treatment was found treatment T_2 (Azadirachtin 10000 ppm), T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) which were at par with each other and recorded (5.95%, 6.79% and 6.93%) pod damage five plants^{-1}, respectively. In treatment T_5 (*Beauveria bassiana*) recorded 10.55 per cent pod damage five plants^{-1} which was at par with treatments T_7 (*Metarrhizium anisopliae*) (11.04%) and T_6 (*Verticillium lecanii*) (11.71%), pod damage five plants^{-1} respectively. Whereas, treatment T_9 (Control water spray) was observed maximum (33.19%) pod damage five plants^{-1}.

Second spray

On 3rd day after second spray the minimum pod damage noticed in treatment T_1 (Spinosad 45 SC) which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded 2.43 and 2.97 per cent pod damage five plants^{-1}. The treatment T_2 (Azadirachtin 10000 ppm) found to be next best treatment which was at par with treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) which recorded (4.89%, 6.23% and 6.38%) pod damage five plants^{-1}, respectively. The treatment T_5 (*Beauveria bassiana*) which was at par with followed by treatment T_7 (*Metarrhizium anisopliae*) and T_5 (*Beauveria bassiana*) recorded 9.45, 10.32 and 10.97 per cent pod damage five plants^{-1}, respectively. The highest (36.29%) pod damage five plants^{-1} was observed in treatment T_9 (Control water spray). The observations on 7th day after second spray revealed that in the treatment T_1 (Spinosad 45 SC) observed (1.46%) pod damage and found to be significantly superior over rest of the treatments which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded 1.67 per cent pod damage five plants^{-1}. The treatment T_2 (Azadirachtin 10000 ppm) found to be next best treatment which was at par with treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded (3.92%, 5.33% and 5.69%) pod damage five plants^{-1}, respectively. The treatments *viz*., recorded 8.46, 9.22 and 10.24 per cent pod damage five plants^{-1}, respectively in T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which was at par with each other. The treatment T_9 (Control water spray) was recorded maximum 37.85 per cent pod damage five plants^{-1}. On 10th day after second spray the treatment T_1 (Spinosad 45 SC) was recorded least 0.98 per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) found to be most effective for minimizing pod borer infestation which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded (1.36%) pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) was recorded 3.65 per cent pod damage five plants^{-1}. While, the treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) found to be next best treatment recorded (4.93% and 5.03%) pod damage five plants^{-1}, respectively which was at par with each other. The remaining treatments *viz*., T_5 (*Beauveria bassiana*) T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which were at par with each other and observed 8.03, 8.25 and 9.18 per cent pod damage five plants^{-1}, respectively. The highest (40.64%) pod damage five plants^{-1} was noticed in treatment T_9 (Control water spray). The data on 14th day after second spray revealed that the treatment T_1 (Spinosad 45 SC) was found significantly superior over rest of the treatments and recorded 0.75 per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded (0.87%) pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) which was at par with treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded (3.00%, 3.62% and 3.64%) pod damage five plants^{-1}, respectively. While, in treatments *viz*., T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) were noticed 7.26, 7.58 and 8.21 per cent pod damage five plants^{-1}, respectively and at par with each other. In treatment T_9 (Control water spray) was observed maximum (43.39%) pod damage five plants^{-1}. The data pertaining to overall mean per cent pod damage five plants^{-1} in year 2017-2018 revealed that the treatment T_1 (Spinosad 45 SC) was significantly superior over rest of the treatments by recording minimum 3.55 overall mean per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) was at par with T_8 (Emamectin benzoate 5 SG) recorded (4.48%) pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) was recorded (6.25%) pod damage which was at par with treatments T_3 (Deltamethrin 2.8 EC) (7.56%) and T_4 (Malathion 50 EC) (7.71%) pod damage five plants^{-1}, respectively. Whereas, the next treatments *viz*., T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which were at par with each other and recorded (10.76%, 11.38% and 12.05%) pod damage five plants^{-1}, respectively. The maximum 32.60 per cent pod damage five plants^{-1} was observed in treatment T_9 (Control water spray).

2. To study the efficacy of insecticides on pod borer, *M. vitrata* infesting lablab bean during *Rabi* 2018-19

The data pertaining on the per cent pod damage of lablab bean by pod borer, *M. vitrata* per five plants during *Rabi* 2017-2018 at 3rd, 7th, 10th and 14th days after spraying are presented in Table 2 and graphically illustrated in Fig 1. The efficacy of different insecticides on pod borer, *M. vitrata* infesting lablab bean during *Rabi* 2018-2019, the per cent pod damage of lablab bean by pod borer, *M. vitrata* five plants^{-1} prior to prior to application of insecticides ranged from 11.15 to 19.45 and data was statistically non-significant 19.45 and data was statistically non-significant.

First spray

The data on per cent pod damage five plants^{-1} on 3rd day after first spray revealed that minimum pod damage (10.26%) recorded in treatment T_1 (Spinosad 45 SC) which was at par with treatments and T_8 (Emamectin benzoate 5 SG) and T_2 (Azadirachtin 10000 ppm) which recorded 12.97 and 13.07 per cent pod damage five plants^{-1}, respectively. The next best treatments *viz*., T_3 (Deltamethrin 2.8 EC), T_4 (Malathion 50 EC), T_5 (*Beauveria bassiana*) and T_7 (*Metarrhizium anisopliae*) recorded (15.41%, 15.48%, 17.94% and 18.60%) pod damage five plants^{-1}, respectively and were at par with each other. Whereas, in the treatment T_6 (*Verticillium lecanii*) was noticed 19.11 per cent pod damage five plants^{-1}. The maximum (22.23%) pod damage five plants^{-1} observed in T_9 (Control water spray).The observations recorded on 7th day after first spray revealed that the treatment T_1 (Spinosad 45 SC) which was at par with treatments T_8 (Emamectin benzoate 5 SG) and T_2 (Azadirachtin 10000 ppm) recorded 7.97, 9.66 and 11.65 per cent pod damage five plants^{-1}. The treatment T_3 (Deltamethrin 2.8 EC) was found to be next best treatment and at par with treatments T_4 (Malathion 50 EC), T_5

(*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) recorded (13.38%, 13.76%, 15.75%, 16.51% and 17.09%) pod damage five plants^{-1}, respectively. The treatment T_9 (Control water spray) was recorded maximum 22.48 per cent pod damage five plants^{-1}. On 10th day after first spray indicated that the treatment T_1 (Spinosad 45 SC) recorded minimum pod damage (6.66%) which was at par with treatments and T_8 (Emamectin benzoate 5 SG) and T_2 (Azadirachtin 10000 ppm) which recorded 7.91 and 9.56 per cent pod damage five plants^{-1}, respectively. The treatment T_3 (Deltamethrin 2.8 EC) found to be next best treatment which was at par with the treatments T_4 (Malathion 50 EC), T_5 (*Beauveria bassiana*) and T_7 (*Metarrhizium anisopliae*) recorded (10.44%, 10.44%, 14.32% and 14.16%) pod damage five plants^{-1}, respectively. Whereas, in treatment T_6 (*Verticillium lecanii*) was recorded 15.50 per cent pod damage five plants^{-1}. The highest 29.40 per cent pod damage five plants^{-1} was observed in treatment T_9 (Control water spray).The observations recorded on 14th day after first spray revealed that the treatment T_1 (Spinosad 45 SC) found to be significantly superior over rest of the treatments and which was at par with treatment T_8 (Emamectin benzoate 5 SG) and recorded 4.98 and 5.47 per cent pod damage five plants^{-1}. The next best treatments found to be *viz*., T_2 (Azadirachtin 10000 ppm), T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) which recorded (7.35%, 8.19% and 8.33%) pod damage five plants^{-1}, respectively and were at par with each other. In treatment T_5 (*Beauveria bassiana*) recorded 11.95 per cent pod damage five plants^{-1} which was at par with treatments *viz*., T_7 (*Metarrhizium anisopliae*) (12.44%) and T_6 (*Verticillium lecanii*) (13.11%), pod damage five plants^{-1} respectively. Whereas, treatment T_9 (Control water spray) was observed maximum (34.59%) pod damage five plants^{-1}.

Second spray

On third day after second spray the minimum pod damage noticed in treatment T_1 (Spinosad 45 SC) which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded 3.53 and 4.07 per cent pod damage five plants^{-1}. The treatment T_2 (Azadirachtin 10000 ppm) found to be next best treatment followed by treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded (5.99%, 7.33% and 7.48%) pod damage five plants^{-1}, respectively and were at par with each other. The treatment T_5 (*Beauveria bassiana*) which was at par with the treatments T_7 (*Metarrhizium anisopliae*) and T_5 (*Beauveria bassiana*) recorded 10.55, 11.42 and 12.07 per cent pod damage five plants^{-1}, respectively. The highest (37.39%) pod damage five plants^{-1} was observed in treatment T_9 (Control water spray). The observations on seventh day after second spray revealed that in the treatment T_1 (Spinosad 45 SC) observed (2.96%) pod damage and found to be significantly superior over rest of the treatments which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded 3.17 per cent pod damage five plants^{-1}. The treatment T_2 (Azadirachtin 10000 ppm) found to be next best treatment followed by treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded (5.42%, 6.83% and 7.19%) pod damage five plants^{-1}, respectively and were at par with each other. The treatments *viz*., T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) recorded 9.96, 10.72 and 11.74 per cent pod damage five plants^{-1}, respectively and were at par with each other. The treatment T_9 (Control water spray) was recorded maximum 39.35 per cent pod damage five plants^{-1}. On tenth day after second spray the treatment T_1 (Spinosad 45 SC) was recorded least 1.43 per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) found to be most effective for minimizing pod borer infestation which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded (1.81%) pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) was recorded 4.10 per cent pod damage five plants^{-1}. While, the treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) found to be next best treatment recorded (5.38% and 5.48%) pod damage five plants^{-1}, respectively which was at par with each other. The remaining treatments *viz*., T_5 (*Beauveria bassiana*) T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which were at par with each other and observed 8.48, 8.68 and 9.63 per cent pod damage five plants^{-1}, respectively. The highest (41.09%) pod damage five plants^{-1} was noticed in treatment T_9 (Control water spray). The data on fourteenth day after second spray revealed that the treatment T_1 (Spinosad 45 SC) was found significantly superior over rest of the treatments and recorded 1.00 per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) which was at par with treatment T_8 (Emamectin benzoate 5 SG) recorded (1.12%) pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) which was at par with treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded (3.25%, 3.87% and 3.89%) pod damage five plants^{-1}, respectively. While, in treatments *viz*., T_5 (*Beauveria bassiana*) T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) were observed 7.51, 7.83 and 8.46 per cent pod damage five plants^{-1}, respectively and at par with each other. In treatment T_9 (Control water spray) was noticed maximum (43.34%) pod damage five plants^{-1}. The data pertaining to overall mean per cent pod damage five plants^{-1} in year 2018-2019 revealed that the treatment T_1 (Spinosad 45 SC) was significantly superior over rest of the treatments by recording 4.85 overall mean per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) was at par with T_8 (Emamectin benzoate 5 SG) recorded 5.77 per cent pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) which was at par with treatments T_3 (Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded (13.80%, 16.41% and 16.72%) pod damage five plants^{-1}, respectively. Whereas, the next treatments T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which were at par with each other and recorded 12.06, 12.67 and 13.34 per cent pod damage five plants^{-1}, respectively. The treatment T_9 (Control water spray) was recorded highest 33.90 per cent pod damage five plants^{-1}.

3. Pooled efficacy of insecticides on pod borer, *M. vitrata* infesting lablab bean during *Rabi* 2017-18 and *Rabi* 2018-19

The data pertaining to the pooled per cent pod damage five plants^{-1} by pod borer, *M. vitrata* infesting lablab bean of both years for different days and different sprays was analyzed. Similarly data on overall mean of different days and two sprays was analyzed and presented in Table 3 and graphically presented in Fig. 1. A pre-count observation prior to application of insecticides was non-significant. The data on overall mean per cent pod damage five plants^{-1} of all observations revealed that the treatment T_1 (Spinosad 45 SC) was significantly superior over rest of the treatments by recording 4.20 overall mean per cent pod damage five plants^{-1}. The treatment T_1 (Spinosad 45 SC) was at par with T_8 (Emamectin benzoate 5 SG) recorded 5.13 per cent pod damage five plants^{-1}. The next best treatment T_2 (Azadirachtin 10000 ppm) which was at par with treatments T_3

(Deltamethrin 2.8 EC) and T_4 (Malathion 50 EC) recorded 6.90, 8.21 and 8.36 per cent pod damage five plants^{-1}, respectively. Whereas, the next treatments T_5 (*Beauveria bassiana*), T_7 (*Metarrhizium anisopliae*) and T_6 (*Verticillium lecanii*) which were at par with each other and recorded (11.41%, 12.03% and 12.70%) pod damage five plants^{-1}, respectively. The maximum (33.25%) pod damage five plants^{-1} was recorded in treatment T_9 (Control water spray). The present findings are strongly conformity with the studies carried out by the earlier workers. Among the eleven different insecticides tested in cowpea, spinosad 0.002 per cent recorded the lowest percentage of pod damage (4.11%) which was followed by novaluron 0.0075 per cent (Gurjar, 2006)[4].Karmarkar (2006) [5] conducted field experiment on management of *M. vitrata* on cowpea was carried out and noticed that the treatment with cypermethrin + profenophos 44 EC @ 0.04 per cent and emamectin benzoate 5 SG @ 0.002 per cent were significantly superior over rest of the treatments at all the three sprays Rekha (2005) [10] observed that the newer molecules were generally superior over the conventional insecticides as well as the indigenous materials on pod borer complex of lablab bean. It was noticed that emamectin benzoate 5 SG @ 0.002 per cent recorded very high larval reduction of 37.17, 75.91, 80.39 and 85.19 per cent after first, second, third and fourth spray, respectively. The next to follow were spinosad (32.79, 71.76, 73.66 and 84.00%), indoxacarb 14.5 SC @ 0.014 per cent (31.88, 70.32, 68.27 and 82.90%) and fenvelrate (21.45, 55.21, 61.27 and 76.06%). The treatments recorded lower pod and seed damage (11.75 to 14.73 and 20.67 to 23.28, respectively).Thejaswi *et al*. (2006)[15] studied that among the treatments spinosad 2.5 SC (1 ml l^{-1}) emerged as best treatment which brought about 36.44, 27.09 and 29.24 per cent reduction in pod borer populations after first, second and third spray, respectively as well as least pod and seed damage of 14.38 and 10.66 per cent, respectively.Vaidya (2008) [17] carried out the field experiment to evaluate the efficacy of some insecticides against spotted pod borer *M. vitrata* infesting cowpea. He reported that the treatment 0.003 per cent emamectin benzoate 5 SG @ 0.003 per cent recorded least bud damage and found to be very effective in minimizing bud infestation (6.63%) followed by 0.0035 per cent spinosad (7.79%), 0.005 per cent lambda cyhalothrin (9.40%), 0.05 per cent endosulfan (11.48%) and 0.05 per cent quinalphos (11.79%). Mollah *et al*. (2009) [7] evaluated that the efficacy of insecticides against bean pod borers. Among the insecticides, Neem oil and emamectin benzoate 5 SG performed best by reducing 59.46 and 45.95 per cent infested pod production respectively. A field experiment conducted at Navsari, Gujarat using different insecticides against *M. vitrata* revealed that spinosad 0.009 per cent was the best treatment by recording 90.19, 90.87 and 89.09 per cent death of larvae after 1, 3 and 7 days after spraying (Shinde, 2011) [12]. Patel *et al.* (2012) [9] conducted the field experiment at Centre of Excellence for Research on Pulses, S. D. Agricultural University, Sardarkrushi nagar during 2008-09 to 2010-11. In pooled results emamectin benzoate 5 SG (2.70%) found significantly better to reduce the spotted pod borer damage which was equally effective with indoxacarb 14.5 SC (2.98%) and spinosad 45 SC (3.58%).Patel Kshama (2014) [8] reported that the imidacloprid 17.8 SL in combination with spinosad 45 SC was the best in reducing almost all the five major insect pests, recording 2.05 aphid index, 2.21 jassids leaf^{-1}, 2.51 whiteflies leaf^{-1}, 3.01 pod borer larvae plant^{-1} and 2.76 spotted pod borer larvae plant^{-1}. The same combination also recorded the lowest pod damage caused by both gram pod borer and spotted pod borer by recording 3.64 and 5.77 per cent pod damage respectively. Umbarkar and Prasana (2014) [16] evaluated that the field efficacy of different insecticides against *Maruca vitrata* (Geyer) infesting green gram at Junagadh Agricultural University campus, Junagadh during *kharif* 2008. The results revealed that spinosad 0.009 per cent, indoxacarb 0.0075 per cent, profenophos 0.05 per cent and cypermethrin 0.009 per cent were found the most effective in reducing the *M. vitrata* population. Chaudhary *et al*. (2015) [2] revealed that the application of emamectin benzoate 5 SG @ (0.0025%) and spinosad 45 SC (0.015%) proved to be effective against pod borer infesting Indian bean. Shinde *et al*. (2015)[13] reported that the treatment indoxacarb (0.01%) was found most effective and recorded least overall mean per cent damage (7.5%) and was at par with spinosad (0.007%), emamectin benzoate (0.002%), lambda cyhalothrin (0.005%), novaluron (0.015%), cypermethrin (0.006%) and nimbicidine (0.004%) and mean per cent damage were (8.5%, 9.1%, 9.4%, 9.5%, 9.7% and 10.1%), respectively. Kaushik *et al.* (2016) [6] conducted the field trial to evaluate the relative efficacy of nine insecticides against spotted pod borer, *Maruca vitrata* infesting cowpea. The results revealed that spinosad 45 EC @ 2ml l^{-1} was found to be the most effective treatment caused highest mortality (68 to 71%) and lowest pod damage (7%) of *M. vitrata* over control, followed by lambda-cyhalothrin 5 EC @ 2ml l^{-1} and prophenofos 40 EC @ 3ml l^{-1} which caused (63 to 70% and 60 to 64%) mortality over control, respectively. Shelke (2017) [11] carried out the field experiment to evaluate the efficacy of some insecticides against pod borer, *M. vitrata* infesting lablab bean. He revealed that from the overall mean per cent of pod damage with two sprays it was revealed that the treatment of emamectin benzoate 5 SG @ 0.002 per cent was effective (2.57%) in reducing the pod damage and was at par with indoxacarb 14.5 SC @ 0.014 per cent (3.51%).

Table 1: Efficacy of different insecticides against pod borer, *M. vitrata* on lablab bean during *Rabi* 2017-18

Treatments	Per cent pod damage five plants^{-1}									
	Pre count	Ist spray				IInd spray				Overall mean
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS	
T_1	9.65(18.06)*	7.91 (16.32)	6.77 (14.98)	4.56 (11.84)	3.58 (10.71)	2.43 (8.95)	1.46 (6.83)	0.98 (5.65)	0.75 (4.95)	3.55 (10.15)
T_2	13.28 (21.25)	10.72(19.08)	10.45(18.79)	7.46 (15.84)	5.95 (14.10)	4.89 (12.77)	3.92 (11.38)	3.65 (10.98)	3.00 (9.93)	6.25 (14.14)
T_3	14.63 (22.38)	13.06 (21.14)	12.18 (20.37)	8.34 (16.73)	6.79 (15.09)	6.23 (14.43)	5.33 (13.33)	4.93 (12.82)	3.62 (10.93)	7.56 (15.64)
T_4	14.72 (22.56)	13.13 (21.18)	12.56 (20.70)	8.34 (16.77)	6.93 (15.27)	6.38 (14.60)	5.69 (13.76)	5.03 (12.96)	3.64 (10.96)	7.71 (15.80)
T_5	16.52 (23.78)	15.59 (23.14)	14.55 (22.27)	12.22 (20.41)	10.55 (18.94)	9.45 (17.90)	8.46 (16.90)	8.03 (16.45)	7.26 (15.63)	10.76 (19.00)
T_6	17.95 (25.04)	16.76 (24.15)	15.89 (23.46)	13.40 (21.43)	11.71 (20.00)	10.97 (19.34)	10.24 (18.65)	9.18 (17.63)	8.21 (16.64)	12.05 (20.18)
T_7	17.89 (24.90)	16.25 (23.74)	15.31 (23.00)	13.06 (21.12)	11.04 (19.38)	10.32 (18.71)	9.22 (17.66)	8.25 (16.69)	7.58 (15.98)	11.38(19.56)
T_8	12.47 (20.64)	10.62 (18.95)	8.46 (16.67)	5.81 (13.79)	4.07 (11.63)	2.97 (9.87)	1.67 (7.39)	1.36 (6.68)	0.87 (5.28)	4.48 (11.37)
T_9	16.18 (23.70)	20.88 (27.18)	21.28 (27.45)	27.30 (31.41)	33.19 (35.15)	36.29 (37.03)	37.85 (37.95)	40.64 (39.60)	43.39 (41.20)	32.60 (34.64)
SE (m±)	0.26	0.98	1.38	1.52	0.87	0.61	0.77	0.41	0.52	0.91
CD at 0.05%	NS	2.94	4.14	4.56	2.61	1.83	2.32	1.23	1.56	2.60

*Figures in parenthesis are arcsine transferred values

(DAS- Days after Spraying)

Table 2: Efficacy of different insecticides against pod borer, *M. vitrata* on lablab bean during *Rabi* 2018-19

Treatments	Per cent pod damage five plants^{-1}									
	Pre count	Ist spray				IInd spray				Overall mean
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS	
T_1	11.15(19.48)*	10.26(18.67)	7.97(16.32)	6.66(14.69)	4.98(12.78)	3.53(10.82)	2.96(9.87)	1.43(6.85)	1.00(5.73)	4.85(12.03)
T_2	14.78(22.51)	13.07(21.17)	11.65(19.90)	9.56(18.00)	7.35(15.72)	5.99(14.16)	5.42(13.44)	4.10(11.66)	3.25(10.35)	7.55(15.57)
T_3	16.13(23.58)	15.41(23.08)	13.38(21.41)	10.44(18.81)	8.19(16.62)	7.33(15.69)	6.83(15.14)	5.38(13.40)	3.87(11.31)	8.85(16.96)
T_4	16.22(23.75)	15.48(23.12)	13.76(21.72)	10.44(18.84)	8.33(16.78)	7.48(15.85)	7.19(15.53)	5.48(13.54)	3.89(11.34)	9.01(17.11)
T_5	18.02(24.94)	17.94(24.97)	15.75(23.24)	14.32(22.20)	11.95(20.21)	10.55(18.95)	9.96(18.39)	8.48(16.92)	7.51(15.91)	12.06(20.14)
T_6	19.45(26.15)	19.11(25.91)	17.09(24.39)	15.50(23.15)	13.11(21.22)	12.07(20.33)	11.74(20.03)	9.63(18.08)	8.46(16.90)	13.34(21.26)
T_7	19.39(26.02)	18.60(25.53)	16.51(23.95)	15.16(22.87)	12.44(20.63)	11.42(19.73)	10.72(19.10)	8.68(17.13)	7.83(16.25)	12.67(20.67)
T_8	13.97(21.92)	12.97(21.06)	9.66(17.91)	7.91(16.24)	5.47(13.52)	4.07(11.61)	3.17(10.25)	1.81(7.72)	1.12(6.03)	5.77(13.10)
T_9	17.68(24.85)	22.23(28.80)	22.48(28.29)	29.40(32.76)	34.59(36.00)	37.39(37.69)	39.35(38.84)	41.09(39.86)	43.64(41.34)	33.90(35.47)
SE (m±)	1.42	0.92	1.32	1.36	0.80	0.57	0.70	0.39	0.50	0.90
CD at0.05%	NS	2.75	3.96	4.09	2.40	1.71	2.10	1.17	1.50	2.57

Table 3: Pooled efficacy of different insecticides against pod borer, *M. vitrata* on lablab bean during *Rabi* 2017-18 and 2018-19

Treatments	Per cent pod damage five plants^{-1}		
	Overall mean		Pooled Mean
	2017-18	2018-19	
T_1 : Spinosad 45 SC @ 0.015%	3.55 (10.15)*	4.85(12.03)	4.20(11.09)
T_2 : Azadirachtin 10,000 ppm @ 0.003%	6.25 (14.14)	7.55(15.57)	6.90(14.86)
T_3 : Deltamethrin 2.8 EC @ 0.0025%	7.56 (15.64)	8.85(16.96)	8.21(16.30)
T_4 : Malathion 50 EC @ 0.05%	7.71 (15.80)	9.01(17.11)	8.36(16.46)
T_5 : *Beauveria bassiana* @ 5 g l^{-1}	10.76 (19.00)	12.06(20.14)	11.41(19.57)
T_6 : *Verticillium lecanii* @ 5 g l^{-1}	12.05 (20.18)	13.34(21.26)	12.70(20.72)
T_7 : *Metarrhizium anisopliae* @ 5 g l^{-1}	11.38 (19.56)	12.67(20.67)	12.03(20.12)
T_8 : Emamectin benzoate 5 SG @ 0.0016%	4.48 (11.37)	5.77(13.10)	5.13(12.24)
T_9 : Control (Water spray)	32.60 (34.64)	33.90(35.47)	33.25(35.06)
SE (m±)	0.91	0.90	0.91
CD at 0.05%	2.60	2.57	2.59

*Figures in parenthesis are arcsine transformed values

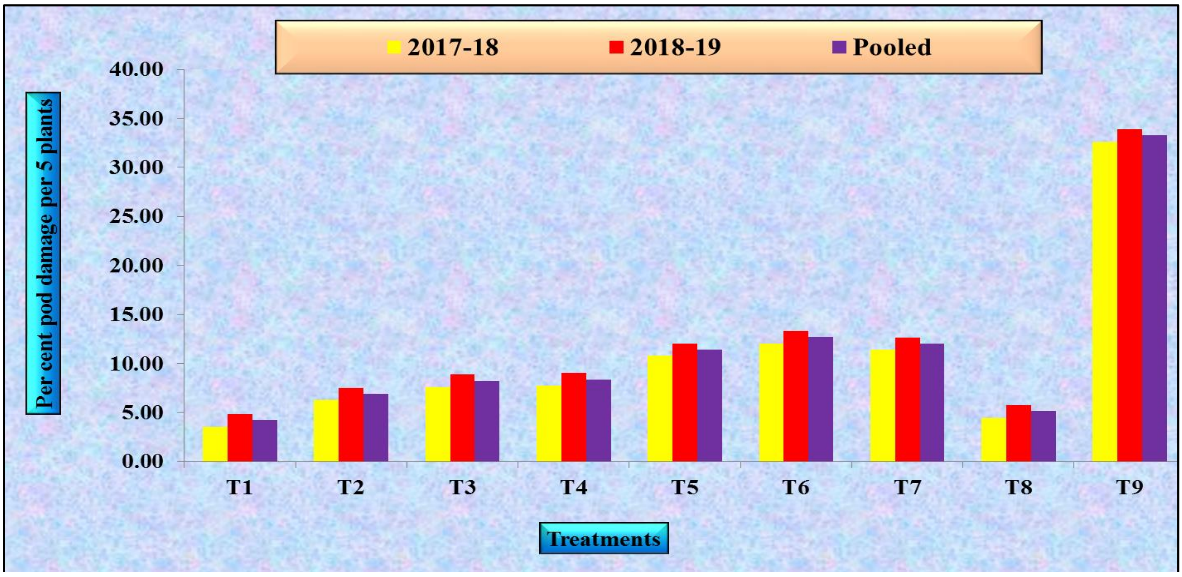

Fig 1: Pooled efficacy of different insecticides against pod borer, *M. vitrata* on lablab bean during *Rabi* 2017-18 and *Rabi* 2018-19

Conclusion

Present study concluded that among the different insecticides evaluated, the application of spinosad 45 SC @ (0.015%) and emamectin benzoate 5 SG @ (0.0016%) was most effective against pod borer. Followed by Azadirachtin 10000 ppm (1%) @ (0.003%), deltamethrin 2.8 EC @ (0.0025%) and Malathion 50 EC @ (0.05%) were reduce the pod damage. After that *Beauveria bassiana*, *Metarrhizium anisopliae* and *Verticillium lecanii* @ 5 g l^{-1} were also minimize the pod borer infestation. When an entomopathogenic fungus is also getting favorable climatic condition then it shows reduction of pod borer infestation on lablab bean crop.

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