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Eco-friendly management of pod borer complex in pigeon pea

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Abstract
An experiment was conducted during *Kharif*, 2016 and 2017 at the Regional Research and Technology Transfer Station, Bhawanipatna to find out suitable eco-friendly management practices of pod borer complex in pigeon pea. The trial was laid out in randomized block design with three replications taking thirteen treatments. Experimental results showed that the lowest mean population of spotted pod borer larvae (0.02/plant) was recorded in the treatment *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha followed by Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha with 0.06/plant and *Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha with 0.07/plant as compared to the control (3.03/plant). Two times spraying of Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha recorded the lowest mean larval population (0.02/plant) of *H. armigera* followed by *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha with 0.04/plant, *Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha with 0.07/plant and *Bt* @ 1 kg/ha + Emamectin Benzoate 5 SG @ 200 g/ha with 0.09/plant compared to the untreated control (3.22 larvae/plant). Lowest spiny pod borer population was reported in *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha and *Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha (0.02 larvae/plant) compared to control (1.50 larvae/plant). Highest grain yield (14.6 q/ha) was recorded in *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha followed by Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha with 14.2 q/ha. *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha recorded the highest B: C ratio (2.19) followed by Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha (2.17).

Keywords: Insecticides, spotted pod borer, gram pod borer, spiny pod borer, pigeon pea

Introduction

India is the largest producer of pulses in the world occupying an area of about 29.28 million hectare, with annual production of 22.40 million tones with a productivity of 765 kg/ha. Pigeon pea contributed 18.4% area and 20.5% production of the total pulse in India. In Odisha, the total area under pigeon pea production is about 0.138 million hectares with an annual production of 0.123 million tonnes and productivity of 888 kg/ha (Anonymous, 2016) [1]. Cuttack, Puri, Kalahandi, Koraput, Dhenkanal, Bolangir, Rayagada, Nuaparha and Sambalpur are the major pulse growing districts of Odisha. More than 300 insect species belonging to 8 orders and 61 families have been found to infest pigeon pea starting from seedling stage and continues till harvesting and even during the storage condition (Keval *et al.*, 2010) [2]. However, about 60% damage is solely caused by the pod borer complex (Wadasker *et al.*, 2013) [3]. The pod borer complex of pigeon pea includes gram pod borer (*Helicoverpa armigera*), spotted pod borer (*Maruca vitrata*) and spiny pod borer (*Etiella zinckenella*). The pod borer complex which attack at the reproductive stage causes more yield loss as compared to the vegetative stage.

Regular and indiscriminate use of chemical insecticides and the misuse of synthetic pesticides on the crop have led to development of insecticide resistance in target pests, pest resurgence and secondary pest outbreaks, loss of bio-diversity, environmental pollution and residual toxicity and occurrence of human health hazards. However, in present day context chemical control has its own popularity over the other methods of pest control due to its immediate action and remarkable pest control. Recent reports revealed that the borers had developed resistance to most of the old insecticides (Armes *et al.*, 1992) [4]. Crop protection with need based use of safer insecticides is considered as an effective and dependable component of IPM and one of the most important aspects of agro-ecosystem management with regards to the ecological & socio-economic values.

In this context, bio-pesticides can be mixed with some newer group of insecticides at recommended dose for reduction of pesticide load and bringing about effective pest management. Keeping this in mind, an experiment was conducted taking chemicals, bio pesticides in combination for management of pod borer complex in arhar.

Materials and Methods

The experiment was conducted during *Kharif*, 2016 and 2017 at the Regional Research and Technology Transfer Station, Bhawanipatna in Kalahandi district of Odisha. The experiment was laid out in Randomized Block Design with thirteen treatments (Table-1) and three replications. The seeds were sown at a depth of 5 cm and with a spacing of 60 cm x 30 cm. The pigeon pea variety ICPL 88039 was sown on 16th August, 2016 and 8th August, 2017 with a fertilizer dose of 20:40:40 kg NPK/ha. Intercultural and weeding operations were carried out as needed. Two sprays of insecticides as per treatment were done, first spray at 50% flowering stage and second 15 days after the first spray. The observations on incidence of pod borer complex *viz*, Gram pod borer (*H. armigera*), Spotted pod borer (*Maruca vitrata*) and Spiny pod borer (*Etiella zinckenella*) larval population and pod damage % were recorded from randomly selected 5 plants in each plot. Observations were taken one day before spray and 5, 10 and 15 days after spray. The plot yield in each treatment was recorded. The rainfall received during the crop season was 734.0 mm and 626.8 mm, the mean maximum was 31.5 and 30.4 ^{0}C and the mean minimum temperature was 16.9 and 19.9 ^{0}C, respectively.

The data recorded on pest population and extent of insect damages obtained from the experiment were subjected to square root transformation, and then data were analyzed following procedures laid out by Gomez and Gomez, 1984 [5]. The treatment variations were tested for significance by "F" test. The standard error of means SE(m) $\pm$ and critical differences (CD) at 5% level of significance were calculated following the standard procedure and treatment means were compared using critical differences(CD). Based on the statistically analyzed data, the results of the investigation have been interpreted and conclusions have been drawn.

Pod damage was recorded from 5 randomly selected plants in each replication after harvest and the percent pod infestation was computed using the formula:

$$\% \text{ pod infestation} = \frac{\text{Number of infested pods}}{\text{Number of infested pods}} \times 100$$

Results and Discussion

Spotted pod borer: The mean data of two years presented in Table 1. revealed that spotted pod borer population varied from 1.66 - 2.11/plant before first spraying. After 1st spraying the lowest mean spotted pod borer population was recorded in T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml /ha) with 0.04/plant followed by T_2 (Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha) with 0.07/plant. After second spraying the mean population was zero per plant in T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha), T_8 (*Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha), T_{10} (*Bt* @ 1 kg/ha + Emamectin Benzoate 5 SG @ 200 g/ha), T_5 (Ozoneem @ 1.5 lit./ha + Emamectin Benzoate 5 SG @200 g/ha) followed by T_2 (Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha) and T_3 (Ozoneem @ 1.5 lit./ha + Spinosad 45 SC @ 200 ml/ha) with 0.04/plant.

After two spraying the lowest mean population of spotted pod borer larvae (0.02/plant) was recorded in T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha) followed by T_2 (Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha) with 0.06/plant and T_8 (*Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha) with 0.07/plant as compared to the control (3.03/plant).

Gram pod borer: The data presented in Table 2. revealed that with first spraying *H. armigera* larvae population varied from 0.44 – 0.89 /plant. After 1st spraying the lowest mean population of *H. armigera* larvae (0.04/plant) was recorded in T_2 (Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha) followed by T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha) with 0.07/plant and T_8 (*Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha) with 0.15/plant. After 2nd spraying minimum mean population of zero per plant was recorded from T_7, T_2 and T_8 followed by T_{10} and T_3 (0.04/plant). Two times spraying of Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha (T_2) recorded the lowest mean larval population (0.02/plant) of *H. armigera* followed by T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha) 0.04/plant, T_8 (*Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha) 0.07/plant and T_{10} (*Bt* @ 1 kg/ha + Emamectin Benzoate 5SG @ 200 g/ha) 0.09/plant compared to the untreated control (3.22 larvae/plant).

Table 1: Effect of different eco-friendly management practices on spotted pod borer population in pigeon pea (Mean of two years)

Treatment	Mean Spotted pod borer population/plant									Pooled Mean after spray
	Before Spray	After 1st spray				After 2nd spray				
	1DBS	5 DAS	10 DAS	15 DAS	Mean	5 DAS	10 DAS	15 DAS	Mean	
T_1- Ozoneem @ 1.5 lit./ ha + Indoxacarb 14.5 SC @ 500 ml / ha	1.89 *(1.54)	0.22 (0.84)	0.33 (0.90)	0.33 (0.91)	0.29 (0.88)	0.00 0.71	0.11 (0.78)	0.22 (0.84)	0.11 (0.78)	0.20 (0.83)
T_2- Ozoneem @ 1.5 lit./ ha + Flubendiamide 48 SC @ 200 ml /ha	2.11 (1.61)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.00 0.71	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.06 (0.74)
T_3- Ozoneem @ 1.5 lit./ ha + Spinosad 45 SC @ 200 ml / ha	1.89 (1.54)	0.11 (0.78)	0.22 (0.84)	0.22 (0.84)	0.18 (0.82)	0.00 0.71	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.11 (0.78)
T_4- Ozoneem @ 1.5 lit./ ha + Novaluron 10 EC @ 500 ml /ha	2.11 (1.61)	0.44 (0.97)	0.44 (0.97)	0.55 (1.02)	0.48 (0.98)	0.11 0.78	0.11 (0.78)	0.22 (0.84)	0.15 (0.80)	0.31 (0.89)
T_5- Ozoneem @ 1.5 lit./ ha + Emamectin Benzoate 5 SG @200g/ha	1.88 (1.53)	0.22 (0.84)	0.33 (0.91)	0.22 (0.84)	0.26 (0.87)	0.00 0.71	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.13 (0.79)
T_6- *Bt* @ 1 kg / ha + Indoxacarb 14.5 SC @ 500 ml / ha	1.66 (1.47)	0.22 (0.84)	0.55 (1.02)	0.33 (0.90)	0.37 (0.92)	0.11 0.78	0.00 (0.71)	0.11 (0.78)	0.07 (0.75)	0.22 (0.84)
T_7- *Bt* @ 1 kg / ha + Flubendiamide 48 SC @ 200 ml /ha	1.78 (1.51)	0.00 (0.71)	0.11 (0.78)	0.00 (0.71)	0.04 (0.73)	0.00 0.71	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.02 (0.72)

T8- *Bt* @ 1 kg / ha + Spinosad 45 SC @ 200 ml / ha	1.89 (1.54)	0.22 (0.84)	0.11 (0.78)	0.11 (0.78)	0.15 (0.80)	0.00 0.71	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.07 (0.75)
T9- *Bt* @ 1 kg / ha + Novaluron 10 EC @ 500 ml /ha	1.66 (1.47)	0.66 (1.08)	0.44 (0.97)	0.33 (0.91)	0.48 (0.98)	0.11 0.78	0.11 (0.78)	0.11 (0.78)	0.11 (0.78)	0.29 (0.88)
T10- *Bt* @ 1 kg / ha + Emamectin Benzoate 5 SG @ 200 g/ha	1.88 (1.53)	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.00 0.71	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)
T11- Ozoneem @ 1.5 lit./ ha	1.66 (1.47)	2.33 (1.68)	2.00 (1.58)	2.11 (1.61)	2.15 (1.62)	1.33 1.35	2.00 (1.58)	2.11 (1.61)	1.81 (1.51)	1.98 (1.57)
T12- Bt @ 1 kg /ha	1.66 (1.47)	1.00 (1.22)	0.89 (1.18)	0.89 (1.18)	0.92 (1.19)	0.55 1.02	0.66 (1.08)	0.66 (1.08)	0.62 (1.06)	0.77 (1.12)
T13- Untreated Control	1.89 (1.54)	2.66 (1.78)	3.11 (1.90)	3.33 (1.96)	3.03 (1.88)	3.00 1.87	3.00 (1.87)	3.11 (1.90)	3.03 (1.88)	3.03 (1.88)
SE (m)	0.11	0.07	0.09	0.08	0.08	0.06	0.06	0.07	0.06	0.07
CD (0.05)	0.22	0.15	0.18	0.16	0.16	0.13	0.12	0.14	0.13	0.15

*Figure in parenthesis are square root transformed values

Table 2: Effect of different eco-friendly management practices on *H. armigera* population in pigeon pea (Mean of two years)

Treatment	Mean *H. armigera* population / plant									Pooled Mean after spray
	Before Spray	After 1st spray				After 2nd spray				
	1DBS	5 DAS	10 DAS	15 DAS	Mean	5 DAS	10 DAS	15 DAS	Mean	
T1- Ozoneem @ 1.5 lit./ ha + Indoxacarb 14.5 SC @ 500 ml / ha	0.55 *(1.02)	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.00 (0.71)	0.11 (0.78)	0.22 (0.84)	0.11 (0.78)	0.17 (0.81)
T2- Ozoneem @ 1.5 lit./ ha + Flubendiamide 48 SC @ 200 ml /ha	0.66 (1.07)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.02 (0.72)
T3- Ozoneem @ 1.5 lit./ ha + Spinosad 45 SC @ 200 ml / ha	0.66 (1.07)	0.11 (0.78)	0.22 (0.84)	0.22 (0.84)	0.18 (0.82)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.11 (0.78)
T4- Ozoneem @ 1.5 lit./ ha + Novaluron 10 EC @ 500 ml /ha	0.55 (1.02)	0.11 (0.78)	0.44 (0.97)	0.44 (0.97)	0.33 (0.90)	0.00 (0.71)	0.11 (0.78)	0.22 (0.84)	0.11 (0.78)	0.22 (0.84)
T5- Ozoneem @ 1.5 lit./ ha + Emamectin Benzoate 5 SG @200 g/ha	0.55 (1.02)	0.11 (0.78)	0.22 (0.84)	0.22 (0.84)	0.18 (0.82)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.11 (0.78)
T6- *Bt* @ 1 kg / ha + Indoxacarb 14.5 SC @ 500 ml / ha	0.55 (1.02)	0.22 (0.84)	0.44 (0.97)	0.44 (0.97)	0.37 (0.93)	0.11 (0.78)	0.00 (0.71)	0.11 (0.78)	0.07 (0.75)	0.22 (0.84)
T7- *Bt* @ 1 kg / ha + Flubendiamide 48 SC @ 200 ml /ha	0.66 (1.07)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.04 (0.73)
T8- *Bt* @ 1 kg / ha + Spinosad 45 SC @ 200 ml / ha	0.55 (1.02)	0.11 (0.78)	0.11 (0.78)	0.22 (0.84)	0.15 (0.80)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.07 (0.75)
T9- *Bt* @ 1 kg / ha + Novaluron 10 EC @ 500 ml /ha	0.44 (0.97)	0.33 (0.91)	0.33 (0.91)	0.44 (0.97)	0.37 (0.93)	0.11 (0.78)	0.11 (0.78)	0.22 (0.84)	0.15 (0.80)	0.26 (0.86)
T10- *Bt* @ 1 kg / ha + Emamectin Benzoate 5 SG @ 200 g/ha	0.89 (1.18)	0.11 (0.78)	0.11 (0.78)	0.22 (0.84)	0.15 (0.80)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.09 (0.76)
T11- Ozoneem @ 1.5 lit./ ha	0.44 (0.97)	1.55 (1.43)	1.11 (1.27)	1.33 (1.35)	1.33 (1.35)	1.55 (1.43)	3.89 (2.09)	4.11 (2.14)	3.18 (1.89)	2.26 (1.62)
T12- Bt @ 1 kg /ha	0.66 (1.07)	0.88 (1.17)	0.55 (1.02)	0.66 (1.08)	0.70 (1.09)	0.77 (1.13)	1.33 (1.35)	1.22 (1.31)	1.11 (1.26)	0.90 (1.18)
T13- Untreated Control	0.55 (1.02)	1.66 (1.47)	1.77 (1.51)	2.44 (1.71)	1.96 (1.56)	2.66 (1.78)	5.44 (2.44)	5.33 (2.41)	4.48 (2.21)	3.22 (1.89)
SE (m)	0.11	0.09	0.08	0.09	0.08	0.05	0.06	0.08	0.06	0.07
CD (0.05)	0.22	0.18	0.17	0.18	0.17	0.09	0.12	0.16	0.13	0.15

*Figure in parenthesis are square root transformed values

Table 3: Effect of different eco-friendly management practices on spiny pod borer population in pigeon pea (Mean of two years)

Treatment	Mean Spiny pod borer population / plant									Pooled Mean after spray
	Before Spray	After 1st spray				After 2nd spray				
	1DBS	5 DAS	10 DAS	15 DAS	Mean	5 DAS	10 DAS	15 DAS	Mean	
T1- Ozoneem @ 1.5 lit./ ha + Indoxacarb 14.5 SC @ 500 ml / ha	0.22 *(0.84)	0.00 (0.71)	0.22 (0.84)	0.33 (0.91)	0.18 (0.82)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.13 (0.79)
T2- Ozoneem @ 1.5 lit./ ha + Flubendiamide 48 SC @ 200 ml /ha	0.33 (0.91)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.04 (0.73)
T3- Ozoneem @ 1.5 lit./ ha + Spinosad 45 SC @ 200 ml / ha	0.44 (0.95)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.04 (0.73)
T4- Ozoneem @ 1.5 lit./ ha + Novaluron 10 EC @ 500 ml /ha	0.44 (0.96)	0.22 (0.84)	0.33 (0.90)	0.33 (0.91)	0.29 (0.88)	0.00 (0.71)	0.11 (0.78)	0.22 (0.84)	0.11 (0.78)	0.20 (0.83)
T5- Ozoneem @ 1.5 lit./ ha + Emamectin Benzoate 5 SG @200 g/ha	0.33 (0.90)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.04 (0.73)
T6- *Bt* @ 1 kg / ha + Indoxacarb 14.5 SC @ 500 ml / ha	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.33 (0.91)	0.26 (0.87)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.15 (0.80)
T7- *Bt* @ 1 kg / ha + Flubendiamide 48 SC @ 200 ml /ha	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	0.11 (0.78)	0.04 (0.73)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.02 (0.72)
T8- *Bt* @ 1 kg / ha + Spinosad 45 SC @ 200 ml / ha	0.44	0.00	0.00	0.11	0.04	0.00	0.00	0.00	0.00	0.02

	(0.95)	(0.71)	(0.71)	(0.78)	(0.73)	(0.71)	(0.71)	(0.71)	(0.71)	(0.72)
T_9- *Bt* @ 1 kg / ha + Novaluron 10 EC @ 500 ml /ha	0.33 (0.90)	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.22 (0.84)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.15 (0.80)
T_{10}- *Bt* @ 1 kg / ha + Emamectin Benzoate 5 SG @ 200 g/ha	0.22 (0.84)	0.00 (0.71)	0.11 (0.78)	0.11 (0.78)	0.07 (0.75)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.04 (0.73)
T_{11}- Ozoneem @ 1.5 lit./ ha	0.33 (0.90)	0.89 (1.18)	0.66 (1.08)	0.66 (1.07)	0.74 (1.11)	0.44 (0.95)	1.00 (1.22)	1.00 (1.22)	0.81 (1.13)	0.78 (1.12)
T_{12}- Bt @ 1 kg /ha	0.33 (0.90)	0.33 (0.90)	0.44 (0.97)	0.55 (1.02)	0.44 (0.96)	1.00 (1.10)	0.33 (0.90)	0.33 (0.90)	0.55 (0.96)	0.50 (0.96)
T_{13}- Untreated Control	0.44 (0.97)	1.22 (1.30)	1.44 (1.39)	1.22 (1.31)	1.29 (1.33)	1.44 (1.39)	1.77 (1.51)	1.89 (1.54)	1.70 (1.48)	1.50 (1.41)
SE (m)	0.12	0.08	0.09	0.10	0.09	0.16	0.07	0.07	0.10	0.09
CD (0.05)	0.25	0.16	0.19	0.20	0.18	0.34	0.14	0.15	0.21	0.19

*Figure in parenthesis are square root transformed values

Spiny pod borer: The spiny pod borer population (Table 3.) recorded during the study period was very negligible. Lowest spiny pod borer population was reported in *Bt* @1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha and *Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha (0.02 larvae/plant) compared to control (1.50 larvae/plant).

The results obtained in the present investigation were in agreement with the findings of Subhasree *et al.* (2014) [6], who reported that three consecutive sprays with Flubendiamide 480 SC starting from flowering was found to be most effective pesticide in managing the larval population of *M. Vitrata* with significantly minimum pod damage percentage and highest B:C ratio. Excellent performance of flubendiamide in controlling pod borers in pigeon pea have earlier been reported by Deshmukh *et al.* (2010) [7], Wadaskar *et al.* (2013) [3], Sreekanth *et al.* (2013) [8] and Priyadarshini *et al.* (2013) [9].

Grain yield and economics: Data presented in Table 4. indicated that the maximum grain yield (14.6 q/ha) was recorded in T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha) followed by T_2 (Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha) with 14.2 q/ha, T_8 (*Bt* @ 1 kg/ha + Spinosad 45 SC @ 200 ml/ha) with 13.8q/ha and T_3 (Ozoneem @ 1.5 lit./ha + Spinosad 45 SC @ 200 ml/ha) with 13.3 q/ha. The increase in grain yield in T_7 (*Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha) was 139% over the control. *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha recorded the highest B: C ratio (2.19) followed by Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha (2.17).

Table 4: Seed yield, pod damage percentage and B:C ratio of pigeon pea as influence by different eco-friendly management practices (Mean of two years)

Treatment	Yield (q/ha)	Pod damage (%)	B:C ratio
T_1- Ozoneem @ 1.5 lit./ ha + Indoxacarb 14.5 SC @ 500 ml / ha	12.4	14.94	2.00
T_2- Ozoneem @ 1.5 lit./ ha + Flubendiamide 48 SC @ 200 ml /ha	14.2	2.31	2.17
T_3- Ozoneem @ 1.5 lit./ ha + Spinosad 45 SC @ 200 ml / ha	13.3	5.07	2.09
T_4- Ozoneem @ 1.5 lit./ ha + Novaluron 10 EC @ 500 ml /ha	11.3	21.14	1.82
T_5- Ozoneem @ 1.5 lit./ ha + Emamectin Benzoate 5 SG @200 g/ha	12.6	7.17	2.04
T_6- *Bt* @ 1 kg / ha + Indoxacarb 14.5 SC @ 500 ml / ha	12.1	14.80	1.91
T_7- *Bt* @ 1 kg / ha + Flubendiamide 48 SC @ 200 ml /ha	14.6	1.72	2.19
T_8- *Bt* @ 1 kg / ha + Spinosad 45 SC @ 200 ml / ha	13.8	6.64	2.12
T_9- *Bt* @ 1 kg / ha + Novaluron 10 EC @ 500 ml /ha	11.1	18.97	1.77
T_{10}- *Bt* @ 1 kg / ha + Emamectin Benzoate 5 SG @ 200 g/ha	12.9	12.03	2.05
T_{11}- Ozoneem @ 1.5 lit./ ha	7.1	46.15	1.23
T_{12}- Bt @ 1 kg /ha	9.0	30.57	1.54
T_{13}- Untreated Control	6.1	56.24	1.10
SE (m)	0.78	0.21	-
CD (0.05)	1.60	0.43	-

Conclusion

It can be concluded from the two years experiment that *Bt* @ 1 kg/ha + Flubendiamide 480 SC @ 200 ml/ha or Ozoneem @ 1.5 lit./ha + Flubendiamide 480 SC @ 200 ml/ha may be recommended for effective and economic control of pod borer complex in pigeon pea. The grain yield recorded by these treatments was 14.6 and 14.2 q/ha and was 58.2 and 57.0% more than the control, respectively.

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