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Estimation of crop losses due to major insect pests of field pea in Gangetic plains of West Bengal

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Abstract
The field experiment was conducted during 2016-17 and 2017-18 to assess the crop loss due to infestation of major insect pests on field pea. Gram pod borer, *Helicoverpa armigera* has been assumed the status of major pest on pea which attacks at reproductive stage of the crop. Among the sucking pests pulse aphid, *Aphis craccivora* is the major ones and it was observed in the field from vegetative stage. Highest pod yield, avoidable crop loss and increase in yield over control was recorded from the fully protected plot (T_3), which was treated with Thiamethoxam 25 WG @ 0.2 g/ l of water and Indoxacarb 14.5 SC @ 0.5 ml/ l of water during vegetative stage and reproductive stage of the crop, respectively. The next most effective treatment was treatment (T_2) with Indoxacarb 14.5 SC @ 0.5 ml/ l of water at reproductive stage of the crop however, application of Thiamethoxam 25 WG @ 0.2 g/ l of water at vegetative stage gave the good results against sucking pest. The results revealed that T_3 gave maximum net profit of Rs. 13397.00/ ha and Rs. 14755.00/ ha during 2016-17 and 2017-18, respectively and it was followed by T_2. Per cent pod damage was highest in untreated control (T_4). Though the yield was more in T_3, the incremental cost benefit ratio was highest in T_1.

Keywords: Field pea, Avoidable crop loss, pod borer, pulse aphid, incidence, pod damage, yield, economics

Introduction
Pulses are protein rich crops, which are mainly used to substitute animal protein in human diets. They are also used as a green fertilizer due to their ability to fix atmospheric nitrogen into soil with the help of symbiotic association of *Rhizobium* in root nodules (Stagnari *et al.* 2017) [21]. India is one of the largest producer, consumer and importer of pulses. Indian pulse production contributes nearly 25% of global output and compound annual growth rate registered of pulse production is 0.27% in last five decades (Anon., 2011) [4]. In India, different types of pulses are cultivated in pre-*kharif*, *kharif* and *rabi* seasons however, only *rabi* pulses contribute more than 60 per cent of the total production (Anon., 2014) [5]. Field pea is the third most important *rabi* pulses after dry bean and chick pea. In India, field pea is grown over an area of 11.50 lakh ha with a production of about 10.36 lakh tonnes during 12th Plan period (Anon. 2017) [6]. The protein content of pea ranges from 25.5 to 39.75 per cent (Davies *et al.* 1985) [8]. Though the area under pulses are increasing nowadays but, the yields remained stagnant for the past 2-3 decades as a result of this India is facing severe shortage of pulses. In present situation, one of the major constraints of pulse production is adverse environmental conditions such as drought, flood along with pests and diseases attack (Graham and Vance 2003) [14]. Various types of insect pests attack the pea crop, some of them chew the above and underground plant parts and some suck plant juices. Insect pests like pulse aphid, *Aphis craccivora* (Koch.) and gram pod borer *Helicoverpa armigera* (Hubn.) are considered as the major pest of pea in West Bengal condition.The larvae of pod borers feed on buds, flowers and seeds by entering into the pods and lead to maximum yield loss in pea. The knowledge on the ability to cause crop damage by particular pest or group of pests of a crop in a locality is one of the tools for well-developed pest management system. On the other hand, repeated use of various synthetic chemical insecticides aiming to reduce the pest population below economic threshold level resulted into the development of resistance and resurgence. Keeping this view in mind, the present investigation was undertaken to estimate the crop losses due to incidence of those insect pests and to develop suitable management strategies to suppress the pest population by using some newer pesticide molecules.

Materials and Methods

The field experiment was conducted at 'A-B' Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal. Seeds of field pea var. 'Rachna' were sown in plots having each plot size of 10 m X 10 m maintain row to row and plant to plant distance of 30 cm and 10 cm, respectively during *rabi* seasons of two consecutive years viz. 2016-17 and 2017-18. In first year the crop was sown on 30.11.2016 and in second year it was sown on 02.12.2017. The experiment was laid out in randomized block design (RBD) with five replications. To estimate the comparative losses, 3 treatments were compared with the control plots as well as with the insect pest free treatment. The treatments included: a) Crop protected from sucking pests during vegetative stage using insecticide (Thiamethoxam 25 WG @ 0.2 g/ l of water) i.e. Treatment 1 (T_1), b) Crop protected from pod borer complex during reproductive stage using insecticide (Indoxacarb 14.5 SC @ 0.5 g/ l of water) i.e. Treatment 2 (T_2), c) Crop protected from sucking pests as well as pod borer complex at vegetative stage and reproductive stage using insecticides (both Thiamethoxam 25 WG @ 0.2 g/ l of water and Indoxacarb 14.5 SC @ 0.5 g/ l of water) i.e. Treatment 3 (T_3) and d) Crop left untreated for free access to insect pests throughout the crop season i.e. Treatment 4 (T_4). Routine crop scouting was started from three weeks after sowing and continued up to harvesting of the crop. The number of gram pod borer, *Helicoverpa armigera* (Hubner) was recorded by counting the larval population on ten randomly selected plants from each replication at seven days interval. However, the incidence of pulse aphid, *Aphis craccivora* (Koch) was recorded by counting the nymph and adult population from top 10 cm twigs of ten randomly selected plants in each replication. For counting of aphids they were removed from the plants with the help of a soft, fine brush and placed on a white paper and then their number was counted by proper visual observation. For calculating pod damage percentage, total numbers of healthy and damaged pods per plant were recorded by random sampling, taking ten plants from each replication at the time of harvesting. Yield data was recorded separately after harvesting of the crop for each treatment. Afterwards, grain yield was converted into quintal per hectare. The yield data obtained from protected and untreated unprotected plots were used to calculate avoidable loss. The difference between the weight of grain yield in protected and unprotected plots was considered as loss. The per cent loss was calculated from the following formula (Khosla, 1977) [16].

$$\text{Avoidable yield loss (\%)} = \frac{\text{Yield in treated plots (kg/ha)} - \text{Yield in untreated plots}}{\text{Yield in treated plots (kg/ha)}} \text{ X } 100$$

Per cent increase in yield was calculated by using the following formula given by Pradhan (1969) [17].

$$\text{Avoidable yield loss (\%)} = \frac{\text{Yield in treated plots (kg/ha)} - \text{Yield in untreated plots}}{\text{Yield in untreated plots (kg/ha)}} \text{ X } 100$$

Afterwards, Incremental Cost Benefit Ratio (ICBR) was calculated on the basis of present market price of field pea.

Results and Discussion

In present investigation the major insect pest recorded in field pea ecosystem were one hemipterous pest viz. *Aphis craccivora* Koch. and one lepidopterous pest viz. *Helicoverpa armigera* Hubn. Among these, the borers caused damage mainly in reproductive part (flower, pod, seed) while; aphids suck the plant sap from green vegetative part of the crop.

Incidence of gram pod borer

Among the different chewing pests attacked field pea crop, gram pod borer, *H. armigera* was recorded as the most dominating and damaging pest during two years of experimentation. The data on larval population of gram pod borer during first year and second year are presented in Table 1, Figure 1 and 2 respectively. Average larval population of gram pod borer recorded in different treatments varied from 1.01 to 5.92 per plant and 0.98 to 5.29 per plant during first year and second year, respectively. In first year the minimum gram pod borer infestation (1.01 larvae/ plant) was recorded in the plots treated with both Thiamethoxam 25 WG @ 0.2 g/ l of water and Indoxacarb 14.5 SC @ 0.5 ml/ l of water followed by sole application of Indoxacarb 14.5 SC @ 0.5 ml/ l of water (1.56 larvae/ plant) and Thiamethoxam 25 WG @ 0.2 g/ l of water (3.58 larvae/ plant) whereas, significantly highest number of larval population was recorded from untreated control plot (5.92 larvae/ plant). Similar trend was recorded during second year i.e. the plot (T_3) treated with both Thiamethoxam and Indoxacarb was proved to be the best treatment (0.98 larvae/ plant) and it was found significantly superior to rest of the treatments. Present findings regarding efficacy of different treatments against pod borers are in conformity with the study of Ahmed *et al*. (2004) [3] and Dhawan and Simwat (2000) [10] who obtained the same impact i.e. pod borers infestation were significantly lower in treated plots as compared to control plot. Singh *et al*. (2009) [19] reported that indoxacarb was the best treatment for the management of *H. armigera* in chickpea. Superior performance of indoxacarb against *H. armigera* was also reported by Gunning and Devonshire (2002) [9]. Deshmukh *et al.* (2010) [15] found the low pod borer incidence (18.7%) and high seed yields when plots treated with chemical insecticide.

Incidence of pulse aphid

The mean aphid populations in different treatments were varied from 13.06 to 53.56 per 10 cm apical twig per plant during first year of experimentation and they differed significantly from each other (Table 1). The data revealed that among the different treatments, T_3 in which insecticides (Thiamethoxam 25 WG + Indoxacarb14.5 SC) were applied at both vegetative and reproductive stage of the crop showed the significantly lowest population of aphids (13.06 aphids/ top 10 cm twig/ plant) whereas, maximum population of aphids (53.56 aphids/ top 10 cm/ plant) were recorded from untreated control (T_4). Among the treated plots,T_2 (Indoxacarb14.5 SC) performed least and recorded highest population of aphid (36.50 aphids/ top 10 cm twig/ plant) though it was significantly lower as compared to untreated plot. During second year also a more or less similar trend of efficacy was recorded in various treatments against pulse aphid. All the treatments were found significantly superior over the control. The minimum aphid population (13.80 aphids/ top 10 cm twig/ plant) was recorded in T_3 (Thiamethoxam 25 WG + Indoxacarb 14.5 SC) followed by T_1 (Thiamethoxam 25 WG) with 15.41 aphids/ top 10 cm twig/ plant and T_2 (Indoxacarb 14.5 SC) with 33.70 aphids/ top 10 cm twig/ plant (Table 1). Maximum aphid population (46.22 aphids/ top 10 cm twig/ plant) was recorded in control

plot. Therefore, it can be said that the most effective treatment against pulse aphid was T_3 whereas, the least effective treatment was T_2 but it was better than untreated control. These results are in accordance with Gaikwad *et al*. (2014) [12] who recorded least survival of aphid population with thiamethoxam 25% WG @ 75 g a.i./ ha and it was superior to all other treatments. Similar results were obtained by Abd-Ella (2014) [1] who indicated that thiamethoxam showed a high efficiency against cowpea aphid *Aphis craccivora* Koch. Gaber *et al*. (2015) [11] found that the foliar application of thiamethoxam caused a high significant reduction in cotton aphid population. Ghosh *et al*. (2016) [13] reported a reduction of 92.95% and 99.47% in the population of aphids after first and second spray, respectively with thiamethoxam 25% WG.

Table 1: Efficacy of different treatments against major insect pests of field pea

Treatment No.	Treatment details	Mean pest population			
		Gram pod borer (larvae/ plant)		Pulse aphid (adult + nymph/ top 10 cm twig/ plant)	
		2016-17	2017-18	2016-17	2017-18
T_1	Thiamethoxam 25 WG @ 0.2 g/ l of water at vegetative stage	3.58 (1.89)*	4.68 (2.16)	18.90 (4.40)	15.41 (3.98)
T_2	Indoxacarb 14.5 SC @ 0.5 g/ l of water at reproductive stage	1.56 (1.25)	1.46 (1.21)	36.5 (6.08)	33.70 (5.84)
T_3	$T_1 + T_2$	1.01 (1.00)	0.98 (0.99)	13.06 (3.68)	13.80 (3.78)
T_4	Untreated control	5.92 (2.43)	5.29 (2.30)	53.56 (7.35)	46.22 (6.83)
SEm (+/-)		0.14	0.16	0.38	0.31
CD (p=0.05)		0.48	0.56	1.32	1.10

*Values in parentheses are square root transformed values

Estimation of per cent pod damage, yield and avoidable crop loss

The efficacy of different treatments has been reflected in per cent pod damage and yield data which are presented in Table 2 and Figure 1, 2. The results revealed that all the treatments were significantly effective in reducing the infestation of pod borers and aphid population and thus increasing the yield significantly as compared to control. During first year, maximum pod damage was recorded in control plot i.e. T_4 (26.68 %) and it was followed by T_1, T_2 and T_3. During second year also, least per cent pod damage (2.48 %) was recorded in the plots treated with Thiamethoxam +Indoxacarb and highest pod damage (14.76 %) was recorded in untreated plots. Similar trend was recorded in the yield of field pea during both of the years, 2016-17 and 2017-18. T_3 (Thiamethoxam +Indoxacarb) was proved to be the most effective treatment resulted with 11.25 and 12.00 q/ ha grain yield in first and second year, respectively and was found significantly superior to rest of the treatments. Highest increase in yield (44.64% and 38.24 % during first and second year, respectively) was also recorded in the plots sprayed twice at both vegetative and reproductive stage of the crop. The next best treatment was T_2 (producing 10.27 and 11.40 q/ ha of yield in 2016-17 and 2017-18, respectively) and it was followed by T_1 (producing 9.44 and 9.58 q/ ha of yield in 2016-17 and 2017-18, respectively). Significantly least grain yield was recorded from untreated control plot (7.77 and 8.68 q/ ha in first and second year, respectively). Maximum per cent loss in grain yield (30.93% and 27.66% in 2016-17 and 2017-18, respectively) was recorded from T_3 which was followed by T_2 and T_1. The results are in agreement with Abhilasha and Shekharappa (2017) [2] who recorded maximum yield in fully protected plot and minimum yield from untreated plot in pea. According to Srivastava and Srivastava (1990) [20], mean pod damage by gram pod borer in the protected and unprotected plots was respectively 0.9 and 5.9% in 1984 and 1.0 and 6.4% in 1985. The findings of the present experiment in relation to pod damage and yield are more or less in accordance with the Babariya *et al.* (2010) [7] and Sudha Rani *et al.* (2018) [22] who obtained significantly highest grain yield from the plot sprayed with Indoxacarb as compared to untreated plots in pea.

Table 2: Estimation of pod damage, yield and avoidable yield loss of field pea in different treatments

Treatment No.	2016-17				2017-18			
	Pod Damage (%)	Yield (q/ ha)	Increase in yield over control (%)	Avoidable yield loss (%)	Pod damage (%)	Yield (q/ ha)	Increase in yield over control (%)	Avoidable yield loss (%)
T_1	17.06 (24.77)*	9.44 (3.15)**	21.43	17.69	13.54 (22.01)*	9.58 (3.17)**	10.40	9.39
T_2	4.52 (12.95)	10.27 (3.28)	32.14	24.34	3.92 (12.14)	11.40 (3.45)	31.36	23.85
T_3	3.24 (11.15)	11.25 (3.43)	44.64	30.93	2.48 (9.94)	12.00 (3.54)	38.24	27.66
T_4	26.68 (31.42)	7.77 (2.88)	0.00	-	14.76 (22.99)	8.68 (3.03)	0.00	-
SEm (±)	0.76	0.15	-	-	0.80	0.12	-	-
CD (p=0.05)	2.64	0.52	-	-	2.71	0.49	-	-

* Values in parentheses are arcsine transformed values. **Values in parentheses are square root transformed values

Table 3: Economics of different treatments imposed on field pea

Treatment No.	Cost of Increased yield (Rs./ha)		Plant protection cost (Rs./ha)		Net Profit (Rs./ha)		ICBR	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
T_1	12230	13987	1828	1920	10402	12067	1:5.69	1:6.28
T_2	14238	15889	2235	2346	12003	13543	1:5.37	1:5.77
T_3	17460	19021	4063	4266	13397	14755	1:3.29	1:3.45

T_4	-	-	-	-	-	-	-	-

N.B. - Labour charges: Rs. 190/day; Standard spray volume: 500 l/ha; Sale Price of pea: Rs. 33/Kg and Rs. 35/Kg during 2016-17 and 2017-18 respectively.

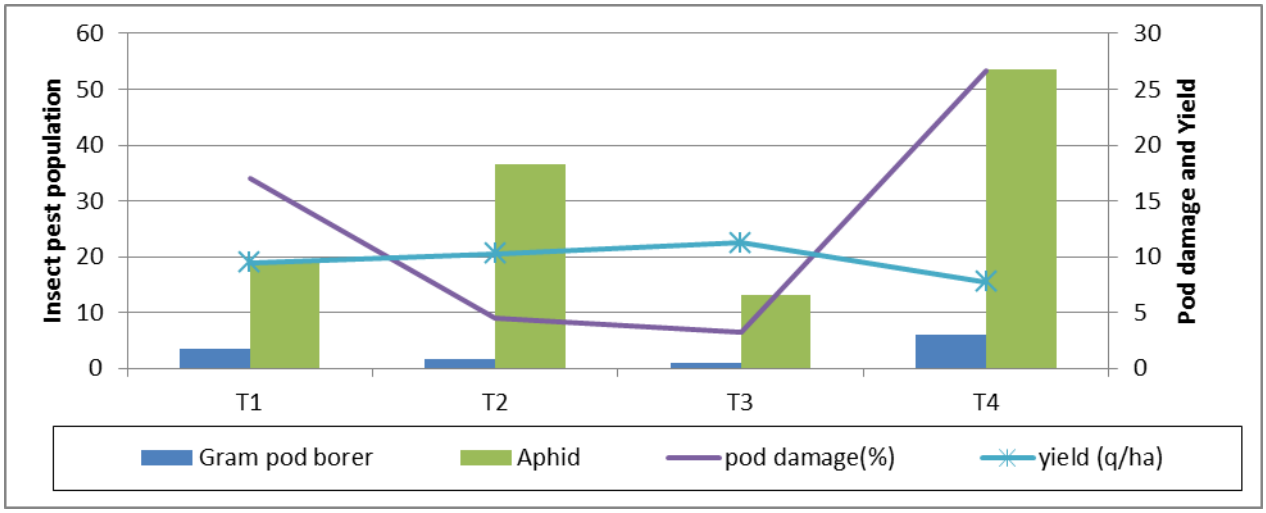

Fig. 1: Impact of different treatments against major insect pests of field pea and corresponding pod damage and yield during 2016-17

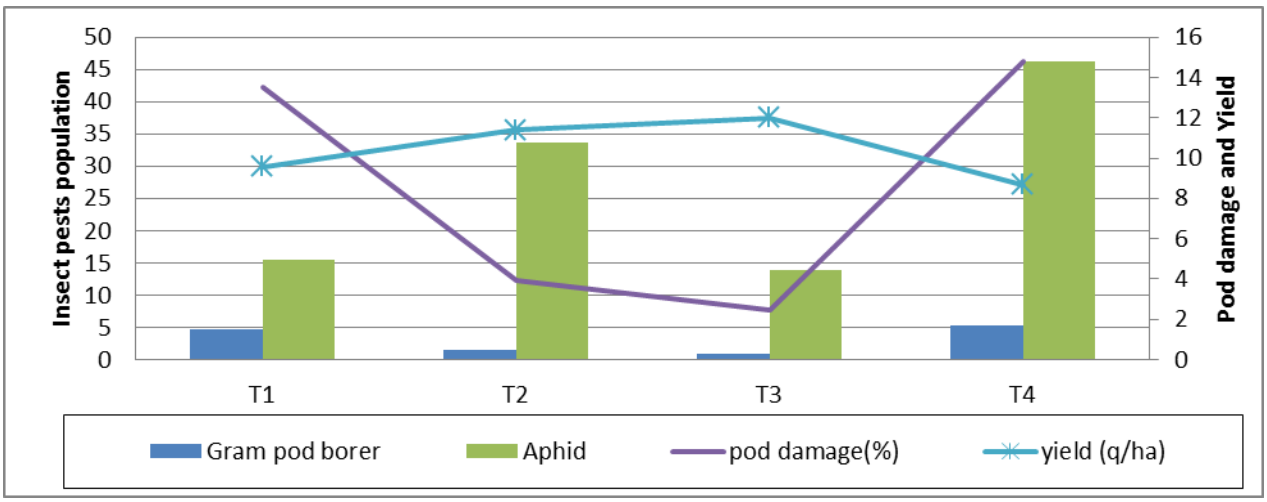

Fig. 2: Impact of different treatments against major insect pests of field pea and corresponding pod damage and yield during 2017-18

Economics of different treatments

The results of the economics study of different treatments (Table 3) revealed that maximum expenditures due to plant protection (Rs. 4063.00/ ha and 4266.00/ ha during 2016-17 and 2017-18, respectively) were made in the plot treated with Thiamethoxam + Indoxacarb and least cost (Rs. 1828.00/ ha and 1920.00/ ha during 2016-17 and 2017-18, respectively) was required in the plot treated with Thiamethoxam. The data indicated that, sole application of Thiamethoxam was found as the most economically viable treatment since this treatment recorded maximum ICBR of (1: 5.69 and 1:6.28 during first and second year, respectively). It was followed by the insecticidal treatment of Indoxacarb which recorded the ICBR of 1:5.37 and 1:5.77 during 2016-17 and 2017-18, respectively. Minimum ICBR (1:3.29 and 1:3.45) was recorded with Thiamethoxam +Indoxacarb. However, the results revealed that the highest net profit (Rs. 13397.00/ ha 14755.00/ ha during first and second year, respectively) was obtained from the plots sprayed with Thiamethoxam + Indoxacarb and it was followed by sole application of Indoxacarb (Rs. 12003.00/ ha and 13543.00/ ha) and Thiamethoxam (Rs. 10402.00/ ha and 12067.00/ ha). The results obtained in the present investigation in relation to cost benefit ratio are to some extant in accordance with the findings of Sahito *et al.* (2012) [18] and Yadav *et al.* (2019) [23] who earlier reported that in pea higher economic return was obtained from the plots treated with chemical pesticides.

Conclusion

The results from both the years of experimentation clearly suggests that to control the insect pests of field pea, the crop should be sprayed during both vegetative and reproductive stages with Thiamethoxam and Indoxacarb at aforementioned doses when two rounds of spraying are allowed. Otherwise, if one spraying is allowed, the crop should be sprayed during reproductive stage with Indoxacarb at prescribed dose. This finding also concludes that pests infested at reproductive stage like pod borers are more important in terms of damaging capability to field pea than sucking pests.

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