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Assessment of various IPM modules against major insect pests of pea (*Pisum sativum* L.)

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Abstract
The present investigation was carried out during *Rabi* season of 2016-17 and 2017-18, at the Agricultural Research Farm of Institute of agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh on pea, to check the efficacy of integrated pest management modules against major insect pests of pea. To evaluate IPM modules field trial was conducted by using high yielding cultivar HUDP- 15 with five IPM modules with three replication in randomized block design, M1 - Pheromone trap, NSKE 5% Imidacloprid, M2 - Pheromone trap, Imidacloprid-Indoxacarb. Mustard is intercrop, M3 - Pheromone trap, Indoxacarb-Dimethoate, M4 - Sprayof Dimethoate- NSKE 5%, and M5– Untreated (control). The study revealed that highest cost: benefit ratio of 1:7.3 and 1:8.5 were obtained in the module 1 while Module 2 was found to have low cost: benefit ratio *i.e.*, 1:3.2 and 1:3.9 during two consecutive years, though it was most effective in reducing pest population. Module 1 is found effective and economical.

Keywords: IPM modules, pests of pea, *Pisum sativum*

Introduction
India is the largest producer and consumer of the pulses in the world covering 33 per cent of world area and 27 per cent of world production (Chaturvedi and Ali, 2002) [3]. Pea (*Pisum sativum*) belongs to Leguminosae family, it is grown all over temperate and semi-tropical regions, because of its high palatability, taste, nutritive values, short duration, fast growth and high yield potential being an important protein source there is increase in demand for this pulse crop both for animal feed as well as for human consumption (Santalla *et al.* 2001) [8] and restores soil fertility by its atmospheric nitrogen fixation capacity with symbiotic relationship with *Rhizobium* (Singh *et al.* 2002) [10]. Although, India stands the first place in an area under pulses the productivity of this crop in our country is quite low as compared to other developed countries. The important factors responsible for the low yield potential of garden pea might be attributed to lack of high yielding varieties, its cultivation on marginal land and submarginal lands, a heavy infestation of pests and diseases and untimely application of fertilizer, irrigation, and plant protection. Invasion of an array of insect pests at different stages seriously felt as one of the major constraints in realizing the potential yield and in India, the crop is devasted by 17 insect pests which are lowering down they yield of the crop both qualitatively and quantitatively of which leaf miner, pea aphid, gram pod borer, pea semi looper, pea stem fly and pea thrips could be considered of major significance (Dhamdhere *et al.*1970) [4].
The chemical control is one of the most effective and quicker methods in India, where farmers realize results within a short period. But their indiscriminate uses over a longer period resulted in the loss of biodiversity, development of resistance in pests, the build-up of resurgence, a secondary outbreak of pests, destruction of natural enemies and toxicological hazards due to pesticides residue etc. (Kranthi, 2002) [6]. Further this unilateral approach of controlling pest by use of insecticides has necessitated the cost effective, eco-friendly, target specific and safe management strategy and for effective management of these wide arrays of destructive insect pests and for achieving the best results in insect pest control.
Integrated pest management is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, and modification of cultural practices, use of resistant varieties, biopesticides and need-based use of insecticides. Thus, the fundamental importance of IPM is the evidence in its recent adoption as a basic tenet of the sustainable agriculture movement (Gnanasambandhan *et al.* 2000) [5]. Keeping the above aspects into consideration, the following investigation was therefore undertaken to safeguard the pea crop from insect pests and to avoid the damage loss caused by the major insect pests.

Materials and methods
Moderately high yielding HUDP 15 cultivar of pea was sown in plots of 7 rows of 4-meters length and row to row distance of 30 cm and pant to the spacing of 10 cm in *Rabi* season of

2016-17 and 2017-18. The crop was grown in Randomized Block Design following normal agronomic practices with three replications and five treatments.

Table 1: Details of IPM module evaluated against

S. No.	IPM Module Details
M1	Installation of pheromone traps at early vegetative stage of crop. Spray of NSKE 5% at flowering stage followed by spray of Imidacloprid @17.8 SL@ 0.25ml/litre at 15 days interval.
M2	Mustard is grown as intercrop in the ratio of 1:5. Pheromone trap was installed in vegetative stage. Two sprays of insecticides were made. First spray of Imidacloprid 17.8 SL@ 0.25ml/litre at early flowering stage and second spray of Indoxacarb15.8 EC @73g a.i/ha at pod formation stage.
M3	Mustard grown as intercrop with pea at 1:5 ratio. First spray of Dimethoate 30EC@600g a.i/ha followed by Indoxacarb @ 15.8 EC @73g a.i/ha at 15 days interval in flowering and podding stage of crop.
M4	Spray of Dimethoate 30EC@ 600g.a./ha and NSKE 5% at 15 days interval in flowering and podding stage of crop.
M5	Untreated (Control)

Pods and leaves damage assessment

Pod and leaf damage observation was done by counting a total number of affected leaves and pods out of total leaves and pods respectively taken for observation from five plants. Damage assessment was made based on the holes created by pod borer during their entry feeding or at the time of emergence. The percent pod damage was worked out by using following formula:

$$\text{Per cent pod damage} = \frac{\text{Number Of Damaged Pod}}{\text{Total Number Of Pods Taken For Observation}} \times 100$$

Cost-benefit analysis of the treatments

The grain yield from the net plot of $12m^2$ area was recorded from each treatment and then yield was converted into Kg/ha and increase in yield over control (%) was computed.

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield In Treated Plot} - \text{Yield In Control Plot}}{\text{Yield In Control Plot}} \times 100$$

The benefit-cost ratio of each module was calculated taking into account of the prevailing market price of inputs and outputs *i.e*., the produce, pheromone trap, intercropping and labour charges.

Statistical analysis

Data obtained on various aspects was subjected to ANOVA as per Randomized Block design mean population data of *Helicoverpa armigera* was transformed by square root transformation method and mean *Aphis craccivora* population by log(x+1) transformation method.

Results and Discussions

Effect of various IPM modules on larval population of *H. armigera*

The incidence of *H. armigera* was observed from 3rd standard week and persisted up to 11th standard week during both the years *i.e*., 2016-17 and 2017-18 and presented in table 2 and figure 1. When the overall mean population was considered together the mean larval population was varied from 1.45 to 3.76 larvae/meter row length), the minimum larval counts (1.45 larvae/meter row length) was observed in module 2 followed by module 3 (1.70 larvae/meter row length), and the highest number of larvae (2.23 larvae/meter row length) was observed in module 4 over the control (3.76 larvae/meter row length). Similarly, during 2017-18 the overall mean population was varied from 1.23 to 3.70 (larvae/meter row length) and the minimum population (1.23 larvae/meter row length) was observed in module 2, while the maximum population (3.70 larvae/meter row length) was found in module 5. The present findings were supported by the Anandhi *et al.* (2011) [1] stated that among the treatments, Indoxacarb recorded the highest reduction of pod borer population in first and second spray, followed by Spinosad. Among the plant products, the best treatment with the highest reduction of pod borer population in the first and second spray was NSKE, followed by garlic extract.

Effect of various treatment modules on mean population of *Aphis craccivora*

Data on effect of various treatment modules on mean population of *A.* craccivora is depicted in table 4 and figure 3. When overall mean of the population of *A. craccivora* was considered together, the minimum aphids (17 aphids/top 15 cm twig) were observed in module 2 followed by module 3 (18.88 aphids/top 15 cm twig), and highest aphids count was observed in module 4 when compared to module 5 (untreated control). Similarly during, 2017-18, the minimum aphids (16.04 aphids/top 15 cm twig) were observed in module 2 followed by module 3 (20.73aphids/top 15 cm twig), and highest aphids count was observed in module 1 (22.20 aphids/top 15 cm twig when compared to module 5 (untreated control. The present findings were similar with the findings of Swarnalata *et al.* (2015) [11] who observed that the treatment Imidacloprid 0.005 % was most effective followed by Thiamethoxam 0.01 %, *Verticillium lecanii* 0.40 %, Azadirachtin 0.002 % and Dimethoate 0.03 % were the next in order. However, the highest marketable pod yield was recorded from the plots treated with Thiamethoxam 25 WG @ 0.01 %. Similar results were obtained by Bora *et al.* (2014) [2] who found that lowest incidence and the highest population reduction of aphid was achieved with Imidacloprid at 30g a.i./ ha. Followed by Fipronil 60g a.i./ ha.

Cost benefit analysis of the different IPM modules

During the year 2016-17, the cost: benefit analysis has been calculated for different IPM modules and it was revealed that highest ratio of 1:7.3 was obtained in the module 1, next highest cost: benefit ratio 1:5.9 was occurred in module 4 fallowed by 1:4.6 in module 3 and however the lowest cost benefit ratio of 1:3.2 found in module 2. Similarly, during the year 2017-18, the cost: benefit analysis has been calculated for different IPM modules and it was revealed that highest ratio of 1:8.5 was obtained in the module 1, next highest cost: benefit ratio 1:4.5 was occurred in module 4 fallowed by 1:39 in module 2 and however the lowest cost benefit ratio of 1:2.25 resulted in the module 4. The present findings were somewhat similar with the findings of Kumar *et al.* (2015) [7] who reported that the maximum benefit-cost ratio of 1:4.28 was obtained from the plots treated with neem leaves extract 5% at weekly interval starting with the initiation of pod formation.

During the both the years of the study, the cost: benefit analysis calculated for different IPM modules revealed that highest ratio of 1:7.3 and 1:8.5 were obtained in the module 1. The results of evaluation of different integrated pest management modules revealed that module 1 comprising of pheromone trap, 1st spray with NSKE5% followed by second spray of Imidacloprid 17.8 SL@0.25ml/litre at 15 days

interval was most economical as well as effective in management of insect pests of pea, hence this module can be considered for recommendation to farmers of this region.

Table 2: Estimation of larval population of *H. armigera* in different IPM modules during 2016-17 and 2017-18

Treatment module	Population of *H. armigera* during 2016-17									Population of *H. armigera* during 2017-18								
	3rd SW	4th SW	5th SW	6th SW	7th SW	8th SW	9th SW	10th SW	11th SW	3rd SW	4th SW	5th SW	6th SW	7th SW	8th SW	9th SW	10th SW	11th SW
M1	0.52 (1.23)*	1.20 (1.47)	1.48 (1.54)	1.19 (1.54)	1.72 (1.63)	2.70 (1.91)	2.10 (1.75)	3.10 (2.02)	3.50 (2.11)	1.19 (1.47)*	1.96 (1.71)	1.10 (1.44)	1.74 (1.5)	1.58 (1.59)	1.46 (1.56)	2.22 (1.77)	1.50 (1.57)	2.06 (1.73)
M2	0.40 (1.18)	1.22 (1.48)	1.42 (1.46)	0.96 (1.50)	1.32 (1.51)	2.12 (1.75)	1.62 (1.60)	1.74 (1.65)	2.28 (1.80)	0.94 (1.38)	1.58 (1.64)	0.78 (1.32)	0.84 (1.34)	1.08 (1.42)	1.95 (1.39)	1.62 (1.61)	0.96 (1.39)	1.32 (1.51)
M3	0.37 (1.17)	1.50 (1.56)	1.98 (1.52)	0.98 (1.58)	1.48 (1.54)	2.20 (1.77)	1.90 (1.68)	2.36 (1.82)	2.70 (1.92)	1.16 (1.46)	1.90 (1.69)	1.17 (1.46)	2.00 (1.73)	1.66 (1.62)	1.50 (1.57)	2.46 (1.85)	1.62 (1.61)	1.50 (1.61)
M4	1.59 (1.50)	1.18 (1.47)	1.92 (1.63)	1.30 (1.84)	2.00 (1.72)	3.30 (2.07)	2.30 (1.81)	3.10 (2.02)	3.46 (2.11)	0.88 (1.36)	2.24 (1.78)	1.98 (1.71)	1.94 (1.71)	1.41 (1.54)	1.66 (1.62)	2.44 (1.83)	2.10 (1.75)	1.80 (1.67)
M5 (control)	0.91 (1.38)	1.95 (1.71)	3.80 (2.12)	3.50 (1.75)	4.85 (2.41)	3.90 (2.21)	5.30 (2.50)	4.70 (2.38)	4.95 (2.43)	1.60 (1.61)	2.50 (1.87)	4.00 (2.2)	3.90 (2.21)	5.30 (2.5)	2.85 (1.96)	5.02 (2.45)	4.20 (2.28)	4.00 (2.23)
SE(m) ±	0.12	0.07	0.04	0.11	0.08	0.08	0.06	0.04	0.05	0.06	0.05	0.07	0.045	0.08	0.039	0.09	0.06	0.05
CD (5%)	N/S	N/S	0.14	N/S	0.26	0.24	0.20	0.14	0.16	N/S	N/S	0.216	0.137	0.24	0.118	0.298	0.18	0.16

* Data in the parenthesis are square root transformed value.
SW = Standard week

Table 3: Estimation of mean population of *A. craccivora* in different IPM modules during 2016-17 and 2017-18

Treatment module	Population of *A. craccivora* during 2016-17									Population of *A. craccivora* during 2017-18								
	3rd SW	4th SW	5th SW	6th SW	7th SW	8th SW	9th SW	10th SW	11th SW	3rd SW	4th SW	5th SW	6th SW	7th SW	8th SW	9th SW	10th SW	11th SW
M1	58.00* (7.25)	40.25 (7.06)	18.80 (4.43)	30.80 (5.63)	13.00 (3.7)	9.00 (3.15)	1.76 (1.65)	0.52 (1.21)	0.10 (1.08)	50.80 (6.00)*	58.80 (7.72)	17.60 (4.30)	34.80 (5.96)	15.40 (4.02)	17.40 (4.27)	4.00 (2.21)	1.00 (1.39)	0.20 (1.14)
M2	57.40 (7.12)	46.60 (6.89)	13.00 (3.71)	21.00 (4.68)	8.10 (3)	6.10 (2.64)	0.66 (1.28)	0.30 (1.12)	0.00 (1.00)	41.40 (7.16)	38.20 (6.22)	12.60 (3.60)	31.40 (5.65)	10.00 (3.30)	8.60 (3.07)	1.60 (1.50)	0.64 (1.26)	0.10 (1.00)
M3	55.00 (6.53)	48.80 (7.05)	19.00 (4.46)	24.00 (4.99)	12.20 (3.61)	8.60 (3.08)	1.38 (1.53)	0.80 (1.29)	0.16 (1.02)	43.20 (43.40)	48.80 (7.05)	20.40 (4.6)	39.60 (6.32)	14.04 (3.86)	14.20 (3.81)	4.80 (2.37)	1.30 (1.49)	0.24 (1.08)
M4	53.00 (6.83)	48.00 (6.98)	22.00 (4.87)	30.20 (5.57)	12.00 (3.59)	7.56 (2.91)	1.94 (1.70)	0.20 (1.08)	0.14 (0.14)	43.40 (6.63)	50.80 (7.18)	21.00 (4.62)	39.80 (6.34)	13.20 (6.55)	15.60 (4.02)	4.00 (2.21)	1.78 (1.65)	0.20 (1.31)
M5 (control)	64.00 (8.06)	56.00 (7.55)	68.00 (8.30)	42.00 (6.55)	30.50 (5.60)	15.00 (4.00)	8.50 (3.08)	2.00 (1.73)	0.20 (0)	64.50 (6.65)	68.00 (8.30)	65.00 (4.3)	71.00 (8.48)	42.00 (6.55)	25.00 (5.09)	9.00 (3.16)	3.50 (2.12)	0.30 (1.14)
SE(m) ±	0.12	0.15	0.18	0.13	0.125	0.12	0.07	0.10	0.08	0.259	0.215	0.107	0.318	0.14	0.211	0.17	0.10	0.088
CD (5%)	N/S	N/S	0.54	0.40	0.37	0.36	0.23	0.32	N/S	0.785	0.651	0.324	0.961	0.437	0.639	0.51	0.309	N/S

* Data in the parenthesis are log (x+1) transformed value.
SW = Standard week

Table 4: Percent reduction over control and over all mean population of major insect pests of pea during 2016-17 and 2017-18.

Treatment module	*H. armigera*				*A. craccivora*			
	% reduction over control		Over all mean		% reduction over control		Over all mean	
	2106-17	2017-18	2016-17	2017-18	2106-17	2017-18	2106-17	2017-18
Module 1	29.29	48.50	1.94	1.66	50.00	33.33	19.13	22.20
Module-2	53.93	67.00	1.45	1.23	100.00	66.66	17.00	16.04
Module-3	45.45	62.50	1.7	1.64	20.00	20.00	18.88	20.73
Module-4	30.10	55.00	2.23	1.82	25.00	33.33	19.40	21.08
Module-5 (control)	-	-	3.76	3.70	-	-	31.80	38.70

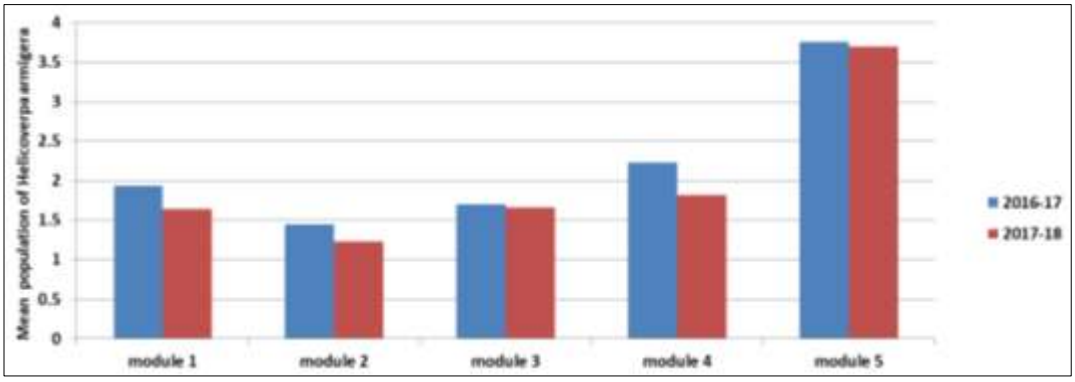

Fig 1: Population of gram pod borer, *H. armigera* in IPM modules during 2016-17 and 2017-18.

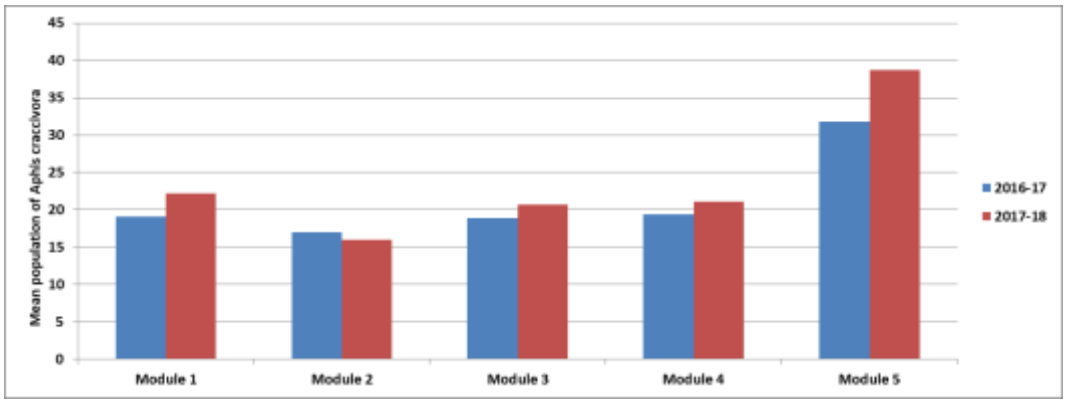

Fig 2: Population of pea aphid, *A.craccivora* in IPM modules during 2016-17 and 2017-18.

Table 5: Cost- benefit analysis of different IPM modules against insect pests of pea

Treatment module	Grain Yield of pea(Kg/ha)		yield increase over control (Kg/ha)		Grain yield of mustard (Kg/ha)		Additional income (Rs/ha) [A]		Additional Cost (Rs/ha) [B]		Net profit (Rs/ha) [A-B]		Cost: benefit Ratio(CBR)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Module 1	704	630.59	362.3	362.3	-	-	10869	11593.6	3966.8	4066.8	6902	7526.8	1:7.3	1:8.5
Module 2	895	938.5	622	669.1	105	120	21810	25611.6	5089	5189.8	16721	20421.8	1:3.2	1:3.9
Module 3	753	705.00	480	437	123	140	18582	18884	3303	3403	15279	15481	1:4.6	1:4.5
Module 4	502	510	229	231.71	-	-	15060	7414.72	2180	2280	12880	5134	1:5.9	1:2.2
Module 5	273	278.29	-	-	-	-	-	-	-	-	-	-	-	-

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