



Evaluation and Validation of Different Integrated Pest Management Modules for Field Pea

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ABSTRACT

This research was carried out during *rabi* (November–March) 2020–21 at Agronomy Instructional Farm, S. D. Agricultural University, Sardarkrushinagar, Gujarat, India to evaluate the efficacy of seven different Integrated Pest Management (IPM) modules against insect-pests of field pea. Five IPM modules were tested for their efficacy against insect-pest. The result revealed that the module M₄ (Border crop with chickpea+treating seeds by imidacloprid 600FS @ 3 ml kg⁻¹ seed+yellow sticky trap @ one module⁻¹+sprays of azadirachtin 1500 ppm @ 40 ml 10 l⁻¹ water+HaNPV 250 LE @ 10 ml 10 l⁻¹ of water+profenophos 50 EC @ 10 ml 10 l⁻¹ water) exhibited significantly minimum population of 1.47 aphid 10 cm⁻¹ shoot, 1.00 leafhopper trifoliolate⁻¹, 0.62 whitefly trifoliolate⁻¹, 0.08 larva plant⁻¹ with lowest pod borer damage (0.30%) and thus proved to be most effective module which was at par with module M₁. The highest field pea seed yield (1250 kg ha⁻¹) was also harvested from module M₄. The maximum (42.04%) increase in yield was obtained in the plots framed with M₄ followed by module M₁. The avoidable losses in field pea yield were minimum (9.36%) in module M₁. The highest (₹ 87,500 ha⁻¹) gross realization was obtained from the plots framed with module M₄. The highest Protection Cost: Benefit Ratio (PCBR) was obtained in module M₄ (1:3.56) which clearly indicated that module M₄ was also the most economical module amongst all.

KEYWORDS: IPM, modules, field pea, *Pisum sativum*, insect-pest

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1. INTRODUCTION

Field pea (*Pisum sativum* Linnaeus) is also known as 'Dry pea' and it is called 'Matar' in India. It plays an important part not only in India but also as a crop that is in high demand worldwide for food, feed, and fodder (Parihar et al., 2022). It belongs to the family Fabaceae and sub-family Faboideae. Field pea is an important rabi pulse crop grown in 0.64 mha with an annual production of 0.88 m tonnes during 2020–21 (Anonymous, 2021). The average productivity of this crop has increased considerably over the years which is now to the tune of 1.4 t ha⁻¹ (Anonymous, 2022). India is the world's greatest producer and consumer of pulses, accounting for 26% of production and 36% of area (Anonymous, 2020). Plenty of studies have proven the contribution of pulses in raising the yield of later cereal and oilseed crops through nitrogen fixation (Liu et al., 2019; Herridge et al., 2022; Lasisi and Liu, 2023).

India's average consumption of pulses is still low and has decreased over time, despite large imports. Overall availability per capita was 22 kg in 1951, 18.7 kg in 1971, 15.2 kg in 1991 and 11 kg in 2001. More recently, it grew to 18 kg in 2021 (Anonymous, 2023). Furthermore, an estimated one billion individuals are affected by severe hunger due to inadequate intake of nutrients like minerals and vitamins and protein-rich foods (Shivay, 2015; Sheoran et al., 2022; Bhardwaj et al., 2024). Between 1961 and 2020, pulses area, production, and average productivity worldwide increased (Kumar et al., 2023). However, to compensate for the deficit, India imports about two to three million tons of pulses annually (Singh et al., 2022). For efficient use of resources, appropriate techniques must be very location-specific and provide a solution for an exponential increase in pulse yields on predicted patterns (Prahara et al., 2023; Reddy et al., 2023).

An estimated 2.5 to 3.0 mt of pulses vanish each year as a result of pest incidents, with the damages from insect pests totaling close to ₹ 6,000 crores (Reddy, 2009). The pea crop is attacked by numerous kinds of insect-pests, especially pod borer (*Helicoverpa armigera*), whitefly (*Bemisia tabaci*), leafhopper (*Empoasca kerri*) and aphid (*Aphis craccivora*) (Khan et al., 2024). The frequent use of several synthetic chemical pesticides to lower the pests under the economic threshold level led to the development of resistance and an upsurge of pests (Karlsson et al., 2020; Routray et al., 2021). Concerns have also been raised over the sublethal effects of increased pesticide use on beneficial insects and pollinators (Reshi et al., 2024), as well as the presence of residue in food. (Munir et al., 2024). This integrated strategy reduces pesticide contamination and other environmental hazards (Deguine et al., 2021; Subba et al., 2022).

According to Trivedi and Ahuja (2011), integrated pest

management is an ecological approach concentrating on long-term preventative measures or reduction of damage using a variety of methods, including biological control, habitat manipulation, alteration of cultural techniques, use of resistant varieties, microbial pesticides and need-based pesticide application. IPM's recent acceptance as a fundamental element of the sustainable agricultural movement has been demonstrated (Gnanasambandan et al., 2000; Dara, 2019).

The suggested research was created with the necessity of integrated pest control in mind. Our research aims to secure food sustainability through innovative IPM strategies in field peas. Thus, taking into account the crop's economic importance as well as the current status of insect pest attacks. Therefore, the current study was conducted on IPM using seven different IPM modules.

2. MATERIALS AND METHODS

Field experiment was conducted in *rabi* season (November–March) of 2020–2021 at Agronomy Instructional Farm, SDAU, Sardarkrushinagar, Gujarat, India (24° 19' N Latitude, 72° 18' E Longitude with elevation 154.52 m above mean sea level) which comes under the North Gujarat zone and North-West climatic zone of state. The soil of the experimental location is deep; light brown in colour and loamy sand-type texture with pH ranging from 7.5 to 7.9. Five IPM modules (Table 1) were tested for their efficacy against insect-pest and each module was considered as one treatment. Each plot was 6.0×6.0 m² in size, with a 30×10 cm² plant gap which replicated four times. For this purpose, field pea variety Dantiwada Field pea 1 was procured from Pulses Research Station, SDAU, Sardarkrushinagar.

2.1. Method of insecticidal application

The crop was grown using standard, advised agronomical methods. The first treatment of the appropriate insecticides for that module was made as soon as the pests started to appear, and any additional applications were made 15 days later using a physically operated knapsack sprayer fitted with a duromist nozzle. Before applying every module, the sprayer was carefully cleaned.

2.2. Method of recording observations

For this purpose, number of sucking pests viz., aphids were recorded from 10 cm shoots, and leafhoppers and whitefly were counted from three leaves of each tagged plant in each quadrat at weekly intervals during morning hours for second week after sowing to the crop maturity. Larva of *H. armigera* were recorded randomly from the same selected plants in each quadrat. Per cent pod damage and seed yield were both observed for individual modules as the crop was being harvested. The economics of the treatments were worked out on the basis of prevailing market prices of

Table 1: Details about IPM modules tested against insect-pests of field pea during 2020–21

Treatments	Details of treatment
M ₁ : IPM-1	In module M ₁ , sowing two rows of mustard as border crop with field pea. Two weeks after sowing yellow sticky trap @ one module ⁻¹ was installed at the middle of the module. Three sprays of insecticides were made. At the initiation of pests, foliar spray of azadirachtin 1500 ppm @ 40 ml 10 l ⁻¹ water was applied and second spray of spinosad 45 SC @ 3 ml 10 l ⁻¹ litre water was applied at 50% flowering stage after 15 days of 1st spray. Third spray of <i>HaNPV</i> 250 LE @ 10 ml 10 l ⁻¹ of water was made at 50% podding stage
M ₂ : IPM-2	In module M ₂ , two rows of fenugreek as border crop with field pea. At the initiation of pests, first spray of Giant milkweed (<i>Calotropis gigantea</i>) leaves+cow urine @ 500 g+1 litre 10 litre ⁻¹ water; second spray of morning glory (<i>Ipomoea carnea</i>) leaves+cow urine @ 500 g+1 litre 10 litre water ⁻¹ ; third spray of wild sage (<i>Lantana camera</i>) leaves+cow urine @ 500 g+1 l 10 l ⁻¹ water and fourth and last spray of NSKE @ 5%+cow urine @ 500 g+1 litre 10 litre water ⁻¹ was applied subsequent at the 15 days interval
M ₃ : IPM-3	At the initiation of pests, first spray of <i>Beauveria bassiana</i> (1×10 ⁸ cfu g ⁻¹) 1.15% WP @ 40 g 10 l water ⁻¹ ; second spray of <i>Lecanicillium lecanii</i> (1×10 ⁸ cfu g ⁻¹) 1.15% WP @ 40 g 10 l water ⁻¹ ; third spray of <i>Bacillus thuringiensis</i> powder (1×10 ¹¹ cfu g ⁻¹) 0.5% WP @ 15 g 10 l water ⁻¹ and of <i>HaNPV</i> 250 LE @ 10 ml 10 l ⁻¹ of water was impose subsequent on 15 days interval at 50% podding stage of the crop
M ₄ : IPM-4	Two rows of chickpea as border crop with field pea. Field pea seeds were treated thoroughly with imidacloprid 600 FS @ 3 ml kg ⁻¹ seeds in water and the seeds were smeared with insecticidal solution in the polythene bag and dried in shade before sowing. Two weeks after sowing yellow sticky trap @ one module ⁻¹ was installed at the middle of the module. At the initiation of pests, foliar spray of azadirachtin 1500 ppm @ 40 ml 10 l water ⁻¹ was applied and second spray of <i>HaNPV</i> 250 LE @ 10 ml 10 l ⁻¹ of water at 50% podding stage and third spray of profenophos 50 EC @10 ml 10 litre ⁻¹ water subsequent at 15 days interval
M ₅ : IPM-5	Untreated control

inputs and outputs. Large Plot Sampling (CRD) design was utilized during the experiment and replicate four times. The data thus obtained were statistically analyzed.

3. RESULTS AND DISCUSSION

3.1. Efficacy of different modules against aphid, *A. craccivora*

It was evident from (Table 2) pooled mean of the *A.*

craccivora indicated that module M₄ comprised of border crop with chickpea+seed treatment through imidacloprid 600 FS+sticky trap (yellow)+alternate sprays of Azadirachtin 1500 ppm+*HaNPV* 250 LE+spray of profenophos 50 EC exhibited significantly minimum aphid (1.47) population in *P. sativum* and proved to be the most effective module which was at par with module M₁ (2.13). Module M₃ and M₂

Table 2: Bio-efficacy of different modules against aphid, *A. craccivora* on field pea

Sl. No.	Modules	No. of aphid 10 cm ⁻¹ shoot									Pooled mean	
		Week after sowing										
		6 th	7 th	8 th	9 th	10 th	11 th	12 th	13 th	14 th		15 th
1.	M ₁	1.56 ^a (2.01)	1.41 ^a (1.53)	1.56 ^a (1.97)	1.47 ^a (1.70)	1.73 ^{ab} (2.53)	1.59 ^{cd} (2.11)	1.89 ^{ab} (3.17)	1.77 ^{ab} (2.71)	1.56 ^a (1.99)	1.43 ^a (1.58)	1.60 ^a (2.13)
2.	M ₂	2.11 ^b (4.00)	1.86 ^b (3.03)	2.24 ^b (4.58)	2.05 ^c (3.72)	2.31 ^c (4.91)	2.16 ^c (4.19)	2.45 ^c (5.56)	2.32 ^c (4.90)	2.09 ^b (3.91)	1.86 ^b (2.98)	2.14 ^c (4.17)
3.	M ₃	1.88 ^b (3.05)	1.66 ^b (2.28)	1.90 ^c (3.16)	1.79 ^b (2.75)	1.79 ^b (2.75)	1.77 ^b (2.65)	2.13 ^b (4.06)	1.98 ^b (3.47)	1.90 ^b (3.15)	1.69 ^b (2.41)	1.86 ^b (3.02)
4.	M ₄	1.33 ^a (1.29)	1.25 ^a (1.08)	1.37 ^a (1.41)	1.34 ^a (1.32)	1.52 ^a (1.84)	1.38 ^a (1.43)	1.61 ^a (2.13)	1.51 ^a (1.80)	1.35 ^a (1.35)	1.27 ^a (1.12)	1.39 ^a (1.47)
5.	M ₅	2.61 ^c (6.33)	2.64 ^c (6.53)	2.68 ^d (6.72)	2.98 ^d (8.39)	3.07 ^d (8.97)	3.20 ^d (9.80)	3.61 ^d (12.60)	3.18 ^d (9.65)	2.79 ^c (7.34)	2.15 ^c (4.17)	2.89 ^d (8.05)
	SEm±	0.09	0.08	0.08	0.07	0.08	0.08	0.10	0.09	0.08	0.07	0.02
	CV %	9.73	9.15	8.13	7.01	7.53	8.17	8.55	8.61	7.90	8.25	8.35

Figures in parentheses are original values; Treatment means with the letter(s) in common are not significant by DNMR at 5% level of significance

registered 3.02 and 4.17 aphids ten cm⁻¹ shoot, respectively and found as less effective. However, significantly maximum number of aphids was noted from control (8.05). According to Swarnalata et al. (2015), the treatment of Imidacloprid (0.005%) was the most efficient for *A. craccivora* on pea, followed by Thiamethoxam (0.01%), *L. lecanii* (0.40%), Azadirachtin (0.002%) and Dimethoate (0.03%).

3.2. Efficacy of different modules against leafhopper, *E. kerri*
Summarily, it was obvious that module M₄ exhibited lowest

(1.00) pooled mean population of leafhopper in field pea (Table 3) and also proved to be the most effective module which was at par with module M₁ (1.31). Module M₃ and M₂ harboured 1.84 and 2.45 leafhoppers 3 leaves⁻¹, respectively and they were less effective against *E. kerri*. However, highest number of leafhoppers were noted from control (4.25).

3.3. Efficacy of different modules against whitefly, *B. tabaci*
It was evident from (Table 4) pooled mean that module

Table 3: Bio-efficacy of different modules against leafhopper, *Empoasca kerri* on field pea

Sl. No.	Modules	No. of leafhopper 3 leaves ⁻¹										Pooled mean
		Week after sowing										
		6 th	7 th	8 th	9 th	10 th	11 th	12 th	13 th	14 th	15 th	
1.	M ₁	1.33 ^{cd} (1.27)	1.12 ^a (0.77)	1.37 ^a (1.40)	1.27 ^{ab} (1.12)	1.50 ^{ab} (1.78)	1.38 ^{ab} (1.41)	1.52 ^a (1.82)	1.37 ^a (1.40)	1.27 ^a (1.14)	1.22 ^{ab} (1.00)	1.33 ^a (1.31)
2.	M ₂	1.62 ^b (2.17)	1.53 ^c (1.86)	1.80 ^c (2.78)	1.68 ^c (2.36)	1.87 ^c (3.04)	1.80 ^c (2.77)	1.92 ^c (3.23)	1.79 ^c (2.74)	1.58 ^b (2.00)	1.46 ^c (1.64)	1.71 ^c (2.45)
3.	M ₃	1.52 ^{bc} (1.82)	1.32 ^b (1.26)	1.58 ^b (2.03)	1.42 ^b (1.55)	1.64 ^b (2.24)	1.56 ^b (1.98)	1.72 ^b (2.50)	1.62 ^b (2.16)	1.45 ^b (1.64)	1.33 ^{bc} (1.29)	1.52 ^b (1.84)
4.	M ₄	1.17 ^a (0.93)	1.01 ^a (0.55)	1.24 ^a (1.05)	1.14 ^a (0.86)	1.36 ^a (1.38)	1.25 ^a (1.09)	1.34 ^a (1.32)	1.29 ^a (1.17)	1.21 ^a (0.97)	1.12 ^a (0.77)	1.21 ^a (1.00)
5.	M ₅	1.88 ^d (3.07)	2.03 ^d (3.65)	2.13 ^d (4.08)	2.21 ^d (4.39)	2.21 ^d (4.39)	2.24 ^d (4.56)	2.43 ^d (5.44)	2.56 ^c (6.08)	2.25 ^c (4.61)	1.64 ^d (2.25)	2.16 ^d (4.25)
SEm±		0.07	0.05	0.06	0.08	0.06	0.07	0.07	0.05	0.05	0.06	0.01
CV %		9.77	7.05	7.01	9.93	7.04	8.03	7.34	5.59	6.57	8.10	7.70

Figures in parentheses are original values; Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

Table 4: Bio-efficacy of different modules against whitefly, *Bemisia tabaci* on field pea

Sl. No.	Modules	No. of whitefly 3 leaves ⁻¹										Pooled mean
		Week after sowing										
		6 th	7 th	8 th	9 th	10 th	11 th	12 th	13 th	14 th	15 th	
1.	M ₁	1.10 ^{ab} (0.72)	1.05 ^{ab} (0.61)	1.18 ^{ab} (0.91)	1.13 ^{ab} (0.79)	1.25 ^{ab} (1.08)	1.19 ^{ab} (0.94)	1.34 ^{ab} (1.32)	1.22 ^{ab} (1.00)	1.11 ^{ab} (0.74)	1.01 ^a (0.53)	1.16 ^{ab} (0.86)
2.	M ₂	1.29 ^c (1.18)	1.22 ^c (1.01)	1.37 ^c (1.40)	1.32 ^c (1.26)	1.50 ^c (1.75)	1.42 ^c (1.53)	1.62 ^c (2.15)	1.52 ^c (1.83)	1.35 ^c (1.36)	1.20 ^b (0.99)	1.38 ^c (1.44)
3.	M ₃	1.20 ^{bc} (0.94)	1.16 ^{bc} (0.85)	1.27 ^{bc} (1.14)	1.21 ^{bc} (0.99)	1.35 ^b (1.34)	1.29 ^b (1.18)	1.45 ^b (1.62)	1.37 ^{bc} (1.39)	1.28 ^{bc} (1.16)	1.17 ^b (0.89)	1.27 ^{bc} (1.15)
4.	M ₄	1.02 ^a (0.55)	0.99 ^a (0.49)	1.06 ^a (0.64)	1.03 ^a (0.58)	1.13 ^a (0.80)	1.08 ^a (0.69)	1.22 ^a (1.00)	1.12 ^a (0.77)	0.95 ^a (0.42)	0.91 ^c (0.34)	1.05 ^a (0.62)
5.	M ₅	1.43 ^d (1.58)	1.54 ^d (1.92)	1.66 ^d (2.27)	1.74 ^d (2.57)	1.87 ^d (3.01)	2.01 ^d (3.58)	2.12 ^d (4.01)	2.01 ^d (3.58)	1.82 ^d (2.87)	1.40 ^c (1.47)	1.76 ^d (2.68)
SEm±		0.04	0.05	0.05	0.05	0.04	0.04	0.05	0.06	0.06	0.05	0.01
CV %		6.28	8.16	7.30	7.04	6.16	6.08	6.15	8.04	8.90	8.57	7.28

Figures in parentheses are original values; Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

M₄ (0.62) proved to be an efficient module by decreasing the population of whiteflies which was at par with module M₁ (0.86). Module M₃ (1.15) and M₂ (1.44) registered comparatively higher number of whiteflies in field pea and found to be less effective. Whereas, significantly maximum number of whiteflies were noted from control (2.68).

3.4. Efficacy of different modules against pod borer, *H. armigera*

The pooled mean number of larvae varied between 0.08 to 0.64 larva plant⁻¹ (Table 5). The module M₄ had the

lowest (0.08) larval population and was the most efficient which was at par with module M₁ (0.13). Modules M₃ and M₂ registered 0.31 and 0.35 larvae plant⁻¹ and found as less effective. However, highest (0.64) number of larvae was noted from control. According to Anandhi et al. (2011), NSKE @5% was the plant product that provided the best management and the greatest decrease in pod borer density after the first and second sprays. Thus, present results conform with their earlier findings.

Table 5: Bio-efficacy of different modules against pod borer, *H. armigera* on field pea

Sl. No.	Modules	No. of pod borer larvae plant ⁻¹										Pooled mean
		Week after sowing										
		6 th	7 th	8 th	9 th	10 th	11 th	12 th	13 th	14 th	15 th	
1.	M ₁	0.75 ^{ab} (0.07)	0.75 ^{ab} (0.06)	0.81 ^{ab} (0.16)	0.75 ^a (0.08)	0.83 ^{ab} (0.20)	0.80 ^{ab} (0.15)	0.88 ^a (0.29)	0.82 ^a (0.19)	0.78 ^a (0.11)	0.75 ^a (0.06)	0.79 ^a (0.13)
2.	M ₂	0.84 ^c (0.22)	0.83 ^b (0.20)	0.92 ^b (0.38)	0.90 ^b (0.34)	0.95 ^b (0.43)	0.93 ^c (0.40)	1.02 ^b (0.56)	0.96 ^b (0.44)	0.91 ^b (0.35)	0.85 ^b (0.24)	0.91 ^b (0.35)
3.	M ₃	0.83 ^{bc} (0.19)	0.81 ^{ab} (0.16)	0.90 ^b (0.32)	0.89 ^b (0.30)	0.92 ^b (0.36)	0.89 ^{bc} (0.31)	1.01 ^b (0.53)	0.95 ^b (0.41)	0.90 ^b (0.33)	0.83 ^b (0.20)	0.89 ^b (0.31)
4.	M ₄	0.73 ^a (0.05)	0.73 ^a (0.04)	0.76 ^a (0.08)	0.75 ^a (0.06)	0.76 ^a (0.09)	0.75 ^a (0.07)	0.84 ^a (0.21)	0.80 ^a (0.14)	0.74 ^a (0.06)	0.73 ^a (0.03)	0.76 ^a (0.08)
5.	M ₅	0.93 ^d (0.38)	0.98 ^c (0.47)	1.07 ^c (0.65)	1.10 ^c (0.73)	1.13 ^c (0.79)	1.15 ^d (0.83)	1.19 ^c (0.92)	1.10 ^c (0.73)	1.03 ^c (0.57)	0.91 ^c (0.34)	1.06 ^c (0.64)
	SEm±	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.01
	CV %	6.77	6.14	9.64	9.66	9.29	8.91	6.45	6.30	7.61	4.51	7.82

Figures in parentheses are original values; Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

3.5. Pod damage (%) by *H. armigera*

Minimum (0.30%) pod damage was observed in module M₄ and proved to be effective module which was at par with module M₁ (1.07%). Whereas, modules M₂ and M₃ were third and fourth effective modules which recorded 2.15 and 2.92% pod damage, respectively (Table 6). The effectiveness of botanical pesticides over chickpea pod borer was assessed by Bhushan et al. (2011). The results suggest that NSKE at 5% was the most efficient for reducing larvae population as well as pod damage. Thus, present results conform with their earlier findings.

3.6. Seed yield

Perusal of the outcomes shows that every module was considerably better than the control (880 kg ha⁻¹) (Table 7). Significantly maximum field pea seeds were harvested from module M₄ (1250 kg ha⁻¹) which comprised of border crop with chickpea+seed treatment and imidacloprid 600 FS+yellow sticky trap+alternate sprays of Azadirachtin 1500 ppm+*Ha*NPV 250 LE+final spray of profenophos 50 EC. Plots treated with module M₁ produced 1133 kg seed

Table 6: Per cent pod damage due to *H. armigera* in field pea

Sl. No.	Modules	Per cent pod damage at harvest
1.	M ₁	5.82 ^a (1.07)
2.	M ₂	9.72 ^c (2.92)
3.	M ₃	8.81 ^b (2.15)
4.	M ₄	3.09 ^a (0.30)
5.	M ₅	16.21 ^d (7.79)
	SEm±	0.062
	CV %	7.07

Figures in parentheses are retransformed values of arc sine transformation. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

Table 7: Impact of various modules on yield and avoidable loss in field pea

Sl. No.	Modules	Yield (kg ha ⁻¹)	Increase in yield over control (%)	Avoidable loss (%)
1.	M ₁	1133 ^{ab}	28.75	9.36
2.	M ₂	996 ^{bc}	13.18	20.32
3.	M ₃	1030 ^{bc}	17.00	17.60
4.	M ₄	1250 ^a	42.04	-
5.	M ₅	880 ^c	-	29.6
	SEm±	47.30	-	-
	CV %	8.94	-	-

Treatment means with the letter(s) in common are not significant by DNMR at 5% level of significance

hectare⁻¹ and at par with module M₄. Module M₃ and M₂ yield significantly less (1030 and 996 kg ha⁻¹, respectively) field pea seeds gave as par the efficacy in reducing insect pests was concerned.

3.7. Increase in yield over control

The data on increase in yield over control was worked out and presented in Table 7 its result showed that highest (42.04%) increase in yield was obtained from plot treated with M₄ next best module was M₁ (28.75%) over control. Modules M₃ and M₂ registered 17.00 and 13.18% increase in yield over control.

3.8. Avoidable loss

Avoidable loss in yield of field pea fluctuated between 9.36 to 29.6% in different modules (Table 7). It can be seen from the data that the highest seed yield was obtained in module M₄ which also proved to be the best module. However, avoidable losses in field pea yield were minimum (9.36%) in module M₁ followed by module M₃ (17.60%). Comparatively higher (20.32%) avoidable loss due to insect pests was obtained in the plot sprayed with module M₂. On the other hand, the highest avoidable loss in field pea yield due to insect pests was incurred in control to the tune of 29.6%.

3.9. Economics

Results revealed that the higher (₹ 87500 ha⁻¹) gross realization was obtained from the plot framed with module M₄ followed by module M₁ (₹ 79310 ha⁻¹) (Table 8). Modules M₃ and M₂ recorded comparatively lower gross realization with ₹ 72100 ha⁻¹ and ₹ 69720 ha⁻¹, respectively as against untreated control (₹ 61,600 ha⁻¹). The highest PCBR was obtained from module M₄ (1:3.56) which clearly indicated that module M₄ was most economical among various modules. Modules M₃, M₁ and M₂ showed PCBR of 1:1.42, 1:1.27 and 1:0.63, respectively and found to be less economical. Thus, it can be seen that highest PCBR was obtained from module M₄ which proved economical as compared to other modules.

Table 8: Economics of various modules evaluated against insect pests of field pea

Sl. No.	Modules	Cost of materials (₹ ha ⁻¹)	Labour charge (₹ ha ⁻¹)	Total cost of treatment (₹ ha ⁻¹)	Yield (kg ha ⁻¹)	Gross realization (₹ ha ⁻¹)	Net realization (₹ ha ⁻¹)	Net gain (₹ ha ⁻¹)	Protection cost:benefit ratio (PCBR)
1.	M ₁	5857	1944	7801	1133	79310	17710	9909	1:1.27
2.	M ₂	2392	2592	4984	996	69720	8120	3136	1:0.63
3.	M ₃	1738	2592	4331	1030	72100	10500	6169	1:1.42
4.	M ₄	3739	1944	5683	1250	87500	25900	20217	1:3.56
5.	M ₅	-	-	-	880	61600	-	-	-
	SEm±	47.30	-	-					
	CV %	8.94	-	-					

Note: Price of field pea: ₹ 70 kg⁻¹; B. bassiana: ₹ 240 kg⁻¹; L. lecanii: ₹ 240 kg⁻¹; B. thuringiensis: ₹ 585 kg⁻¹; Imidacloprid 600 FS: ₹ 520 litre⁻¹; Spinosad 45 SC: ₹ 1855 75 ml⁻¹; HaNPV: ₹ 150 250 ml⁻¹; Profenophos ₹ 882 l⁻¹; Yellow sticky trap: ₹ 30 2 trap⁻¹; Azadirachtin 1500 ppm: ₹ 456 l⁻¹; Cost of labour for preparation of plant extract ₹ 260 labour⁻¹; Cow urine: ₹ 10 l⁻¹; Labour charges: ₹ 324 day⁻¹ labour⁻¹ for spraying; 1US\$=INR 72.79 (Average value for the March, 2021)

4. CONCLUSION

Module M₄ exhibited significantly minimum population of 1.47 aphids 10 cm⁻¹ shoot, 1.00 leafhoppers 3 leaves⁻¹, 0.62 whiteflies 3 leaves⁻¹, 0.08 larva plant⁻¹, minimum pod damage (0.30%) and proved to be most

effective module which was at par with module M₁. Module M₄ showed the highest field pea seed yield (1250 kg ha⁻¹) and gross realization (₹ 87,500 ha⁻¹), with a 42.04% increase in yield and a PCBR of 1:3.56, making it the most economical module.

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