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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 M_4 (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+*Ha*NPV 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 trifoliate^{-1}, 0.62 whitefly trifoliate^{-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 M_1. The highest field pea seed yield (1250 kg ha^{-1}) was also harvested from module M_4. The maximum (42.04%) increase in yield was obtained in the plots framed with M_4 followed by module M_1. The avoidable losses in field pea yield were minimum (9.36%) in module M_1. The highest (₹ 87,500 ha^{-1}) gross realization was obtained from the plots framed with module M_4. The highest Protection Cost: Benefit Ratio (PCBR) was obtained in module M_4 (1:3.56) which clearly indicated that module M_4 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 (Praharaj 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 m^2 in size, with a 30×10 cm^2 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 quadrate 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 quadrate. 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 M1, 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 *Ha*NPV 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 (*Calotropis gigantea*) leaves+cow urine @ 500 g+1 litre 10 litre^{-1} water; second spray of morning glory (*Ipomoea carnea*) leaves+cow urine @ 500 g+1 litre 10 litre water^{-1}; third spray of wild sage (*Lantana camera*) 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 *Beauveria bassiana* (1×10^{8} cfu g^{-1}) 1.15% WP @ 40 g 10 l water^{-1}; second spray of *Lecanicillium lecanii* (1×10^{8} cfu g^{-1}) 1.15% WP @ 40 g 10 l water^{-1}; third spray of Bacillus thuringiensis powder (1×10^{11} cfu g^{-1}) 0.5% WP @ 15 g 10 l water^{-1} and of *Ha*NPV 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 *Ha*NPV 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 M_4 comprised of border crop with chickpea+seed treatment through imidacloprid 600 FS+sticky trap (yellow)+alternate sprays of Azadirachtin 1500 ppm+*Ha*NPV 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 M_1 (2.13). Module M_3 and M_2

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										
		6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	
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 DNMRT 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 M_4 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 M_1 (1.31). Module M_3 and M_2 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										
		6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	
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										
		6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	
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

M_4 (0.62) proved to be an efficient module by decreasing the population of whiteflies which was at par with module M_1 (0.86). Module M_3 (1.15) and M_2 (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 M_4 had the lowest (0.08) larval population and was the most efficient which was at par with module M_1 (0.13). Modules M_3 and M_2 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										
		6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	
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 M_4 and proved to be effective module which was at par with module M_1 (1.07%). Whereas, modules M_2 and M_3 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.

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

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 M_4 (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 M_1 produced 1133 kg seed

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 DNMRT at 5% level of significance

hectare^{-1} and at par with module M_4. Module M_3 and M_2 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 M_4 next best module was M_1 (28.75%) over control. Modules M_3 and M_2 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 M_4 which also proved to be the best module. However, avoidable losses in field pea yield were minimum (9.36%) in module M_1 followed by module M_3 (17.60%). Comparatively higher (20.32%) avoidable loss due to insect pests was obtained in the plot sprayed with module M_2. 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 M_4 followed by module M_1 (₹ 79310 ha^{-1}) (Table 8). Modules M_3 and M_2 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 M_4 (1:3.56) which clearly indicated that module M_4 was most economical among various modules. Modules M_3, M_1 and M_2 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 M_4 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 M_4 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 M_1. Module M_4 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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6. REFERENCES

Anandhi, D.M., Elamathi, S., Simon, S., 2011. Evaluation of bio-rational insecticides for management of *Helicoverpa armigera* in chickpea. Annals of Plant Protection Sciences 19(1), 207–209.

Anonymous, 2020. India at a glance. United Nations Food and Agriculture Organization (FAO) statistical division. Rome. Available from https://www.fao.org/india/fao-in-india/india-at-a-glance/en/. Accessed on 26th September, 2024.

Anonymous, 2021. Annual Report of 2020–21. Indian Institute of Pulses Research, Kanpur (UP). Available from https://iipr.icar.gov.in/wp-content/themes/ICAR-wp/images/pdf/IIPR%20AR-2020%20English.pdf. Accessed on 26th September, 2024

Anonymous, 2022. Project Coordinator's Report of AICRP on MULaRP. Annual Group Meet on *Rabi* Pulses held on August 17–18, 2022 at IGKV, Raipur (Chhattisgarh). Available from https://iipr.icar.gov.in/wp-content/uploads/2023/07/PC-Report-MULLaRP_Rabi_2021-22.pdf. Accessed on 26th September, 2024.

Anonymous, 2023. Agriculture At a Glance, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi. Available from https://agriwelfare.gov.in/en/ Agricultural_Statistics_at_a_Glance. Accessed on 10th January, 2024.

Bhardwaj, R.L., Parashar, A., Parewa, H.P., Vyas, L., 2024. An alarming decline in the nutritional quality of foods: the biggest challenge for future generations' health. Foods 13(6), 877. https://doi.org/10.3390/foods13060877

Bhushan, S., Singh, R.P., Shanker, R., 2011. Bio-efficacy of neem and *Bt.* against pod borer, *Helicoverpa armigera* in chickpea. Journal of Biopesticides 4(1), 87–89.

Deguine, J.P., Aubertot, J.N., Flor, R.J., Lescourret, F., Wyckhuys, K.A., Ratnadass, A., 2021. Integrated pest management: good intentions, hard realities: A review. Agronomy for Sustainable Development 41(3), 38.

Gnanasambandan, S., Balakrishnamurthy, P., Pillai, K.S., 2000. Integrated pest management in the twenty-first century. Pestology 24(2), 9–11.

Herridge, D.F., Giller, K.E., Jensen, E.S., Peoples, M.B., 2022. Quantifying country-to-global scale nitrogen fixation for grain legumes II. Coefficients, templates and estimates for soybean, groundnut and pulses. Plant and Soil 474(1), 1–15. https://doi.org/10.1007/s11104-021-05166-7.

Karlsson, G.K., Stenberg, J.A., Lankinen, A., 2020. Making sense of integrated pest management (IPM) in the light of evolution. Evolutionary Applications 13(8), 1791–1805. https://doi.org/10.1111%2Feva.13067.

Khan, A., Singh, G., Singh, H., Singh, D.V., Khilari, K., 2024. Insect pest complex of field pea crop. Journal of Advances in Biology & Biotechnology 27(1), 87–93. http://dx.doi.org/10.9734/JABB/2024/v27i1683.

Kumar, S., Gopinath, K.A., Sheoran, S., Meena, R.S., Srinivasarao, C., Bedwal, S., Praharaj, C.S., 2023. Pulse-based cropping systems for soil health restoration, resources conservation, and nutritional and environmental security in rainfed agroecosystems. Frontiers in Microbiology 13, 1041124. https://doi.org/1041124.10.3389/fmicb.2022.1041124.

Lasisi, A., Liu, K., 2023. A global meta-analysis of pulse crop effect on yield, resource use, and soil organic carbon in cereal-and oilseed-based cropping systems. Field Crops Research 294, 108857. https://doi.org/10.1016/j.fcr.2023.108857.

Liu, K., Blackshaw, R.E., Johnson, E.N., Hossain, Z., Hamel, C., St-Arnaud, M., 2019. Lentil enhances the productivity and stability of oilseed-cereal cropping systems across different environments. European Journal of Agronomy 105, 24–31. https://doi.org/10.1016/j.eja.2019.02.005.

Munir, S., Azeem, A., Zaman, M.S., Haq, M.Z.U., 2024. From field to table: ensuring food safety by reducing pesticide residues in food. Science of The Total Environment 922, 171382. https://doi.org/10.1016/j.scitotenv.2024.171382.

Parihar, A.K., Yadav, R., Lamichaney, A., Mishra, R.K., Chandra, A., Gupta, D.S., Tripathi, K., Hazra, K.K., Dixit, G.P., 2022. Field pea breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (Eds), Fundamentals of field crop breeding. Springer, Singapore. https://doi.org/10. 1007/ 978-981- 16-9257-4_25.

Reddy, A., 2009. Pulses production technology: Status and way forward. Economic and Political Weekly 34(52), 73–80.

Reddy, A.A., Bhagwat, K.D., Tiwari, V.L., Kumar, N., Dixit, G.P., 2023. Policies and incentives for promotion of pulses production and consumption: A Review. Journal of Food Legumes 36(4), 209–228. https://doi.org/10.59797/jfl.v36.i4.157.

Reshi, M.S., Sheikh, T.A., Javaid, D., Ganie, S.Y., Ganie, M.A., Malik, M.A., 2024. Pesticide pollution: potential risk to insect pollinators and possible management strategies. In Insect Diversity and

Ecosystem Services. Apple Academic Press. ISBN 9781003471196 (eBook) pp. 55–73.

Routray S., Mishra, H.P., 2021. Evaluation of developmental and reproductive fitness of laboratory selected thiamethoxam resistance in black legume aphid *Aphis craccivora* Koch. International Journal of Bio-resource and Stress Management 12(3), 151–157. https://doi.org/10.23910/1.2021.2199a.

Sheoran, S., Kumar, S., Ramtekey, V., Kar, P., Meena, R.S., Jangi, C.K., 2022. Current status and potential of biofortification to enhance crop nutritional quality: an overview. Sustainability 14, 3301. https://doi.org/10.3390/su14063301.

Shivay, Y.S., 2015. Role of agronomic biofortification in alleviating malnutrition. International Journal of Economic Plants 2(3), 153–158. Retrieved from https://ojs.pphouse.org/index.php/IJEP/article/view/4432.

Singh, J.M., Kaur, A., Chopra, S., Kumar, R., Sidhu, M.S., Kataria, P., 2022. Dynamics of production profile of pulses in India. Legume Research – An International Journal 45(5), 565–572. http://dx.doi.org/10.18805/LR-4274.

Swarnalata, B., Patel, S.M., Pandya, H.V., Patel, S.D., 2015. Bio-efficacy of insecticides against aphid (*Aphis craccivora* Koch) infesting cowpea [*Vigna unguiculata* (L.) Walp.]. Asian Journal of Biological Sciences 10(1), 83–88. http://dx.doi.org/10.15740/HAS/AJBS/10.1/83-88.

Subba, B., Chaudhari, N., Senapati, S.K., 2022. Assessment of crop loss in okra (*Abelmoschus esculentus* L.) due to damage by the major insect pests. International Journal of Bio-resource and Stress Management 13(12), 1504–1510. https://doi.org/10.23910/1.2022.3273a.

Trivedi, T.P., Ahuja, D.B., 2011. Integrated pest management: approaches and implementation. Indian Journal of Agricultural Sciences 81(11), 981–993.