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Evaluation of bio-intensive pest management (BIPM) packages against major pests of pigeonpea

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ABSTRACT

A field study was conducted during the kharif season of 2018 in Pune, Maharashtra to evaluate the efficacy of various bio-intensive pest management (BIPM) packages against the major pod borer complex of pigeonpea (*Cajanus cajan* cv Vipula) and their impact on natural enemies. Eight treatments were tested, including six BIPM packages, one chemical control (chlorpyriphos – chlorpyriphos – chlorantraniliprole – spinosad) and an untreated control. The primary pests monitored were the gram pod borer (*Helicoverpa armigera*), Tur pod fly (*Melanagromyza obtusa*), Tur plume moth (*Exelastis atomosa*) and spotted pod borer (*Maruca vitrata*). The chemical control treatment consistently recorded the lowest mean larval population across all four pests, achieving maximum reduction ranging from 79.38 to 82.90 per cent over the control. Consequently, chemical control treatment recorded the lowest total pod damage (7.51%) with an 83.24 per cent reduction in infestation. Among the BIPM packages, neem seed extract – *Metarhizium anisopliae* – *Ha*NPV – *Bacillus thuringiensis* treatment was the most effective, recording the second-lowest overall pod damage (10.62%, 76.31% reduction) and the highest reduction against the gram pod borer (51.74%). A crucial trade-off was observed concerning non-target organisms: the chemical insecticides were found to adversely affect the populations of natural enemies (coccinellids, chrysopids, and spiders). In contrast, the BIPM package (neem seed extract – *M anisopliae* – *Ha*NPV – *B thuringiensis*) actively supported the maximum buildup of natural enemy populations (coccinellids at 2.20, chrysopids at 0.63 and spiders at 1.23 per plant). While chemical control provided immediate, maximum pest reduction, BIPM packages, particularly neem seed extract – *M anisopliae* – *Ha*NPV – *B thuringiensis*, offerred significant, eco-friendly control (around 36 to 52% reduction in individual pests) while safeguarding the essential pest-defender balance.

Keywords: Pigeonpea; BIPM; biopesticides; natural enemies; pod borer complex; chemical control

INTRODUCTION

Pigeonpea is the second most important pulse crop grown in India after chickpea and grown predominantly under rainfed conditions (Sarkar et al 2020). India dominates the global market for pigeonpea, producing over 90 per cent of the world's supply. Pigeonpea production in India was 3.42 million tonnes from an area of 4.13 million hectares and productivity of 827 kg per hectare (Anon 2024).

Despite this, pigeonpea productivity remains low, primarily due to insect pests. These pests are the major biological factor limiting the crop's yield. While over 250 insect species have been recorded feeding on pigeonpea, only a small number of these species cause consistent and significant damage (Khamoriya et al 2017). A study conducted by Nair et al (2017) in Tripura, India, identified a total of 64 insect pests on pigeonpea, spanning 7 orders and 32 families. These pests were categorized based on their impact: 9 species were classified as major, 30 as minor and the remaining 25 as negligible. The most significant threat came from the pod borer complex, which comprised eleven species. Among this complex, three species – *Maruca vitrata* (Fabricius), *Melanagromyza obtusa* (Malloch) and *Apion clavipes* (Gerst) were found to be the most destructive key pests.

Chemical insecticides effectively control pests, but they often rapidly destroy natural enemies, throwing the essential pest-defender balance off kilter. To manage pests sustainably, we need to promote biopesticides because they specifically target the pest species while remaining harmless to natural enemies and safe for people. Although biopesticides currently make up a small fraction of plant protection, they are a crucial, environmentally friendly alternative to chemical sprays and must be a major part of future pest management strategies for seasonal crops (Bhoge et al 2025).

With this view, the present study was conducted to evaluate of bio-intensive pest management packages against major pests of pigeonpea.

MATERIAL and METHODS

Field experiment on evaluation of different bio-intensive pest management packages (BIPM) against pests infesting pigeonpea was conducted on the research farm of agricultural entomology section of College of Agriculture, Pune, Maharashtra during kharif 2018. For the experiment, pigeonpea variety Vipula was selected. The spacing of 90 cm (row to row) × 20 cm (plant to plant) was maintained. All the recommended crop management practices were carried out as and when required except pesticide application. Application of five biocontrol components in different sequences formulated six BIPM packages in the current investigations. The treatments used were T_1: Neem seed extract (NSE) – *Metarhizium anisopliae* (*Ma*) – *Helicoverpa armigera* nuclear polyhedrosis virus (*Ha*NPV) – *Bacillus thuringiensis* (*Bt*), T_2: NSE – *Beauveria bassiana* (*Bb*) – NSE – *Bt*, T_3: *Ma* – NSE – *Bb* – *Bt*, T_4: *Bb* –*Ha*NPV – *Ma* – NSE, T_5: *Ha*NPV – *Ma* – *Bt* – *Bb*, T_6: *Ma* – *Bb* – *Ma* – *Bb*, T_7: Chemical control (chlorpyriphos – chlorpyriphos – chlorantraniliprole – spinosad) and T_8: Untreated control. The treatments were used at 20 days interval. The effect of these BIPM components on surviving larval population of *Helicoverpa armigera*, *Melanagromyza obtusa*, *Exelastis atomosa* and *Maruca vitrata* was assessed by recording observations at 3, 7 and 10 days after each of four sprays. Observations were recorded from five randomly selected and tagged plants from each treatment plot, a day prior to treatment taken as pre-count. The post-counts of survived larvae were recorded at 3, 7 and 10 days after each of the four spray applications and cumulative averages of the surviving larval population of the pod borers was worked out from the pest number recorded at different intervals after each spray of BIPM components as well as insecticides. The number of pods damaged by the larvae of tissue borer as well as number of healthy pods on the tagged plants were counted on the date of observations. The pods showing holes were considered as infested ones.

RESULTS and DISCUSSION

Data on the effect of different BIPM packages on larval population of *H armigera*, *M obtusa*, *E atomosa* and *M vitrata* on pigeonpea are presented in Table 1.

Gram pod borer (*H armigera*): The mean larval population of *H armigera* per plant was recorded lowest (0.64) in treatment T_7 (Chemincal control) (chlorpyriphos – chlorpyriphos – chlorantraniliprole – spinosad) exhibiting maximum of 82.22 per cent reduction over control and it was found to be significantly superior over other treatments. The next promising treatment was the BIPM package T_1 {Neem seed extract (NSE) – *Metarhizium anisopliae* (*Ma*) – *Helicoverpa armigera* nuclear polyhedrosis virus (*Ha*NPV) – *Bacillus thuringiensis* (*Bt*)} which recorded 1.74 mean larvae per plant with 51.74 per cent reduction over control. T_5 (*Ha*NPV – *Ma* – *Bt* – *Bb*), T_2 {NSE – *Beauveria bassiana* (*Bb*) – NSE – *Bt*} and T_4 (*Bb* – *Ha*NPV – *Metarhizium anisopliae* (*Ma*) – NSE) with 1.92, 1.97 and 1.97 mean surviving larvae per plant respectively, showed 45.28 to 46.81 per cent reduction in pest population over control and occupied the subsequent rank in respect of their effectiveness.

Tur pod fly (*M obtusa*): The larval population of *M obtusa* per plant was recorded lowest (0.66) in T_7 exhibiting 82.90 per cent reduction over control. The next promising treatment was T_2 which recorded 1.89 larvae per plant with 51.03 per cent reduction over control. T_6 (*Ma* – *Bb* – *Ma* – *Bb*) was the next best treatment with 2.08 larvae per plant with 46.11 per cent reduction over control. Next best treatments T_5 and T_1 recorded 2.30 and 2.36 larvae per plant respectively and were at par. Both these treatments showed 40.41 and 38.86 per cent reduction over control respectively. T_3 (*Ma* – NSE – *Bb* – *Bt*) and T_4 (*Bb* – *Ha*NPV – *Ma* – NSE) which registered 2.73 and 2.75 surviving larvae per plant, were on par with each other and exhibited 29.27 and 28.75 per cent reduction

Table 1. Effect of different BIPM packages on insect larval population on pigeonpea

Treatment	*H armigera*			*M obtuse*		
	Pre-count	Mean larval population/plant	Mean reduction over control (%)	Pre-count	Mean larval population/plant	Mean reduction over control (%)
T_1	3.40 (1.97)	1.74 (1.49)	51.74	2.89 (1.84)	2.36 (1.69)	38.86
T_2	3.29 (1.94)	1.97 (1.57)	45.35	2.80 (1.81)	1.89 (1.54)	51.03
T_3	4.19 (2.17)	2.45 (1.71)	31.88	3.64 (2.03)	2.73 (1.79)	29.27
T_4	3.44 (1.98)	1.97 (1.57)	45.28	3.88 (2.09)	2.75 (1.80)	28.75
T_5	4.23 (2.17)	1.92 (1.55)	46.81	3.75 (2.06)	2.30 (1.67)	40.41
T_6	4.16 (2.16)	2.05 (1.59)	43.19	3.54 (2.00)	2.08 (1.60)	46.11
T_7	3.80 (2.07)	0.64 (1.06)	82.22	2.81 (1.81)	0.66 (1.07)	82.90
T_8	4.11 (2.15)	3.60 (2.02)	-	3.95 (2.11)	3.86 (2.08)	-
SE(m)±	0.04	0.01		0.03	0.01	
$CD_{0.05}$	NS	0.03		NS	0.03	

Table 1. Contd…..

Treatment	*E atomosa*			*M vitrata*		
	Pre-count	Mean larval population/plant	Mean reduction over control (%)	Pre-count	Mean larval population/plant	Mean reduction over control (%)
T_1	6.95 (2.72)	4.47 (2.22)	27.43	1.85 (1.53)	1.14 (1.28)	38.37
T_2	6.64 (2.67)	4.36 (2.20)	29.22	1.80 (1.52)	1.16 (1.29)	51.03
T_3	6.56 (2.66)	4.19 (2.16)	31.98	1.98 (1.57)	0.99 (1.22)	46.48
T_4	7.50 (2.83)	5.01 (2.34)	18.66	1.86 (1.54)	1.46 (1.40)	21.08
T_5	6.90 (2.72)	3.90 (2.09)	36.68	1.97 (1.57)	1.32 (1.34)	28.64
T_6	6.54 (2.65)	4.32 (2.19)	29.87	1.93 (1.56)	1.33 (1.35)	28.10
T_7	6.75 (2.69)	1.27 (1.33)	79.38	1.35 (1.36)	0.34 (0.91)	81.62
T_8	6.43 (2.63)	6.16 (2.58)	-	1.97 (1.57)	1.85 (1.53)	-
SE(m)±	0.04	0.01		0.04	0.01	
$CD_{0.05}$	NS	0.02		NS	0.02	

T_1: Neem seed extract (NSE) – *Metarhizium anisopliae* (*Ma*) – *Helicoverpa armigera* nuclear polyhedrosis virus (*Ha*NPV) – *Bacillus thuringiensis* (*Bt*), T_2: NSE – *Beauveria bassiana* (*Bb*) – NSE – *Bt*, T_3: *Ma* – NSE – *Bb* – *Bt*, T_4: *Bb* – *Ha*NPV – *Ma* – NSE, T_5: *Ha*NPV – *Ma* – *Bt* – *Bb*, T_6: *Ma* – *Bb* – *Ma* – *Bb*, T_7: Chemical control (chlorpyriphos – chlorpyriphos – chlorantraniliprole – spinosad), T_8: Untreated control; Figures in parentheses are $\sqrt{x}$ + 0.5 transformations; NS = Non-significant over control respectively. Maximum mean larval population of *M obtusa* per plant (3.86) was recorded in untreated control plot (T_8).

Tur plume moth (*E atomosa*): The lowest (1.27) mean larval population of *E atomosa* per plant was recorded in the treatment T_7 and exerted 79.38 per cent reduction in larval population over control. The next promising treatment was T_5 which registered 3.90 larvae per plant with 36.68 per cent reduction over control. T_3 showing 31.98 per cent reduction in larval population over control was the next best treatment that recorded 4.19 larvae per plant. T_6 and T_2, being at par, recorded 4.32 and 4.36 larvae per plant and exhibited 29.87 and 29.22 per cent reduction over control respectively. Maximum larval population per plant (6.16) was recorded in untreated control plot (T_8).

Spotted pod borer (*M vitrata*): The lowest (0.34) mean population of larvae per plant was recorded in the treatment T_7 that exhibited maximum (81.62%) reduction in the pest population over control plot followed by T_3 having 0.99 larvae per plant with 46.48 per cent reduction over control. T_1 and T_2 with 1.14 and 1.16 larvae per plant and 38.37 and 51.03 per cent reduction over control respectively were the next best treatments. These were followed by T_5 and T_6 registering 1.32 and 1.33 larvae per plant and 28.64 and 28.10 per cent reduction over control respectively, which were at par. Maximum larval population of *M vitrata* per plant (1.85) was recorded in untreated control plot (T_8).

The results consistently showed that the full chemical control (T_7) was the most effective against all four pests, achieving the highest reduction rates, ranging from 79.38 per cent against Tur plume moth to 82.90 per cent against Tur pod fly. Among BIPM packages, T_1 (Neem + *Ma* + *Ha*NPV + *Bt*) was the second most effective treatment for gram pod borer (51.74% reduction), while T_2 (Neem + *Bb* + neem + *Bt*) performed best against the Tur pod fly (51.03% reduction). Overall, while chemical control provided the highest reduction in pest populations, several BIPM packages (T_1, T_2 and T_3) offered significant control, demonstrating reductions between 36 and 52 per cent for most pests.

Pod damage due to pod borer complex of pigeonpea and natural enemies

Data in Table 2 reveal that lowest pod damage (7.51%) was observed in the treatment T_7 reducing 83.24 per cent infestation of pod borer complex. Amongst the BIPM packages tested, T_1 was found most effective that recorded 10.62 per cent pod damage exerting 76.31 per cent reduction over control followed by T_2 and T_3 which showed 12.40 and 13.56 per cent mean pod damage and suppressed the pest damage to the extent of 72.33 and 69.72 per cent respectively, the two being at par. T_5 and T_4 recorded 14.26 and 14.28 per cent pod damage reducing 68.19 and 68.14 per cent pod damage respectively over control. However, the total pod damage due to pod borer complex was maximum 44.83 per cent in untreated control plot (T_8).

Among all the treatments, T_7 registered lowest pod damage by *H armigera* (0.92%), *M obtusa* (3.28%), *E atomosa* (2.30%) and *M vitrata* (1.01%). The BIPM package T_1 performed the next best by recording relatively least pod damage by *H armigera* (1.98%), *M obtusa* (3.98%), *E atomosa* (2.75%) and *M vitrata* (1.91%).

The populations of natural enemies viz coccinellids, chrysopid and spiders were adversely affected by the sprays of chemical insecticides in the treatment T_7. However, the BIPM package T_1 supported building up of coccinellids (2.20/plant), chrysopid (0.63/plant) and spiders (1.23/plant) to the maximum extent as compared to other treatments.

The study found that the chemical control (T_7) was the most effective treatment for managing the pigeonpea pod borer complex, resulting in the lowest pod damage (7.51%) and the highest damage reduction (83.24%) over the untreated control (T_8, 44.83% damage). While T_7 caused the least damage from individual pests, its chemical nature adversely affected the populations of natural enemies (coccinellids, chrysopids and spiders). Conversely, the BIPM package T_1 was the most effective biological treatment, achieving the second-lowest overall damage (10.62%) and notably supported the maximum buildup of natural enemy populations (coccinellids at 2.20, chrysopids at 0.63 and spiders at 1.23/plant).

Earlier, Malathi (2007) reported that spraying of chlorpyriphos 20 EC @ 2.5 ml per litre at 50 per cent flowering stage recorded maximum reduction in *M vitrata* (67.98%) on pigeonpea. Rao et al (2007) found that application of newer insecticides such as spinosad 45 SC @ 0.4 ml per litre and indoxacarb 14.5 EC @ 0.4 ml per litre resulted in lowest pod damage

Table 2. Effect of different BIPM packages on pod damage due to pod borer complex of pigeonpea and natural enemies

Treatment	Pod damage (%)*				Total borer complex pod damage (%)	Reduction over control (%)	Mean population of natural enemies/plant after treatment**		
	H armigera	*M obtusa*	*E atomosa*	*M vitrata*			Coccinellids	Chrysopids	Spiders
T_1	1.98 (8.09)	3.98 (11.50)	2.75 (9.54)	1.91 (7.94)	10.62 (19.01)	76.31	2.20 (1.64)	0.63 (1.06)	1.23 (1.32)
T_2	3.13 (10.19)	4.02 (11.56)	3.25 (10.38)	2.00 (8.13)	12.40 (20.61)	72.33	2.03 (1.56)	0.59 (1.04)	1.11 (1.27)
T_3	3.47 (10.73)	5.26 (13.25)	3.00 (9.97)	1.83 (7.76)	13.56 (21.60)	69.72	2.05 (1.60)	0.61 (1.05)	1.04 (1.24)
T_4	2.34 (8.80)	5.98 (14.15)	3.98 (11.50)	1.98 (8.09)	14.28 (22.20)	68.14	1.96 (1.57)	0.58 (1.04)	1.13 (1.28)
T_5	2.56 (9.20)	5.45 (13.49)	4.00 (11.53)	2.25 (8.62)	14.26 (22.18)	68.19	2.11 (1.62)	0.56 (1.03)	1.09 (1.26)
T_6	7.72 (16.13)	6.04 (14.22)	3.99 (11.52)	2.32 (8.76)	20.07 (26.61)	55.23	1.76 (1.50)	0.51 (1.00)	1.05 (1.24)
T_7	0.92 (5.50)	3.28 (10.43)	2.30 (8.72)	1.01 (5.77)	7.51 (15.90)	83.24	0.29 (0.89)	0.21 (0.84)	0.43 (0.96)
T_8	10.60 (18.99)	13.00 (21.13)	12.23 (20.46)	9.00 (17.45)	44.83 (42.03)	-	2.43 (1.71)	0.70 (1.10)	1.35 (1.36)
SE(m)±	0.27	0.22	0.26	0.26	0.42		0.02	0.03	0.01
$CD_{0.05}$	0.84	0.66	0.80	0.81	1.22		0.06	0.09	0.03

T_1: Neem seed extract (NSE) – *Metarhizium anisopliae* (*Ma*) – *Helicoverpa armigera* nuclear polyhedrosis virus (*Ha*NPV) – *Bacillus thuringiensis* (*Bt*), T_2: NSE – *Beauveria bassiana* (*Bb*) – NSE – *Bt*, T_3: *Ma* – NSE – *Bb* – *Bt*, T_4: *Bb* – *Ha*NPV – *Ma* – NSE, T_5: *Ha*NPV – *Ma* – *Bt* – *Bb*, T_6: *Ma* – *Bb* – *Ma* – *Bb*, T_7: Chemical control (chlorpyriphos – chlorpyriphos – chlorantraniliprole – spinosad), T_8: Untreated control; *Figures in parentheses are arc sine transformed values, **Figures in parentheses are $\sqrt{x}$ + 0.5 transformations

by spotted pod borer in pigeonpea. Similarly, Sunitha et al (2008) reported that indoxacarb 14.5 SC and spinosad 48 SC were highly effective against third instar larvae of *M vitrata* with 80 and 50 per cent mortality respectively, in pigeonpea. Singh et al (2008) recorded the higher efficacy of spinosad 45 SC at 73 g ai per ha against pod borers in pigeonpea. Sreekanth and Seshamahalakshmi (2012) observed lowest inflorescence as well as pod damage of *M vitrata* in spinosad 45 SC treated plots as compared to biopesticides like *Bt* and *Beauveria bassiana* formulations. Chaitanya et al (2013) recorded highest reduction of *M vitrata* larvae on pigeonpea with the application of thiodicarb 75 WP, followed by spinosad 45 SC, novaluron 10 EC and chlorpyriphos 20 EC + DDVP 76 EC.

Yogesh and Kumar (2014) found that the chemical insecticides viz cypermethrin 25 EC, coragen 18.5 SC and imidacloprid 17.8 SL were effective than biopesticides like NPV against *H armigera* in reducing its larval population as well as pod damage and increased the yield of pigeonpea. Satpathi et al (2016) also reported that the pesticide-based IPM-II module was superior than biopesticide based module in managing the attack of sucking pests and pod borers on cowpea. Patra et al (2017) reported that the infestation of *A clavipes* and *M obtusa* was significantly reduced in fipronil 5 SC treated plots as compared to botanicals. Similarly, Rahman et al (2017) found that application of chemical insecticides like emamectin benzoate, dimethoate, indoxacarb, dichlorvos and fenvalerate showed higher mortality of pod fly than NSKE 4 per cent in pigeonpea. The chemical insecticides showed detrimental effects on the population of natural enemies viz coccinellids, chrysopid and predatory spiders, while, the BIPM components viz NSE, *Ha*NPV, *B thuringiensis*, *M anisopliae* and *B bassiana* were found relatively safe to the natural enemies. Thus the BIPM package could safeguard the interest of eco-friendly pest management in pigeonpea crop.

CONCLUSION

The study demonstrated that chemical control, consisting of sequenced applications of chlorpyriphos, chlorantraniliprole and spinosad, provided the highest level of immediate control across the pigeonpea pod borer complex, resulting in the lowest larval populations and minimum pod damage of 7.51 per cent. However, the findings confirmed the established risk of chemical usage, as chemical control significantly and adversely affected the populations of natural enemies. Conversely, the BIPM package comprising neem seed extract – *M anisopliae* – *Ha*NPV – *B thuringiensis* proved to be the most superior bio-based alternative, achieving the second-lowest pod damage (10.62%) while simultaneously supporting the maximum build-up of beneficial insects and spiders. This outcome aligns with previous research advocating for biopesticides as a safer alternative to conventional chemical insecticides. Therefore, the BIPM package is highly recommended for the sustainable and eco-friendly management of pigeonpea pests, safeguarding the interest of a balanced ecosystem while providing high economic returns.

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