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Integration of Some Components of Pest Management against Pod Pest Complex on Early Maturing Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Authors' contributions

This work was carried out in collaboration between all the authors. Author RK designed the study, wrote the protocol and reviewed all drafts of the manuscript. Author Hanumanth carried out the field experiments and prepared the first draft of the manuscript. Authors SC and SG performed the statistical analysis of data, managed the literature searches and also assisted in performing field experiments and drafting of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the comparative efficacy of different insecticidal treatments against *Helicoverpa armigera*, *Maruca vitrata*, *Melanagromyza obtusa*, and *Clavigralla gibbosa* on two cultivars of pigeonpea.
Experimental Design: Factorial Randomized Block Design with three replications.
Place and Duration of Study: Field experiments were conducted at Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Kharif* seasons of 2015-16 and 2016-17.
Methodology: The experiment consisted of seven treatments having different combinations of insecticides and biopesticides including untreated control. The effectiveness of these treatments was determined on the basis of percent pod damage due to significant insect pests on two early maturing pigeonpea cultivars (ICPL 87 and UPAS 120).
Results: There was a significant effect of variety (cultivar) and different insecticidal treatments on

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per cent pod damage and grain yield. However, their interaction (variety x treatment) exhibited no significant effect on pod damage. The treatment comprising of sequential application of Indoxacarb 15.8 EC @ 73 g a.i./ha followed by the second spray of Rynaxypyr 18.5 SC @ 30 g a.i./ha at 15 days interval was significantly superior in managing *H. armigera, M. vitrata* and *M. obtusa*, while, NSKE 5% - Indoxacarb 15.8 EC @ 73 g a.i./ha resulted in effective management of *C. gibbosa* on pigeonpea over rest of the treatments in terms of lower pod damage and higher grain yield. However, all the insecticidal treatments were found significantly superior over untreated control. The yield of the cultivar UPAS 120 was also found to be considerably higher than ICPL 87.

Conclusion: Use of UPAS 120 along with sequential application of Indoxacarb 15.8 EC @ 73 g a.i./ha - Rynaxypyr 18.5 SC @ 30 g a.i./ha or NSKE 5% - Indoxacarb 15.8 EC @ 73 g a.i./ha may be considered for recommendation in alternate sprays for managing major insect pests on early maturing pigeonpea in Varanasi region of Indo-Gangetic plain.

Keywords: Bio-efficacy; novel insecticides; biopesticides; pod borers; pod bug; pigeonpea.

1. INTRODUCTION

Pulses form an integral part of vegetarian diets across the globe and they have great potential to improve human health, conserve our soils, protect the environment and contribute to global food security [1]. Pigeonpea [*Cajanus cajan* (L.) Millsp.] also known as red gram, arhar, tur etc. is the second most important pulse crop grown in India after chickpea [2]. In India, pigeonpea is grown in an area of 3.9 million hectares with 3.62 million tons of production and productivity of 813 kg/ha [3]. Though India accounts for more than 90 per cent of the world's pigeonpea production, the low productivity of the crop over the past few decades is a major cause of concern [4]. Many efforts have been made in boosting up the pigeonpea production by the introduction of high yielding varieties which have characters of close planting, reduced vegetative growth habit and higher harvest index compared to old and traditional varieties [5]. Research efforts in recent years have led to the development of new, relatively dwarf, short duration cultivars and hybrids [6]. These newly developed short duration genotypes have a higher harvest index than currently grown cultivars, and have shown high productivity in sole cropping systems at high plant density [7].

In spite of all the improvements brought about in the cultivation of pigeonpea crops, insect-pests still continue to be the major biotic constraint [8]. The crop is attacked by nearly 250 insect pests but the damage caused by pod pest complex i.e., gram pod borer [*Helicoverpa armigera* (Hübner)], legume pod borer [*Maruca vitrata* (Geyer)], pod fly [*Melanagromyza obtusa* (Malloch)] and pod bug (*Clavigralla gibbosa* Spinola) results in major reduction in its grain yield [9]. *H. armigera* and *M. obtusa* cause significant economic damage in red gram leading to very low yield levels of 500 to 800 kg ha^{-1} as against the potential yield of 1800 to 2000 kg ha^{-1} [10]. Similarly pigeonpea plants infested with 8 to 16 larvae of *M. vitrata* suffers huge grain yield losses ranging between 50 to 68 per cent [11]. Next to pod borers, tur pod bug, *Clavigralla gibbosa* Spinola (Hemiptera: Coreidae) has become a real threat to quality grain production in pigeonpea [12]. The damage in grain yield due to this bug generally ranges between 25 to 40 per cent [13].

Pesticides are no doubt effective in managing these pests [14] but their indiscriminate use leads to development of resistance in pests, increase in the cost of plant protection and pollute the ecosystem [15]. Most of the farmers follow plant protection practices based on the advice of pesticide dealers. Considering these, it is imperative to integrate various alternative strategies for management of pigeonpea pests [16]. Integrated Pest Management which uses a combination of compatible control techniques is the best way for safe, long-term pest management with minimal adverse effects on the surrounding environment [17]. Use of Biocides like Neem Seed kernel extract (NSKE), Neem Oil and *Bacillus thuringiensis* (Bt) showed varied levels of potency either alone or in combination with insecticides [18]. Thus, the fundamental importance of IPM is evidence in its recent adoption as a basic tenet of the sustainable agriculture movement [19]. Considering above facts, the present investigation was carried on to evaluate the effectiveness of certain components of pest management against pod pest complex on early maturing pigeonpea.

2. MATERIALS AND METHODS

The present investigation was conducted at Agriculture Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Kharif* 2015 and 2016. Two short duration pigeonpea varieties/ cultivars (ICPL 87 and UPAS 120) were grown at a spacing of 75 cm X 10 cm with three replications and seven treatments including control in factorial randomized block design. Two applications of respective insecticides, first at 50% flowering and second at 15 days after the first spray were made using knapsack sprayer with hollow cone nozzle. All the recommended practices were adopted for raising the crop. Pod damage at maturity of the crop was recorded from pods of ten plants selected at random in each plot. Sample pods were critically examined for the damage of major insect pests' *viz*. *H. armigera*, *M. vitrata*, *C. gibbosa* and *M. obtusa*, as described by Yadav and Dahiya [20]. The total yield per plot including the yield of pods sampled earlier for assessment of pod damage was then computed on kilogram per hectare basis. All the data of pod damage and yields were statistically analyzed by the following procedure of Factorial RBD. Calculations were made after applying the test of significance of the means [21] using the statistical package SPSS – 16 version.

3. RESULTS AND DISCUSSION

3.1 Effects of Crop Cultivars, Insecticidal Treatments and Their Interactions on Per Cent Pod Damage Due to Pod Pest Complex

During both the years of experimentation, there was a significant effect of variety (cultivar) and different insecticidal treatments on per cent pod damage caused by *H. armigera*, *M. vitrata*, *C. gibbosa* and *M. obtusa*. However, their interaction (variety x treatment) exhibited no significant effect on per cent pod damage due to above mentioned insect pests. During both years, the application of treatment 1 (first spray of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC at 15 days interval) exhibited minimum pod damage due to *H. armigera*, *M. vitrata* and *M. obtusa*, in both the varieties i.e. ICPL 87 and UPAS 120. While in case of pod bug (*C. gibbosa*) minimum per cent pod damage was recorded in case of treatment 3 where first spary of NSKE 5 per cent followed by Indoxacarb 15.8 EC was done.

<u>3.1.1 Per cent pod damage due to gram pod borer, *H. armigera*</u>

During *Kharif* 2015, the per cent pod damage due to *H. armigera* in the variety ICPL 87 ranged from 2.3 per cent with the application of treatment 1 (first spray of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC at 15 days interval) to 10.6 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 1.6 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 7.6 per cent in control (untreated) (Table 1). Similarly, in the year 2016, per cent pod damage caused by *H. armigera* in the variety ICPL 87 ranged from 4.3 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 11.3 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 3.0 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 8.3 per cent in control (untreated) (Table 2). Effectiveness of Rynaxypyr against *H. armigera* has also been reported by several authors [22,23,24,25, 26]. Dhawan et al. [27] also reported that Indoxacarb @ 55 and 73 g a.i./ha rendered effective control of tobacco caterpiller on cotton, while Maheshkumar et al. [28] observed Indoxacarb at 0.1% and 0.75% to be best against diamond back moth in cabbage. Maurya et al. [29] also reported Cyantraniliprole 10 SE @ 60 g a.i./ha to be highly efficacious against *H. armigera* on pigeonpea that resulted in cent per cent reduction of larval population over control while Chandi and Suri [30] observed Indoxacarb 14.5 SC @ 500 mLha^{-1} to be most effective against *H. armigera* in tomato. These reports further support the present findings.

<u>3.1.2 Per cent pod damage due to legume pod borer, *M. vitrata*</u>

During *Kharif* 2015, per cent pod damage due to *M. vitrata* in the variety ICPL 87 ranged from 9.6 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 36.3 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 8.0 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 32.6 per cent in control (untreated) (Table 1). Similarly, in the year 2016, per cent pod damage by legume pod borer in the variety ICPL 87 ranged from 11.0 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 37.6 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 9.3 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 34.0 per cent in control (untreated). Treatments where two consecutive sprays of NSKE 5% were made, was found to be least effective against *M. vitrata*. However, treatments having combinations of biopesticides along with chemical insecticides were also found to be effective against *M. vitrata* (Table 2). Randhawa and Saini [31] also reported Chlorantraniliprole 10 EC (1 ml/l) and Indoxacarb 14.5 SC (1 ml/l) to be highly efficacious against *M. vitrata* in pigeonpea. The present findings are also partially in accordance with the results of Ameta et al. [32] who reported that Flubendiamide 480 SC, Indoxacarb14.5 SC and Spinosad 48 SC insecticides brought significantly high reduction in larval population of *Maruca testulatis* (Geyer) as well as flower and pod damage in pigeonpea. More recently, Roy et al. [33] also reported about superior efficacy of Indoxacarb 14.5 SC and Chlorantraniliprole 10 SC combinations against *M. testulalis* infesting cowpea.

3.1.3 Per cent pod damage due to tur pod fly, *M. obtusa*

During *Kharif* 2015, per cent pod damage by pod fly in the variety ICPL 87 ranged from 9.3 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 27.3 per cent in control (untreated) (Table 1). Whereas, in the variety UPAS 120 the corresponding values ranged from 7.0 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 22.3 per cent in control (untreated). In the year 2016, per cent pod damage by pod fly in the variety ICPL 87 ranged from 11.0 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 28.6 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 8.3 per cent with the treatment of Indoxacarb 15.8 EC, followed by second spray of Rynaxypyr 18.5 SC to 24.0 per cent in control (untreated). Treatments where two consecutive sprays of NSKE 5% or alternate sprays of NSKE 5% and *Bt* were made was found to be least effective against *M. obtusa* (Table 2). Sambathkumar et al. [34] also found Chlorantraniliprole 18.5 SC @ 30 g a.i./ha and Indoxacarb 15.8 EC @ 75 g a.i/ha highly effective against *M. obtusa* in pigeonpea that resulted in significantly lower per cent pod damage (11.7% and 13.0%, respectively) as compared to 21.7% in untreated control. The present findings are also in close conformity with Patel et al. [35] who reported that Chlorantraniliprole 18.5% SC @ 30 g a.i./ha registered the lowest pod damage due to pod borer and pod fly and recorded the highest yield of pigeonpea. Karmakar and Patra [36] also reported that Indoxacarb 14.5 SC @ 60 g a.i./ha is effective againt pod fly on pigeonpea. More recently, Patange and Chiranjeevi [37] also found Rynaxypyr 18.5 SP @ 30 g a.i./ha to be highly efficacious against *M. obtusa* in pigeonpea.

3.1.4 Per cent pod damage due to tur pod bug, *C. gibbosa*

During *Kharif* 2015, the per cent pod damage by pod bug in the variety ICPL 87 ranged from 15.0 per cent with the treatment of NSKE 5 per cent, followed by second spray of Indoxacarb 15.8 EC to 20.6 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 13.3 per cent with the treatment of NSKE per cent, followed by second spray of Indoxacarb 15.8 EC to 17.3 per cent in control (untreated) (Table 1). Similar trend was also observed in the consecutive season of experimentation i.e., 2016. The per cent pod damage due to *C. gibbosa* in the variety ICPL 87 ranged from 16.0 per cent with the treatment of NSKE 5 per cent, followed by second spray of Indoxacarb 14.6 EC to 22.0 per cent in control (untreated). Whereas, in the variety UPAS 120 the corresponding values ranged from 14.6 per cent with the treatment of NSKE 5 per cent, followed by second spray of Indoxacarb 15.8 EC to 18.6 per cent in control (untreated) (Table 2). Srinivasan and Sridhar [38] also reported that NSKE 5 per cent was found to be effective against *C. gibbosa* in reducing the bug population and obtaining higher yields. A similar result was also found by Gopali et al. [14] who investigated the efficacy of some insecticides, botanicals and biological control agents against *C. gibbosa* on pigeonpea and found Dimethoate and NSKE moderately effective in reducing the pod bug population. Narasimhamurthy and Keval [39] also reported that spraying of Indoxacarb 14.5 SC @ 60 g a.i/ha and NSKE 5% attributed to lesser incidence of *C. gibbosa* and pod damage in red gram.

Table 1. Integrated management of pod pest complex on short duration pigeonpea during *Kharif* 2015

S. no.	Treatment details	Per cent pod damage due to								Yield (kg/ha)	
		Gram pod borer (*H. armigera*)		Legume pod borer (*M. vitrata*)		Pod fly (*M. obtusa*)		Pod bug (*C. gibbosa*)			
		ICPL 87	UPAS 120	ICPL 87	UPAS 120	ICPL 87	UPAS 120	ICPL 87	UPAS 120	ICPL 87	UPAS 120
1.	Indoxacarb 15.8 EC @ 73 g a.i./ha > Rynaxypyr 18.5 SC @ 30 g a.i./ha	2.3 (8.7)	1.6 (7.3)	9.6 (18.1)	8.0 (16.4)	9.3 (17.7)	7.0 (15.3)	15.3 (23.0)	14.0 (21.9)	640	730
2.	Bt @ 1 kg/ha > Indoxacarb 15.8 EC @ 73 g a.i./ha	3.6 (11.0)	3.3 (10.4)	14.6 (22.5)	11.6 (19.9)	15.0 (22.7)	10.6 (18.9)	16.6 (24.0)	14.6 (22.5)	380	430
3.	NSKE 5% > Indoxacarb 15.8 EC @ 73 g a.i./ha	4.6 (12.4)	4.0 (11.4)	13.0 (21.0)	10.6 (19.0)	12.0 (20.2)	9.3 (17.7)	15.0 (22.7)	13.3 (21.4)	600	690
4.	NSKE 5% > Rynaxypyr 18.5 SC @ 30 g a.i./ha	5.0 (12.9)	3.6 (11.0)	14.0 (21.9)	11.3 (19.6)	13.3 (21.4)	10.0 (18.2)	16.3 (23.8)	14.0 (21.9)	560	670
5.	NSKE 5% > Bt @ 1 kg/ha	6.3 (14.5)	4.3 (11.9)	18.0 (25.0)	16.3 (23.8)	15.3 (23.0)	11.3 (19.6)	17.6 (24.8)	15.6 (23.3)	350	390
6.	NSKE 5% > NSKE 5%	6.6 (14.8)	5.3 (13.3)	19.6 (26.3)	18.6 (25.5)	12.6 (20.8)	9.3 (17.7)	16.6 (24.0)	14.3 (22.2)	390	430
7.	Control (Untreated)	10.6 (19.0)	7.6 (16.0)	36.3 (37.0)	32.6 (34.8)	27.3 (31.4)	22.3 (28.1)	20.6 (27.0)	17.3 (24.5)	310	330
Effect of variety											
S.Em±		(0.23)		(0.23)		(0.30)		(0.16)		2.47	
C.D. (P = 0.05)		0.68		0.69		0.90		0.49		7.23	
Effect of treatments											
S.Em±		(0.43)		(0.44)		(0.57)		(0.31)		4.62	
C.D. (P = 0.05)		1.27		1.29		1.68		0.92		13.53	
Effect of interaction (variety x treatments)											
S.Em±		(0.61)		(0.62)		(0.81)		(0.44)		6.54	
C.D. (P = 0.05)		NS		NS		NS		NS		19.13	

Figures in parentheses are arcsin transformed values; NS = Non Significant; Bt = Bacillus thuringiensis kurstaki (Cezar 0.5% WP)

Table 2. Integrated management of pod pest complex on short duration pigeonpea during *Kharif* 2016

S. No.	Treatment details	Per cent pod damage due to								Yield (kg/ha)	
		Gram pod borer (*H. armigera*)		Legume pod borer (*M. vitrata*)		Pod fly (*M. obtusa*)		Pod bug (*C. gibbosa*)			
		ICPL 87	UPAS 120	ICPL 87	UPAS 120	ICPL 87	UPAS 120	ICPL 87	UPAS 120	ICPL 87	UPAS 120
1.	Indoxacarb 15.8 EC @ 73 g a.i./ha > Rynaxypyr 18.5 SC @ 30 g a.i./ha	4.3 (11.9)	3.0 (9.8)	11.0 (19.3)	9.3 (17.7)	11.0 (19.3)	8.3 (16.7)	16.3 (23.8)	15.0 (22.7)	630	720
2.	Bt @ 1 kg/ha > Indoxacarb 15.8 EC @ 73 g a.i./ha	5.0 (12.8)	4.0 (11.4)	16.3 (23.8)	13.0 (21.1)	16.3 (23.8)	11.6 (19.9)	17.6 (24.8)	15.3 (23.0)	380	420
3.	NSKE 5% > Indoxacarb 15.8 EC @ 73 g a.i./ha	5.3 (13.3)	4.6 (12.4)	14.6 (22.4)	11.6 (19.9)	13.3 (21.4)	11.0 (19.3)	16.0 (23.5)	14.6 (22.5)	590	680
4.	NSKE 5% > Rynaxypyr 18.5 SC @ 30 g a.i./ha	6.0 (14.1)	4.3 (11.9)	15.3 (23.0)	12.6 (20.8)	15.0 (22.7)	11.3 (19.6)	17.6 (24.8)	15.3 (23.0)	550	650
5.	NSKE 5% > Bt @ 1 kg/ha	6.6 (14.9)	5.0 (12.8)	19.3 (26.0)	17.3 (24.5)	16.6 (24.0)	13.0 (21.1)	19.0 (25.8)	17.0 (24.3)	330	370
6.	NSKE 5% > NSKE 5%	7.0 (15.3)	6.0 (14.1)	20.6 (27.0)	19.6 (26.3)	14.0 (21.9)	12.0 (20.2)	18.0 (25.0)	15.6 (23.2)	380	420
7.	Control (Untreated)	11.3 (19.6)	8.3 (16.7)	37.6 (37.8)	34.0 (35.6)	28.6 (32.3)	24.0 (29.3)	22.0 (27.9)	18.6 (25.5)	300	320
Effect of variety											
S.Em±		(0.24)		(0.16)		(0.16)		(0.14)		1.97	
C.D. (P = 0.05)		0.70		0.48		0.47		0.42		5.77	
Effect of treatments											
S.Em±		(0.44)		(0.31)		(0.30)		(0.27)		3.69	
C.D. (P = 0.05)		1.31		0.91		0.87		0.79		10.79	
Effect of interaction (variety x treatments)											
S.Em±		(0.63)		(0.44)		(0.42)		(0.38)		5.22	
C.D. (P = 0.05)		NS		NS		NS		NS		15.27	

Figures in parentheses are arcsin transformed values; NS = Non Significant; Bt = Bacillus thuringiensis kurstaki (Cezar 0.5% WP)

3.2 Effects of Variety, Insecticidal Treatments, and Their Interactions on Grain Yield of Pigeonpea

The variety, effect of various treatments as well as their interaction (variety x treatment) had significant effect on the grain yield (kg/ha). During *Kharif* 2015, the yield of the variety ICPL 87 varied from 310 kg/ha to 640 kg/ha. It was recorded to be highest (640 kg/ha) with treatment of Indoxacarb 15.8 EC followed by Rynaxypyr 18.5 SC. This was followed by the treatment of NSKE 5 per cent and Indoxacarb 15.8 EC alternate sprays which gave the yield of 600 kg/ha. The lowest yield of 310 kg/ha was recorded in the untreated control. In UPAS 120 also highest yield was recorded from treatment of Indoxacarb 15.8 EC followed by Rynaxypyr 18.5 SC, which gave the yield 730 kg/ha. This was closely followed by the treatment of NSKE 5 per cent and Indoxacarb 15.8 EC alternate sprays which gave the yield of 690 kg/ha. The lowest yield of 330 kg/ha was recorded in the untreated control (Table 1).

Similarly during *Kharif* 2016, the yield of the variety ICPL 87 varied from 300 kg/ha to 630 kg/ha. It was highest (630 kg/ha) with treatment of Indoxacarb 15.8 EC followed by Rynaxypyr 18.5 SC. This was followed by the treatment having first spray of NSKE 5 per cent, followed by second spray of Indoxacarb 15.8 EC which gave the yield of 590 kg/ha. The lowest yield of 300 kg/ha was recorded in the untreated control. In UPAS 120 also highest yield was recorded with the treatment of Indoxacarb 15.8 EC followed by Rynaxypyr 18.5 SC, which gave the yield 720 kg/ha. This was closely followed by the treatment having first spray of NSKE 5 per cent, followed by second spray of Indoxacarb 15.8 EC at 15 days interval, which gave the yield of 680 kg/ha. The lowest yield of 320 kg/ha was recorded in the untreated control. The yield of the cultivar UPAS 120 was better in general as compared to ICPL 87. Even in untreated control the yield of the cultivar UPAS 120 was significantly higher than the corresponding value of ICPL 87 during both the years of experimentation (Table 2).

The above findings are in conformity with those of Jakhar et al. [40] who reported Indoxacarb 15.8 EC as superior molecule giving maximum control of pod borers and pod fly damage incidence in pigeonpea crop. Similarly, Rathod et al. [41] reported that combinations of bio-pesticides with insecticides like *B. thuringiensis* @ 0.5 kg/ha + Indoxacarb 0.004 per cent, *B. thuringiensis* @ 0.5 kg/ha + Rynaxypyr 0.003 per cent to be the most effective treatment against *H. armigera* in pigeonpea crop. The findings of Chakravarty and Agnihotri [42] about higher potency of Rynaxypyr 18.5 SC @ 30 g a.i./ha against pod borer complex *viz.*, *M. vitrata*, *H. armigera* and *M. obtusa* in terms of minimum per cent pod damage and maximum grain yield further strengthens the present findings. Wadaskar et al. [24] also reported rynaxypyr to be highly efficacious against insect pest complex of pigeonpea while Satpute and Barkhade [43] reported that Rynaxypyr 20 SC (30 and 40 g a.i ha^{-1}) was most effective in reducing the pod damage as well as pest population with maximum yield of 16.15 and 17.52 q ha^{-1} respectively.

4. CONCLUSION

The present study concluded that sequential application of Indoxacarb 15.8 EC @ 73 g a.i./ha and Rynaxypyr 18.5 SC @ 30 g a.i./ha is very effective against *H. armigera, M. vitrata* and *M. obtusa* (as it resulted in minimum pod damage due to these insect pests), while, NSKE 5% > Indoxacarb 15.8 EC @ 73 g a.i./ha sequential application treatment provided better control of *C. gibbosa* on pigeonpea. Higher grain yield was also obtained from these treatment plots as compared to other insecticidal treatments and untreated control. The yield of the cultivar UPAS 120 was better in general as compared to ICPL 87. Hence use of UPAS 120 along with sequential application of these chemicals and biopesticides may be considered for recommendation in alternate sprays for managing the gram pod borer, legume pod borer, tur pod fly and tur pod bug on early maturing pigeonpea.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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