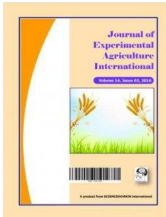

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Efficacy of Selected Insecticide and Biopesticide Combinations against Major Insect Pests of Late Maturing Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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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 RKR 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 chemical insecticide and biopesticide combinations against tur pod fly [*Melanagromyza obtusa* (Malloch)], gram pod borer [*Helicoverpa armigera* (Hübner)] and tur pod bug (*Clavigralla gibbosa* Spinola) on pigeonpea.
Study Design: 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 eight treatments having different combinations of insecticides and biopesticides including untreated control. Effectiveness of these treatment regimes was determined on the basis of per cent pod and grain damage due to major insect pests and grain yield of pigeonpea.

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Results: Treatment regimes having combinations of chemical insecticides and biopesticides were found to be more effective in comparison to treatments modules where there was sole use of biopesticides. The treatment comprising of sequential application of Multineem 0.03% followed by second spray of Rynaxypyr 18.5 SC @ 30 g a.i./ha and third spray of Indoxacarb 15.8 EC @ 73 g a.i./ha at 15 days interval was significantly superior in managing *M. obtusa*, *H. armigera* and *C. gibbosa* on pigeonpea over rest of the treatments in terms of lower pod and grain damage and higher grain yield. However, all the insecticidal treatment modules were found significantly superior over untreated control.

Conclusion: Sequential application of Multineem 0.03% - Rynaxypyr 18.5 SC @ 30 g a.i./ha - Indoxacarb 15.8 EC @ 73 g a.i./ha may be considered for recommendation in alternate sprays for managing major insect pests on long duration pigeonpea in Varanasi region of Indo-Gangetic plain.

Keywords: Pigeonpea; insect pests; efficacy; novel insecticides; biopesticides.

1. INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a valuable grain legume grown in semi-arid tropical and sub-tropical areas of the world [1]. It is the second most important pulse crop grown in India after chickpea [2]. Though India contributes for nearly 90% of world's total pigeonpea production [3], the yields of this crop has remained stagnant over the past few decades largely due to its vulnerability to several biotic and abiotic stresses [4]. The average national yield (about 712 kg/ha) is disappointingly low in comparison to potential yields of 1.2-1.5 tons/ha in short duration and 2.0-3.0 tons/ha in long duration cultivars [5].

Nearly 250 species of insect pests are known to infest pigeonpea crop at its various growth stages in India [6] but the damage caused by gram pod borer [*Helicoverpa armigera* (Hübner)], tur pod fly [*Melanagromyza obtusa* (Malloch)] and tur pod bug [*Clavigralla gibbosa* Spinola] results in major reduction in grain yield [7]. Considerable loss in grain yield is inflicted on account of their association with fruiting bodies [8]. *H. armigera* and *M. obtusa* cause adequate economic damage in pigeonpea 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} [9]. Similarly, feeding by nymphs and adults of *C. gibbosa* causes deformation of pods and shriveling of grains [10] resulting in predominant grain yield loss that has been worked out to the tune of 50,000 tonnes annually for Uttar Pradesh alone [11].

A number of insecticides have been reported to be effective for controlling pod pest complex on pigeonpea [12]. However, in the wake of widespread resistance and cross resistance to chemical insecticides [13], a need for an alternative that has higher potency, selective action and less negative impact on beneficial organisms than conventional insecticides is increasingly felt [14]. At present the alternative is the use of target specific newer insecticides having novel mode of action along with biopesticides for the eco-friendly management of these pests [15]. Blending of the biopesticides along with new insecticides not only helps in reducing the reliance on use of chemical insecticides but also helps to delay on set of resistance in insects against these insecticides [16]. Hence, an attempt has been made to evaluate the efficacy of certain novel insecticides along with biopesticides in order to devise an effective module for the management of major insect pests of pigeonpea.

2. MATERIALS AND METHODS

Field experiments on pigeonpea (var. Bahar) were conducted at Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Kharif* seasons of 2015-16 and 2016-17. The crop was grown at a spacing of 75 cm X 10 cm with three replications and eight treatments including control (Table 1) in randomized block design. Three applications of respective insecticides, first at 50 % flowering and remaining at 15 days after first spray were made using knapsack sprayer with hollow cone nozzle. All the recommended agronomic practices were adopted for raising the crop. Pod damage at crop maturity was recorded from pods of ten plants selected at random in each plot. Sampled pods were critically examined for the damage of major insect pests' *viz*. *M. obtusa*, *H. armigera* and *C. gibbosa*, as described by Yadav and Dahiya [17]. The total yield per plot including the yield of pods sampled earlier for assessment of pod and grain damage was then computed on kilogram per hectare basis. The data recorded during the course of investigation were subjected to statistical analysis by using analysis of variance (ANOVA) technique for Randomized Block Design to compare means of different treatments [18].

3. RESULTS AND DISCUSSION

3.1 Effects of Various Treatments on Per Cent Pod and Grain Damage Due to Tur Pod Fly

The different insecticidal treatments applied showed significant ($p<0.05$) difference in the per cent pod and grain damage due to *M. obtusa* (Table 1). Application of module 1, where sequential application of Multineem @ 0.03% – Rynaxypyr 18.5 SC @ 30 g a.i./ha – Indoxacarb 15.8 EC @ 73 g a.i./ha was done at 15 days interval, recorded minimum pod and grain damage due to *M. obtusa* during both the years of experimentation (*Kharif* 2015-16 and *Kharif* 2016-17). This was closely followed by NSKE (Neem Seed Kernel Extract) 5% – *Bt* @ 1kg/ha – Indoxacarb 15.8 EC @ 73 g a.i./ha sequential application treated plots. Module 7 where three sprays of NSKE 5% were made was found to be least effective against *M. obtusa*. However, all the insecticidal treatment modules were found significantly superior over untreated control. Thus, out of seven insecticidal modules tested against pod fly in the present study, the most promising treatment appeared to be module 1 (Multineem 0.03% - Rynaxypyr 18.5 SC @ 30 g a.i./ha – Indoxacarb 15.8 EC @ 73 g a.i./ha).

Sambathkumar et al. [19] 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. Effectiveness of Indoxacarb against *M. obtusa* has also been reported by [20,21]. Patange and Chiranjeevi [22] also reported that Rynaxypyr 18.5 SP @ 30 g a.i./ha rendered effective control of pod fly on pigeonpea, while Patel and Patel [23] observed Chlorantraniliprole 18.5 SC @ 30 g a.i./ha and Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC @ 37.5 g a.i./ha to be most effective against pod fly and other lepidopteran pod borers in pigeonpea. These reports further support the present findings. The findings of Sharma et al. [24] about higher potency of crude neem kernel seed extract (5%) and neem oil (3000 ppm) against *M. obtusa* also fall in line with the present findings. More recently, Rahman et al. [25] also found Indoxacarb (0.004%) and NSKE (4%) combinations highly effective against pod fly in pigeonpea.

3.2 Effects of Various Treatments on Per Cent Pod and Grain Damage Due to Gram Pod Borer

The different insecticidal treatments applied also showed significant differences in the per cent pod and grain damage due to *H. armigera* (Table 1). The per cent pod damage by *H. armigera* was found to be minimum (3.67% and 3.00%, respectively) in Multineem @ 0.03% – Rynaxypyr 18.5 SC @ 30 g a.i./ha – Indoxacarb 15.8 EC @ 73g a.i./ha sequential application treated plots, during both years of investigation. The lowest per cent grain damage (1.51% and 1.29%, respectively) was also recorded from Module 1, closely followed by NSKE 5% – *Bt* @ 1kg/ha – Indoxacarb 15.8 EC @ 73 g a.i./ha sequential application treated plots. Module 7 where three sprays of NSKE 5% were made was found to be least effective against *H. armigera*. However, all the insecticidal treatment modules were found significantly superior over untreated control.

The present findings are in accordance with findings of Chakravarty and Agnihotri [15] who reported that among ten different insecticidal treatments tested against *H. armigera* on pigeonpea, alternate spray of Rynaxypyr 18.5 SC @ 30 g a.i./ha and Spinosad 45 SC @ 56 g a.i./ha was found to be most effective with minimum total per cent pod damage of 10.44% and maximum grain yield of 1346.67 kg/ha. However alternate spray of Indoxacarb 15.8 EC @ 73 g a.i./ha and *Beauveria bassiana* 5% WP @ 2000 g/ha was found most economical with maximum benefit: cost ratio of 6.29 : 1. The findings of Satpute and Barkhade [26] and Patange and Chiranjeevi [22] about higher potency of Rynaxypyr against pod borer complex of pigeonpea also fall in line with present findings. Maurya et al. [27] 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 [28] observed Indoxacarb 14.5 SC @ 500 $mLha^{-1}$ to be most effective against *H. armigera* in tomato.

Table 1. Effect of certain novel insecticides and biopesticides combinations on per cent pod and grain damage by pod pest complex on long duration pigeonpea during *Kharif* 2015-16 and 2016-17

Treatment module	Per cent pod damage						Per cent grain damage						Grain yield (kg/ha)	
	M. obtusa		*C. gibbosa*		*H. armigera*		*M. obtusa*		*C. gibbosa*		*H. armigera*			
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Module 1	10.67 (19.02)	9.33 (17.76)	7.33 (15.65)	6.67 (14.89)	3.67 (10.86)	3.00 (9.88)	4.00 (11.47)	3.67 (11.01)	5.84 (13.96)	5.27 (13.26)	1.51 (6.99)	1.29 (6.49)	1031	1035
Module 2	13.33 (21.39)	11.00 (19.35)	13.00 (21.12)	8.00 (16.40)	5.33 (13.34)	4.00 (11.47)	7.33 (15.70)	5.33 (13.26)	6.75 (15.03)	5.92 (14.06)	1.97 (8.04)	1.75 (7.59)	914	916
Module 3	14.33 (22.20)	11.67 (19.95)	9.67 (18.10)	8.33 (16.73)	6.33 (14.50)	5.33 (13.29)	8.00 (16.40)	5.67 (13.68)	7.83 (16.25)	6.35 (14.58)	2.41 (8.92)	2.07 (8.27)	894	900
Module 4	16.67 (24.08)	12.67 (20.83)	11.00 (19.35)	9.67 (18.10)	8.00 (16.40)	7.67 (16.06)	8.67 (17.07)	6.33 (14.50)	7.26 (15.62)	7.00 (15.33)	3.28 (10.43)	2.93 (9.84)	863	869
Module 5	12.00 (20.25)	10 (18.33)	9.33 (17.78)	7.67 (16.06)	4.00 (11.47)	3.67 (11.01)	6.00 (14.14)	4.67 (12.46)	6.30 (14.47)	5.63 (13.72)	1.81 (7.68)	1.53 (7.05)	987	995
Module 6	16.33 (23.81)	12.00 (20.25)	10.67 (19.02)	8.67 (17.09)	6.67 (14.95)	5.67 (13.75)	8.33 (16.73)	6.00 (14.14)	8.17 (16.60)	6.74 (15.03)	2.65 (9.35)	2.10 (8.33)	880	887
Module 7	22.00 (27.95)	17.00 (24.33)	15.00 (22.77)	13.33 (21.39)	10.67 (19.02)	10.00 (18.41)	13.89 (21.82)	11.33 (19.65)	9.32 (17.75)	8.87 (17.28)	3.99 (11.51)	3.70 (11.08)	830	835
Module 8	32.00 (34.43)	30.67 (33.61)	22.67 (28.42)	21.33 (27.49)	14.33 (22.23)	15.00 (22.78)	20.33 (26.77)	18.33 (25.33)	14.97 (22.75)	13.40 (21.45)	6.66 (14.92)	6.92 (15.22)	679	682
SEm ±	0.72	0.69	0.51	0.73	0.88	0.60	0.89	0.75	0.58	0.42	0.50	0.35	3.18	2.57
CD at 5%	2.20	2.13	1.55	2.24	2.70	1.83	2.72	2.29	1.77	1.28	1.54	1.07	9.64	7.79

Figures presented in parentheses are angular transformed values

(Module 1: Multineem 0.03% - Rynaxypyr 18.5 SC @ 30 g a.i./ha – Indoxacarb 15.8 EC @ 73g a.i./ha; Module 2: NSKE 5% - Bt. @ 1 kg/ha – Rynaxypyr 18.5 SC @ 30 g a.i./ha; Module 3: NSKE 5% - Multineem 0.03% - Indoxacarb 15.8 EC @ 73 g a.i./ha; Module 4: NSKE 5% - Bt. @ 1 kg/ha - Dimethoate 30 EC @ 600 g a.i./ha; Module 5: NSKE 5% - Bt. @ 1 kg/ha – Indoxacarb 15.8 EC @ 73 g a.i./ha; Module 6: NSKE 5% - NSKE 5% - Indoxacarb15.8 EC @ 73 g a.i./ha; Module 7: NSKE 5% - NSKE 5% - NSKE 5%; Module 8: Untreated control.) SC = Suspension Concentrate, EC = Emulsifiable Concentrate

3.3 Effects of Various Treatments on Per Cent Pod and Grain Damage Due to Tur Pod Bug

The different insecticidal treatments applied also showed significant differences in the per cent pod and grain damage due to *C. gibbosa* (Table 1). The per cent pod damage by *C. gibbosa* was found to be minimum (7.33% and 6.77%, respectively) in Multineem @ 0.03% – Rynaxypyr 18.5 SC @ 30 g a.i./ha – Indoxacarb 15.8 EC @ 73 g a.i./ha sequential application treated plots, during both the years of investigation. The lowest per cent grain damage (5.84% and 5.27%, respectively) was also recorded from Module 1, closely followed by NSKE 5% – *Bt* @ 1 kg/ha – Indoxacarb 15.8 EC @ 73 g a.i./ha sequential application treated plots. Module 7 where three sparys of NSKE 5% were made was found to be least effective against *C. gibbosa*. However, all the insecticidal treatment modules were found significantly superior over untreated control.

Indrasen et al. [29] also found Indoxacarb 15.8 EC @ 73 g a.i/ha highly effective against tur pod bug in pigeonpea that resulted in minimum per cent pod damage (9.67%) as compared to 16.00% in untreated control. Gopali et al. [30] also 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. Chandra and Singh [31] also found Indoxacarb 14.5 SC @ 60 g a.i/ha and Rynaxypyr 20 SC @ 40 g a.i/ha highly effective against pod bug in long duration pigeonpea (cv. NDA-1). Narasimhamurthy and Keval [11] 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.

3.4 Effect of Various Treatment Modules on Grain Yield

During both the years of experimentation (2015-16 and 2016-17), significantly highest grain yield (1031 kg/ha and 1035 kg/ha, respectively) was recorded from treatment module 1 where sequential application of Multineem @ 0.03% – Rynaxypyr 18.5 SC @ 30 g a.i./ha – Indoxacarb 15.8 EC @ 73 g a.i./ha was done at 15 days interval. Minimum grain yield (679 kg/ha and 682 kg/ha, respectively) was obtained from untreated control followed by treatment module 7 where three sprays of NSKE 5% was done at 15 days interval (830 kg/ha and 835 kg/ha, respectively). The present findings are in accordance with Jakhar et al. [32] who reported that maximum grain yield of 2144.17 kg/ha was obtained from Indoxacarb 15.8 EC and it was statistically at par with neem soap @ 10 g/l (2100.0 kg/ha). Dabhi et al. [33] also found Indoxacarb 15 EC @ 73g a.i./ha was most effective for the control of pod borers in pigeonpea and it also resulted in significant higher grain yield during both the years of experimentation (1753 and 1652 kg/ha), respectively. The present findings are also in accordance with the earlier reports of Nishantha et al. [34] and Chowdary et al. [35] who reported Rynaxypyr 20 SC @ 30 g a.i./ha as superior molecule in recording lower pod damage and higher grain yield in pigeonpea against pod borer insects.

4. CONCLUSION

The present study concluded that application of module 1 where first spray of Multineem @ 0.03% followed by second spray of Rynaxypyr 18.5 SC @ 30 g a.i./ha and third spray of Indoxacarb 15.8 EC @ 73 g a.i./ha was done at 15 days interval provided better control of *M. obtusa, H. armigera* and *C. gibbosa* on pigeonpea. Higher grain yield was also obtained from module 1 treated plots as compared to other insecticidal treatments and untreated control. Hence sequential application of these insecticides may be considered for recommendation in alternate sprays for managing tur pod fly, gram pod borer and tur pod bug on late maturing pigeonpea. During the course of present study, it was also found that treatment modules having combinations of chemical insecticides and bio-pesticides proved to be more effective in comparison to treatments modules where there was sole use of bio-pesticides only.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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