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Evaluation of sequential application of insecticides against major insect pests on long duration pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract
The present study was conducted to evaluate the comparative efficacy of different insecticidal treatments against tur pod fly [*Melanagromyza obtusa* (Malloch)], tur pod bug (*Clavigralla gibbosa* Spinola) and pod borer [*Helicoverpa armigera* (Hübner)] infesting pigeonpea variety Bahar during *Kharif* 2015-16 and 2016-17. Among all the treatment modules, Module 5 with sequential application of Chlorantraniliprole 18.5 SC @ 30g a.i/ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i/ha and Module 3 with sequential application of Chlorantraniliprole 18.5 SC @ 30g a.i/ha - Acephate 75 SP @ 750g a.i/ha - Acephate 75 SP @ 750g a.i/ha provided better control of *M. obtusa*, *C. gibbosa* and *H. armigera* on pigeonpea in terms of lower pod and grain damage and higher grain yield. Hence, these two treatment modules can be suggested to the farmers for effective management of pod borers and pod bug on long duration pigeonpea.

Keywords: Pigeonpea, insect pests, pod damage, grain damage, insecticides

1. Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important pulse crop grown in semi-arid tropics and sub-tropical areas of the world [1]. India accounts for more than 90 per cent of the world's pigeonpea production and area [2]. In India pigeonpea is grown on 3.88 million hectares of area with an annual production of 3.29 million tonnes and yield of 849 kg/ha [3]. It is a rich source of protein (21.71%) and supplies a major share of protein requirement of the vegetarian population of the country [4]. In spite of all the improvements brought about in the cultivation of pigeonpea crops, the major constraints for low productivity of pigeonpea are inadequate availability of seeds of improved varieties, biotic and abiotic stresses and poor crop management [5]. Abiotic and biotic stresses are the most limiting factors in pigeonpea production. Among the biotic pressures, large numbers of insect pests have been identified to infest pigeonpea. The low yields of pigeonpea crop which have remained stagnant for the past 3 to 4 decades are mainly due to insect pest attack and physiological shrivelling [6].

The crop is highly sensitive to attack by a wide range of insect pests both in the fields and storage. Most of the pests attack the crop at reproductive stage causing direct losses [7]. More than 250 species of insects belonging to 8 orders and 61 families have been found to attack pigeonpea. However, only a few of them cause considerable damage to the crop and are economically important as pests [8]. On an average, one third of the pigeonpea produced annually in India is lost due to the insect pest infestation and the estimated monetary value (nearly one million tonnes) is approximately Rs. 15,000 million [9]. Amongst many insect pests, the legume pod borer [*Maruca vitrata* (Geyer)], plume moth [*Exelastis atomosa* (Walsingham)], blue butterfly [*Lampides boeticus* (L.)], gram pod borer [*Helicoverpa armigera* (Hübner)] and tur pod fly [*Melanagromyza obtusa* (Malloch)] on the pigeonpea are of major importance [10]. Considerable loss in grain yield is inflicted on account of their association with fruiting bodies. Pod borers have been estimated to cause 60 to 90 per cent loss in the grain yield of pigeonpea under favourable conditions [11].

H. armigera and *M. obtusa* cause adequate economic damage 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} [12]. The survey undertaken in Marathwada during 2007-08 revealed that the damage by pod fly (*M. obtusa*) ranged from 25.50 to 36.00 per cent [13]. Next to pod borers, pigeonpea pod sucking bug, *Clavigralla gibbosa* Spinola (Hemiptera: Coreidae) has become a real threat to quality grain production in pigeonpea. The damage in grain yield due to this bug generally ranges between 25 to 40 per cent [14]. For management of pod borer complex, agrochemicals are still the first choice of farmers. Insecticides are most commonly recommended, preferred and adopted means, especially for crop with high remunerative prices like pigeonpea. Hence, chemical measures are often termed as necessary evil in present pigeonpea pest management scenario [15]. Farmers, use chemical pesticides indiscriminately, which leads to increased cost of plant protection resulting in lower profitability. On these grounds, newer insecticides with novel mode of action are needed to be evaluated to find out an effective and economical insecticide for the management of pigeonpea pod borer complex [16]. Keeping these views in mind, present study was conducted to evaluate the efficacy of sequential application of certain insecticides against pod borers and pod bug in pigeonpea ecosystem.

2. Materials and Methods

Field experiments on pigeonpea (var. Bahar) were conducted at Agriculture Research Farm of 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 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*, *C. gibbosa* and *M. obtusa*, as described by Yadav and Dahiya [17]. 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.

2.1 Statistical analysis

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 as suggested by Panse and Sukhatme [18].

3. Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads:

3.1 Effects of various treatments on per cent pod and grain damage due to *M. obtusa*

The treatments applied showed significant difference in the per cent pod and grain damage by pod fly (Table 1). The maximum effectivity against pod fly in terms of per cent pod and grain damage was observed with application of Module 5, where sequential application of Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i./ha was done, during both the years of investigation. This was closely followed by Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Acephate 75 SP @ 750g a.i./ha - Acephate 75 SP @ 750g a.i./ha sequential application treated plot. Module 7 where three sprays of Dimethoate 30 EC @ 600g a.i./ha were made, was found to be least effective as compared to untreated control. Similar result was found by Awale *et al*. [19] who evaluated the efficacy of newer insecticides like Novaluron 10% EC, Indoxacarb 15% SC, against pod fly (*M. obtusa*) and found that all the treatments were significantly superior over untreated control in reducing *M. obtusa* population and damage caused by them. Amongst the treatments, the treatment with Novaluron @ 75g a.i./ha proved to be the best treatment reducing population of *M. obtusa* to a minimum extent of 0.55 maggots/plant, pod damage (8.75%), grain damage (22.75%) and highest grain yield (1686 kg/ha). Narshimhamurthy and Keval [20] also found spinosad 45% SC @ 73g a.i./ha highly effective in reducing per cent pod and grain damage due to pod fly in long duration pigeonpea. Patel and Patel [21] who reported that Chlorantraniliprole @ 30g a.i./ha was the most effective insecticide against pod fly on pigeonpea further supports the present findings.

3.2 Effects of various treatments on per cent pod and grain damage due to *C. gibbosa*

The treatments applied showed significant differences in the per cent pod and grain damage due to pod bug (Table 1). The per cent pod damage by pod bug was found to be minimum (15.00% and 13.00%, respectively) in Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i./ha sequential application treated plot, during both the years of investigation. The Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i./ha sequential application treated plot also gave the lowest per cent grain damage (5.15% and 4.69%, respectively) followed by Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Acephate 75 SP @ 750g a.i./ha - Acephate 75 SP @ 750g a.i./ha sequential application treated plot respectively. A similar result was found by Pandey and Das [22] who reported that among the different insecticides tested, Rynaxypyr 20% SC @ 30g a.i./ha was found to be most effective as it recorded lowest bug population after each spray intervals. Lufenurol 5.4 EC @ 75g a.i./ha was proved lesser effective to reduce the bug population in pigeonpea. Vishwanath and Sinha [23] also found that both Neonicotinoids (Thiamethoxam and Acetamiprid) were effective against sucking insect pests of okra.

3.3 Effects of various treatments on per cent pod and grain damage due to *H. armigera*

The per cent pod and grain damage due to *H. armigera* also showed significant differences among treatments (Table 1). The per cent pod damage due to gram pod borer was recorded to be minimum (1.33% and 2.00%, respectively) in Module 5 (sequential application of Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i./ha), during both the years of investigation. The Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Indoxacarb 15.8 EC @ 73g a.i. /ha - Acetamiprid 20 SP @ 20g a.i./ha sequential application treated plot also gave the lowest per cent grain damage followed by Chlorantraniliprole 18.5 SC @ 30g a.i./ha - Acephate 75 SP @ 750g a.i./ha - Acephate 75 SP @ 750g a.i./ha sequential application treated plot respectively. The present findings are in accordance with findings of Chakravarty and Agnihotri [24] who reported that among ten different insecticidal treatments tested against pigeonpea pod borer complex (*M. vitrata*, *H. armigera* and *M. obtusa*), alternate spray of Rynaxypyr 18.5 SC @ 30g a.i./ha and Spinosad 45 SC @ 56g 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 @ 73g a.i./ha and *Beauveria bassiana* 5% WP @ 2000g/ha was found most economical with maximum benefit: cost ratio of 6.29 : 1. Patange and Chiranjeevi [16] also found Rynaxypyr 18.5 SP @ 30g a.i./ha as most effective insecticide in minimizing the larval population of gram pod borer, plume moth and pod fly on pigeonpea.

3.4 Effect of various treatments on the grain yield

During both the years of experimentation (2015-16 and 2016-17), highest grain yield (1175 kg/ha & 1200 kg/ha, respectively) was recorded from treatment module 5 where sequential application of Chlorantraniliprole 18.5 SC @ 30g a.i/ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i/ha was done at 15 days interval. Minimum grain yield (808 kg/ha & 828 kg/ha, respectively) from treatment module 7 where three sprays of Dimethoate 30 EC @ 600g a.i./ha was done at 15 days interval. But all the insecticidal treatments recorded significantly higher grain yield as compared to untreated control. The present findings are in accordance with Dabhi *et al.* [25] who reported that 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 (1753 and 1652 kg/ha), respectively. Satpute and Barkhade [26] also reported Rynaxypyr 20 SC @ 40g a.i./ha as the most promising insecticide against pod borer complex of pigeonpea and to give highest yield of 17.52 q/ha. The present findings are also in accordance with the earlier reports of [27, 28] who reported Rynaxypyr 20 SC @ 30g a.i./ha as superior molecule in recording lower pod damage and higher grain yield in pigeonpea against pod borer complex.

Table 1: Relative performance of insecticides 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	37.67 (37.84)*	36.67 (37.24)	23.33 (28.87)	21.33 (27.49)	5.67 (13.75)	6.00 (14.14)	17.91 (25.03)	18.09 (25.12)	8.08 (16.51)	6.72 (14.99)	1.56 (7.16)	1.51 (7.05)	927	945
Module 2	39.00 (38.63)	36.67 (37.24)	26.00 (30.64)	24.00 (29.32)	6.67 (14.95)	6.33 (14.50)	18.71 (25.59)	18.30 (25.27)	8.97 (17.41)	7.61 (15.98)	1.91 (7.94)	1.85 (7.81)	907	927
Module 3	33.33 (35.25)	31.67 (34.23)	20.67 (27.02)	19.33 (26.07)	2.67 (9.36)	3.33 (10.49)	15.72 (23.34)	14.27 (22.13)	6.89 (15.21)	6.01 (14.16)	0.74 (4.93)	0.70 (4.79)	1040	1075
Module 4	37.33 (37.65)	34.67 (36.05)	22.00 (27.96)	20.00 (26.55)	4.33 (11.99)	5.00 (12.87)	16.74 (24.14)	18.20 (25.10)	7.59 (15.98)	6.28 (14.51)	1.25 (6.39)	1.26 (6.44)	944	964
Module 5	24.67 (29.76)	31.00 (33.80)	15.00 (22.77)	13.00 (21.12)	1.33 (6.53)	2.00 (7.94)	13.01 (21.12)	13.22 (21.28)	5.15 (13.08)	4.69 (12.42)	0.39 (3.55)	0.44 (3.76)	1175	1200
Module 6	34.00 (35.65)	34.67 (36.05)	21.67 (27.73)	19.67 (26.31)	4.33 (11.99)	4.33 (11.99)	15.81 (23.41)	15.89 (23.47)	7.26 (15.63)	6.04 (14.22)	1.23 (6.37)	1.19 (6.26)	987	1000
Module 7	42.00 (40.38)	38.33 (38.21)	27.67 (31.72)	25.67 (30.43)	7.67 (16.02)	7.00 (15.09)	20.04 (26.56)	18.49 (25.44)	10.29 (18.69)	8.11 (16.42)	2.16 (8.42)	1.93 (7.95)	808	828
Module 8	44.33 (41.72)	45.66 (42.50)	35.33 (36.45)	31.67 (34.23)	9.33 (17.78)	7.33 (15.59)	20.20 (26.68)	27.60 (31.67)	12.89 (21.01)	10.41 (18.70)	2.48 (9.06)	2.49 (9.08)	684	715
SEm ±	0.66	0.87	0.43	0.45	0.56	1.12	0.69	1.14	0.41	0.84	0.26	0.26	4.09	6.41
CD at 5%	2.01	2.67	1.31	1.37	1.74	3.42	2.13	3.48	1.27	2.57	0.81	0.81	12.55	19.63

* Data presented in parentheses are angular transformed values

(Module 1: Acephate 75 SP @ 750g a.i./ha > Acephate 75 SP @ 750g a.i./ha > Acephate 75 SP @ 750g a.i./ha; Module 2: Acetamiprid 20 SP @ 20g a.i./ha > Acetamiprid 20 SP @ 20g a.i./ha > Acetamiprid 20 SP @ 20g a.i./ha; Module 3: Chlorantraniliprole 18.5 SC @ 30g a.i./ha > Acephate 75 SP @ 750g a.i./ha > Acephate 75 SP @ 750g a.i./ha; Module 4: Chlorantraniliprole 18.5 SC @ 30g a.i./ha > Acetamiprid 20 SP @ 20g a.i./ha > Acetamiprid 20 SP @ 20g a.i./ha; Module 5: Chlorantraniliprole 18.5 SC @ 30g a.i./ha > Indoxacarb 15.8 EC @ 73g a.i./ha > Acetamiprid 20 SP @ 20g a.i./ha; Module 6: Chlorantraniliprole 18.5 SC @ 30g a.i./ha > Flubendiamide 480 SC @ 73g a.i./ha > Dimethoate 30 EC @ 600g a.i./ha; Module 7: Dimethoate 30 EC @ 600g a.i./ha > Dimethoate 30 EC @ 600g a.i./ha > Dimethoate 30 EC @ 600g a.i./ha; Module 8: Untreated control.)

4. Conclusion

The present study concluded that Chlorantraniliprole 18.5 SC @ 30g a.i/ha - Indoxacarb 15.8 EC @ 73g a.i./ha - Acetamiprid 20 SP @ 20g a.i/ha and Chlorantraniliprole 18.5 SC @ 30g a.i/ha - Acephate 75 SP @ 750g a.i/ha - Acephate 75 SP @ 750g a.i/ha sequential application treatments provided better control of *M. obtusa, C. gibbosa* and *H. armigera* on pigeonpea. Higher grain yield was also obtained from these treatment plots as compared to other insecticidal treatments and untreated control. Hence sequential application of these chemicals may be considered for recommendation in alternate sprays for managing the tur pod fly, tur pod bug and gram pod borer on long duration pigeonpea.

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