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Effect of selected bio-pesticides on natural enemies in pigeonpea (*Cajanus cajan* L.) crop

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Abstract
The field experiment conducted on Effect of selected bio-pesticides on natural enemies in pigeonpea (*Cajanus cajan* L.) crop was carried out in the experimental field of department of Entomology at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Hyderabad, during 2016-2017 and 2017-2018. Repeated use of single insecticide for pod borers in pigeonpea may create some serious problem of development of resistance and residue in grain. Use of bio-pesticides is best alternate option of toxic insecticides. The our study shows that the use of biopesticides was reduce the cost of pesticides application and result excellent control major of pod borer in pigeonpea and safe guard for natural enemies. The result revealed that all the selected bio-pesticides treatments were found safer to natural enemies which helped to enhancing the activity of natural enemies' population in pigeonpea crop.

Keywords: pigeonpea, natural enemies, biopesticides

1. Introduction
Pigeonpea, (*Cajanus cajan* L.) is an important grain legume and occupies 2nd largest area among the various pulse crops grown in India. It is a staple diet and consumed as green peas as well as dry seeds (Tabo *et. al.,* 1995) [1]. Unlike other grain legumes, pigeonpea production is concentrated in developing countries, particularly in a few South and Southeast Asia and Eastern and Southern African countries. It is the preferred pulse crop in dryland areas where it is intercropped or grown in mixed cropping systems with cereals or other short duration annuals (Joshi *et al.,* 2001) [2]. More than 250 insect pests are known to attack on pigeonpea (Sharma *et al.,* 2008) [3]. The *Helicoverpa armigera* (Hubner) was recorded as major pest on this crop by causing more than 51 percent damage to the crop, whereas, nine insects viz., *Megalurothrips usitatus* (Bangall), *Empoasca kerri* (Pruthi), *Clavigralla gibbosa* (Spinola), *Riptortus pedestris* (Fb)., *Exelastis atomosa* (May.), *Melanagromyza obtuse* (Mlloch), *Cydia ptychora* (Meyr.), *Maruca testulalis* (Geyer) and *Etiella zinckenella* (Treit) were recorded as moderate pests by inflicting damage between 31 to 50 percent, as many as ten insect pests were recorded as minor pests on this crop, while ten were recorded as low importance (Balikai and Yelshetty, 2008) [4]. Repeated use of single insecticide for pod borers in pigeonpea may create some serious problem of development of resistance and residue in grain. Use of bio-pesticides is better option of toxic insecticides. But very little information regarding effectiveness of bio-pesticides either alone or in combination with modern insecticides are available.
However, indiscriminate use of chemicals led to the problems like pest outbreak, development of resistance by pests to insecticides, elimination of natural enemies and risk to human and animal health besides environmental pollution. So, now it is high time to think of those strategies which are eco-friendly and environmentally safe as well as manage the pests efficiently. Ravikumar *et al.,* (1999) [5] and Rosaiah (2001) [6] documented that botanicals were safe to natural enemies in different crop ecosystems. Keeping in view, the present study was undertaken to evaluate the bio efficacy of certain biopesticides against the pod borers in pigeonpea ecosystem. This typical concealed feeding protects the larvae from natural enemies, human interventions or other adverse factors including insecticides (Sharma, 1998) [7].

2. Materials and Methods
The field trial was carried out in the experimental field of department of Entomology at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Hyderabad,

during 2016-2017 and 2017-2018. The trial was laid out in randomized block design with three replications. Pigeon pea variety ICPL-161 was sown at 120 cm spacing (row to row) having plot size of 20x20m. The trial comprised eight treatments namely, *Streptomyces* sp ($5.85x10^7$colonies/ml), HaNPV 500LE/ha, *Metarhizium anisopliae* ($39.2x10^4$ spores/ml), Neem fruit powder (15-20kg/ha), Consortia (*Streptomyces* sp. (SAI-25) + HaNPV+ *Metarhizium anisopliae* + Neem fruit powder) @ ($5.85x10^7$colonies/ml + 500LE/ha+$39.2x10^4$ spores/ml+15-20kg/ha), Farmers practice (mostly chemical) Spinosad 45 % SC and untreated control. Three sprays per treatment were given at 50% flowering stage and pod formation stage. Observations of natural enemies were recorded at day before spray and 3, 7 and 10 days after spray in all treatments. Observations of natural enemies viz, Ladybird beetle (*Cheilomenes sexmaculata*), spider (*Araneus* sp.), Dragonfly (*Crocothemis servilia*) and preying mantid (*Mantis religiosa*) recorded on seven tagged plants per plot (Fig. 1)

Statistical Analysis

The data was analysed using computerised statistical software by using Gen-Stat 14 edition software, SPSS 15.0 Windows@ and Microsoft Excel.

3. Results and discussion

3.1 Effect of biopesticides on ladybird beetle, *C. sexmaculata* in pigeonpea during 2016 and 2017

The pooled mean population of both the year showed more or less similar population among the treatments. In 1st, 2nd and 3rd spray including different days of observation recorded revealed that there was no difference among the treatment across the spraying schedule periods. However, treatment with neem fruit powder (0.31 beetle/ 7 plants) compared to rest of treatments (Table 1). This showed that no treatment showed significant effect on the natural enemies population. The present finding agree with Bhede *et al.,* (2014) [8] who reported that the population of natural enemies of insects like coccinellids (0.21 in IPM and 0.09/plant in non-IPM), chrysopids (0.03 in IPM and 0.01/plant. Singh and Singh (1998) [9] have found that neem products viz., nimbecidine 0.05%, neemazal T/S, neemgold and achook proved, safer to coccinellids. Gosalwad and Tikotkar (2016) [10] conclude that the field study conducted for evaluate the effect of insecticides on the predators of sucking pests, lady bird beetle and green lace wings. Results revealed that the insecticides Btk @ 500 g/ha and HaNPV @ 500 LE/ha were safe, which were followed by NSKE 5 %, azadirachtin 15 EC @ 150 g a.i./ha and spinosad 45 SC @ 75 g a.i/ha. Varghese (2003) [11] has found that, various organics and botanicals as safe to *coccinellid* beetles which were found comparable to untreated plots. Gaikwad *et al.* (2014) [12] studied the effect of different insecticides on lady bird beetles and revealed that thiamethoxam 0.005 percent was found to be safer insecticide to lady bird beetle population followed by profenofos 0.05 percent

3.2 Effect of biopesticides on spider *Araneus* sp. in pigeonpea during 2016 and 2017

The pooled data during the year 2016 and 2017 on *Araneus* sp. are presented in the (Table 2) on 1st, 2nd and 3rd sprays at different days revealed that there was no difference among the all treatments. However, treatment of consortium (0.29 spider/7 plants) was found less lethal effect and recorded more number of spider population compared to rest of treatments. Mittal and Ujagir, (2005) [13] have tested the toxicity of Spinosad (Tracer; 45, 56, 73 and 90 g), on natural enemies associated with insect pests of pigeonpea and the insecticides did not affect the natural population of spiders during the crop growth. Borah and Dutta (2003) [14] have reported that, predatory spiders of *H. armigera* in pigeonpea ecosystem was *Oxyopes ratnae, Araneus* sp. *Neoscona* sp. and *Plexippus paykullii* appeared from flowering until maturity and at senescence. Sahoo and Senapati (2000) [15] have revealed that the occurrence of spiders was recorded in the pigeonpea. Giribabu *et al.* (2002) [16] have reported that the neem at both the concentration and abamectin at 15 g a.i./ha were found to be relatively safe insecticides. Pawar *et al.* (1986) [17] have reported twenty one insects and five spider species as predators of *H. armigera*.

3.3 Effect of biopesticides on dragonfly *C. servilia* in pigeonpea during 2016 and 2017

The pooled data during the both the year 2016 and 2017 on *C. servilia* population on 1st, 2nd and 3rd sprays at different days of observation revealed that there was no difference with each other among the all treatment across the spraying schedule periods. However, all the treatment found less lethal effect and recorded more number of dragonfly population compared to remaining treatments (Table 3). Ravikumar *et al.*, (1999) [5, 18] and Rosaiah (2001) [6, 19] documented that botanicals were safe to natural enemies in different crop ecosystems.

3.4 Effect of biopesticides on praying mantid, *M. religiosa* in pigeonpea during 2016 and 2017

The pooled mean of both the year 2016 and 2017 on *M. religiosa* population was recorded in field condition, on 1st, 2nd and 3rd sprays at different days of observation showed that there was no difference with each other among the all treatment across the spraying schedule periods (Table 4). Sahoo and Senapati (2000) [15, 20] have reported that the occurrence of both nymphs and adults praying mantis was recorded in the pigeonpea, supporting the present findings.

Conclusion

The result revealed that all the selected bio-pesticides treatments were found safer to natural enemies which helped to enhancing the activity of natural enemies' population in pigeonpea crop.

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Table 1: Pooled efficacy of various biopesticides on ladybird beetle *Cheilomenes sexmaculata* (Fab.) population in pigeonpea during 2016 and 2017.

		Pooled Mean number of ladybird beetle /7 plants									
			First spray			Second spray			Third spray		
Sr. No	**Treatments**	**DBFS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**
1	*Streptomyces* sp	0.15 (0.80)	0.22 (0.85)^{b}	0.17 (0.82)^{ab}	0.12 (0.79)	0.07 (0.76)	0.07 (0.75)	0.12 (0.79)	0.07 (0.76)	0.15 (0.80)	0.10 (0.77)
2	HaNPV	0.15 (0.80)	0.15 (0.80)^{ab}	0.17 (0.82)^{ab}	0.15 (0.80)	0.03 (0.73)	0.03 (0.73)	0.05 (0.74)	0.10 (0.77)	0.12 (0.79)	0.03 (0.73)
3	*Metarhizium anisopliae*	0.03 (0.73)	0.17 (0.82)^{ab}	0.19 (0.83)^{ab}	0.15 (0.80)	0.10 (0.77)	0.10 (0.77)	0.07 (0.75)	0.12 (0.79)	0.10 (0.77)	0.07 (0.76)
4	Neem fruit powder	0.12 (0.79)	0.10 (0.77)^{a}	0.31 (0.90)^{b}	0.15 (0.80)	0.10 (0.77)	0.14 (0.80)	0.10 (0.77)	0.10 (0.77)	0.07 (0.76)	0.05 (0.74)
5	Consortium (Sr.no 1to 4)	0.12 (0.79)	0.17 (0.82)^{ab}	0.12 (0.79)^{a}	0.10 (0.77)	0.12 (0.79)	0.10 (0.77)	0.10 (0.77)	0.12 (0.79)	0.10 (0.77)	0.12 (0.79)
6	Spinosad	0.05 (0.74)	0.10 (0.77)^{a}	0.12 (0.79)^{a}	0.05 (0.74)	0.03 (0.73)	0.05 (0.74)	0.05 (0.74)	0.05 (0.74)	0.07 (0.76)	0.00 (0.71)
7	Control (water spray)	0.07 (0.75)	0.10 (0.77)^{a}	0.12 (0.79)^{a}	0.12 (0.79)	0.12 (0.79)	0.14 (0.80)	0.15 (0.80)	0.07 (0.76)	0.05 (0.74)	0.07 (0.76)
	SE±m	0.020	0.016	0.026	0.035	0.029	0.023	0.023	0.024	0.021	0.018
	CD at 5%	NS	0.05	0.08	NS	NS	NS	NS	NS	NS	NS

Figures in parentheses are square root transformed values, NS- Non significant
The values denoted by a common letter are showing significant difference from each other as per DMRT.
DBFS= day before first spray, DAS= days after spray

Table 2: Pooled efficacy of various biopesticides on spider *Araneus* sp. population in pigeonpea during 2016 and 2017.

		Pooled mean number of spider/7 plants									
			First spray			Second spray			Third spray		
Sr. No	**Treatments**	**DBFS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**
1	*Streptomyces* sp	0.12 (0.79)	0.17 (0.81)	0.19 (0.83)	0.19 (0.83)	0.10 (0.77)^{ab}	0.12 (0.79)	0.14 (0.80)	0.12 (0.79)	0.19 (0.83)^{ab}	0.19 (0.83)
2	HaNPV	0.15 (0.80)	0.14 (0.80)	0.17 (0.81)	0.14 (0.80)	0.27 (0.87)^{a}	0.10 (0.77)	0.07 (0.76)	0.12 (0.79)	0.10 (0.77)^{a}	0.17 (0.81)
3	*Metarhizium anisopliae*	0.24 (0.88)	0.19 (0.83)	0.27 (0.87)	0.12 (0.79)	0.05 (0.74)^{a}	0.12 (0.79)	0.12 (0.79)	0.12 (0.79)	0.05 (0.74)^{a}	0.19 (0.83)
4	Neem fruit powder	0.15 (0.80)	0.14 (0.80)	0.15 (0.80)	0.12 (0.79)	0.05 (0.74)^{b}	0.10 (0.77)	0.14 (0.80)	0.12 (0.79)	0.14 (0.80)^{ab}	0.08 (0.76)
5	Consortium (Sr.no 1to 4)	0.12 (0.79)	0.19 (0.83)	0.29 (0.88)	0.14 (0.80)	0.12 (0.79)^{ab}	0.10 (0.77)	0.10 (0.77)	0.14 (0.80)	0.10 (0.77)^{a}	0.19 (0.83)
6	Spinosad	0.15 (0.80)	0.19 (0.83)	0.12 (0.79)	0.07 (0.76)	0.03 (0.73)^{a}	0.08 (0.76)	0.05 (0.74)	0.00 (0.71)	0.00 (0.71)^{a}	0.03 (0.73)
7	Control (water spray)	0.14 (0.80)	0.14 (0.80)	0.10 (0.77)	0.19 (0.83)	0.14 (0.80)^{ab}	0.19 (0.83)	0.17 (0.81)	0.10 (0.77)	0.10 (0.77)^{a}	0.10 (0.77)
	SE±m	0.02	0.03	0.04	0.03	0.02	0.02	0.02	0.03	0.02	0.03
	CD at 5%	NS	NS	NS	NS	0.08	NS	NS	NS	0.07	NS

Figures in parentheses are square root transformed values, NS- Non significant
The values denoted by a common letter are showing significant difference from each other as per DMRT.
DBFS= day before first spray, DAS= days after spray

Table 3: Pooled efficacy of various biopesticides on dragonfly *Crocothemis servilia* (Dru.) population in pigeonpea during 2016 and 2017**.**

		Pooled mean number of dragonfly /7 plants									
			First spray			Second spray			Third spray		
Sr. No	**Treatments**	**DBFS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**
1	*Streptomyces* sp	0.05 (0.74)	0.14 (0.80)	0.05 (0.74)	0.07 (0.76)	0.10 (0.77)	0.00 (0.71)^{a}	0.05 (0.74)	0.10 (0.77)	0.08 (0.76)	0.10 (0.77)
2	HaNPV	0.03 (0.73)	0.10 (0.77)	0.05 (0.74)	0.12 (0.79)	0.03 (0.73)	0.05 (0.74)^{a}	0.10 (0.77)	0.05 (0.74)	0.00 (0.71)	0.00 (0.71)
3	*Metarhizium anisopliae*	0.10 (0.77)	0.07 (0.76)	0.05 (0.74)	0.10 (0.77)	0.12 (0.79)	0.14 (0.80)^{b}	0.08 (0.76)	0.10 (0.77)	0.00 (0.71)	0.03 (0.73)
4	Neem fruit powder	0.03 (0.73)	0.10 (0.77)	0.03 (0.73)	0.10 (0.77)	0.14 (0.80)	0.00 (0.71)^{a}	0.12 (0.79)	0.03 (0.73)	0.05 (0.74)	0.05 (0.74)
5	Consortium (Sr.no 1to 4)	0.05 (0.74)	0.05 (0.74)	0.03 (0.73)	0.03 (0.73)	0.12 (0.79)	0.14 (0.80)^{b}	0.07 (0.76)	0.10 (0.77)	0.00 (0.71)	0.08 (0.76)
6	Spinosad	0.10 (0.77)	0.00 (0.71)	0.05 (0.74)	0.07 (0.76)	0.10 (0.77)	0.05 (0.74)^{a}	0.05 (0.74)	0.00 (0.71)	0.05 (0.74)	0.05 (0.74)
7	Control (water spray)	0.10 (0.77)	0.14 (0.80)	0.10 (0.77)	0.00 (0.71)	0.14 (0.80)	0.03 (0.73)^{a}	0.07 (0.76)	0.05 (0.74)	0.10 (0.77)	0.07 (0.76)

	SE±m	0.032	0.030	0.025	0.022	0.035	0.015	0.026	0.023	0.026	0.022
	CD at 5%	NS	NS	NS	NS	NS	0.05	NS	NS	NS	NS

Figures in parentheses are square root transformed values, NS- Non significant
The values denoted by a common letter are showing significant difference from each other as per DMRT.

Table 4. Pooled efficacy of various biopesticides on praying mantid, *Mantis religiosa* (Lin.) population in pigeonpea during 2016 and 2017.

		Pooled mean number of mantis /7 plants									
			First spray			Second spray			Third spray		
Sr. No	**Treatments**	**DBFS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**	**3DAS**	**7DAS**	**10DAS**
1	*Streptomyces* sp	0.02 (0.72)	0.07 (0.75)	0.02 (0.72)	0.02 (0.72	0.05 (0.74)	0.02 (0.72)	0.07 (0.75)	0.05 (0.74)	0.05 (0.74)	0.02 (0.72)
2	HaNPV	0.02 (0.72)	0.02 (0.72)	0.02 (0.72)	0.02 (0.72)	0.00 (0.71)	0.02 (0.72)	0.02 (0.72)	0.00 (0.71)	0.02 (0.72)	0.02 (0.72)
3	*Metarhizium anisopliae*	0.05 (0.74)	0.05 (0.74)	0.02 (0.72)	0.05 (0.74)	0.02 (0.72)	0.00 (0.71)	0.00 (0.71)	0.02 (0.72)	0.05 (0.74)	0.00 (0.71)
4	Neem fruit powder	0.05 (0.74)	0.05 (0.74)	0.07 (0.75)	0.05 (0.74)	0.10 (0.77)	0.05 (0.74)	0.05 (0.74)	0.00 (0.71)	0.05 (0.74)	0.00 (0.71)
5	Consortium (Sr.no 1to 4)	0.02 (0.72)	0.02 (0.72)	0.05 (0.74)	0.02 (0.72)	0.07 (0.75)	0.02 (0.72)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.02 (0.72)
6	Spinosad	0.00 (0.71)	0.00 (0.71)	0.02 (0.72)	0.05 (0.74)	0.00 (0.71)	0.02 (0.72)	0.00 (0.71)	0.00 (0.71)	0.05 (0.74)	0.02 (0.72)
7	Control (water spray)	0.02 (0.72)	0.00 (0.71)	0.02 (0.72)	0.07 (0.75)	0.00 (0.71)	0.07 (0.75)	0.02 (0.72)	0.00 (0.71)	0.00 (0.71)	0.05 (0.74)
	SE±m	0.019	0.017	0.021	0.024	0.028	0.019	0.014	0.012	0.023	0.017
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figures in parentheses are square root transformed values, NS- Non significant
DBFS= day before first spray, DAS= days after spray

Lady bird beetle Cheilomenes sexmaculata (Fab)

Spider Araneus sp.

Dragonfly Crocothemis servilia

Preying mantid Mantis religiosa

Fig 1: Natural enemies in pigeonpea crop

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