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Field evaluation of spinetoram 12 SC mixtures against blue butterfly, *Lambides boeticus* on pigeonpea

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Abstract
Pigeonpea pods are infested by several pod borers. *Lambides boeticus* is the predominant pod borer species in Tamil Nadu in pigeonpea and responsible for considerable yield loss. Effect of a new biological insecticide molecule, spinetoram 12 SC alone and in combination with quinalphos 25 EC 350 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) was studied on *L. boeticus* at field conditions during 2012-2013 and 2013-2014 kharif seasons. The results of the field experiments showed that Spinetoram 12 SC 45 g alone and in combination with quinalphos 25 EC 350 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) were significantly effective in minimizing the *L. boeticus* when sprayed thrice at 15 days interval and increases the grain yield. All the tested doses of spinetoram 12 SC 45 g alone and in combination with quinalphos 25 EC 350 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) were showed nil phytotoxic symptoms on pigeonpea plants.

Keywords: spinetoram, pigeonpea, field efficacy, *Lambides boeticus*, phytotoxicity

1. Introduction
Pigeonpea (*Cajanus cajan* L.) is an important pulse or a legume crop in semi-arid tropical and subtropical areas of the world. India is the largest producer and consumer of pigeonpea in the world, india is producing 183.4 lakh tonnes of pulses from an area of 96.26 lakh hectares. Pigeonpea is grown in 85.22 lakh hectares with an annual production of 88.33 lakh tonnes with an average productivity of 1036.00 kg/ha. In Tamil Nadu, it is cultivated in an area of 0.071 lakh hectares with 0.045 lakh tonnes of production and with a productivity of 645 kg/ha during 2012-13 (*Anon.*, 2013) [1]. Major constraint on the production of pigeonpea is the damage caused by insect pests with avoidable losses extending up to 78 per cent. The borers damaged 57.07, 54.09 and 40.08 per cent pods and 34.79, 30.90 and 20.20 per cent seeds were the yield losses of 28.07, 21.01 and 15.02 per cent in short, medium and late maturing cultivars, respectively.(Sahoo and Senapati, 2001) [2].
In recent times, new insecticide molecules offer advantages over earlier chemistry in terms of greater levels of safety, better performance and reduced environmental impact. Reports of high level of resistance to the conventional insecticides in pod borer complex have resulted in renewed interest on using using a group of insecticides (Murray *et al.*, 2009) [3]. One such new biological insecticide molecule is spinetoram, which has shown outstanding efficacy against codling moth (*Cydia pomonella* L.*)*, oriental fruit moth *(Grapholita molesta* Busck*)*, army worms (*Spodoptera spp*), cabbage looper (*Trichoplusia ni* Hubner), thrips such as western flower thrips (*Frankliniella occidentalis* Pergande) and onion thrips (*Thrips tabaci* Lindeman*)*, leaf miners (*Liriomyza spp*), chilli thrips (*Scirtothrips dorsalis* Hood), fruit borer (*Helicoverpa armigera*) and many other pests (Dharne & Bagde, 2011)[4]. Therefore, this study was undertaken to investigate the field evaluation of spinetoram 12 SC alone and in combination with quinalphos 25 EC 350 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) against *L. boeticus* and to evaluate their effectiveness for controlling the pest during 2012- 2013 and 2013- 2014

2. Materials and methods
Field experiments were conducted at farmers' field in Dindigul district, Tamil Nadu, India. The experiments were laid out during the year August 2012-April 2013 and August 2013-April 2014 in a randomized block design having plot size of 5 x 5m at Jadhi Goundanpatti and Attur block respectively. Pigeonpea (CO1) was raised as per recommended package of practices

except insect – pest management practices. Effect of eight insecticidal treatments such as spinetoram 12 SC (45 g a.i./ha) + quinalphos 25 EC (350 g a.i./ha); spinetoram 12 SC (22.5 g a.i./ha) + quinalphos 25 EC (175 g a.i./ha); spinetoram 12 SC (45 g a.i./ha) + carbendazim 50 WP (125 g a.i./ha); spinetoram 12 SC (45 g a.i./ha) + carbendazim 50 WP (62.5 g a.i./ha); spinetoram 12 SC (45 g a.i./ha) + urea (2%); spinetoram 12 SC (45 g a.i./ha) alone; spinetoram 12 SC (22.5 g a.i./ha) alone; and untreated check were imposed and each treatment was replicated thrice. Three sprays of each treatment were applied with the help of hand operated knapsack sprayer at fortnightly intervals starting from 50 per cent flower initiation. Observations of the larval population on a basis per plot from ten randomly selected plants were recorded in one day before first spray and on 1, 3, 7 and 10 days after each spray. Grain yield was taken after harvest and represented as yield/ha. Data obtained were subjected to analysis of variance (ANOVA) after the (arc sine for per cent data and square root of population data) of data as per the procedure suggested by Gomez and Gomez (1984) [5] and original values are given in Tables.

3. Results and Discussion

3.1 Effect of spinetoram 12 SC on *L. boeticus*

L. boeticus larval population varied from 3.6 to 4.8 per plant during the season before imposing treatments (Table 1) and crossed the economic threshold level (ETL). Mean larval population ranged from 1.9 to 10.4 per plant due to various treatments. Spinetoram 12 SC 45 g + quinalphos 25 EC 350 g, spinetoram 12 SC 45 g + urea (2%), spinetoram 12 SC 45 g alone and spinetoram 12 SC 45 g + carbendazim 50 WP 125 g were significantly superior in minimizing the population to 1.9, 2.1, 2.2 and 2.3 per plant along with 81.7, 79.8, 78.8 and 77.8 per cent reduction respectively when compared to 10.4 per plant of untreated plot. Spinetoram 12 SC 22.5 g + quinalphos 25 EC 175 g, spinetoram 12 SC 22.5 g + carbendazim 50 WP 62.5 g and spinetoram 12 SC 22.5 g alone were next best treatments, which achieved a population of 4.1, 5.0 and 5.1 per plant along with 60.5, 51.9 and 50.9 per cent reduction respectively.

Data pertaining to larval population of *L. boeticus* during during the season for 1, 3, 7 and 10 DAT after three sprays are presented in Table 1. Mean larval population of 1, 3, 7 and 10 DAT ranged from 2.0 to 11.6 larvae per plant due to treatments. Spinetoram 12 SC 45 g + quinalphos 25 EC 350 g, spinetoram 12 SC 45 g alone, spinetoram 12 SC 45 g + carbendazim 50 WP 125 g and spinetoram 12 SC 45 g + urea (2%) were significantly superior in minimizing the population in 2.0, 2.1, 2.3 and 2.4 per plant along with 82.7, 81.8, 80.1 and 79.3 per cent reduction respectively when compared to 11.6 per plant of untreated plot. Spinetoram 12 SC 22.5 g + quinalphos 25 EC 175 g, spinetoram 12 SC 22.5 g + carbendazim 50 WP 62.5 g, spinetoram 12 SC 22.5 g alone and were next best treatments, which achieved a population of 5.2, 5.5 and 5.6 per plant along with 55.1, 52.5 and 51.7 per cent reduction respectively. These results are in agreement with Mittal and Ujair (2005) [6] also opined that lower pod damage was due to spinosad 90, 73, 56 and 45g treatments as against control over two years. Similarly, greater grain yields were also recorded due to spinosad 90g (1741 kg/ha), spinosad 73g (1463 kg/ha), spinosad 45g (1218 kg/ha) and spinosad 56g (1213 kg/ha), as compared to control (768 kg/ha). Naik *et al.* (2008) [7] who found that spinosad 0.015 per cent individually and combination with novaluron was most effective in reducing shoot infestation.

3.2 Effect of spinetoram 12 SC on grain yield

Pigeonpea grain yield ranged from 23.8 to 10.7 q/ha due to treatments. There was significant difference due to spinetoram 12 SC alone and combination with other agrochemicals. Highest grain yield was recorded due to spinetoram 12 SC 45 g + urea (2%) (23.8 q/ha), spinetoram 12 SC 45 g + carbendazim 125 g (23.4 q/ha), and spinetoram 12 SC 45 g alone (22.9 q/ha) teratments. These treatments were followed by spinetoram 12 SC 45 g + quinalphos 25 EC 350 g (22.8 q/ha) which also contributed higher yield. Spinetoram 12 SC 22.5 g + carbendazim 50 WP 62.5 g was the next best treatment (13.8 q/ha). However, spinetoram 12 SC 22.5 g alone and spinetoram 12 SC 22.5 g + quinalphos 25 EC 175 g registered lower grain yield of 13.4 and 13.4 q/ha compared to untreated plot which recorded 10.7 q/ha grain yield.

Pigeonpea grain yield ranged from 9.7 to 21.7 q/ha due to treatments. There was significant difference due to spinetoram 12 SC applications. The highest grain yield was recorded due to spinetoram 12 SC 45 g + urea (2%) (21.7 q/ha) and spinetoram 12 SC 45 g + quinalphos 25 EC 350 g (21.3 q/ha). Spinetoram 12 SC 45 g + carbendazim 125 g and spinetoram 12 SC 45 g alone were the next best treatments, which contributed moderate yield of 21.0 and 20.4 q/ha respectively. However, spinetoram 12 SC 22.5 g alone (12.1 q/ha), spinetoram 12 SC 22.5 g + quinalphos 25 EC 175 g (12.1 q/ha), and spinetoram 12 SC 22.5 g + carbendazim 62.5 g (11.9/ha) registered lower grain yield of 38.3q/ha compared to untreated plot which recorded 27.8q/ha grain yield (Table 1). Similar observation by Sreekanth and Seshamahalakshmi (2012) [8], who reported that highest grain yield was recorded in spinosad 45 SC 73 g a.i/ha treated plots (831.0 kg/ha), followed by Bt.1 @ 1.5 kg/ha (743.1 kg/ha) and *B. bassiana* SC formulation @ 300 mg/l (694.4 kg/ha) with 104.0, 82.4 and 70.7 per cent yield increase over control respectively as against the minimum yield of 407.4 kg/ha in the untreated check. There were no phytotoxicity symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty recorded on 7th DAT after each spray due to any doses of spinetoram 12 SC on pigeonpea plants.

Table 1: Effect of spinetoram 12 SC against *L. boeticus* and grain yield on pigeonpea (2012-13 and 2013-14) kharif seasons)

Treatments and doses (g a.i. /ha)	Aug 2012- Mar 2013				Aug 2013- Mar 2014			
	Mean larval population			Grain yield (q/ha)	Mean larval population			Grain yield (q/ha)
	Pre count	Over all Mean	Per cent reduction over control		Pre count	Over all Mean	Per cent reduction over control	
Spinetoram 12 SC 45 g a.i./ha + Quinalphos 25 EC 350 g a.i./ha	4.9	1.9^{a}	81.7	22.8^{a}	3.8	2.0^{a}	82.7	21.3^{ab}
Spinetoram 12 SC 22.5 g a.i./ha + Quinalphos 25 EC 175 g a.i./ha	4.0	4.1^{c}	60.5	13.4^{b}	4.7	5.2^{c}	55.1	12.1^{b}
Spinetoram 12 SC 45 g a.i./ha + Carbendazim 50 WP 125 g a.i./ha	3.8	2.3^{b}	77.8	23.4^{a}	3.9	2.3^{ab}	80.1	21.0^{bc}

Spinetoram 12 SC 22.5 g a.i./ha + Carbendazim 50 WP 62.5 g a.i./ha	4.8	5.0^{d}	51.9	13.8^{b}	3.8	5.5^{cd}	52.5	11.9^{d}
Spinetoram SC 45 g a.i./ha + Urea 2%	3.6	2.1^{ab}	79.8	23.8^{a}	3.5	2.4^{b}	79.3	21.7^{a}
Spinetoram 12 SC 45 g a.i./ha	4.6	2.2^{ab}	78.8	22.9^{a}	4.6	2.1^{ab}	81.8	20.4^{c}
Spinetoram 12 SC 22.5 g a.i./ha	4.6	5.1^{d}	50.9	13.4^{c}	4.3	5.6^{d}	51.7	12.1^{d}
Untreated check	3.6	10.4^{e}		10.7c	3.8	11.6^{e}		9.7^{e}
CD (0.05%)	-	0.30			-	0.31		0.60
SED	-	0.14			-	0.14		0.28

Data are mean values of three replications
Figures were transformed by square root transformation and the original values are given
Means within columns lacking common lower case superscript are significantly different (P<0.

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