**In-Vivo and field evaluation of spinetoram 12 SC against *Lampides boeticus* on pigeonpea**

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**ABSTRACT**

The young larvae of *L. boeticus* damage flowers and pods. A new biological insecticide molecule, spinetoram 12 SC was evaluated for acute toxicity on greenhouse environment reared *L. boeticus* and persistence on pigeonpea pods at laboratory; and effect on *L. boeticus* on pigeonpea at field conditions during 2012-2013 and 2013-2014. Acute toxicity studies revealed that LC$_{50}$'s of spinetoram on third instar larvae after 24, 48 and 72 hours after treatment were 6.71, 2.23 and 1.28 ppm respectively. In persistence studies, spinetoram 12 SC 27 g a.i./ha was upto 11 DAT and 14 DAT for spinetoram 12 SC 36 and 45 g a.i./ha. More than 50 per cent mortality was observed in spinetoram 12 SC at 45 g a.i./ha upto 9 DAT, spinetoram 12 SC at 27 and 36 g a.i./ha, spinosad 45 SC 78 g a.i./ha and emamectin benzoate 5 SG at 11 g a.i./ha upto 7 DAT, monocrotophos 36 SL at 500 g a.i./ha upto 5 DAT, respectively. Results indicated that spinetoram 12 SC was significantly effective at 36 and 45 g a.i./ha when sprayed thrice at 15 days interval and minimized the incidence of *L. boeticus* on pigeonpea plants and increases the grain yield. All the spinetoram doses did not show any phytotoxic symptoms on pigeonpea plants.

**Key words:** Acute toxicity, Field efficacy, *Lampides boeticus*, Pigeonpea, Phytotoxicity.

**INTRODUCTION**

Major constraint in the production of pigeonpea was the damage caused by insect pests with avoidable losses extending up to 78 per cent. The pod borers together damaged 57.07, 54.09 and 40.08 per cent pods and 34.79, 30.90 and 20.20 per cent seeds incurring the yield losses of 28.07, 21.01 and 15.02 per cent in early, medium and late maturing cultivars, respectively in pigeonpea (Sahoo and Senapati, 2001). The pod borers were considered to be the most important group causing crop loss to the tune of 80 to 100 per cent (Katagihallimath and Siddappaji, 1962). Vishakantiah and Jagadeesh Babu (1980) estimated the infestation levels to range from 9 to 51 per cent under Bangalore conditions in pigeonpea. Karel (1985) also observed more larvae (52.3%) on flowers than on pods (37.8%) and leaves (9.9%). Shantibala and Singh (2004) reported EIL of pea pod borer (*L. boeticus*) in Manipur as 1.24 per cent pod infestation. This infestation was observed between the last week of January and first week of February (at Manipur). Larva of *Etiella zinckinella* bore into pods and feed on the seeds. Spotted pod borer is known to cause damage by web leaves, bud, flower and pods together and feed inside *L. boeticus* (L.) chew leaves, buds, flowers and pods. Larvae of *E. atomosa* feed on buds, flowers and pods (Patel et al., 2012).

The loss caused due to *Maruca* was estimated to be about 84 per cent (Dharmasena et al., 1992) accounting to US $ 30 million (Saxena et al., 2002).

Synthetic insecticides provide dramatic effect and hence chemical control methods are still in use among farmers. Earlier, conventional insecticides like endosulfan (Shivalingaswamy et al., 2008 and Rath and Mukherjee, 2009), malathion and hostathion (Sanjeev Kumar and Gill, 2010), chlorpyriphos (Kuttalam et al., 2008), azadirachtin 1%, phosalone and quinalphos (Anonymous., 2011), synthetic pyrethroids and endosulfan alternatively with NSKE 4% (Anonymous., 2009), and fenvalerate, methomyl, azinphosmethyl, carbaryl and pyrethrin/rotenone (Anonymous, 2012) were reported in management of pests on onion.

In recent times, new insecticide molecules offer advantages over earlier chemistry in terms of greater levels of safety, better performance and reduced environmental impact. One such new insecticide molecule is spinetoram, has shown outstanding efficacy against tomato caterpillar (*Spodoptera litura* Fabricius) (Muthukrishnan et al., 2013a), shoot and fruit borer (*Leucinodes orbonalis* Guenee) (Muthukrishnan et al., 2013b), codling moth (*Cydia pomonella* L.), oriental fruit moth (*Grapholita molesta* Busck), army worms (*Spodoptera spp*), cabbage looper...
Persistence toxicity = Average residual toxicity × Period for which the toxicity persisted (days)

The number of days for which the toxicity persisted was recorded as ‘P’. The average of the mortality percentage constituted the residual toxicity ‘T’. The product of ‘P’ x ‘T’ was calculated. Based on the ‘PT’ value the order of relative efficacy (ORE) was worked out. Here, greater the ‘PT’ value, better was the treatment. The procedures of Saini (1959) and elaborated further by Pradhan (1967) and Sarup et al. (1970) were adopted to calculate the persistent toxicity.

Field evaluation of spinetoram 12 SC against L. boeticus on pigeonpea: Two field experiments were conducted at farmer’s field at Jadhi Goundanpatti, Attur Block, Dindigul district, Tamil Nadu, India during September to March months of 2012-13 and 2013-14 in a randomized block design with a plot size of 5 x 5m. Pigeonpea (var. CO1) was raised as per recommended package of practices except insect pest management practices. Effect of seven insecticidal treatments comprising spinetoram 12 SC @ 45, 36 and 27 g a.i. ha\(^{-1}\) along with emamectin benzoate 5 SG @ 11 g a.i. ha\(^{-1}\), spinosad 45 SC @ 78 g a.i. ha\(^{-1}\) and monocrotophos 36 SL @ 500 g a.i. ha\(^{-1}\) was determined and each treatment was replicated thrice. Three sprays of each insecticide were applied with the help of knapsack hand sprayer up to the point of runoff at fortnightly intervals starting from 30 per cent flower initiation. Observations on the total number of pods and damaged pods from 10 randomly selected plants per plot were recorded at one day before and on 1, 3, 7 and 10 days after treatment (DAT) after each spray. Grain yield was also taken after harvest and represented as yield per ha. Data obtained were subjected to analysis of variance (ANOVA) after transformation (arc sine for per cent data and square root for population data) of data as per the procedure suggested by Gomez and Gomez (1984) and original values are given in Tables. The observations on phytotoxicity symptoms (leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty) were recorded on 7th day after each spray by using visual scoring (rating 1 to 10).

RESULTS AND DISCUSSION

Acute toxicity of spinetoram 12 SC against L. boeticus on pigeonpea: Toxicity test on a greenhouse environment reared strain of the third instar larva of the L. boeticus was...
carried out at different concentrations after 24, 48 and 72 hours after treatment. Data in (Table 1) indicates that per cent mortality of *L. boeticus* larvae have positive correlations with the spinetoram concentrations. LC$_{50}$ values of spinetoram 12 SC estimated by pod dip method to the third instar larvae were 6.71, 2.23 and 1.28 ppm and LC$_{50}$ values were 37.71, 9.71 and 8.04 ppm after 24, 48 and 72 h treatment. The probit regression line for spinetoram 12 SC were $Y = 3.37 + 1.97x$, $Y = 4.07x + 2.68$ and $Y = 4.61x + 2.56$ after 24, 48 and 72 h after treatment respectively. Regarding slope values of the regression line, spinetoram 12 SC had the least slope of 1.97 with 24 h after exposure, while slope values were 2.68 and 2.56 with 48 h and 72 h after exposure respectively, (Table-1)

The results are in rationale with the reports of Jarrod *et al.* (2011), LC$_{50}$ value of spinosad was 0.557 µg/ml against fall army worm, *S. frugiperda* using diet-incorporated bioassay and was less toxic than spinetoram 12 SC. Similar result was found by Gamal and Allah (2010) that spinetoram 12 SC showed better results than its analogue spinosad about ten times in topically and feeding bioassays in laboratory conditions. The present investigation clearly elicited that spinetoram 12 SC has high insecticidal activity and are far better than other insecticides. Kumar *et al.* (2008) who reported that spinosad was the most toxic against *Earias vittella* (Fab.) when compared to emamectin benzoate, abamectin and indoxacarb and the order of toxicity in terms of LD$_{50}$ (mg / larva) to *E. vittella* was spinosad (0.00188) > abamectin (0.00264) > emamectin benzoate (0.00266) > indoxacarb (0.09270), respectively. However Gupta *et al.* (2005) revealed that LC$_{50}$ of spinosad was 0.0004 per cent for five day old larvae of *E. vittella*. Differences in the observed values may be due to difference in the age of the larvae used and method of application. Kranthi *et al.* (2000) reported 0.058 and 9.85 mg per larvala as LD$_{50}$ and LD$_{90}$ for spinosad against *H. armigera* and suggested 10 mg per larvae as the diagnostic dose for resistance monitoring. LC$_{50}$ of spinosad for *H. armigera* was 2.944 mg per ml (Stanley, 2004) and less than equal to 5.0 ppm against *H. zeae* (Lopez *et al.*, 1997). Thus the toxic values of spinetoram had significant effect on insects.

**Persistence of spinetoram 12 SC against *L. boeticus* on pigeonpea:** The spinetoram 12 SC was applied at 45 g a.i./ha, hundred per cent mortality of third instar larvae of *L. boeticus* was observed upto 3 DAT (Table 3). Spinetoram 12 SC 45 g a.i./ha registered 98.8, 80.0 and 63.3 per cent mortality at 5, 7 and 9 DAT respectively. Persistence for spinetoram 12 SC 27 g a.i./ha was upto 11 DAT and 14 DAT for spinetoram 12 SC 36 and 45 g a.i./ha. More than 50 per cent mortality was observed in spinetoram 12 SC at 45 g a.i./ha upto 9 DAT respectively, spinetoram 12 SC at 27 and 36 g a.i./ha, spinosad 45 SC 78 g a.i./ha and emamectin benzoate 5 SG at 11 g a.i./ha upto 7 DAT, monocrotophos 36 SL at 500 g a.i./ha upto 5 DAT respectively. There was a reduction in the mortality of *L. boeticus* larvae as the time increased and there was no mortality after 21 DAT. The order of relative efficacies (ORE) of the insecticides based on the persistent toxicity index (PTI) values was spinetoram 12 SC 45 g a.i./ha > spinetoram 12 SC 36 g a.i./ha > spinosad 45 SC 78 g a.i./ha > emamectin benzoate 5 SG at 11 g a.i./ha > spinetoram 12 SC 27 g a.i./ha > monocrotophos 36 SL at 500 g a.i./ha. (Table-2).

Present findings were in conformity with Shinde *et al.* (2010) who found on the basis of PTI values, spinosad 0.005% (1026.2) was effective against 1st instar larvae of *E. vittella* and the highest PT value was obtained for spinosad 0.005% (764.9) against 3rd instar larvae of *E. vittella* on okra fruits. According to Kumar and Poehling (2007) persistence

### Table 1: Acute toxicity of spinetoram 12 SC at different concentrations against *L. boeticus* on pigeonpea

<table>
<thead>
<tr>
<th>Dose (ml/l)</th>
<th>Concentration (ppm)</th>
<th>Mean no. of dead larvae</th>
<th>Mortality (%)</th>
<th>Mean no. of dead larvae</th>
<th>Mortality (%)</th>
<th>Mean no. of dead larvae</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>1.2</td>
<td>3.00</td>
<td>10.00</td>
<td>9.33</td>
<td>31.10</td>
<td>16.66</td>
<td>55.55</td>
</tr>
<tr>
<td>0.02</td>
<td>2.4</td>
<td>7.00</td>
<td>23.33</td>
<td>14.66</td>
<td>48.86</td>
<td>20.00</td>
<td>66.66</td>
</tr>
<tr>
<td>0.03</td>
<td>3.6</td>
<td>9.66</td>
<td>32.2</td>
<td>21.33</td>
<td>71.10</td>
<td>24.00</td>
<td>80.00</td>
</tr>
<tr>
<td>0.04</td>
<td>4.8</td>
<td>11.33</td>
<td>37.76</td>
<td>23.00</td>
<td>76.66</td>
<td>25.00</td>
<td>83.33</td>
</tr>
<tr>
<td>0.05</td>
<td>6.0</td>
<td>13.66</td>
<td>45.53</td>
<td>26.66</td>
<td>88.86</td>
<td>28.66</td>
<td>95.53</td>
</tr>
<tr>
<td>0.06</td>
<td>7.2</td>
<td>17.33</td>
<td>57.77</td>
<td>28.33</td>
<td>94.43</td>
<td>30.00</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>LC$_{50}$ and Fiducial limit</strong></td>
<td><strong>6.71 (5.04 - 8.94)</strong></td>
<td>2.23 (1.72 - 2.89)</td>
<td>1.28 (0.81 - 2.04)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LC$_{50}$ and Fiducial limit</strong></td>
<td><strong>37.71 (14.21 - 100.08)</strong></td>
<td>9.71 (6.51 - 14.50)</td>
<td>8.04 (4.76 - 13.56)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>1.97</td>
<td>2.68</td>
<td>2.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Regression equation</strong></td>
<td><strong>Y=3.37X+1.97</strong></td>
<td><strong>Y=4.07X+2.68</strong></td>
<td><strong>Y=4.61X+2.56</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Persistent toxicity of spinetoram 12 SC to *L. boeticus* on pigeonpea

<table>
<thead>
<tr>
<th>Treatments and doses</th>
<th>Per cent larval mortality (days after treatment)</th>
<th>P</th>
<th>T</th>
<th>PTI</th>
<th>ORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Spinetoram12 SC 27 g a.i./ha</td>
<td></td>
<td>93.3</td>
<td>86.6</td>
<td>68.8</td>
<td>56.6</td>
</tr>
<tr>
<td>Spinetoram12 SC 36 g a.i./ha</td>
<td></td>
<td>98.8</td>
<td>91.1</td>
<td>83.3</td>
<td>63.3</td>
</tr>
<tr>
<td>Spinetoram12 SC 45 g a.i./ha</td>
<td></td>
<td>100</td>
<td>100</td>
<td>98.8</td>
<td>80.0</td>
</tr>
<tr>
<td>Emamectin benzoate 5 SG 11 g a.i./ha</td>
<td></td>
<td>95.5</td>
<td>88.8</td>
<td>81.1</td>
<td>58.8</td>
</tr>
<tr>
<td>Spinosad 45 SC 78 g a.i./ha</td>
<td></td>
<td>96.6</td>
<td>91.1</td>
<td>85.5</td>
<td>61.1</td>
</tr>
<tr>
<td>Monocrotophos 36 SL .500 g a.i./ha</td>
<td></td>
<td>81.1</td>
<td>73.3</td>
<td>68.8</td>
<td>46.6</td>
</tr>
</tbody>
</table>

P – Period of toxicity persistence (days)
T – Mean per cent mortality
PTI – Persistent toxicity index
ORE – Order of relative efficacy

of spinosad was comparably high in the laboratory (100% nymphal mortality at 6-9 days post application), but in the greenhouse a faster decline of activity was evident by increased egg deposition, egg hatch and reduced rates of immature mortality. Sharma *et al.* (2007) also reported that spinosad persisted in cabbage and cauliflower up to 7 and 10 days following spinosad application at lower and higher dosages. However, spinetoram 12 SC has translaminar activity, thereby providing a relatively prolonged residual action (Yee *et al.*, 2007). Razmi *et al.* (1991) evaluated the persistent toxicity of nine *viz.*, fenitrothion, methyl parathion, malathion, endosulfan, monocrotophos, quinalphos, phosphamidon, carbaryl and dimethoate against neonate larvae of *L. orbonalis*. Among these insecticides, phosphamidon proved extremely persistent based on PT index (PT = 12528.00) while malathion was the least persistent insecticide (PT = 5376.36).

**Field evaluation of spinetoram 12 SC against *L. boeticus* on pigeonpea:** *Lampides boeticus boeticus* larval population varied from 4.3 to 5.4 per plant during first season before imposing treatments (Table 3) and crossed the economic threshold level (ETL). Mean larval population ranged from 1.7 to 7.5 per plant due to various treatments. Spinetoram 12 SC 45 g a.i./ha and spinetoram 12 SC 36 g a.i./ha were

Table 3: Effect of spinetoram 12 SC against *L. boeticus* on pigeonpea (2011 and 2012 seasons)

<table>
<thead>
<tr>
<th>Treatments and doses (g a.i. /ha)</th>
<th>1 season (Aug 2012 – Mar 2013)</th>
<th>II season (Aug 2013 – Mar 2014)</th>
<th>Mean reduction over control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Precount</td>
<td>Over all</td>
<td>Per cent reduction</td>
</tr>
<tr>
<td>Spinetoram 12 SC 27 g a.i./ha</td>
<td>4.8</td>
<td>2.6(1.76)</td>
<td>65.3</td>
</tr>
<tr>
<td>Spinetoram 12 SC 36 g a.i./ha</td>
<td>4.7</td>
<td>2.0(1.58)</td>
<td>73.3</td>
</tr>
<tr>
<td>Spinetoram 12 SC 45 g a.i./ha</td>
<td>4.3</td>
<td>1.7(1.48)</td>
<td>77.3</td>
</tr>
<tr>
<td>Emamectin benzoate 5 SG 11 g a.i./ha</td>
<td>4.7</td>
<td>3.0(1.87)</td>
<td>60.0</td>
</tr>
<tr>
<td>Spinosad 45 SC 78 g a.i./ha</td>
<td>4.7</td>
<td>2.3(1.67)</td>
<td>69.3</td>
</tr>
<tr>
<td>Monocrotophos 36 SL .500 g a.i./ha</td>
<td>5.2</td>
<td>3.3(1.94)</td>
<td>56.0</td>
</tr>
<tr>
<td>Untreated check</td>
<td>5.4</td>
<td>7.5(2.82)</td>
<td>6.4</td>
</tr>
<tr>
<td>CD (0.05%)</td>
<td>-</td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>SED</td>
<td>-</td>
<td>0.08</td>
<td>-</td>
</tr>
<tr>
<td>CV</td>
<td></td>
<td>6.34</td>
<td></td>
</tr>
</tbody>
</table>

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 upper case superscript are significantly different (P<0.05)
Data pertaining to larval population of *L. boeticus* during second season for 1, 3, 7 and 10 DAT after three sprays are presented in Table 3. Larval population varied from 5.7 to 6.8 per plant during before imposing treatments. Mean larval population of *L. boeticus* ranged from 1.5 to 8.9 per plant due to various treatments. Spinetoram 12 SC 45 g a.i./ha and spinetoram 12 SC 36 g a.i./ha were significantly higher in minimizing the population to 1.5 and 1.8 per plant along with 83.1 and 79.7 per cent reduction, respectively when compared to 8.9 per plant of untreated plot. Spinosad 45 SC 78 g a.i./ha was on par with spinetoram 12 SC 27 g a.i./ha and registered larval population 2.1 and 2.2 per plant along with 76.4 and 75.2 per cent reduction over control. Emamectin benzoate 5 SG at 11 g a.i./ha and monocrotrophos 36 SL at 500 g a.i./ha were next effective treatments, which achieved population of 2.6 and 3.4 per plant along with 70.7 and 61.7 per cent reduction respectively.

Sunita et al. (2008) reported that spinosad was effective against third instar larvae of *M. vitrata*. Spinosad 45 SC @ 90 g a.i./ha was the most potent insecticide in reducing the larval population (0.29 larvae/plant), pod damage (5.62%), grain damage (22.85%) and producing highest grain yield of 1681 kg/ha. It was followed by flubendiamide 20 WDG @ 50 g a.i./ha and novaluron 10 EC @ 75 g a.i./ha (Tamboli and Lolage, 2008). Rao et al. (2007) reported that *M. vitrata* can be managed effectively with new chemicals, spinosad and indoxacarb (82 and 72% reduction in population) within two days after application. Since the reduction in larval population is faster with these chemicals as compared to other conventional chemicals and also registered lowest seed damage (3.9/plant) and highest grain yield (795 kg/ha). It would be worth keeping these new chemicals as one of the best options in IPM (Integrated Pest Management) module for effective management of this species.

Memon and Memon (2005) reported that insecticide Tracer remained the most effective against the pest activity and resulted in the maximum reduction percentage of larval population of pod borer and the pods damage percentage was also decreased as comparison to other insecticides in lentil crop. Tracer (spinosad) was the most effective insecticide in reducing the population of pod borer and pod damage, followed by Lorsban and Thiodan. Curacron was found to be the least effective insecticide. The maximum increase in seed yield per hectare was obtained with Tracer, whereas Thiodan resulted in minimum increase seed yield over control (Mittal and Ujagir, 2005). Bhoyar et al. (2004) reported that treatment of spinosad 2.5 SC (25 g a.i./ha) and endosulfan 35 EC (0.07%) were the most promising treatments in terms of almost mean per cent pod damage of 11.85 and 17.80, respectively by the pod borer complex of pigeonpea. Banajgole (2004) reported that spinosad 90 g a.i./ha was most effective against pigeon pea pod borers in reducing the pod infestation and grain damage. Ahmed et al. (2004) reported that Tracer (spinosad) 240SC @ 60 ml was the most effective treatment in restricting the pest infestation followed by Steward and Lanante. These findings were in agreement with Lakshmi et al. (2002) found out that the application of spinosad 0.005 per cent was most effective against *M. vitrata* recording highest mean per cent larval reduction (63.99%) over untreated control in urdbean.

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**REFERENCES**


Stanley, J. 2004. Studies on base line toxicity of Emamectin and Spinosad to *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fab.) and their bio-efficacy on brinjal fruit borers. M.Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore, India. 90p.


