Pakistan J. Zool., vol. 47(5), pp. 1413-1420, 2015.

Management of Brinjal Shoot and Fruit Borer, *Leucinodes orbonalis* Guenee, with Selected Insecticides

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Abstract.- Brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee is a serious insect pest of brinjal (*Solanum melongena* L.) in all brinjal growing countries. It is the most important pest in Asia, including Pakistan. Different insecticides were evaluated for the control of BSFB in a field study at Sahiwal, Pakistan during spring and fall sowing seasons. The study was carried out using Nirala variety of brinjal. Transplanting of nursery was done in the field on March 11 and August 15, 2012 for spring and fall seasons crop, respectively. The experiment was laid out in a Randomized Complete Block Design having four replications. Each plot had four rows at 50.0 cm spacing and plant to plant spacing was 30.0 cm. Insecticides used were spinosad (Tracer 240SC), flubendiamide (Belt 48 SC), emamectin benzoate (Timer 1.9EC), bifenthrin (Talstar 10EC), spinetoram (Delegate 25WG) and chlorantraneiliprole (Coragen 20SC). Insecticides were sprayed on April 2, 17 and May 2 for spring sown crop and on September 3, 18 and October 4 for fall sown crop. All infested fruits were picked from plots one day before insecticide application. Infected shoots were marked by tying a ribbon to all drooping shoots one day before spray. Fruit and shoot infestations were recorded seven and 14 days after insecticide application from plants in the middle two rows of each plot. All treatments reduced shoot and fruit infestation significantly as compared to the control. However, flubendiamide (Belt 48SC) and emamectin benzoate (Timer 1.9EC) treated plots had the least shoot infestation. For control of the borer in fruits, spinosad (Tracer 240SC) proved to be the most effective insecticide.

Keywords: Eggplant, aubergine, chemical control, shoot borer infestation, fruit borer infestation.

INTRODUCTION

Brinjal, *Solanum melongena* Linnaeus is one of the most important vegetables in South and South-East Asia (Thapa, 2010) where hot and wet climates prevail (Hanson *et al*., 2006). It belongs to the plant family Solanacae and is the most commonly grown vegetable of this family (Kantharajha and Golegaonkar, 2004). The Indo-Pak Subcontinent is reported to be the native land of brinjal (Dunlop, 2006). Its worldwide cultivation is more than 1,600,000 ha and production is 50 million Mt (FAO, 2012). In Pakistan it is cultivated in 9,000 ha and production is 87,000 tons per annum (FAO, 2014).

Different insect pests attack brinjal from time of planting till its harvesting. Some important insect pests are brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis*), coccinelide beetle (*Epilachna vigintioctopunctata*), jassid (*Amrasca bigutulla bigutulla*), aphid (*Aphis gossyppii*) and white fly (*Bemisia tabaci*) (Latif *et al*., 2009). BSFB is the major pest of brinjal (Latif *et al*., 2010; Chakraborti and Sarkar, 2011; Saimandir and Gopal, 2012) and is found in all brinjal producing countries (Dutta *et al*., 2011). It is the most important insect pest of brinjal in Asia, especially in India, Pakistan, Sri Lanka, Nepal, Bangladesh, Thailand, Philippines, Cambodia, Laos, Vietnam (AVRDC, 1994), Africa, Sahara and South-East Asia (CABI, 2007). Areas having a hot and humid climate are conducive for its distribution and incidence (Srinivasan, 2009). It causes severe damage in South Asia (Thapa, 2010) , where yield losses may reach up to 85 to 90 percent (Misra, 2008; Jagginavar *et al*., 2009).

The larvae bore into tender shoots at the vegetative stage, flower and fruit (CABI, 2007). Flower infestation is very rare, but infested flowers cannot produce fruit (Alam *et al*., 2006). It is also reported to infest the petiole and midrib of leaves (Alpureto, 1994; AVRDC, 1998) causing withering and drooping of young leaves and shoots. But once fruit setting has been initiated, shoot infestations

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0030-9923/2015/0005-1413 $ 8.00/0

become negligible (Kumar and Dharmendra, 2013) or completely disappear (Naqvi *et al*., 2009). The larvae, after hatching, bore inside fruit and the minute entrance hole is closed by the excreta of feeding larvae (Alam *et al*., 2006). Larvae feed on the mesocarp of fruit and the feeding and excretion result in fruit rottening (Neupane, 2001), making it unfit for human consumption (Baral *et al*., 2006). On average a larva can infest 4 to 7 fruits during its life span (Jayaraj and Manisegaran, 2010). Infestation by this pest results in lowering the vitamin C content up to 80 percent in infested brinjal fruit (Sharma, 2002).

BSFB has become a noxious insect pest in brinjal growing areas of Pakistan. In the Sahiwal, region twice a week applications of insecticides for BSFB control are a common practice of farmers. Extensive use of these conventional insecticides reduces their efficacy against BSFB and increases the cost of production. Since insecticide have several health hazardous effects, there is a need to use environmentally safe insecticides or less number of sprays and doses of insecticides. The present study was carried out to evaluate the efficacy of different insecticides to find the best practice if insecticides have to be applied for management of the borer.

MATERIALS AND METHODS

The study was conducted in the field at the COMSATS Institute of Information Technology, Sahiwal (30°39′52″N 73°6′30″E) for two growing seasons, *i.e.*, spring and fall of 2012. Seeds of brinjal variety Nirala were obtained from the vegetable section of the Ayub Agricultural Research Institute, Faisalabad. The variety Nirala is reported to be resistant against cotton jassid (Yousafi *et al., 2013)* and using this in the present study would make it an important component of multiple pest management package for brinjal. The nursery was raised in 30cm earthen pots. Seeds for spring and fall crop were sown on February 12, and July 7, respectively. The experiments were laid out in a Randomized Complete Block Design in four replications having seven treatments including a control (Table I). Seedlings in the three to four true leaf stage were transplanted in the field by dibbling on March 11 for the spring trial and August 15 for the fall trial. Each treatment plot had four rows of 5.0 m length and row to row spacing was 0.5 m. Plant to plant spacing was 30.0 cm. Plots and replications were separated by 1.0 m of non-cropped area. Light irrigation was given right after transplanting. Subsequent irrigations were given at two to three days intervals. Fertilizer was applied @ 10:75:100 NPK kg/ha. Three insecticide sprays were applied at 15 days intervals using a knapsack sprayer fitted with a hollow cone nozzle and operated at 16 bar pressure while spraying. First spray at vegetative growth stage was applied on April 2 on the spring sown crop and on September 3 on the fall sown crop. Subsequently two sprays were applied on April 17 and May 2 for the spring and on September 18 and October 4 for the fall sown crop in the fruiting stage. Water was applied to control plots when insecticides were sprayed.

Treatments were applied to the whole plots but data were recorded from the middle two rows in each plot. One day before each application of insecticides all infested fruits were harvested from all plots. After sprays, all marketable fruits were harvested from the plants in the middle two rows to note the number of healthy and infested fruits. Percent fruit infestation was calculated using the following formula:

$$\text{Percent fruit infestation} = \frac{\text{No. of infested fruit}}{\text{Total no. of fruits}} \times 100$$

For recording shoot infestation, healthy and infested shoots were counted on 10 randomly selected plants in the middle two rows of each plot. Data were recorded one day before spray and seven and fourteen days after treatment. All the infested fruits were picked one day before spray. The infested shoots from selected plants were marked using a ribbon tied around the shoot to avoid recounting during the next data recording. Percent shoot infestation was calculated by using the following formula:

$$\text{Percent shoot infestation} = \frac{\text{No. of infested shoots}}{\text{Total no. of shoots}} \times 100$$

Data were analyzed by using analysis of variance and mean separation was done by calculating least significance difference at P = 0.05.

Table I.- Treatments for brinjal shoot and fruit borer (*L. orbonalis*) control at Sahiwal on brinjal (*S. melongena*) shoot and fruit.

Treatment	Common name	Trade name	Manufacturer	Dose
T1	Spinosad	Tracer 240SC	Dow Agrosciences	60ml/acre (148.26 ml/ ha)
T2	Flubendiamide	Belt 48SC	Bayer Cropscience	50ml/acre (74.13 ml/ha)
T3	Emamectin benzoate	Timer 1.9EC	Hebbei Vian Biochemical Co.	200ml/acre (494.2 ml/ha)
T4	Bifenthrin	Talstar 10EC	FMC Corporation	200ml/acre (494.2 ml/ha)
T5	Spinetoram	Delegate 25WG	Dow Agrosciences	50 gm/acre (123.55 gm/ha)
T6	Chlorantraneiliprole	Coragen 20SC	Dupont	50ml/acre (74.13 ml/ha)
T7	Control	-	-	-

Table II.- Effect single spray of different insecticides on brinjal shoot and fruit borer (*L. orbonalis*) infestation on shoots of brinjal (*S. melongena*) crop sown in spring and fall 2012.

Insecticide (Common Name)	Dose/ha	BSFB shoot infestation[a] (%) (Mean ± SEM)		
		7 DAA[b]	14 DAA	Mean
Crop sown in spring				
Spinosad (Tracer 240SC)	148.26 ml	1.69±0.2b	2.74±0.4bc	2.22±0.3bc
Flubendiamide (Belt 48SC)	74.13 ml	0.98±0.2bc	1.91±0.3c	1.45±0.2c
Emamectin benzoate (Timer 1.9EC)	494.2 ml	0.81±0.2bc	2.20±0.3bc	1.50±0.3c
Bifenthrin (Talstar 10EC)	494.2 ml	1.21±0.2bc	2.50±0.5bc	1.86±0.3bc
Spinetoram (Delegate 25WG)	123.55 gm	1.58±0.5bc	3.22±0.4b	2.40±0.4b
Chlorantraneiliprole (Coragen 20SC)	74.13 ml	0.92±0.2bc	2.80±0.2bc	1.86±0.2bc
Control		4.70±0.2a	6.2±0.4a	5.45±0.1a
LSD		**0.78**	**1.07**	**0.79**
Crop sown in fall				
Spinosad (Tracer 240SC)	148.26 ml	1.92±0.2b	2.56±0.2b	2.24±0.2b
Flubendiamide (Belt 48SC)	74.13 ml	1.27±0.3b	1.94±0.1b	1.61±0.2b
Emamectin benzoate (Timer 1.9EC)	494.2 ml	1.31±0.2b	2.28±0.2b	1.80±0.1b
Bifenthrin (Talstar 10EC)	494.2 ml	1.87±0.4b	2.43±0.3b	2.15±0.3b
Spinetoram (Delegate 25WG)	123.55 gm	1.77±0.4b	2.63±0.2b	2.20±0.3b
Chlorantraneiliprole (Coragen 20SC)	74.13 ml/	1.35±0.2b	2.76±0.5b	2.05±0.3b
Control		3.80±0.6a	4.06±0.8a	3.93±0.7a
LSD		**1.10**	**1.11**	**1.02**

[a] Values followed by the same letter in columns are not significantly different (LSD; P > 0.05).
[b] DAA= Days after application.

RESULTS AND DISCUSSION

Shoot infestation in spring sown crop during 2012

Shoot infestations were significantly lower in treated as compared to that in control plots on seven days after application (DAA) of insecticides (Table II). All insecticide treated plots had non-significantly different shoot infestation among them Fourteen DAA all insecticide treated plots had a significantly lower borer infestation than that in control plots. Lowest infestation was recorded in plots treated with flubendiamide (Belt 48SC). Spinetoram (Delegate 25WG) treated plots had a significantly lower infestation than that in the control plot but higher than all other treated plots. Plots treated with spinosad (Tracer 240SC), emamectin benzoate (Timer 1.9EC), bifenthrin (Talstar 10EC) and chlorantraneiliprole (Coragen 20SC) had non-significant difference in infestation, which ranged from 2.20 to 2.80 percent. Emamectin benzoate (Timer 1.9EC) provided good control up to seven days but flubendiamide (Belt 48SC) was more effective up to 14 days.

When mean infestation after seven and 14

DAA was observed, flubendiamide (Belt 48SC) and emamectin benzoate (Timer 1.9EC) treated plots had the lowest BSFB infestation, followed by that in bifenthrin (Talstar 10EC), spinosad (Tracer 240SC), and chlorantraneiliprole (Coragen 20SC) treated plots.

Shoot infestation in fall sown crop during 2012

During fall, as in spring, control plots had significantly higher BSFB infestation seven and 14 DAA as compared to that on insecticide treated plots (Table II). Seven DAA, infestation was non-significantly different among plots treated with different insecticides. However, among the tested insecticides flubendiamide (Belt 48SC) was relatively more effective as the plots treated with it had a lower infestation than that in other plots. Fourteen DAA all the insecticide treated plots had non-significantly different infestations, indicating that all the insecticides were equally effective against BSFB but flubendiamide (Belt 48SC) was again relatively more effective as plots treated with this had relatively lower infestation. For shoot infestation control flubendiamide (Belt 48SC) was relatively better than other products tested because plots receiving its application had relatively lower infestation in both seasons 14 DAA.

These results are in accordance with the study conducted by Shah *et al*. (2012), who found that emamectin benzoate (Timer 1.9EC) and flubendiamide (Belt 48SC) were promising insecticides to lower BSFB fruit and shoot infestation and produce high fruit yield. Latif *et al.* (2009a) also suggested the application of flubendiamide (Belt 48SC), in combination with mechanical control, potash and field sanitation, for reducing fruit and shoot infestation. Our findings also confirm the results of the studies conducted by Latif *et al*. (2010), who found that flubendiamide (Belt 48SC) and endosulfan caused maximum larval mortality of BSFB in laboratory trials while field trials reduced brinjal shoot and fruit infestation70-80%. Mean infestation after seven and 14 DAA in the present study revealed that flubendiamide (Belt 48SC) and emamectin benzoate (Timer 1.9EC) were better chemicals for the control of this pest. However, flubendiamide (Belt 48SC) was superior as it provided control for two weeks. Flubendiamide has been reported to control a lepodipterous pest on rice also (Haider *et al.*, 2014).

Fruit infestation in spring sown crop during 2012

Data of fruit infestation by BSFB for two sprays of different insecticides is presented in Table III. Among the plots receiving first spray, control plots had significantly higher infestation as compared to that in plots where insecticides were applied. Among the insecticides treatments chlorantraneiliprole (Coragen 20SC) was the most effective having the least fruit infestation 7 DAA. Infestations were non-significantly different between plots treated with bifenthrin (Talstar 10EC) and spinetoram (Delegate 25WG). These treatments had significantly higher infestation than the chlorantraneiliprole (Coragen 20SC) treated plots. Control plots again had the highest infestation as compared to insecticides treated plots14 DAA. Spinosad (Tracer 240SC) treated plots had the lowest infestation, followed by that in plots receiving flubendiamide (Belt 48SC) and bifenthrin (Talstar 10EC). Chlorantraneiliprole (Coragen 20SC) was most effective insecticide against BSFB 7 DAA, whereas spinosad (Tracer 240SC) was the most effective 14 DAA.

Seven days after the second spray insecticide treated plots had a significantly lower infestation as compared to that in control plots. Among the insecticide treated plots infestation was significantly different. Highest infestation was noted in plots treated with spinetoram (Delegate 25WG). Plots treated with spinosad (Tracer 240SC), flubendiamide (Belt 48SC), bifenthrin (Talstar 10EC) and chlorantraneiliprole (Coragen 20SC) had non-significantly different infestation among them 7 DAA. The lowest infestation was recorded in plots treated with emamectin benzoate (Timer 1.9EC). Fourteen days after treatment treated plots again had significantly lower infestation than that in control plots. Difference in infestation was non-significant among spinosad (Tracer 240SC), emamectin benzoate (Timer 1.9EC), bifenthrin (Talstar 10EC) and chlorantraneiliprole (Coragen 20SC) treated plots. Plots sprayed with flubendiamide (Belt 48SC) had the highest infestation while the lowest infestation was recorded in plots treated with spinetoram (Delegate 25WG) 14 DDA.

Table III.- Effect of two sprays of different insecticides on brinjal shoot and fruit borer (*L. orbonalis*) infestation on fruits of brinjal (*S. melongena*) crop sown in spring and fall 2012.

Insecticide Common name	Dose/ha	BSFB fruit infestation (%) (Mean ± SEM				Mean
		First spray		Second spray		
		7 DAA[b]	14 DAA	7 DAA	14 DAA	
Crop sown in spring						
Spinosad (Tracer 240SC)	148.26 ml	5.59±1.8bc	10.70±3.4c	6.00±3.8bc	10.79±2.6bc	8.27±0.6d
Flubendiamide (Belt 48SC)	74.13 ml	6.45±2.8bc	14.45±2.7b	6.62±0.86bc	13.36±7.0b	10.22±0.9b
Emamectin benzoate (Timer 1.9EC)	494.2 ml	4.81±0.22bc	11.59±1.0bc	3.90±1.2c	11.46±7.7bc	7.95±0.6d
Bifenthrin (Talstar 10EC)	494.2 ml	7.21±2.5b	13.94±7.0b	5.77±2.8bc	12.38±6.2bc	9.83±1.3bc
Spinetoram (Delegate 25WG)	123.55 gm	7.26±1.3b	12.06±0.4bc	7.46±3.1b	9.87±5.7c	9.2±0.6bcd
Chlorantraneiliprole (Coragen 20SC)	74.13 ml	4.32±0.9c	13.22±8.6bc	5.10±0.6bc	12.61±2.9bc	8.81±0.5cd
Control		28.39±8.6a	30.24±4.3a	28.90±12.4a	27.78±8.0a	28.83±2.1a
LSD		2.55	3.00	2.99	3.13	1.34
Crop sown in Fall						
Spinosad (Tracer 240SC)	148.26 ml	5.78±1.6bc	9.83±1.6d	5.04±1.2d	11.47±2.8e	8.03±0.6e
Flubendiamide (Belt 48SC)	74.13 ml	6.18±4.0bc	16.40±6.3b	7.20±2.8bc	17.47±3.1bc	11.81±1.6bc
Emamectin benzoate (Timer 1.9EC)	494.2 ml	4.95±0.1c	14.24±5.1bc	5.65±1.8cd	15.28±10.4cd	10.03±1.2cd
Bifenthrin (Talstar 10EC)	494.2 ml	8.02±0.8b	16.30±4.3b	7.90±1.4b	18.12±1.5b	12.58±0.4b
Spinetoram (Delegate 25WG)	123.55 gm	5.36±0.6c	13.22±1.2bc	5.12±1.0d	10.20±0.1e	8.47±0.1de
Chlorantraneiliprole (Coragen 20SC)	74.13 ml	4.60±1.7c	12.99±2.6cd	5.19±1.7cd	14.68±4.5d	9.31±1.3de
Control		26.21±8.7a	27.70±11.7a	26.40±5.5a	27.70±6.8a	27.00±5.5a
LSD		**2.45**	**3.29**	**2.03**	**2.81**	**1.79**

Values followed by the same letter in columns are not significantly different (LSD; P > 0.05).
[b] DAA, Days after application.

After the second treatment emamectin benzoate (Timer 1.9EC) was the most effective after seven days and spinetoram (Delegate 25WG) after 14 days of spray. When mean infestation after two spray applications was considered, spinosad (Tracer 240SC) and emamectin benzoate (Timer 1.9EC) treated plots had the lowest infestation. No insecticide was consistently better than others. Each application resulted in a different insecticide to be more effective for control BSFB after different interval, *i.e.*, seven or 14 DAA. Based on the mean of two applications, spinosad (Tracer 240SC) proved to be the best insecticide for maximum control of BSFB on the spring sown brinjal crop.

Fruit infestation in fall sown crop during 2012

Data of BSFB infestation for different treatments for fall 2012 crop is presented in Table III. In first and second spray treatments and in mean infestation of the two sprays, all insecticide treated plots had significantly lower fruit infestation as compared to that in control plots. Seven days after first treatment highest infestation was recorded in plots treated with bifenthrin (Talstar 10EC) and lowest in plots treated with emamectin benzoate (Timer 1.9EC), spinetoram (Delegate 25WG) and chlorantraneiliprole (Coragen 20SC). Other insecticides were observed to have intermediate toxicity. Fourteen DAA of the first spray, plots treated with spinosad (Tracer 240SC) had the lowest infestation. Highest infestation was recorded in plots treated with flubendiamide (Belt 48SC) and bifenthrin (Talstar 10EC), followed by plots receiving applications of emamectin benzoate (Timer 1.9EC) and spinetoram (Delegate 25WG). Plots treated with chlorantraneiliprole (Coragen 20SC) had significantly higher infestations than that in plots treated with spinosad (Tracer 240SC) and lower than that in all other insecticides treated plots.

Seven DDA of second treatment lowest infestation was noted in plots receiving treatment of spinosad (Tracer 240SC) and spinetoram (Delegate 25WG) and highest in plots treated with bifenthrin (Talstar 10EC). Plots treated with flubendiamide (Belt 48SC) had significantly lower infestation than that in the plots treated with bifenthrin (Talstar

10EC), but higher than that in all other insecticide treated plots. Fourteen DAA lowest infestation among insecticide treatments was noted in plots treated with spinosad (Tracer 240SC) and spinetoram (Delegate 25WG,whereas, highest infestation was found in plots sprayed with bifenthrin (Talstar 10EC). When mean infestation was calculated for the two sprays, lowest infestation was observed in plots treated with spinosad (Tracer 240SC). Highest infestation was noted in plots receiving application of bifenthrin (Talstar 10EC).

The results revealed that emamectin benzoate (Timer 1.9EC), spinetoram (Delegate 25WG) and chlorantraneiliprole (Coragen 20SC) resulted in lowest infestation seven days after first spray, whereas spinosad (Tracer 240SC) resulted in lowest infestation 14 days after application. After the second spray treatment, spinosad (Tracer 240SC) and spinetoram (Delegate 25WG) had the lowest infestation seven and 14 DAA. When the mean of the two sprays was considered, spinosad (Tracer 240SC) proved to be the best treatment having the lowest infestation.

The results for two seasons after insecticides spray proved that emamectin benzoate (Timer 1.9EC), chlorantraneiliprole (Coragen 20SC) and spinetoram (Delegate 25WG) were persistently effective against BSFB in reducing fruit infestation seven days after spray. Spinosad (Tracer 240SC) was effective seven DAA of second spray in fall 2012, while spinosad (Tracer 240SC) and spinetoram (Delegate 25WG) proved effective for 14 DAA in both seasons *i.e.*, spring and fall 2012.

The results of the present study support the findings of several previous studies. Pareet (2006) also found spinosad (Tracer 240SC) and emamectin benzoate (Timer 1.9EC) to be effective up to last harvest in reducing brinjal fruit borer damage. Deshmukh and Bhamare (2006), Adiroubane and Raghuraman (2008) and Aprana and Dethe (2012) found that spinosad (Tracer 240SC) was effective in controlling BSFB on brinjal. Anil and Sharma (2010), Sharma and Sharma (2010), Wankhede and Kale (2010), Chatterjee and Mondal (2012) and Shah *et al*. (2012) reported that emamectin benzoate (Timer 1.9EC) was the most effective insecticide in reducing BSFB infestation and increasing marketable fruit yield. Hamdy and Sayed (2013) found the highest reduction in infestation of *Helicoverpa armigera* on tomato was achieved with spinetoram (Delegate 25WG). Spinetoram (Delegate 25WG) was found effective in controlling pink bollworm in cotton without causing considerable damage to natural enemies (Sabry *et al*., 2014). According to Kodandaram *et al.* (2010) chlorantraneiliprole was effective at a lower dose of 15-20 g ai/ha against brinjal shoot and fruit borer.

It is concluded that the tested insecticides reduced shoot and fruit infestation in treated as compared to those in untreated plots. For control of shoot infestation, flubendiamide (Belt 48SC) and emamectin benzoate (Timer 1.9EC) were better in both seasons. There is no established economic threshold level based on shoot infestation of brinjal by BSFB and shoot infestation was quite low to justify any control measures in the present studies. For fruit infestation control, spinosad (Tracer 240SC) and emamectin benzoate (Timer 1.9EC) proved better in spring sown crop. On fall sown crop spinosad and chlorantraneiliprole (Coragen 20SC) resulted in better borer control. Overall results indicated that spinosad application provided relatively better and consistent control of BSFB.

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(Received 9 January 2015, revised 6 May 2015)