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Efficacy of chemical insecticides against shoot and fruit borer, *Leucinodes orbonalis* Guenee and economics of treated crop in Allahabad: A review

Ramkinkar Sahu, Ashwani Kumar, Hadi Husain Khan, Dharmveer Habil, Narendra Singh Dhaked and Huma Naz

Abstract
Brinjal crop is regularly and simultaneously attacked by several insect pests like leafhopper (*Amrasca bigutulla bigutulla* Ishida), whitefly (*Bemisia tabaci* Gennadius) and brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. The yield lossescaused are as high as 70-92% in India and the pest is reported to cause 3.3-68.9% damage to flowers and 47.6-85.8% damage to fruits in Orissa. The management of this pest is through calendar spraying of conventional insecticides irrespective of pest incidence. Insecticides suchas bio-pesticides, botanicals and chitin synthesis inhibitors, have been evaluated against *L. orbonalis* in the past and are being used. The bio-efficacy of thiodicarb (0.28125, 0.46875 and 0.75 kg a.i./ha) and other insecticides, *i.e.* Cartap hydrochloride [cartap] (0.5 kg a.i./ha), diflubenzuron (0.1 kg a.i/ha), carbofuran (1.0 kg a.i./ha) and Triazophos (0.5 kg a.i./ha) and Fipronil (0.1 kg a.i./ha), against brinjal shoot and fruit borer, *Leucinodes orbonalis*. The results revealed the superiority of thiodicarb at its highest dose of 0.75 kg a.i/ha as it recorded the lowest shoot (1.41%) and fruit damage (20.86%). This compound at its highest dose also recorded the highest aubergine fruit yield of 148.45 q/ha. The efficacy of some new groups of insecticides against the shoot and fruit borer (*Leucinodes orbonalis*) and beetles (*Epilachna* spp.) infesting aubergine cv. Utkal Madhuri,), application of fipronil+ triazophos + cartap hydrochloride recorded the lowest shoot borer (% shoot infestation) and beetle damage (% leaf infestation) of 11.89 and 3.05%, respectively.

Keywords: Pest, Insecticide, *L. orbonalis*, Fruit borer

Introduction
In India, Production share of Brinjal with 8.3 % stands at fourth position among vegetable crops after potato, tomato and onion with 25.5, 11.9 and 11.5 per cent respectively. This crop is regularly and simultaneously attacked by several insect pests like leafhopper (*Amrasca bigutulla bigutulla* Ishida), whitefly (*Bemisia tabaci* Gennadius) and brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Bhadauria *et al*., 1999) [4]. Some of the other reports by the authors regarding loss caused by the brinjal shoot and fruit borer in India and elsewhere. The yield lossescaused are as high as 70-92% in India (Rosaiah, 2001) [23] and the pest is reported to cause 3.3-68.9% damage to flowers and 47.6-85.8% damage to fruits in Orissa (Patnaik, 2000) [22]. The management of this pest is through calendar spraying of conventional insecticides irrespective of pest incidence. Insecticides such as bio-pesticides, botanicals and chitin synthesis inhibitors, have been evaluated against *L. orbonalis* in the past (Chatterjee and Roy, 2004, Sharma *et al*., 2004, Mishra and Dash, 2007) [8, 28, 19] and are being used, besides the conventional insecticides. The increased dependence onpesticides, calendar based sprays by the farmer and/or shortresidual action of certain group of insecticides have notonly lead to higher costs of production but also have notresulted in adequate control of pest.

Efficacy of chemical insecticides against shoot and fruit borer, *Leucinodes orbonalis* Guenee and Economics of treated crop
Sahu *et al.* (2004) [24] evaluated the bioefficacy of thiodicarb (0.28125, 0.46875 and 0.75 kg a.i./ha) and other insecticides, *i.e.* Cartap hydrochloride [cartap] (0.5 kg a.i./ha), diflubenzuron (0.1 kg a.i/ha), carbofuran (1.0 kg a.i./ha) and Triazophos (0.5 kg a.i./ha) and Fipronil (0.1 kg a.i./ha), against brinjal shoot and fruit borer, *Leucinodes orbonalis*. The results revealed the superiority of thiodicarb at its highest dose of 0.75 kg a.i/ha as it recorded the lowest shoot (1.41%) and fruit damage (20.86%). This compound at its highest dose also recorded the highest aubergine fruit yield of 148.45 q/ha.
Bharadiya and Patel (2005) [5] evaluated the efficacy of different insecticides against the shoot and fruit borer (*Leucinodes orbonalis*) infecting aubergine cv. SKN BSR-1. The following

insecticides were sprayed 3 times at fortnightly intervals starting from 50% flowering stage: monocrotophos 0.04%; endosulfan 0.07%; profenofos 0.04%; ethion 40 EC + cypermethrin 5 EC 0.09%; acephate 25 EC + fenvalerate 3 EC at 0.07%; malathion 0.05%; neem oil 0.09%; triazophos 0.1%; and profenofos 40 EC + cypermethrin 4 EC 0.04%. Monocrotophos and endosulfan recorded the lowest percentage of damaged shoots one week after spraying (1.54 and 1.56%, respectively). However, endosulfan recorded the lowest average percentage of damaged fruits on number (7.25%) and weight basis (6.34%) as well as the highest marketable fruit yield (15 840.85 kg/ha).

Chiranjeevi *et al.* (2005) [9] conducted an experiment for three seasons *viz.*, 2000, 2001 and 2002 during Rabi season at Vegetable Research Section, Rajendranagar, Hyderabad in a randomized block design with three replications. Brinjal variety Bhagyamathi was transplanted at 5 week's stage of growth in plots of 4.5 x 3.6 m with a spacing of 60 cm between row to row and 50 cm between plant to plant. The different treatments imposed were spraying of NSKE - profenofos - cypermethrin (T1), No spray - profenofos - cypermethrin / NSKE – profenofos - cypermethrin (T2), NSKE 5 sprays from flower initiation (T3), profenofos 5 sprays from flower initiation (T4), cypermethrin 5 spray from flower initiation (T 5), stem application with imidacloprid @ 1 ml/lit 30 DAT (T6) and untreated control (T7). The treatments were imposed along with the IPM package consisting; selection of a variety tolerant to leafhopper / fruit borer; root dipping in imidacloprid @ 1 ml/lit of water for 3 hours and weekly shoot clipping and destruction of shoots till shoot infestation persists. In control treatment only tolerant variety was taken without root dipping and shoot clipping.

Panda *et al.* (2005) [21] evaluated the efficacy of some new groups of insecticides against the shoot and fruit borer (*Leucinodes orbonalis*) and beetles (*Epilachna* spp.) infesting aubergine cv. Utkal Madhuri. The treatments were: thiodicarb at 375 g, 625 g and 1.0 kg/ha; alternate spraying of cartap hydrochloride (0.5 kg a.i./ha) and diflubenzuron (100 g a.i./ha); carbofuran 3G (1.0 kg a.i./ha) + triazophos (400 g a.i./ha) + cartap hydrochloride (0.5 kg a.i./ha); fipronil 0.4G (100 g a.i./ha) + triazophos (400 g a.i./ha) + cartap hydrochloride (0.5 g a.i./ha); and fipronil5% SC (50 g a.i./ha). Application of fipronil+ triazophos + cartap hydrochloride recorded the lowest shoot borer (% shoot infestation) and beetle damage (% leaf infestation) of 11.89 and 3.05%, respectively.

Deshmukh and Bhamare (2006) [10] evaluated newer insecticides in comparison with conventional insecticides against aubergine shoot and fruit borer, *Leucinodes orbonalis*. Amongst newer insecticides, cartap hydrochloride 50 SP at 0.1% was found most effective in reducing shoot infestation (4.20%) and fruit infestation (23.72% on number basis and 25.30% on weight basis) and in increasing aubergine fruit yield (78.73 q/ha). Spinosad 45 EC at 0.01% and thiodicarb 75 WP at 0.1% were also found effective in reducing shoot and fruit borer infestation and in increasing fruit yield. Among the conventional insecticides, cypermethrin 25 EC at 0.006% was found to be superior in terms of efficacy and yield. However, the incremental cost benefit ratio (ICBR) showed that the application of cypermethrin 25 EC at 0.006% was economically most viable treatment (1:27.02), followed by monocrotophos 36 WSC at 0.05% (1:26.85).

Kalawate and Dethe (2006) [13] reported the bioefficacy of Spinosad (56.25, 72 and 90 g a.i. ha-1) and Emamectin benzoate (5, 6.25 and 12.5 g a.i.ha-1) was studied in comparison to Cypermethrin (50 g a.i. ha-1) and self-formulated Neem seed extract (5 %). Field experiments were undertaken for two cropping seasons during *kharif* 2005 and summer 2006. From the study it was found that spinosad afforded moderate control of jassid, whitefly and aphid. However, it was found to be the most effective against BSFB. Although corresponding yield recorded in cypermethrin (check treatment) was higher (16.30 and 21.01 t ha-1) it was not significantly different than that noticed in spinosad and emamectin benzoate.

Adiroubane and Raghuraman (2008) [1] reported that Oxymatrine (1.2 EC @ 0.2 per cent) and spinosad (45 SC @ 225 g a.i. /ha) were found to be effective against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee.). Oxymatrine was effective at early vegetative stage. Highest per cent reduction of shoot damage was observed in oxymatrine and it is on par with spinosad. Spinosad was effective at fruiting stage. Maximum per cent reduction of fruit damage was recorded in spinosad and it was on par with oxymatrine.

Misra (2008) [20] evaluated two new insecticides, *viz.*, rynaxypyr 20% SC and flubendiamide 480 SC against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. during winter, 2007 and summer, 2008 at the Central Research Station farm, Orissa University of Agriculture and Technology, Bhubaneshwar with brinjal cv. "UtkalAnushree". Four foliar spray applications of the chemicals were given at 11 days intervals starting from fruit initiation. The results revealed that rynaxypyr 20% SC @ 40 and 50g a.i.lha gave 95-97% reduction in the 'shoot damage and 87-90% reduction in-fruit damage on number basis and 88-90% on weight basis at ten days after fourth spray, compared to untreated control. Both the new compounds were safe to natural enemies at 0, 3, 7 and 10 days after spraying. The healthy fruit yield recorded was significantly highest in plots treated with rynaxypyr 20% SC @ 40 and 50g a.i.lha during both the seasons of field testing.

Latif *et al.* (2009) [15] conducted a field experiment to evaluate the efficacy of flubendiamide as an IPM component for the management of brinjal shoot and fruit borer and eight IPM packages were evaluated. Among the different IPM packages, package 6 (mechanical control + potash @100 kg/ha + field sanitation in combination with flubendiamide 24WG applied at 5% level of shoot and fruit infestation) showed the better performance by reducing 80.63% fruit infestation over control and produced the highest number of healthy and total fruits/plant (25.0 and 27.20, respectively). The same package also increased 108.83% healthy fruit yield and decreased 74.13% infested fruit yield over control. The highest benefit cost ratio (5.53) was recorded in IPM package 2 (Potash @100 kg/ha + flubendiamide 24WG applied at 5% level of fruit infestation), where 9 sprays were required. The BCR of 4.12 and 4.00 was obtained in IPM package 6 and package 5 with 8 and 5 sprays, respectively. The results of this study suggested that application of flubendiamide at 5% level of fruit infestation in combination with mechanical control + potash @ 100 kg/ha + field sanitation may be used for the management of brinjal shoot and fruit borer and economical control of the pest. Whereas, *Bt* was less effective and more expensive in controlling the pest even in combination with carbaryl or endosulfan.

Anil and Sharma (2010) [2] conducted an field experiment during the 2006 *kharif* season to evaluate the effectiveness of bifenthrin (25 and 50 g a.i./ha), fipronil (50 g a.i./ha), carbosulfan (187.5 g a.i./ha), cartap hydrochloride (500 g a.i./ha) and endosulfan (700 g a.i./ha) against *Amrasca*

biguttula and *Leucinodes orbonalis* infesting aubergine. All the insecticides were effective in managing *A. biguttula biguttul a*and *L. orbonalis*. The percent damage due to *L. orbonalis*in various treatments varied from 4.06 (cartap hydrochloride) to 8.26 (fipronil) while it was 18.89 in the untreated control. Carbosulfan at 187.5 g a.i/ha gave maximum (48.95%) increase in yield over the control.

Sinha *et al.* (2010) [31] reported that efficacy of indoxacarb against *Leucinodes orbonalis* and its persistence in brinjal (*S. melongena*) fruit were studied. Three foliar sprays of indoxacarbat 70 and 140 g/ha were performed at fortnightly intervals starting at flowering/fruiting stage of the crop. For residue analysis, fruit samples were collected at 0, 1, 3, 5, 10 and 15 days after the second spray. Indoxacarb was effective in controlling the shoot and fruit borer of brinjal. On number basis, indoxacarbat its normal and double doses resulted in 6.8 and 4.3% borer infestation while on weight basis it resulted in 7.3 and 4.3% compared to 10.8 and 9.9% borer damage, on number and weight basis, respectively, in the control plot. Hence, both treatments were significantly effective. Indoxacarb recorded yield of 22.552 MT/ha when applied at 140 g/ha and 20.744 MT/ha at 70 g/ha compared to only 14.632 MT/ha in the control. The application of indoxacarbat 70 and 140 g/ha resulted in initial deposits of 0.112 and 0.209 micro g/g. The residues dissipated with a half life of 1.6-2.3 days. The residues persisted for 7 days at normal dose and 10 days at double dose. No residues of indoxacarb were detected in fruits on the 15th day at both rates.

Tayde and Simon (2010) [32] conducted that field experiment during *kharif*, 2009-2010 at SHIATS, Allahabad (U.P.) to compare the efficacy of insecticides, Spinosad and *neem* products against brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guen.) which revealed that Spinosad45 SC @ 0.01% was found most effective and showed (09.84%) shoot infestation, per cent fruit infestation (06.87% on number basis and 07.35% on weight basis) and increasing yield of brinjal fruit (239.30 q/ha). Whereas, Carbaryl 50 WP @ 0.2% and Endosulfan 35 EC @0.05% were also found effective in reducing per cent infestation shoot and fruit infestation and increasing yield. Amongst *neem* products NSKE 5% was found to be superior in terms of efficacy and yield. However, the increment cost benefit ratio (ICBR) showed that the application of Quinalphos 25 EC @0.05% was economically most viable treatment (1:67.86) followed by Endosulfan 35 EC @ 0.05% (1:66.19).

Chand *et al.* (2011) [7] conducted that farm test the different insecticides against fruit borer, *Leucinodes orbonalis* Guenee of brinjal cv. Pant Rituraj during *Rabi* crop season (2006-07). Four insecticides *viz.*, dichlorovos 76EC, quinalphos 25 EC, endosulfan 35 EC and monocrotophos 36 EC each @ 0.01%, 0.02% and 0.03% were tested. At 0.03%, 0.02% and 0.01% concentrations dichlorovos was found to be more effective by reducing 77.6%, 67.5% and 59.3% fruit borer population respectively over control. Its efficacy was higher than otherinsecticides tested. Endosulfan was least effective by reducing 63.5%, 59.5% and 53.0% of fruit borer. In population over control during the *rabi* crop season in the year 2006.

Chakraborti and Sarkar (2011) [6] reported that *Leucinodes orbonalis* Guenee (Pyraustidae: Lepidoptera) is a fruit and shoot borer which is the key pest of eggplant (also known as brinjal and aubergine). *L. orbonalis* causes broad-based problems in eggplant cultivation. An effort was made to control the borer during the Indian rainy season, as this is the time when the problem is at its worst. The impact of treatments on natural enemies as well as pollinators was also assessed. Integration of phytosanitation, mechanical control and prophylactic application of neem seed kernel extract (NSKE) exerted a satisfactory impact on the incidence and damage of *L. orbonalis.* After two need-based applications of new generation pesticide molecules like flubendiamide or rynaxypyr or emamectin benzoate, fairly good, healthy yields were produced. A ready-mix formulation (triazophos 40% + cypermethrin 4%), and carbofuran also offered good protection against the borer but both were found highly toxic and unsafe for predators i.e. predatory coccinellids and spiders and pollinating bees. Flubendiamide and rynaxypyr appeared comparatively more unsafe for bees than emamectin benzoate, while both allowed a substantial proportion of coccinellids and spiders to survive. Naturolyte, with the active ingredient emamectin benzoate, was found safe for predators and bees and on par with the untreated check.

Mishra *et al*. (2011) [18] reported that Chlorantraniliprole 20 SC was evaluated in the field against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee during winter, 2007 and summer, 2008 with recommended package of practices except plant protection. Four foliar sprays of the chemical were given starting from fruit initiation at 11 days intervals at various doses along with a standard check carbosulfan 25 EC @ 500 g a.i./ha and untreated control. The results revealed that treatments chlorantraniliprole @ 40 and 50 g a.i./ha were significantly superior and statistically on par with each other with regard to its efficacy resulting in around 95-97 per cent reduction in the per cent shoot damage; 87-90 per cent reduction in fruit damage on number basis and 88-90 per cent reduction in fruit damage on weight basis, 10 days after fourth spray, compared to untreated.

Sharma *et al*. (2012) [27] evaluated that potential of two botanicals viz; ozoneem and neem seed kernel extract (NSKE) and three chemical insecticides viz; imidacloprid, alphamathrin, chlorpyriphos 50% EC + cypermethrin 5% EC against *Leucinodes orbonalis*, during the years from 2008 to 2009. Botanicals were tested alone and in combination with cultural practices. On the basis of the pooled means, the results revealed that three sprays of chlorpyriphos + cypermethrin @ 0.01% active substance (a.s.) in 15 days intervals was found to be the most economical, resulting in minimum shoot (2.15%) and fruit (12.95%) infestation respectively, followed by alphamathrin @ 0.01% a.s. with a highest marketable yield of 87.77 q/ha. Maximum marketable yield was received from the treatment with alphamathrin, but due to high costs involved in the use of this chemical, it took second place. Three sprays of NSKE @ 5 ml/lt. recorded a maximum of shoot (3.91%) and fruit (24.49%) infestation, respectively. However, shoot and fruit infestation was brought down and marketable yield increased to some extent, when these treatments were combined with cultural methods. It is therefore, suggested that the combination of chlorpyriphos 50% EC + cypermethrin 5% EC, being the most effective and economically viable

Beemrote *et al*. (2012) [3] conducted field experiment during summer 2011 to evaluate ten novel and conventional insecticides for the control of shoot and fruit borer, *Leucinodes orbonalis*. The results revealed that minimum per cent shoot infestation was observed in plots treated with indoxacarb 14.5 SC @ 100 g a.i./ha (3.33%). Similarly, number of infested fruits was significantly lower in insecticide treated plots. The treatment with indoxacarb 14.5 SC @ 100 g a.i./ha was the most effective insecticide with

10.31 per cent fruit damage, followed by carbaryl 50 WP @ 1000 g a.i./ha with 15.01 per cent fruit infestation. It was, however, on par with chlorpyrifos 20 EC @ 200 g a.i./ha (16.15%). Highest yield (31.18 q/ha) was registered in the plots treated with indoxacarb 14.5 SC (100 g a.i./ha) followed carbaryl 50 WP @ 1000 g a.i./ha (29.85 q/ha) and chlorpyrifos 20 EC @ 200 g a.i./ha (16.77 q/ha).

Dattatray *et al*. (2012) conducted field experiments during *Kharif* 2009 and 2010 to evaluate the efficacy of chlorantraniliprole 18.50% SC (Coragen), flubendamide 39.35% SC (Fame), indoxacarb 14.50% SC (Avaunt), chlorfenapyr 10% SC (Intrepid) and spinosad 45% SC (Spintor) against brinjal fruit and shoot borer, *Leucinodes orbonalis* (Guenee). Chlorantraniliprole 18.50% SC and flubendamide 39.35% SC proved their superiority over other insecticides in reducing infestation of *L. orbonalis* and resulted in higher yields.

Sinha and Nath (2011) [30] reported the efficacy of five insecticides *viz.*, spiromesifen (100g a.i./ha), chlorantraniliprole (20g a.i./ha), novaluron (75g a.i./ha), flubendamide (25g a.i./ha) and carbosulfan EC (250g a.i./ha) were studied against insect pests of brinjal. Two foliar sprays at 21 days interval were given which revealed that all insecticides were effective against leafhoppers and whiteflies. As far as infestation of *Leucinodes orbonalis* was concerned, damage in various treatments ranged 4.0-14.2% as compared to 23.1% of control on weight basis while it ranged from 3.5-12.2% in treatments on number basis; it was 20.6% in untreated check.

Shah *et al.* (2011) [26] conducted field experiments in a randomized block design with 12 treatments (eleven insecticides and one control) and 3 replications during *kharif* 2010 at College Agronomy Farm, Bansilal Amritlal College of Agriculture, Anand Agricultural University, Anand to evaluate newer molecules of insecticides for their bio-efficacy against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) in brinjal (*Solanum melongena* Linnaeus) crop. The order of effectiveness was emamectin benzoate (Proclaim 5 WG) 0.0025% (89.56) >flubendiamide (Fame 480 SC) 0.01% (83.70) >rynaxypyr (Coragen 20 SC) 0.006% (81.04) >lufenuron (Match 5 EC) 0.005% (74.62) >novaluron (Remon 10 EC) 0.01% (69.03) >indoxacarb (Fego 15.5 SC) 0.007% (67.46) >thiodicarb (Larvin 75 WP) 0.075 (61.66) >spinosad (Spintor 45 SC) 0.0135% (59.55) >endosulfan (Thiodan 35 EC) 0.07% (52 32) >dichlorvos (Nuvan 76 EC) 0.076% (45.97) >fenvalerate (Tatafen 20 EC) 0.01% (36.63) based on per cent reduction in shoot damage; emamectin benzoate (75.06) >flubendiamide (63.02) >rynaxypyr (61.55) >lufenuron (49.93) >novaluron (47.69) >indoxacarb (45.34) >thiodicarb (41.08) >endosulfan (39.98) >spinosad (37.27) >dichlorvos (25.58) >fenvalerate (24.51) based on per cent reduction in fruit damage; emamectin benzoate (151.41) >flubendiamide (123.46) >novaluron (110.07) >rynaxypyr (107.81) >spinosad (106.66) >thiodicarb (96.67) >indoxacarb (95.51) >lufenuron (88.85) >endosulfan (75.38) >dichlorvos (70.46) >fenvalerate (67.56) based on per cent increase in fruit yield; and dichlorvos (1:19.27) >endosulfan (1:15.26) >fenvalerate (1:13.42) >indoxacarb (1:8.42) >thiodicarb (1:7.70) >emamectin benzoate (1:6.92) >flubendiamide (1:6.10) rynaxypyr (1:5.56) >spinosad (1:5.49) >novaluron (1:5.33) >lufenuron (1:5.25) based on net incremental cost: benefit ratio. Novaluron and fenvalerate were found to be “moderately harmful”, while rest of the insecticides were “harmless” to predatory spiders in brinjal crop.

Ghosal *et al*. (2013) [12] evaluated the efficacy of some insecticides (flubendiamide 20 WDG, indoxacarb 14.5 SC, novaluron 10 EC, fipronil 5 SC, rynaxypyr 18.5 SC, carbosulfan 25 EC and thiomethoxam 25 WG) for the management of shoot and fruit borer of brinjal, during *pre kharif* season of 2011 and 2012. The results showed that rynaxypyr 18.5 SC 40 g ai ha-1 was found to be superior over other treatments against *Leucinodes orbonalis* Guen., recorded lowest shoot (2.65%) and 14.07% fruit infestation in brinjal. The next effective treatment was flubendiamide (2.77% shoot, 15.33% fruit infestation) followed by fipronil (3.43% and 15.85%), carbosulfan (3.76% and 16.78%), indoxacarb (3.96%, 17.18%) and novaluron (4.34%, 18.78%) respectively. Rynaxypyr recorded the highest marketable fruit yield (156.25 q ha-1).

Al Mamun *et al*. (2014) reported brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee is a serious pest of brinjal or eggplant (*Solanum melongena* L.). Due to increasing levels of resistance of *L. orbonalis* to different insecticides there is an urgent need to test new chemicals. Studies were carried out in the Entomology Field Laboratory, Bangladesh Agricultural University (BAU) to evaluate the efficacy of three insecticides *viz*., impale 20SL (imidacloprid), advantage 20EC (carbosulfan), libsen 45SC (spinosad) against the infestation of *L. orbonalis*. All the tested insecticides were found to be effective in controlling brinjal shoot and fruit borer although spinosad was the most effective. Minimum shoot damage and maximum protection was provided by spinosad (libsen 45SC) which was followed by carbosulfan (advantage 20 EC) and imidacloprid (impale 20 SL). Similarly, minimum fruit damage and maximum protection was also provided by spinosad but in contrast with shoot damage, imidacloprid was found comparatively effective than carbosulfan although the difference was insignificant. Moreover, minimum fruit loss and maximum protection was provided by spinosad which was followed by imidacloprid and carbosulfan. Therefore, all the insecticides were found significantly effective in comparison with that in the water-treated control regarding shoot and fruit damage as well as fruit losses caused by *L. orbonalis*. In conclusion, the comparative efficacies of the selected insecticides were spinosad, imidacloprid, carbosulfan to protect shoot and fruit damage of brinjal caused by *L. orbonalis*.

Mahata *et al*. (2014) [16] conducted a field evaluation of new diamide and other insecticides against *Leucinodes orbonalis* Guenee in brinjal revealed that flubendiamide 30 g a.i. ha-1 was superior over other treatments recording the lowest shoot (2.65%) and fruit (14.07%) infestation followed by chlorantraniliprole 27.25 g a.i. ha-1 (2.77% shoot, 15.33% fruit infestation), flubendiamide 20 g a.i. ha-1 (3.43% and 15.85%), chlorantraniliprole 18.5 g a.i ha-1 (3.76%, 16.78%), indoxacarb 72.5 g a.i. ha-1 (3.96% and 17.18%) and thiamethoxam 62.5 g a.i. ha-1 (6.62% and 26.75%), respectively. Flubendiamide 30 g a.i. ha-1 recorded the highest marketable fruit yield of 156.25 q ha-^{1}.

Devi *et al*. (2014) [11] conducted field experiments were conducted during 2012-2013 at Indira Gandhi Krishi Viswavidayalaya, Raipur (C. G.), India to evaluate the efficacy of seven insecticides, i.e., Emamectin benzoate 5SG @ 125 g/ha, Spinosad 45SC @ 160 ml/ha, Profenophos50EC @ 1000 ml/ha, Rynaxypyr 20EC @ 400ml/ha, Deltamethrin 1% + Triazophos 35%EC @ 2000 ml/ha, Acephate 75SP @ 666.66 g/ha Carbosulfan 25EC @ 875 ml/ha and untreated control, against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. The obtained results indicated that the

insecticide Rynaxypyr 20 EC @ 400 ml/ha was effective and significantly superior over other treatments in controlling shoot and fruit borer incidence.

Kaur *et al.* (2014) [14] determined the baseline susceptibility of second instar larvae of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee to novel insecticides and biopesticide viz. emamectin benzoate, indoxacarb, spinosad, chlorantraniliprole and delfin for the populations collected from three different locations viz. Amritsar, Malerkotla and Hoshiarpur of Punjab state. LC50 values obtained for different locations ranged between 0.061-1.6 ppm. Emamectin benzoate showed highest toxicity against *L. orbonalis* for Amritsar and Malerkotla populations with LC50 values 0.49 and 0.061 ppm respectively followed by chlorantaniliprole, indoxacarb, delfin and spinosad. However in Hoshiarpur population there was not any appreciable difference between the LC50 values of emamectin benzoate and indoxacarb. The toxicity ratios of emamectin benzoate for Amritsar, Malerkotla and Hoshiarpur populations were 3.26, 6.72 and 3.37 respectively. Baseline toxicity of these new insecticides will be helpful in understanding the level of resistance developed by this pest in future.

Samota *et al.* (2014) [25] evaluated the bio-efficacy of newer insecticides and bio-pesticides against shoot and fruit borer, *Leucinodes orbonalis* in brinjal crop revealed that acephate (0.05%) proved most effective resulting in minimum infestation of pest on shoots as well as fruits followed by indoxacarb (0.005%), while *Btk* (1 l/ha) was found least effective followed by diflubenzuron (0.02%) and spinosad (0.01%). The remaining insecticides viz., cartap hydrochloride (0.1%) and endosulfan (0.05%) were found moderately effective. The maximum fruit yield (220.25 q/ha) was obtained in the plots treated with acephate followed by indoxacarb (214.25 q/ha), whereas minimum was in *Btk* (182.65 q/ha) followed by diflubenzuron (186.78q/ha) and spinosad (190.74 q/ha).

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