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Efficacy of synthetic insecticides and natural products against *Leucinodes orbonalis* Guen. infesting brinjal shoots and fruits.

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Abstract

Emamectin, spinosad and thiacloprid seems to be quite effective against Leucinodes orbonalis on the perusal of these findings. However, the investigations differed from location to location and were also dependent on the environmental factors which are also variable. These three insecticides have managed the pest in a very effective manner as has been observed from the findings of mentioned authors.. Therefore, it can be concluded that emamectin, spinosad and thiacloprid can be recommended for effective suppression of this serious pest of brinjal which causes extensive damage to crop in our country. Natural products like EPN and plant extracts particularly neem oil/ extract has great potential to be used against this pest. However more is still to investgated on the efficacy, their stability and shelf life enhancement (Plant extracts and EPNs for use under field conditions)

Key words: *Emamectin* **;***Leucinodes orbonalis; spinosad; thiacloprid; suppression; EPN; natural products*

Introduction

Brinjal crop is attacked by more than 70 species of insect pests (Subbaratnam, 1982). The insects attacking egg plant include fruit and shoot borer (*Leucinodes orbonalis* Guen.), leaf hopper (*Amrasca biguttula biguttula* Ishida), spotted beetle (*Henosepilachna vigintiopunctata* Fab.), stem borer (*Euzophera perticella* Ragonot), aphid (*Aphis gossypii* Glover), white fly (*Bemisia tabaci* Gennadius) and non-insect pests red spider mite(*Tetranychus macfurlanei* Baker and Pritchard) etc. (Vevai, 1970) and yield losses of the crop to the extent of 70-92% have been observed (Chakraborti & Kanti, 2011). The damage of the crop by caused by shoot and fruit borer (*Leucinodes orbonalis*) is a matter of great concern to the farmers throughout the year. Single egg is laid by female insect on lower side of the buds, leaves, tender parts and flowers (Taley et al.,

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1984; Alpuerto, 1994; CABI, 2007). During vegetative stage of the crop, larvae after hatching bore through nodal region into growing tips of young shoots (Pradhan, 1969) and feed on outer portion of the stem in circular manner causing 12-16% damage to shoots (Maureal et al., 1982). During humid and warm conditions more than 95% damage was inflicted by the pest in India and 90% in Bangladesh (Naresh et al., 1986). The flower buds and young fruits are pierced by larvae which make holes around the calyx in the reproductive phase of brinjal crop (Butani & Verma, 1976) and cause damage to the tune of 20-60% (Maureal et al., 1982) there by reducing the market value and consumption of the fruits (Shaukat et al., 2018). Field data showed that first three instars of larvae cause higher damage in the half-opened flowers (Sandanayake & Edirisinghe, 1992). The infestation by this pest has also been reported to cause reduction in the 'Vitamin C' content up to 68% (Hemi, 1955). The larvae after completing their larval instar fall down to the ground and their pupation takes place on the dried leaves or inside the soil (Shaukat, et al., 2018) which take a day to finally enter into the pupal stage as per the laboratory observations (Sandanayake & Edirisinghe, 1992). Growers rely heavily on chemical pesticides to protect their brinjal crop. The cost of production in brinjal has increased by the ample use of pesticides. Total share of the pesticide cost in brinjal production was found to be as high as 55% in Philippines (Orden et al., 1994) and many farmers refused to grow brinjal due to this escalating cost (Gapud & Canapi, 1994). The losses caused by various pests to brinjal crop can be avoided by adopting proper pest control tactics. Due to the non-judicious use of chemicals on crop, environment and human health is negatively affected, food production becomes more expensive and many pest species developed resistance (Natekar et al., 1987; Harish et al., 2011).

Efficacy of new chemical insecticides against *Leucinodes orbonalis* infesting brinjal shoots and fruits:

Stanley *et al*. (2007) had observed emamectin 5 SG with 10g a.i./ha dosage to be more efficient in suppressing brinjal fruit borer infestation than emamectin 5 SG 8.75 & 7.25g active ingradient per hectare (g a.i. ha^{-1}), profenophos 50 EC 750g a.i./ha and h-cyhalothrin 5 EC 30g a.i./ha. Similarly Anil & Sharma (2010) observed emamectin benzoate (0.002%) to be better in bringing brinjal shoot attack to lowest level of shoot droppings per plant followed by endosulfan (0.05%) , novaluron (0.01%), lambda cyhalothrin (0.004%), spinosad 0.0024%. Deltamethrin and emamectin benzoate also showed superiority in reducing brinjal fruit infestation over endosulfan, agro spray oil T (0.2%) and spinosad, out of the evaluated new molecules viz. emamectin benzoate 5 SG (200 g ha^{-1}),

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profenophos 50 EC (2000 ml ha^{-1}), rynaxypyr 20 EC (150 ml ha^{-1}), pyriproxyfen 10 EC (500 ml ha^{-1}), diafenthiuron 50WP (600 g ha^{-1}) and pyriproxyfen 5 EC + fenpropathrin 15 EC (500 ml ha^{-1}) against this insect pest, Pachori *et al*. (2013) recorded that emamectin benzoate 5 SG treated plots were less infested, preceded by rynaxypyr. Emamectin benzoate 5 SG (10g a.i. ha^{-1}) treated plot was least infested by the pest in comparison to pyriproxyfen 10 EC + fenpropathrin 15 EC (500 ml ha^{-1}) rynaxypyr 20 EC (30g a.i. ha^{-1}), diafenthiuron 50 WP (300g a.i. ha^{-1}), pyriproxyfen 10 EC (50g a.i. ha^{-1}) which was significantly lower than untreated plot (Patel, 2013). Similarly lower infestation of shoot and fruit borer treated with emamectin benzoate, than cypermethrin , fenvalerate, spinosad, profenophos, chlorpyrifos and untreated control was observed by Anwar et al. (2015). Emamectin benzoate 25 WG at 11 g a.i. ha^{-1} doage was very impressive against this pest and gave higher harvest of fruits (23.61 t.ha-1) than spinosad 45 SC 75g a.i.ha^{-1} (20.83 t ha-1) but its efficacy was lower than chlorantraniliprole 20 SC 40g a.i./ha (27.08 t ha-1) (Kameshwaran & Kumar, 2015). Yousafi *et al*. (2015) also observed the higher efficiency of emamectin in reducing *L. orbonalis* damage on shoots during spring and winter season than chlorantraniliprole and spinosad, respectively. In spring, emamectin benzoate treated fruits were least damaged by this pest followed by spinosad and chlorantraniliprole. While in winter season spinosad treatment was most effective with less fruits damage than Chlorantraniliprole and emamectin. Chlorantraniliprole 18.5SC and acephate 75 SP had shown their superiority over all tested insecticides in reducing pest incidence. Moderate control in managing the pest population was shown by emamectin benzoate 5 SG, cartap hydrochloride 50 SP and indoxacarb 14.5 SC treatment, whereas malathion 50 EC and spinosad 45 SC were least effective (Baddhri, 2016). Emamectin benzoate 5 SG at 10g a.i. ha^{-1} was obseved to be highly efficient in reducing brinjal fruit infestation followed by emamectin benzoate 3.7% + diafenthiuron 46.3% WP at 9.25+115.75g a.i ha^{-1}, emamectin benzoate 3.7% + diafenthiuron 46.3% WP at 7.40+92.60 g a.i/ha^{-1}, emamectin benzoate 3.7% + diafenthiuron 46.3% WP at 5.60+69.45g a.i. ha^{-1}, diafenthiuron 50% WP @ 300g a.i ha^{-1} and lambda cyhalothrin 5 EC 600g a.i. ha^{-1} (Pawar, 2016). Similar observations were reported by Singh *et al*. (2016) where emamectin benzoate 5 SG applied at 12.5g a.i. ha^{-1} showed lowest infestation of pest succeeded by flubendiamide 480 SC at 90g a.i. ha^{-1}, novaluron 10 EC at 100g a.i. ha^{-1}, indoxacarb 14.5 SC 50g a.i. ha^{-1}, spinosad 45 SC 73 g a.i. ha^{-1}, fipronil 5 SC at 100 g a.i.ha^{-1}, dimethoate 30 EC 1 lit ha^{-1}, imidacloprid 17.8 SL 50 g a.i. ha^{-1} and abamectin 1.9 EC 14.4 g a.i. ha^{-1}, respectively. Spinosad 45 SC @ 225g a.i.ha^{-1} showed its superiority in reducing infestation of *L. orbonalis* on fruits, whereas

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oxymatrine 1.2 EC 0.2% on shoots among the evaluated different plant products and microbial formulations (Adiroubane & Raghuraman, 2008). Patra *et al.* (2009) obseved spinosad 2.5 SC at 50g a.i. ha^{-1} to be more efficient in reducing the attack of fruit and shoot borer than emamectin benzoate 5 SG 15g a.i. ha^{-1} and Indoxacarb 14.50 SC 50g a.i. ha^{-1}. Nayak *et al.* (2011) recorded lower infestation (2.3 & 8.3%) of pest on shoots and fruits after spinosad treatment than flubendiamide, fipronil, indoxacarb and cartap hydrochloride, however, rynaxypyr was the best treatment. These results were also in agreement to the observations by Kalawate & Dethe (2012) when they evaluated spinosad (56.25, 72 and 90g a.i.ha^{-1}), emamectin benzoate (5, 6.25 & 12.5g a.i.ha^{-1}) as compared to 50g a.i. ha^{-1} cypermethrin, and 5% extract of neem.They found spinosad (72g a.i. ha^{-1}) to be the most effective insecticide in controlling BSFB infestation. Devi, (2013) also reported spinosad 45 SC at160ml/ha dosage to be more effective in reducing infestation of *L. orbonalis* on shoots and fruits than emamectin benzoate 5SG 125gha^{-1}. Their findings also had similarity to those of Nayak *et al.* (2011) where rynaxypyr 20 EC (400ml ha^{-1}) was the best chemical in controlling this pest. According to observations of Ghosal (2013) after fipronil application, less infestation of *Leucinodes orbonalis* on brinjal shoots and fruits, respectively was observed followed by carbosulfan 25 EC, indoxacarb 14.5 SC, novaluron 10 EC and thiamethoxam 25 WG. However, they recorded rynaxypyr 18.5 SC and flubendiamide to be highly efficient among all evaluated insecticides. Devi *et al*. (2014) reported that after spinosad 45 SC applied at 50g a.i. ha^{-1}) application there was less damage by pest to fruits and shoots than emamectin benzoate 5 SG 12g a.i.ha^{-1} and far less in comparison to untreated plot. As per the report of Mahata *et al*. (2014) new diamide insecticide flubendiamide 30g a.i. ha^{-1} was highly effective against *L. orbonalis* than chlorantraniliprole 27.25g a.i. ha^{-1}, flubendiamide 20g a.i. ha^{-1} chlorantraniliprole 18.5g a.i ha^{-1}, indoxacarb 72.5g a.i. ha^{-1} and thiamethoxam 62.5g a.i. ha^{-1}. Furthermore, Mainali *et al*. (2015) findings showed less infestation of *L. orbonalis* on fruit weight and number basis treated with spinosad 45 SL at a dose 0.25 ml lt^{-1} insecticide than tozen, abamectin, borer gourd at dose 2 ml lt^{-1}, karanjin 2 EC at 2ml lt^{-1} and emamectin benzoate. Their findings also showed similar trend to those of Nayak *et al*. (2011); Devi (2013) where chlorantraniliprole 18.5 EC applied at a dose 0.25 ml lt^{-1} to the crop recorded less infestation by the pest. Thiacloprid insecticide had superiority in reducing the infestation of pest on fruits , based on number and weight, respectively whereas, chloropyriphos + cypermethrin was most effective on shoots infestation out of the evaluated insecticides viz. thiacloprid, chloropyriphos + cypermethrin, cyhalothrin and neem based

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insecticides (Rahman, 2015). Spinosad 45 SC at 0.1ml lt^{-1} dosage was found to be highly efficient insecticide in suppressing borer attack as compared to emamectin benzoate 5 SG and thiacloprid 240 EC whereas, flubendiamide 480 SC @ 0.1ml/lit and cyantranilprole 10 OD @ 0.3ml lt^{-1} was found to be the most effective than the tested chemicals (Sajjan & Rafee, 2015). Singh *et al*. (2016) observed lowest infestation of pest on brinjal after fipronil 5 SC @ 100g a.i. ha^{-1} treatment than dimethoate 30 EC 1lit ha^{-1}, imidacloprid 17.8 SL 50g a.i. ha^{-1} and abamectin 1.9 EC @ 14.4g a.i. ha^{-1}, respectively. As per the report of Niranjana *et al*. (2017) low damage to brinjal shoots and fruits by *L. orbonalis* on was recorded after spinosad 2.5 SC treatment than flubendiamide 20 WG applied at 0.75g lt^{-1}, imidacloprid 17.8 SL 0.3ml lt^{-1}, thiacloprid 21.7 SC at 2ml lt^{-1} dosage, thiodicarb 75 WP 2g lt^{-1}, emamectin benzoate 5 SG 0.4g lt^{-1}, diafenthiuron 50WP 0.8g lt^{-1}, chlorpyrifos 20EC 1ml lt^{-1} and dimethoate 30EC 0.7ml lt^{-1}. Their findings also had similarity to those of Nayak *et al*. (2011); Devi (2013); Mainali *et al*. (2015) where chlorantraniliprole 18.5 SC at 0.4ml/lt dosage recorded less infestation by pest while thiacloprid treatment had shown less shoot infestation (18.3%) than diafenthiuron 50 WP applied at 0.8g lt^{-1} and emamectin benzoate 5 SG @ 0.4g lt^{-1} whereas, less fruit infestation was recorded in emamectin benzoate 5 SG @ 0.4g lt^{-1} treatment than thiacloprid and diafenthiuron. Sanghamitra *et al*. (2018) observed that thiacloprid 21.7 SC w/w applied at 180 g a.i ha^{-1} reduced *L. orbonalis* infestation on brinjal shoots and fruits over untreated control in two seasons while combination product of flubendiamide 24% + thiacloprid 24% SC w/v sprayed at 84 + 84 g a.i ha^{-1} provided higher relief from pest.

Efficacy of EPN against *Leucinodes orbonalis*

The EPN isolate (PDBC EN 3.1 of S. bicornutum, PDBC EN 6.11 from *S. carpocapsae* and PDBC EN 13.3 from *H. indica* at 50 IJ $larva^{-1}$ caused maximum mortality of *Leucinodes orbonalis* after an exposure period of 48-72hrs under in vitro conditions. Under field conditions, preliminary trial with EPN isolate indicated that infestation of shoot and fruit borer decreased on fruits with the increase in concentration of IJ $larva^{-1}$ dose and out of two isolates species (PDBC EN 6.11 from *S. carpocapsae* and PDBC EN 6.71 from *H. indica*) PDBC EN 6.11 (*S. carpocapsae*) were found to be more effective in reducing the pest infestation than PDBC EN 6.71 (*H. indica*) (Hussaini *et al*., 2002).

Efficacy of *Azadirachta* against *Leucinodes orbonalis*

Among the evaluated ten plant products (Leaf extract of *Azadirachta indica A. Juss*. 5.0%, *Lantana camara* Linn. 5.0%, *Calotropis gigantean*. R. Br. 5.0%, *Pongamia glabra* Linn. 5.0%, *Prosopis*

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juliflora Linn. 5.0%, *Vitex negundo* L. 5.0%, garlic extract 5.0%, neem cake extract 5.0%, nimbecidine ® 2ml/lit and neem oil 2.0%) with the carbaryl 0.1% standard check and untreated control the neem oil, nimbecidine, neem cake extract and *C. gigantean* plant extract was found to reduce the infestation of Leucinodes orbonalis by more than 50% on shoots of brinjal crop during kharif. Neem oil and nimbecidine were found to give consistent effects in Kharif and Rabi crops, respectively. However plant products were moderately effective in suppressing the infestation of this pest on fruits (Murugesan & Murugesh, 2009). NSKE at a dosage 5g a.i. ha^{-1} was highly efficient in reducing the damage by fruit and shoot borer in egg plant over untreated control. It was followed by NSKE 1.25g a.i. ha^{-1}, NSKE 2.50g a.i. ha^{-1}, monocrotophos 126g a.i. ha^{-1}, adjuvants applied at 0.05g a.i. ha^{-1} and commercial neem 0.2g a.i. ha^{-1} (Mandal *et al*. 2010). Tayde & Simon (2010) evaluated the efficacy of carbaryl 50 WP at 0.2%, imidacloprid 17.8 SL at 0.004%, endosulfan 35 EC at 0.05%, quinolphos 25 EC at 0.05%, spinosad 45 SC at 0.01% doses, neem oil 1% and neem seed extract 5% against *L. orbonalis* infesting brinjal., Spinosad treated fruits and shoots (on number and weight basis) were less infested (9.84, 6.87 and 7.35%) among the all treatments. Neem seed extract 5% treated shoots and fruits (on number and weight basis) were less infested than 1% neem oil. Ashadul *et al*. (2014) reported that extract from neem leaves provided highest control of *L. orbonalis* infestation over control on shoots and fruits of brinjal, followed by tobacco leaf extract, aktara 25 WG, mahogany seed extract, at leaf extract, bon kolmi leaf extract, and tamarind fruit extract, respectively. Singh & Sachan (2015) observed neemarin (neem oil) at a dose 3 lit ha^{-1} to be more successful in bringing down the damage of the borer on fruits and shoots of brinjal as compared to *Bacillus thuringiensis*, *Beauveria bassiana*, neemarin-Bt-Bb and Bt-Bb-Bt. While spinosad 45 SC applied at 200 ml ha^{-1} were observed to be most compelling among all treatments succeeded by chlorpyriphos 20 EC at 1 lit ha^{-1}. Kolhe *et al*. (2017) evaluated the efficacy of some chemicals and neem products on *L. orbonalis* ravaging brinjal. Their observations showed that carbosulfan 25 EC with sprayed 0.05% conc. on eggplant, shoots and fruits were less infested than all other treatments, supervened by quinolphos 20 EC application at 0.05%, cypermethrin 25 EC 0.05% , chlorpyriphos 20 EC 0.05% , neem oil 2% , NSKE 5% and extract from neem leaves 5% , respectively. Kumar & Thakur (2017) observed that cypermethrin 10 EC at a dose of 2ml/l treated brinjal shoots and fruits were less infected by the *L. orbonalis* succeeded by pungamia oil 2%, illuppai oil 2%, NSKE 5% , neem oil 2% , extract of neem leaves, *Beauveria bassiana* and untreated, respectively. Sureshsing & Tayde (2017) recorded less infestation of

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Leucinodes orbonalis on shoots and fruits of brinjal crop after application of spinosad 45 SC at 0.05 ml lt^{-1} succeeded by cypermethrin 25 EC 2ml lt^{-1}, neem oil 20ml lt^{-1}, NSKE 50 gm lt^{-1}, pongamia oil 30ml lt^{-1}, garlic bulb extract 50ml lt^{-1}, neem leaf extract 50ml lt^{-1} and untreated control respectively.

Conclusion:

Emamectin, spinosad and thiacloprid seems to be quite effective against *Leucinodes orbonalis* on the perusal of these findings. However, the investigations differed from location to location and were also dependent on the environmental factors which are also variable. These three insecticides have managed the pest in a very effective manner as has been observed from the findings of mentioned authors.. Therefore it can be concluded that emamectin, spinosad and thiacloprid can be recommended for effective suppression of this serious pest of brinjal which causes extensive damage to crop in our country. Natural products like EPN and plant extracts particularly neem oil extract has great potential to be used against this pest. However more is still to be investigated on the efficacy, their stability and shelf life enhancement (Plant extracts and EPNs for use under field conditions)

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