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Compatibility of selected biorational pesticides with the predatory arthropods in brinjal ecosystem

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Abstract

Susceptibility of three predatory arthropods namely Asian lady beetle, *Harmonia axyridis* (Pallas), lynx spider, *Lycosa pseudoannulata* (Boescriberg and Strand), and wolf spider, *Oxyopes javanus* (Thorell) to four commonly used biorational molecules viz. buprofezin, spinosad, emamectin benzoate and abamectin were determined in a brinjal ecosystem. Biorational pesticides were applied singly and in some selected combinations and their toxicity on the predators was recorded up to three sprayings in a confined habitat. Buprofezin caused no significant mortality of predators (2.87%, 0.32%, 0.96% mean mortality per spray of Asian lady beetle, lynx spider, and wolf spider respectively) and was found most compatible among the biorational molecules. However, other three tested molecules were found highly toxic for all predatory natural enemies when applied singly or in combination with buprofezin. Spinosad was most toxic for Asian lady beetles (21.84% mean mortality per spray) and lynx spiders (15.32 % mean mortality per spray) whereas abamectin (17.78% mean mortality per spray) for wolf spiders. It was observed that the number of spraying was very crucial and had a proportionate relationship with the mortality percentage of predators. Based on this study it is suggested that buprofezin could be considered to incorporate safely in the IPM program for brinjal pest management.

Introduction

Eggplant (*Solanum melongena* L.) is one of the most admired and economically important vegetables in South Asia and cultivated worldwide in more than 1,600,000 ha land and production is 50 million Mt per annum (FAO, 2012). In Bangladesh, it is cultivated in both rabi (winter) and kharif (summer) seasons having an annual production of 0.45 million Mt (BBS, 2015). Brinjal is prone to attack of many insect pests throughout its life cycle in the field. Brinjal shoot and fruit borer is the key pest in almost all brinjal producing countries particularly in Bangladesh, where the hot and humid climatic conditions favor the reproduction and incidence of this notorious pest (Chakraborty and Sarkar, 2011; Srinivasan, 2009). The neonate larvae bore into tender shoots at the vegetative stage and flowers and fruits at the reproductive stage of plants, causing a yield loss of up to 85 to 90 percent (Misra, 2008; Yousafi *et al.*, 2015). Moreover, many sucking pests of brinjal like jassid *(Amrasca bigutulla bigutulla*), whitefly (*Bemisia tabaci*), aphid (*Aphis gossyppii*), and spider mite (*Tetranychus cinnabarinus*) also cause significant loss of brinjal production by sucking cell sap from plant tissue and consequently reducing the vigor and vitality of plants (Latif *et al*., 2009). Some sucking pests like aphid, jassid, and whitefly also act as vectors of different viral plant diseases (Srinivasan, 2009).

Farmers usually rely on the application of different chemical pesticides for controlling the insect pests of brinjal. Being a vegetable crop, use of these pesticides leaves considerable toxic residues on brinjal fruits which cause serious health hazards. In addition, all these synthetic pesticides adversely affect the natural enemies i.e. predators, parasitoids, and pathogens in the brinjal ecosystem (Desneux *et al.*, 2007). To combat such problems, in the recent years, farmers are encouraged to use different biorational pesticides which pretend to be more target specific and safer for the natural enemies and environments (Chakraborty and Sarkar, 2011; Islam *et al.*, 2016).

Spinosad, a derivative of the soil actinomycete (*Saccharopolyspora spinosa*), is the most widely used biorational pesticide against brinjal shoot and fruit borer (Orr *et al.*, 2009). Emamectin benzoate is another biorational molecule which is also effective for controlling BSFB (Islam *et al.*, 2016). Buprofezin, an insect growth regulator which acts as a potent chitin synthesis inhibitor, has been reported to be effective against the sucking pest complex in brinjal (Das and Islam, 2014). Abamectin is a bacterial fermented biopesticide derived from the soil bacterium *Streptomyces avermitilis* and widely used for controlling spider mites (Ismail *et al.*, 2007).

Thousands of reports are available on the efficacy of these biorational molecules against the insect pests of brinjal, however, the safety of these pesticides to the predatory arthropods in the brinjal ecosystem are rarely investigated. In the current study, the compatibility of four commonly used biorational molecules viz. buprofezin, emamectin benzoate, abamectin, and spinosad with three prevailing predators namely Asian lady beetle, lynx spider, and wolf spider was evaluated in a brinjal ecosystem. The multicolored Asian lady beetle, *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) is a very effective predator of many soft-bodied pests of brinjal like aphid, jassid, whitefly, and spider mite (Koch, 2003). Both the Lynx spider, *Oxyopes javanus* (Thorell) (Araneae: Oxyopidae) and wolf spider, *Lycosa pseudoannulata* (Boescriberg and Strand) (Araneae: Lycosidae) are generalist predators and play significant roles in the biological control of aphids, jassids, moths, and thrips (Rajeswaran *et al.*, 2005). In the present study, selected biorational pesticides were evaluated solely as well as in some chosen combinations, as farmers usually apply a cocktail of pesticides to combat the pest complex viz. lepidopteran borer, plant suckers, and mite pests in the brinjal field.

Materials and Methods

The study was conducted in the field laboratory of the Department of Entomology at Bangladesh Agricultural University, Mymensingh, Bangladesh, during winter 2016. The study consisted of eight treatments using four biorational pesticides either solely or in selected combinations. Treatments were: T_1-Suspend 5 SG (Emamectin Benzoate) @ 1g/L, T_2- Benten 1.8 EC (Abamectin) @ 1mL/L, T_3- Libsen 45 SC (Spinosad) @ 1mL/L, T_4- Award 40 SC (Buprofezin) @ 1mL/L, T_5-Award 40 SC (1mL/L) + Suspend 5 SG (1 g/L), T_6-Award 40 SC (1mL/L) + Benten 1.8 EC (1 mL/L), T_7-Award 40 SC (1 mL/L) + Libsen 45 SC (1 mL/L), T_8-Untreated control. The experiments were carried out in a randomized complete block design with three replications for each treatment.

The experimental field was divided into 3 identical blocks having 8 equal plots in each. The size of the individual plot was 2.5 m × 2 m. Amjhuri, a local brinjal cultivar of Mymensingh, was selected for the experiment. Healthy and disease free seedlings were collected at three to four-leaf stages from the local nursery and transplanted on raised beds followed by a light irrigation immediately to withstand transplanting shock. Seedlings were planted in each plot keeping 80 cm and 60 cm plant to plant and row to row distances, respectively and the plots and replications were separated by a non-cropped area of 1 m. All the intercultural operations like weeding, mulching, irrigation were done properly as and when necessary. Chemical fertilizers were applied at the rate of 100-75-75 kg/ha of N, P, and K, respectively. Each plot was covered with mosquito nets at the time of fruit set for ensuring a confined habitat for the existing natural enemies.

The population of Asian lady beetle, lynx spider, and wolf spider in each plot were recorded before treatment application. Biorational pesticides were sprayed in the morning using a knapsack sprayer equipped with a hollow cone nozzle operated at 16 bar pressure. Three sprayings were given at 12 days intervals and the mortality of the predators was recorded at 3, 5, and 10 days after each spraying. Mortality of predators was calculated from the unit plot using the following formula:

$$\%\text{mortality} = \frac{\text{Total number of dead predator after spraying}}{\text{Number of predator before spraying}} \times 100$$

Finally, the mean percentage of mortality of predators was calculated for each of the treatment from three replicated plots. The recorded data were analyzed by the analysis of variance and the mean separation among the treatments was done by calculating least significant difference at 5 % probability to decide the significance of individual treatment effect.

Results

Toxicity of biorational molecules on the Asian lady beetle

After first spraying, the highest amount of dead lady beetles was recorded in spinosad treated plots (10.34%) and the lowest was in buprofezin (1.46%) treated plots (Table 1). No mortality was observed in control plots. For all treatments, mortality of lady beetle increased proportionately with the number of spraying. After third spraying, percent mortality of lady beetles was approximately three times higher than first spraying in most of the treated plots (Table 1). Considering the percentage of mean mortality per spraying, spinosad (21.84%) was the most toxic pesticide for lady beetle which was closely followed by buprofezin + spinosad (20.25%), whereas buprofezin (2.87% mortality) was the safest molecule.

Table 1. Toxicity of different biorational molecules on the Asian lady beetle

Treatments	% Mortality ± SEM			
	1st spray	2nd spray	3rd spray	Cumulative mean mortality
Emamectin benzoate	7.88±0.25 c	16.18±0.19 c	22.92±0.34 c	15.66±4.34 abc
Abamectin	7.34±0.23 cd	15.55±0.2 c	21.10±0.1 d	14.66±4.00 abc
Spinosad	10.34±0.23 a	20.19±0.31 b	34.99±0.28 a	21.84±7.16 a
Buprofezin	1.46±0.36 e	2.87±0.06 f	4.29±0.12 f	2.87±0.67 d
Buprofezin + Emamectin benzoate	7.66±0.39 cd	13.05±0.37 d	21.68±0.61 d	14.13±4.08 bc
Buprofezin + Abamectin	6.89±0.75 d	10.83±0.25 e	19.87±0.13 e	12.53±3.84 c
Buprofezin + Spinosad	9.44±0.11 b	21.69±0.16 a	29.62±0.38 b	20.25±5.90 ab
Untreated control	0.00 f	0.00 g	0.00 g	0.00 d
LSD $_{0.05}$	0.773	0.643	0.962	7.44

Values followed by different letters in columns are significantly different (LSD; P > 0.05).

Toxicity of biorational molecules on the lynx spider

Among the treatments, the highest percent mortality after first spraying was recorded in buprofezin + abamectin (7.06%) treated plots and the lowest was in emamectin benzoate (3.53%) treated plots (Table 2). Percent mortality of lynx spider increased tremendously with repeated exposure to all pesticides except buprofezin, resulting in three to four times mortality after third spraying compared to the first one. However, no mortality was recorded in control treatment and only 0.96% dead spiders were found after third spraying in buprofezin treated plots which was the least toxic molecule for lynx spider. Considering mean mortality per spray, all the biorational molecules excluding buprofezin showed close toxicity to lynx spiders causing 11.99 to 15.32% mortality.

Table 2. Toxicity of different biorational molecules on the lynx spider

Treatments	% Mortality ± SEM			
	1st spray	2nd spray	3rd spray	Cumulative mean mortality
Emamectin benzoate	3.53±0.20 e	11.96±0.04 cd	20.48±0.48 d	11.99±4.89 a
Abamectin	5.31±0.18 d	14.18±0.51 b	22.54±0.24 bc	14.01±4.97 a
Spinosad	6.43±0.16 b	15.55±0.6 a	23.98±0.19 a	15.32±5.07 a
Buprofezin	0.00 f	0.00 e	0.96±0.12 e	0.32±0.32 b
Buprofezin +Emamectin benzoate	5.16±0.16 d	12.60±0.31 c	22.35±0.25 c	13.37±4.98 a
Buprofezin + Abamectin	7.06±0.03 a	11.38±0.2 d	23.83±0.55 a	14.09±5.02 a
Buprofezin + Spinosad	5.78±0.10 c	11.10±0.3 d	23.44±0.47 ab	13.44±5.23 a
Untreated control	0.00 f	0.00 e	0.00 f	0.00 b
LSD $_{0.05}$	0.418	0.969	0.913	7.02

Values followed by different letters in columns are significantly different (LSD; P > 0.05).

Toxicity of biorational molecules on the wolf spider

Toxicity of biorational molecules towards wolf spider was in the following order abamectin > buprofezin + abamectin > spinosad > buprofezin + emamectin benzoate > buprofezin + spinosad > emamectin benzoate > buprofezin. Besides treatment, the number of spraying was found as a key factor influencing percent mortality of wolf spiders i.e. the highest mortality was found after third spraying in all pesticide-treated plots which was followed by second and first spraying, respectively (Table 3). Regarding mean mortality per spray, abamectin was found to be the most toxic molecule for wolf spider causing 17.78% mortality and buprofezin was least toxic causing only 0.6% mortality. No dead wolf spider was recorded in control plots.

Table 3. Toxicity of different biorational molecules on the wolf spider

Treatments	% Mortality ± SEM			
	1^{st} spray	2^{nd} spray	3^{rd} spray	Cumulative mean mortality
Emamectin benzoate	3.22±0.06 e	8.09±0.09 e	22.68±0.19 b	11.33±5.85 a
Abamectin	8.31±0.55 a	17.5±0.26 a	27.53±0.25 a	17.78±5.55 a
Spinosad	6.09±0.34 bc	12.44±0.29 c	21.66±0.67 bc	13.48±4.52 a
Buprofezin	0.00 f	0.00 f	1.8±0.15 d	0.6±0.6 b
Buprofezin + Emamectin benzoate	5.65±0.10 c	12.33±0.24 c	21.23±0.59 c	13.07±4.51 a
Buprofezin + Abamectin	6.66±0.17 b	15.42±0.18 b	21.33±0.14 c	14.47±4.26 a
Buprofezin + Spinosad	4.79±0.15 d	10.00±0.32 d	21.27±0.40 c	12.02±4.86 a
Untreated control	0.00 f	0.00 f	0.00 e	0.00 b
$LSD_{0.05}$	0.679	0.572	1.032	6.921

Values followed by different letters in columns are significantly different (LSD; $P > 0.05$).

Discussion

Use of pesticides is the common and easiest way of controlling insect pests of brinjal (Srinivasan and Huang, 2009). Although IPM programs are recommended to produce blemish-free brinjal fruits, it cannot substitute the use of pesticides, which put a spotlight on the use of environmentally safe biorational pesticides (Mandal *et al.*, 2008). However, the compatibility of frequently used biorational pesticides with the natural enemies in brinjal ecosystem is still a matter of controversy.

In the present study, the susceptibility of three predators namely Asian lady beetle, lynx spider, and wolf spider to some frequently used biorational pesticides in brinjal was evaluated and found that only buprofezin could be considered as utterly compatible with these biocontrol agents as it caused a negligible percentage of predators' mortality. The mortality caused by buprofezin (2.87%, 0.32%, 0.96% mean mortality of Asian lady beetle, lynx spider, and wolf spider, respectively) in the current study are in agreement with Cabral *et al.* (2008) who found that the adult survival, fecundity, and the percentage of egg hatching of *Coccinella undecimpunctata* were not significantly affected by buprofezin. These results are also consistent with the findings of Deng *et al.* (2008) who reported very lower toxicity of buprofezin to wolf spiders under laboratory conditions. Nevertheless, Kumar *et al.* (2012) reported that buprofezin caused 9.00% mortality of coccinellids and 11.52% mortality of spiders after four insecticidal sprays on transgenic cotton.

All other biorational pesticides tested in the present study were found more or less toxic to the predators when applied singly or in chosen combinations. Interestingly, the combined application of buprofezin with other biorational pesticides showed both synergistic and antagonistic actions in different circumstances. For Asian lady beetle, spinosad was the most toxic compound (21.84% mean mortality per spray) which is directly contradictory with the findings of Jalali *et al.* (2009) who reported no lethal effect of spinosad against two-spotted lady beetle, *Adalia bipunctata.* However, the toxicity of spinosad and emamectin benzoate against Asian lady beetle was previously reported by Galvan *et al.* (2005) and Awasthi *et al.* (2013). Toxicity of abamectin against Asian lady beetle (mean mortality 14.66%) in the present study was remarkably lower than 33.3% mortality reported by Youn *et al.* (2003).

Although spinosad is classified as environmentally and toxicologically reduced risk material by the United States Environmental Protection Agency (Williams *et al.*, 2003), it was found highly toxic for lynx and wolf spiders in the present study. The outcomes of the present research work are conflicting with the findings of Karthikeyan *et al.* (2008) who reported no significant harmful effect of spinosad on spider population that predominates the predatory fauna in rice. However, many previous studies documented that spinosad is highly toxic for the natural enemies and it could not be considered to have an environmental safety profile like other established microbial insecticides (Williams *et al.*, 2003, Cisneros, 2002). Results of the present study showed that lynx and wolf spiders were susceptible to the avermectin pesticides (abamectin and emamectin benzoate) which are consistent with several previous studies (Singh *et al.*, 2016).

Based on present findings, it might be concluded that the insect growth regulator buprofezin could be incorporated safely in IPM program with predatory arthropods in the brinjal ecosystem. However, further field experiments are required to evaluate its effect on fecundity, egg hatching, larval and pupal mortality of the natural enemies, as the present study was merely based on the compatibility of adult predators.

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