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Toxicity of botanical and chemical insecticides on stink bug complex (Heteroptera: Pentatomidae) in lablab bean (*Lablab purpureus* Lin.) field

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Abstract
The present study was conducted to findout the prominent control measure for stink bug with least toxicity. Southern green stink bug (*Nezara viridula* L.), brown stink bug (*Euschistus servus* Say) and brown marmorated stink bug (*Halyomorpha halys* Stal) were found during the observation. Abundance of stink bug was counted twice a week. Toxicity of insecticides was determined by counting the number of dead stink bugs in the field just after application of 12 hours. Among the insecticides, Azadirachtin (stored), Azadirachtin (fresh) and Curtap 50 SP reduces the stink bug infestation effectively. Azadirachtin (fresh), Azadirachtin (stored) and Emamectin benzoate 5 SG found least toxic to stink bug resulting 6.09, 24.68 and 30.02% mortality. Results of the study indicated that the botanical Azadiractin along with some chemical insecticides are effective for controlling sting bug infestation and also least toxic and safe for the other insects and environment.

Keywords: Toxicity, Azadirachtin, Insecticide, Stink bug, *Lablab purpureus*

1. Introduction

Stink bugs are (Heteroptera: Pentatomidae) the most common, and most damaging, insect pests in late summer and fall vegetable crops. These are becoming increasingly abundant pests of a variety of crops, including soyabean, cotton and tree fruit [1, 2]. Stink bugs are also significant economic pests of many agricultural crops and have become one of the most difficult pest groups to control in crops such as cotton, soybean, tomato [3]. It does not take many stink bugs to cause a lot of damage in a small planting of beans. There are some species of sting bug which act as predator of legume pod borer (*Helicoverpa armigera*) [4, 5].

There are many species of stink bugs, but all have shield-shaped bodies and most produce a strong, disagreeable odor when handled. Green stink bugs, southern green stink bugs, spotted stink bug and brown stink bugs are the most common species. Brown stink bugs are usually the most abundant species in the spring, with green and southern green stink bugs becoming more abundant in late summer. However, Buntin and Greene [6] have reported an abundance of brown stink bugs in winter wheat. The southern green stink bug, *Nezara viridula* L., is known as a serious plant and fruit pest throughout the tropical, sub-tropical and temperate zones [7]. Brown stink bug [*Euschistus servus* (Say)], southern green stink bug [*Nezara viridula* (L.)], and green stink bug [*Acrosternum hilare* (Say)], are the predominant species in a phytophagous stink bug complex [8].

Stink bug damage varies considerably depending on the crop phenology when attacked and species of plant being fed upon and the stage of development [9]. Stink bugs have piercing-sucking mouthparts, which they use to pierce the peel or hull of fruiting structures and feed on the inner contents. Immature stink bugs, known as nymphs, have the same type mouthparts as adults and feed in the same way. In butter beans, green beans and soyabean, feeding by stink bugs during pod formation may result in deformed seeds and reduced oil yield [9]. Regardless of the crop, stink bug feeding can introduce pathogens and decay organisms at the site of stylet insertion [10], which can cause great damage to the plant. Seed that are damaged when small usually fail to develop. Larger seed will have sunken white or discolored areas where the stink bugs fed. Organophosphates or pyrethroids are the most commonly used insecticides to control stink bugs in most crops [11, 12]. Organophosphates are effective on *Euschistus*, while both organophosphates and Pyrethroids are frequently used to control *Acrosternum* [8].

However, botanicals are also being effectively used for controlling sting bug complex in vegetables. Stink bugs have become more common pests in vegetables, and the frequency of insecticides applied for their control has increased. Therefore, the present study was conducted to find out most effective control agent for stink bug complex and establish base-line insecticide mortality data for future resistance monitoring programs of stink bug complex.

2. Materials and Methods

The present study was carried out at the Research field of Entomology Department in Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. The experiment was laid out in randomized complete block design (RCBD) with three replications. The land was divided into 3 blocks, each block containing 10 plots. Each plot contains only one row with 7 plants per row. The plot size was 5m x 2m and plot to plot distance was 1m and block to block distance was 2m and plant to plant distance was 75 cm. The heat tolerant country bean variety "IPSA Seem 2" was grown following the the recommended practices as described by [13]. The treatments comprised of seven synthetic insecticides, two botanical insecticides application and one untreated control. The treatments were, T_1 = Cypermethrin 10 EC @ 1.0 ml / L water; T_2 = Fenitrothion 50 EC @ 1.0 ml / L water; T_3 = Fenvalerate 20 EC @ 1.0 ml / L water; T_4 = Emamectin benzoate 5 SG @ 1.0 g / L water; T_5 = Deltramethrin 2.5 EC @ 1.0 ml / L water; T_6 = Esfenvalerate 5 EC @ 1.0 ml / L water; T_7 = Curtap 50 SP @ 2.0 g / L water; T_8 = Azadirachtin (fresh) @ 2.5 ml / L water; T_9 = Azadirachtin (stored) @ 2.5 ml / L water; T_{10} = Untreated control.

The synthetic insecticides were collected from the local market of Gazipur; Azadirachtin (fresh) was collected from the Crashing mill located at Kakonhat bazar, Godagari, Chapai Nawabgonj and the 16 month stored Azadirachtin was collected from laboratory of entomology department, Bangabandhu Sheikh Mujibur Rahman Agricultural University. The insecticides were sprayed at 10 days interval from first flowering to last harvest of Lablab bean with the help of knapsack sprayer. Measuring cylinder and balance was used to take the appropriate amount of insecticides for spray solution preparation. Precautions were taken to avoid drift to the adjacent plots. Eight sprays were done during the entire experiment period. For the purpose of counting stink bug species a close monitoring of field was done twice a week through visual search and sweep net and their number per plot was noted. The stink bug species found in the field were southern green stink bug (*Nezara viridula* L.), brown stink bug (*Euschistus servus* Say) and brown marmorated stink bug (*Halyomorpha halys* Stal). For observing the toxicity of botanical and chemical insecticides on stink bug, the number of dead stink bug in the field was observed from just after spray to 24 hours and the number of dead stink bug in each plot was counted to calculate percent mortality.

The collected data were properly compiled, coded, tabulated and analyzed statistically using MSTAT-C software. The means were separated for significant difference using the Duncan's Multiple Range Test (DMRT). Different parameters were measured by utilizing various formulae described bellow:

$$\text{Percent Mortality} = \frac{\text{Number of dead stink bug}}{\text{Total number of stink bug present}} \times 100$$

$$\text{Percent reduction over control} = \frac{\text{Mean value of the control} - \text{Mean value of the treatment}}{\text{Mean value of the control}} \times 100$$

3. Results and Discussion

3.1 Effect of botanical & chemical insecticides on abundance of stink bug in Lablab bean field

Insecticides have prominent effect on the abundance of stink bug in the country bean field as shown in Table 1. In the field, highest number of stink bug was found in untreated control plot (8.44 / plot) which was followed by Fenitrothion 50 EC @ 1.0 ml / L water (7.62 / plot), Esfenvelarate 5 EC @ 1.0 ml / L water (7.25 / plot), Deltramethrin 2.5 EC @ 1.0 ml / L water (5.95 / plot) and Fenvelarate 20 Ec @ 1.0 ml / L water (5.89 / plot) where first one is statistically dissimilar from others and the rest are statistically similar consequtively. On the contrary, the lowest number of stink bug was found in Azadirachtin (stored) @ 2.5 ml / L water treated plot (4.25 / plot) followed by Curtap 50 SP @ 2 g / L water (4.91 / plot), Azadirachtin (fresh) @ 2.5 ml / L water (5.34 / plot), Emamectin benzoate 5 SG @ 1 g / L water (5.48 / plot) and Cypermethrin 10 EC @ 1 ml / L water (5.59 / plot).

Table 1: Effect of different botanical and chemical insecticides on the abundance (number/plot) of stink bug in Lanlab bean field.

Name of the treatments (botanical and chemical insecticides) with applied dose	Mean number of Stink bug / plot	Percent (%) reduction over control
Cypermethrin 10 EC @ 1 ml / L water	5.59 cd	33.77%
Fenitrothion 50 EC @ 1 ml / L water	7.62 b	9.72%
Fenvalerate 20 EC @ 1 ml / L water	5.89 c	30.21%
Emamectin benzoate 5 SG @ 1 g / L water	5.48 cd	35.07%
Deltrametrin 2.5 EC @ 1 ml / L water	5.95 c	29.50%
Esfenvalerate 5 EC @ 1 ml / L water	7.25 b	14.10%
Curtap 50 SP @ 2 g / L water	4.91 de	41.82%
Azadirachtin (fresh) @ 2.5 ml / L water	5.34 cd	36.73%
Azadirachtin (stored) @ 2.5 ml / L water	4.25 e	49.64%
Untreated control	8.44 a	
CV	6.47%	

Values are mean of three replications. In a column, means followed by same letter(s) are statistically identical by DMRT at 5% level of significance.

Toxicity of any specific insecticides depends on its ability to percent reduction of abundance over control. On this regard, the best performance was observed from Azadirachtin (stored) @ 2.5 ml / L water (49.64% reduction) which was followed by Curtap 50 SP @ 2.0 g / L water (41.82% reduction), Azadirachtin (stored) @ 2.5 ml / L water (36.73% reduction), Emamectin benzoate 5 SG @ 1 g / L water (35.07% reduction) and Cypermethrin 10 EC @ 1 ml / L water (33.77% reduction) but that of lowest was observed from Fenitrothion 50 Ec @ 1.0 ml / L water (9.72% reduction) followed by Esfenvelarate 5 EC @ 1.0 ml / L water (14.10% reduction), Deltramethrin 2.5 EC @ 1.0 ml / L water (29.50% reduction) and Fenvalerate 20 EC @ 1 ml / L water (30.21% reduction).

Considering the above discussion, it can be concluded that Azadirachtin (stored) @ 2.5 ml/L water (4.25 / plot), Curtap 50 SP @ 2.0 g / L water (4.91 / plot) and Azadirachtin (fresh) @ 2.5 ml/L water (5.34 / plot) are most effective and toxic for population development of stink bug as they provide lowest number of stink bug per plot and highest reduction over control (49.64%, 41.82% and 36.73% respectively). Both fresh and stored Azadirachtin were less toxic to insect but their repellant, antifeedant; oviposotional deterrent activity reduced the number of stink bug in the treated plots.

On the other hand, Fenitrothion 50 Ec @ 1.0 ml / L water (7.62 / plot), Esfenvalerate 5 EC @ 1.0 ml / L water (7.25 / plot) and Deltrametrin 2.5 EC @ 1.0 ml / L water (5.95 / plot) are congenial as well as safe for the population development of stink bug as they ensure the highest number of stink bug per plot and lowest reduction over control (9.72%, 14.10% and 29.50% respectively).

Similar study was conducted by [14] on insecticidal effect on abundance of legume pod sucking bugs and found that spray without any insecticide confirmed maximum population of pod sucking bugs (130.8/m^2 in 2007 and 130.0/m^2 in 2008) which was followed by two spray of lambda-cyhalothrin (113.7/m^2 in 2007 and 119.8/m^2 in 2008). Also reported by [15] that brown stink bug (*Euschistus servus*) and green stink bug (*Acrosternum hilare*) adult was highly abundant (161 & 70 respectively) among different stink bug species. Beneficial aspects of neem include low toxicity for natural enemies and mammals, and selectivity towards phytophagous insects [16, 17]. In field trials, [18] determined that *N. viridula* populations were reduced in cowpea for up to 10 day after treatment with azadirachtin. [19] suggested that when used against adults, azadirachtin may act as an antifeedant, also an ovipositional deterrent and growth regulator for *N. viridula* in the laboratory.

3.2 Effect of botanical & chemical insecticides for the mortality of stink bug at Lablab bean field

Both the synthetic insecticide and botanicals have detrimental effect on stink bug population as shown in Table 2. Toxicity of any insecticide is expressed by the death and mortality rate of insects after its application. Among the insecticides, the highest dead stink bug was found in Fenitrothion 50 EC @ 1 ml / L water (3.86/ plot) treated plot which was followed by Esfenvalerate 5 EC @ 1 ml / L water (3.28/ plot), Deltrametrin 2.5 EC @ 1 ml / L water (2.74/ plot), Cypermethrin 10 EC @ 1 ml / L water (2.37/plot) as well as Fenvelarate 20 EC @ 1 ml / L water (2.29/ plot) and the lowest of that was found in Azadirachtin (fresh) @ 2.5 ml / L water (0.86/ plot) treated plot followed by Azadirachtin (stored) @ 2.5 ml / L water (1.05/ plot), Curtap 50 SP @ 2 g / L water (1.47/ plot) and Emamectin benzoate 5 SG @ 1 g / L water (2.17/ plot). In the untreated control plots, no dead stink bug was observed. The highest percent mortality of stink bug was found in Fenitrothion 50 EC @ 1 ml / L water (50.59%) followed by Deltrametrin 2.5 EC @ 1 ml / L water (45.99%), Esfenvalerate 5 EC @ 1 ml / L water (45.28%), Cypermethrin 10 EC @ 1 ml / L water (42.31%) and Emamectin benzoate 5 SG @ 1 g / L water (39.53%). On the other hand, the lowest percent mortality was found in Azadirachtin (fresh) @ 2.5 ml / L water (16.09%) followed by Azadirachtin (stored) @ 2.5 ml / L water (24.68%), Curtap 50 SP @ 2 g / L water (30.02%) and Fenvelarate 20 EC @ 1 ml / L water (38.80%). As the control plots were untreated, no dead stink bug was found resulting zero percent mortality.

Table 2: Effect of different botanical and chemical insecticides on the mortality of stink bug in Lablab bean field.

Name of the treatments (botanical and chemical insecticides) with their applied dose	Number of dead Stink bug per plot	Percent (%) mortality of stink bug
Cypermethrin 10 EC @ 1 ml / L water	2.37 d	42.31 bc
Fenitrothion 50 EC @ 1 ml / L water	3.86 a	50.59 a
Fenvelarate 20 EC @ 1 ml / L water	2.29 d	38.80 c
Emamectin benzoate 5 SG @ 1 g / L water	2.17 d	39.53 c
Deltrametrin 2.5 EC @ 1 ml / L water	2.74 c	45.99 b
Esfenvalerate 5 EC @ 1 ml / L water	3.28 b	45.28 b
Curtap 50 SP @ 2 g / L water	1.47 e	30.02 d
Azadirachtin (fresh) @ 2.5 ml / L water	0.86 f	16.09 f
Azadirachtin (stored) @ 2.5 ml / L water	1.05 f	24.68 e
Untreated control	0.00 g	0.00 g
CV	9.23%	7.62%

Values are mean of three replications. In a column, means followed by same letter(s) are statistically identical by DMRT at 5% level of significance.

The above results thus revealed that among the insecticides, Azadirachtin (fresh) @ 2.5 ml / L water, Azadirachtin (stored) @ 2.5 ml / L water and Curtap 50 SP @ 2 g / L water found least toxic to stink bug confirming least mortality rate of stink bug (16.09%, 24.68% and 30.02% mortality respectively) while Fenitrothion 50 EC @ 1 ml / L water, Deltrametrin 2.5 EC @ 1 ml / L water and Esfenvalerate 5 EC @ 1 ml / L water found highly toxic to stink bug resulting highest mortality (50.59%, 45.99% and 45.28% mortality respectively).

It was concluded by [20] that acetameprid, imidacloprid and spinosad were found toxic to adult sting bug. The LC_{50} value showed that imidacloprid had more toxicity and spinosad had lesser toxicity after 24 hours of application. [21] reported that predatory pentatomids, *Podisus connexivus* and *Supputius* *cincticeps* showed high tolerance to Deltamethrin. Fenitrothion was highly toxic to both the species, while cartap and Malathion showed intermediate level of toxicity. [22] reported that Lambda-cyhalothrin @ 2ml/l water and methamidophos @ 10ml/l water demonstrated 87% and 83% mortality rate compared with 2% in water treated control against stink bug species *Nezara viridula*. Topical applications of pyrethroid insecticides (bifenthrin, cypermethrin, *z*-cypermethrin, and cyfluthrin) resulted in 77 to 98% mortality of southern green stink bug adults and nymphs but 20 to 65% mortality of brown stink bug adults and nymphs [23, 24]. found that in field studies, acephate, dicrotophos, and high rates of bifenthrin, cypermethrin, cyfluthrin, *z*-cypermethrin, and λ-cyhalothrin treated plant produced significant levels of brown stink bug adult mortality (52.5 to 89.2%) compared with non-treated controls ($P \leq 0.01$). The organophosphate insecticides, acephate and dicrotophos provided mortality of brown stink bug at 48 h ranging from 53.3 to 89.2% on bolls and foliage [8]. *E. servus* has been reported as having a higher LC50 value than *A. hilare* for pyrethroids and organophosphates [23, 2].

4. Conclusions

The chemical insecticides are detrimental. So, their application needs to be judicious to make the crop products safe for human consumption. When applied these may spread to the environment and make it polluted resulting interrupted ecosystem. In the crop field some beneficial arthropods are also present which may be damaged by the injudicious application of chemicals. The botanicals are safe for environment and they degraded sharply after being applied. In this study it was found that botanical azadiractin was effective for reducing stink bug abundance in the Lablab bean field. It can be recommended that, judicious and appropriate application of chemical insecticides is necessary along with botanicals for successful lablab bean production. This research study can be repeated further for more significant finding. It is also necessary to conduct the study in laboratory condition.

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