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EVALUATION OF SELECTED INSECTICIDES AGAINST WHITEFLY (Bemisia tabaci) ON BRINJAL CROPS AND THEIR EFFECT ON NATURAL ENEMIES

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ABSTRACT

A field study was carried out for two cropping periods in the first season in year 2014 and the second season in 2015. This study was carried out at "share farm", Agrotechnology Plantation UiTM Melaka, Campus Jasin to examine the efficacy of selected insecticides against whitefly (Bemisia tabaci) on brinjal crops and the effect on natural enemies (Spider) under field conditions. Five treatments with four replications were applied. The treatments were T0= Control (water), T1= Imidacloprid (Confidor), T2= Acetamiprid (Mospilan), T3= Dinotefuran (Oshin) and T4= Cyantraniliprole (Benevia). Pre-treatment and post-treatment observation were recorded which is one day before application and 1, 3, 7 and 14 days after application of insecticides. A total of two applications of treatments were done. The results revealed that Imidacloprid was recorded as the most effective and the highest reduction of whiteflies during the first season with 96.73%, followed by Acetamiprid (92.44%), Cyantraniliprole (82.65%) and Dinotefuran (80.74%) while during the second season, Imidacloprid also was recorded as the highest reduction with 79.99%, followed by Acetamiprid (76.34%), Cyantraniliprole (54.09%) and Dinotefuran (36.87%). Overall, chemical control of Imidacloprid was the most effective against whiteflies populations in brinjal particularly in the first season as compared to second season. The effect of these selected insecticides on natural enemies (Spider) revealed that chemical control of Imidacloprid gave the highest reduction of spider with 65.69%), followed by Cyantraniliprole (64.47%), Acetamiprid (41.44%) and Dinotefuran (15.45%). Imidacloprid and Cyantraniliprole were classified as moderately harmful to spider while Acetamiprid and Dinotefuran were classified as harmless or slightly harmful.

Indexing terms/Keywords

Brinjal; Insecticides; Whitefly; Spider; Efficacy

Academic Discipline And Sub-Disciplines

Agriculture and entomology

SUBJECT CLASSIFICATION

Crop protection

TYPE (METHOD/APPROACH)

Field and laboratory experiment

INTRODUCTION

Brinjal (*Solanum melongena*, L) is a family of Solanacea and one of the most widely cultivated crop in the world (EGGNET, 2005). In Asia, Africa and Mediterranean countries, brinjal is one of the most important foods for people consumption and in the 4th rank of fruit vegetables (Collonier *et al.,* 2001). Generally, brinjal in Malaysia consists of two types which are *S. melongena* and *S. macrocarpon*. *S. melongena* are known as elongated brinjal and *S. macrocarpon* are known as round brinjal. Many kinds of soil in Malaysia are suitable for brinjal cultivation and easily for them to grow (Lee, 1979). Brinjal can be adapted to high rainfall and high temperature. Besides that, under hot-wet environment, it is able to produce high yields (Hanson *et al.,* 2006). In Malaysia, the demand of brinjal are changed depends on time and supply.

However, productions of brinjal become low because of some sucking insect pests. The most destructive pest infesting these crops is whitefly (Ghosal and Chatterjee, 2012). Whitefly (*Bemisia tabaci*) is one of the major sucking insect pest for many crops especially brinjal (Norhelina *et al.,* 2013). Both nymphs and adults feed on the leaves surface and suck the phloem sap from sieve tubes. They produce honey dew that reduces the capacity of photosynthetic on the foliage (Rahim Khan *et al.,* 2011). They also act as a vector for a few plant pathogens such as Gemini and Clostero viruses that causes damage to the crop direct or indirect % (Mohd Rasdi *et al.,* 2009). Damaged caused by whitefly contributes to yield losses of brinjal about 70% to 92 (Omprakash and Raju, 2014).

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In Malaysia, controlling of whitefly is very much relies on chemical control (Syed Abdul Rahman *et al.,* 2000). The continuous use of chemical have developed resistance to conventional insecticides and leaving fewer effective insecticides to control the pest in the market (Li *et al.,* 2001). Neonicotinoids is new classes of insecticides that are available in the market which have special mode of action, broad spectrum, good translaminar properties and long systemic activity (Kodandaram *et al.,* 2010). Their selectivity, lower dose and safer to beneficial organisms are very suitable in Integrated Pest Management (IPM) and Insect Resistance Management (IRM) resulting in less insecticidal to environment. In this study efficacies of selected neonicotinoid insecticides on whitefly, *Bemisia tabaci* infesting brinjal were investigated and their effect on natural enemies (Spider) were also examined.

MATERIALS AND METHODS

Experimental sites

A field experiment was conducted at "share farm", Agrotechnology Plantation, UiTM Melaka, Campus Jasin. The experiment was carried out at open field for two growing seasons. First season was started from December 2014 until April 2015. For the second season, the experiment was started from December 2015 until April 2016.

Plant materials

A local variety of 'Giant Naga' F1 hybrid (terung panjang) brinjal was used as a host of pests. Seeds were obtained from local market and soaked in water overnight in order to get better seeds germination. The brinjal seeds were sown in seedling trays that consisting of 104 holes. The seedling trays were filled with peat moss as a growing medium for brinjal seeds. The seedlings were placed and grown in greenhouse about four weeks. The water was supplied through a sprinkler irrigation system. After four weeks, the seedlings at 8 to 10 cm height were transplanted to the field on planting beds that were prepared.

Preparation of land

The experimental area was cleared from any weeds and debris. The land was ploughed and harrowed with tractor to get fine soil texture. All experimental area was mixed with proper proportions of manure (chicken dung).

Field experimental layout and design

The total area of experimental field was 13 m x 11 m (143 m^2). The experimental plots were designed in Randomized Complete Block Design (RCBD). There were five treatments including control. Each treatment was replicated with four replications (four blocks). Overall, there were 20 plots with plot measured 2 m (length) x 1 m (width) each. Alley between each block and each plot was measured at 1 m respectively to minimize effects of insecticides drift and movement of whiteflies to other plots.

There were 20 plots in the experimental field which five plants per plot, giving a total of 100 brinjal plants. The distance between crops was measured at 45 cm and distance between rows was maintained at 30 cm. The plots (planting beds) were covered with black plastic mulches.

Transplanting of brinjal seedlings and cultural management

The seedlings at 8 to 10 cm height were transplanted to the field after four weeks were grown in the greenhouse. Uniform and healthy seedlings were chosen and transplanted on the raised planting beds (plot). After one week, the replacement of dead seedlings was done due to transplanting shock.

For the irrigation, the brinjal crops were watered twice daily (morning and evening) by manually using watering can. Weeding was carried out daily in order to prevent competition between the weeds and brinjal crops. The crops were also pruning twice a month by removing the side buds and all suckers to increase fruit quality and produce high yield.

NPK Green (15:15:15) and NPK Blue (12:12:17) were applied to the brinjal plants. The first application, NPK Green was applied after three weeks transplanting and subsequently second application NPK Blue was applied. Both fertilizers were applied at a rate of 10 g per plant, giving a total of 50 g per planting bed (plot).

Specifications of insecticides and their application

In this experiment, the selected insecticides were chosen based on the product commonly used by farmers and economically accessible in the market. Four insecticides namely confidor (Imidacloprid, 17.8% w/w, 1.25ml/5L), mospilan (Acetamiprid, 3.0% w/w, 15ml/5L), oshin (Dinotefuran, 20.0% w/w, 2.5g/5L) and benevia (Cyantraniliprole, 10.26% w/w, 6.5ml/5L). All these four selected insecticides known as neonicotinoids insecticides and were applied at prescribed rate to control whiteflies on brinjal crops.

The infested plants after reached ETL were sprayed with insecticides for two applications times in each cropping period. The ETL for whiteflies on brinjal crops were considered 5 to 10 whiteflies per leaf (Shivanna et al., 2011). The insecticides were sprayed by using knapsack sprayer (16 L) and were applied in the morning.

During applications of insecticides, consideration was taken to make sure that the whole entire leaves surface was sprayed since whiteflies were attacked at the under sides of leaves.

Sampling of whiteflies (Bemisia tabaci) and natural enemies (Spider) on brinjal crops

A sampling of whiteflies and spider were carried out simultaneously at 0900 am to 1200 pm, one day before application and 1, 3, 7 and 14 days after application of insecticides. A total of 2 applications of treatments were done. The samplings of whiteflies were done by taking the middle leaves of brinjal crops which is 10 leaves from the top (Mohd Rasdi et al., 2009).

Three leaves were randomly selected from three randomly selected plants from each treated plot. Then the leaves were kept in the zipper plastic bag and brought to the laboratory. The whiteflies populations were carefully observed and counted from the upper side and underside of each leaves under dissecting microscope.

The data obtained were expressed as mean populations per 3 leaves. The percentage reduction in whiteflies populations was calculated by using Henderson-Tilton’s formula (Henderson and Tilton, 1955) according to the following equation:

$$\%\text{reduction in population} = 100 \times \quad 1 - \left[\frac{T_a \times C_b}{T_b \times C_a} \right]$$

Where,

T a = Number of insects after treatment

T b = Number of insects before treatment

C a = Number of insects in untreated check after treatment

C b = Number of insects in untreated check before treatment

The sampling of natural enemies was carried out by observing from randomly selected plants from each treated plot. They were calculated at the field from upper, middle and bottom leaves of the plant at one day before application and 1, 3, 7 and 14 days after chemical application. The data obtained were expressed as mean populations per plant. The percentage reduction in predator populations was also calculated by using Henderson-Tilton’s formula (Henderson and Tilton, 1955).

To determine the selectivity effect of different insecticides on natural enemies (Spider) the percentage reduction were categorized according International Organization of Biological Control (IOBC) classification to three categories (Boller *et al.,* 2005) as following: N=harmless or slightly harmful (reduction semi field ranged from 0–50%), M=moderately harmful (reduction semi field ranged from 51–75%), and T=harmful (reduction semi field >75%).

Data analysis

The data regarding the population of whiteflies and spider over the treatment were analyzed by using analysis of variance (ANOVA) of Statistical Package for Social Science (SPSS). The means between the treatments were compared by using Tukeys’s HSD test at 5% significance level.

RESULTS

Effect of selected insecticides against whitefly (*Bemisia tabaci*) on brinjal crops

After first and second spray, mean and percentage reduction of whiteflies populations was recorded after applications of different insecticides in the first and second cropping periods. The results in Table 1 reveal that all the treatments caused significant effect (F= 16.35; df= 4; P<0.01) on the whiteflies populations even at 14 days after first and second spray in the first cropping period. There were also explained that no significant difference (P>0.05) among treatments for both applications before first and second sprays and there was no significant difference (P>0.05) after one day application in both first and second spray.

During the first season (Table 1), after one day application in first spray, maximum reduction of whiteflies was recorded in imidacloprid (90.03%) and acetamiprid (89.34%) while cyantraniliprole and dinotefuran gave minimum reduction with 69.09% and 53.17%, respectively. After three days, three insecticides namely imidacloprid, acetamiprid and dinotefuran were recorded to be able reached maximum reduction of whiteflies with 100% respectively, followed by cyantraniliprole (89.21%), and those treatments were significantly difference (P<0.01) with control (water). Seven days after application, maximum reduction was recorded in imidacloprid (100%) and acetamiprid (100%) followed by dinotefuran (96.68%) and cyantraniliprole (96.34%), which were significantly difference (P<0.01) with control (water). Meanwhile, at days 14, the maximum reduction was recorded in imidacloprid and cyantraniliprole with 100%, followed by acetamiprid (92.97%) and dinotefuran (89.70%), which were significantly difference (P<0.01) with control (water).

After second spray, similarly imidacloprid and acetamiprid were also recorded maximum reduction on the mean number of whiteflies after one day application with 89.42% and 88.04% respectively while minimum reduction was recorded in cyantraniliprole (34.52%) and dinotefuran (23%). All treatments gave maximum whiteflies reduction at three days after chemical application with 100% respectively, and all treatments gave significant effect as compared to control (water). The effectiveness of insecticides decreased against whiteflies at seven days after application, where maximum reduction was recorded in imidacloprid (94.36%) and dinotefuran (88.27%), followed by acetamiprid and cyantraniliprole with 74.50% and 72.06% respectively, which were significantly difference when compared to control (water). After 14 days application, efficacy of insecticides increased, where imidacloprid and cyantraniliprole gave maximum reduction with 100% respectively, followed by acetamiprid (94.69%) and dinotefuran (95.11%), which were significantly difference (P<0.01) with control (water).

The results in Table 2 reveal that all the treatments caused significant effect (F= 75.67; df= 4; P<0.01) on whiteflies populations even at 14 days after first and second spray in the second cropping period. Table 2 was also explained that there was no significant difference (P>0.05) in mean number of whiteflies between the treatments before first and second sprays.

During the second season (Table 2), imidacloprid gave maximum reduction of whiteflies after one day application in first spray with reduction of 89%, followed by acetamiprid (88.91%), while the minimum reduction was showed in cyantraniliprole and dinotefuran with reduction of 40.22% and 25.96%, respectively, which were significantly difference as compared to control (water). After three days application, imidacloprid, acetamiprid and dinotefuran gave maximum reduction of whiteflies with 86.20%, 76.34% and 51.89%, respectively, while cyantraniliprole gave minimum reduction with 49.36%, which gave significant effect compared to control (water). At days seven, maximum reduction was recorded in acetamiprid (70.19%), imidacloprid (68.32%) and cyantraniliprole (59.82%) and dinotefuran gave minimum reduction with 32.31%, which all those treatments gave significant effect (P<0.01) compared to control (water). After 14 days application, the effectiveness of imidacloprid, acetamiprid and dinotefuran increased which maximum reduction was recorded in imidacloprid (88.77%), followed by acetamiprid (72.82%) and dinotefuran (58.59%), meanwhile, the efficacy of cyantraniliprole decreased with reduction of 52.23%, which were significantly difference (P<0.05) as compared to control (water).

In second spray, after one day of treatment, the maximum reduction of whiteflies was recorded in imidacloprid (75.37%) and acetamiprid (71.41%), while cyantraniliprole and dinotefuran gave minimum reduction with 49.79% and 5.97%, respectively, which were significant effect (P<0.05) as compared to control (water). After three days application, similarly imidacloprid and acetamiprid gave maximum reduction with 74.98% and 74.84%, respectively, followed by cyantraniliprole (63.58%) and dinotefuran (54.90%), which were significantly difference (P<0.01) in comparison with control (water). Based on the observation, after seven days application, the effectiveness of all insecticides decreased where the maximum reduction was recorded in imidacloprid (66.03%) and acetamiprid (65.63%), while cyantraniliprole and dinotefuran gave minimum reduction of whiteflies with 46.05% and 6.22%, respectively, these treatments obviously gave significant effect as compared to control (water). After 14 days application, the efficacy of all insecticides increased. The maximum reduction of whiteflies was observed in imidacloprid (91.26%) and acetamiprid (90.55%), followed by cyantraniliprole (68.73%) and dinotefuran (59.13%), which all those treatments were significantly difference (P<0.01) in comparison with control (water).

Overall, imidacloprid was recorded to be the highest percentage reduction of whiteflies for both cropping periods. In the first season, imidacloprid gave 96.73% whiteflies reduction followed by acetamiprid (92.44%), cyantraniliprole (82.65%) and dinotefuran (80.74%). Meanwhile, in the second season, imidacloprid gave 79.99% reduction followed by acetamiprid (76.34%), cyantraniliprole (54.09%) and dinotefuran (36.87%).

These results proved that imidacloprid was the best insecticides among others insecticides in reducing whiteflies populations on brinjal crops for both cropping periods. The results also revealed that the effectiveness of insecticides in the first cropping period was the most effective as compared to the second cropping period

Table 1: Mean and percentage reduction of whiteflies populations on brinjal leaves after applications of different insecticides in the first cropping period

Treatments	Mean and percentage reduction of whiteflies per 3 leaves										Cumulative mean	% reduction over control
	Before spray	Day after 1st spray (application)				Before spray	Day after 2nd spray (application)					
		1	3	7	14		1	3	7	14		
Control (water)	25.5 [a]	2.75 (0.00) [a]	5.25 (0.00) [a]	7.75 (0.00) [a]	12.5 (0.00) [a]	16.5 [a]	2.00 (0.00) [a]	2.25 (0.00) [a]	3.75 (0.00) [a]	4.5 (0.00) [a]	**8.28 [a]**	……
Imidacloprid	23.25 [a]	0.25 (90.03) [a]	0 (100) [b]	0 (100) [b]	0 (100) [b]	20.25 [a]	0.25 (89.42) [a]	0 (100) [b]	0.25 (94.36) [b]	0 (100) [b]	**4.43 [b]**	**96.73**
Acetamiprid	21.75 [a]	0.25 (89.34) [a]	0 (100) [b]	0 (100) [b]	0.75 (92.97) [b]	17.25 [a]	0.25 (88.04) [a]	0 (100) [b]	1 (74.50) [ab]	0.25 (94.69) [b]	**4.15 [b]**	**92.44**
Dinotefuran	24.75 [a]	1.25 (53.17) [a]	0 (100) [b]	0.25 (96.68) [b]	1.25 (89.70) [b]	18.75 [a]	1.75 (23.00) [a]	0 (100) [b]	0.5 (88.27) [b]	0.25 (95.11) [b]	**4.88 [b]**	**80.74**
Cyantraniliprole	22.5 [a]	0.75 (69.09) [a]	0.5 (89.21) [b]	0.25 (96.34) [b]	0 (100) [b]	15.75 [a]	1.25 (34.52) [a]	0 (100) [b]	1 (72.06) [ab]	0 (100) [b]	**4.2 [b]**	**82.65**
Significance level	F= 0.31; df= 4; P > 0.05	F= 2.17; df= 4; P > 0.05	F=32.62; df= 4; **P < 0.01**	F=31.4; df= 4; **P < 0.01**	F= 7.44; df= 4; **P < 0.01**	F= 0.75; df= 4; P > 0.05	F= 1.62; df= 4; P > 0.05	F= 6.94; df= 4; **P < 0.01**	F= 3.66; df= 4; **P < 0.05**	F= 6.32; df= 4; **P < 0.01**	F= 16.35; df= 4; **P < 0.01**	……

*means sharing similar alphabets in each column are not significantly difference (Tukey's HSD, P > 0.05). Values in parenthesis represent percent reduction of whiteflies in each treatment.

Table 2: Mean and percentage reduction of whiteflies populations on brinjal leaves after applications of different insecticides in the second cropping period

Treatments	Mean and percentage reduction of whiteflies per 3 leaves										Cumulative mean	% reduction over control
	Before spray	Day after 1st spray (application)				Before spray	Day after 2nd spray (application)					
		1	3	7	14		1	3	7	14		
Control (water)	16.5 [a]	8a (0.00) [a]	12.75 (0.00) [a]	12.5 (0.00) [a]	11.75 (0.00) [a]	43 [a]	59.5 (0.00) [a]	42.25 (0.00) [a]	24.75 (0.00) [a]	27.5 (0.00) [a]	**25.85 [a]**	….
Imidacloprid	18.75 [a]	1 (89) [c]	2 (86.20) [b]	4.5 (68.32) [b]	1.5 (88.77) [b]	44.75 [a]	15.25 (75.37) [b]	11 (74.98) [b]	8.75 (66.03) [b]	2.5 (91.26) [c]	**11 [d]**	**79.99**
Acetamiprid	23.25 [a]	1.25 (88.91) [bc]	4.25 (76.34) [b]	5.25 (70.19) [b]	4.5 (72.82) [b]	45.5 [a]	18 (71.41) [b]	11.25 (74.84) [b]	9 (65.63) [b]	2.75 (90.55) [c]	**12.5 [cd]**	**76.34**
Dinotefuran	19.5 [a]	7 (25.96) [a]	7.25 (51.89) [ab]	10 (32.31) [ab]	5.75 (58.59) [ab]	44 [a]	57.25 (5.97) [a]	19.5 (54.90) [b]	23.75 (6.22) [a]	11.5 (59.13) [b]	**20.55 [b]**	**36.87**
Cyantraniliprole	17.25 [a]	5 (40.22) [ab]	6.75 (49.36) [ab]	5.25 (59.82) [b]	5.5 (55.23) [ab]	47.5 [a]	33 (49.79) [b]	17 (63.58) [b]	14.75 (46.05) [b]	9.5 (68.73) [bc]	**16.15 [c]**	**54.09**
Significance level	F= 2.18; df= 4; P>0.05	F= 13.33; df= 4; **P<0.01**	F= 5.7; df= 4; **P<0.01**	F= 5.12; df= 4; **P<0.05**	F= 5.48; df= 4; **P<0.01**	F= 0.32; df= 4; P>0.05	F= 26.16; df= 4; **P<0.01**	F= 27.08; df= 4; **P<0.01**	F= 24.78; df= 4; **P<0.01**	F= 39.19; df= 4; **P<0.01**	F= 75.67; df= 4; **P<0.01**	….

*means sharing similar alphabets in each column are not significantly difference (Tukey's HSD, P > 0.05). Values in parenthesis represent percent reduction of whiteflies in each treatment

Effect of selected insecticides on natural enemies (Spider)

Table 3 show that there was significant difference (F= 14.54; df= 4; P<0.01) in mean number of spider populations after application of selected insecticides on brinjal crops during the second season. There was no significant difference (P>0.05) between the mean number of spider among treatments for both before first and second spray. The results also indicated that there was significant effect (P<0.01; P<0.05) in mean number of spider after one day in both applications, however, no significant effect (P>0.05) was showed after three, seven and 14 days application in both first and second spray. However, during the first cropping period, there was no population of spider on brinjal crops.

Imidacloprid gave maximum reduction of spider with 89.29% after one day application in the first spray, followed by cyantraniliprole (82.35%) while dinotefuran and acetamiprid gave minimum reduction of spider with only 20% and 14.29%, respectively, which were significantly difference (P<0.01) compared to control (water). After three days application, the efficacy of cyantraniliprole, imidacloprid and dinotefuran declined but the efficacy of acetamiprid increased where the maximum reduction was observed in cyantraniliprole (51.13%), followed by imidacloprid (40.66%) and acetamiprid (40.66%) while the minimum reduction of spider was recorded in dinotefuran with only 7.69%. After seven days application, cyantraniliprole and acetamiprid gave maximum reduction with 51.87% and 41.56%, respectively, while imidacloprid (29.87%) and dinotefuran (12.73%) gave minimum reduction of spider. At days 14, the effectiveness of cyantraniliprole and imidacloprid on spider increased but the efficacy of acetamiprid and dinotefuran decreased where the maximum reduction was showed in cyantraniliprole (57.65%) and the minimum reduction was observed in imidacloprid (35.71%), acetamiprid (10%) and dinotefuran (4%).

After the second spray, imidacloprid gave maximum reduction of spider after one day application with 100%, followed by cyantraniliprole (78.79%) and acetamiprid (70.83%) while dinotefuran gave minimum reduction with only 12.5% reduction of spider, which gave effect significantly as compared to control (water). After three days application, the effectiveness of acetamiprid and cyantraniliprole increased with maximum reduction of 100% and the efficacy of imidacloprid and dinotefuran was consistently with reduction of 100% and 12.5%, respectively. After seven days application, the maximum reduction was showed in imidacloprid (100%) and cyantraniliprole (57.58%) while acetamiprid and dinotefuran gave similar minimum reduction of spider with 41.67%. The effectiveness of all insecticides declined after 14 days application where all these insecticides gave minimum reduction of spider with 36.36% for cyantraniliprole, 30% for imidacloprid and 12.5% for both acetamiprid and dinotefuran.

Overall, imidacloprid gave the highest percentage reduction of spider with recorded of 65.69%, followed by cyantraniliprole (64.47%), acetamiprid (41.44%) and dinotefuran (15.45%) being the lowest reduction of spider. Imidacloprid and cyantraniliprole were classified as moderately harmful (M= reduction ranged from 51 to 75%) while acetamiprid and dinotefuran were classified as harmless or slightly harmful (N= reduction ranged from 0 to 50%). It can be concluded that, dinotefuran was harmless and slightly harmful to spider (predator) in the second cropping period with the lowest reduction of 15.45% compared to others insecticides.

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Table 3: **Mean and percentage reduction of spider populations on brinjal leaves after applications of different insecticides in the second cropping period**

Treatments	**Mean and percentage reduction of spider per plant**										**Cumulative mean**	**% reduction over control**
	Before spray	**Day after 1st spray (application)**				**Before spray**	**Day after 2nd spray (application)**					
		1	**3**	**7**	**14**		**1**	**3**	**7**	**14**		
Control (water)	4.5 ^{a}	3 (0.00) ^{a}	3.25 (0.00) ^{a}	2.75 (0.00) ^{a}	2.5 (0.00) ^{a}	3.5 ^{a}	1.5 (0.00) ^{a}	0.5 (0.00) ^{a}	0.75 (0.00) ^{a}	0.5 (0.00) ^{a}	**2.28 ^{a}**	….
Imidacloprid	3.5 ^{a}	0.25 (89.29) ^{b}	1.5 (40.66) ^{a}	1.5 (29.87) ^{a}	1.25 (35.71) ^{a}	2.5 ^{a}	0 (100) ^{b}	0 (100) ^{a}	0 (100) ^{a}	0.25 (30) ^{a}	**1.08 ^{c}**	**65.69 (M)**
Acetamiprid	3.5 ^{a}	2 (14.29) ^{a}	1.5 (40.66) ^{a}	1.25 (41.56) ^{a}	1.75 (10) ^{a}	2 ^{a}	0.25 (70.83) ^{ab}	0 (100) ^{a}	0.25 (41.67) ^{a}	0.25 (12.5) ^{a}	**1.28 ^{bc}**	**41.44 (N)**
Dinotefuran	3.75 ^{a}	2 (20) ^{a}	2.5 (7.69) ^{a}	2 (12.73) ^{a}	2 (4) ^{a}	2 ^{a}	0.75 (12.5) ^{ab}	0.25 (12.5) ^{a}	0.25 (41.67) ^{a}	0.25 (12.5) ^{a}	**1.58 ^{b}**	**15.45 (N)**
Cyantraniliprole	4.25 ^{a}	0.5 (82.35) ^{b}	1.5 (51.13) ^{a}	1.25 (51.87) ^{a}	1 (57.65) ^{a}	2.75 ^{a}	0.25 (78.79) ^{ab}	0 (100) ^{a}	0.25 (57.58) ^{a}	0.25 (36.36) ^{a}	**1.2 ^{bc}**	**64.47 (M)**
Significance level	F= 0.47; df= 4; P>0.05	F= 13.83; df= 4; **P<0.01**	F= 2.59; df= 4; P>0.05	F= 3.36; df= 4; P>0.05	F= 2.51; df= 4; P>0.05	F= 1.39; df= 4; P>0.05	F= 4.07; df= 4; **P<0.05**	F= 1.71; df= 4; P>0.05	F= 0.9; df= 4; P>0.05	F= 0.19; df= 4; P>0.05	F= 14.54; df= 4; **P<0.01**	….

*means sharing similar alphabets in each column are not significantly difference (Tukey's HSD, P > 0.05). Values in parenthesis represent percent reduction of spider in each treatment. IOBC toxicity classification (field test): N= harmless or slightly harmful (reduction ranged from 0 to 50%), M= moderately harmful (reduction ranged from 51 to 75%) and T= harmful (reduction>75%).

DISCUSSION

During the first cropping period, there were no significant effect between treatments and control (water) on whiteflies but in the second cropping period, there were significant difference between treatments and control (water) with respect to whiteflies. From the results in the first season, the populations of whiteflies were very low during the experiment. This probably caused by the new environment which did not favour the activity of whiteflies during the first season. In addition, the fields have not been planted by any vegetables crops before this experiment was conducted. During the second season, the experiment was conducted at the same field, hence, the population of whiteflies increased because they had recognized their environment and become to adapt with the environment.

The selected insecticides were showed a variable adverse on whiteflies and this may be due to the great variability in neonicotinoids characteristics influencing the movement in plant tissues such as water solubility which greatly affecting their toxicity especially on piercing sucking insect pests such as whiteflies (Cloyd and Bethke, 2011). The tested neonicotinoid insecticides also variably reduced whiteflies populations living on either during first and second cropping periods. Based on the results obtained, it was noticed that the percentage reduction of whiteflies populations were higher in first season than second season. This may be due to the high temperature during the first cropping. During the first season, it has an intense sunlight and high surrounding temperature that reduced the toxicity of these insecticides compounds. These results agree with findings Zheng and Liu, 1999 who revealed that when the surrounding temperature increasing, the hydrolysis of neonicotinoid insecticides will increase and this affect the toxicity levels.

From this study, it showed that imidacloprid gave the best results with 90.03% and 89.42% whiteflies reduction after one day of first and second spray in the first season and 89% and 75.73% whiteflies reduction after one day of first and second spray in the second season. This finding is parallel with findings Mohan and Katiyar, 2000 who mentioned that imidacloprid was the most effective in reducing whiteflies populations. This results also in accordance with Khattak *et al.,* 2004 who reported that imidacloprid gave significant reduction in the populations of whiteflies after 24, 72 and even 120 hours of application of imidacloprid. Additionally, El-Dewy, 2006 reported that imidacloprid gave fast initial effects in reducing immature whiteflies with long residual action and moderate effect on adult whiteflies. According to Mohammad *et al.,* 2008, it was also proved that imidacloprid causing 87.82% reduction of whiteflies as the general mean of the effect even 7 days after application. In this study, imidacloprid gave 75.73% reduction of whiteflies which is similar with previous study conducted by Mustafa, 2000 who revealed that imidacloprid gave almost 72.6% reductions of whiteflies populations. The results in Tables 1 and 2 explained that the efficacy and residual effect of imidacloprid against whiteflies populations was consistent up to day 14 which is almost supported with finding Khattak, *et al.,* 2004 who mentioned that imidacloprid reduce the populations of whiteflies even 240 hours after application of this insecticide.

The foliar application of neonicotinoid insecticides in this study were significantly reduced the population of spider as compared with the control plot (water) during the second cropping period. This showed that the foliar application of these insecticides cause direct toxicity to the spiders along with possibility of intake of poisonous hosts (prey) (Gaber *et al.,* 2015). The result of this study reveals that under field conditions, imidacloprid and cyantraniliprole were moderately harmful to spider (65.69% and 64.47%, respectively) during second season (Table 3). While acetamiprid and dinotefuran proved to be the least toxic to spider and classified as slightly harmful (41.44% and 15.45%, respectively) (Table 3). Although these insecticides have different toxicity to spider, their relatively persistency at different days after spraying was significant. Our results are contrary to the findings obtained by El-Zahi and Arif, 2011 who found that imidacloprid were harmless to insect predators. Our results are also supported by Ghananand *et al.,* 2011 who mentioned that the imidacloprid are toxicity to spider. Maximum reduction of spider populations were found after first day of imidacloprid and cyantraniliprole in the first and second application suggests that there was a direct effect of microbial pesticides on spider populations rather than indirect by eliminating host species. In brinjal ecosystem, application of imidacloprid and cypermethrin caused highly impact on populations of predatory spiders, coccinellids and braconid wasps compared to when applied with bio-pesticides (Ghananand *et al.,* 2011).

Some researcher has been demonstrated the side effects of neonicotinoids under laboratory conditions in suppressing non- target insects especially predators (Awasthi *et al.,* 2013). In field study, it was reported that neonicotinoid insecticides are less toxicity for a variety of predators (Mensah, 2002). The toxicity of neonicotinoids is not only influence by the method of application, but also feeding behavior of the predators in the laboratory (Ahmed *et al.,* 2014). In this study, field sprayed leaves exposure proved that acetamiprid and dinotefuran are harmless and slightly harmful to spider while imidacloprid and cyantraniliprole are moderately harmful to spider. However, the toxicity of these insecticides to these predators may be related to their feeding on foliage and not just contact with surface residues (Ahmed *et al.,* 2014). These laboratory results contradict suggestions of little impact of these systemic neonicotinoids on parasitoids or predators (Prabhaker *et al.,* 2011). The foliar, drench or granular applications of neonicotinoid insecticides give indirect impact on predators because it may decrease host population levels so that there are not enough hosts to attack and thus sustain predator populations (Cloyd and Bethke, 2011). In some research, it was proved that the foliar application of all the systemic neonicotinoids such as imidacloprid, acetamiprid, thiamethoxam, admire and clothianidin were found harmful and toxic to natural enemies in comparison with fipronil, buprofezin and spirotetramat (Kumar *et al.,* 2012).

CONCLUSION

As conclusion, imidacloprid was the most effective in suppressing whiteflies populations on brinjal crops. However, imidacloprid and cyantraniliprole were considered as moderately harmful to spiders while dinotefuran and acetamiprid were classified as harmless and slightly harmful. Neonicotinoid insecticides are generally more toxic to insects than mammals and these compounds are also relatively non-toxic to non-target species and very effective in managing a wide range of insect pests including aphids, thrips, whiteflies and several Lepidoptera species. They are effective against a broad range of sucking, biting and several chewing insect pests because their high efficacy, selectivity, plant systemic as well as long-lasting effect and versatile applications. From overall these neonicotinoids insecticides, dinotefuran gave the lowest percentage reduction of spider as compared to other insecticides. The present study have shown that the selected insecticides in this study can be suitable candidates for inclusion in Integrated Pest Management of whiteflies in major brinjal ecosystems because they have proved slightly and moderately harmful to spider.

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