International Journal of Bio-resource and Stress Management 2013, 4(4):576-581

Population Dynamics of Whitefly on Cultivated Crops and its Management

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Article History

Manuscript No. 429
Received in 11th August, 2013
Received in revised form 5th October, 2013
Accepted in final form 13th November, 2013

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Keywords

Whitefly, bush bean, okra, soybean

Abstract

Three experiments were carried out at the farm of Sher-e-Bangla Agricultural University during the period from February 2011 to May 2012 to know the population dynamics of whitefly on bush bean, okra and soybean, and to develop its management practices. Insecticides used for bush bean were bamper (imidacloprid) 20 SL, shobicron 425 EC, actara (thiamethoxam), chlorpyriphos 20 EC, sinothrin (cypermethrin) 10 EC, fortap (cartap) 50 SP; for okra, ripcord (cypermethrin), 5% tamarind fruit extract, 10% neem leaf extract, 10% bullock's heart leaf extract, 10% dodder extract, 10% oleander leaf extract, 10%, dhutra leaf extract and 10% dholkolmi leaf extract; for soybean, marshal (carbosulfan) 20 EC, semcap (fenthoate), dursban (chlorpyriphos) 20 EC, basathrin (cypermethrin) 10 EC, fiter (λ-cyhalothrin) 2.5 EC, Shobicron 425 EC, Actara (Thiamethoxam) 25 WG. All three experiments were set in randomized complete block design (RCBD) and treatments were applied at 10 days interval. The population of whitefly was gradually increased with environmental temperature and humidity up to certain age of the cultivated crops then declined with increasing age of the crops. It was lower in okra than bush bean and soybean due to rainfall during the rainy season. All the chemical insecticides reduced the population of whitefly in bush bean and soybean, and increased their yields. In bush bean, imidacloprid showed the best performance by reducing 64.13% population of whitefly and increasing 66.00% yield of fresh fruits. The lowest population of whitefly (4.8 plant^{-1}) and the highest fruit yield (4.92 t ha^{-1}) were obtained by application of dhutra leaf extract on okra. Oleander leaf extract also gave the similar results against whitefly attacking okra and showed better performance than cypermethrin 10 EC in reducing whitefly population and increasing fruit yield.

1. Introduction

The cotton whitefly (*Bemisia tabaci* Gennadius) (Hemoptera: Aleyrodidae) was described over 100 years ago as a pest of tobacco in Greece (Anonymous, 1989). Since then, it has become one of the most important sucking pest of world's industrial and food crops like cotton, sunflower, melon, tomato, brinjal etc. Over 500 plant species from Asia, Africa, America, Europe, Russia, Australia and the Pacific Islands confirms its polyphagous nature. It causes severe damage to cotton, mungbean, soybean, okra, brinjal and other cultivated crops by feeding on sap, secreting honeydew and transmitting virus diseases (Jose and Usha, 2003). Both nymphs and adults of whitefly suck the cell sap from different parts of the plant causing loss of plant vigour and reduces crop yield (Attique et al., 2003). It also secretes honeydew on which black sooty mold grows, reducing the photosynthetic capabilities of plants. It acts as a sole vector of more than 100 plant viruses, which cause diseases to many commercial crops in different parts of the world (Jones, 2003; Atwal and Dhaliwal, 2007).

The population of whitefly varies in different seasons of the year. Atmospheric humidity, temperature, rainfall influence the whitefly population dynamics (Horowitz et al., 1984; Horowitz, 1986). Moreover, host plants and natural enemies like predators and parasitoids regulate the population in the field. Further more, the population of natural enemies also depends on environmental factors (Rafiq et al., 2008). Whiteflies develop rapidly in warm weather, and populations can build up quickly in situations where natural enemies are destroyed and weather is favorable. Adult whitefly is killed by heavy rain and prolonged periods of rain can substantially reduce population. In addition, morphological characteristics of the host plants reduced the population of whitefly.

Whitefly acts as a sole vector for more than 100 plant viruses, which cause diseases to many commercial crops in different parts of the world (Jones, 2003) and the severity of the disease depends on the population of whitefly. *Bemisia tabaci* can rapidly disseminate viruses in the field even when populations are not appreciable, and cause severe crop damage in susceptible plantings.

Insecticides have been the first line of defense against whitefly in its roles as direct pests and virus vectors in most agricultural regions of the world. Unfortunately, the first insecticides used to control whiteflies were conventional, broad-spectrum products applied singly or, more often, in mixtures of organophosphates and pyrethroids, known as *cocktails* (Leite et al., 2005). These products soon failed to control these whitefly pests due to the outstanding genetic capacity that whiteflies have to develop resistance to insecticides of different nature world (Perumal et al., 2009). New insecticides such as neonicotinoids (e.g., imidacloprid, acetamiprid, thiamethoxam, nitenpyram and thiacloprid) and insect growth regulators (e.g., buprofezin and pyriproxyfen), were developed and widely used despite their higher prices. Unfortunately, insecticide abuse (excessive number of applications) and misuse (active ingredient diluted with other products) still occurs in different regions of the world. Alternative whitefly control strategies are available and can be highly effective when used properly. Therefore the present study was undertaken to observe the population dynamics of whitefly and to develop its ecofriendly management practices.

2. Materials and Methods

2.1. Study sites

Three experiments were carried out separately for bush bean (February-April 2011), okra (May-August 2011) and soybean (15^{th} January-May 2012) during the period from February 2011 to May 2012 at the farm of Sher-e-Bangla Agricultural University.

2.2. Crop husbandry

Seeds of bush bean, okra and soybean were directly sown in the field with the spacing of 30×10 cm^2 bush bean, 60×50 cm^2 for okra and 30×5 cm^2 for soybean. Two seeds of each crop were sown in a pit. After sowing seeds light irrigation was applied to each plot for proper germination of seed. Supplementary irrigation was given as and when needed. Weeding and mulching was done to keep the plot free from weeds and to break the soil crust. Fertilizers and manures were applied as per recommendation for bush bean, okra and soybean. For bush bean, the whole amount of cow dung, triple super phosphate (TSP), muriate of potash (MP) and half of the urea was applied during the time of final land preparation and the remaining half of urea was applied at 20 days after sowing as top dressing. The whole amount of cow dung, TSP, MP was applied during final land preparation and urea was applied at 25 and 45 days after sowing as top dressing in case of okra. For soybean, the whole amount of cow dung, TSP, MP half of the urea was applied during the time of final land preparation and the remaining half of Urea was applied at 20 days after sowing as top dressing.

2.3. Treatments and design

For bush bean the treatments were T_1=bamper (imidacloprid) 20 SL 0.5 ml L^{-1} of water, T_2=shobicron 425 EC 2.0 ml L^{-1} of water, T_3=actara (thiamethoxam) 25 WG @ 0.5 g L^{-1} of water, T_4=chlorpyriphos 20 EC @ 2.0 ml L^{-1} of water, T_5=sinothrin (cypermethrin) 10 EC @ 1.0 ml L^{-1} of water, T_6=fortap (cartap) 50 SP @ 1.5 g L^{-1} of water and T_7=untreated control (water).

For okra the treatments were T_1=ripcord (cypermethrin) 10 EC @ 1.0 ml L^{-1}, T_2=5% tamarind fruit (*Tamarindus indica*) extract, T_3=10% neem leaf (*Azadirachta indica*) extract, T_4=10% bullock's heart leaf (*Annona reticulata*), T_5=10% dodder (*cascuta reflexa*), T_6=10% oleander leaf (*Nerium oleander*), T_7=10% dhutra leaf (*Datura metel*), T_8=10% dholkolmi leaf (*Ipomoea carnea*), and T_9=untreated control (water).

For soybean the treatments were viz., T_1=marshal (carbosulfan) 20 EC 3.0 ml L^{-1} of water, T_2=semcap (fenthoate) 20 EC @ 2.0 ml L^{-1}, T_3=dursban (chlorpyriphos) 20 EC @ 2.0 ml L^{-1} of water, T_4=basathrin (cypermethrin) 10 EC @ 1.0 ml L^{-1}, T_5=fiter (λ-cyhalothrin) 2.5 EC @ 1.0 ml L^{-1}, T_6=shobicron 425 EC @ 2.0 ml L^{-1} and T_7=actara (thiamethoxam) 25 WG @ 0.5 g L^{-1} of water and T_8=untreated control (water). All the experiments were set in completely randomized block design (RCBD) with four replications for bush bean and three replications for okra and soybean.

2.4. Treatments application

Insecticides and plant extracts for each crop were applied with the help of knapsack sprayer having a pressure of 4.5 kg cm^{-2}. Mixture of insecticides or plant extracts in the sprayer was shaken well during spraying. Spraying was done at 11:00 am to avoid drift with moisture of leaves. First application was done 15 days after germination of seeds and it was continued at 10 days interval up to final harvest.

2.5. Method of data collection

Data were collected from treated and untreated plots on population of whitefly, fresh fruit yield of bush bean and okra, grain yield of soybean. Five plants were selected randomly from each plot, and the number of adult and nymph of whitefly was counted from upper, middle and lower leaves of each selected plant at 6.00 a.m. The data were collected at an interval of 10 days before spraying commencing from first incidence and continued up to the harvest. From these data the average number of whitefly per plant was calculated and the percent decrease of whitefly population for each treatment was determined. The weight of fresh fruits of bush bean and okra was taken separately from each plot after harvest. In case of soybean the plants were sundried and fruits were separated from the plants. The seeds were separated from the fruits by beating with bamboo stick. After separation the weight of grain was measured separately from each plot. From these data yield per plot was calculated and percent increase of yield over untreated control plot was calculated. Temperature and humidity data were recorded from the field when population of whitefly was counted.

2.6. Data analysis

The data were compiled and tabulated in proper form and were subjected to statistical analysis. The percentage data were subjected to ArcSine transformation. Analysis of variance was done following the computer package MSTAT-C program developed by Russel in 1986. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test at 5% level of significance (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Population trend of whitefly on bush bean, okra and soybean

The population trend of whitefly in untreated control plot on bush bean, okra and soybean in relation to temperature and humidity has been shown in graphs. The Figure 1 shows the population trend of whitefly on bush bean during February to April 2011. The population of whitefly was gradually increased with temprature and humidity and reached the peak during 9th March. Then it was declined with the age of the plant although temperature and humidity was increased. Similar populatin trend was observed in case of okra and the peak population was found on 22nd June (Figure 2). In case of soybean the population of whitefly also increased with increasing temperature and humidity and it ws reached peak on 16th March and then declined with plant age (Figure 3). It was alos observed that the number of insect per plant was lower in okra than bush bean and soybean.

The results on population dynamics of whitefly on bush bean, okra and soybean indicate that the population of the insect was gradually increased with temperature and humidity and declined with the age of the plant. Therefore temperature and humidity have profound effect on population build up of whitefly up to certain age of the crops. Both nymph and adult of whitefly suck the cell sap from the succulent part of the plant and its infestation is reduced older plants. The dry matter accumulation is increased with the age of the plant and thus reduces population of whitefly and its infestation as well. This result agrees with the findings of Rafiq et al. (2008) who reported that whitefly population increased with temperature and humidity. Moreover, Atwal and Dhaliwal (2007) revealed that whitefly preferred succulent part of the plant. Nevertheless, this result also supports the findings of Leite et al. (2005) who

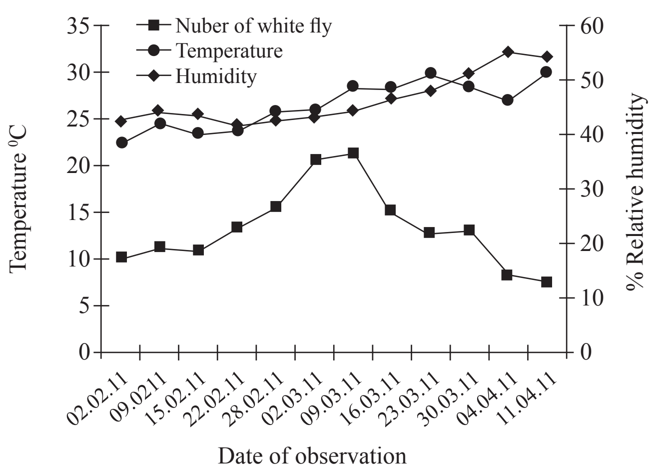

Figure 1: Population trend of whitefly on bush bean in relation to temperature and relative humidity during February to April 2011.

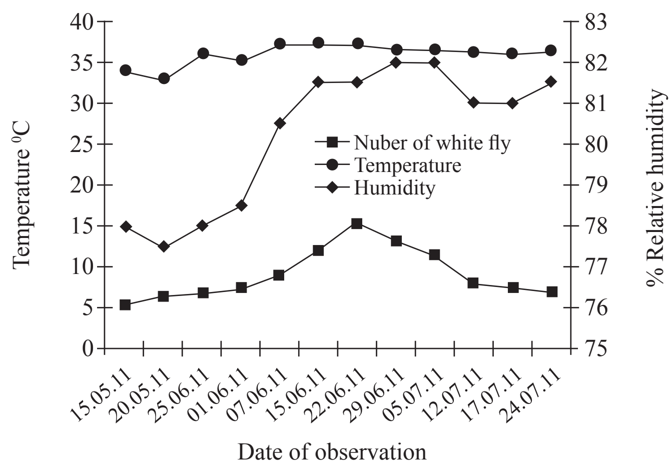

Figure 2: Population trend of whitefly on okra in relation to temperature and relative humidity during May to July 2011.

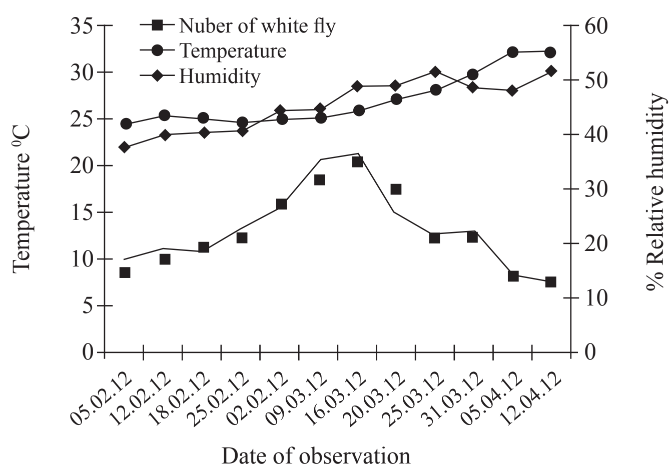

Figure 3: Population trend of whitefly on bush bean in relation to temperature and relative humidity during February to April 2012.

found several peak of whitefly population on okra depending on the age of the plants. Although the population trend of whitefly was similar in three cultivated crops the number of insect per plant in okra was lower than bush bean and soybean. This is due to heavy rainfall in rainy season of Bangladesh. The result supports the findings of Rafiq et al. (2008), Atwal Dhaliwal (2007) who reported that heavy rainfal reduced population of whitefly. However, this result may vary with the findings of others because of geographical and climatic variations, cropping season, presence of natural enemies of the pest.

3.2. Effect of different management practices against whitefly attacking bush bean, okra and soybean

The results on the effect of some chemical insecticides on population of whitefly have been shown in Table 1. The data reveal that the lowest number of whitefly (6.05 plant^{-1}) was found in imidacloprid treated plots followed by 8.23 plant^{-1} in thiamethoxm treated plots having significant difference between them. Cypermethrin and chlorpyriphos had no significant difference in terms of whitefly population although significantly higher population of whitefly was observed in cartap than cypermethrin. The highest number of whitefly (16.93 plant^{-1}) was recorded from untreated control plot. In terms of reduction of whitefly population over control, imidacloprid showed the best performance by reducing 64.13% population of whitefly which was significantly higher than all other insecticides. Other insecticides also reduced significant level of whitefly population over control (Table 1). Cartap showed the least effectiveness against whitefly population among the insecticides. The data also in Table 1 indicate that the highest fruit yield of bush bean (3050.0 g plot^{-1} or 4.068 kg ha^{-1} was obtained from the imidacloprid treated plot which was significantly higher than all other treatments. It increased 66.00% yield of fresh fruit of bush bean which was also significantly higher than all insecticide treatments. Thiamethoxam and shobicron increased more than 50% fresh fruit yield over control. Cartap showed the least effectiveness in terms of fruit yield (2652.5 g plot^{-1} or 3.42 kg ha^{-1}) and percent increase of fruit yield over control (40.56%). Cypermethrin and chlorpyriphos produced statistically similar fruit yield (3.58 and 3.53 t ha^{-1}, respectively) and increased same level of fruit yield.

Table 1: Incidence of whitefly on bush bean, percent decrease of population, fresh fruit yield and percent increase of yield over control over control under different treatments

A	B	C	D	E	F
Imidacloprid	6.05^{f}	64.13^{a}	3050.00^{a}	4.07^{a}	66.00^{a}
Shobicron	9.25^{d}	45.13^{c}	2787.50^{c}	3.72^{c}	51.73^{c}
Thiamethoxam	8.23^{e}	51.31^{b}	2887.50^{b}	3.85^{b}	57.17^{b}
Chlorpyriphos	10.98^{bc}	35.07^{e}	2650.00^{d}	3.53^{d}	44.27^{d}
Cypermethrin	10.20^{c}	39.68^{d}	2687.50^{d}	3.58^{d}	46.28^{d}
Cartap	11.33^{b}	33.09^{e}	2562.50^{e}	3.42^{e}	40.56^{e}
Untreated control	16.93^{a}	-	1837.50^{f}	2.45^{f}	-
CD (p=0.05)	0.87	2.30	46.56	0.06	2.21

A: Treatments; B: Number of whitefly plant^{-1}; C: Percent decrease of whitefly population in different treatments over control; D: Fruit yield (g plot^{-1}); E: Fruit yield (t ha^{-1}); F: Percent increase of fruit yield in different treatments over control

In a column, means followed by the same letter(s) are significantly different at 5% level of probability by DMRT

These results indicate that application of insecticides reduced population of whitefly and increased significant amount of fresh fruit yield of bush bean over untreated control. Imidacloprid was the most effective insecticides in terms of reduction of whitefly population and increasing yield of fresh fruit of bush bean. Cartap was the least effective insecticides against whitefly. The order of effectiveness of the insecticides against whitefly is imidacloprid>thiamethoxam>shobicron>cypermethrin>chlorpyriphos>cartap. This result supports the findings of Rana et al. (2006) who observed that imidacloprid and thiamethoxam were effective against whitefly population and gave higher yield of okra. It also supports the report of Parveen et al. (2007) who reported that foliar spray of imidicloprid and thiamethoxam reduced population of whitefly and increased significant amount of yield.

The results on the effect of different plant extracts on whitefly attacking okra have been presented in Table 2. The data indicate that the lowest number of whitefly (4.88 plant^{-1}) was found in dhutra leaf extract treated plot followed by 4.93 plant^{-1} in oleander leaf extract plot having no significant difference between them. However, significant variation was found with other plant extracts and cypermethrin insecticide. Considering the percent reduction of whitefly population over control, dhutra leaf extract showed the best performance by reducing 33.99% population. Oleander leaf extract gave the similar result (33.32%). Other plant extract also reduced significant level of whitefly population over control. Tamarind fruit extract showed the least effectiveness among all other plant extracts against whitefly population which reduced only 17.55% population of whitefly over control. The effectiveness of cypermethrin against whitefly was lower than dhutra and oleander leaf extract (Table 2).

Application of plant extracts and insecticides significantly increased fruit yield of okra. The highest fruit yield (3690.00 g plot^{-1} or 4.92 t ha^{-1}) was obtained from the plot treated with dhutra leaf extract which was significantly higher than all other treatments. It increased 33.21% fruit yield over control that was also significantly higher than all other treatments.

Cypermethrin increased 25.16% fruit yield of okra but it was significantly lower than dhutra and oleander leaf extracts. Although tamarind fruit extract increased fruit yield of okra, its performance was lower than all other treatments. These results indicate that application of plant extracts and insecticide reduced population of whitefly and increased significant amount of fresh fruit yield of okra over untreated control. Dhutra leaf extract was the most effective plant in terms of reduction of whitefly population and increasing yield of fresh fruit okra. Oleander leaf extract gave the similar result and the effectiveness of cypermethrin was lower than dhutra and oleander leaf extract. Tamarind fruit extract was the least effective against whitefly attacking okra. The order of effectiveness of the insecticide against whitefly is dhutra leaf extract>oleander leaf extract>cypermethrin>bulock's heart leaf extract>dodder extract>dholkolmi leaf extract>neem leaf extract>tamarind fruit extract. This result could not be compared with others because of lack of reference about the effectiveness of plant extract against whitefly. However, it supports the findings of Ahmad et al. (2000) who reported that cypermethrin was not effective against whitefly because it developed resistance against the chemical.

The effect of some chemical insecticides on population of whitefly attacking soybean has been shown in Table 3. The data reveal that the lowest number of whitefly (6.31 plant^{-1}) was recorded form thiamethoxam treated plots having significant difference with other treatments. It was reduced 61.65% population of whitefly over control that was also significantly higher than all other insecticides. However, no significant variation was observed among the other tested insecticides regarding number of whitefly and percent reduction of whitefly over control. The grain yield of soybean was significantly increased by application of insecticides. The highest grain yield (1075 g plot^{-1} or 1.43 t ha^{-1} was obtained by application of thiamethoxam, which was significantly higher than all other insecticides (Table 3). The lowest yield (860.00 plot^{-1} or 1.15 t ha^{-1}) was obtained for λ-cyhalothrin and it was increased only 13.67% grain yield of soybean that is significantly lower than all other insecticides treated plot. The data also indicate that carbosulfan and cholropyriphos increased 36.37% and 32.62% yield of soybean, respectively although there was significant variation between them.

This result indicates that application of chemical insecticides reduced the population of whitefly in soybean and increased grain yield of soybean. Significant variation was observed among the insecticides and thiamethoxam showed the best performance in reducing the population of whitefly and grain yield of soybean. The order of effectiveness of against whitefly attacking okra is amethoxam>carbosulfan>chlorpyriphos>fenthoate>shobicron>cypermthrin>λ-cyhalothrin. This result agrees with the report of Dey et al. (2005) who reported that thiamethoxam and imidacloprid provided effective control against *Bemicia tabaci*. The results on the effectiveness of other insecticides may contradict with others however it is logical because insect may develop resistance against these insecticides.

Table 2: Incidence of whitefly on okra, percent decrease of population, fresh fruit yield of okra and percent increase of yield over control under different treatments

A	B	C	D	E	F
Cypermethrin	5.48^{e}	25.89^{b}	3540.00^{b}	4.72^{b}	27.80^{b}
Tamarind fruit extract	6.10^{b}	17.55^{e}	3123.33^{f}	4.16^{f}	12.75^{f}
Neem leaf extract	5.88^{c}	20.49^{d}	3186.67^{e}	4.25^{e}	15.04^{e}
Bullock's heart leaf extract	5.70^{d}	22.97^{c}	3466.67^{c}	4.62^{c}	25.16^{c}
Dodder extract	5.75^{cd}	22.29^{cd}	3296.67^{d}	4.40^{d}	19.01^{d}
Oleander leaf extract	4.93^{f}	33.32^{a}	3576.67^{b}	4.77^{b}	29.11^{b}
Dhutra leaf extract	4.88^{f}	33.99^{a}	3690.00^{a}	4.92^{a}	33.21^{a}
Dholkolmi leaf extract	5.78^{cd}	21.84^{cd}	3283.33^{d}	4.38^{d}	18.52^{d}
Untreated control	7.40^{a}	-	2770.00^{g}	3.69^{g}	-
CD (p=0.05)	0.15	2.44	44.11	0.05	1.70

A: Treatments; B: Number of whitefly plant^{-1}; C: Percent decrease of whitefly population in different treatments over control; D: Fruit yield (g plot^{-1}); E: Fruit yield (t ha^{-1}); F: Percent increase of fruit yield in different treatments over control

Table 5: Incidence of whitefly population on soybean, percent decrease of population, grain yield of soybean and percent increase of yield over control under different treatments

A	B	C	D	E	F
Carbosulfan	8.12^{b}	50.61^{b}	1031.67^{b}	1.38^{b}	36.37^{b}
Fenthoate	8.60^{b}	47.71^{b}	945.00^{d}	1.26^{d}	24.91^{d}
Chlorpyriphos	8.23^{b}	49.84^{b}	1003.33^{c}	1.34^{c}	32.62^{c}
Cypermethrin	8.23^{b}	49.84^{b}	895.00^{f}	1.19^{f}	18.12^{f}
λ-cyhalothrin	8.53^{b}	48.10^{b}	860.00^{g}	1.15^{g}	13.67^{g}
Shobicron	8.38^{b}	48.96^{b}	925.00^{e}	1.23^{e}	22.27^{e}
Thiamethoxam	6.31^{c}	61.65^{a}	1075.00^{a}	1.43^{a}	42.11^{a}
Untreated control	16.43^{a}	-	766.67^{h}	0.99^{h}	-
CD (p=0.05)	0.57	3.86	12.25	0.02	1.35

A: Treatments; B: Number of whitefly plant^{-1}; C: Percent decrease of whitefly population in different treatments over control; D: Fruit yield (g plot^{-1}); E: Fruit yield (t ha^{-1}); F: Percent increase of fruit yield in different treatments over control

4. Conclusion

The overall results of the present study suggest that high temperature and high humidity increased incidence of whitefly on bush bean, okra and soybean. Imidacloprid and thiamethoxam were the most effective insecticides for the management of whitefly under prevailing environmental condition. Dhutra and oleander leaf extracts were more effective than cypermetrhin for the management of this obnoxious pest. Application of 10% leaf extract of dhutra or oleander may be ecofriendly for the management of whitefly in field crops.

5. Acknowledgment

This research was supported by grants from the Sher-e-Bangla Agricultural University Research System (SAURES) and University Grand Commission (UGC) research fund.

6. References

Ahmad, M., Arif, M.I., Ahmad, Z., 2000. Resistance of cotton whitefly, *Bemisia tabaci* to cypermethrin, α-cypermethrin and ζ-cypermethrin in Pakistan. In: Dugger, P., Richter, D., (Eds.), Proceedings Beltwide Cotton Conferences, San Antonio, USA, 4-8 January, 2000, 2, 1015-1017.

Anonymous, 1989. Management of whitefly, *Bemisia tabaci* G. on cotton, Andhra Predesh Agriculture University, Rajendranagar, Hyderabad, 50.

Attique, M.R., Rafiq, M., Ghaffar, A., Ahmad, Z., Mohyuddin, A.I., 2003. Hosts of *Bemisia tabaci* (Gen.) (Homoptera; Aleyrodidae) in cotton areas of Punjab, Pakistan. Crop Protection 22(5), 715-720.

Atwal, A.S., Dhaliwall, G.S., 2007. Agricultural pests of south Asia and their management. Kalayani Publishers, New Delhi, India, 505.

Dey, P.K., Jana, S.K., Chakraborty, G., Somchoudhury, A.K., 2005. Evaluation of imidacloprid (70WS and 20SL) against sucking pest complex of okra, *Abelmoschus esculentus*. Journal of Entomological Research 29(3), 215-218.

Gomez, K.A., Gomez, A.A., 1984. Statistical procedures for Agricultural Research (2nd Edn.). John Wiley and Sons, Singapore, 704.

Horowitz, A.R., 1986. Population dymanamics of *Bemisia tabaci* (Gennadius):with special emphasis on cotton fields. Agriculture, Ecosystem and Environment 17(1-2), 37-47.

Horowitz, A.R., Podoler, H., Gerling, D., 1984. Life Table Analysis of the Tobaco Whitefly *Bemisia tabaci* (Gennadius) in Cotton Fields in Israel. Acta Oecologica Oecologia Applicata 5(3), 221-233.

Jones, D.R., 2003. Plant viruses transmitted by whiteflies. European Journal of Plant Pathology 109(3), 195-219.

Jose. J., Usha, R., 2003. Bhendi yellow vein mosaic disease in India is caused by association of a DNA beta satellite with a begomovirus. Virology 305(2), 310-317.

Liete, G.L.D., Picnaco, M., Jham, G.N., Moreira, M.D. 2005. Whitefly population dynamics in okra populations. Pesquisa Agropecuaria Brasileira 40(1), 19-25.

Parveen, K.S., Sajjan, A.S., Patil, R.K., Dharmatti, P.R., Kurdikeri, M.B., 2007. Influence of seed treatment and foliar spray with insecticides and neem products on growth and seed yield in okra (*Abelmoschus esculentus* [L.] Moench). Karnataka Journal of Agricultural Science 20(2), 388-390.

Perumal, Y., Marimuthu, M., Salim, A.P., Ponnusamy, B., 2009. Host plant mediated population variations of cotton whitefly, *Bemisia tabaci* Gennadius (Aleyrodidae: Homoptera) characterized with random DNA markers. American Journal of Biochemistry and Biotechnology 5(1), 40-46.

Rafiq, M., Ghaffar, A., Arshad. M., 2008. Population dynamics of whitefly (*Bemisia tabaci*) on cultivated crop gosts and their role in regulating its carry-over to cotton. International Journal of Agriculture and Biology 10(5), 577-580.

Rana, S.C., Singh, P.B., Pandita, V.K., Sinha, S.N., 2006. Evaluation of insecticides as seed treatment for control of early sucking insects pests in seed crop of okra. Annals of Plant Protection Science 14(2), 364-367.

Russel, D.F., 1986. MSTAT-C Package Programme. Dept. of Crop and Soil Science, Michigan State University, USA.