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ABUNDANCE AND CONTROL OF RUGOSE SPIRALING WHITEFLY, *ALEURODICUS RUGIOPERCULATUS* MARTIN, INFESTING COCONUT IN SEVEN COASTAL DISTRICTS OF BANGLADESH

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Abstract

A survey was conducted in the farmers' orchards of 7 coastal districts, namely Patuakhali, Barguna, Barishal, Khulna, Bhola, Laxmipur, and Noakhali of Bangladesh to know the abundance of rugose spiraling whitefly on coconut and an experiment consisting of 5 treatments and an untreated control following RCBD with 3 replications was also carried out for controlling rugose spiraling whitefly at Patuakhlai Science and Technology University (PSTU) campus during January to May, 2022. Results revealed that the highest abundance (23 egg spirals, 34 nymphs, 31 adults per leaflet, respectively) of rugose spiraling whitefly was found at Khulna, followed by Noakhali (19 egg spirals, 31 nymphs, 27 adults per leaflet, respectively) while the lowest (9 egg spirals, 13 nymphs, 11 adults per leaflet, respectively) was in Patuakhali among 7 coastal districts. Although all insecticidal treatments (T_1 = Tyfos 48 EC (Chlorpyrifos) @ 1 ml/L of water, T_2= Caught 10 EC (Cypermethrin) @ 1 ml/L of water, T_3 = Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 1 ml/L of water, T_4= Fyfanon 57 EC (Malathion) @ 1 ml/L of water, T_5= Bioclean @ 1 ml/L of water) effectively reduced the different stages of rugose spiraling whiteflies compared to untreated control, the lowest mean number of egg spirals (0.00), nymphs (0.11) and adults (0.11) per leaflet were obtained by the application of Nitro 505EC @ 1 ml/L of water followed by Bioclean @ 1 ml/L of water at 3 DAS. The highest percent reduction of egg spirals (100%), nymph (98.82%), and adult (98.79%) of whitefly population over control were also obtained by the application of Nitro 505EC @ 1 ml/L of water followed by Bioclean @ 1 ml/l of water at 3 DAS. These two chemicals were found to be very effective for controlling rugose spiraling whiteflies. Considering environmental safety, Bioclean @ 1 ml/L of water is recommended to use against this pest as an eco-friendly approach for safe food production.

Keywords: Abundance, coconut, control, rugose spiraling whitefly, *Aleurodicus rugioperculatus*

Introduction

Coconut palm, *Cocos nucifera* L. (Arecales: Arecaceae), is now widely grown throughout tropical regions of the world, including Brazil (Omena *et al.,* 2012), coastal areas of Bangladesh, and is recognized as an essential source of income for coconut growers.

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Coconut is a fruit of high economic value due to its diversified utilization, which covers 0.65% of Bangladesh's total cultivated lands for fruit crops. About 80% of the country's total production of coconut is contributed by the country's southern areas (BBS, 2011). The national yield of coconut has been estimated at an average of 51 kg/fruit-bearing tree/year with a total production of 3,83,833 MT/year from an area of 9,152 acres (BBS, 2016). But coconut production is enormously hindered by the ravages of various insect and mite pests from seedling to their maturity. Bangladesh is a humid and subtropical country favoring the luxuriant growth of different insect species with rich diversity. Recently, coconut palms have been seen to be seriously affected due to the severe infestation of an alien invasive crop pest known as the Rugose Spiralling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Stemorrhyncha: Aleyrodidae) in Bangladesh. Martin described this species from Belize in Central America in 2004 based on puparia collected from the undersurface of coconut leaves (Martin, 2004). These whitefly species were newly added to the species list of whiteflies in Florida as *A. rugioperculatus* Martin, known initially as the gumbo limbo spiraling whitefly. Still, it is presently named the rugose spiraling whitefly. Foreign species can attain invasive pest status when they are accidentally introduced to new areas where they are isolated from their natural enemies and if indigenous beneficial species like predators and /or parasitoids cannot suppress pest populations (Duan *et al.,* 2015). It is a very destructive pest that mainly threatens coconut plantations. It causes damage to coconut palms and other broad-leaved host plants in its native range (Mayer *et al.,* 2010). The pest was first noticed in Tamil Nadu, Kerala, Karnataka, and Andhra Pradesh in July 2016 (Sundararaj and Selvaraj, 2017; Karthick *et al.*, 2018). The species caused damage to coconut trees across vast areas on a large scale and infested other host plants. It cannot kill the host plant by its infestation. Still, it may hamper the average growth of its host by excreting a sticky glistering liquid substance called honeydew on which sooty mold grows which retards photosynthesis. They can cause stress to the host plant by removing nutrients and water and accelerating the growth of black sooty molds. Ants and wasps are also attracted to honeydew and protect the whiteflies from their natural enemies (Stocks and Hodges, 2012). There are numerous available insecticides to manage whiteflies, but the technique of spraying application and site to use the product vary by label (Mannion, 2010). Sanitation and synthetic chemical control costs can substantially affect homeowners and businesses (Kumar *et al.,* 2013). Considering the above facts, the present experiment was undertaken to determine the abundance of invasive rugose spiraling whiteflies on coconuts and their control in seven selected southern coastal districts of Bangladesh.

Materials and Methods

Survey on the abundance of rugose spiraling whitefly on coconut in seven southern coastal districts of Bangladesh

Systematic surveys were carried out in the farmers' orchards of 7 locations, namely Patuakhali, Barishal, Barguna, Khulna, Bhola, Laxmipur, and Noakhali districts of Bangladesh, to know the abundance of rugose spiraling whitefly on coconut during January to May 2022. Fourteen upazilas, two from each district, were selected as study areas of the survey. Seven hundred plants were selected randomly for data collection by taking fifty coconut trees from each upazila. Out of 50, five trees were selected randomly to observe the abundance of whiteflies (number of egg spirals, nymphs, and adults per 5 leaflets) per frond of a coconut tree.

Evaluation of insecticides for controlling rugose spiraling whitefly on coconut

The experiment was carried out on coconut trees grown in the Patuakhali Science and Technology University campus, Dumki, Patuakhali, from January to May 2022. The experiment was laid out in an RCB design with three replications. One tree was treated as a treatment replication. Five treatments viz., T_1 = Tyfos 48 EC (Chlorpyrifos) @ 1 ml/L of water, T_2= Caught 10 EC (Cypermethrin) @ 1 ml/L of water, T_3 = Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 1 ml/L of water, T_4= Fyfanon 57 EC (Malathion) @ 1 ml/L of water, T_5= Bioclean @ 1 ml/L of water and T_6 = Control were applied. The spraying was done with the help of a hand sprayer. The spraying was done on all frond leaflets by calculating the solution volume required for each treatment. Data on the number of egg spirals/leaflets, nymphs/leaflets, adults/leaflets, and the presence of sooty mold encrustation in fronds were recorded at 3, 6, and 9 days after spraying.

Statistical analyses: The data obtained were statistically analyzed to determine the incidence and control of coconut whiteflies. The mean values of all the characters were calculated, and analysis of variance was performed using WASP 1.0 (Web Agri Stat Package) software, and means were separated by CD values.

Plate 1. Photographs of different treatments applied for controlling rugose spiraling whitefly

Results and Discussion

Abundance of rugose spiraling whitefly

Number of egg spirals per leaflet: Live egg spirals/leaflet ranged between 9.36 and 23.41 in most of the surveyed locations of coastal districts, while the live egg spirals/leaflet was less than 10 in Patuakhali district. The highest number of egg spirals per leaflet was found in the Khulna district (23.41 egg spirals/leaflet), followed by Noakhali (19.31 egg spirals/leaflet) and Bhola (17.18 egg spirals/leaflet). But the lowest number was in Patuakhali (9.36 egg spirals/leaflet), followed by Laxmipur (11.23 egg spirals/leaflet), Barishal (13.24 egg spirals/leaflet) and Barguna (15.16 egg spirals/leaflet) (Fig. 1).

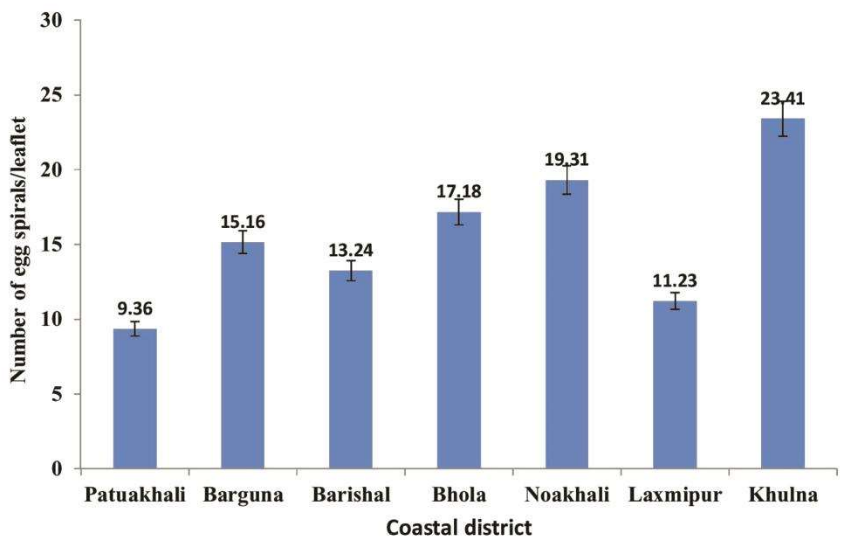

Fig. 1. Number of rugoses spiraling whitefly egg spirals/leaflets of the coconut tree

Number of nymphs per leaflet: Nymphs/leaflets ranged between 13.41 and 34.17 nymphs in the surveyed locations of coastal districts, whereas the population was less than 15 in Patuakhali district. The highest number of nymphs/leaflet was recorded in the Khulna district (34.17 nymphs/leaflet), followed by Noakhali (31.25 nymphs/leaflet), Bhola (27.34 nymphs/leaflet) and Barguna (23.28 nymphs/leaflet). In contrast, the lowest number was in Patuakhali (13.41 nymphs/leaflet), followed by Laxmipur (15.47 nymphs/leaflet) and Barishal (19.16 nymphs/leaflet). (Fig. 2).

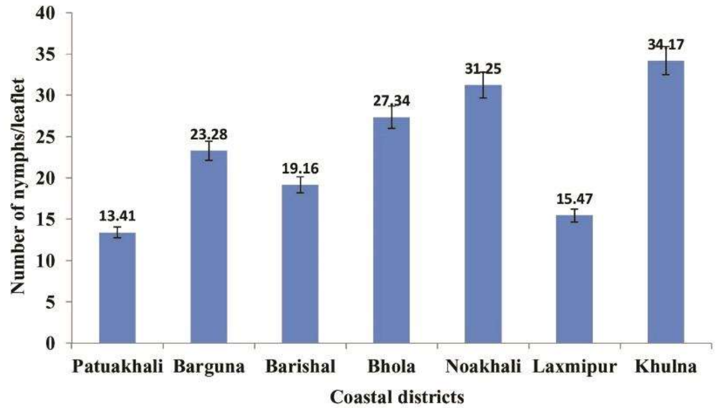

Fig. 2. Number of rugose spiraling whitefly nymphs/leaflet of coconut tree

Number of adults per leaflet:

Number of adults per leaflet: Adults/leaflets ranged between 11.13 and 31.36 in the surveyed locations of coastal districts, whereas the adult population of the pest was less than 15 in Patuakhali and Laxmipur districts. The highest number of adults/leaflet was observed in Khulna district (31.36 adults/leaflet), followed by Noakhali (27.17 adults/leaflet), Bhola (24.29 adults/leaflet) and Barguna (21.34 adults/leaflet) while the lowest number was in Patuakhali (11.13 adults/leaflet) followed by Laxmipur (14.22 adults/leaflet) and Barishal (16.41 adults/leaflet). (Fig. 3).

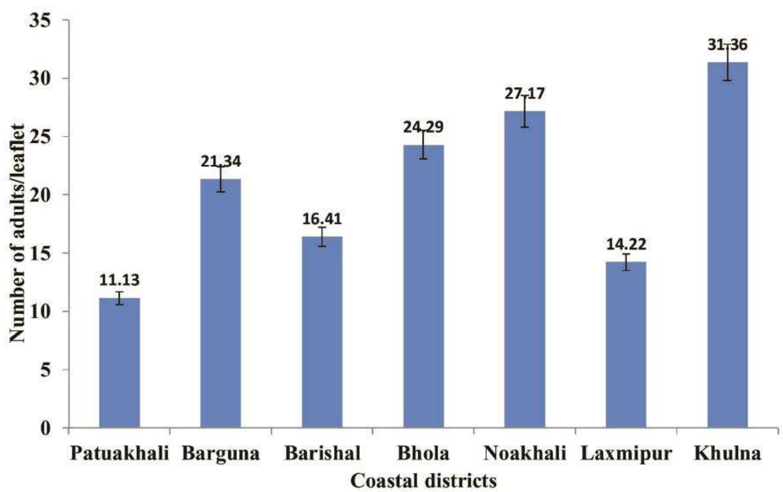

Fig. 3. Several rugose spiraling whitefly adults/leaflets of the coconut tree.

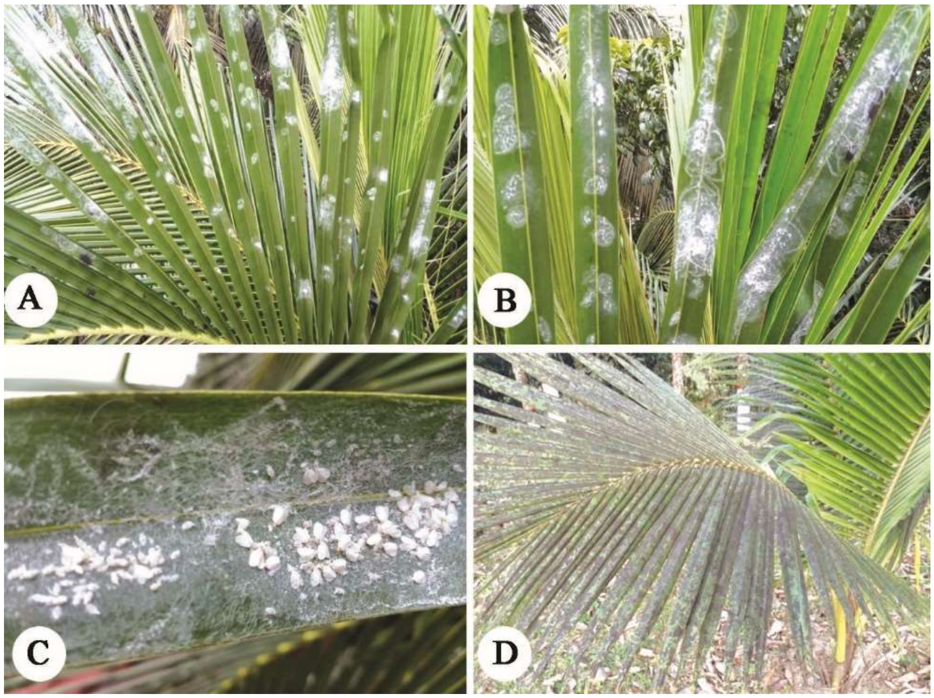

Plate 2. Photographs of the abundance of rugose spiraling whiteflies as egg spirals (A&B), nymphs (A&B), adults (C), and sooty mold symptoms (D).

Control of rugose spiraling whitefly

Efficacy of insecticides on egg spirals of rugose spiraling whiteflies: The effect of insecticides on the egg spirals of rugose spiraling whiteflies on different days after spraying is presented in Table 1. At 3 DAS, no egg spirals were recorded in T_3 (0.00) treated leaflets, but the lowest number of egg spirals was found in T_5 (0.33) treated leaflets, which was statistically similar to T_1 (0.67) and T_2 (1.00) and T_4 (1.33) treated leaflets. The number of egg spirals/leaflets on all insecticidal-treated leaflets differed significantly from untreated control (T_6) leaflets, with the highest number (13.33) of egg spirals/leaflets recorded.

At 6 DAS, no egg spirals were observed in T_3 (0.00) treated leaflets, which was identical to T_5 (0.00), but the lowest number of egg spirals was found in T_1 (0.33), which was statistically similar to T_2 (0.67) and T_4 (0.33) treated leaflets. The number of egg spirals/leaflets on all insecticidal-treated leaflets differed significantly from untreated control (T_6) leaflets, where the highest number (13.97) of egg spirals/leaflets was recorded.

At 9 DAS, no egg spirals were found in all treated leaflets, and no significant differences existed among treatments. However, the number of egg spirals/leaflets on all insecticidal-treated leaflets differed significantly from untreated control (T_6) leaflets, where the highest number (15.39) of egg spirals/leaflets was observed.

The highest percent reduction of egg spirals/leaflets was obtained from T_3 (100%), followed by T_5 (99.23%) and T_1 (97.68%) treated leaflets, and the lowest was in T_2 (95.99%) treated leaflets, followed by T_4 (96.13%).

Table 1. Efficacy of insecticides on egg spirals of rugose spiraling whiteflies at 3, 6, and 9 days after spraying

Treatments	Mean number of egg spirals/leaflets at			Mean	% reduction over control
	3 DAS	6 DAS	9DAS		
T_1	0.67b (1.05)	0.33b (0.88)	0.00b (0.70)	0.33	97.68
T_2	1.00b (1.18)	0.67b (1.05)	0.00b (0.70)	0.57	95.99
T_3	0.00b (0.70)	0.00b (0.70)	0.00b (0.70)	0.00	100.00
T_4	1.33b (1.29)	0.33b (0.88)	0.00b (0.70)	0.55	96.13
T_5	0.33b (0.88)	0.00b (0.70)	0.00b (0.70)	0.11	99.23
T_6	13.33a (3.76)	13.97a (3.79)	15.39a (3.94)	14.23	-
CV (%)	**18.91**	**19.74**	**21.36**		
CD (at 1%)	**1.934**	**2.150**	**2.575**		

DAS = Days after spraying; CD= Critical difference value. Figures in parentheses are transformed values based on square root transformation, values are averages of 3 replications.

T_1 = Tyfos 48 EC (Chlorpyrifos) @ 1ml/L of water, T_2= Caught 10 EC (Cypermethrin) @ 1 ml/L of water, T_3 = Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 1 ml/L of water, T_4= Fyfanon 57 EC (Malathion) @ 1 ml/L of water, T_5= Bioclean @ 1 ml/L of water and T_6 = Control.

Efficacy of insecticides on nymphs of rugose spiraling whiteflies: The effect of insecticides on the nymphs of rugose spiraling whiteflies on different days after spraying is given in Table 2. At 3 DAS, the lowest number of nymphs/leaflets was observed in T_3 (0.33) treated leaflets, which was identical to T_5 (0.33) treated leaflets, followed by T_1

(0.67) and T_2 (0.67) and T_4 (1.00) treated leaflets. The number of nymphs/leaflets on all insecticidal treated leaflets differed significantly from untreated control (T_6) leaflets, with the highest number (12.00) of nymphs/leaflets recorded.

At 6 DAS, no nymph was observed in T_3 (0.00) treated leaflets, but the lowest number of nymph was found in T_5 (0.33), which was statistically similar to T_1 (0.33), T_2 (0.33) and T_4 (0.33) treated leaflets. The number of nymphs/leaflets on all insecticidal treated leaflets differed significantly from untreated control (T_6) leaflets, with the highest number (9.64) of nymphs/leaflets recorded.

At 9 DAS, no nymph was found in all treated leaflets, with no significant difference among treatments. However, the number of nymphs on all insecticidal treated leaflets differed significantly from untreated control (T_6) leaflets, where the highest number (6.23) of nymphs/leaflets was observed.

The highest percent reduction of nymphs/leaflet was obtained from T_3 (98.82%) treated leaflets, followed by T_5 (97.36%) and T_1 (96.45%), which was identical to T_2 (96.45%), but the lowest was in T_4 (95.26%) treated leaflets.

Table 2. Efficacy of insecticides on nymph of rugose spiraling whiteflies at 3, 6, and 9 days after spraying

Treatments	Mean number of nymph/leaflets at			Mean	% reduction over control
	3 DAS	6 DAS	9DAS		
T_1	0.67b (1.05)	0.33b (0.88)	0.00b (0.70)	0.33	96.45
T_2	0.67b (0.99)	0.33b (0.88)	0.00b (0.70)	0.33	96.45
T_3	0.33b (0.88)	0.00b (0.70)	0.00b (0.70)	0.11	98.82
T_4	1.00b (1.18)	0.33b (0.88)	0.00b (0.70)	0.44	95.26
T_5	0.33b (0.88)	0.33b (0.88)	0.00b (0.70)	0.22	97.36
T_6	12.00a (3.60)	9.64a (3.15)	6.23a (2.58)	9.29	-
CV (%)	**21.62**	**21.38**	**23.21**		
CD (at 1%)	**0.886**	**0.723**	**0.670**		

DAS = Days after spraying; CD= Critical difference value. Figures in parentheses are transformed values based on square root transformation, values are averages of three replications.

T_1 = Tyfos 48 EC (Chlorpyrifos) @ 1 ml/L of water, T_2= Caught 10 EC (Cypermethrin) @ 1 ml/L of water, T_3 = Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 1 ml/L of water, T_4= Fyfanon 57 EC (Malathion) @ 1 ml/L of water, T_5= Bioclean @ 1 ml/L of water and T_6 = Control.

Efficacy of insecticides on adult rugose spiraling whiteflies: The effect of insecticides on the adults of rugose spiraling whiteflies on different days after spraying is presented in Table 3. At 3 DAS, the lowest number of adults was observed in T_3 (0.33) treated leaflets, which was identical to T_1 (0.33) and T_5 (0.33) treated leaflets, followed by T_2 (0.67), which was also similar to T_4 (0.67) treated leaflets. The number of adult/leaflets on all insecticidal treated leaflets differed significantly from untreated control (T_6) leaflets, where the highest number (10.00) of adult/leaflets was recorded.

At 6 DAS, no adult was observed in T_3 (0.00) treated leaflets, but the lowest number of egg spiral was found in T_5 (0.33), which was statistically identical and similar to T_1 (0.33), T_2 (0.33), and T_4 (0.33) treated leaflets. The number of adult/leaflets on all insecticidal treated leaflets differed significantly from untreated control (T_6) leaflets, where the highest number (9.24) of adult/leaflets was recorded.

At 9 DAS, no adult was found in all treated leaflets except T_4 (0.33) treated leaflets, and there was no significant difference among treatments. However, the number of adult/leaflets on all insecticidal treated leaflets differed significantly from untreated control (T_6) leaflets, where the highest number (8.00) of adult/leaflets was observed.

Table 3. Efficacy of insecticides on adult rugose spiraling whiteflies at 3, 6, and 9 days after spraying

Treatments	Mean number of adult/leaflets at			Mean	% reduction over control
	3 DAS	6 DAS	9 DAS		
T_1	0.33b (0.88)	0.33b (0.88)	0.00b (0.70)	0.22	97.58
T_2	0.67b (0.99)	0.33b (0.88)	0.00b (0.70)	0.33	96.37
T_3	0.33b (0.88)	0.00b (0.70)	0.00b (0.70)	0.11	98.79
T_4	0.67b (0.99)	0.33b (0.88)	0.33b (0.88)	0.44	95.15
T_5	0.33b (0.88)	0.33b (0.88)	0.00b (0.70)	0.22	97.58
T_6	10.00a (3.23)	9.24a (3.08)	8.00a (2.91)	9.08	-
CV (%)	**24.19**	**27.79**	**18.04**		
CD (at 1%)	**1.151**	**1.260**	**0.682**		

DAS = Days after spraying; CD= Critical difference value. Figures in parenthesis are transformed values after square root transformation, values are means of 3 replications.

T_1 = Tyfos 48 EC (Chlorpyrifos) @ 1 ml/L of water, T_2= Caught 10 EC (Cypermethrin) @ 1 ml/L of water, T_3 = Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 1 ml/L of water, T_4= Fyfanon 57 EC (Malathion) @ 1 ml/L of water, T_5= Bioclean @ 1 ml/L of water and T_6 = Control.

The highest percent reduction of adult/leaflet was obtained from T_3 (98.79%) treated leaflets, followed by T_5 (97.58%), which was identical to T_1 (97.58%), but the lowest was in T_4 (95.15%) treated leaflets followed by T_2 (96.37%).

There is no available research report on the chemical control of rugose spiraling whiteflies due to a new invasive coconut pest. Effective control can be achieved using systemic insecticides in the soil as granular formulations, drenching, burying pellets, or injection, to the trunk as trunk injection and as basal bark spray, or to the leaf; however, soil and trunk applications receive the advantage of the systemic properties of these products and give longer-term control (Mannion, 2010). Quick knockdown of the whiteflies occurred by spraying contact insecticides on the leaves but will provide only a few weeks of control. Elango et al. (2021) stated that the population dynamics of a new invasive whitefly species, *A. rugioperculatus*, was found throughout the year on coconut palms. Observations recorded at weekly intervals showed that the whitefly population accelerated from the first week of July (130.8 nymph/leaf/frond), reaching the maximum during the first week of October (161.0 nymph/leaf/frond), which gradually declined to a minimum during April. The agro-climatic conditions of different regions varied, for which arthropods showed changing trends in their natural incidence and extent of damage to the crop. Weather parameters did not influence the incidence of rugose spiraling whiteflies despite its requirement for developing management strategies. In the case of large trees, there may be some barriers that need to be taken into consideration before concluding.

First, getting sufficient insecticidal active ingredients or volume to large trees can sometimes take much work. Second, it is challenging to design a sampling program to get an accurate representation of the entire infestation of the tree. Third, seasonal leaf shedding reduces the availability of leaves to the whitefly population, and therefore, it is impossible to easily link the density of the whitefly population with insecticidal treatment. Consequently, the efficacy of synthetic chemical insecticides in such a case demands further investigation. These findings are also supported by Taravati et al. (2013). Many reported plant species are expected to be incidental hosts that cannot sustain long-term rugose spiraling whitefly populations and, therefore, need minimal or no management practices. The prevalence of higher temperature increases metabolic activities at a faster rate in insects, resulting in a rapid build-up of pest population density in a shorter period. Likewise, the prevailing of high relative humidity influences the building up of the insect population. The population of both pests and natural enemies is reduced due to increasing rainfall, as heavy rains wash out the different life stages of the pests and natural enemies.

Conclusion

The abundance of rugose spiraling whitefly was the highest and most severe in Khulna and Noakhali districts, while the lowest was in Patuakhali among 7 coastal districts. The application of Nitro 505EC @ 1 ml/L of water and Bioclean @ 1 ml/L of water was found to be very effective for controlling rugose spiraling whiteflies.

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