

Identification of Rugose Spiralling Whitefly Infesting Host Plants in Bangladesh and Assessment of Its Damage Severity

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Abstract: The rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* (Aleyrodidae: Hemiptera) is an invasive insect pest and it was first identified in Bangladesh in 2019 on coconut plants. A baseline survey study was conducted in Bangladesh to identify the RSW-infesting geographical locations, host plants as well as to assess the damage severity. The duration of the survey period was 8 months from May to December 2021. Based on our survey results, we report that RSW has invaded all over Bangladesh with low to very severe infestation level. The highest infestation was noticed in west, south-west and north-east regions while comparatively lower infestation was found in south, south-eastern and central part of the country. It was evident from this study that both border and non-border districts were affected almost equally by this insect pest. During the survey period, sixty onehost plants were identified throughout country where 49.18% were fruit plant species, 21.31% ornamentals and flowers, 8.19% field crops, 8.19% forests and 13.13% other species. Among the host plants, very severe infestation was noticed on coconut where 85.72% native and 81.23% dwarf coconut plants were found to be infested by RSW. Results also showed that comparatively lower leaflet infestation, low leaf area encrustation by sooty mould fungus and low abundances of adult RSW were found in dwarf coconut plants than that of native. After coconut, next infestation severity was observed on banana (low to severe) and guava (low to medium) although the extent of damage varied from district to districts. On the other hand, low infestation was found on the rest of the host plants under different plant groups viz. forests, ornamentals, flowers, field crops, cash crops etc.

Keywords: Rugose Spiralling Whitefly, Geographical Locations, Host Plants, Damage, Severity

1. Introduction

Bangladesh's economy is mainly based on agriculture that contributes 12.68 percent in country's GDP and provides employment to 37.75 percent of the country's workforce [1, 2]. Agriculture provides a vital role in feeding our country's populations and currently the country has achieved self-sufficiency in food. Insect infestations are always a big threat for the successful crop production in our country and a significant amount of crops is damaged every year due to insect infestations. In addition to the native insect species, our agriculture is often threatened due to the invasion of some exotic species. Bangladesh being a tropical country

with a warm and humid climate and free of trade and movement of agricultural commodities has always been vulnerable to threats of exotic pests. Moreover, global climate change for the last several decades, increases in annual temperature, scanty rainfall and widespread human migration worked as key factors for spread and establishment of the invasive species in our country. Few alien species adapt with our farming systems in a big way but most of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and outcompete native species [3]. These alien species, if not accompanied by the natural enemies which

keep them in check in their native range, can multiply in large proportion and cause damage economically.

The rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Aleyrodiade: Hemiptera), a fairly new insect species in the world. The adult whitefly makes distinctive spiralling patterns when laying eggs on the under surface of leaves or on fruits, and hence its common name spiralling whitefly is derived. This insect was first identified in Belize, a Caribbean country in 2004. It was then identified in Florida (Central America) in 2009 [4]. In India, this pest was first identified in Pollachi, Tamil Nadu during August 2016 [5] and around 3 years later in April 2019, this pest was first identified by Bangladesh Agricultural Research Institute (BARI) on coconut plants at Regional Agricultural Research Station (RARS), Jashore [6]. Currently, its aggressive outbreak has also been observed in almost all the geographical locations of the country. Although, coconut is the main host plant of this invasive pest but more than 30 host plants in India and about 118 host plants identified globally [5, 7-15].

Rugose spiralling whitefly is a hemipteran insect that cause damage on plants directly and indirectly. The RSW can cause stress to the plant by removing nutrients and water, and by promoting the growth of black sooty mould. It excretes a sticky, glistening liquid substance (honeydew), which provides an excellent substrate for growth of sooty mould, which turns the shiny liquid into a black-colored viscous liquid. Once it dries, the sooty mould forms thick layers on the host leaves and other non-plant surfaces [16-17]. The thick layers of sooty mould on leaves severely disrupt the photosynthesis process in the host leading to physiological disorders.

Since RSW has recently introduced in Bangladesh, no survey work been conducted yet on its outbreak, host range and nature and extent of damage. As exotic species are always aggressive to new locations, new hosts and in new climatic condition therefore, this invasive alien pest could become a major threat for our agriculture in near future [18]. Moreover, as this alien insect pest attacks a wide range of host plants, so our farmers can be at a greater risk and their income and livelihood may be declined. Considering the above facts, an extensive baseline survey study was carried out for a period of eight months from May to December 2021

in different geographical locations of Bangladesh to ascertain the current outbreak scenario, host plants dynamics as well as severity of infestation caused by rugose spiralling whitefly.

2. Materials and Methods

2.1. Study Area

There are fourteen agricultural regions in Bangladesh under the Department of Agricultural Extension (DAE). In this study, a baseline survey study was carried out in 44 districts ensuring all agricultural regions of Bangladesh through physical visit of different orchards as well as horticulture centers to collect necessary informations regarding the objectives of the present study. There are several upazilas under each district but 2-3 upazilas were randomly selected for collecting data.

2.2. RSW-Infesting Geographical Locations

Based on infestation severity, the entire Bangladesh has divided into different regions like north, east, west, south, north-east, north-west, south-east, south-west and center.

2.3. Identification of RSW-Infesting Host Plants

There are many whitefly species in our country those are abundant on different host plants. The rugose spiralling whitefly is an exotic species and can be distinguished from other whitefly species by some morphological characteristics like presence of distinct spirals on the host plants, large-sized adults than other whitefly species, presence of irregular bands across the wings as well as long pincer-like structures at the end of the abdomen. By confirming these characteristics we have identified the RSW-infesting host plants in different geographical locations of the country. Once identified, all the host plants were categorized into different groups like fruits, ornamental and flowers, forests, field crops and others.

2.4. Overall Infestation Severity on Different Host Plants

Identified host plants were categorized into five groups based on some infestation criteria and then symbolized with ‘+’.

Table 1. Infestation criteria, infestation level and symbols.

Symbol	Infestation level	Criteria to set infestation level
+	Low	<10% plants are infested; fewer than 10 nymphs & adults per leaf or leaflet
++	Medium	11-30% plants are infested; 11-20 nymphs & adults per leaf or leaflet
+++	High	31-60% plants are infested; 21-40 nymphs & adults per leaf or leaflet
++++	Severe	61-90% coconut plants are infested; 41-50 nymphs & adults per leaf or leaflet
+++++	Very severe	>90% coconut plants are infested; more than 50 nymphs & adults per leaf or leaflet.

2.5. Assessment of Infestation Severity on Coconut Plants

As, coconut is the main host of RSW, hence details infestation severity was assessed (both native and dwarf). Four parameters were measured; (i) Percent infested coconut

plant (ii) Percent infested frond (iii) Percent infested leaflet and (iv) Percent leaf area covered with sooty mould fungus.

The following equations were used to measure the above parameters;

$$\text{Percent (\%)} \text{ infested plant} = \frac{b}{a} \times 100$$

b= Total infested coconut plants

a= Total coconut plants

$$\text{Percent (\%)} \text{ Infested frond} = \frac{b}{a} \times 100$$

b= Total infested fronds in a coconut plant

a= Total fronds in a coconut plant

$$\text{Percent (\%)} \text{ infested leaflet} = \frac{b}{a} \times 100$$

b= Total infested leaflets in a frond

a= Total leaflets in a frond

$$\text{Percent (\%)} \text{ leaf area covered with sooty mould fungus} = \frac{b}{a} \times 100$$

b=Total infested leaf area (cm²)

a = Total leaf area (cm²)

Statistical Analysis: Statistical analysis was carried out using ANOVA, followed by Fisher's least significant difference test (Fisher's LSD). Moreover, descriptive analysis such as range, number and percentage, mean, standard deviation etc. were used whenever necessary. Throughout the study, 5% level of probability was used as a basis of rejecting a null hypothesis.

3. Results

3.1. RSW-Infesting Geographical Locations

Based on our survey results, we found that the rugose spiralling whitefly has invaded all over Bangladesh with different level of infestation severity. To know the infestation severity on coconut plants, the whole country has been divided into nine regions viz. north, south, east, west, north-east, north-west, south-east, south-west and central. Among nine regions, the lowest infestation was found in central part of the country (69%) especially in Dhaka and its adjoining districts like Munshiganj and Narayanganj (Figure 1). On the other hand, 76.25% coconut plants were found infested in south and south-eastern districts like Cox's Bazar, Banderban and Chittagong. It was noteworthy that only 20-30% coconut plants were found to be infested in Ramu upazila under Cox's Bazar district. Ramu upazila is famous for extended cultivation of coconut and betel nut at farmer's level. In contrast, high level of infestation was found in Teknaf and about 60-70% coconut plants were found infested at Saint

Martin Island also. Banderban is one of the three hill districts of Bangladesh and 40% coconut plants were found infested. Among nine regions, very severe infestation was found in west, south-west and north-east regions of Bangladesh like Khulna, Bagerhat, Barisal, Pirojpur, Jashore, Chuadanga, Meherpur, Kushtia, Jhenaidah, Mymensingh, Jamalpur and Sherpur districts (Figure 1).

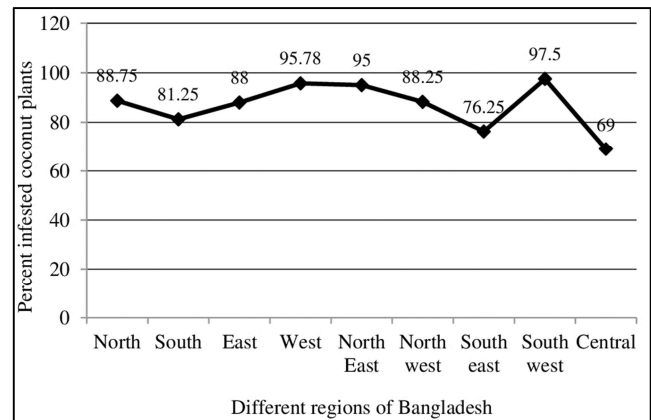


Figure 1. Infestation severity caused by RSW in different geographical regions of Bangladesh.

3.2. Identified Host Plants

Till December 2021, sixty one host plants were identified across the country under different plant groups and families (Table 2, Figure 2, Figure 3). Among the identified host plants, 49.18% were belonged to fruit plants, 21.31% ornamental and flower plants, 8.19% field crops, 8.19% forest plants and 13.13% comprised diverse species (Figure 4). Among the fruit plants, the highest numbers of species were belonged to the family Rutaceae (20%) that was followed by Arecaceae, Anacardiaceae, Myrtaceae and Annonaceae with 10% plant species under each family. Other species were from diverse families. In case of forest plants, five different species were identified during our survey period. RSW was also identified on five field crops like chilli, aroid, sugarcane, soybean and country bean although infestation level was found low. Various ornamentals and flower plants were found to be infested by RSW where infestation level was low to medium. Moreover, RSW was noticed on tea and it is highly worrying for tea industry in Bangladesh. 15-20% betel nut plants were found to be infested by RSW in south and south-western parts of Bangladesh.

Table 2. List of host plants identified in Bangladesh during May to December, 2021.

[a] Fruit plants

Sl. No.	Common name	Botanical name	Family	Overall infestation level
1	Coconut	<i>Cocos nucifera</i> L.	Arecaceae	Low to very severe
2	Banana	<i>Musa paradisiacal</i> L.	Musaceae	Low to severe
3	Guava	<i>Psidium guajava</i> L.	Myrtaceae	Low to medium
4	Date palm	<i>Phoenix dactylifera</i>	Arecaceae	Low
5	Asian Palmyra palm (Tal)	<i>Borassus flabellifer</i>	Arecaceae	Low
6	Jackfruit	<i>Artocarpus heterophyllus</i>	Moraceae	Low
7	Deua or Monkey Jack	<i>Artocarpus lacucha</i>	Moraceae	Low
8	Mango	<i>Mangifera indica</i> L.	Anacardiaceae	Low

Sl. No.	Common name	Botanical name	Family	Overall infestation level
9	Hog plum (Amra)	<i>Spondias mombin</i>	Anacardiaceae	Low
10	Cashew nut	<i>Anacardium occidentale</i>	Anacardiaceae	Low
11	Water apple (Jamrul)	<i>Syzygium samarangense</i>	Myrtaceae	Low
12	Indian Black berry	<i>Syzygium cumini</i>	Myrtaceae	Low
13	Custard apple	<i>Annona reticulata</i>	Annonaceae	Low
14	Sharifa	<i>Annonasquamosa</i>	Annonaceae	Low
15	Corossol or Soursop	<i>Annonamuricata</i>	Annonaceae	Low
16	Lemon (Elachilebu)	<i>Citruslimon</i>	Rutaceae	Low
17	Lime (Kagojilebu)	<i>Citrus aurantifolia</i>	Rutaceae	Low
18	Mandarin (Kamola)	<i>Citrus reticulata</i>	Rutaceae	Low
19	Sweet orange (Malta)	<i>Citrus sinensis</i>	Rutaceae	Low
20	Jara lemon	<i>Citrus medica</i>	Rutaceae	Low
21	Pomelo (Jambura)	<i>Citrus maxima</i>	Rutaceae	Low
22	Dragon	<i>Selenicereusundatus</i>	Cactaceae	Low
23	Amalaki	<i>Phyllanthusemblica</i>	Phyllanthaceae	Low
24	Olive	<i>Oleaeuropaea</i>	Oleaceae	Low
25	Rambutan	<i>Nepheliumpulapeum</i>	Sapindaceae	Low
26	Litchi	<i>Litchi chinensis</i>	Sapindaceae	Low
27	Papaya	<i>Carica papaya</i>	Caricaceae	Low
28	Jujube	<i>Ziziphusjuzuba</i>	Rhamnaceae	Low
29	Pomegranate (Dalim)	<i>Punicagranatum</i>	Lythraceae	Low
30	Tamarind	<i>Tamarindusindica</i>	Fabaceae	Low

[b] Forest plants

Sl. No.	Common name	Botanical name	Family	Overall infestation level
1	Bakul	<i>Mimusops elengi</i>	Sapotaceae	Low
2	Banyan tree	<i>Ficusbenghalensis</i>	Moraceae	Low
3	Debdaru	<i>Polyalthialongifolia</i>	Annonaceae	Low
4	Akashmoni	<i>Acacia auriculiformis</i>	Fabaceae	Low
5	Mahogany	<i>Swietenia macrophylla</i>	Meliaceae	Low

[c] Field crops

Sl. No.	Common name	Botanical name	Family	Overall infestation level
1	Chilli	<i>Capsicum annum</i>	Solanaceae	Low
2	Aroid	<i>Colocasiaesculenta</i>	Araceae	Low to medium
3	Sugarcane	<i>Saccharum officinarum</i>	Grasses	Low
4	Country bean	<i>Lablab puepureus</i> L.	Fabaceae	Low
5	Soybean	<i>Glycine max</i>	Fabaceae	Low

[d] Flowers and ornamental plants

Sl. No.	Common name	Botanical name	Family	Overall infestation level
1	Croton	<i>Codiaeumvariegatum</i>	Euphorbiaceae	High
2	Ixora	<i>Ixoracoccinea</i>	Rubiaceae	High
3	Araucaria	<i>Araucaria columnaris</i>	Araucariaceae	Low
4	Gondharaj	<i>Gardenia jasminoides</i>	Rubiaceae	Low
5	Duranta	<i>Duranta repens</i>	Vervencaceae	Low
6	Thuja	<i>Thujastandishii</i>	Cupressaceae	Low
7	Allamonda	<i>Allamonda</i> spp.	Apocynaceae	Low
8	Bely	<i>Jasminumsambac</i>	Oleaceae	Low
9	Night-blooming Jasmine	<i>Cestrum nocturnum</i>	Sonaceae	Low
10	Velvetflower	<i>Amaranthuscaudatus</i>	Amaranthaceae	Low
11	Rose	<i>Rosa chinensis</i>	Rosaceae	Low
12	Kamini (Jasmine)	<i>Murrayapaniculata</i>	Rutaceae	Low
13	Kolaboti (Indian shot)	<i>Canna Indica</i>	Cannaceae	Low

[e] Others

Sl. No.	Common name	Botanical name	Family	Overall infestation level
1	Coffee	<i>Coffeaarabica</i>	Rubiaceae	Low
2	Tea	<i>Camellia sinensis</i>	Theaceae	Low
3	Haritaki plant	<i>Terminaliachebula</i>	Combretaceae	Low
4	Areca palm	<i>Dypsislutescens</i>	Arecaceae	Low
5	Palm (Florida Royal Palm)	<i>Roystonearegia</i>	Arecaceae	Low
6	Oil palm	<i>Elaeiguineensis</i>	Arecaceae	Low
7	Betel nut	<i>Areca catechu</i>	Arecaceae	Low to medium
8	Elephant apple (Chalta)	<i>Dilleniaindica</i>	Dilleniaceae	Low

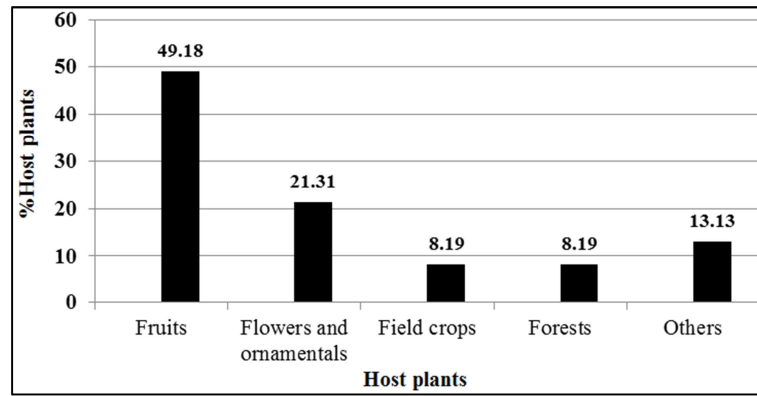


Figure 2. Percent RSW-infested host plants belonged to different plant species.



Figure 3. Some important host plants infested by rugose spiralling whitefly.

3.3. Overall Infestation Severity on Different Host Plants

We have identified sixty one host plants throughout the country under different plant groups and among them thirty were fruit plants (Table 2 & Figure 2). The extent of damage was assessed only on coconut plants in details but for other fruit plant species an overall infestation level was estimated through simple visual observation method following some fixed criteria and finally graded the infestation level as low (+) to very severe (+++++) (Table 1). Our survey study showed that coconut plants were severely infested by RSW in most of the surveyed districts that was followed by banana (low to severe) and guava (low to medium) respectively although infestation on banana and guava was not country-wide and restricted in some districts (Table 2). On the other hand, a low infestation was found on the rest of the fruit plants like mango, jackfruit, litchi, papaya, citrus, dragon, custard apple etc. Similarly, low or low-medium infestation was found in the rest of the thirty one host plants under different plant groups *viz.* forests, ornamentals, flowers, field crops, cash crops etc.

3.4. Infestation Severity on Dwarf and Native Coconut Plants

Approximately 12,000 native and 8500 dwarf (Siam blue, green and DJ Sompurna) coconut plants were investigated randomly in all the surveyed districts to know the scenario of infestation caused by rugose spiralling whitefly. About 85.72% native and 81.23% dwarf plants were found to be infested by RSW (Figure 4). We have noticed different level of infestation (20-100%) across the country in both of the native and dwarf varieties. In case of native, low-medium infestation was found in Dhaka, Thakurgaon and Banderban districts while very severe infestation was noticed in some districts like Khulna, Bagerhat, Barisal, Pirojpur, Chandpur, Mymensingh, Jamalpur, Sherpur, Sirajganj, Jashore, Jhenaidah, Chuadanga and Kushtia. Almost similar infestation severity was found on Siam blue, Siam green and DJ Sompurna varieties.

3.5. Percent Frond, Leaflet and Leaf Area Infestation

Data on RSW-infested frond, leaflet and leaf area covered with sooty mould fungus has been shown in figure 5. Based on our survey results, the mean percentage of frond infestation was found 75.66% with the range of 15.56 to 88.17% on native coconut plants although it was somewhat lower (mean: 69.21%; range: 5.45 to 89.23%) on dwarf varieties. Approximately, 78.12% leaflet infestation was found on native coconut plant that was significantly lower in dwarf coconut varieties (65.26%). Similarly, sooty mould encrustation was found higher on native varieties than that of dwarf varieties. No significant difference was found among the dwarf varieties like Siam blue, Siam green and DJ Sompurna in terms of infestation level although it varied from region to regions or orchard to orchards.

3.6. Abundances of Adult RSW and Egg Spirals Per Leaflet

Approximately, 46 adults per leaflet were counted on native coconut plants with the range of 14.50-257.50 that was significantly lower in dwarf varieties (mean: 37/leaflet; range 19.50-187.50). On the other hand, there had insignificant differences between native and dwarf varieties in terms of mean number of egg spirals/leaflet (Figure 6).

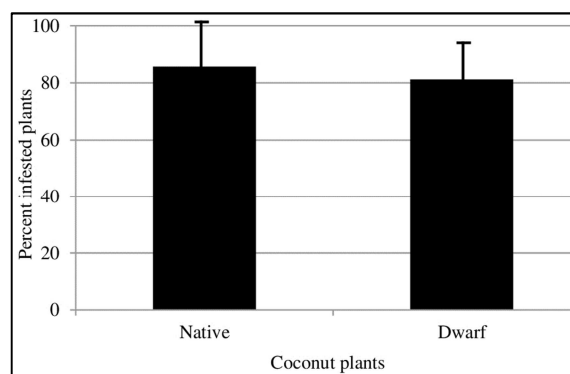


Figure 4. Percent infested native and dwarf coconut plants caused by rugose spiralling whitefly.

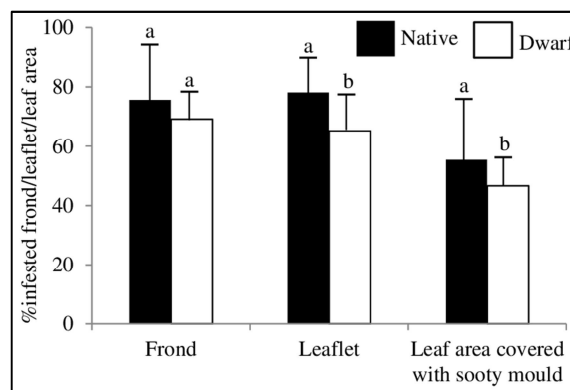


Figure 5. Percent infested frond, leaflet and leaf area covered with sooty mould fungus caused by RSW. Different letter (s) on the bars indicates significant difference from each other. * $P < 0.05$.

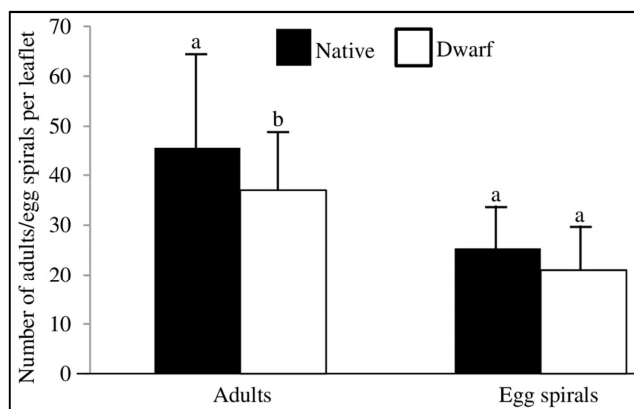


Figure 6. Mean number of adult RSW and egg spirals per leaflet. Different letter (s) on the bars indicates significant difference from each other. * $P < 0.05$.

4. Discussion

The rugose spiralling whitefly is a new insect pest in Bangladesh and first identified in 2019 on coconut plants in Jashore. After that it spreads gradually all over the country and identified on different host plants sporadically. For the first time in Bangladesh, a comprehensive survey was conducted across the country over a period of eight months to identify the host plants as well as to assess the severity of damage. Till December 2021, sixty one host plants were identified across the country under different plant group's viz. fruit plants, ornamental and flower plants, field crops, forest plants and other diverse species. About 118 host plants belonging to 43 families were identified in Florida, United States as the hosts of RSW [11]. In 2016, 12 plants species were identified in Kerala as the hosts of RSW [13]. In Tamil Nadu, a total of 15 hosts belonging to 13 families have been reported [19]. About 9 hosts were recorded in Karnataka in 2017 [14]. A recent survey study conducted in Tamil Nadu during 2018 to 2020 to study the expanding host range of RSW which revealed the presence of the pest in about 67 host plants including coconut [12]. They have identified RSW on different plant species viz. ornamental and medicinal plants, fruit crops, vegetables, fibre crops, biofuels, flower crops, millets, oilseeds, plantation and timber crops, pulses, fodder crops etc. As RSW is polyphagous in nature, its host range may be expanded in Bangladesh since the completion of the survey.

From this study it is evident that comparatively lower number of infested frond, leaflet, adults and egg spirals per leaflet as well as low area of sooty mould encrustation were found on dwarf coconut varieties than that of native and it might be associated with frequent application of various insecticides on dwarf coconut plants. Our survey study revealed that various insecticides were applied on dwarf plants almost in a weekly basis for controlling RSW although this practice varied from location to locations or orchard to orchards. As our native coconut plants are much taller than that of dwarf plants and hence, almost no chemical insecticides were applied on native plants. The significant reduction in the number of adult RSW on dwarf coconut plants may be due to the direct contact of sprayed insecticides with the target insects. In contrast, numbers of egg spirals were not reduced significantly in dwarf plants than that of native plants and this may be due to the fact that the eggs are covered by a waxy coating that prevents the insecticide from coming into direct contact with the eggs.

Rugose spiralling whitefly is indeed an alarming threat to our agriculture because of its wide host range and high adaptation. Till now the severity of infestation is pronounced on coconut but it may cause economic loss to other horticultural and field crops as well within its host range, if not managed properly. Strong monitoring is needed to stop or restrict its proliferation to our major field crops as well as ensuring food security in Bangladesh.

5. Conclusion

Based on our extensive survey, we report that RSW has invaded all over Bangladesh with low to very severe infestation level. The highest infestation was noticed in west, south-west and north-east regions while comparatively lower was found in south-eastern and central part of the country. It was evident from this study that both border and non-border districts were affected almost equally by this insect pest. Moreover, 61 host plants were identified till now where approximately half of them were fruit plant species that was followed by ornamentals and flowers, crops, forests and others respectively. Among the host plants, coconut (native and dwarf) was affected severely by RSW that was followed by banana and guava respectively. Low to medium infestation was observed on other host plants from different groups like fruits, ornamentals, forest, field crops etc. Thus, it is concluded that the existing quarantine rules should be followed strictly to restrict the invasion of any exotic insect pest through the plants or plant parts.

Conflict of Interest

The authors declare no conflict of interest.

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