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A review on rugose spiralling whitefly, *Aleurodicus rugioperculatus* martin (Hemiptera: Aleyrodidae) in India

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Abstract
India is agriculture based country and globalization has led to free agricultural trade which facilitated free movement of plant materials from foreign countries. In spite of strict quarantine laws, various insect pests, diseases and weeds have entered our country through accidental introduction. These newly introduced species pose threat to the biodiversity of the introduced area. A part from biodiversity threat, these introduced species are major threat to bio-security of our country. Further, these newly introduced species may outcompete the native species and capable of replacing the native species. This is mainly due to lack of their specific natural enemies in the newly introduced region. Many insect pests *viz.*, eriophyid mite *Aceria guerreronis*, the cotton mealy bug *Phenacoccus solenopsis*, the papaya mealy bug *Paracoccus marginatus*, the eucalyptus gall wasp *Leptocybe invasa* have entered India. Recently, Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae) had been reported from Kerala during 2016. This insect is native of Belize (Central America) and entered India. It is a polyphagous pest infesting coconut, banana, mango, jack fruit etc and the feeding by this whitefly cause stress to the plant by removing nutrients and water. Besides, it excretes a sticky, glistening liquid substance (honeydew), which provides an excellent substrate for growth of sooty mold. Presently, infestation of RSW increased over the time and spread across the southern states in India and extending its host ranges at greater level which could be due to its polyphagous nature. Considering these points, an attempt was made to review the biology, host range, nature of damage and management through biological control in detail as possible.

Keywords: Invasive species, rugose spiralling whitefly, polyphagous, sooty mold

Introduction
Indian economy is mainly based on agriculture sector contributing 18 per cent of India's gross domestic product (GDP) and provides employment to 50% of the countries workforce (Madhusudan, 2015) [11]. Agriculture plays a vital role in feeding our country's population. India had an acute food shortage at the initial stage of independence because of low productivity and production in agriculture sector. But the situation has totally changed after introduction of green revolution. The goal of introducing green revolution was increase production of food grains through increasing per hectare yield of food grain crops by adaptation of new technology. This adaptation has brought fruitful results in agriculture sector (Joshi, 1999) [9]. The introduction of HYV's during sixties leads to improvement in per hectare yield of several horticultural and field crops. Later, India has achieved considerable growth in per hectare yield of cereals, pulses, vegetables, fruits and milk. The production of horticultural crops during 2007-2008 was 65587 metric tones which has raised to 86283 metric tones during 2014-15 (Anonymous, 2018) [2]. During 1990-92, economic reforms paved way for globalization which increased international trade including agricultural trade, movement of seeds and planting materials that enhanced the bio-security risks of introduction of alien pests into India. The main factors to be considered for managing bio-security risks are globalization, ever increasing requirement of food production, adoption of new technologies, legal obligations for signatories of relevant international agreements, movement of people across borders increase the incidence of pest and disease across the world, dependence of some countries on food, import/ export. The increasing demand to gain more production by adopting new technologies and changing agricultural practices results in new hazards to health that are readily able to cross borders. This free trade and movement of plant materials across political and geographical borders has led to the introduction of certain plant, insect and pathogen species to new localities. Such non-native species are termed as Alien species. Alien species

are non-native or exotic organisms that occur outside their natural adapted habitat and dispersal potential. Many alien species support our farming and forestry systems in a big way. However, some 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. (Raghubanshi *et al.*, 2005) [22]. These 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 to economically important plant species and crop plants which makes them invasive. Some examples are invasion of coconut eriophyid mite *Aceria guerreronis*, the cotton mealy bug *Phenacoccus solenopsis*, the papaya mealy bug *Paracoccus marginatus*, the eucalyptus gall wasp *Leptocybe invasa* and rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae) (Ananthakrishnan, 2009) [1]. Recently, fall army worm, *Spodoptera frugiperda* (J.E. Smith) has been reported from maize fields in Karnataka (Ganiger *et al*., 2018) [7].

International Union for Conservation of Nature and Natural Resources (IUCN) defines Alien Invasive Species as 'one which becomes established in natural or semi natural ecosystems or habitat, and threatens native biological diversity'. These invasive species are widely distributed in all kinds of ecosystems throughout the world and include all categories of living organisms. Nevertheless, plants, mammals and insects comprise the most common types of invasive alien in terrestrial environments. Many non-native plants have allowed increasing productivity in agriculture, becoming a fundamental part of human economy, whereas others have developed into serious ecological problems. However, besides non-native plants, potential bio-safety risk factors comprise two additional groups: (a) taxa resulting from traditional breeding, and (b) genetically modified plants (GMPs) (Hoenicka and Fladung, 2006) [8]. The spread of Invasive Alien Species (IAS) is now recognized as one of the greatest threats to the ecological and economic well-being of the country.

These species are causing enormous damage to biodiversity and the valuable natural agricultural systems upon which we depend. The direct and indirect health effects are increasingly becoming serious and the damage to nature and environment is often irreversible. The effects are exacerbated by global change and chemical and physical disturbance to species and ecosystems.

Table 1: List of some invasive alien insect pests (Sujay *et al.*, 2010) [29]

Scientific name	Common name	Introduced from	Year of introduction	Host Plants
Eriosoma lanigerum (Hausmann)	Woolly apple aphid	China	1889	Primarily apple and pea
Quadraspidiotus perniciousus Comstock	San Jose scale	China	1911	*Populus spp.*; *Salix spp.*; *Aesculus spp.*; *Alnus spp.*; *Betula spp.*; *Celtis spp.*; *Fagus spp.*; *Fraxinus spp.*; *Morus spp.* It also damages species of *Aesculus, Alnus, Betula, Celtis, Fagus, Fraxinus and Morus.*
Orthezia insignis (Browne)	Lantana bug	Sri Lanka; West Indies	1915	Mainly lantana, Coffee, Jacaranda, Citrus, Sweet potato, Gumwood, Brinjal, Rose etc
*Icerya purchasi (*Maskell)	Cottony cushion scale	-	1921	*Acacia decurrens*; *A. dealbata* in addition to numerous other forestry and agricultural Plant species
Phthorimaea operculella (Zeller)	Potato tuber moth	Italy	1937	Tobacco, tomato & brinjal
Plutellc xylostella (Linnaeus)	Diamond-back moth	Europe	1941	Crucifers *viz*., cabbage, cauliflower, radish, knoll khol (rabi), turnip, beetroot, mustard.
Pineus pini (Macquart)	Pine woolly aphid	Australia, Europe, New Zealand	1970	*Pinus* spp.; *Pinus patula*
Heteropsylla cubana Crawford	Subabul psyllid	Sri Lanka	1988	Subabul
Liriomyza trifolii Burgess	Serpentine leaf miner	USA to Kenya & rest of the world	1990	It is a polyphagous species affecting more than 78 plant species, especially serious on greens, cucurbits, tomato, castor and ornamental plants (Srinivasan *et al.*, 1995).
Hypothenemus hampei Ferrari	Coffee berry borer	Sri Lanka	1990	Both *arabica* and *robusta* types of coffee.
Aleurodicus disperses Russell	Spiraling whitefly	Hawaii to Srilanka and India	1994	It is a polyphagous affecting wide range of host plants – 481 plants
Bemisia argentifolii Bellows and Perring	Silver leaf whitefly	-	1999	It is associated with an outbreak of tomato leaf curl virus disease (ToLCVD) which resulted in failure of tomato crop.
Quadrastichus erythrinae Kim	Erythrina gall wasp	May be Taiwan	2006	Black Pepper
Leptocybe invasa (Fisher and LaSalle)	Eucalyptus gallwasp	Australia	2006	*Eucalyptus camaldulensis; E. tereticornis; E. grandis; E. deanei; E. globules; E. nitens; E.botryoides; E. saligna; E.gunii, E. robusta; E. bridgesiana; E. viminalis*
Phenacoccus solenopsis (Tinsley)	Cotton mealybug	unknown	2008	Cotton, bhendi, tomato, potato, pomegranate, hibiscus, parthenium, etc
Paracoccus marginatus Williams and Granara de Willink	Papaya mealybug	unknown	2008	Papaya, citrus, yams, cassava, and hibiscus, and several other unconfirmed hosts.

Recently, Rugose Spiraling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae) entered India infesting coconut plantations across Kerala, Tamil Nadu, Karnataka and Andhra Pradesh.

Presently, infestation of RSW increased over the time and spread across the southern states in India and extending its host ranges at greater level which could be due to its polyphagous nature. Immature stages of RSW produce profuse quantity of wax filaments both tufts of fluffy and long crystal like glassy rods. Furthermore, RSW produce honey dew which results in development of sooty mould. The severity of infestation ranged between 40-60 % in coconut and 25-40 % of leaf in banana and population including all the immature stages varied from 18 to 43 nymphs/sq.cm of leaf and very high at midrib region. Complete drying of banana leaves was also noted in several places in Tamil Nadu and Kerala (Selvaraj *et al.*, 2016) [25].

Origin and Distribution

Rugose spiralling whitefly was initially reported from Miami-Dade County, Florida, United States of America from gumbo limbo, *Burera simaruba* (L.) Sarg in 2009 as a pest. However, it was originally described from Belize in 2004 on coconut (Martin, 2004) [17] where its natural population was reported. This whitefly is believed to have originated from Central America and distribution of this pest in Central and North America is limited to Belize, Mexico, Guatemala and the United States (Evans 2008) [5]. In the continental United States, the first established population of rugose spiraling whitefly was reported from Florida in 2009, and since then its distribution range has expanded considerably within the state and subsequently, it has spread to 22 other countries in Central and South America, including Florida, USA. India is the only country in the Oriental region where the whitefly has been introduced. Initially, this whitefly was observed in several coconut farms in the Pollachi area of Coimbatore district, Tamil Nadu and first reported in Kottayam from Kerala during July – August 2016 (Sundararaj and Selvaraj, 2017) [25]. RSW was noticed on coconut palms, mango and guava at Changanassery, Kottayam District, Kerala in India through accidental introduction. The pest has also been recorded from in Kadiyapulanka nurseries in Coastal Andhra Pradesh during October-November, 2016. The possible entry to Andhra Pradesh may be via coconut seedlings from nurseries in Tamil Nadu and Kerala.

Description and Biology

Rugose spiralling whitefly was first described by Martin in 2004 [17] from samples collected in Belize on coconut palm leaves (Martin, 2004) [17].

Adults

Rugose spiralling whitefly adults are about three times larger (approx. 2.5 mm) than the commonly found whiteflies and are lethargic by nature. Rugose spiraling whitefly adults can be distinguished by their large size and the presence of a pair of irregular light brown bands across the wings (Stocks and Hodges, 2012) [27]. Males have long pincer-like structures at the end of their abdomen.

Eggs

Females lay eggs on the underside of leaves in a concentric circular or spiral pattern and cover it with white waxy matter. Eggs are elliptical and creamy white to dark yellow in color.

Immature stages

Rugose spiralling whitefly has 5 developmental stages. The first instar, known as the crawler stage (because it is the only mobile immature stage) hatches out of the egg, and looks for a place to begin feeding with its needle-like mouth parts and sucks plant sap. Crawlers molt into immature stages that are immobile, oval and flat initially but become more convex with the progression of its life cycle (Mannion, 2010) [16]. Nymphs are about 1.1 - 1.5 mm long but may vary in size depending on instars. The nymphs are light to golden yellow in color, and will produce a dense, cottony wax as well as long, thin waxy filaments (Stocks and Hodges 2012) [27] which get denser over time.

Puparium

This species is typically characterized by broadly cordate vasiform orifice, operculum ventro-basally spinulose and dorsally characteristically rugose, with a pair of ventro-median fine setae; lingula head protruding beyond vasiform orifice, finely spinulose, apically acute, its four setae situated close to apex. Anterior marginal, cephalic and first abdominal setae absent, Posterior marginal, and 12 pairs of outer sub-marginal setae present (including nominal caudal pair); single submedian pairs of pro-, meso, and meta-throacic setae and eighth abdominal setae situated fully anterior to vasiform orifice, opposite anterior corners of operculum present. Cephalic and anterior 4 pairs of abdominal compound pores distinct, 2 pairs of much smaller pores present on abdominal segments VII and VIII. Submargin defined by zone of crowded, wider immed pores that stand proud from puparial surface, inner boundary of zone forming mesally-directed lobes, the pore band interrupted immediately posterior to lingular apex. (Martin, 2004; Sundararaj & Selvaraj, 2017) [17, 30].

Table 2: Distinguishing puparial characters of Rugose spiralling whitefly and Spiralling whitefly (Shanas *et al.*, 2016) [26]

S. No	Puparial character	*A. rugioperculatus*	*A. dispersus*
1	Cuticle on dorsum	Reticulated	Smooth
2	Compound pores on abdominal segements VII and VIII	Present	Absent
3	Corrugations / rugosity on the surface of operculum	Present	Absent
4	Shape of the apex of lingula	Acute	Oval

Host range

It is a polyphagous pest feeding on a wide range of host plants including palms, woody ornamentals, and fruits (Mannion 2010) [16]. Florida Department of Agriculture and Consumer Services (FDACS), Division of Plant Industry (DPI) records from 2009 to 2015 identified rugose spiraling whitefly on at least 118 plant species, which include a combination of edibles, ornamentals, palms, weeds, as well as native and invasive plant species (Stocks, 2012) [28]. Further, host plants recorded from 2009 to 2012 at Florida shows that 22% of rugose spiraling whitefly affected hosts were palm species, 16% were gumbo limbo, 10% were *Calophyllum* spp., 9% were avocado, 4% were black olive, and 3% were mango varieties (Francis *et al.*, 2016) [6]. Within the family Arecaceae (palms), 44% of host records were from coconut. Based on incidence records, these plant species can be considered as primary or preferred hosts of this pest. However, all plant species reported have not been documented as true hosts of

the pest and may not require management. An insect must be able to complete its entire life cycle (egg to adult) to be considered a true host plant. Some plant species may not support the complete development of rugose spiraling whitefly but may still be used by adult whiteflies for feeding and laying eggs. Thus, the level of feeding by adult whiteflies and development of other stages will determine the impact the whitefly has on the host plant and if management is required. A total of 17 plant species under 11 families were recorded as preferred hosts of *A. rugioperculatus* at Kerala. (Shanas *et al*., 2016) [26].

Table 3: Host plants of *A. rugioperculatus* at Kerala (Karthick *et al.*, 2018) [10]

S. No.	Common name	Scientific name	Family
1	Coconut	*Cocos nucifera L.*	Areaceae
2	Banana	*Musa* sp.	Musaceae
3	Wild jack fruit	*Artocarpus hirsutus* Lam.	Moraceae
4	Jack fruit	*Artocarpus heterophyllus* Lam.	Moraceae
5	Brahma's banyan	*Ficus exasperate* Vahl.	Moraceae
6	Mango	*Mangifera indica L.*	Anacardiaceae
7	Guava	*Psidium guajava L.*	Myrtaceae
8	Brown salwood	*Acacia mangium* Willd.	Fabaceae
9	Malabar tamarind	*Garcinia gummi-gutta* (L.)	Clusiaceae
10	Portia tree	*Thespesia populnea* (L.)	Malvaceae
11	Wire weed	*Sida acuta* Burm. f.	Malvaceae
12	Indian Almond	*Terminalia catappa L.*	Combretaceae
13	Rangoon creeper	**Combretum indicum* (L.)	Combretaceae
14	Golden trumpet	**Allamanda cathartaca L.*	Apocynaceae
15	Oleander	**Nerium oleander* L.	Apocynaceae
16	Garden croton	**Codiaeum verigatum* (L.)	Euphorbiaceae
17	Crown of thorns	**Euphorbia milii* Des Moul.	Euphorbiaceae

Nature of damage and Symptoms

Rugose spiralling whitefly can cause stress to the plant by removing nutrients and water. Besides, whitefly excretes a sticky, glistening liquid substance (honeydew), which provides an excellent substrate for growth of sooty molds, which turn the shiny liquid into a black-colored viscous liquid. Once it dries, the sooty mold forms thick layers on the host leaves and other non-plant surfaces. The layers of sooty mold on leaves may disrupt the photosynthesis process in the host leading to physiological disorders. Honeydew also attracts ants and wasps that protect the whiteflies from their natural enemies (Stocks and Hodges 2012) [27]. In addition to damaging its host, rugose spiraling whitefly also creates a nuisance in the area of infestation. Honeydew, sticky wax, sooty mold and bodies of dead whiteflies fall onto understory plants and non-plant surfaces such as automobiles, patios, and furniture. Further, dried sooty mold does not wash off easily and may require pressure washing and/or professional cleaning.

Symptoms of Damage (Mayer *et al.*, 2010) [18]

- Egg spirals of rugose spiraling whitefly on the underside of leaves
- Presence of heavy white, waxy material
- Presence of sticky honeydew around the whitefly infested area
- Black sooty mold formation
- Leaf damage and early leaf drop (not evident on all types of plants)

Management

Application of 1 % starch solution on leaflets to flake out the sooty moulds. In severe case, spray neem oil 0.5 %. Neonicotionoid insecticides can be applied with foliar, soil or trunk applications. Soil applications include drenching with water using granular formulations on the soil surface, or burying pellets. Trunk application includes basal bark sprays and trunk injection with systemic insecticides *viz.*, Acetamiprid, Clothianidin, Dinotefuran and Imidacloprid can be done (Mannion, 2010) [16].

Central Plantation Crop Research Institute (CPCRI), Kasargod, has recommended the following measures:

- Spraying starch solution (1%) to dislodge the heavy sooty mould deposition on the leaves of infested plants.
- Use of yellow sticky traps to trap the adult whiteflies.
- In case of severe infestation, spray neem oil 0.5%

The current incidence of RSW in India is alarming due to its polyphagous nature and hence it has a great potential to extend its host range and spread to other coconut growing countries in the Oriental region. Being a non-native species in newly introduced areas, it can achieve invasive pest status due to absence of their natural enemies and if local (indigenous) beneficial species (predators and/or parasitoids) are unable to suppress pest population (Duan *et al.*, 2015) [4]. Therefore, a holistic approach is needed for the adaptation of rapid response strategies against its invasion by educating farmers, creating awareness and extension entomologists working along with other stakeholders. A coordinated program involving coconut growing countries to contain its spread and develop suitable management strategies is needed.

Biological control

Parasitoids *viz.*, *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae) was known to parasitise *A. rugioperculatus* while Poorani and Thanigairaj, 2017 [21] reported *Encarsia dispersa* Polaszek parasitizing *A. rugioperculatus* in surveys conducted at Tamil Nadu. A heavy parasitisation ranging from 40 to 70% was recorded on banana alone by *E. guadeloupae* (Poorani and Thanigairaj, 2017) [21]. However, survey conducted by Selvaraj *et al.* (2016) [25] recorded 20–60% parasitism of *A. rugioperculatus* by *E. guadeloupae* on coconut in Tamil Nadu and Kerala. Among the two parasitoids, *E. guadeloupae* was more predominant, causing 60–70% overall parasitism while *Encarsia dispersa* was found in much fewer numbers compared to *E. guadeloupae* and the extent of parasitism was <5% (Poorani and Thanigairaj, 2017) [21]. A brief history of

introduction and nomenclature and diagnostic details of *E. dispersa* are given in this paper with notes on the predators of the rugose whitefly.

Encarsia guadeloupae

Encarsia guadeloupae was first reported from Minicoy Island in the Lakshadweep in 1999 and later deliberately introduced into the mainland and established there (Ramani, 2000; Mani *et al*., 2000a, b; Beevi & Lyla, 2001) [23, 13, 14, 3]. It is likely these parasitoids migrated from the Maldives into Minicoy and other islands of the Lakshadweeps and later, assisted by the intentional release and colonization, spread to other areas of peninsular India (Ramani, 2000; Mani *et al*., 2000b) [23, 14]. It is also likely that the parasitoids were found only after their numbers increased phenomenally through breeding for several years on the expanding host population, although they had been introduced along with the host.

Key diagnostic characters of female *E. guadeloupae* are: body dark brown, except side lobes of mesoscutum and scutellum; mid lobe largely dark brown; axillae brown; TVII yellow or brown laterally; third valvula pale yellow. Wings hyaline, hind coxa and femur dark brown, legs otherwise pale yellow to white. Antennal formula, 1142; clava as long as last two funicle segments; mesoscutum with usually 9 pairs of setae (sometimes with variable number of setae, 15–20); scutellum with two pairs of setae; axillae normally with one setae each. Fore wing basal cell with 3 setae before parastigma. Mid tarsi-4 segmented; fore and hind tarsi-5 segmented. Similarly, *E. guadeloupae* and *Encarsia* sp. were recorded as potential parasitoids of many whiteflies including RSW (Evans, 2008: Taravati *et al*., 2013; Francis *et al.,* 2016) [5, 31, 6]. Furthermore, the COI gene (658 bp) of the parasitoid was amplified, sequenced and deposited as *Encarsia* sp. (GenBank Acc. No. KY223606). The per cent parasitism ranged from 20.0-60.0 % in different locations, with highest parasitism recorded in Kerala as compared to other surveyed states (Selvaraj *et al.,* 2016) [25].

***Encarsia dispersa* (Polaszek)**

Encarsia dispersa Polaszek, is an exotic parasitoid of New World (Neotropical) origin. This species has been widely and erroneously referred to as *Encarsia haitiensis* Dozier, *Encarsia* sp. nr. *haitiensis* and occasionally as *Encarsia* sp. nr. *meritoria* Gahan by different authors from India (Ramani *et al.,* 2002) [24] and elsewhere. It has been both deliberately and fortuitously introduced around the world for the biological control of spiralling whitefly, *Aleurodicus dispersus* Russell (Polaszek *et al.,* 2004) [20]. Polaszek *et al.* (1992) [19] regarded *Encarsia haitiensis*, *Encarsia* sp. nr. *haitiensis* and *Encarsia* sp. nr. *meritoria* as distinct, though very closely related. Based on variations in DNA sequence data for the D2 region of 28S nuclear ribosomal genes, Polaszek *et al.* (2004) [20] formally described this species as *Encarsia dispersa* and included it as part of the *luteola* species-group and the *Encarsia meritoria*-species complex and defined the species limits of *E. haitiensis*, *E. meritoria* and other related species. The widely introduced populations of *E. dispersa* probably originated from a single, or a few, original populations brought from Trinidad to Hawaii (Polaszek *et al*., 2004) [20]. *Encarsia dispersa* was the first of two species of *Encarsia* accidentally introduced in South India along with its host, *A. dispersus*, in the late 1990s, the other one being *E. guadeloupae* (Ramani *et al.,* 2002) [24]. In an apparent case of competitive displacement, *E. guadeloupae* completely displaced *E. dispersa* within a short span of 2–3 years in most of the places in South India where it was colonized (Ramani *et al.,* 2002; Mani *et al.*, 2004; Mani, 2010) [24, 15, 12].

Predators of *Aleurodicus rugioperculatus*

Many indigenous predators have been observed feeding on *A. rugioperculatus* as in the case of *A. dispersus*. Poorani and Thanigairaj, 2017 [21] collected predators of rugose whitefly on coconut at Kerala and Coconut Research Station (TNAU), Aliyar Nagar, were also brought to our attention. Among these, *Pseudomallada* sp. (Neuroptera: Chrysopidae), *Cybocephalus* sp. (Coleoptera: Cybocephalidae), *Diadiplosis* sp. (Diptera: Cecidomyiidae) and *Jauravia pallidula* Motschulsky (Coleoptera: Coccinellidae) were the most predominant.

Natural enemies such as parasitoids and predators including predatory mite and coccinellids associated with RSW were recorded. The most commonly found natural enemies are green lacewing (*Mallada* spp.) and *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae).

Future perspectives

In summary, rugose spiralling whitefly is exotic pest which entered India. This pest has caused huge crisis for horticulture farmers due to its polyphagous nature coupled with difficulty in management. In this review a clear attempt was made to touch every possible aspect of this pest Detailed studies on some of the aspects of this pest needs to be carried out in future for finer understanding.

- Biology of the rugose spiralling whitefly has to be studied in detailed under our climatic conditions on various host plants.
- Status of rugose spiralling whitefly incidence on alternate hosts needs to be carried out in detail.
- Studies on the economic yield loss of rugose spiralling whitefly on various hosts plants in general have to be conducted.
- The other potential hosts of rugose spiraling whitefly are needed to be identified and confirmed.
- Mass multiplication techniques for parasitoids and predators have to be standardized under laboratory conditions and evaluated for their field efficacy against rugose spiralling whitefly.
- Eco-friendly and potential bio-pesticides are to be identified for the better management of rugose spiralling whitefly.
- Influence of the weather parameters on the rugose spiralling whitefly has to be recorded to device the forecasting models.
- Regular survey and monitoring has to be done to identify hot spot areas of the rugose spiralling whitefly and vigil to prevent faster spread of this pest by further strengthening the quarantine measures is need of the hour.

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