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First report of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin, an invasive pest on sugarcane in Andhra Pradesh, India

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Abstract

An invasive pest, rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin, incidence has been noticed on matured sugarcane crop (2-10%) in localized spots which are in close proximity to coconut plantation in research farm of Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India during October-December, 2020. Initially, severe infestation was observed on coconut plantation, later it has spread to sugarcane and other crops viz., banana, mango, citrus, guava, areca palm and other ornamental plants in research farm. Rugose Spiraling whitefly egg spirals were observed on the underside of sugarcane leaves. Symptoms viz., presence of heavy white waxy material, sticky honeydew around the whitefly infested area, black sooty mould formation on upper side of the leaves and partial to complete drying of infested leaves were observed on sugarcane under moderate to severe infestation. This confirms first report of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin incidence on sugarcane from Andhra Pradesh in India. Natural enemies viz., lady bird beetles, *Cryptolaemus montrouzieri*, *Chilocorus nigrita*, *Scymnus nubilus* and the parasitoid wasp, *Encarsia guadelopae* were recorded in sugarcane ecosystem. Nevertheless, it needs a more comprehensive study on biology and population genetics to confirm its evolution there by its impact on sugarcane crop. Though, RSW spread is relatively less in sugarcane ecosystem compared to coconut and banana, regular monitoring and preventive measures need to be taken up in areas where coconut and banana are cultivated in close proximity to sugarcane crop.

Keywords: Sugarcane, rugose spiraling whitefly, Andhra Pradesh, invasive pest, morphological identification

1. Introduction

Sugarcane (*Saccharum officinarum* L.) is one of the major commercial crops cultivated in tropical and subtropical regions of India. Sugarcane is attacked by many insect pests viz., borers, sap sucking insect pests, root feeders etc. Among these, after borer pests, sucking pests plays a major role in affecting the quantitative and qualitative parameters of sugarcane. Whiteflies are generally small insects belonging to order Hemiptera. They belong to the family Aleyrodidae and super family Aleyrodoidea. Among the species of whiteflies, only 3 species are known to infest the sugarcane, viz., *Aleurolobus barodensis*, *Neomaskellia bergii* and *N. andropogonis* of which the latter two species are sporadic in occurrence and only *Aleurolobus barodensis* is reported to occur in serious proportions under stress conditions (viz., drought and water logging conditions) in Andhra Pradesh. Severe infestation of *A. barodensis* results in both qualitative and quantitative losses in sugarcane and the losses reaches up to 86% and reduction in sugar recovery up to 1.4-1.8% [3].

The rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae) originally described from Belize [1] is naturally distributed in Belize, Guatemala, Mexico [2] and subsequently, it has spread to 22 other countries in Central and South America, including Florida, USA on more than 100 plant species [23]. It was reported from India from Karnataka, Tamil Nadu, Kerala and Andhra Pradesh during October-November, 2016 [1, 5, 16; 17a].

It is an invasive pest that attacks a wide range of host plants including palms, woody ornamentals, and fruits. Coconut and banana are among the most preferred host plants. It was found in localized spots in Maharashtra [6], Lakshwadeep, Maldives, Odisha, Bangladesh and Srilanka (www.cabi.org/isc/datasheet/4141, 2016). It infests coconut palms and other broad-leaved hosts in its native range [12].

Severe infestation by the RSW on coconut was observed in Kerala and Tamil Nadu and total of 17 plant species under 11 families were recorded as preferred hosts of *A. rugioperculatus* at Kerala [17, 18]. Heavy sooty mould deposition and near total drying of leaves were observed on banana in some places. Since, the first report of occurrence in August, 2016, the distribution of RSW is expanding over the period time in entire southern states of India [17, 18]. The quick spread might be through transport of seedling, plant materials, tender coconut and vehicle movement. Moreover, the pest was found extending its host ranges at greater level on many cultivated and ornamental plant species due to its polyphagous nature. Severe infestation of the pest was noticed on coconut and banana especially in the coastal areas of Andhra Pradesh and it has a great potential to extend its host range and spread to other crops growing in coconut cultivated areas. Hence, surveys were conducted in Visakhapatnam district and the sugarcane and other crops were regularly monitored in research farm of RARS, Anakapalle to assess the level of RSW infestation on sugarcane and other crops.

2. Materials and Methods

Regularly monitored the sugarcane fields near coconut plantation in Research farm of Regional Agricultural Research Station, Anakapalle and surveys were conducted in Visakhapatnam district for RSW infestation during the months of September -December 2020. Coconut plantations and other cultivated crops were also monitored for RSW and to assess the infestation of RSW on palms and cultivated crops in Research farm. Intensity of damage was assessed randomly on five plants in three locations. Host plant leaves infested with immature stages, puparium in the paper envelopes and adult whiteflies in 70% alcohol were collected. Part of the collection of host plant leaves/parts infested with immature stages and puparium were placed in rearing jar for the emergence of parasitoids. Identification of RSW and its natural enemies were confirmed by morphology.

2.1 Analysis of juice quality & growth parameters

At maturity of crop, ten canes were randomly selected from the infested and healthy canes. The canes samples were crushed and the extracted juice was analyzed separately for different quality parameters *i.e.*, Brix% and also purity%. The growth parameters *viz.*, height, weight and girth of the cane were also recorded at harvest.

3. Results and Discussion

Since 2019, RSW incidence has been observed on sugarcane leaves. Often, the distinctive egg spirals were seen on leaves but with no developing larvae or pupae on the sugarcane leaves. During the months of October- December, 2020, low to moderate incidence of RSW was observed in research farm of Regional agricultural Research Station, Anakapalle. It has been observed that the females were found to lay eggs on leaves of sugarcane which are near to coconut trees. The pest infestation was very high on coconut, banana and areca nut.

Infestations were extremely dense with almost complete coverage on under surface of leaf with overlapping generation of the pest species. In Florida, the RSW host plants include agricultural, horticultural and ornamental plants species [23, 7]. The severity of RSW infestation was ranged from 40-60% in coconut and 25-40% in banana [17, 17a]. After the accidental introduction of this pest species in India, the pest has spread on many host plants across the peninsular India in a short time which shows the economic importance of the pest. Along with the pest, the natural enemies were also spread almost every place wherever pest occurs. Although, visible reduction in pest population was witnessed across the locations due to action of the aphelinid parasitoids, however, its population was significantly found less in comparison to pest. Therefore, there is a need to conserve the natural enemies especially *E. goudeloupeae* and *E. dispersa* to suppress the RSW [14].

3.1 Morphological Identification

Rugose Spiraling whitefly was identified by its larger size and sluggish nature compared to other whitefly species found in India under field conditions [11]. The pest has colonized underside of the sugarcane leaves with white waxy matter dispersed in a spiraling pattern (Fig.1B). Generally, the colonies were poor in condition with groups of woolly wax puparia unitedly grouped underside of the sugarcane leaves. The puparium of this species has a pair of small compound pores on each of seventh and eighth abdominal segments, characteristically rugose/corrugated operculum, reticulated dorsal cuticle and acute lingual apex which are easily distinguishable from *A. dispersus* [16]. On forewings of the RSW adult, brown patches similar to colour of the cinnamon bark were observed (Fig. 1D, E). In some individuals, however, the patches were not clearly indistinguishable. At the tip of the abdomen, a pair of sword-like pincer structures were noticed in males (Fig.1F). Adults under microscope (Nikon SMZ25, 1x, WD: 60) revealed deposition of waxy materials in spiraling manner (Fig. 1A). The whole body of the adult is white and appeared like a small moth. Further, examination of underside of leaves revealed that elliptical, yellowish eggs were laid in a spiral pattern. Nymphs were oval shaped with white waxy material all over the body (Fig 1C). Pseudopuparium represented the final stage of the nymphs, white in colour covered with much waxy material. Rugose spiraling 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 used to suck 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 [10]. 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 [21] which get denser over time. The puparium of this species is used for taxonomic identification.

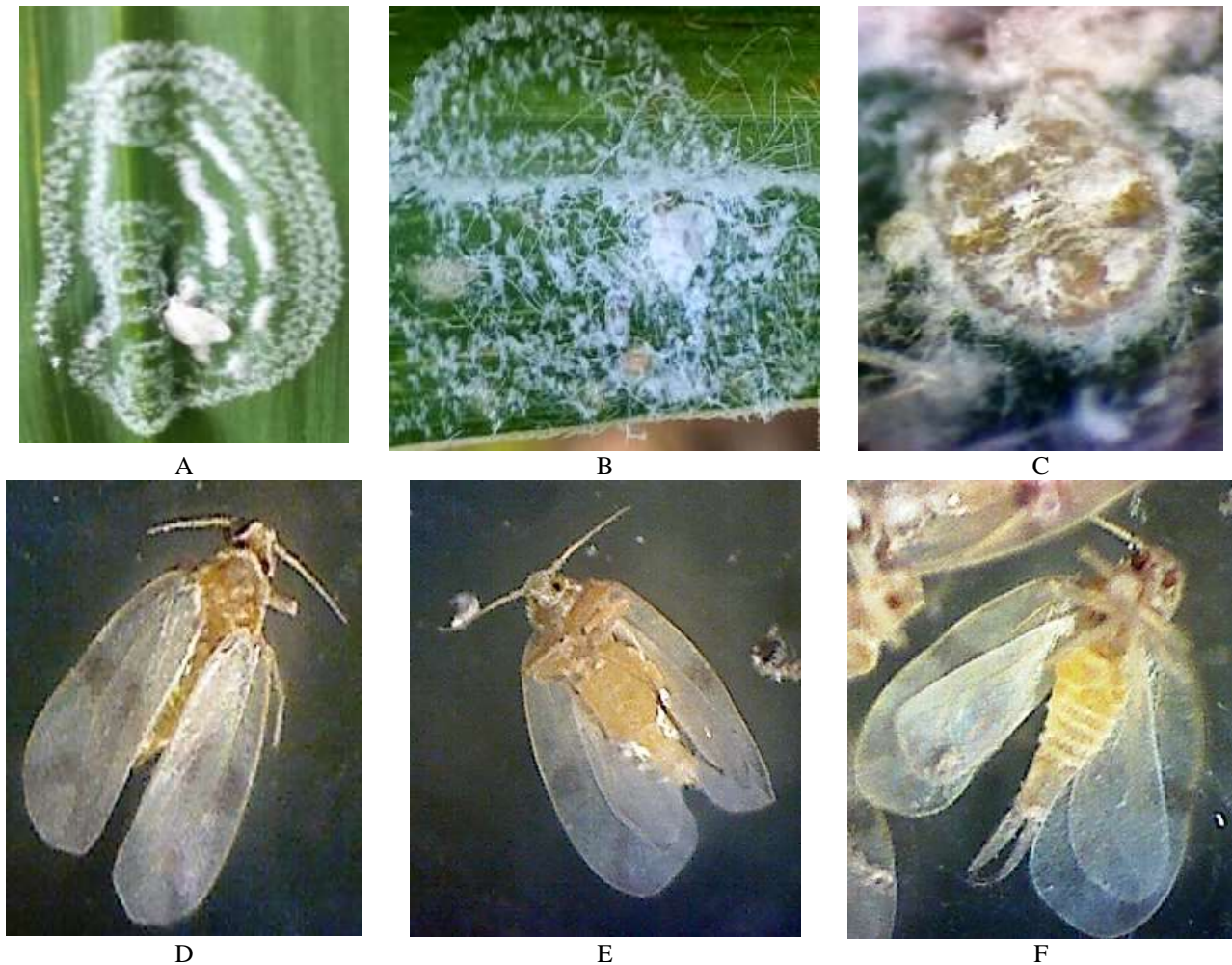


Fig 1: Life stages of rugose spiraling whitefly A) Eggs laid in spiral shape, B) Established colony of RSW, C) Nymph, D) Female adult (dorsal view), E) Female adult (Ventral view), F) Male adult (Ventral view)

3.2 Damage symptoms

Though the initial feeding and colonization of RSW was observed on sugarcane since 2019 but continuous feeding and population establishment was not observed on sugarcane plants earlier. Under heavy infestation on coconut plantations, the RSW population has spread to sugarcane and colonies have been established on sugarcane leaves. About 2-5% of sugarcane plants on a sugarcane variety, 2010A 229, in close proximity to coconut plantations have severely infested with RSW in research farm during the months of October-December, 2020 (Fig. 1).

RSW caused stress to the sugarcane plant by removing nutrients and water, and thereby promoted the growth of black sooty moulds under moderate to severe conditions (Fig. 2D). Infestation of this pest usually does not kill the sugarcane plant, but it may interfere with the normal growth of sugarcane. It also excreted a sticky, glistening liquid substance (honeydew), which provides an excellent substrate for growth of sooty moulds. The layers of sooty mould on sugarcane leaves disrupted the photosynthesis process lead to physiological disorders *viz.*, partial to complete drying of sugarcane leaves under severe infestation (Fig. 2E).

Initially, population of RSW were observed on coconut during the months of September- October. Subsequently, its population increased tremendously and spread to other crops at sugarcane research farm of RARS, Anakapalle during

October–December months. During the observational period, the prevailing warm weather conditions, 24–33.6°C temperature with 50–92% RH favoured RSW. At the same location, the web mite, *Schizotetranychus krungthepensis* was found co-existing with RSW (Fig 2C). It seems that the web mite and RSW have a partial niche overlap and population regulation is governed by several sets of determinate and indeterminate factors. Due to high rainfall received during the month of November, the RSW population has declined rapidly by the end of December month.

Incidence of RSW was observed on coconut, banana, guava, citrus, areca palm, teak, ornamentals and *Bauhinia* plants and severe infestation on few trees of each species in many places of coastal districts of Andhra Pradesh. Coconut was reported as the major host in Kerala and *Psidium guajava*; *Musa* sp., *Myristica fragrans*; *Colocasia* sp., *Garcinia* sp., *Annona muricata*; *Murraya koenigii*; *Spondia smombin*; *Mangifera indica* and *Artocarpus heterophyllus* as alternate hosts of *A. rugioperculatus* [4]. Honeydew also attracts ants and wasps that protect the whiteflies from their natural enemies [21]. South West coastal regions of India comprising parts of Kerala, Karnataka, Goa, Maharashtra and Maharashtra - Gujarat border [4], Andhra Pradesh, Odisha, Madhya Pradesh, Bihar, Uttar Pradesh, Uttarakhand, Chhattisgarh, and West Bengal have favourable climatic conditions for the establishment of this pest [16].

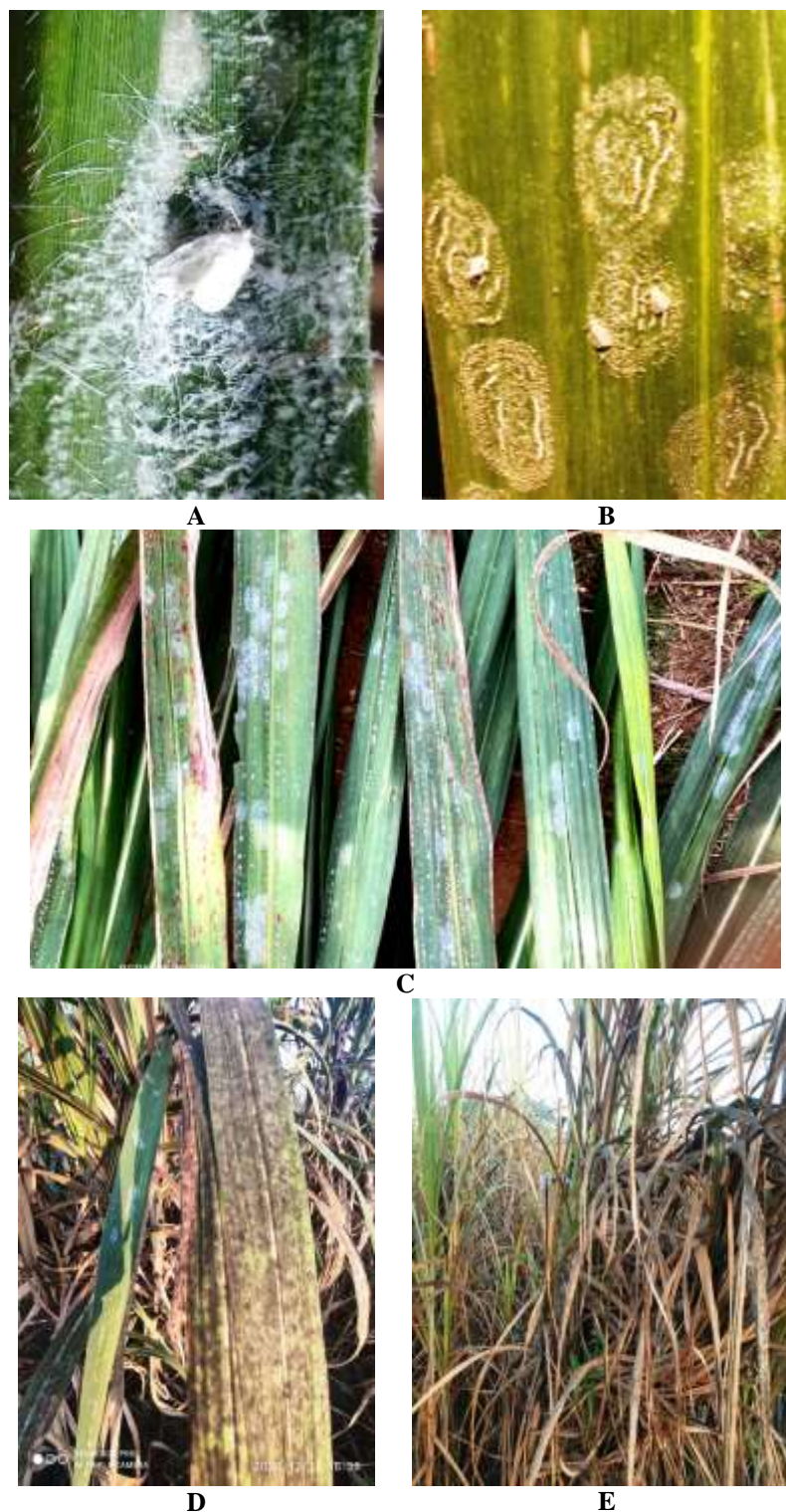


Fig 2: Damage symptoms on sugarcane A) Established colony of RSW, B) colonies on sugarcane leaf, C) RSW infested leaves, D) Sooty mould on upperside of the sugarcane leaf, E) partial to complete drying of sugarcane leaves in close proximity to coconut

3.3 Extent of damage

Preliminary studies on impact of RSW infestation on sugarcane revealed that moderate to severe infestation of rugose spiraling whitefly on sugarcane leaves caused reduction in per cent juice sucrose (18.01%) when compared to healthy plants (19.73%) whereas no considerable difference was observed in growth parameters *viz.*, cane height, girth and weight as the infestation occurred at maturity stage of the crop in a sugarcane variety 2010A 229 during October- December months. Infestation of *A. barodensis* reduces plant growth, cane yield and sucrose depending on the level of infestation, age and variety of the sugarcane crop [3]. High infestation of

A. barodensis causes stunted crop growth and reduces juice quality in sugarcane. There is a loss of 30-40 per cent in sucrose in whitefly affected cane [19]. Severe whitefly infestation may result in reduction in cane yield up to 24% and loss in sugar up to 2.9 units [9]. Water logging coupled with low levels of nitrogen causes severe outbreak of pest [2, 8].

3.4 Natural enemies

Natural enemies *viz.*, lady bird beetles, *Cryptolaemus montrouzieri*, *Chilocorus nigrita*, *Scymnus nubilus* and the parasitoid wasp, *Encarsia guadelopae* Viggiani were recorded

on RSW in sugarcane ecosystem. Several tiny wasp parasites *Encarsia inaron* (Walker) and *Eretmocerus delhiensis* Mani (Hymenoptera: Aphelinidae), as well as ladybird beetle predators were found to attack the whiteflies viz., *Aleurolobus barodensis* and *Neomaskellia bergii* in sugarcane ecosystem and the presence of these natural enemies, may not allow the colonisation/ establishment of RSW on sugarcane crop in an alarming way. *E. guadeloupa*, *Mallada* spp. and *Cybocephalus* Spp are common natural enemies of RSW in Tamil Nadu, Andhra Pradesh and Kerala, and *E. guadeloupa* was found as a dominant one with highest parasitism (20.0-60.0%) in coconut and banana crops [17]. Similarly, many natural enemies such as parasitoids, *E. guadeloupa*, *E. noyesi*, *Aleuroctonus* spp.; predators viz., *Nephaspis oculata*, *Azya orbiger*, *Chilocorus cacti*, *Cryptolaemus montrouzieri*, *Delphastus pallidus*, *Harmonia axyridis*, *Hyperaspis bigeminata*, *Cybocephalus* sp. and *chrysopid*, *Ceraeochrysa* spp. in Florida associated with RSW [7, 23]. Biological control of rugose spiraling whitefly with *Encarsia* is more feasible in a crop like sugarcane where chemical control is uneconomical. Augmentative releases of *Encarsia* parasitoid will suppress RSW population. Further research is needed to improve the use of these potential parasitoids to maintain RSW densities with in below ETL.

3.5 Host range

It mainly infests coconut palms and other broad-leaved hosts in Coastal districts of Andhra Pradesh. Coconut and banana were found as common and preferred hosts and smaller infestations were observed on sugarcane, areca palm, guava, mango, maize, greengram and *Heliconia* spp (Table 1 & Fig.3). Severe infestation by the RSW on coconut and banana caused heavy sooty mould deposition and near total drying of leaves in many places in Coastal districts of Andhra Pradesh. The RSW infestation was also observed on the leaves of Indian almond (*Terminalia catappa*), teak (*Tectona grandis* L.), Brahma's banyan tree (*Ficus exasperate* Vahl.) wherein the RSW infested leaves showed dropping and drying symptoms with the underside of leaf largely covered with nymphs and adults with white mealy matter. On guava, the two-tailed mealybug, *Ferrisia virgata* Cockerell was found co-existing with RSW. It seems that the mealy bug and RSW have a partial niche overlap and population regulation is governed by several sets of determinate and indeterminate factors. RSW was reported on coconut palm, banana, bird of paradise, custard apple, butterfly palm and oleander in Tamil Nadu, Kerala and Andhra Pradesh [17a]. Its host ranges of about 118 plant species in 43 families [7] and similarly, about 95 host plants recorded in Florida [21, 22].

Table 1: Host Plants for RS Win North Costal districts of Andhra Pradesh

S. No	Common name	Botanical name	Family	Remarks
1	Coconut palm	<i>Cocos nucifera</i> (L.)	Arecaceae	Severe
2	Banana	<i>Musa acuminata</i> Colla, <i>M. balbisiana</i> Colla	Musaceae	Severe
3	Areca palm	<i>Dyopsis lutescens</i>	Arecaceae	Severe
4	Mango	<i>Mangifera indica</i> L.	Anacardiaceae	Moderate
5	Guava	<i>Psidium guajava</i> (L.)	Myrtaceae	Moderate
6	Maize	<i>Zea mays</i>	Gramineae	Low
7	India almond	<i>Terminalia catappa</i> L.	Combretaceae	Low
8	Green gram	<i>Vigna radiata</i>	Fabaceae	Traces
9	Brahma's banyan	<i>Ficus exasperate</i> Vahl.	Moraceae	Severe
10	Sugarcane	<i>Saccharum officinarum</i>	Poaceae	Moderate
11	Teak	<i>Tectona grandis</i>	Lamiaceae	Traces
12	Crotons	<i>Heliconia</i> spp	Heliconiaceae	Moderate

Low= more than 3-4 colonies established underside of the leaves; Moderate=5 colonies of RSW established; Severe = more than 5 colonies, affected leaves showing yellowing or dried, brown symptoms accompanied with leaf-fall.



A



B



C



Fig 3: RSW infestation on different host plants A) Coconut, B) Banana, C) Areca nut palm, D) Guava fruit, E) Guava leaf, F) Mango, G) Maize, H) Green gram, I) *Heliconia* spp.

4. Conclusions

All plant species reported have not been documented as true hosts of the RSW and may not require management. 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 the adults of RSW and development of other stages on sugarcane will determine the impact of the RSW on the sugarcane plants. Hence, detailed investigations on genetic variations in populations of RSW in different sugarcane growing areas of Andhra Pradesh and biology on sugarcane under different climatic conditions under different cropping systems need to be studied. Studies on the economic yield loss of RSW on sugarcane have to be conducted.

There is a chance for quick spread of rugose spiraling whitefly in sugarcane through transport of cane, seed material, seedlings from one location to another location. Effective monitoring is necessary in order to keep populations under a damaging level. Regular survey and monitoring has to be done to identify hot spot areas and to prevent faster spread of this pest by further strengthening the quarantine measures. Eco-friendly and potential bio-pesticides are to be identified for the better management in sugarcane ecosystem. Influence

of the weather parameters on the rugose Spiraling whitefly has to be studied to develop the forecasting models. Efforts also may be made to mass produce the potential natural enemies in the laboratory and the same may be augmented against RSW in sugarcane ecosystem. A holistic approach is needed for the adaptation of RSW management strategies by educating farmers, creating awareness to extension personals working in sugar factories.

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