Reviewarticle

Invasion,populationbuild-upandpossiblemanagementstrategyof rugose spiraling whitefly (*Aleurodicus rugioperculatus* Martin) onminorfruitcropsaswellasonmedicinal,aromatic,and ornamental plants in India – Current scenario

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ABSTRACT

Theoccurrenceofrugosespiralingwhitefly,aninvasivepest,wasestablishedin22countiesworldwideincluding India.Itsinvasioninthecountrywasfirstreportedfromcoconutplantationin TamilNaduduring2016.Presently itspresencehasbeennoticedinalmostallthesouthernandpeninsularstatesofthecountryalongwithGujaratof westernpartandWestBengalandAssamofeasternpart.Tilldate67plantspecieshavebeenidentifiedasthehost of this pest including minor fruits, medicinal, aromatic, ornamental, avenue plants. This review article aimed to create awareness to all the stakeholders including scientists, researchers, farmers, students and common man regarding its host diversity among minor fruits, medicinal, aromatic and ornamental plants in the country at present situation so that attention may be paid on its sustainable management in time.

Keywords*:Aleurodicusrugioperculatus*,aromaticplants,invasion,medicinalandornamentalplants,minorfruits, population build-up

INTRODUCTION

Rugosespiraling whitefly(*Aleurodicus rugioperculatus*Martin;Aleyrodidae; Homoptera) is an invasive and destructive pest of different crops. This whitefly is endemic in America and was previously termed as gumbo limbo spiraling whitefly.Sincearelativelynewerpestwhichwas discovered just few decades ago, not so much informationisavailableforthispest.Thispestwas first described from the infested coconut leaves collected from a coconut plantation located at Belize,Florida.Thenaturalhabitatofthispestwas located at Belize, Guatemala and Mexico and the pestbelongstothe*niveus*species-groupunderthe genus*Aleurodicus*.Fromtheoriginatingregionthe whiteflyhasbeenamplifieditshabitattowards22 Central and South American countries including FloridaandUSA.Theyarecharacterizedbytheir unique polyphagous nature with huge host range involved with 118 plant species representing 43 plantfamiliescoveringtheplantshavingeconomic importanceinAmerica(Francis*etal.*,2016).The occurrenceofthiswhiteflyspecieswasconfirmed in22counties.ItsintroductioninIndiaisbelieved to be occurred by trading of ornamental plants (Shanas*etal.*,2016).InvasionofthispestinIndia wasfirstreportedinthemonthofSeptember,2016 from a coconut plantation located at Coimbatore, Tamil Nadu (Sundararaj and Selvaraj, 2017). In Kerala and Tamil Nadu coconut plants were severelyinfestedbythispestand17plantspecies werefoundtobesusceptibletothispestinKerala (Sundararaj andSelvaraj, 2017; Selvaraj *et al.*, 2017).Subsequentreportofoccurrenceofthispest have been came from different states including Andhra Pradesh, Assam, Karnataka and Kerala (Rao *et al.*, 2018), West Bengal (Selvaraj *et al.*, 2019a)and Gujarat (Jethva*et al.*, 2020b). According to Selvaraj *et al.* (2019a) this pest was probably introduced to Purba Midnapur and Howrah district through transport of plant materials from infested areas either from Orissa or South India.Potentialsuitableareasforestablishmentof this pest were mostly found in all coastal and southern states of India. It prefers a warm and humidclimate,indicatingthatthetropics,

subtropicsandeventemperateregionslikeMexico (Evans,2008)areidealforitsspreadandinvasion. The resultsof Maruthaduraiet *al.* (2023) highlightedthatthesuitablehabitatareafor *A. rugioperculatus* was predicted to increase and highest probability of invasion and spread in 2050 and 2070 under future climate change scenarios. On the other hand, India represents diverseagro-climaticconditionshavinguniquesoil and plant types across the country. Diverse agro-climaticconditionsenablethecountryforbearing different fruit plant species.

Apartfromthemajorfruitsandminorfruitslike Capegooseberry(*Physalisperuviana*L.)(Dahiya *et al*., 2022), wood apple (*Feronia limonia*) (Mahato *et al*., 2021), walnut (*Juglans regia* L.) (Kumar*etal*.,2020)*etc*.,Indiaisalsoahotspotfor different aromatic, medicinal and ornamental plants. Majority of these plants are somewhat ravagedbydifferentinsectpests.Ornamentalplants are more preferred by this invasive pest (Stocks and Hodges, 2012). It is also observed that the ecologicalconditionsofAndhraPradesh,Odisha, MadhyaPradesh,Bihar,UttarPradesh, Uttarakhand, Chhattisgarh and West Bengal are very congenial for multiplication of the pest (Selvaraj*etal*.,2017).Therefore,itwillnotbean exaggeration to say that this rugose spiraling whiteflyisalsoapotentialthreattotheproduction of minor fruit crops as well as medicinal and aromaticplants.Again,informationregardingthe susceptibility of different minor fruit crops along with other ornamental, medicinal and aromatic plants including weed hosts against this pest is necessaryfor implementingeffective, environmentally safe and economically viable management strategies for the respective crops. Limitedstudieshavebeenconductedfocusingon range of minor fruit, medicinal, aromatic and ornamental crops acted as hosts of this pest.Aim ofthisstudyistoawarethescientists,researchers, plantersand common people regardingthe identification of host crops of rugose spiraling whiteflyamongtheaforementionedgroupsofcrops inIndiancontextsothattheconcernedpeoplemay pay the attention on its sustainable management.

Infestation of rugose spiraling whitefly on different host plants

The presence of rugose spiraling whitefly can beidentifiedbythepresenceofeggspiralsonthe underside of the infested leaves. Eggs are laid on the leaves in a spiraling pattern with a tiny stalk. Yellowishnymphscreatewhitewaxyfilamentthat covered all the life stages of the whitefly.Adults arequitelargerinsizeandpossesstwopalebrown wavy makings on their forewings. Infested plants canbeeasilydiagnosedfromadistancebynoticing the heavy coating of white filamentous waxy materialsontheundersideoftheleaves.Presence of honeydew along with black sooty mold and prematureleafdropisalsoanimportantdiagnostic characterforrugosespiralingwhiteflyinfestation (Mayer *et al.*, 2010). Occurrence of rugose spirallingwhiteflyindifferenthostplantsinIndia has been evaluated. Srinivasan *et al*. (2016) recorded 70% whitefly infestation on banana. Observations of Selvaraj *et al.* (2016) suggested thatcoconutpalmswereseverelydamagedbythe pestwhereinfestationrangedfrom40-60%and25-40% leaf infestation was observed in banana. Severe drying and scorching of leaves due to whiteflyinfestationinbananaorchardwasnoticed in certain places of Tamil Nadu and Kerala. In Mangaluru and Udupi, 20 to 35% infestation of coconut plantationand 24 to 38 % banana plantation were infested by this whitefly during 2017 (Selvaraj *et al.*, 2017). In West Godavari districtofAndhraPradeshitwasobservedthatper centinfestationcausedbyrugosespiralingwhitefly rangedbetween75.85-95.0%,82.93%and63.50-79.0%oncoconut,bananaandguavarespectively, whereas the incidence was ranged from 81.42-100.0%,83.13-100.0%and83.13-100.0%on coconut,bananaandguava,respectively (Sushmitha *et al.,* 2020b). A Tamil Nadu based surveybyElangoandNelson(2020a)revealedthat a total of 20 host plant species from 15 families were recorded as hosts of *A. rugioperculatus*. Among them, 8 hosts viz. *Cocos nucifera*, *Musa paradisiaca*, *Annona squamosa*, *Citrus limon*, *Myristicafragrans*,*Psidiumguajava*,*Theobroma cacao*and*Manihotesculanta*hadallthelifestages of whitefly, whereas in other 12 host plants viz. *Areca catechu*, *Azadirachta indica*, *Jatropha curcas*, *Mangifera indica*, *Abelmoschus esculentus*, *Pipernigrum*,*Achraszapota*,*Solanummelongena*, *Gossypium hirsutum*, *Zea mays*, *Pennisetum glaucum*and*Hibiscusrosasinensis*theeggsstages onlywereobserved.Anothersurveybased

experiment in Bhubaneswar (Sri *et al.*, 2022) highlightedthat85.0-100.0%,100.0%and35.0% whitefly incidence was occurred on coconut, bananaandguava,respectively.Inastudy,almost 100% incidencewas observedon the plant belongingto the familyAmaryllidaceae, Moraceae, Malvaceae,Magnoliaceae,Combretaceae, Myrtaceae and Sterlitzaceae. The plant families Annonaceae, Arecaceaeand Sapotaceae experiencedmorethan90%whiteflyincidence.A surveywork in Tamil Nadu (Nandhiniand Srinivasan,2022)revealedthatamongstthe67host plantsrecorded,17fellundertheornamentalplants category,followedby14underfruitcrops,9under medicinalplants,5undervegetables,4underfibre crops, 2 each under biofuels, flower crops, green leaf manures, millets, oilseeds, plantation crops and timber crops, besides 1 host each under pulses, avenue trees, fodder crop and tuber crops. Das *et al*. (2023) from Bangladesh reported that 49.18% fruit plants, 21.31% ornamental and floral plants, 15-20%arecanutplants,8.19%fieldcrops,8.19% forestplantsand13.13%miscellaneousplantswere infested by this pest.

Bio-ecological features of rugose spiraling whitefly

The concerned whitefly *A. rugioperculatus* pertainedtothesubfamilyAleurodicinaeunderthe family Aleyrodidaebelongs to the suborder Sternorrhynchaunder the order Hemiptera. Characteristicdepositingofeggsinaspiralmanner is the reason for describing them as spiraling whiteflyandsincetheyhaveirregularlycorrugated or fluted(Rugose) operculumin their pseudopuparial stage they are termed as rugose spiraling whitefly. They are comparatively larger (almost three times) than other whitefly species withsluggishmovement.Theycanbedifferentiated from other whiteflies with distinct simple and compoundpores.The4thinstari.e.thepupariumis distinctly thick and larger than the commonly occurring species *Bemisia tabaci* (Mondal *et al.*, 2020). Theirpupariumis mainlyusedfor taxonomicidentification.Apairofsmallcompound poreispresentintheseventhandeighthabdominal segment of the puparium (Selvaraj *et al.*, 2017). They lay their dark yellow to creamy whitish ellipticaleggsontheundersideoftheleavesand coveredtheeggswithwhitishfilamentouswaxlike coatings. Egg was observed to be translucent yellowish green or light green to yellow, though according to Pradhan *et al.*(2020), the eggs changed itscolourfromtranslucenttopaleyellowandbefore hatchingtobrown.Theyhavefourdevelopmental instars before reaching the adulthood. First three instarsaretermedasnymphandtheyarecontinuous feeder.Firstinstarnymphsaregenerallyconsidered as crawlers as they are only mobile stage after hatching.Theymoverandomlyonthehostsurface and after finding suitable feeding site they fix themselvesandstartfeeding.Aftermoltingcrawler turns into immobile oval and flat instars and with theprogressionoflifetheybecomeovalandmore convex in shape.The golden yellow nymphs also producewhitishwaxyfilamentouscottonygrowth onthemselvesandsurroundingareaaswell.Adult flieshavelightbrownpairedbandpresentontheir wings.Malespossesslongswordshapedpincerlike structureattheabdominalend.Limitedinformation regardingthebiologyofrugosespiralingwhitefly is available, except for few studies in Florida and inIndia(TaravatiandMannion,2014;Taravati*et al.*,2018;Elango*etal.*,2019).Theresearchwork regarding its life history on our target crops is negligible. The observations by Pradhan *et al.* (2020) in NBAIR, Bengaluru, India revealed that the fecundity, duration of nymphal instars and durationoftotallifecyclewere56.60±5.04,25.7± 1.66 and 42.9± 2.95 days, respectively on *Canna indica*, an ornamental crop.

Invasioninminorfruits

Severalauthorsreportedtheinvasionofrugose spiralingwhiteflyfromdifferentminorfruitcrops atlowtomoderatelevelindifferentregionsofthe country.ObservationsfromthesurveyinKarnataka by Selvaraj *et al*. (2017) suggested that different fruit crops including sapota, India almond, water apple,laurel ball tree or punnai were invaded by rugosespiralingflyandhadsevere(11-20%),very severe(>20%),moderate(6-10%)andverysevere (>20%)infestation,respectively.InKeralathepest invadedthecropslikewildjackfruit(*Artocarpus hirsutus*), jack fruit, Malabar tamarind (*Garcinia gummi-gutta*)andIndianalmond(Karthick*etal.*, 2018). Survey report in West Bengal stated that differentminorfruithostcommunitycomprising

waterapple,jamun,custardapple[Plate1]andjack fruit [Plate 2] were infested by rugose spiraling whitefly (Selvaraj *et al.*, 2019a). In 2020, several minor fruit crops including sapota, custard apple, White wax jambu (*Syzygium samarangense*) and Indianalmondwasinvadedby*A.rugioperculatus* in Junagadh district, Shaurastra region of Gujarat (Jethva*etal*.,2020a).ElangoandNelson(2020a) reported that custard apple recorded relatively higher number of eggs laid per female (26.9 eggs perspiral),highestmaleemergence(46.13%)and medium in female emergence (53.57%). The sex ratio (female: male) was 1: 0.86 on custard apple accordingto them.Sri *et al.* (2022)from Bhubaneswar reported that the minor fruit crop species comprising Bael, custard apple, jackfruit, jamun,phalsa,Ramphal(*Annonareticulata*),rose apple(*Syzygiummalaccense*),sapotawereinfested by rugose spiraling whitefly with a per cent incidenceof32.50%,65.30%,51.30%,100.00%, 5.60%,93.20%,85.50%and91.30%,respectively, though in case of bael and phalsa only egg stage was found. They also recorded lowest number of nymphs of this pest (15.0 per leaf) on jack fruit and lowest number of pupae (12.0 per leaf) on sapota.RajmohanaandSushama(2022)observed the concerned pest infestation in wild date palm (*Phoenix sylvestris*) fromWest Bengal. Nandhini and Srinivasan (2022) from their survey based studyinTamilNaduobservedthatrugosespiraling whiteflysurviveduptonymphalstagein *Annona muricata,A. squamosa,A. reticulate*and *Theobroma cacao*. The other minor fruits they foundasthehostswhichsupportedeggstageonly werebael,karanda(*Carissacarandas*),starapple, wood apple (*Feronia elephantum*), sapota, avocado (*Persea americana*),Indiangooseberry (*Phyllanthus emblica*), jamun, Sour sop (*Annona muricata*)andSpanishcherry(*Mimusopselengi*). Several fruit crops were infested by this pest in Bangladeshhavingalmostsimilarkindofclimatic conditionlikeWestBengalandtheyaredatepalm, palmyra palm, jackfruit, deua or monkey jack (*Artocarpus lacucha*), hog plum or amra, cashew nut, water apple or jamrul, Indian black berry, custardapple,sharifa(*Annonasquamosa*),pomelo orjambura(*Citrusmaxima*),amlaki(*Phyllanthus emblica*),olive (*Oleaeuropaea*),rambutan (*Nepheliumlappaceum*),jujube(*Ziziphusjujube*), elephantappleorchaltaandtamarind(*Tamarindus indica*) with relatively less infestation where less than 10% plants were infested with 10 or less nymph or adult per leaflet (Das *et al*., 2023).

Invasioninornamentalplants

Apartfromthedifferentmajorandminorfruit crops, some of the ornamental plants are also invadedbytherugosespiralingwhitefly.Justafter introducinginIndiathepestalsoinfestedbutterfly palm (*Dypsis lutescens*) and ruffled fan palm (*Licualagrandis*)severelyinKarnataka(Selvaraj *etal*.,2017).Sri*etal.*(2022)fromBhubaneshwar enlisted several ornamental plants invaded by the pestincludesAcalypha(*Acalyphamacrophylla,A. wilkesiana*),Asoka (*Saraca asoca*), beach spider lilly (*Hymenocallis littoralis*), bird of paradise (*Sterlitzia reginae*), butterfly palm, Chinese fan palm(*Livistonia chinensis*),gardencroton (*Codiaeum variegatum*), Dracaena (*Dracaena marginata*), golden thryallis (*Galphimia glauca*), Ixora (*Ixora chinensis*),Jatropa(*Jatropa curcas*), Philodendron(*Thaumatophyllumbipinnatifidium*) andsongofIndia(*Dracenareflexa*)with68.2,66.2, 53.5,100.0,100.0,95.0,70.0,41.0,10.5,53.0,19.0, 41.0,65.0and11.5percentincidence,respectively. Among these, bird of paradise was recorded with highestnumberofnymphs,pupaeandadults(38.5, 28.9 and 78.5 per leaf, respectively) and lowest numberwasnoticedongoldenthryallis(12.0,5.0 and 16.3 per leaf, respectively). Das *et al*. (2023) recordedlow infestationof this pestfrom Bangladesh in Florida royal palm (*Roystonea regia*).According to Mondal *et al.* (2020), potted palm and bird of paradise were severely infested by the pest in West Bengal.

Invasion in medicinal, aromatic and avenue plants

Important medicinal and aromatic plants were also invaded by this notorious pest.Among them two crops betel vine (*Piper betle*) and rubber fig (*Ficus elastic*) faced minor infestation in Karnataka (Selvaraj*etal*.,2017).Differentavenuetreeslike brown salwood (*Acacia mangium*), portia tree (*Thespesia populnea*), wire weed (*Sida acuta*), Brahma's banyan (*Ficus exasperate*), Rangoon creeper (*Combretum indicum*), golden trumpet (*Allamandacathartaca*)andoleander(*Nerium*

Plate1:Incidence of rugose spiralling whitefly on custard apple

Plate2:Incidence of rugose spiralling whitefly on jackfruit

oleander)werealsoreportedtobeattackedbythis insectinKerala(Karthik*etal*.,2018).Infestation ofthis whitefly was also recorded fromWest Bengal on areca nut (*Areca catechu*), betel vine, Spanish cherry, akashmoni (*Acacia auriculiformis*) and areca palm (*Dypsis lutescens*) (Selvaraj *et al.*, 2019b).FromGujarattherewasareportofwhitefly infestationincurrytree(*Murrayakoenigii*)(Jethva *etal*.,2020).Bhavani*etal*.(2020)observedsevere infestation on areca palm and Brahma's banyan, moderateinfestationoncrotons(*Heliconas*p.)and traces of infestation on teak (*Tectona grandis*) in AndhraPradesh.MedicinalplantslikeAloe(*Aloe vera*), neem (*Azadirachta indica*) and turmeric (*Curcuma longa*) with an infestation of 66.60%, 56.50% and 40.20%, respectively were also recordedatBhubaneswar,Odisha(Sri*etal*.,2022; Nandhini and Srinivasan, 2022). Sri *et al.* (2022) recorded the highest number of eggs (187.0 per leaf) onneemandlowestnumberofeggs(35.0perleaf) inAloeamongmedicinalplantsandamongavenue treesmaximumnumberofnymphs(36.5perleaf) was recorded on Indian almond while minimum numberofnymphs(21.0perleaf)wasregistered on Cassia. Indian almond also recorded highest number of pupae (26.0 per leaf) and adults (83.5 perleaf)whereasCassiarecordedleastnumberof pupae(14.6perleaf)andadults(32.0perleaf).In TamilNadu,severalotherplantswereinvadedby this notoriouspest likeAlexandrianlaurel (*Calophylluminophyllum*),banyan(*Ficus benghalensis*),Fernleaftree(*Filiciumdecipiens*), Gliricidia (*Gliricidia sepium*), Indianelm (*Holopteleaintegrifolia*),Jatropha,mahua,Indian beech(*Milletia pinnata*L.),Philodendron (*Philodendron hederaceum var aureum)*, false Asoka tree (*Polyalthia longifolia*), Indian sandal wood (*Santalum album* L.), Asoka tree(*Saraca asoca*), mahogany (*Swietenia macrophylla*), peepal (*Ficusreligiosa*)andteak(*Tectona grandis*).The entire host supported only egg stage except teak, whichsupportedallthethreestagesviz.egg,nymph and adult (Nandhini and Srinivasan, 2022). A surveyconductedbyMondal*etal*.(2020)inWest Bengal revealed the pest's severe to medium infestationonrubberfig,deodarandAcacialeaves. Das *et al*. (2023) reported that croton and Ixora experiencedhigherwhiteflyinfestationwhilebakul

(*Mimusops elengi*), banyan, debdaru (*Polyalthia longifolia*), akashmoni, mahogany and haritaki (*Terminaliachebula*)experiencedlessinfestation in Bangladesh.

Population dynamicsof rugosespiraling whitefly

Numbers of research works (Srinivasan *et al*., 2016 on coconut; Sundararaj and Selvaraj, 2017 on coconut; Mohan *et al*., 2017 on coconut; Josephrajkumar *et al.*, 2018 on coconut; Mane, 2019 on coconut; Elango and Nelson, 2020b on coconut; Sushmitha *et al*., 2020a on coconut and guava; NBAIR, 2021; Chavan *et al*., 2022 on coconut)areavailableonthepopulationdynamics of this pestand mostof the studieswere concentratedoncoconut.Weatherparametershave significanteffectontheinfestationofthewhitefly. Reduced rainfall, prolonged dry spell, high temperature,lowhumidity,brightsunshinehours, availabilityoflargeareaofhostplantsandabsence ofnaturalenemiesareverymuchcongenialforup-surging of its population according to them. Information regarding its population dynamics in othercropsparticularlyminorfruits,medicinaland aromatic plants is scanty. Avitha *et al.* (2022) in their study on wild date palm in West Bengal supportedthereportofNBAIR(2021)whoopined thatsevereinfestationofthispestinWestBengal mightbeduetohotandhumidclimaticcondition, the availability of number of host plants and the lack of natural enemies.

Possiblemanagementstrategies

Taravati*etal*.(2013)andFrancis*etal*.(2016) reportednumberofnaturalenemiesassociatedwith rugosespirallingwhiteflysuchasparasitoidslike *Encarsia guadeloupae*, *E. noyesi*, *Aleuroctonus* spp. and predators like *Nephaspis oculata*, *Azya orbigeraorbigera,Chilocoruscacti,Cryptolaemus montrouzieri*, *Delphastus pallidus*, *Harmonia axyridis*, *Hyperaspis bigeminata*, *Cy-bocephalus* sp.and*Ceraeochrysa*spp.inFlorida.Sel-varaj*et al.* (2016) documented three species of natural enemies from Tamil Nadu, Andhra Pradesh and Kerala e.g. *E. guadeloupae*, *Mallada* spp. and *Cybocephalus*spp.and amongthem*E. guade-loupae* was found as a dominant one with highest parasitism (20.0-60.0%). Survey by Selvaraj*etal*.(2017)inKarnatakarevealednatural parasitism of rugose spiraling whitefly by the parasitoids *E. guadeloupae* and *E. dispersa* with percentparasitismof5-15%incoconut,7-18%in bananaand22-30%insapota.Gupta*etal*.(2017) recorded *Xenasteia* members (Diptera: Brachycera: Cyclorrhapha)onrugosespiralingwhiteflycolony inthecoastalareasofKarnataka.Sushmithaetal. (2020a) reported spiders and coccinellid beetles (*Menochilussexmaculata*)aspredatorsincoconut andguava.Naturalenemies*viz*.,ladybirdbeetles, *Cryptolaemus montrouzieri*, *Chilocorus nigrita*, *Scymnusnubilus*andtheparasitoidwasp,*Encarsia guadelopae*wererecordedinsugarcaneecosystem fromAndhraPradesh(Bhavani*etal*.,2020).Elango and Nelson (2020a) recorded the predators viz. *Cybocephalus* spp., *Cryptolaemus montrouzieri*, *Chilocorus nigrita*, *C. sexmaculata*, *Curinus coeruleus,Malladaastur,Malladaboninensis*and *C.zastrowisillemi*,prayingmantis,spidersandone parasitoid*E.guadeloupae*asnaturalenemiesof*A. rugioperculatus* in Tamil Nadu. Several natural enemies including predators like *Cybocephalus* spp.,*Chrysoperla*sp.,*Nephaspisoculata,Oxyopes salticus*and*Uloborus*sp.andaparasitoid,*Encarsia* sp. werereportedon thiswhiteflyfrom Bhubaneswar (Sri *et al.*, 2022). Rajmohana and Sushama (2022) recorded *E. guadeloupae* as natural parasitoid and *Dichochrysa astour* as predator of rugose spiraling whitefly in *Phoenix sylvestris*fromWestBengalthoughearliersurvey conducted by Selvaraj *et al.* (2019a) revealed the absenceof*E.guadelouape*fromWestBengaland theynoticedchrysopid,*Dichochrysaastour*asthe solenaturalenemy.Selvaraj*etal*.(2019b)observed that among the natural enemies, *E. guadeloupae* wasdominantandpotentialtoprovideabout41% natural parasitism in Andhra Pradesh and it was less than 20% in Kerala and Karnataka. Drastic reductioninrugosespirallingwhiteflywasnoticed by Visalakshi *et al.* (2021) in coconut orchards sprayedwith*Isariafumosorosea*fungus(NBAIR-Pfu-5) @ 5 g/ l with sticker @ 10 g/ l, two times with introductory release of parasitoid, *Encarsia guadeloupae*. The attempt made by Elango *et al.* (2022) revealed that under laboratory conditions, *Isaria fumosorosea*, a microbial pathogen with a spore load of 1×10^8 cfu caused 34.54% egg mortality,37.39%nymphalmortalityand48.30% adultmortalityofrugosespiralingwhitefly,

followedby*Lecanicilliumlecanii*(24.54,30.76and 28.01%)and*Metarhiziumanisopliae*(20.56,32.51 and42.92%)foregg,nymphalandadultmortality, respectivelyincoconutunderlaboratorycondition, whereas, under field conditions, *I. fumosorosea* causednymphalmortalityof29.60%,followedby *M.anisopliae*(24.30%)and*B.bassiana*(21.00%) at 15 days after spray.This study also proved the safetyof*I.fumosorosea*tothechrysopidpredator, *Mallada boninensis.*So, there is a huge scope for utilizing natural enemies specially *Encarsia guadeloupae, Isaria fumosorosea* and *Mallada boninensis*insuppressingthisnotoriouspest.The incidence and intensity of the whitefly was significantlyreducedfrom75.5to37.7%and85.7 to 42.9%, respectively on coconut treated with ecofriendlyIPMpracticesinTamilNadu(Alagar *et al.*, 2021).The IPM treatmentsincluded installation of light traps @ 5/ ha, fixing yellow stickytrapsheets@25/ha,sprayingthreerounds of0.5%neemoilat15daysintervalontheunder surfaceofleaves,threeroundsofjetwatersprayat 10 days interval about 15 days after spraying of neem oil and stapling of leaflets containing, *E. guadeloupae*parasitisedpupariaonpalmleaflets. According to Saranya *et al.* (2022), antibiotic treatment,carbenicillin100ìg/mL+ciprofloxazin 5ìg/mLsignificantlyreducedtheovipositionand %egghatchabilityofrugosespiralingwhiteflies reared in coco-nut (13 eggs/ spiral and 61.54%), banana (15 eggs/ spiral and 60.00%), sapota (15 eggs/spiraland66.67%)andguava(16eggs/spiral and56.25%).TheexperimentconductedbyNavin Kumar *et al.* (2022) suggests that Neemazal- T/S @10000ppmconcentrationcouldeffectivelykill the earlyand lateinstarsnymphsof *A. rugioperculatus* in coconut, mango, banana and guava. Trunk application including basal bark spraysand trunkinjectionwithsystemic insecticides *viz.*, Acetamiprid, Clothianidin, DinotefuranandImidaclopridcanberecommended incoconut(Mannion,2010).Asubstantialcontrol of this pest on coconut plantation inWest Bengal was achieved by spraying with Flonicamid 50% WDGandLancerGold(Acephate50% +Imidacloprid1.8%SP)@5gand2g/l respectivelyandroot-feedingwithMonocrotophos 36SL@4ml/plantasimmediateremedymeasure (Mondal *et al.*, 2020).

CONCLUSION

Fromtheearlierresearchworksandsurveysit is concluded that rugose spiralling whitefly has becomeaseriousthreatinvadingseveralhostssuch as plantation crops, fruit crops, medicinal plants, spices, ornamentals, avenue trees, vegetables and field crops belonging todifferent plant families, thoughcoconut,bananaandguavawereprovedto be preferred host for this pest. Indiscriminate use ofpesticidestocontrolthispestinitspreferredhost plants like coconut, banana or guava may lead to populationshiftingonotherhostplantslikeminor fruits, medicinal, aromatic or plantation crops of ourconcern.Though,climateandhostavailability playsignificantrolesindeterminingitspopulation fluctuation, accidental dispersal may also play a crucial role in its new outbreaks. Inoculative releases of natural enemies identified in the early stagesofwhiteflyestablishmentmaybebeneficial tomanagethepest.Therefore,suitabledevicesof integrated pest management should be advocated againstthepestwithspecialemphasisonutilization of biocontrol agents, microbial pathogens and botanicals.

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