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Managing the Rugose Spiraling Whitefly Using Novel Technologies: Feasibilities and Possibilities

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Rugose spiraling whitefly (RSW), Aleurodicus rugioperculatus *Martin. is an invasive pest feeding on all the green leaved plants including oil palm causing nutrient as well as photosynthetic loss resulting in yield reductions. To manage the pest incidence, use of various possible and feasible measures in an integrated manner is the only available answer. Although many of these measures are not fool proof in giving 100 per cent control of the pest, in the present conditions it is the only solution to implement in the infested areas to reduce the pest incidence and infestation to below threshold limits. Based on the results obtained at different places, Good Agricultural Practices have been drawn for the successful mitigation of the pest. Most of these were tested in farmers' fields and found suitable to implement in all the infested areas in an integrated manner rather than alone. The compatibility among different practices when implemented together shows the significance of individual as well as combined practices in managing the pest population. Since the pest is an invasive one with no boundaries on feeding, it is required to draw attention on Intergrated Pest Management (IPM) practices to check the population effectively. For this purpose all the possible measures like stopping procurement of nursery plants from the infested areas, taking control measures on all the feeding plants, growing pest repellent plants like marigold all around the garden, hanging sticky traps in the gardens to attract the adult flies and thereby reduce the pest load, conservation of existing and release of available parasitoids and predators need to be carried out in an integrated manner. Entomopathogen,* Isaria fumosorosea *fungus is a good and effective Myco biocontrol agent for causing maximum mortality of the pest population. The feasible practices on its multiplication using locally available low cost material were developed at ICAR-Indian Institute of Oil Palm Research, Pedavegi. The methodology to multiply the mother culture by farmers in their homes was also developed which is helpful for further multiplication and usage of it against the pest. The cost of multiplication of mother culture using locally available materials was found to be half the price to that of the laboratory prepared one. This methodology nullifies the farmers' dependency for mother culture on various institutes/laboratories and helps to have sufficient culture with them.*

Keywords*: Rugose spiraling whitefly,* Isaria fumosorosea, Encarsia guadeloupae, *oil palm.*

Rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin is an invasive pest to India (Anon, 2018). The incidence and intensity of the pest is increasing every year since its entry into the country i.e. in 2016 in Tamil Nadu and Kerala and in 2017 in Andhra Pradesh causing severe losses to the growth of the plants (Sundararaj & Selvaraj, 2017; Kalidas, 2018). The pest has shown its severity (*Figure 1*) in 2018 in East and West Godavari districts of Andhra Pradesh resulting in severe yield losses (Kalidas, 2019). Apart from sucking the sap and thereby draining the nutrients, the honeydew secretion by the pest results in a sooty mold fungus forming as a layer over the leaves (*Figure 2*). This makes the plants

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Figure 1 Incidence of rugose spiraling whitefly

Figure 2 a. Sooty mold layer on the leaves
b. Severity of incidence on oil palm

appear black hindering photosynthetic activity. Though the quantification of the losses due to the pest infestation has not been done for any crop, it is essential to draw on management practices to curb the incidence. Since the pest is new to the crop and country and moreover an invasive species, no foolproof readymade information is available on its management. Hence recommendations were given based on logical or hypothetical interpretations from the previous experiences gained from cotton whitefly or citrus black fly etc. during the initial period of its infestation. However the continuous efforts carried out on its management in various research institutes yielded fruitful results and are worth practicing for the successful mitigation of the pest. If all these practices are followed in an integrated manner, the pest can be curbed to below threshold levels. The possibilities and feasibilities in implementation of the developed technologies at farmers' level are discussed in this paper.

CULTURAL PRACTICES

The pest which was first observed in the states of Tamil Nadu and Kerala on coconut plants during 2015-2016 (Anon., 2018) was found migrating through the coconut nursery plants and nuts to different places. In this journey it landed in Kadiyam (16.9167°N 81.8333°E) of Andhra Pradesh through the coconut seedlings that were brought from Kerala and Tamil Nadu states. The pest has developed its progeny in these nurseries where there is plenty of food in the form of nursery plants of different species. However its presence was not found on plants like coleus, rose and non green coloured plants. From this area, the pest has further migrated to different places by means of these nursery plants and started its incidence mostly on plantation crops like coconut and oil palm.

Hence it is essential to stop multiplication of the pest in these nurseries to further stop the incidence and its spread to new areas. For this purpose, it is suggested to follow the below mentioned practices.

Since the pest migrates from one plant and one area to another, utmost care is needed while purchasing and transporting the planting material. As the pest is a tiny sized one (Chalapathi Rao *et al*., 2018), it is essential to check thoroughly each and every plant for the presence of the pest. Only those plants which are free from the pest infestation (having no single spiral of eggs) should be procured/ planted. Even after planting, continuous supervision should be carried out at regular intervals for the skipped population, if any. To arrest the migration of the pest, it is recommended to stop procuring the plants from already infested areas till such time the incidence has subsided.

Growing marigold plants all around the garden or interspersed within the target crops is a good cultural practice to suppress the whitefly. The limonene content present in these flowers may repel the flies and do not kill them, thus there is no pest resistance and no negative impact on beneficial insects (Anon, 2019).

Since most of the green plants including weeds in the vicinity of the infested plants act as collateral hosts (Antonino *et al.*, 2017) for the pest development, it is advised to remove them or take control measures on these too.

Physical measures

The adult insects are tiny flying insects (*Figure 3*) which may get carried to far off places along with even small wind currents (Stocks & Hodges, 2012). These flying insects come out of their colonies during dawn and dusk in search of new hosts (Taravati *et al.*, 2013). Hence it is recommended to trap them by keeping the sticky traps at different places in the garden. The adult whiteflies that come out during dusk are attracted to these sticky traps and ultimately get killed.

Since most of the whiteflies including silverleaf whitefly (*Bemisia tabaci*) on cotton, are attracted towards yellow colour, it is recommended to hang sticky traps of yellow colour against this pest also. However it needs to be repeated at frequent intervals. The frequency is based on the number of flies covered on the trap. For this purpose, tarpaulin sheets of yellow or green colour can also be used by pasting grease or castor oil which also acts as sticky traps. These are cheap and handy to farmers. Since the pest is more

Figure 3 Adults of rugose spiraling whitefly (a. colony, b. close up of adults)

attracted to green coloured plants, it is better to use green coloured tarpaulin sheets, if available in markets as it is found effective compared to other coloured ones (white). These sheets of 0.46 m to 0.61 m (1.5 ft to 2 ft) in size (*Figure 4*) may be wrapped around the stem of coconut/oil palm plants and grease or castor oil applied on the sheets. These traps need to be serviced on alternate days by wiping the sheets to remove the trapped adults and reapplying grease or castor oil. This is a good and cost effective practice to suppress the adult population. It needs to be repeated at frequent intervals to reduce the pest population in the plantation.

Biological methods

Although the pest has entered the country as an invasive pest, its natural enemies like parasitoids and predators are not present. Most probably this could be the reason for the pest outbreaks in many parts as there are no natural enemies to check its population. However the locally available natural enemies that are in existence in the ecosystem are able to curb the pest from spreading. Bio-agents namely parasitoids, predators and entomopathogenic fungi are found effective in suppressing the pest during winter and rainy seasons but their efficacy is found to be reduced with high temperature, especially summer.

Parasitoids

Although a number of parasitoids were reported feeding on the pest in Florida (Taravati *et al*., 2013; Vivek Kumar *et al*., 2013), in India very few parasitoids were found feeding on the late nymphal stages of the pest (Selvaraj *et al*., 2016). The nymphal parasitoid, *Encarsia guadeloupae* that was collected from the spiraling whitefly, *Aleurodicus dispersus* infested areas is found to be an effective parasitoid on rugose spiraling whitefly also (Poorani, 2017). These parasitoids that were collected from the already infested areas of Kerala and Tamil Nadu (in the form of parasitised rugose spiraling whitefly nymphs) proved to be partially effective in Andhra Pradesh causing up to 20 per cent parasitisation during winter. The parasitised nymphs appeared black indicating the parasitisation. The characteristic of a parasitised nymph is a hole

Figure 4 Yellow tarpaulin sheets wrapped on coconut stem

on the top of the thorax indicating through which the parasitoids emerge after killing the pest (*Figure 5*). However, its efficacy was not found to be encouraging even after inundative releases in the infested plantations. The parasitoids were not multiplying and maintaining their generations indicating the adverse impact of the climate i.e. extreme hot conditions during summer months.

Predators

The locally available neuropteran predator *Dichochrysa astur* (Banks) was found feeding on different stages of the pest (Selvaraj *et al*., 2016). Although the larvae of the predator were found moving into the pest colonies by carrying the eaten carcasses on their back as hump, the feeding capacity of the predator is much less compared to the pest multiplication. Along with these larvae, the eggs as well as the adults (*Figure 6*) were also

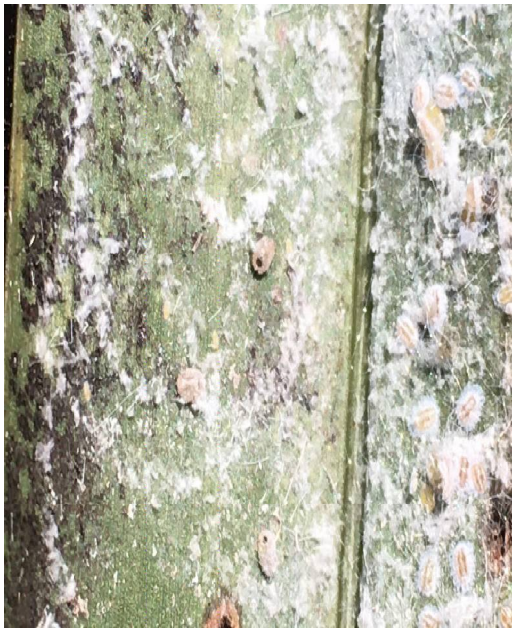

Figure 5 Parasitised nymphs of rugose spiraling whitefly (holes on the body)

Figure 6 Eggs (a) and adult (b) of Neuropteran predator

visible either on the host plants or on the intercrops. Though Selvaraj *et al*. (2016) reported many other species of predators feeding on rugose spiraling whitefly in Tamil Nadu and Kerala states, only the neuropteran predator was found feeding on the pest in Andhra Pradesh. Even though the impact of predators on mitigation of the pest population is meagre, however it can also be included in the IPM programme as one of the management tools.

Myco-biocontrol

Entomopathogenic fungus, *Isaria fumosorosea* is an effective microbial organism that develops

and multiplies on the whiteflies worldwide causing yellow muscardine sickness leading to mortality of the pest (Sandhu *et al*., 2012). Research work carried out in the University of Florida, United States of America (Vivek Kumar *et al*., 2016) revealed the efficacy of the fungus against the pest. Accordingly work was carried out at ICAR- IIOPR, Pedavegi using locally available strain of the fungus and it was found to be effective in killing the pest population during all the seasons (*Figure 7*). Since it is a microbial fungicide, pollution to the environment and resurgence problems do not crop up. The multiplication procedures at both laboratory and field levels were standardised to produce maximum number of spores per millilitre.

The multiplication of the fungus is made easy to be carried out by the farmers themselves in their fields by supplying mother culture with spore count of more than 100 x 10^8. The fungus developed fast in jaggery and starch materials at a short time of 15 days. Reinoculation studies carried out using the infected rugose spiraling whitefly confirmed the mortality of the pest due to the fungus, *Isaria fumosorosea* only. Hence it is also recommended to include this fungus in IPM practices for rugose spiraling whitefly.

Chemical control

Though some new insecticides are found effective in controlling the pest (Anon., 2010), mostly the adult stage, reoccurrence of pest incidence is observed in all the plantations within 15 days. It is mainly due to the waxy floccus material (*Figure 8*) that is released by the pest to cover its immature stages like eggs and nymphs. This acts as a barrier for the insecticides to penetrate. As commonly used insecticides do not have the capacity to dissolve the wax material, hence they were found ineffective in controlling the hidden immature stages. It was observed that when the wax material dissolved, it is easy to eradicate the pest using any insecticide including neem oil.

Application of neem oil at 10 000 ppm concentration mixed with washing powders is found to be a good and effective practice in reducing the pest population. It was observed that the washing powder dissolved the waxy material present over the pest stages exposing them to biotic and abiotic conditions. The neem oil was observed to act over the exposed immature stages of the pest and suppress their activity by means of its antifeedant and oviposition deterrent characters. The other concentrations of neem oil (1000 and 1500 ppm) that are available in the market are also

Figure 7 Isaria *fungus infected nymphs (a) and adults (b) of rugose spiraling whitefly*

Figure 8 Waxy floccus material of rugose spiraling whitefly

effective but higher dosage needs to be applied which may increase the cost of application (Stocks & Hodges, 2012).

Multiplication of entomopathogenic fungi

Methodologies have been standardised for the multiplication of entomopathogenic fungus, *Isaria fumosorosea* in the laboratory on various media using locally available materials. Similarly its multiplication in the farmers' fields using mother culture supplied by this Institute has been standardised by using simple materials like starch powder and jaggery. This paved the way for all the interested persons to multiply it on their own with little investment. It is possible to implement all these technologies in an integrated manner and they have proved to be effective in reducing the pest population.

Application of biological and chemical insecticides

Since oil palm are tall growing plants, application of different treatment materials including the microbial organisms and insecticides is a herculean task for the farming community. Hence the methods of application also need to be standardised. Using turbo sprayers, which can pump the spray liquid as high as 40 feet, has been found to be a good and effective practice to mitigate the pest. This has been found to be very effective in getting maximum mortality of the pest compared to traditional sprayers like knapsack, foot pumps and power operated ones.

Three applications of the developed entomopathogenic fungus culture with a minimum spore count of 10^8 per millilitre mixed with any of the detergent powders at 5 g per litre (depending on the incidence and wax molecules) at weekly intervals have proved to be effective in controlling the pest population and hence is recommended. As this does not have any adverse effect on other organisms, it is recommended to be implemented along with other practices such as release of parasitoids, predators, hanging of sticky traps, application of neem oil in an integrated manner.

Since it was observed that chances are remote for the development of pest resurgence on the nursery plants due to their short stay, it is recommended to use systemic insecticides like imidacloprid as and when needed and invariably before releasing the planting material for sale. Use of insect growth regulating insecticides (chitin inhibitors) like buprofezin that has proved to be effective in USA (Vivek Kumar *et al.*, 2016) when used in combination

with *Isaria fumosorosea* fungus, may also be a good practice to follow.

All the above-mentioned practices are feasible techniques that can be carried out without much investment and drudgery by the farming community. Hence possibilities for the management of the pest seem to be high and a reality as the technologies are viable and valuable. By following the above-mentioned practices in an integrated manner, the whitefly menace can be curbed effectively.

CONCLUSION

Rugose spiraling whitefly, an invasive pest on oil palm, causes severe yield losses by sucking the sap and allowing the sooty mold fungus to grow on its honey dew. Effective management of the pest using integrated practices is discussed. Avoidance of the procurement of nursery plants from already infested areas, raising marigold plants all along the borders and intermittent areas to repel the pest, erecting the yellow sticky traps in the plantation, wrapping of yellow tarpaulin sheets to the stem and applying grease/castor oil to attract the adult flies, release of parasitoids and predators in the infested plantations, application of neem oil by mixing with washing powder, are few practices that are recommended to curb the pest. Application of locally available strain of myco biocontrol agent, *Isaria fumosorosea* by mixing with washing powder proved effective in controlling the pest infestation. Methodologies on multiplication of the fungus at both laboratory as well as farm levels were standardised after confirming the results obtained from reinoculation studies and hence can be included in IPM practices of the pest.

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