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Non chemical approach for management of whitefly in cotton - A Review

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ABSTRACT : Whitefly has become a major constraint in cotton production. Apart from causing direct loss to cotton, it also acts as a vector of CLC virus which causes a deadly disease in cotton plants. The continuous and injudicious use of insecticides has resulted in development of resistance in whitefly against a number of insecticides due to which the management of this pest has become a major challenge for the cotton growers. Under such circumstances, it has become imperative to follow the non chemical approach for management of this pest. It was found that early or timely sowing of the crop, wider spacing, balanced use of nitrogenous fertilizers, intercropping with some trap crop (sesame, maize, cowpea, castor etc.) and avoidance of water stress conditions play an important role in escaping of cotton from whitefly incidence. The yellow sticky trap can also be used for trapping whitefly adults. Conservation of natural enemies (parasitoids/predators) by avoiding spray of any chemical insecticide and additional release of these organisms have been found effective and safe management practices for cotton whitefly. Similarly, use of entomopathogenic fungi like *Paecilomyces fumosoroseus* (*Isariafumorosea)*, *Verticillium lecanii* and *Beauveria bassiana* etc. have also resulted in better suppressing of whitefly population. The botanicals, particularly *neem* was found very effective against whitefly due to its antifeedant, toxicological, repellent, sterility inducing and growth inhibiting effects. The insect growth regulators (novaluron, buprofezin etc.) can also be used for management of this pest as they reduce the adult emergence to a greater extent. Further, the combination of two or more non-chemical practices gives better results than applied alone.

Key words: Cotton, management, non chemical practices, whitefly

Among various insect pests causing damage to cotton crop, the sucking pest complex now occupies major pest status in *Bt* cotton which adversely affects the yield (Ghosh, 2001). *Bt* cotton is infested by a number of sucking pests including the whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), which is a major threat to the *Bt* cotton throughout the country (Patel *et al.*, 2010). It was first collected and described from tobacco, *Nicotiana* spp., as *Alerodes tabaci* by Gennadius in Greece in 1889; and later synonymized by Russell in 1957 into *Bemisia*. It is known by several common names e.g. tobacco whitefly, cotton whitefly, cassava whitefly or sweet potato whitefly. In India, *B. tabaci* was first reported from Pusa (Bihar) on cotton during 1905 and was described as *Bemisia gossypiperda* M. and L. (Mishra and Lamba, 1929). This pest was reported to attain pest status in southern parts of India during 1985-87 and in northern parts during 1987-95 on cotton, brinjal, tobacco, tomato and several ornamental plants (Sharma and Batra, 1995; Palaniswami *et al.*, 2001).

It is widespread in tropics and sub tropics. Earlier it was a minor pest of cotton but from 1984-1985 onwards, it has emerged as a major pest (Regu *et al.,* 1990). It has a wide host range and globally it has been reported to feed on over 600 host plant species (Attique *et al.*, 2003). It has a high reproductive rate with its ability to readily disperse among host plants and breed year round.

Whitefly causes damage in three ways *i.e.* directly, indirectly and by transmission of deadly virus (Berlinger, 1986). Direct damage is caused by sucking of sap from the foliage of plants. Indirectly by blackening of leaves and cotton lint due to development of sooty mould on honey dew sacreted by the best which reduces the cotton yield quantitatively as well as qualitatively (Sakalbale *et al.*, 1991; Hendrix *et al.*, 1995; Naranjo *et al.*, 1995; Drost *et al.*, 1998).Whitefly also acts as a sole vector for more than 100 plant viruses, which cause diseases to many commercial crops in different parts of the world (Jones, 2003). Important diseases transmitted by *B. tabaci* include abutilon mosaic, cassava mosaic, cotton leaf curl, tomato yellow leaf curl, soybean yellow mosaic, sweet potato mild mottle and tobacco leaf curl. *B. tabaci* can rapidly disseminate viruses in the field even when populations are not appreciable, and can cause severe crop damage in susceptible plantings.

In order to reduce the pest population and plant damage, several measures are available, but due to easiness in application and availability, farmers prefer to apply chemical insecticides only. So insecticides have been the first line of defence against whitefly. Unfortunately, the first insecticides used to control whiteflies were conventional, broad-spectrum products applied singly or more often in mixtures of organophosphates and pyrethroids, known as cocktails (Liete *et al.*, 2005). These products soon failed to control this pest due to the outstanding genetic capacity of the whiteflies i.e. development of resistance to insecticides of different nature (Perumal *et al.*, 2009). New insecticides such as neonicotinoids (e.g., imidacloprid, acetamiprid, thiamethoxam, nitenpyram and thiacloprid) and insect growth regulators (*e.g.,* buprofezin and pyriproxyfen) were developed and used widely despite their higher prices. Unfortunately, insecticide abuse (excessive number of applications) and misuse (active ingredient diluted with other products) still occurs in different regions of the world. The overall reliance upon pesticides with indiscriminate use has resulted in cropping out of many negative consequences, mainly 3'R's *viz.* Resurgence, Resistance and Residue aspects (Gupta, 1998); and also the disruption of the population of predators and parasitoids (Natarajan, 1992).

Under these circumstances, the management of cotton whitefly with the use of insecticides only has become a challenging task. Alternative whitefly control strategies are also available and can be highly effective when used properly. Keeping this in view, the various non-chemical practices suggested by different workers have been reviewed for better management of whitefly in cotton.

POPULATION DYNAMICS : It has been observed that several weather parameters i.e. temperature, relative humidity and precipitation play an important role in the multiplication and development of whitefly (Rao and Chari, 1993;

Meena *et al.*, 2013; Shera *et al.*, 2013; Zia *et al.*,2013). The climatic conditions largely influence the pest numbers and activity as well as several predators and parasites either directly or indirectly (Arif *et al.*, 2006; Chaudhari *et al.*, 1999). Whiteflies develop rapidly in warm weather. The most important abiotic factor is temperature which has dominant role in pest population variation (Bale *et al.*, 2002). It affects egg laying, increases rate of feeding, metabolism, herbivory and development of whitefly (Pedigo, 2002). Similarly, relative humidity had significantly positive correlation with whitefly population on cotton crop (Ashfaq *et al.*,2010; Sahito *et al.*, 2012 and Safdar *et al.*, 2005). Further more, the morning relative humidity had positive correlation while the evening relative humidity was negatively correlated (Kalkal *et al.*, 2013). A combination of 27^0 C temperature and 72 per cent relative humidity appears to be highly conducive for population buildup of the whitefly (Singh and Butter,1985). Increase in maximum and minimum temperature had adverse effect on population buildup of whitefly. On the other hand any increase in morning relative humidity favored the population build up of *B. tabaci* (Mehra and Rolania, 2017).Thus, decrease in temperature and increase in RH favor the population buildup of whitefly (Singh *et al.*, 2015). Heavy and prolonged periods of rain can substantially reduce the whitefly population (Bashir *et al.*, 2001 and Shivanna*et al.*, 2011). It is evident that rainfall and minimum temperature exerted 67 per cent effect on the population fluctuation of whitefly (Singh *et al.*, 2015).Maximum population was observed at average rainfall, average temperature, average relative humidity of 29.8, 33.1°C, 85 per cent, respectively(Kadam *et al.* 2015 and Rolania *et al.*, 2018).

As the host plants and natural enemies like predators and parasitoids also regulate the population of whitefly in the field, the population of the natural enemies also depends on environmental factors (Rafiq *et al.*, 2008).

Thus, the knowledge about the impact of various weather parameters on population of whitefly can be used for forecasting and formulating effective management practices well in time.

MANAGEMENT : Some non-chemical practices such as cultural practices, physical control, use of biological agents and botanicals found very effective against whitefly are reviewed as under.

CULTURAL PRACTICES : Cultural interventions are generally labor intensive but are largely preventative. They can affect pest population in three ways. First, they can make the plant or agroecosystem unacceptable to the pest, and the pest will avoid the crop. Second, they can displace the crop plants in time and space, causing it unavailable to the pest during the period when it normally feeds. Third, they can make agroecosystem a dangerous place for the pest by increasing the beneficial insect population. Cultural practices include sowing time, spacing, intercropping, use of fertilizers, irrigation etc.

Sowing time : One of the most important agronomic considerations for growers to optimize yield and quality is to select an appropriate sowing time for a crop like cotton. Choosing the best time of sowing in a particular region can often be difficult, as it is a decision that must strike a balance between sowing too early and too late and enduring problems of different pests and diseases. But sowing time of cotton crop plays an important role in reducing the whitefly incidence.The cotton sown early was not affected by slight development of population of whitefly but as sowing time was delayed, the plants become more prone to infestation (Nagargoje *et al.*, 2002). Thus, the whitefly population increased as the sowing of cotton is delayed from April to May (Acharya and Singh, 2007). But the timely sown crop escaped from the heavy infestation of whitefly as compared to the late sown crop (Singh and Saini, 2017).

Spacing : Proper spacing between the rows as well as the plants is also an important cultural practices to manage the whitefly population. The space between plants affects air flow and sunlight penetration and therefore, moisture and humidity levels. Whitefly populations was significantly affected by plant spacing and decreased with the increase in plant spacing (Arif *et al.*, 2006, Singh *et al.*, 2015, Patel *et al.*, 2013; Patel and Desai, 2014; Shrirame *et al.*, 2016). It might be due to increase in relative humidity in closer spaced crop which favours the population build-up of whitefly (Singh *et al.*, 2015). Thus, wider spacing results in reduction of pest population.

Use of fertilizers : The whitefly population is greatly influenced by the application of chemical fertilizers, the nitrogenous fertilizers in particular. The higher doses of these fertilizers favoured the multiplication of whitefly in cotton (Rustamani *et al.*, 1999, Patel *et al.*, 2013; Shrirame *et al.*, 2016, Patel and Desai, 2014).

The excessive dose of nitrogenous fertilizers may produce lush green plants, which attract a number of pests. Moreover, higher dose of fertilizer also affect the maturity of the crop. The late application of the fertilizer induces the pest attack and also results in profuse plant growth which makes it difficult to follow cultural practices in the field properly.So basing fertilizer need on yearly soil sample and applying an amount for reasonable projected yield will tend to eliminate this plant growth (Ahmed *et al.*, 2007). Therefore, fertilizer should be applied at proper time and in balanced form as well.

Intercropping : Growing two or more crops in the same, alternate or double rows often results in reduced pest problems. Carefully chosen intercrops can disrupt visual and odour cues that pests use to locate the crop plants, physically limiting dispersion and enhancing natural enemies. Cotton intercropped with maize, sesame and soybean enhanced the population of various natural enemies and suppressed the population of insect-pests attacking cotton, and increased the seed cotton yield (Godhani *et al.*, 2010, Singh and Saini, 2017). Whitefly population can be suppressed by cotton interspersed with maize (10%) and cow pea sown in between two rows of cotton (Patel *et al.*, 2012). Castor also plays an important role in reducing the population of whitefly if intercropped in*Bt* cotton as one row of castor after each 10 rows of cotton (Dhawan *et al.*, 2008). Green manuring of intercrop also plays a vital role in reducing the whitefly population considerably.

Intercropping with marigold in two rows in between cotton rows and in corporating it on 30DAS had contributed ultimately less incidence of whitefly (Vaiyapuri *et al.*, 2007).The cucumber plants were also found to be the highly preferable host to whitefly (Fargalla *et al.*, 2011) which can be used as trap crop to prevent the cotton from whitefly infestation.

Border crop : Crop sown at the periphery of the main crop that specifically prevents the entry of the pest into a crop field or harbours beneficial insects is called as border crop. It can consist of single crop species, a mixture of species, or a mixture of wild species. It was reported that the cotton crop bordered by sorghum showed significantly lower aleyrodid populations (Rao and Chari, 1992). Similarly, the soybean field surrounded with maize or moongbean might offer a reliable protection against the infestation of cotton whitefly (Abdallah, 2012) which can be used in cotton crop also.

Irrigation : Both method as well as rate of irrigation exerts a greater influence on whitefly population. The nymphal population of whitefly was found higher in the furrow irrigated fields than the drip irrigated as in later case the irrigation is applied as and whenthe plants require and thus avoiding the water stress conditions. Similarly, highest number of whitefly nymphs was observed on cotton applied with less irrigation. As the irrigation rate in both the methods was increased, significantly lower population of whitefly nymphs was observed. Increasing the irrigation rates in both methods seems to be the most practical way to obtain the lower populations of whitefly associated with reduced water stress (Gencsoylu *et al.*, 2003). Cotton crop under water stress condition also recorded highest number of whitefly nymphs (Mor, 1987). So, avoidance of water stress in cotton is the main cultural practice necessary to reduce whitefly population (Mattson and Haack, 1987).

PHYSICAL CONTROL : The most important component of the physical control is trapping of the pests by a suitable trap. The yellow sticky traps are commonly used for population monitoring of many pests. Suspending of a yellow cardboard or yellow piece of wood with a very sticky substance applied to it can be used for control of whitefly adults. Apparently, whiteflies are attracted to yellow colour and they cannot free themselves from the glue. In recent decades, studies of these traps mainly focused on how to use them to monitor populations of pest species such as whiteflies, leaf miners and aphids (Shen and Ren, 2003; Zhou *et al.*, 2003; Qiuand Ren, 2006; Gu *et al.*, 2008). But in recent years yellow sticky traps have also been used as a method for the control of some pests, especially the whitefly. It was also demonstrated that yellow sticky traps can significantly reduce the density of *B. tabaci* in field (Abdel-Megeed *et al.*, 1998).

A rectangular yellow sticky trap with stick-gum (polyisobutane) and castor oil was found very effective to catch the adults of whitefly. Placing of trap at suitable height is also important as yellow sticky traps showed maximum catches at heights of 1.50 m and regular replacement at weekly interval (Dhawan and Simawat, 1998).Traps placed facing the sky either inside or adjacent to the field attracted the most aleyrodids (Rao *et al.*, 1991). Further, the use of sticky trap for the management of cotton whiteflies over a large area may give much better results than used in restricted one.

BIOLOGICAL CONTROL : For the control of whitefly, several parasitoids, predators and pathogens have also been reported to be very effective.

Parasitoids and predators : The primary parasitoids of *B. tabaci* are known from the genera *Encarsia, Eretmocerus* (Hymenoptera, Aphelinidae) (Gerling *et al.*, 2001) and *Amitus* (Hymenoptera, Platygasteridae) (Joyce and Bellows, 2000). Only from the genera *Encarsia*, many parasitoids like *Encarsia transvena, E. flava, E. shafeei, E. sublutea* and*Encarsia* sp. have been reported parasitizing *B. tabaci* nymphs on cotton (Kapadia and Puri, 1989). In a study, it has also been reported that *E. lutea* (Masi) can parasitize *B. tabaci* on cotton up to 45.11 per cent (Sharma *et al.*, 2003).

The predators feeding on *B. tabaci* include arthropods belonging to 9 orders and 31 families. Most of these are beetles, (Coccinellidae), true bugs (Miridae, Anthocoridae), lacewings (Chrysopidae, Coniopterrydae), mites (Phytoseiidae) and spiders (Araneae) (Gerling *et al.*, 2001). Green lacewing larvae have a voracious appetite. They attack whitefly as well as other pests including aphids, mealy bugs, spider mites, leafhopper nymphs, moth eggs, scales and thrips. They are available in the form of eggs from commercial insectaries and after hatching, stay in a larval stage for one to three weeks. The adult insects can fly and feed only on pollen, honey and nectar to reproduce. *C. carnea*can consume on an average 203.18 nymphs of*B. tabaci* (Kapadia and Puri, 1992). Another predator, lady bird beetle was also found very effective against cotton whitefly. In Europe, three species of lady bird beetles *viz., Clistostethus arcuatus, Delphastusca talinae and Serangium montazerii* were used for the control of whiteflies (Booth and Polaszek, 1996). In north India, *Serangium parcesetosum* has also been reported feeding on *B. tabaci* nymphs and consumed 560.2 nymphs during its larval duration of 12.8 days (Kedar, 2014). Another species of lady bird beetle, *Axinoscymnus cardilobus* preferred to feed on early stages of *B. tabaci* (Huang *et al.*, 2006).To achieve better control of whitefly through the bioagents, it needs to avoid the application of chemical insecticides as it adversely affects the predator population (Hasan-Omer-Kannan, 2000).

Entomopathogenic fungi : Insects may also suffer from the attack of diseases. At a favorable condition, the attack of pathogen may reduce the insect population from a point of great abundance to one of scarcity. The minute organism such as bacteria or fungi may cause a disease to the insect. They live on or in the bodies of insect. Entomopathogenic fungi may be used as a means of biological control for white fly. In order to use the fungi to control the white fly, the spore of the fungi are mixed with a water and sprayed over the plants infested with whitefly (Metcalf and Flint, 1962).

Entomopathogenic fungi are easy to apply, although good coverage is required on the abaxial foliar surfaces where whiteflies reside. These fungi present essentially no risk to human health and most studies showed that they are relatively innocuous to other natural enemies also (Goettel *et al.* 2001; Vestergaard *et al.* 2003; Zimmerman, 2008). Use of fungal products is also compatible with many insecticides, and no resistance against any mycopesticides has yet been reported.

Three species of entomopathogenic fungi active against *B. tabaci* are available commercially *viz. Paecilomyces fumosoroseus* (*Isaria fumorosea)*, *Verticillium lecanii* and *Beauveriabassiana* (Faria and Wraight, 2001). The first two are naturally found infecting whiteflies whereas, *B. bassiana* is only seen infecting whiteflies when applied as part of a formulation. The *P. fumosoroseus* is best for controlling the nymphs of whitefly.The ability of this fungus to grow extensively over the leaf surface under humid conditions is a characteristic that certainly enhances its ability to spread rapidly through whitefly populations (Wright *et al.*, 2000). Under certain conditions, natural epizootics of this fungus can also suppress *B. tabaci* populations. Epizootics caused by *P.fumosoroseus* can lead to substantial reductions in *B. tabaci* populations during or immediately following rainy seasons or even prolonged periods of cool, humid conditions in the field or greenhouse (Lacey*et al.*, 1993). The fungus cover the whitefly's body with slight mycelia threads and stick them to the underside of the leaves. The nymphs show a "feathery" aspect and are surrounded by mycelia and conidia (Shannon, 1996).

Another fungus that has good prospect in the future to be as whitefly biocontrol agent is *V. lecanii*. This fungus attacks nymphs as well as adults (Shannon, 1996). *V. lecanii* is a widely distributed fungus, which can cause large epizootia in tropical and subtropical regions, as well as in warm and humid environments (García and López, 1997).Fungus *B. bassiana* was also found to be effective against many insect pests especially cotton whitefly that offers great scope in ecology based cotton pest management (Jalali and Singh, 2003; Jat and Jeyakumar, 2006). *B. bassiana* (Naturalis-O™ and Botanigard™), is effective against eggs, immature and adults of whitefly (Aroiee*et al.*, 2005). The fungi,*Aschersonia aleyrodis* and *Orthomyces aleyrodis* can also be used as whitefly biocontrol agents (Steinkraus *et al.*, 1998).

BOTANICALS : About 2400 plant species of plants have been listed having insecticidal or acaricidal properties distributed in 189 plant families (Grainage and Ahamd, 1988). *Neem* (*Azadirachta indica*) and pyrethrum (*Chrysanthemum cinerariaefolium*) are commonly used commercial botanicals but*neem* based insecticides are most widely used against various insect pests, cotton whitefly in particular. *Neem* products act both systemic as well as contact poisons and inhibit the insect growth by acting as antifeedant, toxic, repellent, sterility inducers or insect growth inhibitors (Gahukar, 2000). All parts of *neem* tree are biologically active, however, maximum insecticidal activity is found in the seed kernels. *Neem* seed kernel extracts (NSKE) have generally been found to deter the feeding of most of the insects evaluated so far (Singh, 2000) and when fed or applied to juvenile stages of the insects, arrest their growth. Depending on dose, the insects are either killed before reaching adult stage or produce malformed or miniature adults. Other physiological effects recorded are prolongation of larval period, production of larval-pupal and pupal-adult intermediates. Both *neem* seed oil and extract of *neem* seed kernel have been reported to deter oviposition by adult insects (Karuppuchamy, 1995).It was found that weekly spray of neem can reduce the whitefly population significantly as compared to the chemical insecticides (Singh and Saini, 2017, Phadke *et al.*, 1998).

The growth and development of whitefly nymphs were suppressed variously by *neem* oil. The nymphs affected severely by *neem* oil died within 3 days after treatment. Such nymphs showed exudation of body fluids through disruption of the tissue on the second day after treatment. As a consequence, further development was completely arrested and the nymphs turned brown and scaly (Natarajan and Sundaramurthy,1990).Among botanicals, *neem* based products affected insects in many ways, which possessed a potent antifeedant and growth disrupting properties (Kaur *et al.*, 2001). Application of leaf extract of *dhatura* or oleander may also be eco-friendly for the management of whitefly in field crops (Latif and Akhter, 2013).

In general, the botanicals were effective up to 3 days after treatment (Borkar *et al.*, 2012) but the *neem* products have been found to reduce the whitefly population up to 60 per cent, 7 days after spray also (Jat and Jeyakumar, 2006).

INSECT GROWTH REGULATORS : A new approach to control insect pests is the use of substances that adversely affect insect growth and development. These substances are classified as "insect hormone mimics" or "insect growth regulators" (IGRs) owing to their effects on certain physiological regulatory processes essential to the normal development of insects or their progeny. These affect the juvenile insects, either causing death or abnormality in newly hatched insects, or preventing sexual maturity. Insect growth regulators are usually synthetic version of natural occurring hormones. Hormones are chemicals produced in one part of pest's body that affect the growth and behaviour of other parts of the body. IGRs are highly selective and are extremely toxic to other organism including human. They generally control insects either through regulation of metamorphosis or interference with reproduction (Riddiford and Truman, 1978). Compounds developed to disrupt metamorphosis ensure that no reproductive adult is formed. Those interfere with reproduction may lead to the development of adults with certain morphogenetic abnormalities that reduce their reproductive potential. Adults may be sterile or possess abnormally developed genitalia which hinders the mating process or the capacity to produce fertile offspring (Tunaz and Uygun, 2004). Chitin synthesis inhibitors, juvenile hormone analogues and anti-juvenile hormones analogues are examples of insect growth regulators.Novaluron, a noval benzoylphenyl urea chitin synthesis inhibitor, was found to have activity against *B. tabaci* (Ishaaya *et al.*, 1996). At a concentration of 1 mg a.i./l, novaluron reduced the adult emergence by more than 90 per cent when first instar nymphs of *B. tabaci* were exposed to treated cotton seedlings. The compound apparently worked by contact with *B. tabaci* eggs and nymphs, and appeared to have no significant effects on any parasitoid or phytoseiid, and a mild effect on other natural enemies (Ishaaya *et al.*, 1997). Its efficacy against *B. tabaci* under field conditions has been shown to resemble or exceeds other IGRs (Ishaaya *et al.*, 2001). Another insect growth regulator, buprofezin was also found to be significantly superior to the chemicals such as imidacloprid and acephate and was also found safe to natural enemies like spider and coccinellids (Nadagouda *et al.*, 2015)

COMBINATION OF VARIOUS NON-CHEMICAL PRACTICES : The combination of various non-chemical practices gives better results than applied alone. The plant spacing and fertigation level hassignificant impact on the population of sucking pests in *Bt* cotton. The wider spaced plants applied with the lower fertigation level recorded the lower infestation as comparedto the closer spaced plants with the higher fertigation levels. It is required to adopt plant spacing and nutrition level sprecisely in *Bt* cotton so as to limit the sucking pest population at an economically acceptable level (Patel *et al.*, 2015).

The intercropping of cotton with lucerne (1:1 row proportion) along with two sprays of NSKE (5%) on cotton at monthly interval and release of *Chrysoperla carnea* (Stephens) grubs starting from about one and half month of sowingmay reduce the whitefly population considerably (Hanumantharaya *et al.*, 2008). Spray of nimbecidine and intercropping of cotton with sesame may also result in lowering the population of whiteflies through higher parasitization by the natural enemies. The insecticides, particularly the synthetic pyrethroids, had the greatest adverse effect on the parasitoids of whitefly (Sharma *et al.*, 2008) and hence the cotton intercropped with sesame, sprayed with neem and release of *Trichogramma chilonis* recorded significantly lower population of whitefly adults as compared to chemical insecticides (Singh and Saini, 2017).

The combination of yellow sticky traps and release of parasitoids has also proven to be an effective method for the control of *B. tabaci* in a greenhouse (Shenand Ren, 2003; Gu*et al.*, 2008) which can also be used in field conditions.Similarly, color trap with spraying of *azadirachtin* 10000 ppm @2ml/l was found very effective in trapping highest whitefly population/ trap (Bantewad and Thakare, 2017).The maximum catches of whitefly were recorded on yellow color sticky trap with castor oil followed by application of *azadirachtin* 10,000 ppm @ 2 ml/ lit as compared to without spray of *azadirachtin* on cotton crop (Khaire, 2014).The *neem* was compatible with *B. bassiana*; and the soil application of *neem* along with foliar application of *B. bassiana* might be useful for the control of *B. tabaci* (Md-Touhidul-Islam *et al.*, 2011).

CONCLUSION

Due to development of resistance in cotton whitefly against insecticides, it has become very difficult to control this pest. To overcome this problem, various non-chemical practices such are modification in cultural practices, use of sticky traps, biological control agents, botanicals and insect growth regulators can be used alone and in combinations which have been reported to be very effective against this pest by various workers.

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