Hexapoda (*Insecta indica*)

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Status of invasive wooly aphid management on sugarcane in India

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ABSTRACT: The sugarcane wooly aphid (SWA) - *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphididae) is an important invasive insect pest in recent times in India. This overview seeks to synthesize the existing knowledge base with reference to R&D undertaken in the country as well as elsewhere. The local surveys on their incidence and spread, the extent of impact made on yield and quality of the canes harvested as well as the varietal differences in the incidence level of SWA are indicated. The case studies of promising biocontrol agents which can be multiplied in situ and also redistributed to new areas are illustrated. The scope for future R&D initiatives to further promote the biocontrol-based IPM development is highlighted.

Key words: sugarcane woolly aphid, biocontrol, R&D, IPM, India

Introduction

Sugarcane wooly aphid, *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphididae) was first reported from West Bengal in 1958 and later from north-east India (Basu and Banerjee, 1958, Tripathi, 1995). It has invaded tropical India during 2002-03 beginning with Maharashtra and Karnataka and later extending to Tamil Nadu and Andhra Pradesh (Patil *et al.*, 2004 and Srikant *et al.*, 2016). It is also known from Nepal, Bangladesh, China, Indonesia, Japan, Malaysia, Myanmar, Philipines, Sri Lanka, Thialand, Vietnam, Fiji and Papua New Guinea (Takahasi, 1927 and Varghese, 1916) with variable pest status (Joshi and Viraktamath, 2004). The aphid has appeared first time in epidemic form in Sangli district of Maharashtra during 2002 (Rabindra *et al.*, 2002 and Rabindra and Mohanraj, 2004). Later,

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incidence spread to other districts of Maharashtra (Kolhapur, Satara, Pune, Solapur, Ahmednagar, Aurangabad, Jalna, Latur and Osmanabad) (Patil, 2003; Patil *et.al.* 2003 and Kulkarni *et.al.* 2003).The pest spread to Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Uttar Pradesh, Uttrakhand and Bihar (Srikant, 2005 and Joshi *et al.*,2018).

It occurs in colonies (gregarious form) on the underside of sugarcane leaves along the midrib and characterized by the presence of fuzzy, white wax that covers the body (Srikant, 2016). The wax filaments give a fluffy cottony appearance, as though they are covered with wool (Takara, 1968). The nymphs and adults are phloem feeders and colonize on the leaves and young canes and suck the sap from the host. The soil beneath the crop looks white and covered with the powdery coating of fallen wax coatings of aphids.

1.2. Damage and Losses: The wooly aphid, *C. lanigera* has been reported to cause severe damage to sugarcane from germination till harvest (Patil, 2002). Overlapping generation exists and life cycle varies according to the agro climatic conditions (Patil *et al*, 2004a). Continuous infestation leads to reduction in the girth, weight and length of internode and loss in tonnage as well as sugar recovery (Tripathi, 2008; Gupta and Goswami, 1995). It causes injury due to withdrawal of large quantities of sap from the dorsal surface of the leaves. The excreted honeydew from *C.lanigera* falls on the upper surface of the leaves beneath, which forms thick black sooty mould, *Capnodium* sp. develops, forming a thick black coating, which severely impairs photosynthesis (Singh, *et al.*, 2009; Takara, 1968; Hill, 1993 and Kishore *et al.*, 2019). As a result, vigour, plant growth, tonnage and quality of the cane deteriorate. It causes significant loss in cane yield and sugarcane recovery up to 15% (Gupta and Goswami, 1995; Nerkar, 2003; Patil *et.al.* 2004a and Anonymous, 2003).

1.3. Host Plant: The primary host plant for woolly aphid is sugarcane, while bamboo, *Miscanthus sinensis*, *Bambusa arundinaceous*, *Bambusa* sp., *Cynodon dactylon, Grassum* sp., *Oplismenus* sp., *Themeda* sp. and *Xylosma longifolia* are secondary hosts (Aoki *et.al*, 1984; Raychaudhuri, 1984; Hill, 1993; Anonymous, 2002 and Joshi and Viraktamath, 2004). Its colonies were also recorded on leaves of wild sorghum, *Sorghum halepense* and wild maize, *Coix lacryma* Linn which were present inside the sugarcane fields (Anonymous, 2005).

1.4. Factors conducive for outbreak of sugarcane woolly aphid: The ability of the woolly aphid to rapidly adapt to any climatic conditions, apparently due to high reproductive rates (Srikant, 2005). Population of aphids changed in relation to weather parameters, time of planting and ratooning. Long periods of dry and wet seasons inhibited SWA population and alternating rainy, high temperature and less rainfall (Suhartawan, 1996; Takano, 1935 and Uichanko, 1928). An early rainy season was the major cause for attack during the succeeding year and dry season with high humidity being also conducive for aphid infestation (Saputro *et al.*, 1995). Heavy precipitation coupled with high temperatures was causing decline in the aphid population (Joshi and Viraktamath, 2004). In general, cloudy weather, rainfall exceeding 100 mm, moderate temperature (19 - 35^{0}C) and relative humidity (50 - 95%) were found to be favourable factors for increasing the aphid incidence coupled with ample availability of food and shelters in sugarcane (Patil *et.al*, 2004a). Low infestation was recorded in crops which were planted in July onwards where as severe infestation was observed in adsali crop planted in

January or February 2002 (Tripathi *et al*, 2001), while excessive use of nitrogenous fertilizers also caused severe attack of woolly aphid (Joshi *et al.*, 2018).

1.4.1. Varietal incidence of woolly aphid: The occurrence of *C. lanigera* in cane fields differed significantly from year to year and among different cane varieties (Yamasaki and Arikadu, 1939 a & b). Early maturing and high sugarcane soft sugarcane varieties with broad and dropping leaves were more susceptible to SWA (Patil, 2002; Takano, 1937 and Uichanko, 1935).Lingappa *et al* (2003) reported that varieties with acute leaf (narrow and erect types) viz., CoM 88121, Co 86032, Co 89010 were less colonized by woolly aphid than with broader and droopy. The high sucrose with broad and droopy leaves of Co 92020 was severely infested with woolly aphid (Patil *et al*, 2003). Varieties with low concentration of cell sap had lower infestation compared to those with high cell sap concentration (Yamazaki and Arikado, 1939a &b). Patil *et al* (2005) reported that partial colonization on resistant clones SNK44 which later resulted in 100% mortality within 48-72 h and suggested possible antibiosis and/or non-preference mechanism.

The range of varieties studied and their response to wooly aphid is summarized in Table.1.

Table 1. Infestation of sugarcane woolly aphid on different varieties

State	Variety	Intensity	Reference
Maharashtra	Co 86032 CoC 671	Highly susceptible	Patil and Nerker, 2004, Marimuthu *et al.*, 2004 Thirumirugan *et.al.* 2004)
Tamil Nadu	CoC 671 CoG 94077 Co 90063 Co 86032 Co 86249 CoC 85061 MC 707	Nil, Moderate Low to highly susceptible ----do----	
	CoG 93076	Low to medium Susceptible	
	CoC 85061 CoG 94077 Co 90063 Co 86032 Co 86249 CoC 85061 MC 707	Low to highly susceptible	
	Co 63040	Low	
	83R23	Nil	
Kerala	Co 716, Co 717, Co 718,Co 818, Co 819,Co 820, Co 822, Co 823, Co 825	Low	Srikant, 2005
Uttar Pradesh	CoS 88230 (R) CoS 767 (R)	Low to highly susceptible	Anonymous, 2005
	CoPt 84212 CoJ 64(R)	Highly Susceptible	
	CoS 8432 (Plant and Ratoon) CoS 95255(P&R)	Low	

2. Present pest status in India

The surveys and surveillance of woolly aphid under AICRP(S) in sugarcane-growing areas of India revealed the incidence of woolly aphid varied from 1.8 to 65.0 % in different states (A.P., Maharashtra, Karnataka and Tamil Nadu).It was also observed that natural enemies (*Encarsia* and *Dipha*) were found parasitizing on this pest (Anonymous,2020).

Table 2. Status of Sugarcane woolly aphid in different states

State	Incidence (%)	Reference
Andhra Pradesh (Anakapalli and Vishakhapatnam)	10-50	Anonymous,2020
Maharashtra		
Pune	2.2-37.2	
Satara	5.2-25.2	
Kolhapur	16.3-45.5	
Sangli	12.0-47.0	
Karnataka (Mandya)	40-65	
Tamil Nadu (Erode and Coimbatore)	1.8-2.68	

3. Management

3.1. Mechanical Control: Proper sanitation, stripping of infested leaves, avoidance of movement of insect pests-infested leaves from one area to another, removal of other alternate hosts in the vicinity, removal and destruction of infested leaves by employing laborers, avoiding lodging of canes and avoiding use of canes from infested fields for sowing are recommended for management of woolly aphid (Patil, 2002; Ganeshaiah *et al.*, 2003; Yamazaki, 1937).

3.2. Chemical Control: The application of dimethoate is recommended after June to manage *C. lanigera* without harming natural enemies (Liu *et al.,* 1985). In China, carbophos 40 EC resulted in more than 95% mortality of *C. lanigera* (Haung, 1995).For managing woolly aphid in Maharashtra and Karnataka, the recommended insecticides include, endosulphan, phosalone, monocrotophos, dimethoate, metasystox, acepahte and methyl parathion (Patil, 2002 and Liganppa, 2003).

3.3. Biological Control: The indiscriminate use of insecticides resulted in mortality of natural enemies and health risks to operators, apart from being uneconomical (Joshi *et al.*, 2018). Spraying of insecticides is not practicable in sugarcane ecosystem due to due to dense canopy and impermeable nature of stalk and hence promoted the use of bio-agents.

Bio-agents were found to naturally suppress the woolly aphid and play a significant role in suppressing its population. Tripathi (1995) recorded *Antrocephalus* sp. *Encarsia flavoscutellum* Zehntner and *Diaeretiella rapae* (M'intosh) in Dimapur (Nagaland) parasitizing this pest. Thirty species of predators have been reported in the world (Joshi and Viraktamath, 2004) and during outbreak (2002-2006) *Cheilomenes sexmaculata* (Coleoptera: Coccinellidae), *Chrysoperla carnea* (Neuroptera:

Chrysopidae), *Eupeodes confrater* (Diptera: Syrphidae), *Dipha aphidivora* (Lepidoptera: Pyralidae), *Micromus igorotus* (Neuroptera: Hemerobiidae) and *Encarsia flavoscutellum* (Hymenoptera: Aphelinidae) were found on SWA (Varghese *et al.*, 2016). Of all the bio-agents collected, *E. flavoscutellum, D.aphidivora* and *M.igorotus* showed the greatest promise.The pyralid predator, *D.aphidivora* was reported to be more voracious and under congenial condtions, it completely devoured the pest population (Tripathi, 1992 & 1995). *E. flavoscutellum* caused natural parasitization of up to 30% in Java (Joshi and Virakthamath, 2004).

Brown lacewing, *Micromus igorotus*, (Neuroptera: Hemerobiidae) was found to rapidly colonize the woolly aphid-infested sugarcane fields and reduce the pest population (Singh *et al.*,2009, Lingappa *et al.*, 2004; Patil *et al.*, 2006; Mulimani *et al.*, 2006). Release of *M. igorotus* @ 2000 larvae and *D. aphidivora* @1000 larvae/ha at 15 days interval from August to October significantly reduced the incidence of woolly aphid (Joshi *et al.*, 2021) while release *Micromus* or *Dipha* @ 500-1000 per acre in early stages effectively suppressed woolly aphid (Sannaveerappanavar *et al.*, 2005).The parasitoid *E. flavoscutellum* showed signs of establishment in southern India about a year after it was introduced from Assam, multiplied in insectaries and released in aphid-invaded areas (Pan *et a.*, 1984.).

The available high humidity in sugarcane field is favorable for rapid multiplication and dispersal of entomopathogenic fungi offering an ideal ecosystem for successful management of sugarcane woolly aphid (Kishore *et al.*, 2019). The use of entomopathogenic fungi has increased, as alternative to chemical insecticides, due to the great potential they have in pest management and their ecofriendly nature in recent years. The entomopathogenic fungi like *Acremonium zeylanicum, Beaveria bassiana, Cladosporium oxysporum, Metarhizium anisopliae, Nomuraea riley* and *Verticillium lecanii* are promising agents (Patil *et al.*, 2011 and Srikant *et al*, 2016,). The fungus *Acremonium zeylanicum* was a first record on woolly aphid in Sankeshwar, Karnataka (Tippannavar *et al.*, 2006). Sprays of *M. anisopliae* are being recommended and are also proving effective (Lingappa *et al.*, 2003 and Nirmala *et al.*, 2003).These recommendations are similar to the strategy of pathogenic fungi being more effective for pest management in the sugarcane eco-system (David and Easwaramoorthy, 1986) due to this annual crop offering microclimate with high humidity and facilitating rapid spread of *M. anisopliae*, which can also be easily multiplied on artificial media.

4. Future prospects for management of Sugarcane woolly aphid

The indiscriminate use of pesticides may lead to outbreak of invasive sucking pests. There is need for more emphasis on augmentation and conservation of natural enemies. Natural enemies are found to manage the woolly aphid effectively, and farmers to be advised not to apply insecticides and encourage natural build-up of parasitoids and predators. The bio-agents are to be multiplied rapidly and applied on the woolly aphid, thus preventing outbreaks in areas where insecticides were not applied (Joshi *et al.*, 2018). The efforts should be made to mass multiply of natural enemies (*D. aphidivora*, S. *grandis, A. Dilatata* and *E. flavoscutellum*) in the laboratory, conserve it *in situ* in the field and also redistribute it to new areas of infestation.

The predatory lacewing, *M. igorotus* is quite abundant and appears to be potential candidate for mass multiplication and release (Anonymous, 2003) as it impacts even under low pest population by feeding on first and second instars of the aphid. It can easily be reared on sugarcane woolly aphid under controlled condition and therefore also a possible candidate for mass releases for biological control of sugarcane woolly aphid (Singh *et al.*, 2009).

There is scope for R&D on habitat manipulation, biological control and varietal resistance towards being included in development of IPM program for this pest. Locally prevalent key mortality factors are also to be identified for better management of this pest by exploiting the weak links in the life cycle of SWA. There is need to study density dependent and population regulating factors of the pest which can also be exploited. Several entomopathogenic fungi evaluated against the aphid in the field either produced variable results (Nirmala *et al.*, 2007) or failed to suppress the aphid population despite concentration-dependant mortality in the laboratory. Large-scale validation of impact of entomopathogen on this pest is the need of the hour.

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