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Status and prospects of managing fall armyworm on sugarcane in India

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ABSTRACT: The fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) *(Lepidoptera: Noctuidae)* began its onslaught in India on maize in Karnataka State in mid-2018. In the same year, it spread its tentacles to sugarcane beginning with Maharashtra State and extending to Tamil Nadu and Karnataka States. The following year (2019), the pest attacked sugarcane experimental plots and growers' farms for the first time in Andhra Pradesh State and re-appeared in the crop in Karnataka and Tamil Nadu. The sporadic occurrence of FAW in sugarcane has generally been confined to tropical India and damage restricted to tillering phase. Foliar and whorl damage caused by the C strain of FAW in sugarcane is similar to the symptoms produced by R strain in maize. Intermittent appearance, rapid adoption of control measures and absence of reappearance precluded elaborate studies on biology, ecology and management of FAW in sugarcane. However, knowledge gained and experience accumulated in fields of biological control and host plant resistance, the two main components of pest management in sugarcane, hitherto, provide a strong foundation for the development of a management package for FAW in sugarcane, should the pest adapt to the crop in a more regular and serious manner. Involvement of research organizations and sugar industry would expedite the process of generation and dissemination of technologies. Currently available information on FAW in sugarcane is reviewed and prospects of its management in the crop are discussed in this paper.

Key words: Fall armyworm, *Spodoptera frugiperda*, sugarcane, damage, host plant resistance, biological control, management, prospects

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1. Prelude

Sugarcane, *Saccharum officinarum L.,* had an early inventory of over 220 pests (David *et al.,* 1986) to which several other species have been appended in the later years (Mukunthan and Nirmala, 2002; Singaravelu *et al.,* 2015). In the distant and recent past, several pests moved between subtropical and tropical sugarcane belts of the country, more frequently from the former to the latter region, transcending geographical barriers. Examples of major pests include the entry of subtropical root borer *Polyocha depressella* Swinhoe (Lepidoptera: Pyralidae) in to Tamil Nadu first in the early 1990s followed by a quick decline but a flare up two-and-half decades later (Srikanth *et al.,* 2014), and the emigration of woolly aphid *Ceratovacuna lanigera Zehntner* (Homoptera: Aphididae) from north-eastern India to tropical States around 2002 (Srikanth, 2004). Besides, a minor subtropical leaf miner *Asamangulia cuspidata* Maulik (Coleoptera: Chrysomelidae: Cassidinae: Hispini) appeared recently in Tamil Nadu in a mild form (Srikanth *et al.,* 2015a).

In what can be described as the first recorded instance of an alien or exotic insect pest on sugarcane in India, the fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) made landfall on the crop during September-October 2018 in Maharashtra State (Chormule *et al.,* 2019) but not before it invaded the more preferred maize in Karnataka State in mid-2018 (Ganiger *et al.,* 2018; Sharanabasappa *et al.,* 2018; Shylesha *et al.,* 2018).Within a month of its first occurrence in Maharashtra, the pest surfaced on sugarcane (November 2018) in Tamil Nadu State (Srikanth *et al.,* 2018) and in December 2018 in Belgaum district, Karnataka (Matti and Patil, 2019). The following year (February-April 2019), the pest appeared in sugarcane experimental plots and growers' farms in Andhra Pradesh State (Bhavani *et al.,* 2019; Visalakshi *et al.,* 2019) and in April 2019 in Bagalkot, Belgaum and Dharwad districts of Karnataka (Chouraddi *et al.,* 2019).Thus, FAW in sugarcane is confined to tropical India in contrast to its rapid proliferation all over the country in maize in the year after its entry in to the country (EPPO, 2019; CABI, 2020; Naganna *et al.,* 2020; Suby *et al.,* 2020). The pest displayed spatial and temporal discontinuity in sugarcane in the succeeding year of its first occurrence in Tamil Nadu, where roving surveys throughout the State in mid-2019 revealed sporadic occurrence in growers' farms and experimental plots (Srikanth *et al.,* 2019).

2. Damage pattern and attack rates

A cursory examination of the few reported cases of FAW in sugarcane hitherto (Table 1) reveals that its attack was confined to tillering phase of the crop and extensive surveys indicated lack of infestation in the later stages (Srikanth *et al.,* 2019). In attacked plants, young larvae scraped leaf surface leaving behind silvery, irregular pin holes or windows (Fig. 1). Grown-up larvae punched windows on leaves, fed on leaf margins, and often nibbled and sheared the central shoot. While grown-up larvae and fresh frass could be seen in the whorls, patches of dry frass were visible on older leaves (Srikanth *et al.,* 2018; Bhavani *et al.,* 2019; Visalakshi *et al.,* 2019). Attack rates were generally low but varied considerably in different studies (Table 1), apparently due to climatological differences and habitat variation. Higher levels of attack in maize monocrop system (Visalakshi *et al.,* 2019) and lower incidence rate in sugarcane (0.2%) than in maize (86.4%) in a mixed crop system (Srikanth *et al.,* 2019) indicated clear-cut preference for maize in free-choice and no-choice situations. Intermittent low levels of attack in the few popular and upcoming sugarcane varieties in different locations preclude any speculation on their relative preference for the pest (Srikanth *et al.*, 2019). Severe damage and crop losses were not reported in sugarcane possibly due to swift adoption of insecticidal control measures following sporadic occurrence and lack of recurrent infestation in the post-tillering phase.

Table 1: Attack rates of fall armyworm *Spodoptera frugiperda* in sugarcane in India

State	Month & year	Variety	Age of crop (d)	% incidence	Reference
Maharashtra	Sep-Oct 2018	Co 86032	45-80	2.0-5.0	Chormule et al. (2019)
Tamil Nadu	Nov 2018	Co 86032	75-120	1.9-30.9	Srikanth et al. (2018)
Tamil Nadu	Jan-Apr 2019	CoVC14061 Co 86032	45-90	0.2-20.0	Srikanth et al. (2019)
Karnataka	Dec 2018	Co 86032	30-45	5.0-10.0	Matti and Patil (2019)
Karnataka	Apr 2019	Co 86032 Co 91010 Co 92005	45-60	3.0-5.0	Chouraddi et al. (2019)
Andhra Pradesh	Feb-Apr 2019	-	20-60	5.0-25.0	Bhavani et al. (2019)
Andhra Pradesh	Apr-2019	93V46 87A298	30-60	1.0-5.0	Visalakshi et al. (2019)

3. Molecular diversity

Between the two races of FAW, i.e. 'rice strain' (R strain) and 'corn strain' (C strain) distinguishable only molecularly, the former is thought to preferentially feed on rice and various pasture grasses and the latter on maize, cotton and sorghum (CABI, 2020). Determination of populations attacking maize and other hosts as R strain (Mahadeva Swamy *et al.*, 2018) as opposed to those on sugarcane as C strain (Bhavani *et al.*, 2019; Chormule *et al.*, 2019) in the country seemed to suggest unorthodox host adaptation of the strains besides confirming the entry of C strain too. Consequently, while genetic variability information may allow inferences about their origin, it is unlikely to facilitate accurate prediction of

Fig 1: Fall armyworm damage in sugarcane: (a) leaf damage (b) nibbled central shoot with faecal pellets in the whorl (c) grown-up larva visible in the whorl (d) grown-up larva partly hidden in the whorl (Srikanth et al., 2018)

host expansion pattern of the two known strains. The spread of FAW almost throughout the country (Naganna *et al.,* 2020; Suby *et al.,* 2020), albeit in maize and a few minor hosts, pointed to not only its adaptability to both tropical and subtropical climatic zones but also its likely shift to sugarcane in subtropical India sooner than later. Molecular characterization of populations in maize and sugarcane, whenever such shift occurs, may shed more light on the spread and host adaptability pattern of the strains.

4. Biology and phenology

In the laboratory, incubation, larval and pupal periods were 2-3, 16-22 and 13-14 days, respectively; pre-oviposition, oviposition and post oviposition periods of female moths ranged 4-5, 2-3 and 3-4 days, respectively (Matti and Patil, 2019); slightly shorter larval and pupal periods were observed in another study (Bhavani *et al.,* 2019). Larvae originating from sugarcane and maize showed similar percent of pupation, pupal weight, pupal period and percent of adult emergence when reared on respective hosts but higher proportion of males in maize than in sugarcane (Srikanth *et al.,* 2019). Sugarcane pests in tropical India display year-round activity due to moderate climatic conditions and semi-perennial stature of the crop created by staggered planting (Srikanth *et al.,* 2016). FAW seemed to be following this trend as its temporal spread all through the year indicates (Table 1). Although the spatial spread of FAW in sugarcane is limited to four tropical States presently, it is very likely to adapt to the crop even in the subtropical region but with some variation due to extremes of weather conditions to which the predominantly tropical FAW is likely to respond differently (CABI, 2020). Notwithstanding the hypotheses about inherent resistant factors (Srikanth *et al.,* 2019), current discrete occurrence of FAW at low levels disallows any assumptions about its phenology in sugarcane.

5. Natural enemy association

An array of natural enemies, including egg, larval and larval-pupal parasitoids, the entomopathogenic fungus *Metarrhizium (=Nomuraea) rileyi* (Farl.) Kepler, Rehner & Humber (Shylesha *et al.,* 2018; Srikanth *et al.,* 2019; Naganna *et al.,* 2020; Suby *et al.,* 2020), and indigenous nucleopolyhedroviruses (Sivakumar *et al.,* 2020; Firake *et al.,* 2020), has been observed on FAW in maize. However, FAW infesting sugarcane did not support activity of the larval parasitoid *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae) and *M. rileyi* that were observed on the pest infesting maize in the same habitat (Chormule *et al.,* 2019). Similarly, *M. rileyi* occurred at high intensity in FAW attacking maize (76.5%) but was not observed in sugarcane (Srikanth *et al.,* 2019). On the other hand, besides general predator activity, the egg parasitoid *Trichogramma chilonis* was detected on the pest in sugarcane in what appears to be a preliminary study; consequently, the suggestion that the parasitoid could be exploited through augmentative releases (Visalakshi *et al.,* 2019) should be treated with caution due to the absence of data on parasitization rates.

6. Management prospects

6.1. Interim measures

As pointed out above, prompt insecticidal treatments following detection led to suppression of FAW with no further recurrence in the early instances of occurrence. Taking cues from earlier experience on woolly aphid, whose incursion into tropical India was categorized as 'invading phase' and 'established phase' (Mukunthan *et al.,* 2007), the following interim control measures were outlined deeming the then FAW scenario in sugarcane as invading phase (Srikanth *et al.,* 2018).

6.1.1. Survey and monitoring

Regular surveys in both susceptible tillering phase and later phases of plant and ratoon crop were recommended to determine preferential attack in different crop stages. Other crops known to be major hosts should be monitored to understand and assess the host shifting behavior of FAW. Growers need to be sensitized about the pest to enable them report its occurrence.

6.1.2. Preventive care

Assuming that a specific strain (C strain) alone was attacking sugarcane, transport of seedlings from infested areas for planting should be avoided or monitored to prevent accidental dispersal. In the absence of information on suitability of older crop, movement of cane tops should also be avoided. Clean cultivation to deny alternative hosts, selective intercropping to enhance diversity, light earthing-up to expose hiding larvae and pupae, fertilizer application to promote recovery from low level damage, mechanical collection of visible stages, etc. should be practiced to minimize population buildup. Commercial sex pheromone lures need to be used after stringent field validation and biological control based on published literature needs to be deployed with caution.

6.1.3. Curative care

Prophylactic or quarantine treatment of seedlings introduced for planting should be adopted, if they originate from FAW prone area. Use of botanicals like azadirachtin or neem oil may prevent oviposition and early larval feeding. In the absence of economic thresholds in sugarcane, 5-10% attack rate, assessed by random sampling, can be used for deciding insecticidal control, which itself needs to be adopted judiciously due to reported resistance elsewhere. Since no insecticides are registered against FAW in sugarcane, chlorpyrifos and monocrotophos, recommended for pests like shoot borer *Chilo infuscatellus* Snellen (Lepidoptera: Crambidae) (Ramasubramanian and Srikanth, 2015) may be used directing the spray fluid to the whorls; spot application may be followed in the early stages or if attack occurs in patches.

6.2. Future strategies

While the status of the invasive FAW appears to have reached the 'established phase' in maize due to its almost pan-India distribution and impact on the crop in all phenological stages, the pest has not yet crossed the 'invading phase' in sugarcane. Thus, the interim management measures elaborated in the preceding section will remain valid for FAW management in sugarcane as long as it appears sporadically in the crop. However, if the C strain of sugarcane and/or the R strain of maize in the country adapt to sugarcane the way the latter colonized maize, research efforts need to be stepped up in a multi-pronged approach to evolve effective sugarcane-oriented management strategies.

6.2.1. Damage assessment

Current data available on FAW damage in India is limited to levels of occurrence in maize and sugarcane but no accurate estimates of crop losses are available even in maize (Lamsal *et al.,* 2020). Lack of attack in the post-tillering phase was suggested to be due to hardy nature of the crop, absence of fruiting body (Srikanth *et al.,* 2018) and changes in phytochemical profile (Srikanth *et al.,* 2019) such as decrease in chlorophyll content, increase in crude silica content (Jain *et al.,* 1999) and increase in phenolics (K.P. Salin, unpubl. data) from early to late stages of the crop. Even in the tillering phase, attacked plants suffered leaf and whorl damage but not dead-heart formation (Srikanth *et al.,* 2018) though attack on young maize is known to kill the growing point resulting in dead-heart (Lamsal *et al.,* 2020). While extensive foliar damage could debilitate the plant, whorl damage in primary and secondary shoots could lead to tiller mortality and reduction in number of millable canes. These parameters should be assessed to establish the economic impact of FAW on sugarcane and decide the need for control measures.

6.2.2. Host plant resistance

Pests, ranked second to diseases in importance, hardly ever receive priority in varietal development programs in sugarcane, a recent exception being the invasive and explosive woolly aphid (Patil et al., 2005; Srikanth *et al.,* 2009). Most studies focus on identification of resistance sources in species clones to be labeled as genetic stock and seldom used in breeding programs. Our earlier studies revealed resistance sources in hybrids, exotic clones, *Saccharum* spp. and *Erianthus* spp. against lepidopteran pests such as pink borer Sesamia inferens (Walker) (Lepidoptera: Noctuidae) (Mahesh *et al.,* 2014), shoot borer (Punithavalli and Salin, 2018), internode borer *Chilo sacchariphagus indicus* (Kapur) (Lepidoptera: Crambidae) (Mahesh et al., 2018) and leaf folder *Cnaphalocrocis ruralis* Walker (Lepidoptera: Crambidae) (Mahesh et al., 2019a). Low levels of natural FAW occurrence in diverse species clones raised in experimental plots (Srikanth *et al.,* 2019) threw no light on their true resistance status. However, being an important component in integrated pest management program, it is desirable to identify resistant commercial hybrids for tactical use in endemic areas and screen available sugarcane germplasm (Mahesh *et al.,* 2019b) to select resistant types for introgression of FAW resistance, if the need arises. Occurrence of FAW in tillering phase alone expedites the screening process under both natural infestation in the field and artificial colonization in glass house, though damage assessment in terms of loss of NMC, yield, quality, etc. entails year-long maintenance of the crop. Mass multiplication on existing artificial diets (Srikanth *et al.,* 2016) or improvised sugarcane-based diet facilitates screening under controlled conditions of artificial infestation.

Diverse morphological and biochemical features have been attributed to FAW resistance in maize (Suby *et al.,* 2020). In sugarcane germplasm, morphological characters, brix and sucrose content showed variable relationship with internode borer (Mahesh *et al.,* 2018), leaf folder (Mahesh *et al.,* 2019a) and scale insect *Melanaspis glomerata (*Green) (Homoptera: Diaspididae) (Mahesh *et al.,* 2020) resistance. Leaf phenolics in resistant and susceptible hybrids were differentially related to woolly aphid attack rates (Srikanth *et al.,* 2009). Proteinase inhibitors differed quantitatively in different parts of *Erianthus arundinaceus* genotypes and affected larval and pupal development of shoot borer by inhibiting gut proteinase activity in laboratory tests (Punithavalli and Jebamalaimary, 2019). Some of these plant traits are likely to affect FAW development and genotypes possessing them can serve as the base material for a systematic screening program to identify potential resistant parents.

Transgenic maize cultivars harboring *cry* genes from *Bacillus thuringiensis (Bt)* have been approved for commercial cultivation in several countries (*Suby et al.,* 2020), though not in India. Identification of novel toxin genes, including a couple of novel *cry1* holotypes, in our earlier studies (Singaravelu *et al.,* 2017 & 2020) help circumvent intellectual property issues and strengthen the arsenal of crop protection against lepidopteran pests in sugarcane. Techniques standardized for the development and evaluation of the first sugarcane transgenics in the country with cry genes against top borer *Scirpophaga excerpatalis* Walker (Lepidoptera: Pyralidae) (Christy *et al.,* 2009) and shoot borer (Arvinth *et al.,* 2010) can suitably be applied to FAW management after identifying effective *cry* genes. Considerable knowledge gained in sugarcane transgenic research the world over and newer approaches outlined (Srikanth *et al.,* 2011) will lay the foundation for a strong transgenic program in FAW management, notwithstanding the improbability of translation of the technology to end users due to policy reasons related to genetically modified organisms.

In preliminary studies on induction of resistance against internode borer, sugarcane plants treated with the inducer molecule methyl jasmonate showed higher, yet differential, phenolics production in leaf and stem tissues and reduced borer damage (Salin *et al.,* 2020). Similar resistance induction with methyl jasmonate and other inducer molecules can be envisaged against FAW in early stage sugarcane.

6.2.3. Biological control

Slow adaptation of FAW to sugarcane, probably due to delayed entry of C strain, restriction to early crop stage mediated by differential biochemical composition in different phenological stages (Jain *et al.,* 1999), low host populations, rapid action that brought down FAW levels and non-systematic surveys may have been some reasons for poor or no natural enemy adaptation and/or detection in sugarcane. Current knowledge of limited natural enemy profile in sugarcane hardly allows any hypothesis about their potential use in the crop. However, the amenability of the semi-perennial sugarcane crop system to biological control (Srikanth *et al.,* 2016) and the legacy of its success in the crop (Srikanth, 2019) emphasize the significant role biocontrol agents can play in FAW management in the crop. The wide array of natural enemies recorded on the pest in maize hitherto (Naganna *et al.,* 2020; Suby *et al.,* 2020) is unlikely to adapt to FAW-sugarcane system due to host plant effect in the tri-trophic milieu. Introduction, multiplication and colonization of native parasitoids that worked remarkably well with some oligophagous pests like woolly aphid in sugarcane (Srikanth *et al.,* 2012 & 2015b) may not be as effective with FAW, even in maize, due to polyphagy and prevalence of strains. Mixed cropping of sugarcane and maize in the habitat could lead to dispersal and preferential colonization of FAW in maize by parasitoids dispensed in augmentative mode. Detection of natural associations in sugarcane will perhaps be the key to developing effective biological control packages with parasitoids, predators or pathogens in the augmentative mode.

Entomopathogens, such as nucleopolyhedrosis viruses, *Bt* strains, fungi and nematodes adapted to maize crop system and displaying high mortality levels (Srikanth *et al.,* 2019; Sivakumar, 2020; Suby *et al.,* 2020;) could be of some use in sugarcane due to surface feeding habits of FAW and targeted delivery, despite strain differences and tri-trophic effects known to affect entomopathogenic fungi (EPF) (Cory and Ericsson, 2010). Variability in temporal and spatial distribution and levels of natural occurrence of different entomopathogens may necessitate their selective use in different agro-climatic regions. Availability of mass culture techniques for EPF (Easwaramoorthy *et al.,* 2002), *Bt* (Anonymous, 2019) and nematodes (Sankaranarayanan *et al.,* 2018), and development of a mass culture method for nucleopolyhedrosis virus govern their large-scale application in the amenable tillering phase.

6.2.4. Semiochemicals

The major component of FAW sex pheromone from moths collected in India was established as the one identified earlier elsewhere (Suby *et al.,* 2020). Due to possible variation of components in different strains, there is a need to confirm the components of the strain colonizing sugarcane and evaluate them in the field before resorting to large-scale deployment for monitoring or mass trapping. Commercially available lures promoted for use in maize need to be validated in sugarcane crop system before recommending their field use (Srikanth *et al.,* 2018).

Allelochemicals that mediate tri-trophic interactions can be exploited to enhance the field-performance of potential biological control agents. In sugarcane, frass extracts of *Chilo partellus* Swinhoe (Lepidoptera: Crambidae) (Srikanth *et al.,* 2000) and four purified kairomonal principles of shoot borer frass (Salin et al., 2012) displayed enhanced retention of the larval parasitoid *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) in bioassays. Mechanically injured plants topped up with larval regurgitant of shoot borer or internode borer produced headspace volatiles of diverse chemical profile with implications for natural enemy recognition (Salin et al., 2017). Such positive results indicate the possibility of exploring these principles to enhance the efficiency of potential parasitoids of FAW in sugarcane.

6.2.5. Chemical control

Insecticidal and ovipositional deterrent properties of several plant species against FAW have been demonstrated (Suby *et al.,* 2020). Commercially available botanicals are likely to show similar effects on FAW attacking sugarcane in the tillering phase. However, there is a need to assess the efficacy of early season application in the field before recommending their use as a control measure. The time of application can probably be decided by monitoring moth activity with sex pheromone traps.

Insecticide usage is much lower in sugarcane than in other crops like cotton due to the regenerative ability of the crop and consequent high economic thresholds, and inclement canopy that discourages field application (Srikanth *et al.,* 2016). Also, tissue feeding habits of borers and imperviousness of pests like white grub *Holotrichia serrata* F. (Coleoptera: Scarabaeidae) relegate the use of insecticides to a lower slot in the general management schedule. Insecticides approved on an ad hoc basis by the Central Insecticide Board and Registration Committee, Ministry of Agriculture and Farmers Welfare, Government of India (http://ppqs.gov.in/sites/default/files/mup_insecticide.pdf), against FAW, but not for any crop, may be used as a last resort.

Insecticide resistance in sugarcane pests has never been investigated seriously due to the general low volumes used, except for frequent application against top borer in subtropical India. It is essential to minimize the use of insecticides against FAW to prevent not only the exacerbation of resistance levels already prevalent in its populations but also the conversion of sugarcane pest management from biocontrol mode to insecticide mode (Srikanth *et al.,* 2019).

6.2.6. Agro-ecological approach

Habitat manipulation has been reported to exert significant effect on FAW abundance. For example, maize intercropped with the legume *Desmodium* sp. supported lower FAW attack than maize monocrop; activity of egg parasitoid and predators was also higher in legume intercropped maize (Udayakumar *et al.,* 2020). In sugarcane agro-ecosystem, crop-crop diversity with spices in the subtropical belt and legumes in tropical sugarcane, and crop-weed diversity reduced pest abundance and enhanced natural enemy activity (Srikanth, 2010) indicating agro-ecological possibility for FAW management too; caution needs to be exercised in the selection of companion crops due to polyphagy in FAW. Push-pull companion cropping system comprising repellent (push) *Desmodium intortum* (Mill.) Urb. (Fam: Leguminosae) as intercrop and attractant (pull) *Brachiaria* (Fam: Poaceae) as border crop reduced FAW numbers and plant damage, and enhanced yields compared to maize monocrop (Midega et al., 2018). Such system can be extended to sugarcane wherein maize, found to be a more preferred host than sugarcane even in companion cropping (Srikanth *et al.,* 2019), itself can be used as a border crop to attract (pull) FAW. The possible negative impact of cultural practices such as mulching and earthing-up on pupation and pupal survival of FAW may need investigation. Fertilizer application at earthing-up may help rejuvenate the crop suffering minor damage.

6.2.7. Integrated pest management

Current erratic and low levels of occurrence may necessitate dependence on chemical control, both botanicals and insecticides. As with other pests, the action thresholds for FAW are likely to be high in sugarcane and higher than those adopted in maize (Rakshit *et al.,* 2019). Hence, an arbitrary threshold of 10% infested plants can be followed for decision-making until systematic studies establish yield loss and action thresholds. In the stable semi-perennial sugarcane crop system, any integrated management package envisaged for FAW would ideally comprise biological control as the major component as is the case with other pests (Srikanth *et al.,* 2016). Besides, several agro-ecological options evaluated for the management of FAW in maize (Harrison *et al.,* 2019) can be applied suitably in sugarcane.

7. Conclusion

Although reported and undocumented occurrences of FAW in sugarcane are few and far between, and do not raise serious concerns, constant monitoring and early detection are vital for the adoption of timely control measures. If and when it establishes as a regular and serious pest in the crop, mobilization of concerted organizational research endeavors may be needed to evolve management strategies. In this regard, involvement of National Organizations, All India Network Projects and State Agricultural Universities would enable them integrate the experiences gained in both maize and sugarcane crop systems. Sugar industry, as always, can play an important role in liaising the conduct of experiments and dissemination of biocontrol and other technologies.

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