

SHORT COMMUNICATION

FIRST REPORT OF OCCURRENCE OF FALL ARMYWORM *SPODOPTERA FRUGIPERDA* IN SUGARCANE FROM TAMIL NADU, INDIA

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Abstract

The first occurrence of the exotic fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in sugarcane from the south Indian state of Tamil Nadu, India, is reported in this communication. The pest was observed in a few farms in the sugarcane belts of M/s Sakthi Sugars Ltd., Modakurichi, Erode district, and M/s E.I.D. Parry (India) Ltd., Pugalur, Karur district, Tamil Nadu, India, in November 2018. In both places, young crop (2.5-4.0 months age) of the popular variety Co 86032 was attacked with incidence levels ranging 1.85-30.86% in the three affected farms. Leaves of infested plants showed skeletonization, irregular holes or windows on the lamina and margin feeding symptoms in both mother shoots and tillers. In some plants, the central shoot was nibbled, apparently by grown-up larvae, and in many plants the spindle was sheared. Infested shoots and tillers, however, did not show meristem damage. In severely affected plants, mature larvae, visible or hidden in the whorl, amidst large quantities of fresh faecal pellets were observed; patches of dry frass were seen on older outer leaves. Curative chemical control adopted in the affected farms appeared to have controlled the pest with no subsequent recurrence. An interim strategy to monitor and manage FAW in sugarcane has been outlined.

Key words: Fall armyworm, *Spodoptera frugiperda*, sugarcane, first record, Tamil Nadu, interim management

Fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), native to tropical and subtropical regions of the Americas, feeds on leaves and stems of more than 80 plant species. Among these, cultivated grasses such as maize, rice, sorghum and sugarcane have been recorded as major hosts whereas several dicotyledonous vegetable crops and cotton, besides wild grasses, have been documented as minor hosts. Often intercepted at quarantine in Europe, it has been documented as eradicated or absent in Germany, Netherlands and Slovenia (CABI 2018; EPPO 2018). First reported from Africa in 2016 as an invasive alien pest (Goergen et al. 2016), it has spread to more than 30 countries in the continent causing significant damage to

maize crop with great potential for further spread and economic damage (CABI 2018; EPPO 2018). Fall armyworm has been reported from the Indian subcontinent in mid-2018 in the form of pest alerts (ICAR-NBAIR 2018a), factsheets (ICAR-NBAIR 2018b) and internet news reports (compiled in CABI 2018; EPPO 2018), primarily on maize, in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Telangana and Maharashtra.

Sugarcane has been included in the host list of FAW in an early compilation of Latin American literature (Andrews 1988). In other documentations too, it has been listed as one of the hosts (CABI 2018) or a major host (EPPO 2018) of FAW in different parts of the world. Consequent to its first report of occurrence on maize in West and Central

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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

Africa (Goergen et al. 2016), concerns (Hill 2017) were expressed and refutations (Uys 2017) issued about its possible threat and spread to sugarcane in South Africa. However, there appear to be no confirmed reports of FAW's attack on sugarcane in the African continent. Even in India, where FAW's first arrival was reported primarily on maize by several sources (EPPO 2018; Shylesha et al. 2018; Ganiger et al. 2018; Sharanabasappa et al. 2018), conflicting and unconfirmed statements were issued to mass media about its spread to sugarcane (Abha Toppo 2018). The first confirmed report of occurrence of FAW in sugarcane in India appears to be in Maharashtra in September 2018 (Chormule et al. 2019 a & b). Against this backdrop, we report the occurrence of *S. frugiperda* in sugarcane from

two districts of Tamil Nadu, with notes on its incidence levels and interim management tactics.

Following reports of suspected occurrence of FAW in the sugarcane belts of M/s Sakthi Sugars Ltd., Modakurichi, Erode district, and M/s E.I.D. Parry (India) Ltd., Pugalur, Karur district, Tamil Nadu, in November 2018, infested farms were inspected, pest symptoms and stages examined and extent of damage was assessed. While two farms (1.4-2.2 ha) that were visited at Modakurichi featured young sugarcane crop of 3.0-4.0 months age, a solitary farm (0.56 ha) at Pugalur had 2.5 month old crop of the popular variety Co 86032. In both locations, young plants exhibited characteristic symptoms of FAW damage documented worldwide in maize crop. In affected plants, leaves showed skeletonization typical of gregarious neonate larval feeding, irregular holes or windows on the lamina and margin feeding symptoms (Fig. 1a). In some plants, the central shoot was nibbled (Fig. 1b), apparently by grown-up larvae, and in many plants the spindle-shearing was observed. However, no dead hearts were observed despite such reports in maize. Both mother shoot and tillers in a clump displayed damage but when such plants were split open meristem damage was not observed. In severely affected plants, large quantities of fresh faecal pellets were seen in the whorl with mature larva either visible (Fig. 1c) or hidden (Fig. 1d) in the whorl; older outer leaves showed patches of dry frass. Affected plants did not show symptoms of withering or drying. The identity of FAW was established based on larval (Fig. 2a), pupal (Fig. 2b) and adult (Fig. 2c & d) morphology, male genitalia and COI sequences following standard methodology (Ramasubramanian et al. 2018).

At Modakurichi, the mean rate of attack assessed from 50 plants at each of the 10 spots chosen randomly was lower (1.85%) in the older crop in Farm-I than that in Farm-II (14.20%). At Pugalur, the farm with the youngest crop displayed a higher

mean attack rate of 30.86%. The presence of grown-up larvae in all three farms indicated that the invasive pest would have completed at least one generation. Assuming that the incursion or shift from maize has occurred simultaneously in the two locations, the damage inflicted by immigrant populations in the tillering phase of sugarcane seems to be inversely related to the age of the crop. At Pugalur farm, an 11-month old sugarcane crop adjacent to the FAW infested young crop showed no serious attack except for symptoms of leaf damage and faecal matter without larval presence in the top whorls of only a few plants in the border row. This was probably due to the dispersal of a few larvae to the older crop whose tops were at near-ground level due to lodging. Further, sugarcane of varying age in a few other farms showed no evidence of FAW attack. However, it remains to be seen if FAW attacks sugarcane foliage in maturity stage as it lacks fruiting body akin to cobs in maize. Following the observations of Chormule et al. (2019 a & b) on the occurrence of FAW in sugarcane in Maharashtra, the present report (ICAR-SBI 2018; Jitendra 2018) constitutes its first record from Tamil Nadu and second in the country on sugarcane.

With regard to the origin, and mode and point of incursion of FAW into India, resemblance of DNA sequences of Karnataka populations of FAW with those from Canada, Costa Rica (Shylesha et al. 2018), USA (Florida), Ghana, Nigeria and Uganda (Sharanabasappa et al. 2018) indicated that it may have originated from any of these countries. The recorded ability of adult moths to disperse from Mississippi to Canada in 30 h using low-level jet stream (CABI 2018) can hardly endorse the conjectural air or sea route entry from Africa or Americas. Any of the states that have reported FAW recently could be the first point of introduction through commodity import (Sharanabasappa et al. 2018), given the permeability to international

trade and inadequate quarantine in place. The arrival of larvae in Europe carried by air-freight on vegetables, fruits and herbaceous ornamentals (CABI 2018) supports this speculation.

Reports from different states of India indicate that FAW primarily targeted maize in all the initial points of entry moving subsequently to other hosts like sweet corn and sorghum (Mahadeva Swamy et al. 2018). Although apprehensions that other known major hosts, i.e. sugarcane and paddy (EPPO 2018) could fall prey to the marauding pest unnerve entomologists, research from the epicenters of FAW indicates otherwise. For example, sugarcane emerged as the least and rice among the last four suitable hosts, relative to maize, among 17 host plants tested in Brazil (Boregas et al. 2013), a world leader in the production of both sugarcane and maize. Similarly, sugarcane turned out to be a non-preferred host for FAW when assessed in crop associations comprising eight hosts and weeds in Argentina (Murúa et al. 2009). However, FAW attacked sugarcane in Maharashtra (Chormule et al. 2019 a & b), and Modakurichi and Pugalur, Tamil Nadu (ICAR-SBI 2018), within six months of its first occurrence in maize. Molecular diversity studies of 22 FAW populations collected on maize, sweet corn and sorghum from five tropical states of the country revealed the prevalence of “R” strain (Rice) and not “C” strain (Corn) (Mahadeva Swamy et al. 2018), the two forms in which FAW has been known to occur with the former being predominant on rice and pasture grasses and the latter on maize, cotton and sorghum (Prasanna et al. 2018).

Determination of the populations attacking sugarcane in Maharashtra as “C” strain (Chormule et al. 2019 b) indicated that both strains of *S. frugiperda* have entered India. It appears that while the “R” strain has colonized maize, sweet corn and sorghum (Mahadeva Swamy et al. 2018), “C” strain has started adapting to sugarcane.

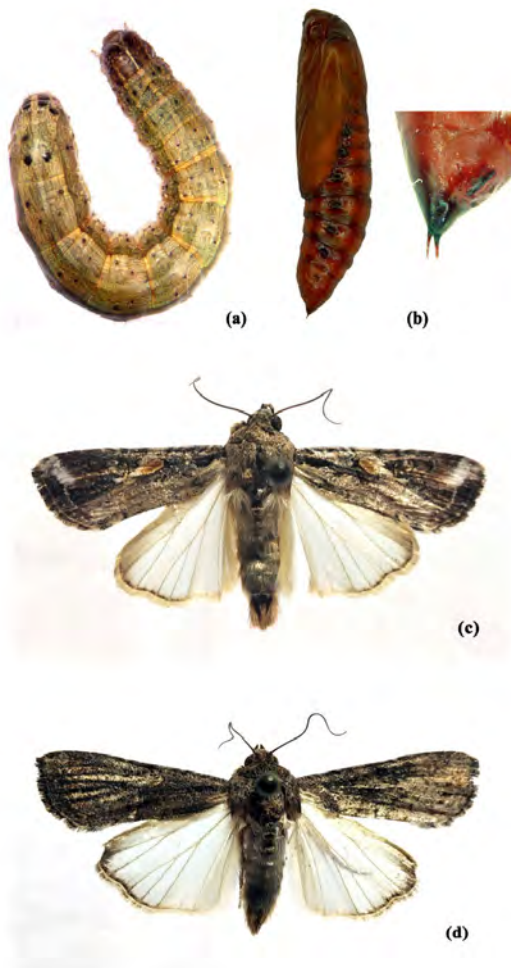


Fig. 2. Fall armyworm life stages from sugarcane:
 (a) grown-up larva (b) pupa and cremaster with two spines (c) male (d) female

Interestingly, the pest was not observed on young paddy and sorghum in the sugarcane habitat in our preliminary surveys. The relative biomass of sugarcane presenting a huge niche vis-à-vis these two hosts in the habitat may be governing the colonization of sugarcane by the “C” strain, known to occur on maize, cotton and sorghum elsewhere (Prasanna et al. 2018). Subsequent to the occurrence of FAW in Modakurichi and Pugalur, we have observed the pest in a few other sugarcane tracts of Tamil Nadu on both sugarcane

and maize. Characterization of these populations vis-à-vis those examined earlier would give a comprehensive picture of the prevalence of the two strains and the pattern of their spread in the habitat. The high dispersal ability and reproductive capacity, and the likely absence of diapause in tropical climate may accelerate expansion of its geographical range within the country and neighboring countries (Sharanabasappa et al. 2018).

Regardless of the status of the strains and their implications for host expansion and management of FAW, its occurrence and expansion primarily in south Indian states indicated the ability of the pest to thrive in moderate tropical conditions where it is likely to remain round the year. Continuous generations throughout the year reported in much of Africa, favored by the tropical and subtropical climate (Prasanna et al. 2018), support this contention. In the event of its spread to subtropical India, it is likely to survive there too with some variation due to the extremes of weather conditions.

Concerted efforts by researchers over the next few years will throw more light on the biology, ecology and management of FAW under Indian conditions. The recent experience gained from the management of woolly aphid *Ceratovacuna lanigera* Zehntner (Homoptera: Aphididae) in tropical parts of the country following its invasion from north-eastern India (Mukunthan et al. 2007) can provide guidance and direction. Augmentative releases of predators that accompanied the aphid (Srikanth et al. 2015) and introduction and colonization of a parasitoid from among the native natural enemy fauna (Tripathi 1995) led to stabilization of woolly aphid populations (Srikanth et al. 2012), apparently abetted by the narrow host range of the aphid (Joshi and Viraktamath, 2004). However, polyphagous nature, and prevalence of crop specific and insecticide resistant strains, despite the occurrence of a wide spectrum of

natural enemies (CABI 2018; Mahadeva Swamy et al. 2018; Chormule et al. 2019 b), may render the management of FAW a more daunting task in maize-based monoculture and polyculture agro-ecosystems. The scenario seems to be less alarming in sugarcane as interim insecticide treatments appear to have suppressed the pest with no further recurrence in the focal fields at both Pugalur and Modakurichi. The hardy nature of the crop and the absence of a fruiting body as in maize are likely to make sugarcane vulnerable to FAW attack in the tillering phase alone and hence management strategies need to be focused on this phase of the crop.

Pending long-term research efforts and development of effective management strategies, it is imperative to outline and adopt provisional crop-specific prophylactic and curative management tactics to prevent its proliferation. Some interim measures summarized for sugarcane (ICAR-SBI 2018) on the basis of the information available in worldwide literature for maize and in the light of our experience with woolly aphid in sugarcane are elaborated hereunder.

Interim management strategy for FAW:

Survey and monitoring

- ❖ Regular surveys need to be conducted, particularly in young crop, in registered and unregistered cane areas to detect the occurrence of FAW. Routine inspection of grown-up crop in the vicinity of young crop would reveal the expansion of the pest to the maturity phase.
- ❖ Both plant and ratoon crop should be monitored from the germination and tillering phases to maturity phase to assess the progression of the pest and preference of different stages.
- ❖ Besides sugarcane, other crops recognized worldwide as major hosts, such as maize sorghum and paddy should be monitored

to understand and assess the host shifting behavior of FAW.

- ❖ Growers need to be sensitized to report the occurrence of the pest in their farms.

Preventive measures

- ❖ Movement of seedlings from infested areas to other areas for planting purpose should be avoided or monitored to prevent the entry and dispersal of the pest in new areas.
- ❖ Transport of cane to long distances for crushing or as seed material should be avoided or monitored to prevent accidental dispersal through infested leaves.
- ❖ Movement of cane tops should also be avoided to prevent possible dispersal, though the suitability of older crop is not clear presently.
- ❖ Since FAW is known to survive on grasses, clean cultivation should be practiced.
- ❖ Enhanced diversity, particularly intercrops with pulses, has been reported to reduce FAW incidence and enhance natural enemy populations. However, it should be practiced with caution since the pest is polyphagous.
- ❖ Sex pheromone lures of FAW being sold in the market need to be used after stringent field validation.
- ❖ Light earthing-up and fertilizer application should be followed without delay. Earthing-up is likely to disturb the soil and expose the hiding larvae and pupae to the action of general predators. Fertilizer application can boost plant growth and facilitate quick recovery from low level damage.
- ❖ Collection and destruction of visible larval stages from infested plants should be carried out wherever possible.
- ❖ Biological control recommendations are based on published literature and not on

detailed experimentation in India. They can be followed for long-term benefit in a routine and prophylactic manner until conclusive evidence emerges on the effectiveness of specific biocontrol agents.

4. Curative measures

- ❖ Seedlings introduced for planting should be examined for the presence of FAW and treated with insecticide. If the seedlings originate from FAW prone area, prophylactic or quarantine treatment may be resorted to.
- ❖ Early application of plant products like azadirachtin or neem oil may prevent oviposition and early larval feeding.
- ❖ Assessment of field incidence levels on the basis of damage symptoms or larval presence on the leaves or whorls will help in decision making for insecticide application. Percent FAW incidence can be assessed by selecting 5-10 spots randomly in the field and counting infested plants among 50 plants, both mother shoots and tillers, at each spot. Since no economic thresholds are available for FAW in sugarcane, 5-10% attack rate can be used for deploying insecticidal control.
- ❖ Since no insecticides are registered against FAW in sugarcane in India, chlorpyrifos and monocrotophos, recommended for early season lepidopteran pests like shoot borer (Ramasubramanian and Srikanth 2015), can be used following the arbitrary threshold level of 5-10% incidence. Ensuring that the spray fluid is directed to the whorls, spot application may be followed if infestation is seen in patches in the early stages but this may need constant monitoring and repeated application. Judicious deployment of insecticides is advised as resistance has already been reported elsewhere though not in India yet.

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References

- Abha Toppo (2018) Fall armyworm detected in sugarcane. <https://krishijagran.com/news/fall-armyworm-detected-in-sugarcane/> [Accessed on 08 December 2018]
- Andrews KL (1988) Latin American research on *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Florida Entomologist 71(4): 630-653.
- Boregas, KGB, Mendes SM, Waquil JM, Fernandes GW (2013) [Fitness stage of *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on alternative hosts] Estádio de adaptação de *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) em hospedeiros alternativos [Pt.]. Bragantia 72(1):61-70.
- CABI (2018) *Spodoptera frugiperda* (fall armyworm). In: Invasive Species Compendium. Wallingford, UK: CAB International. <https://www.cabi.org/isc/datasheet/29810> [Accessed on 19 December 2018]
- Chormule A, Shejawal N, Nagol J, Brown ME (2019a) American fall armyworm (*Spodoptera frugiperda*): alarming evidence of infestation in sugarcane, maize and jowar. <https://docs.google.com/document/d/1-4jGbCvAbdcOurqgy5LV-84D5qr5P9CTd-w5Ub4e36c/edit?fbclid=IwAR2mtUPA7xUHnu0lyw2iFOTFpT17SRXO2xhhf3ItN>

- 6bIOEbMwAP128-Zuc4 [Accessed on 07 January 2019]
- Chormule A, Shejawal N, Sharanabasappa, Kalleshwaraswamy CM, Asokan R, Mahadeva Swamy HM (2019b) First report of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae) on sugarcane and other crops from Maharashtra, India. Journal of Entomology and Zoology Studies 7(1): 114-117.
- EPPO (2018) EPPO Global Database: *Spodoptera frugiperda* (LAPHFR). <https://gd.eppo.int/taxon/LAPHFR> [Accessed on 08 December 2018].
- Ganiger PC, Yeshwanth HM, Muralimohan K, Vinay N, Kumar ARV, Chandrashekara K (2018) Occurrence of the new invasive pest, fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), in the maize fields of Karnataka, India. Current Science 115(4):621-623.
- Goergen G, Kumar PL, Sankung SB, Togola A, Tamò M (2016) First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (JE Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. PLoS ONE 11(10): e0165632. doi:10.1371/journal.pone.0165632
- Hill M (2017) Armyworms may invade South Africa sugar fields after corn. <https://www.bloomberg.com/news/articles/2017-02-16/south-africa-concerned-about-fall-armyworms-in-sugarcane-crops-iz8cu7y2> [Accessed on 08 December 2018].
- ICAR-NBAIR (2018a) PEST ALERT: 30th July, 2018. *Spodoptera frugiperda* (Smith, J.E.) (Insecta: Lepidoptera). http://www.nbair.res.in/recent_events/Pest%20Alert%2030th%20July%202018-new1.pdf
- ICAR-NBAIR (2018b) *Spodoptera frugiperda* (J. E. Smith). ICAR-National Bureau of Agricultural Insect Resources (NBAIR), India. http://www.nbair.res.in/insectpests/Spodoptera_frugiperda.php
- ICAR-SBI (2018) Fall armyworm *Spodoptera frugiperda* attack on sugarcane: an advisory. https://sugarcane.icar.gov.in/images/sbi/announcements/faw_advisory_111218.pdf [Accessed on 11 December 2018]
- Jitendra (2018) Fall armyworm detected on sugarcane crops in Tamil Nadu. <https://www.downtoearth.org.in/news/agriculture/fall-armyworm-detected-on-sugarcane-crops-in-tamil-nadu-62436> [Accessed on 20 December 2018].
- Joshi S, Viraktamath CA (2004) The sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphididae): its biology, pest status and control. Current Science 87(3):307-316.
- Mukunthan N, Srikanth J, Singaravelu B (2007) Integrated management of sugarcane woolly aphid. In: *Woolly Aphid Management in Sugarcane*. (eds. N. Mukunthan, J. Srikanth, B. Singaravelu, T. Rajula Shanthi, R. Thiagarajan, D. Puthira Prathap). Ext Publ No. 154, pp. 111-118. Sugarcane Breeding Institute, Coimbatore.
- Murúa MG, Juárez ML, Prieto S, Gastaminza G, Willink E (2009) [Spatial and temporal distribution of *Spodoptera frugiperda* (Smith) (Lep.: Noctuidae) larval populations on different host plants in northern Argentina provinces] Distribución temporal y espacial de poblaciones larvarias de *Spodoptera frugiperda* (Smith)

- (Lep.: Noctuidae) en diferentes hospederos en provincias del norte de la Argentina [Spanish]. Revista industrial y agrícola de Tucumán (Argentina) 86(1): 25-36.
- Prasanna BM, Joseph E Huesing, Regina Eddy, Virginia M Peschke (eds.) (2018) Fall Armyworm in Africa: A Guide for Integrated Pest Management, First edition. Mexico, CDMX:CIMMYT.
- Ramasubramanian T, Srikanth J (2015) Insecticides for the Management of Sugarcane Pests in Tropical India – An Advisory for Intelligent Use. ICAR-Sugarcane Breeding Institute, Coimbatore, 21p.
- Ramasubramanian T, Nilavuckkarasi RK, Yogambal C, Ramaraju K (2018) Cloning and characterizing the Folmer region of mtCOI gene diagnostic for sugarcane top borer, *Scirpophaga excerptalis* (Walker) (Lepidoptera: Pyralidae). Journal of Sugarcane Research 8(1): 86-93.
- Sharanabasappa, Kalleshwaraswamy CM, Asokan R, MahadevaSwamy HM, Maruthi MS, Pavithra HB, Kavita Hedge, Shivaray Navi, Prabhu ST, Goergen G (2018) First report of the fall armyworm, *Spodoptera frugiperda* (J E Smith) (Lepidoptera: Noctuidae), an alien invasive pest on maize in India. Pest Management in Horticultural Ecosystems 24(1):23-29.
- Shylesha AN, Jalali SK, Ankita Gupta, Varshney R, Venkatesan T, Shetty P, Ojha R, Ganiger PC, Navik O, Subaharan K, Bakthavatsalam N, Ballal CR (2018) Studies on new invasive pest *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) and its natural enemies. Journal of Biological Control 32(3):1-7. <http://www.informaticsjournals.com/index.php/jbc/article/view/21707/18418> [Accessed on 19 December 2018]
- Srikanth, J, Singaravelu B, Kurup, NK (2012) Natural control of woolly aphid by *Encarsia flavoscutellum* prevents yield and quality loss in sugarcane. Journal of Sugarcane Research 2(1):64-68.
- Srikanth J, Singaravelu B, Kurup NK, Mukunthan N, Santhalakshmi G, Nirmala R (2015) Predators as natural and applied biocontrol agents of sugarcane woolly aphid *Ceratovacuna lanigera* in India: an appraisal. Journal of Sugarcane Research 5(2): 53-72.
- Tripathi M (1995) Record of parasite, predator complex of sugarcane woolly aphid, *Ceratovacuna lonifera* Zehnt. in Nagaland. Indian Sugar 44:883-885.
- Uys G (2017) No fall armyworm impact on sugar industry, despite concerns. <https://www.farmersweekly.co.za/agri-news/south-africa/no-fall-armyworm-impact-on-sugar-industry-despite-concerns/> [Accessed on 08 December 2018]