

Effective control strategies for sugarcane borers in single-node seedling technology: A study on insecticidal efficacy and yield improvement

Bhavani B^{1*}, Visalakshi M¹, Bharatha lakshmi M²

¹ Department of Entomology, RARS, Anakapalle, ANGRAU, Andhra Pradesh, India

² Department of Agronomy, Agricultural College, Naira Srikakulam, Andhra Pradesh, India

Abstract

In recent years, the use of single-node seedlings for sugarcane cultivation has gained prominence due to its potential to reduce planting costs and enhance seed cane quality. Raising seedlings in portraits or polybags under shade net conditions offers distinct advantages for seed production. However, under these transplanted conditions, the early shoot borer (*Chilo infuscatellus*) has emerged as a major pest, especially under post-transplant stress. Infestation during this vulnerable stage often leads to complete seedling mortality, severely affecting plant stand establishment and ultimately reducing cane yield. To address this issue, a field experiment was conducted over three consecutive seasons (2016–2019) at the Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India, to evaluate the efficacy of selective insecticidal treatments against early shoot borer in transplanted sugarcane. The most effective management strategy involved sett treatment with imidacloprid 600 FS @ 1 ml/L, combined with soil application of chlorantraniliprole 0.4G @ 22.5 kg/ha at transplanting and again at 60 days after transplanting (DAT). This integrated approach significantly reduced early shoot borer incidence to 6.57% dead heart (DH), representing a 78.44% reduction compared to the untreated control (30.47% DH). It also resulted in the highest number of millable canes (81,600/ha) and cane yield (102.82 t/ha), translating to a 33.15% yield increase over the control (64,680 canes/ha; 77.22 t/ha). The next most effective treatments were sett treatment with imidacloprid 600 FS @ 1 ml/L plus soil application of fipronil 0.3G @ 25 kg/ha at transplanting and 60 DAT, and foliar application of chlorantraniliprole @ 0.3 ml/L before transplanting and again at 60 DAT. These treatments achieved yield increases of 28.58% and 26.39% over the control, respectively, and were statistically at par.

Keywords: Sugarcane, *chilo infuscatellus* snellen, single node seedlings, chlorantraniliprole, fipronil, bioefficacy

Introduction

The early shoot borer (*Chilo infuscatellus* Snellen) (Lepidoptera: Crambidae) poses a serious threat to sugarcane cultivation across India, leading to notable economic losses (Avasthy & Tiwari, 1986) [2]. In Andhra Pradesh, its infestation commonly begins at the germination phase and, under unfavourable climatic conditions such as drought or inadequate rainfall, can extend into the stalk development stage, where it acts as an internode borer (Avasthy, 1969). Historical studies have indicated that this pest can destroy between 26% and 65% of mother shoots (Khan & Krishnamurthy Rao, 1956) [11], causing yield reductions of up to 33% in cane, 12% in sugar recovery, and 27% in jaggery production (Patil & Hapse, 1981) [14]. Its impact is especially severe in rainfed conditions, where damage to over 70% of shoots has been reported (Prasad Rao *et al.*, 1991) [17].

Unchecked infestations can persist beyond the early growth stages, with the pest attacking new internodes approximately 120 days after planting. This leads to hardened, uncrushable canes and a decline in juice quality. The extent of sucrose loss varies based on crop variety, age, and infestation severity. Various insecticidal strategies have historically been adopted for managing this pest in conventionally planted crops using three-budded setts (Patil *et al.*, 1982; Kennedy, 1993; Jena *et al.*, 1994; Jhansi & Ramachandra Rao, 1995) [8, 9, 10, 15]. Among newer control agents, chlorantraniliprole has emerged as an effective option, exhibiting strong activity against lepidopteran pests while posing minimal risk to beneficial insects, pollinators, and non-target soil organisms (Dinter *et al.*, 2008) [7]. Its low application dose and favourable toxicological profile make

it suitable for integrated pest management (Sharma *et al.*, 2013) [18]. However, research on early shoot borer management in transplanted sugarcane especially under single-bud sett technology is limited. Key knowledge gaps remain regarding the ideal timing, mode of application, and comparative effectiveness of soil-applied and foliar insecticides in these systems. Considering these challenges, the current study aims to evaluate the performance of selected insecticidal treatments in managing early shoot borer under transplanted conditions, with a focus on enhancing plant establishment and improving final cane yield.

Materials and Methods

Single-bud seedlings of sugarcane variety CoA 99082 were raised in poly trays after treating with imidacloprid 600FS @ 1 ml/L prior to planting. After 6–7 weeks of nursery growth, seedlings were transplanted along with the root mass into small pits spaced at 90 × 45 cm. The field experiment followed a Randomized Block Design (RBD) with ten treatments, each replicated three times, and was conducted over three consecutive crop seasons (2016–17, 2017–18, and 2018–19) at the Regional Agricultural Research Station, Anakapalle, Andhra Pradesh. Details of the treatment combinations are provided in Table 1. The crop was established in plots measuring 5.0 m × 0.9 m × 6 rows, with transplanting carried out during the second fortnight of March each year. All standard agronomic practices including land preparation, fertilization, irrigation, and weed control were implemented according to the recommended package for sugarcane in the North Coastal Zone of Andhra Pradesh. To assess pest infestation, the

incidence of early shoot borer (ESB) was recorded as dead heart symptoms at 30, 60, 90, and 120 days after planting (DAP) in each plot. For insecticidal treatments, granular formulations were applied into the soil using the pocketing/placement method at planting (0 DAP) and 60 DAPS, targeting the base of the sugarcane clumps. Foliar insecticide applications were carried out at 30, 45, and 60 DAPS, using spray volumes of 450, 675, and 900 L/ha, respectively, ensuring complete coverage of tillers during

the tillering phase. Dead heart incidence was calculated by counting the number of affected and healthy tillers in each plot, with results expressed as percent infestation. Additional observations included sucrose content in juice, number of millable canes, and cane yield, all measured at harvest. Data from all three years were subjected to appropriate statistical analysis and summarized in Tables 2 and 3.

Table 1: Details of the treatments

Sr. No.	Treatment
1	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of monocrotophos 36SL @ 1.6ml/L at 7 days before transplantation of seedlings and 4 th , 6 th and 9 th weeks after transplanting
2	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of monocrotophos @ 1.6ml/L at 7 days before transplantation of seedlings and 60 days after transplanting
3	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of chlorantraniliprole 18.5SC @ 0.3ml/L at 7 days before transplantation of seedlings and 60 days after transplanting
4	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of monocrotophos @ 1.6ml/L at 7 days before transplantation + soil application of fipronil 0.3G @ 25 kg/ha at after 60 days transplanting
5	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of monocrotophos @ 1.6ml/L at 7 days before transplantation + soil application of chlorantraniliprole 0.4G @ 22.5kg/ha at after 60 days transplanting
6	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of chlorantraniliprole 18.5SC @ 0.3ml/L before transplantation + soil application of fipronil 0.3G @ 25 kg/ha at after 60 days transplanting.
7	Sett treatment with imidacloprid 600FS @ 1ml/L + soil application of fipronil 0.3G @ 25kg/ha at the time of transplantation and 60 days after transplanting
8	Sett treatment with imidacloprid 600FS @ 1ml/L + soil application of chlorantraniliprole 0.4G @ 22.5kg/ha at the time of transplantation and 60 days after transplanting
9	Sett treatment with imidacloprid 600FS @ 1ml/L + Spray of chlorantraniliprole 18.5SC @ 0.3ml/L before transplantation + Soil application of chlorantraniliprole 0.4G @ 22.5kg/ha at 60 days after transplantation
10	T10- Untreated control

Results and Discussion

1. Early shoot borer (*Chilo infuscatellus*)

The data presented in Table 2 clearly indicates that all insecticidal treatments significantly outperformed the untreated control in mitigating early shoot borer (ESB) incidence up to 120 days after planting (DAP). Among the tested strategies, soil-applied insecticides demonstrated greater efficacy than foliar sprays in suppressing the borer population. The most effective treatment involved sett treatment with imidacloprid 600FS @ 1 ml/L, combined with soil application of chlorantraniliprole 0.4G @ 22.5 kg/ha both at transplanting and at 60 DAPS. This approach

resulted in the lowest ESB incidence of 6.57% dead hearts (DH), translating to a 78.44% reduction compared to the untreated control (30.47% DH). The next most promising treatment consisted of sett treatment with imidacloprid 600FS @ 1 ml/L, paired with soil application of fipronil 0.3G @ 25 kg/ha at transplanting and 60 DAPS. This treatment recorded 8.78% DH, corresponding to a 71.18% reduction over the control. These findings highlight the superior performance of systemic and soil-applied insecticides in managing ESB under transplanted sugarcane conditions.

Table 2: Efficacy of different treatments on the incidence of early shoot borer & internode borer in single node seedlings (Pooled data)

Treatment	Cumulative incidence of ESB (%)					Incidence of internode borer (%)				
	2016-17	2017-18	2018-19	Mean	Reduction over control (%)	2016-17	2017-18	2018-19	Mean	Reduction over control (%)
T1	11.44	16.07	20.53	16.01(23.44)	47.46	35.45	43.33	61.82	46.87(43.16)	19.18
T2	13.81	13.87	33.70	20.46(26.38)	32.85	33.33	45.00	53.33	43.89(41.42)	24.31
T3	13.58	12.56	4.80	10.31(3.30)	66.16	26.67	25.45	36.67	29.60(32.87)	48.96
T4	19.59	18.95	37.20	25.25(18.34)	17.13	42.12	46.67	56.67	48.15(44.11)	16.97
T5	11.61	13.83	27.24	17.56(29.87)	42.37	24.85	25.00	50.00	33.28(34.95)	42.61
T6	14.30	16.02	21.84	17.39(24.40)	42.93	29.39	26.67	50.26	35.44(36.34)	38.89
T7	8.12	7.00	11.21	8.78(17.15)	71.18	55.76	35.45	40.00	43.74(41.34)	24.57
T8	3.97	6.21	9.52	6.57(14.63)	78.44	26.67	10.00	58.89	31.85(33.20)	45.08
T9	14.81	14.73	18.55	16.03(23.56)	47.39	47.22	46.67	46.67	46.85(43.18)	19.21
T10	32.05	19.72	39.63	30.47(33.27)	-	54.54	53.33	66.11	57.99(49.62)	-
'F' test				Sig.	-				Sig.	-
SE (m)				2.27					3.24	
CD (P=0.05)				6.80					9.71	
CV%				16.71					14.04	

ESB: Early shoot borer; Figures in parenthesis are angular transformed values

2. Internode borer (*Chilo sacchariphagus indicus*)

As presented in Table 2, notable differences were observed among treatments in reducing internode borer incidence.

The most effective treatment was the sett treatment with imidacloprid 600FS @ 1 ml/L, coupled with foliar application of chlorantraniliprole 18.5SC @ 0.3 ml/L

applied both prior to transplanting and again at 60 days after transplanting (DAT). This combination resulted in the lowest infestation level of 29.60%, corresponding to a 48.96% reduction compared to the untreated control. The next most effective treatment involved sett treatment with imidacloprid 600FS @ 1 ml/L along with soil application of chlorantraniliprole 0.4G @ 22.5 kg/ha at transplanting and 60 DAT, which recorded 31.85% internode borer incidence, achieving a 45.08% reduction over control. These results underline the effectiveness of both foliar and soil-applied chlorantraniliprole when used in conjunction with systemic sett treatments for managing internode borer under transplanted sugarcane cultivation.

3. Juice sucrose & Number of millable canes and cane yield

The percentage of juice sucrose did not show significant variation among the ten treatments evaluated. The highest

number of millable canes (81,860 NMC/ha) and cane yield (102.82 t/ha) were observed in the treatment combining sett treatment with imidacloprid 600FS @ 1 ml/L and soil application of chlorantraniliprole 0.4G @ 22.5 kg/ha at planting and again at 60 days after planting. This treatment resulted in a 33.15% increase in cane yield compared to the untreated control, which recorded 64,680 millable canes/ha and 77.22 t/ha cane yield. The next best performing treatments were sett treatment with imidacloprid 600FS @ 1 ml/L plus soil application of fipronil 0.3G @ 25 kg/ha at transplanting and 60 days after, yielding 79,200 millable canes/ha and 99.29 t/ha cane yield, and sett treatment with imidacloprid 600FS @ 1 ml/L combined with foliar spray of chlorantraniliprole 18.5SC @ 0.3 ml/L applied before transplanting and at 60 days after transplanting, which resulted in 79,650 millable canes/ha and 97.60 t/ha cane yield. Both treatments were statistically comparable (Table 3).

Table 3. Impact of insecticidal treatments on NMC, cane yield and benefit cost ratio in single node seedlings (Pooled data)

Treatment	NMC ('000/ha)					Cane yield (t/ha)					BCR
	2016-17	2017-18	2018-19	Mean	Increase over control (%)	2016-17	2017-18	2018-19	Mean	Increase over control (%)	
T1	78.83	86.98	61.63	75.81(8.74)	19.80	96.36	102.00	79.17	92.51 (9.66)	19.80	2.18
T2	74.17	84.72	65.10	74.66 (8.69)	15.90	85.83	103.49	79.17	89.50 (9.50)	15.90	2.15
T3	76.79	87.85	74.31	79.65 (8.98)	26.39	89.51	110.05	93.23	97.60 (9.92)	26.39	2.24
T4	74.01	85.24	69.44	76.23 (8.78)	19.10	85.62	106.05	85.24	91.97 (9.65)	19.10	2.17
T5	77.87	85.42	71.18	78.16 (8.89)	23.98	91.02	107.31	88.89	95.74 (9.83)	23.98	2.20
T6	73.55	83.85	65.28	74.23 (8.66)	18.73	84.97	110.81	79.25	91.68 (9.61)	18.73	2.16
T7	80.22	87.93	69.44	79.20 (8.95)	28.58	98.30	110.00	89.58	99.29 (10.01)	28.58	2.25
T8	84.69	87.98	72.92	81.86 (9.10)	33.15	104.57	110.84	93.06	102.82 (10.18)	33.15	2.26
T9	76.64	87.33	72.92	78.96 (8.94)	24.54	89.29	109.81	89.41	96.17 (9.85)	24.54	2.20
T10	66.91	83.72	43.40	64.68 (8.04)	-	77.44	99.54	54.69	77.22 (8.78)	-	1.99
SE (m)				0.17					0.26		
CD (p=0.05)				0.51					0.56		
CV%				3.35					3.31		

NMC: Number of millable canes; Figures in parenthesis are square root transformed values

These results align with earlier studies that have demonstrated the effectiveness of chlorantraniliprole 0.4 GR and fipronil 0.3 GR in reducing early shoot borer (ESB) infestations and improving sugarcane yields (Bhavani *et al.*, 2017; Badgujar *et al.*, 2017) [3, 4]. Research by Pandey (2014) [13], Shobharani *et al.* (2018) [19], and Penn *et al.* (2023) [16], confirmed that the granular formulation of chlorantraniliprole (0.4 GR) performs comparably to its 20 SC counterpart in managing ESB populations. Choudary *et al.* (2018) [5], recommended applying chlorantraniliprole 0.4 GR at 22.5 kg/ha or fipronil 0.3 GR at 25 kg/ha both at planting and at 60 days after planting to achieve effective control of this pest. Similarly, Umashankar *et al.* (2018) [18],

reported significant reductions in cumulative infestation of *Chilo infuscatellus* with these insecticides, which translated into higher cane yields than untreated controls. Douressamy *et al.* (2019) also found chlorantraniliprole 35 WG at 75 g active ingredient per hectare to effectively suppress infestations by both early shoot borer and internode borer in sugarcane. The efficacy of soil-applied fipronil in managing shoot borer has been well documented as well, with studies by Patil *et al.* (1993) [15], Nagalakshmi *et al.* (1999) [12], Talpur *et al.* (2002) [20], and Dheer Singh and Tomar (2003) [6], confirming its ability to maintain reduced levels of early shoot borer infestation.



Fig 1: Early shoot borer: Dead heart, Larva inside the shoot



Fig 2: Internode borer: Bored holes on the cane; sprouting of buds on infested cane; exit hole made by INB adult, exit hole plugged with excreta and reddening of the internal tissue due to INB damage

Conclusion

The present study demonstrates that sett treatment with imidacloprid 600 FS @ 1 ml/L, combined with either soil application of chlorantraniliprole 0.4 GR @ 22.5 kg/ha or fipronil 0.3 GR @ 25 kg/ha at transplanting and again at 60 days after transplanting (DAT), or foliar spraying of chlorantraniliprole @ 0.3 ml/L before transplanting and at 60 DAT, effectively managed early shoot borer in sugarcane. These treatment regimens resulted in the highest number of millable canes and a 33.15% increase in cane yield compared to the untreated control.

Acknowledgments

The authors gratefully acknowledge the Director of Research, ANGRAU, Andhra Pradesh, and the Associate Director of Research, Regional Agricultural Research Station, Anakapalle, for providing the facilities and logistical support essential for conducting the field investigations.

Conflict of interest: The authors declare that there is no conflict of interest.

Consent for publication: All authors agree to publish the paper in International Journal of Entomology Research

Funding: No funding

References

1. Avasthy PN, Sugarcane pests in India and their control. PANS,1967:13:111–117.
2. Avasthy PN, Tiwari NK, The shoot borer *Chilo infuscatellus* Snellen in sugarcane entomology in India. Sugarcane Breeding Institute Publication, 1986, 69–92.
3. Badgujar MP, Chaudhari PM, Ajiotikar MV, Solanke AV, Evaluation of new chemical molecules against sugarcane early shoot borer (*Chilo infuscatellus* Snellen). Proceedings International Symposium on Sugarcane Research Since Co205: 100 Years Beyond (SucroSym 2017), ICAR-Sugarcane Breeding Institute, Coimbatore, India, 2017, 374–376.
4. Bhavani B, Visalakshi M, Bharathalakshmi M, Venugopala Rao N. Bioefficacy of chlorantraniliprole against sugarcane early shoot borer in North coastal zone of Andhra Pradesh, India. Proceedings International Symposium on Sugarcane Research Since Co205: 100 Years Beyond (SucroSym 2017), ICAR-Sugarcane Breeding Institute, Coimbatore, India, 2017, 380–381.
5. Choudary AK, Amrate PK, Chatterjee A. Bioefficacy of some insecticides for the management of early shoot borer, *Chilo infuscatellus* (Snellen) in sugarcane. International Journal of Chemical Studies,2018:6(3):1371–1373.
6. Dheer Singh, Tomar PK, Effects of insecticides on juice quality and productivity in late planted sugarcane. Indian Journal of Sugarcane Technology,2003:18(12):70–71.
7. Dinter A, Brugger K, Bassi A, Frost NM, Woodward M D. Chlorantraniliprole (DPX-E2Y45, Rynaxypyr, Coragen 20 SC and Altacor 35WG) – A novel DuPont anthranilic diamide insecticide demonstrating low toxicity and low risk for beneficial insects and predatory mites. IOBC WPRS Bulletin,2008:35:128–155.
8. Jena BC, Nayak N, Parida AK, Control of sugarcane early shoot borer, *Chilo infuscatellus* Snellen in Orissa. Indian Sugar,1994:44:251–255.
9. Jhansi K, Ramachandra Rao B. Chemical control of shoot borer, *Chilo infuscatellus* Snellen. Bharatiya Sugar,1995:21:21–22.
10. Kennedy FJ, S. Evaluation of certain insecticides against early shoot borer (*Chilo infuscatellus* Snellen) in sugarcane. Mededelningen-van-de Pakistan Sugar Journal,1993:8:3–5.
11. Khan MQ, Krishnamurthy Rao. Assessment of loss due to *Chilo infuscatellus* Snellen in sugarcane. Proceedings of International Society of Sugarcane Technology,1956:9:870–879.
12. Nagalakshmi KV, Balaji K, Gowrishanker S. Evaluation of insecticides in the management of sugarcane early shoot borer *Chilo infuscatellus* Snellen. Proceedings of the 61st Annual Convention of the Sugar Technologists-Association of India, New Delhi, India, 7–9 September, 1999, 142–147.
13. Pandey SK, Comparative efficacy of some insecticides on early shoot borer (*Chilo infuscatellus* Snellen) incidence in sugarcane under subtropical India. Vegetos,2014:27(1):146–148.
14. Patil AS, Hapase DG. Research on sugarcane borers in Maharashtra State. Proceedings of National Symposium on Stalk Borer,1981:165–175.

15. Patil MB, Patel CB, Pastagia JJ, Patel H. Efficacy of certain granular insecticides against borer pests of sugarcane. *Cooperative Sugar*,1993;25(34):117–120.
16. Penn HJ, Richard RT, Johnson RM, Impact of insecticide, rate, and timing combinations against sugarcane borer, 2019–2020. *Arthropod Management Tests*,2023;48(1):055.
17. Prasad Rao VL, V, Rao SS, Rao NV, Factors influencing infestation of early shoot borer (*Chilo infuscatellus* Snellen) in sugarcane. *Cooperative Sugar*,1991;22(8):515–518.
18. Sharma N, Mandal K, Kumar R, Kumar B, Singh B. Persistence of chlorantraniliprole granule formulation in sugarcane field soil. *Environmental Monitoring Assessment*,2013;186:2289–2295.
19. Shobharani M, Rachappa V, Sidramappa, Sunilkumar N M. Evaluation of new insecticide molecules for the management of early shoot borer (*Chilo infuscatellus* (Snellen)) on sugarcane. *International Journal of Current Microbiology Applied Sciences*,2018;7(9):2079–2088.
20. Talpur MA, Nizamani IA, Qureshi KH, Chemical control of sugarcane stem borer, *Chilo infuscatellus* Snellen (Crambidae: Lepidoptera) at Tandojam. *Pakistan Journal of Applied Sciences*,2002;3:341–343.
21. Umashankar HG, Patel VN, Nagaraja T, Vijaykumar L, Sugeetha S. Evaluation of new insecticide molecules for their effectiveness in the management of sugarcane early shoot borer, *Chilo infuscatellus* (Snellen). *Journal of Applied and Natural Science*,2018;10(1):434–438.