

**SEASONAL INCIDENCE AND MANAGEMENT OF
SUGARCANE EARLY SHOOT BORER, *Chilo infuscatellus*
(Snellen) (PYRALIDAE : LEPIDOPTERA)**

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in
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By
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CERTIFICATE

This is to certify that the thesis entitled "**SEASONAL INCIDENCE AND MANAGEMENT OF SUGARCANE EARLY SHOOT BORER, *Chilo infuscatellus* (Snellen) (PYRALIDAE : LEPIDOPTERA)**" submitted by **Mr. KALLAPPA MAGADUM**, for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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With regardful memories

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LIST OF ABBREVIATIONS

@	: At the rate
<	: Less than
>	: More than
%	: Per cent
% Brix	: Per cent brix
% Pol	: Per cent pol
±	: Plus or minus
‘000/ha	: Thousands per hectare
a.i.	: Active ingredient
B:C ratio	: Benefit Cost ratio
°C	: Degree Celsius
C.D. (p = 0.05 %)	: Critical Difference at 5 per cent level
cm	: Centimeter/s
C.V.	: Coefficient Variation
DAP	: Days after planting
EC	: Emulsifiable Concentrate
ESB	: Early shoot borer
<i>etc</i>	: <i>Et cetera</i>
DH	: Dead heart
<i>et al.</i>	: and associates
G	: Granular
g	: Gram
g a.i./ha	: Gram active ingredient per hectare
ha	: Hectare
<i>i.e.,</i>	: that is
kg	: Kilogram
kg/ha	: Kilogram per hectare

l	: Litre
m	: Metre
ml	: Millilitre
ml/l	: Millilitre per litre
mm	: Millimeter
NMC	: Number of Millable Canes
No.	: Number
NS	: Non-significant
r	: Correlation coefficient
RCBD	: Randomized Complete Block Design
Rs.	: Rupees
SC	: Soluble Concentrate
SL	: Soluble Liquid
Sl. No.	: Serial Number
SP	: Soluble Powder
S.Em.	: Standard Error of mean
t	: Tonne
t/ha	: Tonnes per hectare
viz.,	: Namely

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1. INTRODUCTION

Sugarcane, *Saccharum officinarum* L. belongs to family Poaceae is an important commercial crop predominantly grown in tropical and subtropical regions, and was originated in New Guinea, later on it spread to many parts of the world. Sugarcane supplies raw materials to the sugar industry which is the second largest agro based industry after textile. Sugarcane is the main source of sugar which accounts for 80 per cent of sugar production in world and more recently it is a replacement for fossil fuel for motor vehicles.

Globally, the crop occupies over an area of 23.8 million hectares with the production of 1,734.05 million tonnes and productivity of about 72.85 tonnes per ha. The leading sugarcane producing countries are Brazil, India, China, Thailand and Pakistan (Anon., 2016).

In India, sugarcane is grown in 4.43 million ha producing about 306.06 million tonnes of cane with 69.08 tonnes per ha productivity. Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Haryana, Bihar, Gujarat and Punjab are the important sugarcane growing states in India (Anon., 2017a).

In Karnataka, it is grown in 3.97 lakh ha producing about 273.78 lakh tonnes of cane with productivity of 68.96 tonnes per ha. The leading sugarcane growing district in Karnataka are Belagavi, Bagalkot, Vijayapur, Bidar and Mandya, respectively (Anon., 2017a).

The cane yield in sugarcane is prominently influenced by many factors such as biotic and abiotic stresses, soil, variety and cultural practices. Pests are known to cause considerable loss in yield as well as sugar output. Sugarcane is attacked by as many as 288 species of insect pests from germination to harvest (Anon., 2013).

Based on feeding habit, pests infesting sugarcane may be broadly classified as borers, sucking pests, subterranean pests, defoliators and non-insect pests. Among which borers (early shoot borer, internode borer, top shoot borer and root borer *etc.*) are the most detrimental pests at different crop growth stage.

Among the borers, early shoot borer (ESB), *Chilo infuscatellus* (Snellen) (Pyralidae; Lepidoptera) is a serious insect-pest of sugarcane in peninsular regions of India and a vital pest in early stages of the crop growth and causes heavy economic damage (Avasthy and Tiwari, 1986).

The pest starts attacking a month old crop, female lays eggs in the clusters on the lower surface of the leaves by the side of the mid rib. The caterpillars after hatching from eggs get scattered and enter into the young shoots by making the holes just above the ground level and tunnel downward. The central shoot dries up causing 'dead heart'. It is a typical characteristic sign of presence of the pest within the plant. The dead heart can be easily pulled out of the central shoot, rots inside the stem and emits an offensive smell on being pulled out.

It destroys 26-65 per cent of mother shoots (Khan and Rao, 1956) and causes loss between 22-33 per cent in yield, 1.2 per cent in sugar recovery and 2.7 per cent in jaggery (Patil and Hapase, 1981). Prasad Rao *et al.* (1991) reported that in rainfed ecosystem infestation due to ESB in sugarcane crop was to the tune of 70 per cent shoot loss.

Keeping this in view, the present investigation is undertaken with the following objectives.

1. Seasonal incidence of sugarcane early shoot borer, *Chilo infuscatellus* (Snellen).
2. Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*.
3. Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*.
4. Management of sugarcane early shoot borer, *C. infuscatellus* with insecticide molecules.

2. REVIEW OF LITERATURE

The literature pertaining to seasonal incidence of sugarcane early shoot borer, reaction of different genotypes, influence of cultural practices and evaluation of insecticide molecules against ESB has been reviewed and presented here under the following headings.

- 2.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*
- 2.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*
- 2.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*
- 2.4 Management of sugarcane early shoot borer, *C. infuscatellus* with insecticide molecules

2.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*

Sugarcane crop escapes from severe ESB incidence when, it was planted between December to February (Sithanantham *et al.*, 1975).

Sugarcane planted during March to May suffered heavy infestation due to ESB (Thirumurugan *et al.*, 2001).

The monitoring studies using light traps at Hyderabad, India, revealed that the ESB incidence was higher in two peak periods, one during the month of May and another during September (Venugopala Rao and Ramesh Babu, 2004).

Sunil Kumar *et al.* (2007) studied the factors affecting the infestation of ESB and reported that January planted crop noticed low cumulative incidence (34.73 %) as against February (37.98 %) and March (41.41 %) planted crop.

The studies carried out on population dynamics of sugarcane ESB at Pakistan revealed that the adults of ESB emerged from over wintering larvae during fourth week

of February. The population of their adults remained low in early vegetative growth stage, the number of moth/trap increased gradually as the crop advanced and the maximum population of 37.4 ± 2.20 moths were recorded during August. The population of ESB was declined after August (Muhammad *et al.*, 2012).

The experiment conducted at Pakistan during the year 2012 indicated that the lowest infestation (8.30 %) of sugarcane ESB was observed during the third week of June with gradual increase to its peak (52.90 %) in the third week of July (Mohammad *et al.*, 2014).

The highest incidence of ESB was noticed during second week of June (8.8 %) at 43.1 °C maximum temperature, 28.4 °C minimum temperature, 57.0 per cent maximum relative humidity, 21.0 per cent minimum relative humidity and 9.1 sun shine hours. The correlation coefficient showed significant and positive correlation with minimum temperature while it was highly significant and negatively correlated with minimum relative humidity with shoot infestation. The effect of maximum temperature with shoot infestation showed a negative correlation. The maximum relative humidity showed non-significant positive correlation where as it was positively correlated with minimum relative humidity and sun shine hours (Pandey and Ram Kumar, 2014).

Studies conducted by Choudhary *et al.* (2015) on population dynamics of sugarcane ESB at Madhya Pradesh, India, indicated that ESB infests the sugarcane from second week of February to second week of July and its peak activity was observed from last week of March to second week of May.

The infestation of ESB was first noticed during second week of March. The peak dead hearts were observed during last week of March to first week of April (Bhawar *et al.*, 2015).

2.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*

The literature pertaining to studies on reaction of different genotypes of sugarcane against ESB to be evaluated in the present investigation is lacking, since much of the earlier work was restricted to locally cultivated genotypes. However, the

information pertaining to reaction of different sugarcane genotypes against ESB is presented here under.

Seven commercial varieties of sugarcane were screened for their reaction against ESB among them CoS 767 was found least susceptible (Duhra *et al.*, 1994).

Karnatak *et al.* (1999) studied the level of resistance to ESB, in nine mid-late maturing varieties, among which Co 85002 was categorized as most susceptible due to its more sucrose content.

Experiment conducted at Pakistan during 1991-92 revealed that among the fifty varieties of sugarcane screened against ESB attack, none of the varieties recorded immune. Variety CoL-50 was severely infested, followed by Co 385, Co 611, PR-2246, PR-1000 and CP-51/21 with damage ranging from 11.46 to 11.00 per cent in descending order. Variety BF-129 recorded least (8.55 %) damage (Khanzada, 2002).

Among the nine genotypes and two entries as checks screened, genotype viz., 2000A 62 was found promising by recording significantly less incidence of 15.90 per cent due to ESB (Narasimha Rao *et al.*, 2006).

Studies conducted over four-years (2002-2006) at Karnal, Haryana (India) by Chaudhary and Jaipal (2007) revealed that a total of 261 genotypes of sugarcane were screened for their reaction against ESB. Based on their reaction, the genotypes were graded tolerant to highly susceptible. Most of the genotypes were tolerant (78.9 %), whereas 1.5 and 19.5 per cent of the genotypes were susceptible and moderately susceptible, respectively. No genotype was found highly susceptible, the frequency of tolerance varied between the years. CoH 117, C9-9oH 115, Co 7717 and BO 91 were tolerant for at least three years, whereas, Co 99015, CoH 118, CoP 9301, CoP 99217, CoS 8436, CoS 95222 and CoS 96275 were tolerant for at least two years, with a moderately tolerant reaction during another year. Co 116, Co 121, Co 124, CoH 110, CoH 119, CoH 128, CoJ 64, CoLk 9616, CoP 84211, CoS 97248, CoS 97264, CoS 257 and CoS 99259, and HAU selections S 98045 and S 99521 evaluated for two years were found tolerant.

Trials carried out at Kolhapur, Maharashtra (India) where in 17 sugarcane genotypes were screened for their reactions against ESB, among them Co 93021 (9.8 %) recorded significantly lowest per cent infestation. However, it was on par with Co 93009, Co 93016, Co 93010, Co 6304, CoG 93076, Co 93014, Co 7914, Co 93024, Co 86032, Co 7219, Co 93007 and Co 93008 (9.9 to 14.6 %). Thus, all these genotypes were graded as tolerant to ESB. The genotypes viz., CoG 93079, Co 93008, Co 740 and Co 93077 were found moderately resistant to ESB with incidence ranging between 15.1-30 per cent (Hole *et al.*, 2009).

Bhavani *et al.* (2012) conducted field screening of different genotypes of sugarcane against ESB at Andhra Pradesh, India. The results revealed that the genotypes viz., Co 0110, 98 A 165, Co 6806 and 98 A 125 were least susceptible (< 15 % DH), 97 A 85, 2000 A 105, 99 A5 and Co 62175 were moderately susceptible (15-30 % DH) whereas 93A 11, 99 A 33, 94 A 124, Co M 9902 and the susceptible check, 93 A 145 were highly susceptible (> 30 % DH) to ESB at 60 DAP.

The results of the experiment carried out at V.C Farm, Mandya (Karnataka, India) on field screening of different sugarcane genotypes against ESB revealed that the genotypes viz., 00964, 10-65-01, 10-65-01, 10-1708, 10-57-07, 07-10-02, 10-2802 and 09-61-02 were recorded less than 15 per cent of incidence, which were categorized as least susceptible while genotypes 10-17-05, 07-0605, 10-33-33, 10-38-06, 08-15-06 and 06-09-03 have recorded 15 to 30 per cent incidence of ESB were classified as moderately susceptible, whereas checks Co 99463 and Co 86032 have recorded per cent incidence of 4.83 and 22.39, respectively due to ESB (Umashankar *et al.*, 2017).

2.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*

Studies conducted at Coimbatore, Tamil Nadu (India) on the control of sugarcane ESB using GV (Granulosis virus) and cultural practices revealed that ESB damage was significantly less in GV 10⁷ inclusion bodies (IB/ml) applied at 35 and 50 DAP (days after planting) which was superior to all other treatments. The treatments next to follow include trash mulching and GV 10⁷ IB/ml applied at 35 DAP and GV

application at 35 DAP followed by an earthing up which were on par with each other (Parameswaran *et al.*, 1993).

Varun *et al.* (1994) reported that growing of spice crops such as ajawain, coriander, garlic, onion, methi and saunf as intercrops in sugarcane significantly reduced the incidence of ESB.

The experiment carried out at ARS, Sankeshwar revealed that sugarcane intercropped with onion, garlic followed by coriander proved effective by recording lower per cent dead heart (5.58-15.11, 7.27-17.05 and 6.81-18.11 %, respectively). Maize inter cropping recorded higher incidence of ESB (18.00-46.98 %) (Tippannavar *et al.*, 1997).

Sugarcane intercropping with several spices and condiments like garlic and coriander reduces the incidence of ESB (Singh *et al.*, 1999).

The incidence of ESB reduced to about 60 per cent in all the cultivars with a reduction in irrigation interval from 15-20 days to 10-12 days during the formative phase of crop growth (Jaipal, 2000).

Sardana (2000) reported that population of ESB can be managed by flooding of sugarcane fields.

Sugarcane intercropping with black gram, cowpea, green gram and soybean revealed that the incidence of ESB was significantly higher in 25 and 65 days old sugarcane-soybean diculture plot than in sugarcane monocrop plot of corresponding age (Srikanth *et al.*, 2000).

Madan (2001) reported that earthingup in May and June and balanced use of fertilizers to sugarcane crop help in the control of borers.

Rachappa and Krishna Naik (2004) studied the impact of various intercrops (Coriander, Soybean, French bean and Okra) on ESB and results revealed that marked control of ESB was found in the combination of sugarcane + coriander. On the contrary, sugarcane intercropped with okra observed higher per cent infestation of ESB.

The experiment conducted at Tamil Nadu, India indicated that the sugarcane + green gram (9.56 %) followed by sugarcane + sun hemp (10.25 %) recorded significantly lower incidence of ESB than sugarcane + soybean (14.65 %) and sugarcane as sole crop (25.79 %) (Thirumurugan and Koodalingam, 2005).

The studies carried out by Randhawa *et al.* (2009) at Punjab (India) indicated that in newly planted sugarcane crop, irrigation interval of eight days was effective in decreasing the incidence of ESB, followed by 16, 24 and 32 days' irrigation interval.

Siddique *et al.* (2009) conducted field experiment on water management for the control of pests of sugarcane indicated that when there was a soil moisture stress, incidence of ESB increases. When irrigations were given after 25 per cent of available moisture was depleted, the per cent dead heart incidence in a normally manured crop was noted to be 16.46 as against 31.09 when irrigations were given after 75 per cent of available moisture was depleted.

Venugopala Rao *et al.* (2010) reported that among the different intercrops, sugarcane intercropped with green gram registered less incidence of ESB (4.15 %) followed by sugarcane intercropped with black gram (4.25 %) and cowpea (4.85 %) whereas, in sole crop recorded higher incidence of 16.35 per cent.

Ansari (2011) evaluated the sole cultural practices (*viz.*, 10 cm thick trash mulching, two light earthing up @ 45 and 60 DAP and furrow application of chlorpyrifos 10 G @ 1 kg a.i./ha) as well as their combinations with each other against ESB in sugarcane. The lowest per cent dead hearts were observed in the plot treated with all three combinations, followed by the plot treated with two cultural practices (*viz.*, furrow application of chlorpyrifos 10 G @ 1 kg a.i. /ha and two light earthing up @ 45 and 60 DAP). However, the maximum per cent dead hearts were noticed from the plot treated with trash mulching alone.

2.4 Management of sugarcane early shoot borer, *C. infuscatellus* with insecticide molecules

Field studies conducted at Orissa during 1991-93 to evaluate the efficacy of seven different insecticides against ESB revealed that maximum yield with minimum

damage by the pest were recorded with carbofuran 3 G @ 1.5 kg a.i./ha. Effectiveness of other treatments in the decreasing order were phorate 10 G, aldrin 30 EC and aldrin 5 per cent dust (Jena *et al.*, 1994).

Nagalakshmi *et al.* (1999) reported that soil incorporation of fipronil 0.3 G was effective in reducing the ESB infestation.

Field studies carried out on evaluation of four insecticides namely carbofuran, cartap, diazinon and phorate against ESB, among them carbofuran was found superior in checking the infestation over the others (Talpur *et al.*, 2002).

Ahmad *et al.* (2012) evaluated four insecticides namely carbofuran, dithiocarbamate, phorate and thiosultap-monosodium against ESB, among them carbofuran was relatively more effective in reducing the ESB infestation.

Studies conducted on evaluation of different insecticides against ESB at Tamil Nadu, India indicated that chlorantraniliprole 20 SC @ 75 g a.i./ha seems to offer a good control against ESB and was found to be significantly superior to carbofuran 3 G @ 1 kg a.i./ha (Sheeba Jasmine *et al.*, 2012).

Chlorantraniliprole 18.5 SC @ 0.36 ml/l was found superior in checking the ESB infestation over rest of the insecticides evaluated (Padmasri *et al.*, 2014).

The least incidence of ESB was noticed in soil application of chlorantraniliprole 0.4 G @ 22.5 kg/ha at the time of planting and 60 DAP (6.13 %), followed by spraying of chlorantraniliprole 18.5 SC @ 75 ml/ha at 30 and 60 DAP (6.86 %), soil application of fipronil 0.3 G @ 25 kg a.i./ha at the time of planting and 60 DAP (7.49 %). However, maximum incidence of 16.08 per cent was observed in untreated control (Anon., 2015).

Balikai *et al.* (2015) reported that soil application thiamethoxam 75 SG @ 143 g a.i./ha at the time of planting was effective for management of termites and ESB.

The granular insecticide lasenta (imidacloprid 40 % + fipronil 40 %) 80 WG @ 250 g a.i./ha proved to be most effective against ESB by recording least infestation of 5.12 and 3.17 per cent dead heart at first and second application respectively, followed by chlorantraniliprole 0.4 G @ 30 g a.i./ha, fipronil 0.3 G @ 7.5 g a.i./ha, cartap

hydrochloride 4 G @ 750 g a.i./ha, chlorpyrifos 10 G @ 1 kg a.i./ha, carbofuran 10 G @ 750 g a.i./ha and phorate 10 G 750 g a.i./ha (Bhawar *et al.*, 2015).

The field trial conducted at ARS Sankeshwar during 2007-08 revealed that lower damage due to ESB was recorded by chlorpyrifos 10 G @ 30 kg/ha (10.79 and 12.50 % DH) and chlorpyrifos 10 G @ 25 kg/ha (11.40 and 13.66 % DH) followed by standard check (set treatment with chlorpyrifos 20 EC @ 10 ml/l + spraying with endosulfan 35 EC @ 2 ml/l at 50 & 80 DAP) (11.50 and 12.99 % DH) and carbofuran 3 G @ 33.30 kg/ha (11.82 and 13.67 % DH) at 60 and 90 DAP, respectively and were on par with each other (Tippannavar *et al.*, 2016).

Bhavani (2016) carried out an experiment to test the efficacy of granular insecticides over foliar sprays against the ESB for three successive years from 2008 – 2011 at Andhra Pradesh, results indicated that among the granular insecticides, carbofuran 3 G @ 33 kg/ha (13.44 % DH) and fipronil 0.3 G @ 25 kg/ha (14.20 % DH) recorded significantly less incidence of ESB compared to untreated control (69.3 %). The next best treatment was foliar spray with spinosad 45 SC (18.74 % DH) and was on par with the soil incorporated fipronil 0.3 G.

Among the new insecticides evaluated against ESB chlorantraniliprole 20 SC @ 40 g a.i./ha was found most effective, followed by flubendiamide 480 SC @ 30 g a.i./ha, indoxacarb 14.5 SC @ 30 g a.i./ha, cartap hydrochloride 50 SP @ 375 g a.i./ha, lambda cyhalothrin 5 EC @ 25 g a.i./ha, imidacloprid 17.8 SL @ 25 g a.i./ha (Bhawar *et al.*, 2016).

Chlorantraniliprole 18.5 SC @ 75 ml/ha was superior when it was sprayed at 30 DAP and 60 DAP by recording least cumulative incidence of ESB (5.00 %) and highest yield (86.20 t/ha) followed by chlorantraniliprole 0.4 G, flubendiamide, fipronil 0.3 G, carbofuran 3 G, phorate 10 G and spinosad 45 SC (Anon., 2017b).

3. MATERIAL AND METHODS

Investigations on seasonal incidence of sugarcane early shoot borer, reaction of different genotypes, influence of cultural practices and evaluation of insecticide molecules against ESB were carried out at Agricultural Research Station (ARS), Sankeshwar during 2017-18. Seasonal incidence study was carried out both at ARS, Sankeshwar and farmers' fields in three talukas (Chikhodi, Raibag and Hukkeri) of Belagavi district during 2017-18.

The Agricultural Research Station, Sankeshwar, is situated in the transitional tract, Region IV of Karnataka (Zone-8) at 10° 15' North Latitude and 74° 29' East Longitude with an altitude of 623.3 m above mean sea level. The mean annual rainfall of Sankeshwar is about 850.6 mm. The meteorological observations during experimentation period was presented in Appendix-I.

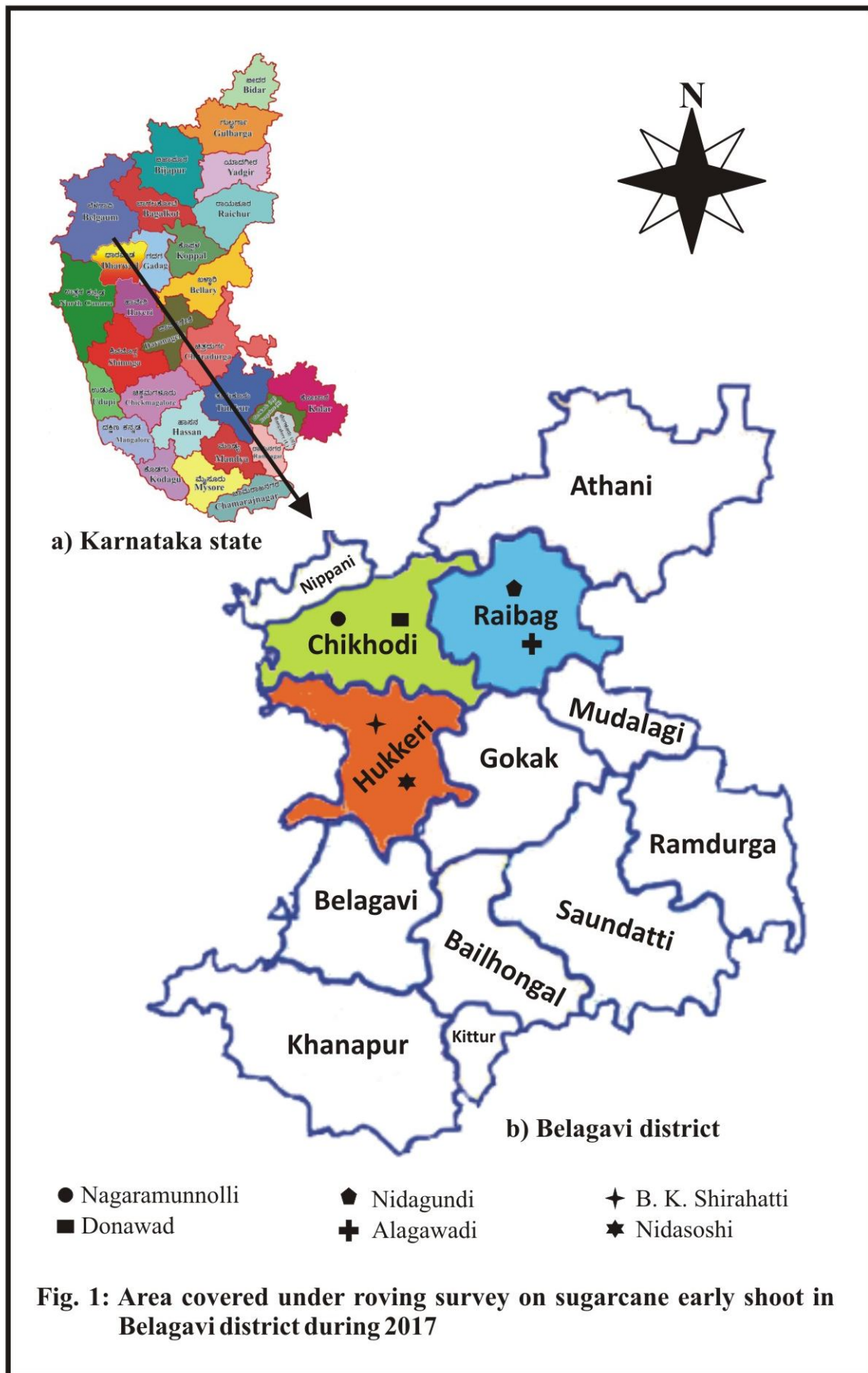
The details of the materials used and the methodology adopted during the course of investigation are delineated here under the following headings.

- 3.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*
- 3.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*
- 3.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*
- 3.4 Management of early shoot borer, *C. infuscatellus* with insecticide molecules

3.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*

3.1.1 Locations

The survey was undertaken to know the seasonal incidence of ESB, *C. infuscatellus* at ARS, Sankeshwar and Chikkodi, Raibag and Hukkeri talukas of Belagavi district.





a) Egg mass



b) Larva



c) Pupa



d) Male



e) Female

Plate 1: Life stage of sugarcane early shoot borer



a) Dead heart



b) Entry hole



c) Tunneling



d) Severely infested field

Plate 2: Visual symptoms of early shoot borer, *Chilo infuscatellus* in sugarcane

3.1.2 Method of survey

3.1.2.1 Roving survey

Roving survey on incidence of sugarcane ESB was carried out at fortnightly interval in and around Chikkodi, Raibag and Hukkeri talukas of Belagavi district from January to June.

Roving survey was conducted in two villages per taluka namely Nagaramunnolli and Donawad in Chikhodi, Nidagundi and Alagawadi in Raibag and B. K. Shirahatti and Nidasoshi in Hukkeri taluka, from each village two fields were selected. In each field five spots were selected randomly, in each spot total number of shoots and number of dead heart (DH) per 20-meter row was recorded and per cent dead was worked out by using the formula,

$$\text{Dead heart (\%)} = \frac{\text{Number of shoots showing dead heart}}{\text{Total number of shoots}} \times 100$$

3.1.2.2 Fixed plot survey

The survey studies were carried out at ARS, Sankeshwar to monitor the pest incidence at different crop stages. The variety Co 86032 was planted during *rabi-summer*, 2016-17 with a row spacing of 1.35 m. Crop was raised as per the package of practices of UAS, Dharwad except the plant protection measures against target pest. The observations on number of shoots showing dead heart due to ESB as well as total number of shoots were recorded regularly at fortnightly interval to assess the per cent incidence of ESB.

3.1.3 Statistical analysis

To study the effect of various weather parameters on the incidence sugarcane early shoot borer, the monthly meteorological data was collected from ARS, Sankeshwar. The data were subjected to statistical analysis and correlation coefficient was worked out by using SPSS software.



Plate 3: General view of experimental plot at ARS, Sankeshwar

3.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*

Field experiment was laid out to study the reaction of different genotypes of sugarcane against ESB. Twelve genotypes were selected for screening, namely Co 09004, SNK 049, SNK 07360, SNK 09211, SNK 09232, CoC 671 in early and CoM 265, SNK 07680, SNK 09227, SNK 09268, SNK 09293 and Co 86032 in mid-late were planted during 2nd fortnight of December 2016 at ARS, Sankeshwar. These genotypes were replicated thrice in Randomized Complete Block Design (RCBD). Plot size was kept at 6.0 m × 5.4 m with row to row spacing of 1.35 m. All recommended crop production practices were adopted during the experimental period. The plant protection measures against other pest and diseases excluding target pest were practiced as per the package of practices of UAS, Dharwad.

Observations were made separately on germination count (30 DAP) and tiller count (60 DAP). Number of shoots showing dead heart (DH) due to ESB as well as total number of shoots per treatment at 45, 60, 75 and 90 DAP was recorded and expressed as per cent DH. After every observation dead hearts were removed and fresh DH count was taken during subsequent observations. Per cent DH was calculated by using the formula as given in 3.1.

The data on per cent DH due to ESB was transformed to arc sine transformation and then subjected to one way ANOVA using M-STATC ® software package. The difference in per cent DH due to ESB among the genotypes was compared by following Duncan's Multiple Range Test (DMRT).

Various growth and yield related parameters viz., cane height, cane girth, single cane weight, number of millable canes, cane yield, per cent brix and per cent pol besides incidence levels were recorded as described here under.

Quantitative parameters (At the time of harvest):

3.2.1 Cane height

The cane height was recorded from the ground level to the last internode of the cane from five randomly selected plants in each plot with the help of measuring scale and the average height was expressed in centimeters (cm).

3.2.2 Cane girth

The diameter of the cane was recorded on the middle internode of the cane by using Vernier Calipers from five randomly selected canes and average girth was expressed in centimeters (cm).

3.2.3 Single cane weight

The single cane weight was recorded by selecting five millable canes randomly in each plot, the average was worked out and expressed as single cane weight in kilograms (kg).

3.2.4 Number of Millable Canes (NMC)

Number of Millable Canes per treatment was recorded and expressed as thousands per hectare ('000/ha).

3.2.5 Cane yield:

All the canes in each plot were harvested close to ground level by removing tops and trashes, cane weight per plot was recorded and expressed as cane yield in tonnes per hectare (t/ha).

Qualitative parameters (At the time of harvest)

3.2.6 Per cent brix

The brix readings were recorded on five randomly selected canes in each plot using brix hydrometer. BUR standards were used to work out the corrected brix readings which were used for calibration of per cent juice in cane.

3.2.7 Per cent pol/Juice sucrose

Five randomly selected canes in each plot were harvested and per cent pol was recorded using polarimeter. The per cent pol was the actual cane sugar present in the juice.

3.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*

The experiment was laid out in RCBD with seven treatments replicated thrice in 6.0 m × 6.75 m plot size with a row spacing of 1.35 m. The variety Co 86032 was planted during *rabi-summer*, 2016-17 at ARS Sankeshwar.

Crop was raised as per the package of practices of UAS, Dharwad except the plant protection measures against the target pest *i.e.*, ESB. Evaluation of different cultural practices was carried out with the treatments as mentioned in Table 1.

Observations were made starting from one month (30 DAP) crop at fortnightly interval upto 90 DAP, germination count was recorded at 30 DAP and tiller count at 60 DAP. After every observation dead heart were removed and fresh DH count was taken during subsequent observations. Visual observations were recorded looking to the symptoms of DH. Number of shoots showing DH due to ESB as well as total number of shoots per treatment at 45, 60, 75 and 90 DAP was recorded and expressed as per cent DH. Per cent DH was calculated by using the formula as given in 3.1.

The data on per cent DH due to ESB was transformed to arc sine transformation and then subjected to one way ANOVA using M-STATC ® software package. The treatment effect was compared by following Duncan's Multiple Range Test (DMRT).

Number of millable canes (NMC) per treatment were recorded at harvest and expressed as '000/ha. At the time of harvest randomly five canes were selected in each treatment and both the quantitative and qualitative parameters were recorded.

3.4 Management of early shoot borer, *C. infuscatellus* with insecticide molecules

The experiment was laid out in RCBD with nine treatments replicated thrice in 6.0 m × 6.75 m plot size with a row spacing of 1.35 m. The variety Co 86032 was planted during *Rabi-summer*, 2016-17 at ARS, Sankeshwar.

Table 1: Treatment details for the evaluation cultural practices against sugarcane early shoot borer

Sl. No	Treatment	Time/period of imposition
1.	Earthing up at 45 DAP (Days after planting)	45 DAP
2.	Earthing up at 60 DAP	60 DAP
3.	Irrigation at weekly interval	Weekly
4.	Irrigation at fortnightly interval	Fortnightly
5.	Intercropping with coriander	At the time of planting
6.	Intercropping with onion	At 15 DAP
7.	Control*	-

*Control- irrigation at 21 days interval, earthing up at 90 DAP and no intercropping

Crop was raised as per the package of practices of UAS, Dharwad except the plant protection measures against target pest. Evaluation of different insecticide molecules was carried out with the treatment details as mentioned in Table 2.

Two insecticidal applications were made at 35 and 60 DAP respectively. T₁ (fipronil 0.3 G @ 20 kg/ha) and T₂ (chlorantraniliprole 0.4 G @ 20 kg/ha) were applied as furrow/soil application and remaining molecules were applied as foliar spray. Before every application DH were removed and fresh DH count was taken during subsequent observations.

Observations were made separately on germination count (30 DAP) and tiller count (60 DAP). Number of millable canes (NMC) per treatment were recorded at harvest and expressed as '000/ha. At the time of harvest randomly five canes were selected in each treatment and both the quantitative and qualitative parameters were recorded. Number of shoots showing DH per treatment due to ESB at 45, 60, 75 and 90 days after planting (DAP) was recorded and expressed as per cent DH. Per cent DH was calculated by using the formula as given in 3.1.

The data on per cent DH due to ESB was transformed to arc sine transformation and then subjected to one way ANOVA using M-STATC ® software package. The treatment effect was compared by following Duncan's Multiple Range Test (DMRT).

Table 2: Treatment details for the management of sugarcane early shoot borer with insecticide molecules

Sl. No	Treatment	Dosage
1	Fipronil 0.3 G (soil application)	20 kg/ha
2	Chlorantraniliprole 0.4 G (soil application)	20 kg/ha
3	Chlorantraniliprole 18.5 SC (foliar application)	0.2 ml/l
4	Imidacloprid 17.8 SL (foliar application)	0.3 ml/l
5	Fipronil 5 SC (foliar application)	1 ml/l
6	Spinosad 45 SC (foliar application)	0.2 ml/l
7	Cypermethrin 10 EC (foliar application)	0.5 ml/l
8	Chlorpyrifos 20 EC (foliar application)	2 ml/l
9	Untreated check	-

4. EXPERIMENTAL RESULTS

Results of the present investigation carried out on sugarcane early shoot borer, *Chilo infuscatellus* pertaining to seasonal incidence, reaction of different genotypes, influence of cultural practices and evaluation of insecticides against ESB are interpreted here under the following headings.

- 4.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*
- 4.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*
- 4.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*
- 4.4 Management of early shoot borer, *C. infuscatellus* with insecticide molecules

4.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*

Roving survey was carried out in and around Chikhodi, Raibag and Hukkeri taluka's of Belagavi district from January to June 2017 to assess the seasonal incidence of sugarcane ESB.

Fixed plot survey was conducted at Agriculture Research Station (ARS) Sankeshwar, to monitor the pest incidence and observations were recorded at fortnightly interval to assess the per cent incidence of the target pest. The data pertaining to survey are presented here under Table 5.

4.1.1 Roving survey

Results pertaining to roving survey indicated that mean per cent DH due to ESB in Belagavi district varied between 13.40 and 18.72. However, the highest incidence was noticed in Raibag taluka to the tune of 18.72 mean per cent DH followed by Chikhodi taluka 17.64 per cent whereas, lowest incidence of 13.44 mean per cent DH was recorded in Hukkeri taluka (Table 3).

Table 3: Status of sugarcane early shoot borer in Belagavi district during 2017

Sl. No	Taluka	Village	Crop stage (DAP)	Dead heart (%)*
1.	Chikhodi	Nagaramunnolli	35-115	17.64
		Donawad	30-120	15.20
	Mean		16.42	
2.	Raibag	Nidagundi	30-115	16.69
		Alagawadi	40-90	18.72
	Mean		17.70	
3.	Hukkeri	B. K. Shirahatti	35-105	13.40
		Nidasoshi	35-90	15.93
	Mean		14.66	

*Mean of 12 observations at fortnightly interval starting from January to June

4.1.1.1 Chikhodi taluka

The result obtained (Table 3) revealed that the mean per cent DH due to ESB was observed in two villages of Chikhodi taluka. The incidence was higher in Nagaramunnolli (17.64 % DH) with 35-115 days old crop, while it was lower in Donawad (15.20 % DH) with 30-120 days old crop.

4.1.1.2 Raibag taluka

During the survey carried out in two villages of Raibag taluka, it was found that the mean per cent DH due to ESB was higher in Alagawadi (18.72 % DH) with 40-90 days old crop and lower in Nidagundi (16.69 % DH) with 30-115 days old crop (Table 3).

4.1.1.3 Hukkeri taluka

Similarly, in Hukkeri taluka, the higher incidence of 15.93 mean per cent DH was recorded in Nidasoshi with 35-90 days old crop whereas, lower incidence of 13.40 mean per cent DH was recorded in B. K. Shirahatti with 35-105 days old crop (Table 3).

Seasonal incidence of ESB on the variety Co 86032 in Belagavi district during the year 2017 revealed that the mean incidence of ESB varied from 11.27 per cent (January) to 23.49 per cent (May). The mean per cent DH of all the three talukas indicated during the month of May (23.49 % DH) maximum mean per cent DH with 50-90 days old crop whereas, least mean per cent DH was observed in January (11.27 % DH) with 30-55 days old crop. However, mean per cent DH recorded during February (14.18 % DH) with 40-60 days old crop, March (16.77 % DH) with 45-75 old crop, April (20.07 % DH) with 45-90 days old crop and June (11.78 % DH) with 80-120 days old crop (Table 4).

4.1.2 Fixed plot survey

Fixed plot survey was carried out at ARS, Sankeshwar (fortnightly interval) during course of study and the results were presented in Table 5.

Incidence of ESB in fixed plot was noticed from February (14.50 % DH) to May (14.70 % DH). However, the higher incidence was noticed during the month of April

Table 4: Seasonal incidence of sugarcane early shoot borer in Belagavi district during 2017

Month	Dead heart (%) in different talukas						Mean*
	Crop stage (DAP)	Chikhodi	Crop stage (DAP)	Raibag	Crop stage (DAP)	Hukkeri	
January	30-45	11.19	30-55	12.47	35-45	10.15	11.27
February	40-60	14.51	40-60	16.11	45-60	11.92	14.18
March	45-60	16.69	45-60	17.89	45-75	15.74	16.77
April	45-75	19.88	48-75	21.44	60-90	18.89	20.07
May	50-90	24.21	60-90	25.41	50-75	20.87	23.49
June	90-120	12.01	80-115	12.91	90-105	10.42	11.78
Mean	16.42		17.70		14.66		16.26

*Mean of three talukas



a) Hukkeri



b) Raibag



c) Chikhodi

Plate 4: Roving survey carried out in Belagavi district during 2017

Table 5: Seasonal incidence of sugarcane early shoot borer at ARS, Sankeshwar (fixed plot) during 2017

Month	Stage of the crop (DAP)	Dead heart (%)	Temperature (°C)		Relative humidity (%)	Rain fall (mm)	Rainy days
			Max.	Min.			
February	45	14.50	34.0	13.5	40	0.0	0
March	60	19.00	35.7	15.0	42	0.0	0
April	90	25.80	37.9	18.5	41	3.8	1
May	> 90	14.70	36.7	20.1	57	52.6	3
Mean		18.50					

DAP-Days after planting, variety- Co 86032

Table 6: Correlation between per cent dead heart due early shoot borer with abiotic factors

Sl. No.	Abiotic factors	Correlation
1	Maximum temperature	0.728
2	Minimum temperature	0.251
3	Relative humidity	-0.441
4	Rain fall	-0.422
5	Number of rainy days	-0.183



Plate 5: Fixed plot survey studies at ARS, Sankeshwar

(25.80 % DH) when the crop was 90 days old, followed by March (19.00 % DH) with 60 days old crop, whereas the lower per cent DH was noticed during the month of February (14.50 % DH) and May (14.70 % DH) when the crop was 45 and more than 90 days old, respectively.

Correlation studies between the per cent DH in relation to weather parameters showed positive correlation with maximum temperature ($r = 0.728$) and minimum temperature ($r = 0.251$) while, it was negatively correlated with relative humidity ($r = -0.441$), rain fall ($r = -0.422$) and number of rainy days ($r = -0.183$) (Table 6).

4.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*

Twelve sugarcane genotypes namely, Co 09004, SNK 049, SNK 07360, SNK 09211, SNK 09232, CoC 671 in early and CoM 265, SNK 07680, SNK 09227, SNK 09268, SNK 09293, Co 86032 in mid-late groups were evaluated for their reaction against ESB under unprotected conditions and the results are presented here under following headings.

4.2.1 Reaction of different genotypes against early shoot borer infestation

4.2.1.1 Germination (%)

The result revealed that the per cent germination among different genotypes at 30 DAP was ranged between 66.98 and 81.15 and were found non-significant among themselves (Table 7).

4.2.1.2 Tiller count

The results indicated that the tiller count at 60 DAP was varied between 131.00 and 217.00 per plot. Among the early genotypes, Co 09004 recorded the maximum tillers of 173.73 per plot and was on par with SNK 09211 (155.67). However, the least tiller count was noticed in SNK 07360 (131.00) and was at par with SNK 09232 (142.00), SNK 049 (143.00) and the check entry CoC 671 (140.67). Among the mid-late genotypes CoM 265 recorded maximum tillers of 217.00 per plot which was on par

Table 7: Reaction of different sugarcane genotypes against early shoot borer

Sl. No	Genotypes	Germination at 30 DAP (%)	Tiller count at 60 DAP (per plot)	Dead heart (%) at				
				45 DAP	60 DAP	75 DAP	90 DAP	Mean
1	Co 09004	78.56 (62.53) ^a	173.33 ^b	3.73 (10.82) ^a	7.71 (16.03) ^a	8.65 (17.01) ^a	11.13 (19.07) ^a	7.81 (16.17) ^a
2	SNK 049	70.45 (57.12) ^a	143.00 ^{cd}	5.57 (13.38) ^{bc}	11.17 (19.46) ^{bc}	13.14 (21.23) ^{bc}	15.34 (23.01) ^{bc}	11.31 (19.63) ^{bc}
3	SNK 07360	73.38 (59.01) ^a	131.00 ^d	8.40 (16.80) ^{def}	16.87 (24.22) ^{def}	19.02 (25.82) ^{def}	21.07 (27.29) ^{def}	16.34 (23.81) ^{ef}
4	SNK 09211	69.80 (56.68) ^a	155.67 ^{bcd}	4.73 (12.29) ^{ab}	9.95 (18.32) ^{ab}	11.65 (19.91) ^b	13.17 (22.15) ^b	9.88 (18.31) ^b
5	SNK 09232	70.26 (57.03) ^a	142.00 ^{cd}	6.80 (15.05) ^{cd}	13.02 (21.11) ^{bcd}	15.10 (22.83) ^{bcd}	17.11 (24.40) ^{bcd}	13.01 (21.12) ^{cd}
6	CoM 265	81.15 (64.76) ^a	217.00 ^a	7.70 (16.08) ^{de}	12.57 (20.74) ^{bcd}	14.14 (22.05) ^{bc}	15.09 (22.85) ^{bc}	12.38 (20.58) ^{cd}
7	SNK 07680	79.06 (63.10) ^a	146.33 ^{cd}	15.07 (23.29) ^h	24.10 (29.33) ^g	26.44 (30.90) ^g	29.91 (33.57) ^g	23.88 (29.22) ^h
8	SNK 09227	72.90 (58.82) ^a	172.33 ^b	12.77 (20.91) ^{gh}	17.73 (24.88) ^{ef}	20.68 (27.01) ^{ef}	24.06 (29.35) ^{ef}	18.81 (25.69) ^{fg}
9	SNK 09268	66.98 (55.13) ^a	176.00 ^b	10.73 (19.10) ^{fg}	15.33 (23.02) ^{def}	16.75 (24.13) ^{cde}	20.15 (26.63) ^{de}	15.74 (23.37) ^e
10	SNK 09293	68.14 (55.72) ^a	200.33 ^a	9.47 (18.16) ^{ef}	14.15 (22.06) ^{cde}	15.17 (22.90) ^{bcd}	18.22 (25.25) ^{bcd}	14.25 (22.17) ^{de}
11	CoC 671(Check E)	70.77 (57.33) ^a	140.67 ^{cd}	7.40 (15.79) ^{cde}	15.15 (22.86) ^{cdef}	17.11 (24.41) ^{cde}	19.34 (26.06) ^{cde}	14.75 (22.57) ^{de}
12	Co 86032 (Check ML)	71.35 (58.17) ^a	165.33 ^{bc}	14.26 (21.97) ^h	19.50 (26.17) ^f	21.68 (27.72) ^f	26.12 (30.50) ^f	20.39 (26.81) ^g
S.Em. ±		3.35	7.63	0.80	1.07	0.99	1.05	0.65
C.D. (p = 0.05)		NS	22.39	2.35	3.12	2.89	3.07	1.92
C.V. (%)		9.88	8.09	8.18	8.26	7.17	7.02	6.04

Figures in the parenthesis are arc sine transformed values, Check E- check in early genotypes, Check ML- check in mid-late genotypes

Means showing similar alphabets do not differ significantly by DMRT (p = 0.05), DAP – Days after planting

with SNK 09293 (200.33) and was found significantly superior over SNK 09268 (176.00) which was on par with SNK 09227 (172.33) and the check Co 86032 (165.33). However, the least tiller count of 149.33 per plot was noticed in SNK 07680. Among both early as well as mid-late genotypes, the entries belong to mid-late group recorded higher tiller count (Table 7).

4.2.1.3 Dead heart (%) due to early shoot borer

Results pertaining to per cent DH at 45 days after planting (DAP) indicated that, among the six early genotypes including check, Co 09004 recorded least per cent DH of 3.73 due to ESB and was at par with SNK 09211 (4.73 % DH). The next best entry was SNK 049 (5.57 % DH) which was on par the entry SNK 09232 (6.80 % DH) and found superior over the check entry CoC 671 (7.40 % DH). However, the genotype SNK 07360 recorded highest per cent DH of 8.40. Among the six mid-late genotypes including the check entry screened against ESB, revealed that, the genotype CoM 265 recorded least per cent DH of 7.70 due to ESB and was on par with SNK 09293 (9.47 % DH). The next best entry was SNK 09268 which recorded 10.73 per cent DH due to ESB and was found at par with the entry SNK 09227 (12.77 % DH) and found superior over the check entry Co 86032 (14.26 % DH). However, the entry SNK 07680 recorded highest per cent DH of 15.07. Among both early as well as mid-late genotypes screened, the entries belongs to early group recorded least per cent DH due to ESB at 45 DAP (Table 7).

At 60 DAP, among early genotypes, Co 09004 recorded least per cent DH of 7.71 due to ESB and was on par with SNK 09211 (9.95 % DH), followed by SNK 049 (11.17 % DH) which was at par with the entry SNK 09232 (13.02 % DH) and found superior over the check entry viz., CoC 671 (15.15 % DH). However, the entry SNK 07360 recorded highest per cent DH of 16.87. Among the mid-late genotypes, CoM 265 recorded least per cent DH of 12.57 and was at par with SNK 09293 (14.15 % DH) and SNK 09268 (15.33 % DH). The next best entry was SNK 09227 which recorded 17.73 per cent DH due to ESB and was on par with the check entry Co 86032 (19.50 % DH). The highest per cent DH of 24.10 was recorded by SNK 07680. However, early genotypes recorded least per cent DH due to ESB among both early and mid-late groups (Table 7).

At 75 DAP, the genotype Co 09004 recorded significantly lower per cent DH of 8.65 due to ESB in early group and was followed by SNK 09211 (11.65 % DH). The next best entry was SNK 049 (13.14 % DH) which was at par with the entry SNK 09232 (15.10 % DH) and found superior over the check entry CoC 671 (17.11 % DH). The genotype SNK 07360 recorded highest per cent DH of 19.02. Among mid-late genotypes CoM 265 recorded least per cent DH of 14.14 and was found at par with SNK 09293 (15.17 % DH) and SNK 09268 (16.75 % DH). The genotype next to follow was SNK 09227 (20.68 % DH) and was on par with check entry Co 86032 (21.68 % DH). However, the entry SNK 07680 recorded highest per cent DH of 26.44. Among both early as well as mid-late genotypes the entries belongs to mid-late group recorded higher per cent DH due to ESB (Table 7).

At 90 DAP, among early genotypes including the check, Co 09004 recorded least per cent DH of 11.13 and was followed by SNK 09211 (13.17 % DH) which was on par with SNK 049 (15.34 % DH) and SNK 09232 (17.11 % DH) and found superior over check entry CoC 671 (19.34 % DH). The highest per cent DH of 21.07 was recorded by the entry SNK 07360. Among the mid-late genotypes including the check entry screened against ESB, indicated that, the genotype CoM 265 recorded least per cent DH of 15.09 and was at par with SNK 09293 by recording 18.22 per cent DH. The next best entry was SNK 09268 which recorded 20.15 per cent DH due to ESB and was on par SNK 09227 (24.06 % DH). However, the genotype SNK 07680 recorded highest per cent DH of 29.91 and was followed by the check entry Co 86032 (26.12 % DH). The early genotypes recorded least per cent DH due to ESB among both early and mid-late genotypes (Table 7).

Results pertaining to mean per cent DH due to ESB indicated that, among the early genotypes, Co 09004 recorded least per cent DH (7.81 %) and was followed by SNK 09211 (9.88 % DH). The next best entry was SNK 049 (11.31 % DH) and was on par with SNK 09232 (12.38 % DH) and found superior over the check entry CoC 671 (14.75 % DH). However, the genotype SNK 07360 recorded highest per cent DH of 16.34. Among the mid-late genotypes CoM 265 recorded least per cent DH of 12.38 which was on par SNK 09293 (14.25 % DH). The genotype next to follow was SNK 09268 (15.74 % DH) and found superior over SNK 09227 (18.81 % DH) and the check entry Co 86032 (20.39 % DH). The entry SNK 07680 recorded highest per cent DH of

23.88. However among both early as well as mid-late genotypes screened, the genotypes belongs to early group recorded least per cent DH due to ESB (Table 7).

4.2.2 Reaction of different sugarcane genotypes against early shoot borer with respect to qualitative and quantitative parameters

Quantitative parameters

4.2.2.1 Cane height

The cane height of different genotypes ranged between 168.13 and 245.93 cm. Among the early genotypes, Co 09004 recorded maximum cane height of 245.93 cm and was at par with SNK 09232 (238.67 cm), SNK 09211 (231.87 cm) and SNK 049 (225.97 cm), followed by the check entry CoC 671 (181.40 cm). However, the entry SNK 07360 recorded least cane height of 168.13 cm. Among the mid-late genotypes, the entry SNK 09268 recorded maximum cane height of 244.93 cm which was on par with SNK 09293 (236.50 cm) and CoM 265 (235.47 cm). The genotype next follow was SNK 07680 which recorded 223.80 cm cane height and was at par with SNK 09227 (217.73 cm). However, the check entry Co 86032 recorded least cane height of 194.87 cm (Table 8).

4.2.2.2 Cane girth

The cane girth of different genotypes varied from 2.49 to 3.37 cm. Among the early genotypes, SNK 07360 recorded maximum cane girth of 3.37 cm and was followed by Co 09004 (2.75 cm) which was at par with the check entry CoC 671 (2.64 cm), SNK 09211 (2.63 cm), SNK 049 (2.58 cm) and SNK 09232 (2.49 cm). Among the mid-late genotypes, SNK 09293 recorded maximum cane girth of 3.26 cm and was followed by SNK 09227 which recorded 3.00 cm cane girth. The next best entry was SNK 07680 (2.95 cm) which was statistically at par with CoM 265 (2.93 cm) and SNK 09268 (2.79 cm). However, the check entry Co 86032 recorded least cane girth of 2.68 cm (Table 8).

Table 8: Reaction of different sugarcane genotypes against early shoot borer with respect to qualitative and quantitative parameters

Sl. No	Genotypes	Cane height (cm)	Cane girth (cm)	Single cane weight (kg)	Brix (%)	Pol (%)	Number of millable canes ('000/ha)	Cane yield (t/ha)
1	Co 09004	245.93 ^a	2.75 ^{bcde}	1.64 ^b	23.33 ^{ab}	88.22 ^{ab}	61.10 ^{bcd}	93.83 ^{cd}
2	SNK 049	225.97 ^{abc}	2.58 ^{de}	1.33 ^{de}	21.67 ^{bcd}	80.38 ^{bc}	63.86 ^{bcd}	82.06 ^e
3	SNK 07360	168.13 ^e	3.37 ^a	1.61 ^b	20.58 ^{cd}	74.32 ^{cd}	44.16 ^e	71.29 ^f
4	SNK 09211	231.87 ^{abc}	2.63 ^{de}	1.56 ^{bc}	23.33 ^{ab}	86.58 ^{ab}	57.61 ^d	90.29 ^{cde}
5	SNK 09232	238.67 ^{abc}	2.49 ^e	1.24 ^{ef}	21.83 ^{bc}	80.45 ^{bc}	66.46 ^{bc}	81.57 ^e
6	CoM 265	235.47 ^{abc}	2.93 ^{bc}	1.59 ^b	20.92 ^{cd}	74.93 ^{cd}	76.44 ^a	107.09 ^{ab}
7	SNK 07680	223.80 ^{bc}	2.95 ^{bc}	1.49 ^{bc}	22.58 ^{abc}	82.05 ^{bc}	61.22 ^{bcd}	93.47 ^{cd}
8	SNK 09227	217.73 ^c	3.00 ^b	1.42 ^{cd}	21.50 ^{bcd}	77.68 ^c	68.57 ^b	96.14 ^c
9	SNK 09268	244.93 ^{ab}	2.79 ^{bcd}	1.56 ^{bc}	20.42 ^{cd}	74.57 ^{cd}	68.50 ^b	99.33 ^{bc}
10	SNK 09293	236.50 ^{abc}	3.26 ^a	1.91 ^a	19.50 ^d	67.45 ^d	60.13 ^{bcd}	116.13 ^a
11	CoC 671(Check E)	181.40 ^{de}	2.64 ^{de}	1.31 ^{de}	24.08 ^a	90.45 ^a	58.60 ^{cd}	80.93 ^e
12	Co 86032 (Check ML)	194.87 ^d	2.68 ^{cde}	1.12 ^f	21.67 ^{bcd}	81.35 ^{bc}	78.31 ^a	85.28 ^{de}
S.Em. ±		6.57	0.09	0.05	0.68	2.41	2.58	3.20
C.D. (p = 0.05)		19.27	0.26	0.14	1.98	7.07	7.56	9.39
C.V. (%)		6.16	6.45	6.56	5.38	5.23	7.01	6.06

Means showing similar alphabets do not differ significantly by DMRT (p = 0.05)

Check E- check in early genotypes, Check ML- check in mid-late genotypes

4.2.2.3 Single cane weight

Among the early genotypes, Co 09004 recorded maximum single cane weight of 1.64 kg which was on par with SNK 07360 (1.61 kg) and SNK 09211 (1.56 kg). However, the entry SNK 09232 recorded least single cane weight of 1.24 kg which was at par with SNK 049 (1.33 kg) and the check entry CoC 671 (1.31 kg). Among the mid-late genotypes, the entry SNK 09293 recorded maximum single cane weight of 1.91 kg and was statistically superior over rest of the genotypes. The genotype next to follow was CoM 265 (1.59 kg) which was at par with SNK 09268 (1.56 kg) and SNK 07680 which recorded 1.49 kg, followed by SNK 09227 (1.42 kg). However, the check entry Co 86032 recorded least single cane weight of 1.12 kg (Table 8).

4.2.2.4 Number of millable canes (NMC) (000's/ha)

Among the early genotypes, SNK 09232 recorded maximum NMC of 66.46 thousands per hectare and was on par with SNK 049 (63.86) and Co 09004 (61.10). The genotype next to follow was CoC 671 (58.60) and was at par with SNK 09211 (57.61). However, the entry SNK 07360 recorded least NMC of 44.16. Among the mid-late genotypes, the check entry Co 86032 recorded maximum NMC of 78.31 which was at par with CoM 265 (76.44) and significantly superior over rest of the genotypes, followed by SNK 09227 (68.57) which was on par with SNK 09268 (68.50) and SNK 07680 (61.22). However, the entry SNK 09293 recorded least NMC of 60.13 thousands per hectare (Table 8).

4.2.2.5 Cane yield

Among the early genotypes, Co 09004 recorded maximum cane yield of 93.83 t/ha and was at par with SNK 09211 (90.29 t/ha). The next best genotype was SNK 049 (82.06 t/ha) which was on par with SNK 09232 (81.57 t/ha) and the check entry CoC 671 (80.93 t/ha). However, the entry SNK 07360 recorded least cane yield of 71.29 t/ha. Among the six mid-late genotypes, SNK 09293 recorded maximum cane yield of 116.13 t/ha which was on par with CoM 265 (107.09 t/ha) followed by SNK 09268



i) Co 09004



ii) CoC 671 (Check)

a) Early genotypes



i) CoM 265



ii) Co 86032 (Check)

b) Mid-late genotypes

Plate 6: Reaction of different sugarcane genotypes against early shoot borer

(99.33 t/ha) and was on par with SNK 09227 (96.14 t/ha) and SNK 07680 (93.47 t/ha). However, the check entry Co 86032 recorded least cane yield of 85.28 t/ha (Table 8).

Qualitative parameters

4.2.2.6 Per cent brix

Among early genotypes, the check entry CoC 671 recorded maximum per cent brix of 24.08 and was at par with Co 09004 (23.33 %) and SNK 09211 (23.33 %), followed by SNK 09232 (21.83 %) which was on par with SNK 049 (21.67 %) and SNK 07360 (20.58 %). Among the mid-late genotypes, SNK 07680 recorded maximum per cent brix of 22.58 which was on par with the check entry Co 86032 (21.67 %) and SNK 09227 (21.50 %), followed by CoM 265 (20.92 %) and was on par with SNK 09268 (20.42 %). However, the genotype SNK 09293 recorded least per cent brix of 19.50 (Table 8).

4.2.2.7 Per cent pol

Among early genotypes, the check entry CoC 671 recorded maximum per cent pol of 90.45 and was at par with Co 09004 (88.22) and SNK 09211 (86.58). However, the genotype SNK 07360 recorded least per cent pol of 74.32 which was at par with SNK 049 (80.38 %) and SNK 09232 (80.45 %). Among the mid-late genotypes, SNK 07680 recorded maximum per cent pol of 82.05 which was on par with the check entry Co 86032 (81.35 %). The next best entry was SNK 09227 (77.68 %) which was on par with CoM 265 (74.93 %) and SNK 09268 (74.57 %). However, the entry SNK 09293 recorded least per cent pol of 67.45 (Table 8).

4.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*

The experiment was conducted at ARS, Sankeshwar during 2017-18 to study the influence of cultural practices against ESB and the results obtained are presented below.

4.3.1 Influence of cultural practices against early shoot borer

4.3.1.1 Germination (%)

The result indicated that the per cent germination at 30 DAP ranged between 63.87 and 78.28 and were found non-significant among treatments (Table 9).

4.3.1.2 Tiller count

The tiller count per plot at 60 DAP was varied between 274.00 and 309.00 and the results were found non-significant among the treatments (Table 9).

4.3.1.3 Dead heart (%) due to early shoot borer

At 45 days after planting (DAP), the treatment T₃ (irrigation at weekly interval) recorded significantly lower per cent dead heart (4.44 % DH) due to ESB and was found superior over remaining treatments, it was followed by T₆ (intercropping with onion) with 6.26 per cent DH and was on par with T₅ (intercropping with coriander) which recorded 6.86 per cent DH. The treatment next to follow was, T₄ (irrigation at fortnightly interval) which recorded 9.55 per cent DH. The higher per cent DH was recorded in T₇ (control) (13.11 % DH) which was at par with T₂ (earthing up at 60 DAP) and T₁ (earthing up at 45 DAP) with 12.86 and 12.10 per cent DH, respectively (Table 9).

At 60 DAP, the treatment T₃ (irrigation at weekly interval) exhibited significantly lower per cent DH of 6.41 per cent due to ESB, which was on par with T₁ (earthing up at 45 DAP) with 6.81 per cent DH and found superior over rest of the treatments. The next best treatments viz., T₆ (intercropping with onion) recorded 9.24 per cent DH which was at par with T₅ (intercropping with coriander) (9.71 % DH), followed by T₄ (irrigation at fortnightly interval) (12.78 % DH). However, the higher per cent DH was noticed in T₇ (control) (18.44 % DH) which was on par with T₂ (earthing up at 60 DAP) with 15.57 per cent DH (Table 9).

At 75 DAP the treatment T₂ (earthing up at 60 DAP) recorded significantly lower per cent DH due to ESB (8.32 % DH) which was at par with T₁ (earthing up at 45 DAP) and T₃ (irrigation at weekly interval) with 8.91 and 9.73 per cent DH,

Table 9: Influence of different cultural practices against sugarcane early shoot borer

Sl. No	Treatment	Germination at 30 DAP (%)	Tiller count at 60 DAP (per plot)	Dead heart (%) at				Mean
				45 DAP	60 DAP	75 DAP	90 DAP	
1	Earthing up at 45 DAP	74.31 (59.88) ^a	299.33 ^a	12.10 (20.33) ^d	6.81 (15.11) ^a	8.91 (17.34) ^a	11.55 (19.75) ^a	9.84 (18.26) ^{ab}
2	Earthing up at 60 DAP	74.72 (59.92) ^a	275.33 ^a	12.86 (21.01) ^d	15.57 (23.22) ^d	8.32 (16.73) ^a	9.53 (17.97) ^a	11.57 (19.86) ^{bc}
3	Irrigation at weekly interval	78.28 (62.42) ^a	309.00 ^a	4.44 (12.15) ^a	6.41 (14.65) ^a	9.73 (18.15) ^a	11.84 (20.11) ^{ab}	8.11 (16.52) ^a
4	Irrigation at fortnightly interval	68.56 (55.96) ^a	273.67 ^a	9.55 (17.98) ^c	12.78 (20.92) ^c	14.71 (22.54) ^c	17.71 (24.87) ^d	13.69 (21.69) ^c
5	Intercropping with coriander	70.76 (57.72) ^a	282.33 ^a	6.86 (15.12) ^b	9.71 (18.13) ^b	12.55 (20.71) ^{bc}	15.55 (23.21) ^{cd}	11.17 (19.49) ^b
6	Intercropping with onion	73.13 (58.65) ^a	295.67 ^a	6.26 (14.45) ^b	9.24 (17.66) ^b	12.21 (20.43) ^b	14.45 (22.32) ^{bc}	10.54 (18.92) ^b
7	Control	63.87 (53.21) ^a	274.00 ^a	13.11 (21.20) ^d	18.44 (25.38) ^d	19.41 (26.12) ^d	23.99 (29.30) ^e	18.74 (25.63) ^d
S. Em. ±		3.87	12.23	0.69	0.71	0.63	0.76	0.61
C.D. (p = 0.05)		NS	NS	2.14	2.18	1.94	2.33	1.86
C.V. (%)		11.50	7.38	6.88	6.35	6.38	6.84	5.23

Figures in the parenthesis are arc sine transformed values,

Means showing similar alphabets do not differ significantly by DMRT (p = 0.05)

DAP – Days after planting

respectively. These were followed by T₆ (intercropping with onion) and T₄ (Irrigation at fortnightly interval) with 12.21 and 14.71 per cent DH, respectively. However, T₅ (intercropping with coriander) recorded 12.55 per cent DH which was on par with both T₆ and T₄, respectively. The treatment T₇ (control) recorded higher per cent DH of 19.41 (Table 9).

At 90 DAP, the treatment T₂ (earthing up at 60 DAP) recorded significantly lower per cent DH due to ESB (9.53 % DH) and was at par with T₁ (earthing up at 45 DAP) and T₃ (irrigation at weekly interval) with 11.55 and 11.84 per cent DH, respectively. The next best treatment was T₆ (intercropping with onion) which recorded 14.45 per cent DH and was on par with T₅ (intercropping with coriander) (15.55 % DH), followed by T₄ (irrigation at fortnightly interval) (17.71 % DH). However, the treatment T₇ (control) recorded higher per cent DH of 23.99 (Table 9).

The results pertaining to mean per cent DH due ESB revealed that among the different treatments mean per cent DH varied from 8.11 to 18.74. However, the treatment T₃ (irrigation at weekly interval) recorded the least mean per cent DH of 8.11 which was at par with T₁ (earthing up at 45 DAP) (9.84 % DH). The next best treatment was T₆ (intercropping with onion) (10.54 % DH) which was at par with T₅ (intercropping with coriander) and T₂ (earthing up at 60 DAP) with 11.17 and 11.57 per cent DH, respectively, followed by T₄ (irrigation at fortnightly interval) (13.69 % DH). However, the treatment T₇ (control) recorded mean higher per cent DH of 18.74 (Table 9).

4.3.2 Effect of different cultural practices against sugarcane early shoot borer with respect to qualitative and quantitative parameters

Quantitative parameters

4.3.2.1 Cane height

The cane height in different treatments ranged from 192.40 to 230.60 cm. Among all the treatments, the treatment T₃ (irrigation at weekly interval) recorded maximum cane height of 230.60 cm which was at par with T₁ (earthing up at 45 DAP), T₆ (intercropping with onion), T₅ (intercropping with coriander) and T₂ (earthing up at 60 DAP) by recording 227.67, 223.80, 220.20 and 214.87 cm cane height, respectively,

followed by T₄ (irrigation at fortnightly interval) (201.07 cm). However, the treatment T₇ (control) recorded least cane height of 192.40 cm (Table 10).

4.3.2.2 Cane girth

The results revealed that the cane girth among different treatments varied between 2.26 and 3.14 cm. The treatment T₃ (irrigation at weekly interval) recorded maximum cane girth of 3.14 cm and was at par with T₁ (earthing up at 45 DAP) (3.03 cm), T₆ (intercropping with onion) (2.91 cm) and T₅ (intercropping with coriander) (2.79 cm), respectively. The next best treatment was T₂ (earthing up at 60 DAP) (2.71 cm) followed by T₄ (irrigation at fortnightly interval) which recorded 2.39 cm cane girth. However, the treatment T₇ (control) recorded least cane girth of 2.26 cm (Table 10).

4.3.2.3 Single cane weight

The maximum single cane weight of 1.51 kg was recorded by the treatment T₃ (irrigation at weekly interval) and was at par with T₁ (earthing up at 45 DAP), T₆ (intercropping with onion), T₅ (intercropping with coriander) and T₂ (earthing up at 60 DAP) which recorded 1.42, 1.38, 1.36 and 1.35 kg single cane weight, respectively. The next best treatment was T₄ (irrigation at fortnightly interval) (1.25 kg cm). However, the least single cane weight of 1.16 kg was recorded in T₇ (control) (Table 10).

4.3.2.4 Number of millable canes (NMC) (000's/ha)

The results (Table 10) indicated that at harvest, the treatment T₃ (irrigation at weekly interval) recorded significantly higher NMC (73.56) and was on par with T₁ (earthing up at 45 DAP) (72.67) and T₆ (intercropping with onion) (70.67), respectively, followed by T₅ (intercropping with coriander) (66.61). The treatment next to follow was T₂ (earthing up at 60 DAP) (63.08) which was on par with T₄ (irrigation at fortnightly interval) (61.53). The lower NMC (52.61) were recorded in T₇ (control).

4.3.2.5 Cane yield

The results (Table 10) revealed that the cane yield among different treatments under study ranged from 73.69 to 97.42 t/ha. The treatment T₃ (irrigation at weekly

Table 10: Effect of different cultural practices against sugarcane early shoot borer with respect to qualitative and quantitative parameters

Sl. No	Treatment	Cane height (cm)	Cane girth (cm)	Single cane weight (kg)	Brix (%)	Pol (%)	Number of millable canes '000/ha)	Cane yield (t/ha)
1	Earthing up at 45 DAP	227.67 ^a	3.03 ^{ab}	1.42 ^{ab}	23.58 ^{ab}	87.75 ^{ab}	72.67 ^{ab}	96.07 ^a
2	Earthing up at 60 DAP	214.87 ^{ab}	2.71 ^{bc}	1.35 ^{ab}	21.25 ^{bcd}	82.77 ^{ab}	63.08 ^c	87.47 ^{bc}
3	Irrigation at weekly interval	230.60 ^a	3.14 ^a	1.51 ^a	24.25 ^a	91.00 ^a	73.56 ^a	97.42 ^a
4	Irrigation at fortnightly interval	201.07 ^{bc}	2.39 ^{cd}	1.25 ^{bc}	20.67 ^{cd}	80.25 ^b	61.53 ^c	85.90 ^c
5	Intercropping with coriander	220.20 ^{ab}	2.79 ^{ab}	1.36 ^{ab}	22.33 ^{abcd}	83.87 ^{ab}	66.61 ^{bc}	91.59 ^{abc}
6	Intercropping with onion	223.80 ^a	2.91 ^{ab}	1.38 ^{ab}	23.02 ^{abc}	85.92 ^{ab}	70.67 ^{ab}	94.28 ^{ab}
7	Control	192.40 ^c	2.26 ^d	1.16 ^c	19.83 ^d	70.08 ^c	52.61 ^d	73.69 ^d
S. Em. ±		6.28	0.12	0.05	0.77	2.45	2.00	2.45
C.D. (p = 0.05)		19.36	0.38	0.16	2.38	7.55	6.16	7.55
C.V. (%)		6.05	7.78	7.55	7.04	6.04	6.26	6.74

Means showing similar alphabets do not differ significantly by DMRT (p = 0.05)



c) Intercropping with onion



b) Earthing up at 45 DAP



a) Irrigation at weekly interval



f) Control



e) Irrigation at fortnightly interval



d) Intercropping with coriander

Plate 7: Influence of different cultural practices against sugarcane early shoot borer

interval) recorded significantly highest cane yield of 97.42 tonnes per hectare, which was at par with T₁ (earthing up at 45 DAP) (96.07 t/ha), T₆ (intercropping with onion) (94.28 t/ha) and T₅ (intercropping with coriander) (91.59 t/ha), respectively, followed by T₂ (earthing up at 60 DAP) (87.47 t/ha) which was on par with T₄ (irrigation at fortnightly interval) (85.90 t/ha). However, the least cane yield of 73.69 t/ha was recorded in T₇ (control).

Qualitative parameters

4.3.2.6 Per cent brix

The per cent brix among different treatments ranged from 19.83 to 24.25. The treatment T₃ (irrigation at weekly interval) recorded significantly highest per cent brix of 24.25, which was at par with T₁ (earthing up at 45 DAP) (23.58 %), T₆ (intercropping with onion) (23.02 %) and T₅ (intercropping with coriander) (22.33 %), respectively. However, the least per cent brix of 19.83 was recorded in T₇ (control) and was on par with T₄ (irrigation at fortnightly interval) and T₂ (earthing up at 60 DAP) by recording 20.67 and 21.25 per cent brix, respectively (Table 10).

4.3.2.7 Per cent pol

The treatment T₃ (irrigation at weekly interval) recorded significantly highest per cent pol (91.00 %) and was found on par with T₁ (earthing up at 45 DAP) (87.75 %), T₆ (intercropping with onion) (85.92 %), T₅ (intercropping with coriander) (83.87 %) and T₂ (earthing up at 60 DAP) (82.77 %), respectively. However, the treatment T₇ (control) recorded least per cent pol of 70.08 and was on par with T₄ (irrigation at fortnightly interval) by recording 80.25 per cent pol (Table 10).

4.4 Management of sugarcane early shoot borer, *C. infuscatellus* with insecticide molecules

The experiment was conducted at ARS, Sankeshwar during 2017-18 to evaluate the efficacy of insecticides against ESB and the results obtained are presented here under.

4.4.1 Efficacy of insecticides against early shoot borer

4.4.1.1 Germination (%)

The result obtained revealed that the per cent germination at 30 DAP was ranged from 60.24 to 78.04 and there was no significant difference was noticed among the treatments (Table 11).

4.4.1.2 Tiller count

The results indicated that the tiller count at 60 DAP was varied between 285.67 and 330.67 per plot and found non-significant among themselves (Table 11).

4.4.1.3 Dead heart (%) due to early shoot borer

The results obtained on the efficacy of insecticides revealed that among the different treatments at 45 DAP, the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly lower per cent DH of 4.22 due to ESB and was found superior over rest of the treatments. The next best treatment was T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (5.79 % DH) which was on par with T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (6.11 % DH), followed by T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (7.95 % DH) which was at par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (8.29 % DH) and found superior over T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (10.24 % DH) which was on par with T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (10.69 % DH). However, T₈ (foliar application of chlorpyrifos @ 2 ml/l) (12.81 % DH) was found inferior over all the treatments except T₉ (untreated check) with per cent DH of 15.12 (Table 11).

At 60 DAP the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) was found significantly superior over rest of the treatments by recording lowest per cent DH of 5.92 due to ESB, followed by T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (8.04 % DH) and was on par with (soil application of fipronil 0.3 G @ 20 kg/ha) (8.37 % DH). The treatment T₅ (foliar

Table 11: Field evaluation of different insecticide molecules against sugarcane early shoot borer

Sl. No	Treatment	Germination at 30 DAP (%)	Tiller count at 60 DAP (per plot)	Dead heart (%) at				Mean
				45 DAP	60 DAP	75 DAP	90 DAP	
1	Fipronil 0.3 G (soil application at 35 and 60 DAP)	70.24 (57.32) ^a	310.00 ^a	6.11 (14.29) ^b	8.37 (16.76) ^b	4.36 (11.90) ^{bc}	5.32 (13.22) ^{bc}	6.04 (14.19) ^b
2	Chlorantraniliprole 0.4 G (soil application at 35 and 60 DAP)	74.13 (59.57) ^a	326.33 ^a	5.79 (13.87) ^b	8.04 (16.42) ^b	4.01 (11.43) ^b	5.04 (12.92) ^b	5.72 (13.80) ^b
3	Chlorantraniliprole 18.5SC (foliar application at 35 and 60 DAP)	78.04 (62.17) ^a	330.67 ^a	4.22 (11.84) ^a	5.92 (14.06) ^a	2.22 (8.56) ^a	3.16 (10.24) ^a	3.88 (11.35) ^a
4	Imidacloprid 17.8 SL (foliar application at 35 and 60 DAP)	69.63 (56.88) ^a	305.00 ^a	10.24 (18.63) ^d	14.89 (22.66) ^d	9.67 (18.09) ^e	11.21 (19.54) ^e	11.50 (19.80) ^d
5	Fipronil 5 SC (foliar application at 35 and 60 DAP)	68.17 (55.88) ^a	303.00 ^a	7.95 (16.36) ^c	10.94 (19.31) ^c	6.13 (14.31) ^{cd}	7.42 (15.76) ^{cd}	8.11 (16.54) ^c
6	Spinosad 45 SC (foliar application at 35 and 60 DAP)	66.72 (54.87) ^a	296.33 ^a	8.29 (16.71) ^c	11.83 (20.06) ^c	6.85 (15.12) ^d	8.37 (16.75) ^d	8.83 (17.26) ^c
7	Cypermethrin 10 EC (foliar application at 35 and 60 DAP)	71.57 (57.95) ^a	294.67 ^a	10.69 (19.06) ^d	15.67 (23.28) ^d	9.91 (18.33) ^e	11.29 (19.61) ^e	11.89 (20.15) ^d
8	Chlorpyrifos 20 EC (foliar application at 35 and 60 DAP)	64.72 (53.63) ^a	291.00 ^a	12.81 (20.95) ^e	18.90 (25.74) ^e	12.82 (20.95) ^f	14.47 (22.32) ^f	14.75 (22.56) ^e
9	Untreated check	60.24 (50.94) ^a	285.67 ^a	15.12 (22.85) ^f	22.86 (28.55) ^f	16.89 (24.25) ^g	18.03 (25.10) ^g	18.23 (25.26) ^f
S. Em. ±		3.66	16.10	0.60	0.73	0.84	0.86	0.57
C.D. (p = 0.05)		NS	NS	1.79	2.19	2.52	2.57	1.70
C.V. (%)		11.20	9.15	6.01	6.09	9.16	8.60	5.51

Figures in the parenthesis are arc sine transformed values,

Means showing similar alphabets do not differ significantly by DMRT (p = 0.05), DAP – Days after planting

application of fipronil 5 SC @ 1 ml/l) recorded 10.94 per cent DH and was at par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (11.83 % DH). The treatment next to follow include T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (14.89 % DH) which was on par with T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (15.67 % DH), followed by T₈ (foliar application of chlorpyrifos @ 2 ml/l) (18.90 % DH). However, the highest per cent DH of 22.86 per cent was recorded in untreated check (Table 11).

At 75 DAP, the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly lowest per cent DH due to ESB (2.22 %) which was found statistically superior over rest of the treatments and was followed by T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (4.01 % DH) and T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (4.36 % DH). The treatment T₅ (foliar application of fipronil 5 SC @ 1 ml/l) recorded 6.13 per cent DH and was at par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (6.85 % DH). The next best treatment was T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (9.67 % DH) and was on par with T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (9.91 % DH), followed by T₈ (foliar application of chlorpyrifos @ 2 ml/l) (12.82 % DH). However, the highest per cent DH of 16.89 per cent was recorded in untreated check (Table 11).

At 90 DAP the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) was found significantly superior over remaining treatment by recording lowest per cent DH of 3.16 due to ESB, followed by T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) and T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) with 5.04 and 5.32 per cent DH, respectively. The treatments next to follow was T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (7.42 % DH) which was on par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (8.37 % DH) and found superior over T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (11.21 % DH) and T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (11.29 % DH), followed by T₈ (foliar application of chlorpyrifos @ 2 ml/l) (14.47 % DH). However, the highest per cent DH of 18.03 was recorded in untreated check (Table 11).

The results indicated that mean per cent DH due to ESB among different treatments varied between 3.88 and 18.23. However, the least mean per cent DH (3.88

%) was recorded in the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) and was found superior over rest of the treatments. The next best treatment was T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (5.72 % DH) which was on par with T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (6.04 % DH), followed by T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (8.11 % DH) and T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (8.83 % DH). The treatment T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) recorded 11.50 per cent DH which was on par with T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (11.89 % DH), followed by T₈ (foliar application of chlorpyrifos @ 2 ml/l) (14.75 DH). The highest mean per cent DH of 18.23 was recorded in untreated check (Table 11).

4.4.2 Effect of insecticide on early shoot borer with respect to quantitative and qualitative parameters

Quantitative parameters

4.4.2.1 Cane height

The cane height in different treatments ranged from 183.67 to 218.27 cm. The treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly higher cane height of 218.27 cm and was found at par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha), T₅ (foliar application of fipronil 5 SC @ 1 ml/l), T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) and T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) by recording 214.07, 211.60, 208.67, 204.67 and 201.80 cm cane height, respectively. However, the treatment T₉ (untreated check) recorded least cane height of 183.67 and was on par with T₈ (foliar application of chlorpyrifos @ 2 ml/l) and T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) with 186.73 and 194.83 cm, respectively (Table 12).

4.4.2.2 Cane girth

The results revealed that the cane girth among different treatments varied from 2.21 to 3.24 cm. The treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) was found significantly superior over rest of the treatment by recording higher cane girth of 3.24 cm, which was at par with T₂ (soil application of chlorantraniliprole

Table 12: Effect of insecticidal application on early shoot borer with respect to qualitative and quantitative parameters

Sl. No	Treatment	Cane height (cm)	Cane girth (cm)	Single cane weight (kg)	Brix (%)	Pol (%)	Number of millable canes ('000/ha)	Cane yield (t/ha)
1	Fipronil 0.3 G (soil application)	211.60 ^{ab}	2.83 ^{ab}	1.40 ^{ab}	23.50 ^{ab}	85.38 ^{ab}	71.51 ^a	98.09 ^{ab}
2	Chlorantraniliprole 0.4 G (soil application)	214.07 ^{ab}	2.91 ^{ab}	1.53 ^a	24.25 ^a	85.33 ^{ab}	72.42 ^a	99.24 ^{ab}
3	Chlorantraniliprole 18.5 SC (foliar application)	218.27 ^a	3.24 ^a	1.55 ^a	24.83 ^a	89.92 ^a	75.42 ^a	101.93 ^a
4	Imidacloprid 17.8 SL (foliar application)	201.80 ^{abc}	2.57 ^{bc}	1.30 ^{bc}	21.63 ^{bcd}	82.77 ^{abc}	68.33 ^a	89.46 ^c
5	Fipronil 5 SC (foliar application)	208.67 ^{ab}	2.63 ^{bc}	1.37 ^b	23.33 ^{ab}	84.50 ^{abc}	70.58 ^a	94.34 ^{abc}
6	Spinosad 45 SC (foliar application)	204.67 ^{abc}	2.58 ^{bc}	1.34 ^b	22.57 ^{abc}	83.03 ^{abc}	70.18 ^a	93.27 ^{bc}
7	Cypermethrin 10 EC (foliar application)	194.83 ^{bc}	2.53 ^{bc}	1.27 ^{bc}	21.33 ^{bcd}	79.13 ^{bc}	60.78 ^b	86.35 ^{cd}
8	Chlorpyrifos 20 EC (foliar application)	186.73 ^c	2.51 ^{bc}	1.26 ^{bc}	20.38 ^{cd}	78.83 ^{bc}	58.45 ^b	80.93 ^d
9	Untreated check	183.67 ^c	2.21 ^c	1.16 ^c	19.67 ^d	76.00 ^c	50.01 ^c	72.70 ^e
S. Em. ±		6.64	0.13	0.05	0.78	2.57	2.26	2.50
C.D. (p = 0.05)		19.90	0.40	0.15	2.33	7.70	6.76	7.50
C.V. (%)		6.68	8.64	6.45	6.01	5.38	6.89	6.17

Means showing similar alphabets do not differ significantly by DMRT (p = 0.05)

0.4 G @ 20 kg/ha) and T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) with 2.91 and 2.83 cm cane girth, respectively. The next best treatment was T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (2.63 cm) and was on par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l), T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l), T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l), T₈ (foliar application of chlorpyrifos @ 2 ml/l) and T₉ (untreated check) by recording 2.58, 2.57, 2.53, 2.51 and 2.21 cm cane girth, respectively (Table 12).

4.4.2.3 Single cane weight

The single cane weight among different treatments ranged between 1.16 and 1.55 kg. The treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly higher single cane weight of 1.55 kg, which was on par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (1.53 kg) and T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (1.40 kg) and found superior over T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (1.37 kg) which was on par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (1.34 kg). The treatment T₉ (untreated check) recorded least single cane weight of 1.16 kg which was on par with T₈ (foliar application of chlorpyrifos @ 2 ml/l) (1.26 kg), T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (1.27 kg) and T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (1.30 kg), respectively (Table 12).

4.4.2.4 Number of millable canes (NMC) (000's/ha)

The results (Table 12) indicated that at harvest, the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly higher NMC of 75.42 and was at par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (72.42), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (71.51), T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (70.58), T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (70.18) and T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (68.33), respectively. The treatments next to follow was T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (60.78) which was on par with T₈ (foliar application of chlorpyrifos @ 2 ml/l) (58.45). However, the lower NMC of 50.01 was recorded in untreated check.

4.4.2.5 Cane yield

The results obtained at harvest revealed that, the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly highest cane yield of 101.93 tonnes per hectare and was found at par T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) and T₅ (foliar application of fipronil 5 SC @ 1 ml/l) with 99.24, 98.09 and 94.34 t/ha, respectively. The next best treatment was T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (93.27 t/ha) which was at par with T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) and T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) by recording 89.46 t/ha and 86.35 t/ha yield, respectively, followed by T₈ (foliar application of chlorpyrifos @ 2 ml/l) with 80.93 t/ha. However, the treatment T₉ (untreated check) recorded least cane yield of 72.70 t/ha (Table 12).

Qualitative parameters

4.4.2.6 Per cent brix

The results (Table 12) indicated that the per cent brix among different treatments ranged from 19.67 to 24.83. The treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly higher per cent brix of 24.83 which was at par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (24.25 %), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (23.50 %), T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (23.33 %) and T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (22.57 %), respectively. However, the least per cent pol of 19.67 was recorded in T₉ (untreated check) which was on par with T₈ (foliar application of chlorpyrifos @ 2 ml/l) (20.38 %), T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (21.33 %) and T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (21.63 %), respectively.

4.4.2.7 Per cent pol

The results (Table 12) revealed that the per cent pol among different treatments varied from 76.00 to 89.92. The treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly higher per cent pol of 89.92 and was at par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha), T₅ (foliar application of fipronil 5 SC @ 1 ml/l), T₆ (foliar

Table 13: Cost economics as influenced by application of different insecticides against early shoot borer in sugarcane

Sl. No	Treatment	Dosage/ha	Cane yield (t/ha)	Cost of production (Rs/ha)	Insecticide cost* (Rs/ha)	Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
1	Fipronil 0.3 G (soil application)	20 kg	98.09	75,000	7,300	82,300	2,74,652	1,92,352	3.34
2	Chlorantraniliprole 0.4 G (soil application)	20 kg	99.24	75,000	11,900	86,900	2,77,872	1,90,972	3.20
3	Chlorantraniliprole 18.5 SC (foliar application)	75 ml	101.93	75,000	3,992	78,992	2,85,404	2,06,412	3.61
4	Imidacloprid 17.8 SL (foliar application)	120 ml	89.46	75,000	1,770	76,770	2,50,488	1,73,718	3.26
5	Fipronil 5 SC (foliar application)	375 ml	94.34	75,000	2,445	77,445	2,64,152	1,86,707	3.41
6	Spinosad 45 SC (foliar application)	100 ml	93.27	75,000	5,785	80,785	2,61,156	1,80,371	3.23
7	Cypermethrin 10 EC (foliar application)	200 ml	86.35	75,000	1,608	76,608	2,41,780	1,65,172	3.15
8	Chlorpyrifos 20 EC (foliar application)	750 ml	80.93	75,000	1,995	76,995	2,26,604	1,49,609	2.94
9	Untreated check	-	72.70	75,000	-	75,000	2,03,560	1,28,560	2.71

Market price of sugarcane-Rs. 2800/t

Price of insecticides used:

Chlorantraniliprole 0.4 G- Rs. 940/4 kg

Chlorpyrifos 20 EC- Rs. 330/1000 ml

Imidacloprid 17.8 SL- Rs. 280/250 ml

Fipronil 5 SC- Rs. 1260/1000 ml

* Cost of insecticide including application cost for two applications

Chlorantraniliprole 18.5 SC- Rs.997/60 ml

Cypermethrin 10 EC- Rs. 270/1000 ml

Fipronil 0.3 G- Rs. 120/kg

Spinosad 45 SC- Rs. 150/7 ml

application of spinosad 45 SC @ 0.2 ml/l), and T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) by recording 85.53, 85.38, 84.50, 83.03 and 82.77 per cent pol, respectively. However, the treatment T₉ (untreated check) recorded least per cent pol of 76.00 and was at par with T₈ (foliar application of chlorpyrifos @ 2 ml/l) (78.83 %) and T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (79.13 %).

4.4.3 Cost economics of newer insecticides

The economic analysis on the viability of various treatments revealed that the highest net returns of Rs. 2,06,412/ha was achieved with T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) followed by T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (Rs. 1,92,352/ha), T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (Rs. 1,90,972/ha), T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (Rs. 1,86,707/ha), T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (Rs. 1,80,371/ha), T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (Rs. 1,73,718/ha), T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (Rs. 1,65,172/ha) and T₈ (foliar application of chlorpyrifos @ 2 ml/l) (Rs. 1,49,609/ha), respectively. The treatment T₉ (untreated check) recorded lowest net returns of Rs. 1,28,560/ha (Table 13).

The highest benefit cost (BC) ratio of 3.61 was recorded in T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/ha), followed by T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (3.41), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (3.34), T₄ (foliar application of imidacloprid 17.8 SL @ 0.3 ml/l) (3.26), T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (3.23), T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (3.20), T₇ (foliar application of cypermethrin 10 EC @ 0.5 ml/l) (3.15) and T₈ (foliar application of chlorpyrifos @ 2 ml/l) (2.94), respectively. However, the lowest BC ratio (2.71) was observed in T₉ (untreated check) (Table 13).

5. DISCUSSION

Results of the present investigation on seasonal incidence, reaction of different genotypes, influence of cultural practices and evaluation of insecticides against sugarcane ESB are discussed here under the following headings.

- 5.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*
- 5.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*
- 5.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*
- 5.4 Management of early shoot borer, *C. infuscatellus* with insecticide molecules

5.1 Seasonal incidence of sugarcane early shoot borer, *C. infuscatellus*

5.1.1 Roving survey

Roving survey was carried out during the year 2017 in three talukas of Belagavi district to assess the seasonal incidence of sugarcane early shoot borer from January to June. The ESB incidence was prevalent in all the areas surveyed.

Among the three talukas surveyed, Raibag recorded the highest mean per cent dead heart (17.70 %) due to ESB, whereas, the lowest mean per cent DH of 16.42 and 14.66 per cent were recorded in Chikhodi and Hukkeri talukas, respectively (Fig. 2). The present findings are in agreement with Tippannavar *et al.* (1997) who reported that the infestation of sugarcane ESB was higher in Raibag followed by, Chikkodi, Hukkeri, Gokak and Athani.

Seasonal incidence of sugarcane ESB on the variety Co 86032 in Belagavi district during the year 2017 revealed that the mean per cent DH due to ESB was higher during the month of May (23.49 % DH) with 50-90 days old crop, followed by April (20.07 % DH) with 45-90 days old crop, March (16.77 % DH) with 45-75 old crop,

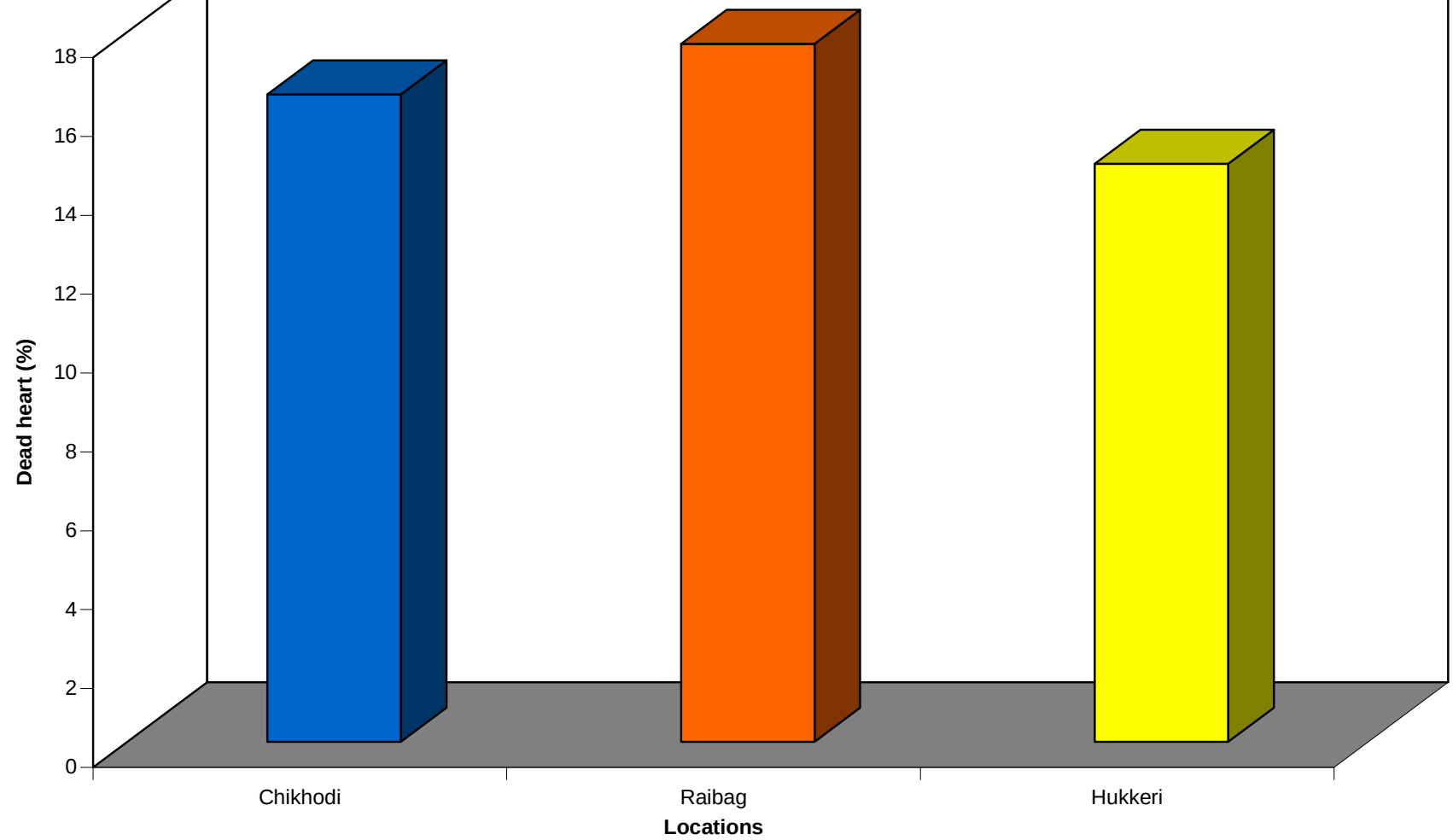
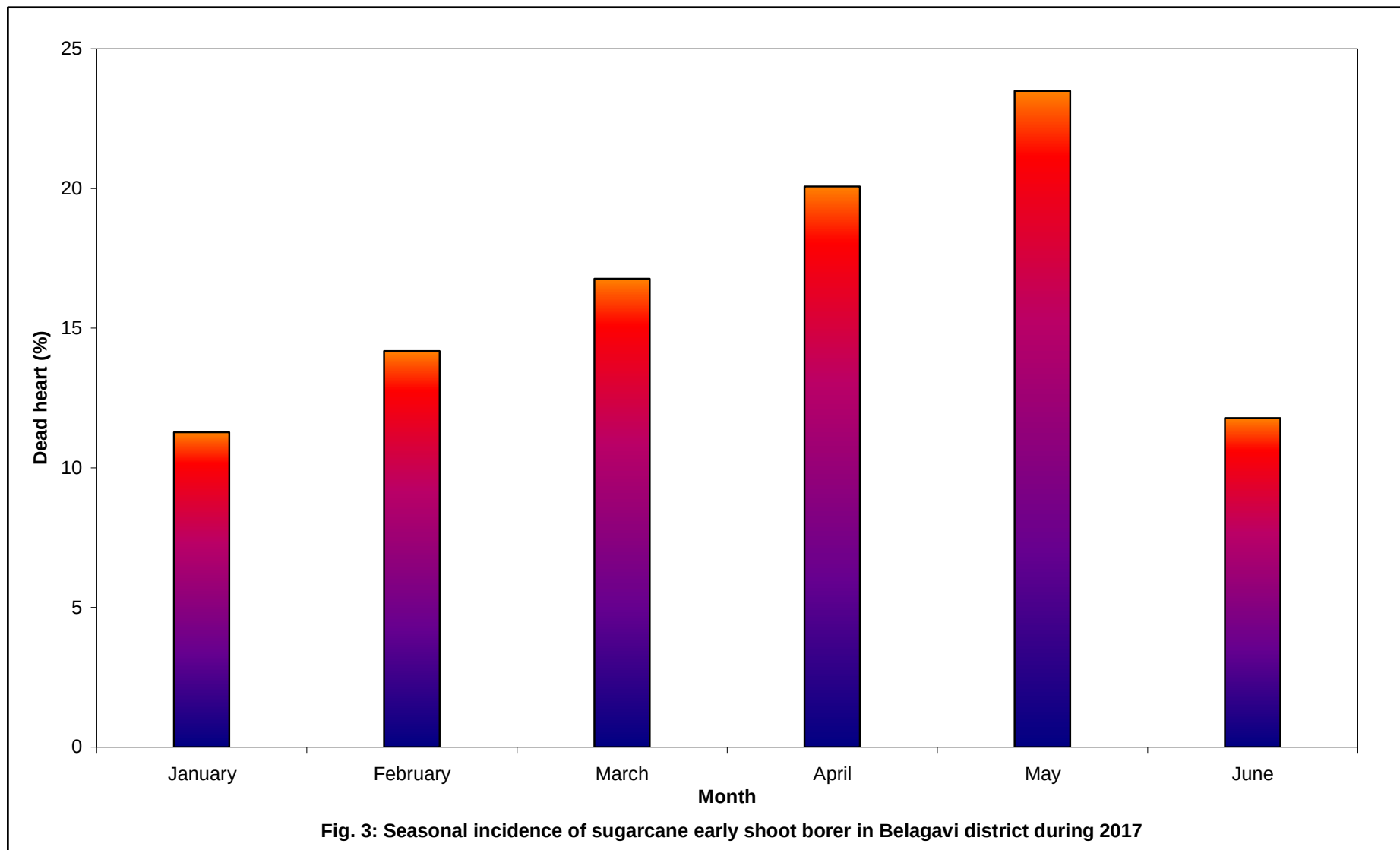


Fig. 2: Status of sugarcane early shoot borer in Belagavi district during 2017



February (14.18 % DH) with 40-60 days old crop, June (11.78 % DH) with 80-120 days old crop and January (11.27 % DH) with 30-55 days old crop, respectively (Fig. 3). The incidence of sugarcane ESB throughout the period of study might be due to staggered planting, whereas, higher per cent infestation in the month of May might be due to coincidence of desirable stage (50-90 days old) of the crop for the pest and higher temperature coupled with lower moisture availability which hinders the crop growth and favors the ESB infestation. Similar observations were also reported by Sunil Kumar *et al.* (2007), they have reported maximum incidence of ESB in the last week of May. From June onwards, pest incidence decreased and became almost nil during mid-July. The peak activity of ESB from last week of April to 2nd week of May was also reported by Choudhary *et al.*, 2015 and Muhammad *et al.*, 2012.

5.1.2 Fixed plot survey

Fixed plot survey was conducted at ARS, Sankeshwar to know the present status of ESB. Results indicated that the highest per cent DH due to ESB was recorded during April month (25.80 % DH) when the crop was 90 days old, followed by March (19.00 % DH), May (14.70 % DH) and February (14.50 % DH) with 60, 45 and more than 90 days old crop, respectively. The higher incidence of the target pest between the months of March and April might be due to congenial weather prevailing for the pest viz., high temperature and low relative humidity during the period of study coupled with slow growth of the crop due to moisture stress, reduced activity of natural enemies due to higher temperature and desirable stage (60-90 days old) of the crop for the pest.

Correlation studies between incidence of early shoot borer and abiotic factors revealed positive and non significant correlation with maximum temperature ($r = 0.728$) and minimum temperature ($r = 0.251$), negative non significant correlation with relative humidity ($r = -0.441$), rainfall ($r = -0.422$) and number of rainy days ($r = -0.183$).

The present findings are in line with Bhawar *et al.* (2015) and Choudhary *et al.* (2015) who observed the peak DH due to ESB during last week of March to first week of April. The incidence of ESB, showed significantly positive correlation with maximum temperature, whereas negative correlation with relative humidity and rainfall. Sunil Kumar *et al.* (2004) reported that temperature (maximum and minimum) has positive impact on the incidence of ESB. However, Pandey and Ram Kumar (2014)

reported that the effect of maximum temperature with shoot infestation showed negative correlation, where as it was positively correlated with relative humidity and sun shine hours.

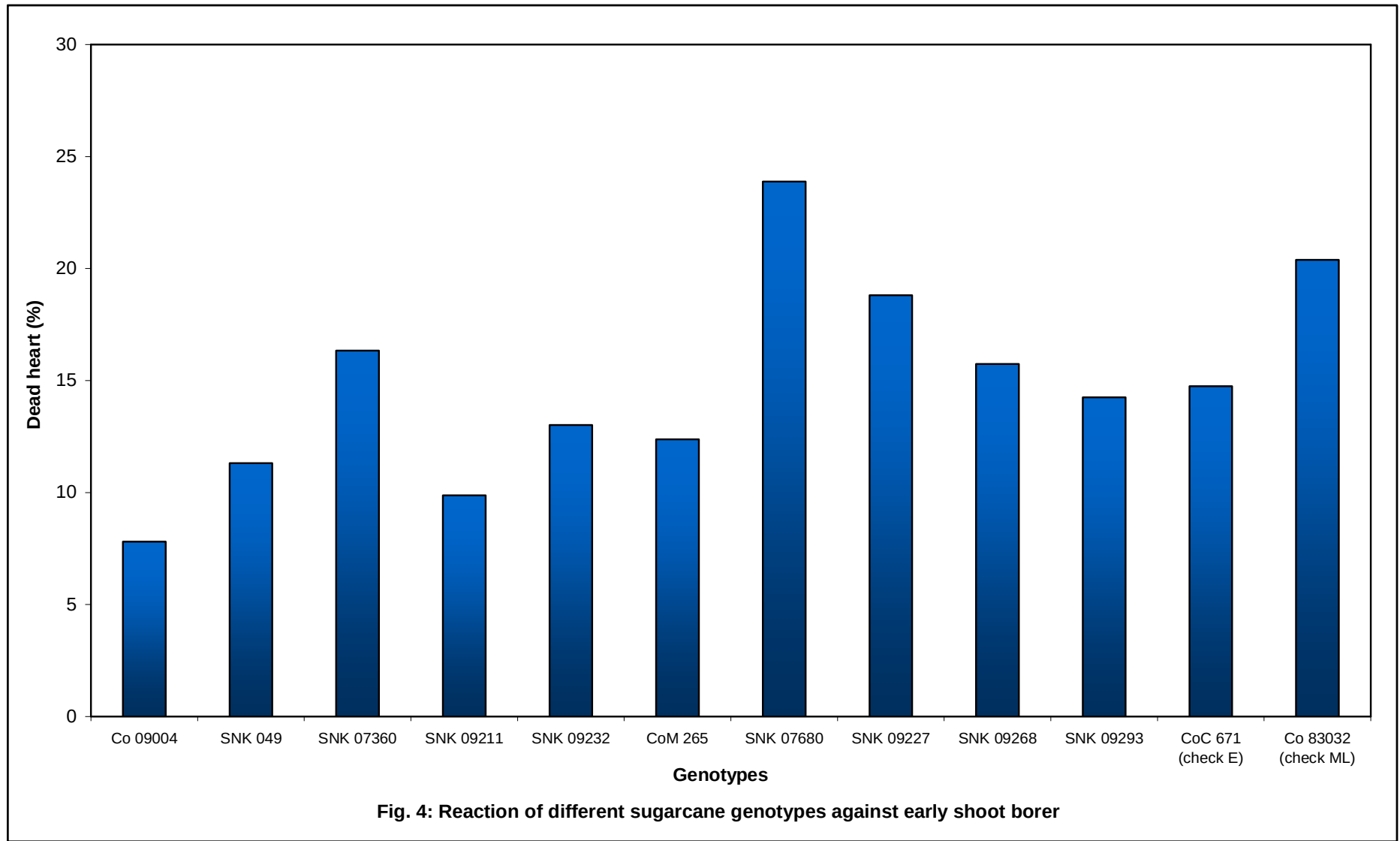
5.2 Studies on reaction of different genotypes of sugarcane against early shoot borer, *C. infuscatellus*

Experiment was carried out at ARS, Sankeshwar during 2017-18 to study the reaction of different genotypes of sugarcane against ESB. The results are discussed here under.

5.2.1 Dead heart (%) due to early shoot borer

Among the twelve different genotypes under study comprising of six early (Co 09004, SNK 049, SNK 07360, SNK 09211, SNK 09232 CoC 671) and six mid-late group (CoM 265, SNK 07680, SNK 09227, SNK 09268, SNK 09293, Co 86032), screened against ESB, the genotype Co 09004 (7.81 %) in early and CoM 265 (12.38 %) in mid-late were recorded lowest mean per cent DH. The lower mean per cent DH in Co 09004 and CoM 265 might be due to higher vigour and higher tillering ability, respectively, whereas, SNK 07360 (16.34 %) in early and SNK 07680 (23.88 %) in mid-late recorded higher mean per cent DH (Fig. 4). The higher mean per cent DH in SNK 07360 and SNK 07680 might be due to their slow growth during initial crop stage coupled with shy tillering ability favored the target pest.

Literature on reaction of different sugarcane genotypes against ESB, is lacking to compare with the present genotypes. However, studies on varietal screening conducted by Umashankar *et al.* (2017) with different varieties for their reaction against ESB at V.C Farm, Mandya revealed that the genotypes viz., 009-64, 10-65-01, 10-65-01, 10-17-08, 10-57-07, 07-10-02, 10-28-02 and 09-61-02 including check Co 99463 which recorded less than 15 per cent of incidence were graded as least susceptible while genotypes 10-17-05, 07-06-05, 10-33-33, 10-38-06, 08-15-06 and 06-09-03 including check Co 86032 have recorded 15 to 30 per cent incidence of ESB were graded as moderately susceptible. Bhavani *et al.* (2012) reported that the varieties viz., Co 0110, 98 A 165, Co 6806 and 98 A 125 were least susceptible (< 15 % DH), 97 A 85, 2000 A



105, 99 A 5 and Co 62175 were moderately susceptible (15-30 % DH), whereas 93A 11, 99 A 33, 94 A 124, Co M 9902 and susceptible check, 93 A 145 were highly susceptible (> 30 % DH) to ESB at Anakapalle (Andhra Pradesh). Hole *et al.* (2009) revealed that the genotype viz., Co 93021, Co 93009, Co 93016, Co 93010, Co 6304, CoG 93076, Co 93014, Co 7914, Co 93024, Co 86032, Co 7219, Co 93007 and Co 93008 were tolerant (< 15 % infestation) and CoG 93079, Co 93008, Co 740 and Co 93077 were found moderately resistant (15.1–30 %) to ESB at Kolhapur.

5.2.2 Tiller count

At 60 DAP, among all the genotypes Co 09004 (173.33) in early and CoM 265 (217.00) in mid-late group recorded significantly higher tiller count per plot, followed by SNK 09211 (155.67) in early and SNK 09293 (200.33) in mid-late group, respectively. However, the genotypes SNK 07360 (131.00) in early and SNK 07680 (146.33) in mid-late group recorded least tiller count of 131.00 and 146.33 per plot, respectively. The lower tiller count in SNK 07360 might be due to its shy tillering ability, while in case SNK 07680 might be due to its shy tillering ability during early crop growth.

5.2.3 Number of millable canes (NMC) (000's/ha)

Among all the genotypes, SNK 09232 in early and Co 86032 in mid-late group recorded higher NMC of 66.46 and 78.31 thousands per hectare, respectively, followed by SNK 049 (63.86) in early and CoM 265 (76.44) in mid-late group. However, the entry SNK 07360 in early and SNK 09293 in mid-late group recorded least NMC of 44.16 and 60.13 thousands per hectare, respectively.

5.2.4 Cane yield

Among all the genotypes, Co 09004 in early and SNK 09293 in mid-late group recorded maximum cane yield of 93.83 and 116.13 t/ha, respectively, followed by SNK 09211 (90.29 t/ha) in early and CoM 265 (107.09 t/ha) in mid-late group. However, the entry SNK 07360 in early and Co 86032 in mid-late group recorded least cane yield of 71.29 and 85.28 t/ha, respectively.

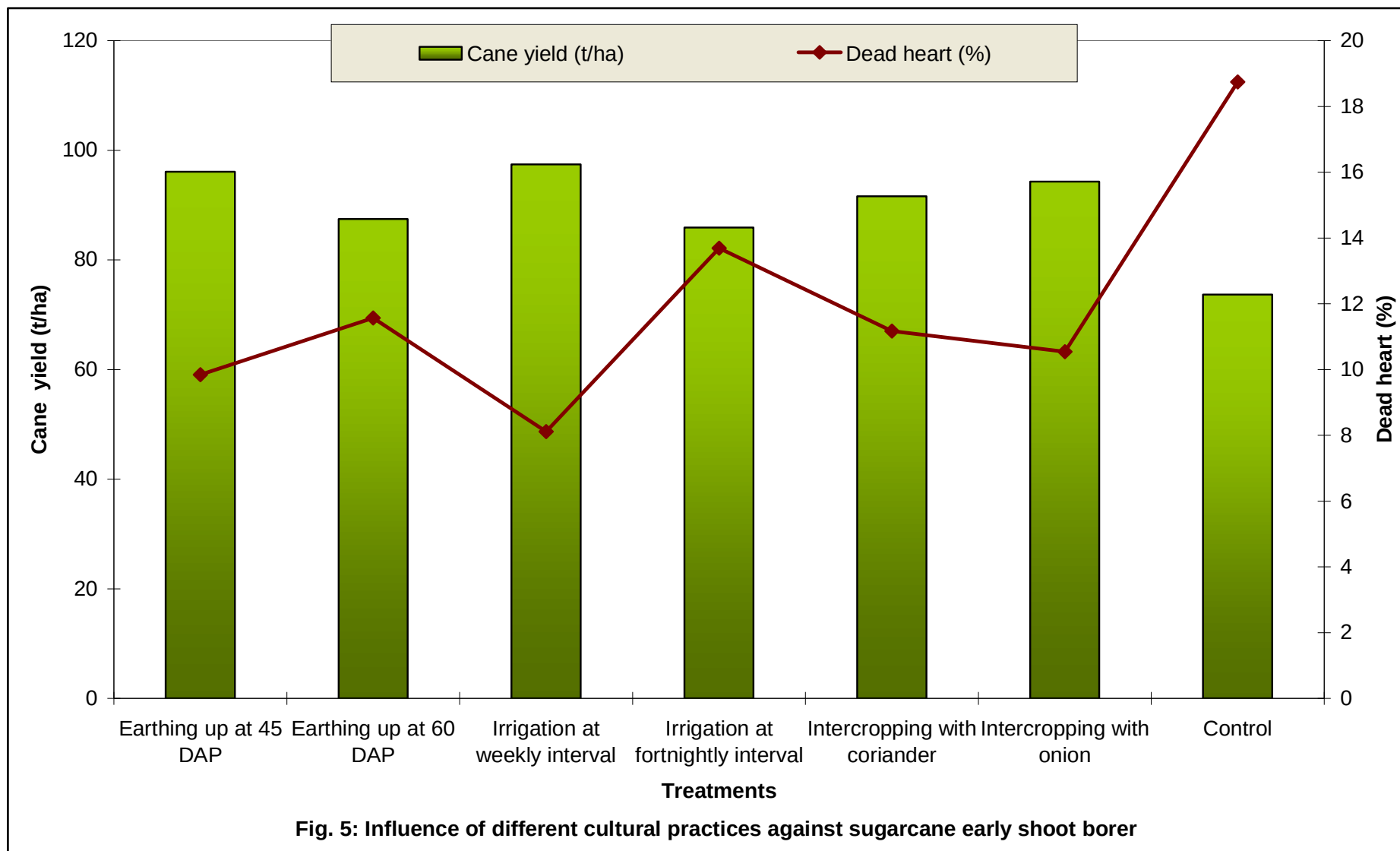
5.3 Influence of cultural practices in the management of sugarcane early shoot borer, *C. infuscatellus*

The experiment was conducted at ARS, Sankeshwar during 2017-18 to study the influence of cultural practices in the management of sugarcane ESB and the results pertaining to this are discussed below.

5.3.1 Dead heart (%) due to early shoot borer

The least mean per cent dead heart due to ESB (8.11 %) was recorded in the treatment T₃ (irrigation at weekly interval) and was followed by T₁ (earthing up at 45 DAP) with 9.84 per cent DH. The treatment next to follow was T₆ (intercropping with onion) (10.54 % DH) and was on par with T₅ (intercropping with coriander) (11.17 % DH), followed by T₂ (earthing up at 60 DAP) (11.57 % DH) and T₄ (irrigation at fortnightly interval) (13.69 % DH). However, higher mean per cent DH were recorded in T₇ (control) (18.74 %) (Fig. 5). Lower mean per cent DH in T₃ (irrigation at weekly interval) might be due to availability of sufficient moisture which might have hasten the vigour of the crop and escaped from the higher infestation, the reduced per cent infestation in case of earthing up might be due to prevention of the larva to enter into the shoots since they enter from the base of the shoot, while in case of intercropping with onion and coriander might be due their phagodeterrent effect.

The present investigations are in accordance with Randhawa *et al.* (2009), who reported that the frequent irrigation caused adverse effect on the borer multiplication, the lowest ESB incidence being recorded at eight days interval as compared to 16, 24 and 32 days interval in Punjab. Jaipal (2000) revealed that the incidence of ESB decreased to 60 per cent in all the cultivars with a reduction in irrigation interval from 15-20 days to 10-12 days during the formative phase of crop growth. Ansari (2011) studied the influence of sole cultural practices (*viz.*, 10 cm thick trash mulching, two light earthing up @ 45 and 60 DAP and furrow application of chlorpyriphos 10 G @ 1 kg a.i./ha) as well as their combinations with each other against ESB in sugarcane. The results indicated that lower per cent dead hearts were recorded from the plot treated with all three combinations, followed by plot treated with two cultural practices (*viz.*, furrow application of chlorpyriphos 10 G @ 1 kg a.i. /ha and two light earthing up @ 45 and 60



DAP). Intercropping with spices like garlic, black cumin, coriander, fennel and fenugreek were effective in reducing the incidence of ESB in autumn planted sugarcane (Singh *et al.*, 1999). Maize as intercrop caused the maximum infestation of ESB (24.00 %) in sugarcane, while onion showed minimum infestation (10.56 %) due to phagodeterrent nature (Sikchi *et al.*, 1988). Tippannavar *et al.* (1997) reported that sugarcane intercropped with onion, garlic followed by coriander proved effective in reducing incidence of ESB by recording lower % DH (5.58-15.11, 7.27-17.05 and 6.81-18.11 %, resp.). Lower infestation might be due to the phagodeterrent properties of these intercrops, whereas maize intercropping recorded higher incidence of ESB (18.00-46.98 %). Rachappa and Krishna Naik (2004) reported that the incidence of ESB in the treatment sugarcane + coriander was significantly lower than all other intercrops viz., soybean, french bean, okra and sole sugarcane. The superiority of coriander in reducing the incidence of ESB might be due to the deterrent nature of the crop (coriander). Varun *et al.* (1994) reported that growing of spice crops such as ajawain, coriander, garlic, onion, methi and saunf as intercrops in sugarcane significantly reduced the incidence of ESB.

5.3.2 Number of millable canes (NMC) (000's/ha)

The treatment T₃ (irrigation at weekly interval) recorded significantly higher NMC (73.56) and was on par with T₁ (earthing up at 45 DAP) (72.67) and T₆ (intercropping with onion) (70.67), respectively, followed by T₅ (intercropping with coriander) (66.61). The treatment next to follow was T₂ (earthing up at 60 DAP) (63.08) which was on par with T₄ (irrigation at fortnightly interval) (61.53). The lower NMC (52.61) were recorded in T₇ (control). The higher NMC in treatment T₃ (irrigation at weekly interval) might be due to lower mean per cent DH (8.11 %) by the ESB, while lower NMC in treatment T₇ (control) might be due to higher mean per cent DH (18.74 %).

The findings of Ansari (2011) indicated that earthing up recorded higher cane NMC (158.71 '000/ha) with lower infestation of 14.33 per cent DH, least NMC (125.26 '000/ha) was recorded in control with higher infestation of 25.59 per cent DH. Tippannavar *et al.* (1997) reported higher NMC in sugarcane intercropped with onion

(305.33/treatment), garlic (289.66/treatment) followed by coriander (287.33/treatment) by recording lower per cent DH (8.03 and 6.07, 8.37 and 6.51, 8.66 and 7.27 % at 45 and 75 DAP, respectively), whereas maize inter cropping recorded least NMC of 305.33 per treatment with higher incidence of ESB (28.27 and 46.98 % at 45 and 75 DAP, respectively). Similar results were also reported by Venugopala Rao *et al.* (2010).

5.3.3 Cane yield

Among the different treatments, the treatment T₃ (irrigation at weekly interval) recorded significantly highest cane yield of 97.42 tonnes per hectare, which was at par with T₁ (earthing up at 45 DAP) (96.07 t/ha), T₆ (intercropping with onion) (94.28 t/ha) and T₅ (intercropping with coriander) (91.59 t/ha), followed by T₂ (earthing up at 60 DAP) (87.47 t/ha) which was on par with T₄ (irrigation at fortnightly interval) (85.90 t/ha). However, the least cane yield of 73.69 t/ha was recorded in T₇ (control) (Fig. 5). The highest cane yield in treatment T₃ (irrigation at weekly interval) might be due to lower mean per cent DH (8.11 %) by the ESB and least cane yield in treatment T₇ (control) might be due to higher mean per cent DH (18.74 %).

The findings of Randhawa *et al.* (2009) revealed that significantly higher cane yield (87.25 t/ha) was recorded from eight days irrigation interval with least per cent DH of 5.24 due to ESB, followed by 16 days irrigation interval (85.00 t/ha) with 9.01 per cent DH and 24 days irrigation interval with 13.13 per cent DH, respectively, the lower cane yield of 80.50 t/ha was recorded in 32 days irrigation interval with higher per cent DH of 18.14. Ansari (2011) reported that earthing up recorded higher cane yield (65.05 t/ha) with lower infestation of 14.33 per cent DH, least cane yield (40.76 t/ha) was recorded in control with higher infestation of 25.59 per cent DH. Tippannavar *et al.* (1997) reported that higher cane yields were recorded in sugarcane intercropped with onion (96.92 t/ha), garlic (91.95 t/ha) followed by coriander (88.03 t/ha) by recording lower per cent DH (8.03 and 6.07, 8.37 and 6.51, 8.66 and 7.27 % at 45 and 75 DAP, respectively). Maize intercropping recorded least cane yield of 62.09 t/ha with higher incidence of ESB (28.27 and 46.98 % at 45 and 75 DAP, respectively). Rachappa and Krishna Naik (2004) reported that the sugarcane + coriander recorded significantly higher cane yield (92.18 t/ha) by recording lower mean per cent DH of 4.75, whereas

sugarcane + okra recorded least cane yield (76.61 t/ha) by recording higher mean per cent DH of 8.77.

5.4 Management of sugarcane early shoot borer, *C. infuscatellus* with insecticide molecules

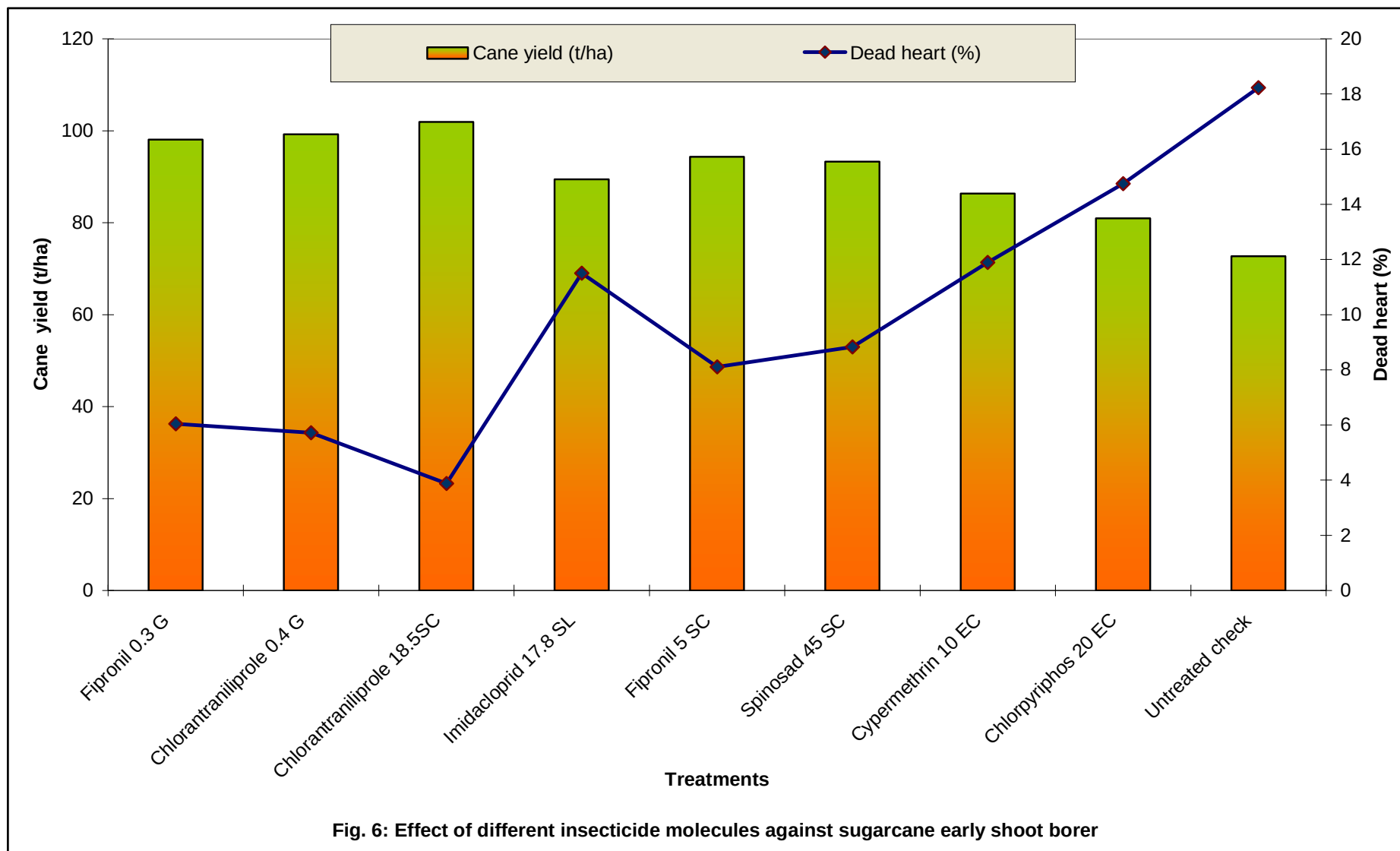
The field experiment was conducted at ARS, Sankeshwar 2017-18, to evaluate the efficacy of different insecticide molecules against sugarcane ESB and the results pertaining to this are discussed below.

5.4.1 Dead heart (%) due to early shoot borer

In the present investigation, chlorantraniliprole 18.5 SC @ 0.2 ml/l was proved to be the excellent among all the treatments by recording lowest per cent DH due to ESB (4.22, 5.92, 2.22 and 3.16 per cent at 45, 60, 75 and 90 DAP, respectively). The next best treatment was chlorantraniliprole 0.4 G @ 20 kg/ha with 5.79, 8.04, 4.01 and 5.04 per cent DH at 45, 60, 75 and 90 DAP respectively, which was followed by fipronil 0.3 G @ 20 kg/ha (6.11, 8.37, 4.36 and 5.32 % DH at 45, 60, 75 and 90 DAP respectively). However, the highest per cent DH (15.12, 22.86, 16.89 and 18.99 % at 45, 60, 75 and 90 DAP, respectively) were recorded in untreated check.

The least mean per cent dead heart due to ESB (3.88 %) was recorded in the treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) and was found superior over rest of the treatments. The next best treatment was T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (5.72 % DH) and was on par with T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (6.04 % DH), followed by T₅ (foliar application of fipronil 5 SC @ 1 ml/l) (8.11 % DH) which was on par with T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) (8.83 % DH). However, the highest mean per cent DH due to ESB (18.23 %) was recorded in untreated check (Fig. 6).

The present investigations are in line with the findings of Anon. (2017b) who reported that the chlorantraniliprole 18.5 SC @ 75 ml/ha was the most effective in reducing the incidence of the ESB, followed by chlorantraniliprole 0.4 G @ 22.5 kg/ha, fipronil 0.3 G @ 25 kg/ha. According to Padmasri *et al.* (2014) chlorantraniliprole 18.5 SC @ 0.36 ml/l proved superior in checking the ESB infestation over the remaining



insecticides. Bhawar *et al.* (2016) revealed that chlorantraniliprole 20 SC @ 40 g a.i./ha was most effective against ESB, followed by flubendiamide 480 SC @ 30 g a.i./ha, indoxacarb 14.5 SC @ 30 g a.i./ha, lambda cyhalothrin 5 EC @ 25 g a.i./ha and imidacloprid 17.8 SL @ 25 g a.i./ha, respectively. Anon. (2015) reported that soil application of chlorantraniliprole 0.4 G @ 22.5 kg/ha at the time of planting and 60 DAP was found most effective against ESB, followed by spraying of chlorantraniliprole 18.5 SC @ 75 ml/ha at 30 and 60 DAP (6.86 %), soil application of fipronil 0.3 G @ 25 kg a.i./ha at the time of planting and 60 DAP (7.49 %). The findings of Bhawar *et al.* (2015) indicated that lasenta (imidacloprid 40 % + fipronil 40 %) 80 WG @ 250 g a.i./ha found most effective against ESB, followed by chlorantraniliprole 0.4 G @ 30 g a.i./ha and fipronil 0.3 G @ 7.5 g a.i./ha. In similar line, Sheeba Jasmine *et al.* (2012) reported that chlorantraniliprole 20 SC @ 75 g a.i./ha seems to offer a good control and was found to be significantly superior to carbofuran 3 G @ 1 kg a.i./ha.

However, Bhavani (2016), Ahmad *et al.* (2012), Talpur *et al.* (2002) and Jena *et al.* (1994) reported that carbofuran 3 G was effective against ESB. Tippannavar *et al.* (2016) reported that lower damage due to ESB was recorded by chlorpyrifos 10 G @ 30 kg/ha followed by chlorpyrifos 10 G @ 25 kg/ha and carbofuran 3 G @ 33.30 kg/ha. Balikai *et al.* (2015) revealed that thiamethoxam 75 SG @ 143 g a.i./ha as soil application at the time of planting was effective for the management of ESB.

5.4.2 Number of millable canes (NMC) (000's/ha)

The treatment T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) recorded significantly higher NMC of 75.42 and was found superior over remaining treatments. It was on par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (72.42), T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (71.51) and T₅ (foliar application fipronil 5 SC @ 1 ml/l) (70.58) However, the lower NMC (58.45) was recorded in untreated check. The lower NMC in untreated check might be due to higher mean per cent DH (18.23 %) due to ESB.

The findings of Tippannavar *et al.* (2016) indicated that higher NMC were recorded in set treatment with chlorpyrifos 20 EC @ 10 ml/l + spraying with

endosulfan 35 EC @ 2 ml/l at 50 & 80 DAP (55.80 thousand/ha) with lower infestation of 11.50 and 12.99 per cent DH at 60 and 90 DAP, respectively, followed by chlorpyrifos 10 G @ 30 kg/ha (54.89 thousand/ha) (10.79 and 12.50 % DH) and chlorpyrifos 10 G @ 25 kg/ha (54.86 thousand/ha) (11.40 and 13.66 % DH) as against 34.43 thousand/ha in untreated check with lower infestation of 19.31 and 22.48 per cent DH at 60 and 90 DAP, respectively. Balikai *et al.* (2015) revealed that highest NMC (45.30 thousand/ha) was obtained in thiamethoxam 75 SG @ 143 g a.i./ha with least infestation of 3.80 and 4.30 per cent DH at 60 and 90 DAP, respectively as against 41.10 thousand/ha in untreated check with highest infestation of 28.40 and 30.40 per cent DH at 60 and 90 DAP, respectively. Padmasri *et al.* (2014) reported that chlorantraniliprole 18.5 SC @ 0.36 ml/l recorded higher NMC (81.49 thousand/ha) by recording least per cent DH of 11.07, followed by indoxacarb 14.5 SC @ 1 ml/l (79.87 thousand/ha) (13.74 % DH) and Spinosad 45 SC @ 0.3 ml/l (75.73 thousand/ha) (12.34 % DH).

5.4.3 Cane yield

Significantly highest cane yield of 101.93 t/ha was recorded in T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) and was found superior over remaining treatments. However, this was on par with T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (99.24 t/ha) and T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (98.09 t/ha), followed by T₅ (foliar application of fipronil 5 SC @ 1 ml/l) and T₆ (foliar application of spinosad 45 SC @ 0.2 ml/l) recorded 94.34 and 93.27 t/ha, respectively and were found on par with each other. However, the least cane yield (72.70 t/ha) was recorded in untreated check (Fig. 6). The least cane yield in untreated check might be due to higher per cent dead heart (18.23 %) due to ESB.

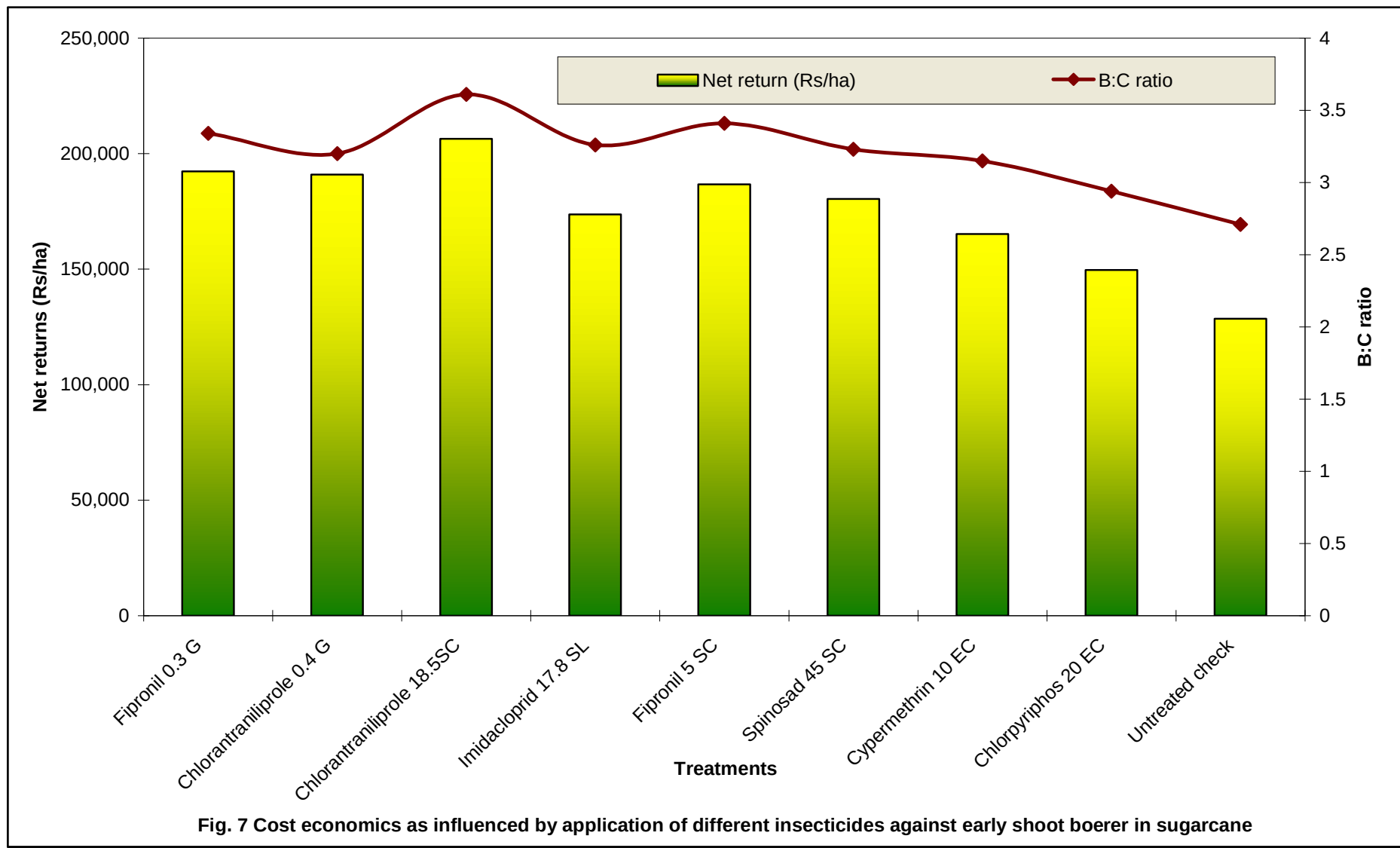
The findings of Anon. (2017b) indicated that significantly higher cane yield (86.20 t/ha) was recorded from chlorantraniliprole 18.5 SC @ 75 ml/ha with least per cent DH of 5.00 due to ESB, followed by chlorantraniliprole 0.4 G @ 22.5 kg/ha (85.00 t/ha) with 5.95 per cent DH and flubendiamide 480 SC 0.2 ml/l (83.20 t/ha) with 7.00 per cent DH, respectively. Bhavani (2016) reported that cane yield were higher in carbofuran 3 G @ 33 kg/ha (88.40 t/ha) and fipronil 0.4 G @ 25 kg/ha (88.15 t/ha) and were statistically on par with each other by recording least per cent DH of 13.44 and 14.20, respectively, as against 76.30 t/ha yield in untreated control with higher

infestation of 29.33 per cent DH. Tippannavar *et al.* (2016) reported that higher cane yield was recorded with chlorpyrifos 10 G @ 30 kg/ha (97.31 t/ha), followed by set treatment with chlorpyrifos 20 EC @ 10 ml/l + spraying with endosulfan 35 EC @ 2 ml/l at 50 & 80 DAP (96.71 t/ha) by recording lower per cent DH of 10.79 and 12.50, 11.50 and 12.99, respectively at 60 and 90 DAP, as against 76.32 t/ha in untreated check with higher infestation of 19.31 and 22.48 per cent DH at 60 and 90 DAP. Anon. (2015) reported that the higher cane yield of sugarcane was recorded in chlorantraniliprole 0.4 G @ 22.5 kg/ha (127.92 t/ha) with lower infestation of 14.33 per cent DH and it was at par with chlorantraniliprole 18.5 SC @ 375 ml/ha (124.62 t/ha) (15.18 % DH), fipronil 0.3 G @ 25 kg/ha (119.74) (15.88 % DH) and significantly lower cane yield was recorded in untreated control (77.54 t/ha) with highest incidence of 23.64 per cent DH due to ESB. Balikai *et al.* (2015) revealed that thiamethoxam 75 SG @ 143 g a.i./ha registered highest cane yield of 108.2 t/ha with least per cent DH of 3.80 and 4.30 at 60 and 90 DAP, respectively as against 94.5 in untreated check with highest per cent DH of 28.40 and 30.40 at 60 and 90 DAP, respectively. Padmasri *et al.* (2014) indicated that chlorantraniliprole 18.5 SC @ 0.36 ml/l recorded higher cane yield (85.05 t/ha) with lower per cent DH of 11.07, followed by indoxacarb 14.5 SC @ 1 ml/l (84.01 t/ha) (13.74 % DH), spinosad 45 SC @ 0.3 ml/l (83.16 t/ha) (12.34 % DH), while untreated control recorded 79.01 t/ha with higher per cent DH of 19.64. Sheeba Jasmine *et al.* (2012) reported that the chlorantraniliprole 20 SC @ 75 g a.i./ha, recorded higher cane yield (102.50 t/ha) with least per cent DH of 15.43 while untreated check recorded cane yield of 70.33 t/ha with highest per cent DH of 38.98.

5.4.4 Cost economics of newer insecticides

The economic analysis on the feasibility of various treatments revealed that the highest net returns of Rs. 2,06,412 per ha could be achieved with T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) followed by T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (Rs. 1,92,352/ha) and T₂ (soil application of chlorantraniliprole 0.4 G @ 20 kg/ha) (Rs. 1,90,972/ha), whereas, the lowest net returns (Rs. 1,28,560/ha) was observed in T₉ (untreated check) ((Fig. 7).

The highest benefit cost (BC) ratio (3.61) was recorded in T₃ (foliar application of chlorantraniliprole 18.5 SC @ 0.2 ml/l) followed by T₅ (foliar application of fipronil



5 SC @ 1 ml/l) (3.41) and T₁ (soil application of fipronil 0.3 G @ 20 kg/ha) (3.34), while, the lowest BC ratio (2.71) was registered in T₉ (untreated check) (Fig. 7).

Future line of work

1. The promising genotypes (Co 09004, SNK 09211, CoM 265 and SNK 09293) against ESB can be further studied for biochemical bases of resistance viz., total phenols, total sugars, reducing sugars, cellulose, lignin and silica contents in shoot tissues.
2. Phagodeterrent nature of bio-chemical constituents of intercrops like onion and coriander in sugarcane which resulted in lower incidence of ESB need to be studied.
3. Evaluation of effective time and method of application of chlorantraniliprole against early shoot borer can be studied.

6. SUMMARY AND CONCLUSIONS

Investigations were carried out on various aspects of sugarcane early shoot borer, *Chilo infuscatellus* viz., seasonal incidence, reaction of different genotypes, influence of cultural practices and evaluation of different insecticides against ESB at Agricultural Research Station, Sankeshwar, University of Agricultural Sciences, Dharwad, Karnataka, during 2017-18. The results of the investigations are summarized here under.

Roving survey conducted in three talukas of Belagavi district viz., Chikhodi, Raibag and Hukkeri revealed that relatively higher mean per cent dead heart due to sugarcane ESB were recorded in Raibag taluka (17.70 %) whereas, lower mean per cent DH of 16.42 and 14.66, were recorded in Chikhodi and Hukkeri, respectively. Irrespective of location during the cropping period, the lowest mean per cent DH (11.27 %) due to ESB was recorded during the month of January whereas, the highest mean per cent DH (23.49 %) was recorded during the month of May. The peak activity of target pest was observed during April and May.

Fixed plot survey carried out at ARS, Sankeshwar during period of study indicated that the lowest mean per cent DH due to ESB (14.50 %) was recorded during the month of February whereas, the highest mean per cent DH (25.80 %) were recorded during the month of April. The correlation studies between the per cent dead heart in relation to weather parameters showed positive correlation with maximum temperature ($r = 0.728$) and minimum temperature ($r = 0.251$) whereas, negatively correlated with relative humidity ($r = -0.441$), rain fall ($r = -0.422$) and number of rainy days ($r = -0.183$).

The studies on reaction of different genotypes of sugarcane against ESB indicated that the genotype, Co 09004 in early and CoM 265 in mid-late groups were recorded lower DH of 7.81 and 12.38 per cent, respectively due to ESB. These genotypes are promising against ESB attack while the genotype SNK 09211 in early and SNK 09293 in mid-late group which recorded 9.88 and 14.25 per cent DH, respectively could be considered as relatively tolerant. However, SNK 07360 (16.34 %) in early and SNK 07680 (23.88 %) in mid-late group, recorded the higher DH due to ESB.

The studies on influence of different cultural practices against ESB revealed that irrigation at weekly interval emerged as the best cultural practice by recording lowest dead heart (8.11 %) due to ESB followed by earthing up at 45 DAP (9.84 % DH), intercropping with onion (10.54 % DH), intercropping with coriander (11.17 % DH), earthing up at 60 DAP (11.57 % DH) and irrigation at fortnightly interval (13.69 % DH).

Among the different insecticides evaluated against ESB, chlorantraniliprole 18.5 SC @ 0.2 ml/l was found superior over rest of the insecticides by recording lowest DH (3.88 %) due to ESB, highest cane yield (101.93 t/ha) and highest net returns (Rs. 2,06,412/ha) and was followed by chlorantraniliprole 0.4 G @ 20 kg/ha (5.72 % DH, 99.24 t/ha cane yield and Rs. 1,90,972/ha net returns) and fipronil 0.3 G @ 20 kg/ha (6.04 % DH, 98.09 t/ha cane yield and Rs. 1,92,352/ha net returns).

Conclusions

Based on the outcome of present investigations it could be concluded that, the peak incidence of early shoot borer was noticed during summer season (April and May months) in major sugarcane growing talukas viz., Chikhodi, Raibag and Hukkeri in Belagavi district when the crop was 30 to 120 day old (seedling to tillering phase).

Among the different genotypes, Co 09004 in early and CoM 265 in mid-late group were recorded lower mean per cent DH due to ESB and emerged as promising genotypes against ESB attack.

Irrigation at weekly interval emerged as the best cultural practice by recording lowest mean per cent dead heart due to ESB followed by earthing up at 45 DAP, intercropping with onion and intercropping with coriander.

Chlorantraniliprole 18.5 SC @ 0.2 ml/l was found most effective in reducing ESB incidence and was followed by chlorantraniliprole 0.4 G @ 20 kg/ha and fipronil 0.3 G @ 20 kg/ha.

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Appendix I: Meteorological data recorded during the year 2017 at ARS, Sankeshwar (Belagavi)

Month	Relative humidity (%)	Temperature (°C)		Rainy days	Rainfall (mm)	Wind speed (kmph)
		Max.	Min.			
January	47	30.7	11.3	0	0.0	3.1
February	40	34.0	13.5	0	0.0	4.2
March	42	35.7	15.0	0	0.0	4.7
April	41	37.9	18.5	1	3.8	6.3
May	57	36.7	20.1	3	52.6	8.5
June	74	30.1	21.4	11	111.8	9.5
July	84	27.5	20.3	18	240.0	9.7
August	83	28.3	19.6	11	115.8	7.2
September	82	29.7	18.8	12	148.0	4.0
October	75	30.7	16.9	7	177.6	2.2
November	56	30.8	12.1	0	1.0	2.5
December	56	30.2	11.6	0	0.0	3.9
Total				63	850.6	

SEASONAL INCIDENCE AND MANAGEMENT OF SUGARCANE EARLY SHOOT BORER, *Chilo infuscatellus* (Snellen) (PYRALIDAE: LEPIDOPTERA)

KALLAPPA MAGADUM

2018

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ABSTRACT

Investigations were carried out on various aspects of sugarcane early shoot borer (ESB), *Chilo infuscatellus* (Snellen) viz., seasonal incidence, reaction of twelve genotypes, influence of cultural practices and evaluation of insecticide molecules against ESB at Agricultural Research Station, Sankeshwar during 2017-18.

Survey results indicated that incidence of ESB was higher in Raibag taluka i.e., 17.70 per cent dead heart (DH) whereas, lower incidence of 16.42 and 14.66 per cent DH, were recorded in Chikhodi and Hukkeri, respectively. Irrespective of location during the study, the higher incidence (23.49 % DH) was recorded during the month of May. Fixed plot survey revealed that incidence of ESB was noticed from February (14.50 % DH) to May (14.70 % DH) and peak incidence was noticed during April (25.80 % DH).

The studies on reaction of twelve genotypes of sugarcane against ESB indicated that the genotype, Co 09004 in early and CoM 265 in mid-late groups emerged as promising against ESB attack with lower mean per cent DH of 7.81 and 12.38 per cent, respectively.

Among the different cultural practices evaluated against ESB, irrigation at weekly interval performed superior by recording lowest mean per cent DH (8.11 %) due to ESB followed by earthingup at 45 DAP (9.84 % DH) and intercropping with onion (10.54 % DH).

Among the different insecticides evaluated against ESB, chlorantraniliprole 18.5 SC @ 0.2 ml/l was found superior by recording lowest mean per cent DH (3.88 %) due to ESB, followed by chlorantraniliprole 0.4 G @ 20 kg/ha (5.72 % DH) and fipronil 0.3 G @ 20 kg/ha (6.04 % DH).

For the effective management of ESB we can go for early planting, growing the genotypes viz., Co 09004 or CoM 265, frequent irrigation if available, intercropping with onion/coriander and lastly application of chlorantraniliprole 18.5 SC @ 0.2 ml/l.