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Identification and Monitoring of Stem Borers (Lepidoptera: Noctuidae) at Tendaho Sugar Factory, Ethiopia.

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Abstract

Field study was conducted at Tendaho sugarcane plantation to determine the composition of stem borer species and extent of damage, monitoring under field condition using four commercial sugarcane varieties during 2013/14 cropping season. From 96 surveyed fields, a total of three different lepidopteran stem borer species were identified. a complex of three stem borers: *S. calamistis, C. partellus* and *E. saccharina* were recorded at Tendaho. Among these species, *S. calamistis* and *C. partellus* were the most dominant species. Among the different factors considered variety and cuttings had a significant effect on incidence and severity of stem borer. Both incidence and severity of stem borer increased in the season. Among the different cuttings, ratoon had a significant variation in stem borer incidence and severity in the season. Moreover, among the varieties, CO680 had showed significant variation in incidence and severity of stem borer as compared to the other varieties in the plantation. as well as, in terms of severity the varieties B52/298, NCO334 and N14 showed significant variation unlike the other varieties. The study also confirmed that stem borer had a significant effect on stem height, cane and sugar yield. The average height of affected stem was about 10.24% less than the non – affected stems. Cane and sugar yield of affected stem were 24.86% and 34.34% less than the non – affected stem, respectively. The study showed that the damage by stem borers had a significant effect on stem length, cane and sugar yield. The average stalk borer tunnel length was 9.63 cm, and the average height of severely damaged stem was about 10.24% less than the undamaged stems. In addition, the study showed stem with tunnel length had a great effect on cane and sugar yield. In general, stem borer damage in the sugarcane plantations of Ethiopia can cause a potential yield loss of about 27.3%. Monitoring of stem borer was conducted on four varieties of ratoon crops in two growing stage of sugarcane sprouting and tillering and grand growth stage. The study indicates that damaged status of stem borer was high in grand growth stage than the other.

Keywords: Stem borers, Grand growth, sugarcane, insect pest.

Introduction

Sugarcane, *Saccharum* spp. L. (Poaceae) is a perennial crop that is grown as a source of sugar primarily in the tropical and subtropical areas of the world, including several countries in Africa, the Mascarene Island and Madagascar (Overholt *et al*. 2003). The taxonomic status and the origins of cultivated sugarcane varieties are not clear but the varieties of noble canes, *Saccharum officinarum* L., are thought to have originated in Melanesia and the ancestral form is thought to be the wild *Saccharum robustum* L. of New Guinea and adjacent islands (Pemberton and Williams, 1969). Other cultivated sugarcanes, *Saccharum barberi* L. and *Saccharum sinense* L., are believed to have been derived through natural hybridization of *S. officinarum* with the wild *Saccharum spontaneum*L. (Stevenson, 1965). Sugarcane has been grown in gardens in New Guinea since time immemorial (Pemberton and Williams, 1969) and cultivation of the crop in Africa and neighbouring islands was first recorded in the Cape Verde Islands in the early 15^{th} century (Polaszek and Khan, 1998). According to FAO (2011), a total of 23.8 million hectares of land is allocated to sugarcane in 100 countries of the world. So far there is no well documented reference about how, when and who introduced sugarcane to Ethiopia except the clue provided by Duri (1969) regarding the probable time of introduction; which is estimated to be sometime during the early 18^{th} century (Aregaw, 2002).

Although sugarcane is not an indigenous crop to Ethiopia, it has been grown in some parts of the country even before the commencement of large scale commercial plantation and establishment of the first modern sugar factory at Wonji meant mainly for local consumption (Aregaw, 2000).

Modern production in Ethiopia commenced in 1954 at Wonji by the Dutch Company, Handle Vereening Amsterdam (HVA) with sugar plantation of 5,000 ha. Late in 1962, the company established the second sugar factory, Shoa, expanding the cane plantation by 2000 ha. Similarly, other sugarcane plantations were established at Metahara (over 10,000 ha) and Finchaa (over 8,000 ha) in 1969 and 1998, respectively (Abera and Tesfay, 2001). The country's annual production of sugar from the three sugar estates is about 400,000 tons (Personal communication, 2013).

Sugarcane is one of the major cash crops providing immense income for many countries around the world. In Ethiopia, sugar industry plays a great role in the country's economy. Sugar and its by products are used for local consumption and export. The industry has also created job opportunity for a large number of people. International Sugar Organization (ISO) estimated, the present annual consumption of sugar in Ethiopia is 4.4 kilogram per capita; this is considered low even by Africa standards, which is estimated to be 20 kilograms per capital (ISO, 2013). The report also revealed that in order to reach to the Africa standard, Ethiopia still needs to produce an additional 80,000 metric tons per year to satisfy the current total demand. Thus, much effort has to be made to increase sugar production in the country. To bridge the gap between supply and demand as well as to exploit the international market, Ethiopia is on the verge of establishing new sugar factories in many corner of the country with large tract of sugarcane plantation besides expanding the existing ones. From the newly established plantations, Tendaho sugarcane estate is the largest and when fully planted it will cover around 50, 000 hectares.

In addition to the aforementioned efforts, intensification of sugarcane cultivation is of a paramount importance. However, weeds, disease and insect pests are among the major constrains of sugarcane production in the country. In Ethiopia, insect damage to sugarcane has been recognized since the establishment of the first sugarcane plantation. Presence of world major sugarcane insect pest has also been reported in the first three sugarcane plantations of the country. According to Tesfay and Solomon (2007), about 14 insect pests are reported from the sugarcane plantation of Ethiopia. Despite record of these insect pests, only few: *Heteronychus licas* Klug (Coleoptera: Scarabaeidae), *Macrotermes sp. a*nd *Odontotermes sp.* (Isoptera: Termitidae), *Sesamia calamistis Hampson and Busseola spp.* (Lepidoptera: Noctuide), *Chilo partellus* Swinhoe (Lepidoptera: Crambidae) are considered to be economically important (Abera and Tesfay, 2001; Yoseph *et al*., 2006; Tesfay and Solomon, 2007).

The lepidopterous stem and cob borers are among the most injurious insect pest of maize, sorghum, millet, rice and sugarcane in sub Saharan Africa (Kfir *et al.*, 2002). Maes (1998) listed 21 species of stem borers that cause economic losses, however, within any region crop combination, a small sub set are damaging (Kfir *et al.*, 2002)

In the Ethiopia sugar estates; although no quantified yield loss report exists, it is observed that the sugarcane plantations are suffering from damage of stem borer species complex. It is usually difficult to estimate the loss caused by borers. However, different methods have been developed to estimate the amount of sucrose lost because of bores. In Papua New Guinea (Ramu), losses of 0.82 tons of cane per hectare, 0.13 tons of sugar per hectare and 0.15% pol were estimated for every 1% of bored and rotting stems (Eastwood *et al*, 1998; Kuniata, 1998; Allsopp and Sallam, 2001). Similarly, in Mauritius, *C. sacchariphagus* caused an average loss of 0.8% recoverable sucrose for every 1% of internodes bored (Ganeshan, 2001). In Indonesia, the yield loss due to *C. sacchariphagus* was reported to reach up to 10% of recoverable sugar for 20% internodes bored (Kuniata, 1994). Up to 43% reduction in recoverable sucrose was recorded in Taiwan due to 8.9% level of infestation by stem borers (Cheng, 1994).

The sugarcane borer larvae damage the plant in several ways. They reduce total biomass, quantity and quality of sugarcane. Tunnelling in the stem reduces stem weight as well as makes the stem susceptible to lodging and breakage. Larval entry holes also serves as a point of entrance for pathogens especially red rot disease (Ogunwolu *et al.,* 1991). The damage by insects reduces cane yield and adversely affects the quality of cane juice, which results in lower recovery of sucrose in the mill (Kuniata, 1998, 2000; Posey, 2004). In addition, larval feeding results in increased fibre, glucose, fructose and rafenose contents and reduced glucose/fructose ratio (Eastwood *et al.,* 1998; Posey, 2004).

Identifying the insect pest and understanding their significance in the sugarcane production system is the primary step in pest management program. In this regard, except few attempts that indicated the presence of complex stem borer (Yoseph *et al*., 2006), no extensive works have been undertaken in Tendaho sugarcane plantations. Identification of stem borer species complex according to their significance to the estates has a paramount importance in their management. The sugar plantation is located in the border of the country and previously maize had been grown in the area, which might be the source of the current stem borer infestation on sugarcane that has been affecting the sugar estates. Therefore monitoring to determine the pest status of stem borers is a key factor for generating knowledge and useful information.

Materials and Methods

Description of the study Area

Tendaho is situated in the lower Awash plain in Afar Regional Government State located in the rift valley of Ethiopia at $11^{0}44`$ N latitude and $41^{0}$ 05` E longitude and at an altitude of 374 m a.s.l. It receives an average of 200 mm annual rainfall distribution (from June to September). The mean minimum and maximum temperatures are 22.91°C and 37.72°C, respectively. The estate sugarcane production is undertaken with irrigation.

Survey of Sugarcane Borers complex

Survey of sugarcane stem borer was conducted between July to September 2013 randomly on selected fields. Sugarcane fields to be evaluated were randomly identified from production data sheets from the estate, with due consideration given to including four varieties and age groups. Selected sugarcane fields were then inspected for signs of stem borer infestation, such as the presence of dead hearts, larval frass and/or adult exit holes.

The crop type of the site was further categorised into plant cane and ratoon crops with due consideration in including four varieties and age groups. In each crop type and varieties, twelve fields were surveyed.

In each field, 100 stem samples were randomly collected using destructive sampling and examined for stem borers larvae, pupae and plant damage (Yoseph et al., 2006). Thirty of the 100 stem samples were collected by walking from the top left corner diagonally to bottom right corner of the field and the other 30 stem samples were collected from the top right corner diagonally to the bottom left corner. The reaming 40 sample were collected by walking through the field from the centre of each side of the field. Stems were examined *in situ* for frass or exit holes, and those with borer holes were recorded as bored plants.

To determine the occurrence of borers and extent of damage caused by borers, 10 – 30 infested stalks of the total 100 were harvested, dissected longitudinally and carefully examined for any stages of borer. Any stem borer larva and pupa found was collected and placed into 30 ml plastic vial containing a piece of sugarcane stem (Graham and Conolong, 1988; Yoseph, 2006). The data collected included the level of damage (number of bored internode). The identity of the borer species (if known) and development stage (larvae and/or pupae), cane variety name and crop type (plant cane and ratoon crop), age and site of collection (the estate) were documented.

The recovered adult specimens were pinned and packed following the procedure stated by Oldroyd (1958). The pupal specimens or adult were put in to perforated vials. Finally both specimens (adults) were sent to Kenya sugarcane research institute for identification and conformation.

Data analyses

Data on the number of bored stem per total stem sample, number of bored internodes per stem, number of internodes per stem, stem length, tunnel length, and total length of damaged stem were recorded. The methods described by Yoseph *et al.*, (2006) and Le Ru *et al.*, (2006) were used to summarize the collected data as presented below.

- **Percentage infestation (Incidence):** was determined by dividing the number of bored plants by the total number of plants examined per field, and multiplying the resulting value by 100.
- **Proportion of internodes bored (Severity):** was calculated by dividing the number of bored internodes by the total internodes in the sample plant, and this value was multiplied by 100 to get the percentage damaged internodes.
- **Relative abundance of each stem borer species:** was determined as the total number of that species found, expressed as the percentage of the total population of all stem borer species found in the estate.
- **Berger – Parker dominance index (*d*):** this index used the abundance of the dominant species relative to the abundance of all species together.

Finally, the influence of stem borer incidence and severity on sugarcane growth, cane and sugar yield was tested using JAPIN software. The association of different factors (types, cutting and sugarcane varieties) with stem borer incidence and severity were also analyzed using JAPIN version 4.0.3 Computer Software.

Monitoring of Population of Stem Borer Complex and their Damage

For monitoring of stem borer four ratoon crop fields were selected, in every 15 days interval starting 45 day after ratooning days until 8 months, the fields were assessed for the borers damage status at on 9 spots in 1.5m x 2 furrow spot sizes by “W” shape. Up to 4 months of age, the data was taken without destructive samplings whereas after 4 months of age of the plant destructive sampling was used to record damage data. The data were collected and analysed by using JMPIN version 4.0.3 software.

Results and Discussion

Sugarcane Stem Borer Species Composition and Abundance.

From 96 fields surveyed during the present work three different Lipidopteran stem borer species were identified. These are *S. calamistis*, *C. partellus* and *E. Succharina. E. Succharina* was reported for the first time in the sugarcane plantation of Ethiopia. It was observed that *B. fusca*, *S. calamistis* and *C. partellus* were prevalent in the sugarcane plantation of Ethiopia. These species were, however, never been considered as important pests of sugarcane in Africa (Charpentier and Mathes, 1969; Way and Kfir, 1997; Yoseph, 2006). The most important borer in Africa sugarcane, *S. calamistis*, is also found to be the most prevalent species in the sugarcane plantations.

In Ethiopia *B. fusca*, *S. calamistis* and *C. partellus* were reported to be the predominant stem borers of sorghum, maize and sugarcane under small scale farmers (Assefa, 1985, Emana *et al.*,2001; Yoseph, 2006; Leul, 2006), moreover, different authors reported that cropping practice had a significant effect in the prevalent and composition of stem borer under small scale farming (Seshu Reddy and Walker, 1990, Emana *et al.*,2001, Amanual, 2006). Hence, the mixed cropping practice in the small scale farming could be one of the reasons for the prevalence of stem borer in sorghum and maize as opposed to sugarcane plantations which is large scale and monoculture. Noctuidae dominated the stem borer community in the sugarcane plantation of Ethiopia. It constituted about 85% of the total borer collection species composition and abundance varied in the plantation. At Tendaho sugarcane plantation stem borer sepecies composition and releatve abundance were *S. calamisitis*, *C. partellus* and *E. Saccharina* was 58.7%, 32.1% and 9.2% respectively.

In the sugarcane plantation, sugarcane was infested by three species of stem borer; among them *S. calamistis* and *C. partellus* were the most prevalent. This indicates that there is a close relationship between sugarcane and stem borers, which could be resulted from the crop and site characteristics, i.e. long period presence of the crop in the field, presence of alternative grass species and site location (the sugarcane farms are located in maize growing areas) as reported by (Leul *et al.,* 2006) and (my personal observation).

At Tendaho a complex of three, stem borers: *S.calamistis*, *C. partellus* and *E. saccharina* were recorded. Tendaho sugarcane plantation are located at low altitude (< 374 m a.s.l) several studies in Ethiopia have reported that *C. partellus* and *E. saccharina*, was reported to be well established in low and mid altitude (Assefa, 1985, Emana, 2002; Seshu Reddy, 1983; Otieno *et al.*,2006; Leul, 2006). While, *S.calamistis* were recorded at all elevation. Amanual (2006) reported that *S.calamistis* was prevalent in low and high altitude indifferently.

At Tendaho sugarcane plantation *S. calamistis* was observed the most predominant stem borer followed by *C.partellus* and *E.saccharina*, respectively (Table 1) whilst *S, calamistis* was the most dominant species followed by *C.partellus.* At Tendaho proportion of the dominant species was 0.59. *S. calamistis* was dominant in Tendaho having d= 0.59 (Table 1). However, *C.partellus* relatively dominated the sugarcane plantation with d = 0.32 this indicates that there is a complex stem borer in the sugarcane plantation: Nevertheless, only two species, i.e., *S.calamistis* and *C. partellus* dominated the plantation.

Table 1. Borger – Parker dominance indices of Sugarcane stem borer species in the sugarcane plantation of Tendaho in 2013.

Individual Abundance	Berger – Parker (d)	Dominant Species
64	0.59	*S. calamistis*
35	0.32	*C. partellus*
10	0.09	*E. saccharina*

Stem Borer Incidence and Severity.

Incidences of stem borers in the plantation was 97.9 %, which was as high as the level of damage usually reported from sorghum and maize fields. Tendaho had the highest incidence 97.9%. This could be resulted from site characteristics, i.e, before the establishment of Tendaho sugar Factory in 2006; maize had been cultivated in the area and moreover, weed survey conducted at Tendaho in 2005/06 indicated that monocotyledon plants belonging to the family Poaceae and Cyperaceous were more prevalent (Firehun *et al.*, 2007). In this regard, reports also indicated that the presence of complex wild host plants and the presence of old cane or over age cane considered as reservoirs for various stem borer pests (Sampson and Kumar, 1986; Polaszek and khan, 1998, Emana *et al.*, 2001; Le Ru *et al.*, 2006, Leul et al., 2012).

The analysis of stem borer incidence and severity indicated that the pest attacks sugarcane in the plantation regardless of site and soil types (Table 2). On the other hand, the incidence of stem borer appeared to be significantly affected by crop type/cutting, and variety (Table 2 & 3). Among the difference cuttings first ratoon had a strong significant association at $F_{(3,42)} = 3.98$, $p< 0.0139$)with stem borer incidence in the plantation (Table 3). In the plantation infestation was high in ratoon crop than in plant cane. It was observed that stem borer invariably attacked the different cuttings across the different soil management groups. The differences in percent stem infestation across cuttings could be attributed to the progressive establishment of natural enemies besides difference in crop management practices (Yoseph *et al.,* 2006). Moreover, sugarcane varieties showed significant variation in incidence and severity of stem borer in both crop types (Table 2 & 3). Among the varieties in plant cane in terms of incidence there was no significance difference between varieties, but in severity CO680 variety had showed highly significant difference among the others at ($F_{(3,44)} = 8.45$, $p< 0.0002$). Among the varieties in ratoon crop CO680 had showed significantly different variation at ($F_{(3, 42)} = 3.98$, $p< 0.0139$) in incidence as compared to the other varieties in the plantation. (Table 3). As well as, in terms of severity CO680 variety showed highly significantly different variation at ($F_{(3, 42)} = 7.90$ $p< 0.0003$) among others varieties there was no significant difference (Table 3). Severity of stem borers, however, was higher on CO – variety than other varieties (Leul *et al.*, 2006). Different author reported that varietal differences in incidence and severity of stem borers (Kumar, 1997; White *et al.*, 2001; Posey, 2004).

In Tendaho incidence and severity of stem borer were higher in the area due to the favours of environmental condition. This could be because of close relationship of the stem borers with the different environmental factors such as temperature, rainfall, relative humidity and the like as reported by Polaszek (1998), Emana (2002) and Amanuel (2006).

Table 2. Mean (± SE) of stem borer incidence and severity in different varieties of sugarcane in plant cane.

Variety	Incidence Overall mean ± SE	Severity Overall mean ± SE
NCO334	39.67 ± 6.37a	3.67 ± 0.76a
B52/298	47.50 ± 15.62a	5.50 ± 2.90a
N14	47.95 ± 4.24a	5.14 ± 0.63a
CO680	60.77± 8.85a	10.57 ± 1.27b
F-value	1.44	8.45
P-value	0.2446	<0.0002

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test.

Table 3. Mean (± SE) of stem borer incidence and severity in different varieties of sugarcane in ratoon cane.

Variety	Incidence Overall mean ± SE	Severity Overall mean ± SE
N14	33.79 ± 4.80a	4.31 + 0.70a
NCO334	42.23 ± 6.02a	4.23 + 0.79a
B52/298	48.30 ± 7.98a	6.10 + 1.41a
CO680	62.67 ± 4.09b	10.78 + 1.39b
F-value	3.98	7.90
P-value	<0.0139	<0.0003

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test.

Mean of incidence and severity between difference crop age in plant cane shows no significant different, as well as in ratoon crop incidence of stem borer shows significant difference between crop ages at ($F_{(2,43)} = 6.30$, $p<0.0040$), but the difference among the others was not significant (Table 4 & 5). In severity, there was no significant difference among different crop age in ratoon crop.

Table 4.Mean (± SE) of stem borer incidence and severity in different crop Age of sugarcane in plant cane.

Crop Age (months)	Incidence Overall mean ± SE	Severity Overall mean ± SE
4	52.93 ± 5.89a	6.96 ± 1.31a
8	41.39 ± 5.67a	5.44 ± 0.97a
12	56.87 ± 6.77a	6.87 ± 1.10a
F-value	1.82	0.62
P-value	0.1732	0.5423

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test

Table 5.Mean (+ SE) of stem borer incidence and severity in different crop Age of sugarcane in ratoon cane.

Crop Age (months)	Incidence	Severity
	Overall mean + SE	Overall mean + SE
4	37.10 + 5.34a	6.18 + 1.28a
8	35.13 + 5.96a	4.36 + 1.14a
12	56.70 + 4.00b	7.00 + 0.86a
F-value	6.30	1.78
P-value	<0.0040	0.1809

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test.

Figure 1. Sugarcane stem damaged by stem borers and larvae of stem borer.

Effect of Stem Borer Damage on Sugarcane Growth and Yield

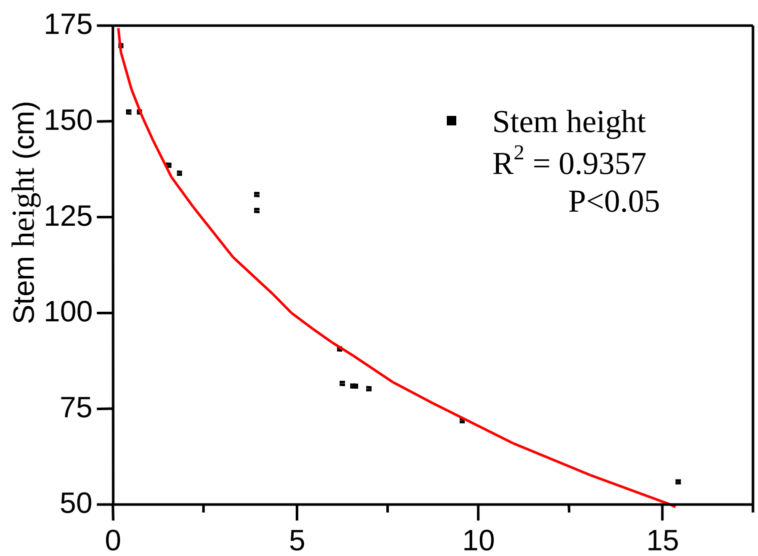
Of the 100 stem dissected in each field, on average 49 had symptom of stem borer infestation and 24 were infested with stem borer larvae (alive) in the plantation. In this study, it was noted that stem borer tunnel length and number of bored internod significantly reduced stem height, cane and sugar yield. The average stem borer tunnel length was 9.63 cm and the average height of affected stem was about 10.65% less than the non- affected stems. Beside, cane and sugar yield of affected stems were about 24.86% and 34.34% less than the non – affected stems, respectively (Table 6). The heavier the stem borer damage, the poorer the cane growth and yield (Schexnayder *et al.*,2001 and Leul *et al.*,2006).

Table 6. Mean (+ SE) Bored stem height and Tunnel length of three different sugarcane crop age.

Crop Age (months)	Over all Mean + SEM	
	Bored Stalk Height	Tunnel Length
4	49.31+ 7.28a	4.00+ 0.84a
8	63.58+ 12.14a	6.72+ 1.80ab
12	99.74+ 7.20b	9.63+ 1.05b
F – Value	8.15	4.27
P- Value	<0.0010	<0.0204

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test.

In general stem borer tunnelling had a strong linear relation with stem height, cane yield and sugar yield (Fig 2). About 93.6%, 87.0% and 92.3% variation in stem height, cane yield and sugar yield respectively, were accounted for the extent of tunnel length. Similar findings indicated that tunnel length is a good indicator of stem borer's damage on cane and sugar yield (Songa *et al.*, 2001).



Tunnel length cm (A)

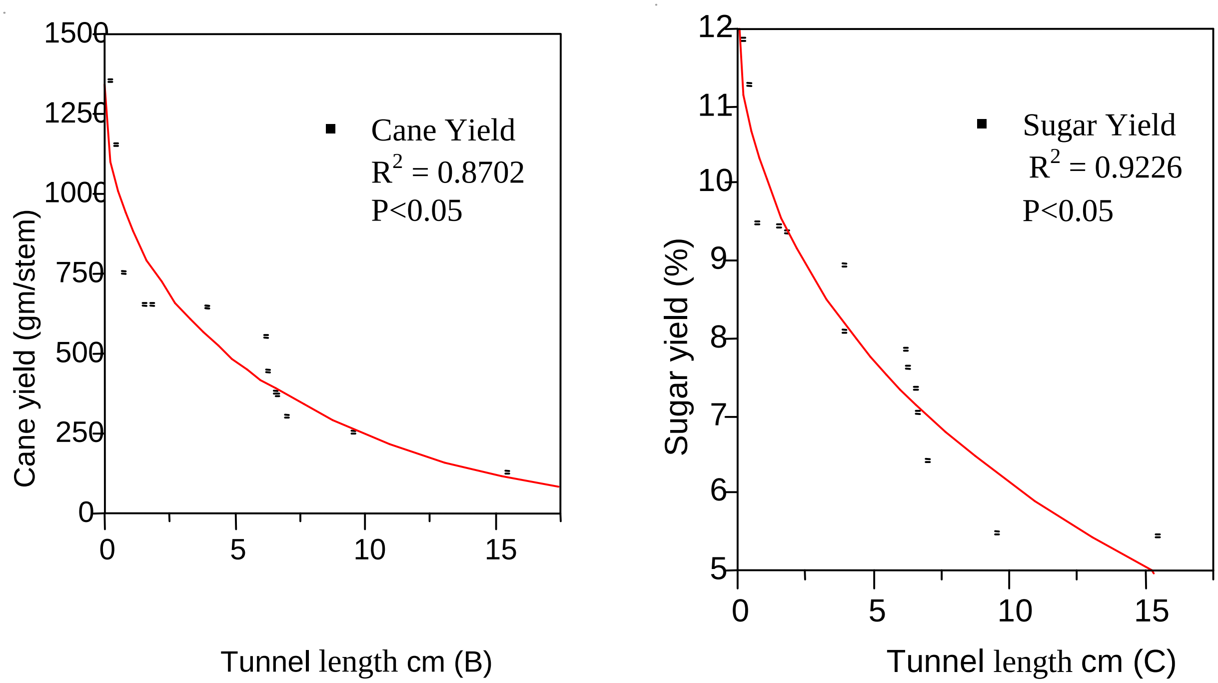


Figure 2. Effect of Stem Borers tunneling on (A) Stem height (B) Cane yield (C) Sugar yield

Monitoring of population of stem borer complex and their damage, in different growth stage.

Sprouting and Tillering stage.

A significant difference in dead shoot was detected ($F_{(3, 44)}$ = 3.82, p<0.0205) among the four sugarcane varieties B52/298, NCO334, CO680 and N14 (Table 7). The highest dead shoot was counted in N14. When treated individually N14 had significant higher dead shoot than B52/298. Varieties B52/298, NCO334 and CO680 had no significant difference, the same was true in between varieties NCO334, CO680 and N14 (Table 7). The physiology of the crop might have also contributed to the increase of the pest density as the early infestation in sugarcane led to the production of succulent tiller, which served as a food for the pests. The major stem borer species at all the stages of crop growth was present at the early stages. There was a high stem borer density per plant at the sprouting and tillering stages. Similar finding indicates that stem borer was high density per plant at the seedling and vegetative stage of maize crops. (Emana Getu 2001).

Table 7. Mean (± SE) stem borer damage on shoot of four different sugarcane varieties at sprouting and tillering stage.

Variety	Dead Shoot	Healthy Shoot
	Overall Mean ± SE	**Overall Mean ± SE**
B52 298	3.50 ± 0.65a	61.46 ± 2.85ab
NCO334	4.15 ± 0.93ab	57.18 ± 2.66a
CO680	6.05 ± 1.22ab	58.68 ± 2.80ab
N14	7.82 ± 1.09b	71.40 ± 3.59b
F- value	3.82	4.56
P- value	<0.0205	<0.0101

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test.

Grand Growth Stage.

A significant difference in bored internode number was detected ($F_{(3, 44)} = 4.29$, p<0.0171) among the four sugarcane varieties B52/298, NCO334, CO680 and N14 (Table 8). When treated individually N14 had significant higher bored internod number than variety B52/298, NCO334 and CO680. Among varieties B52/298, NCO334 and CO680 had no significant difference (Table 8). The damaging status of stem borer had high in this stage.

Table 8. Mean (± SE) stem borer damage on stalk of four different sugarcane varieties at grand growth stage.

	Bored internod number	Bored internod length	Healthy internod length
Variety	Overall Mean ± SE	Overall Mean ± SE	Overall Mean ± SE
NCO334	1.84 ± 0.12a	7.41 ± 0.30ab	8.31 ± 0.34a
B52 298	1.90 ± 0.06a	6.64 ± 0.51a	8.28 ± 0.52a
CO680	2.01 ± 0.20a	6.22 ± 0.16a	7.38 ± 0.23a
N14	2.72 ± 0.31b	8.45 ± 0.23b	10.98 ± 0.98b
F - value	4.29	8.98	6.92
P - value	<0.0171	<0.0006	<0.0022

Means followed by the same letter (s) variation a column are not significantly different from each other at 5%, Tukey–Kramer Test.

A significant difference in bored internod length was detected ($F_{(3,44)} = 8.98$, p<0.0006) among the four sugarcane varieties B52/298,NCO334,CO680 and N14 in bored interned length (Table 8). Peak bored interned length was observed in N14. When treated individually N14 had significant higher bored interned length than variety B52/298, NCO334 and CO680. In variety B52/298, NCO334 and CO680 had no significant difference (Table 8).

A significant difference in healthy internod length was detected ($F_{(3,44)} = 6.92$, p<0.0022) among the four sugarcane varieties B52/298,NCO334,CO680 and N14 in healthy interned length (Table 8). Peak healthy interned length was observed in N14. When treated individually N14 had significant higher healthy interned length than variety B52/298, NCO334 and CO680. In variety B52/298, NCO334 and CO680 had no significant difference (Table 8).

Conclusion

A total of three different Lepidoptera stem borer species belonging to three families were recorded. These are; *S. calamistis*, *C. partellus* and *E. saccharina*. Moreover, based on Berger-dominance index analysis, *S. calamistis* and *C. partellus* were recorded as the most dominant species in the plantation. There is a threat that *E. saccharina* could invade sugarcane fields already being present in the estates. Intense supervision is required to control the level of infestation by borers and prevent colonization of sugarcane by *E. saccharina*.

In addition, the study revealed that among the different factors considered in the study, variety and cuttings had a significant effect on incidence and severity of stem borers. Both incidence and severity of stem borers increased in ratoon crop as compared to plant cane. On the other hand, among the varieties, CO680 showed the highest level of incidence of stem borers as compared to the other varieties in the plantation. Also varieties CO680 had high levels of severity followed by B52/298 and NCO334. The study showed that the damage by stem borers had a significant effect on stem length, cane and sugar yield. The average stem borer tunnel length was 9.63 cm, and the average height of severely damaged stem was about 10.24% less than the undamaged stems. Cane and sugar yield of stem borer severely damaged stems were also about 24.86% less than the undamaged stems, respectively. In addition, the study showed stem with tunnel length had a great effect on cane and sugar yield. In general, stem borer damage in the sugarcane plantations of Ethiopia can cause a potential yield loss of about 27.3%.

Monitoring of stem borer was conducted on four varieties of ratoon crops in two growing stage of suagarcane sprouting and tillering and grand growth stage. The study indicates that damaged status of stem borer had high in grand growth stage than the other.

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