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Full Length Research Paper

Effect of Sugarcane Borers on Some Yield Components under Natural Conditions in Guneid, Sudan

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Field trials were conducted at Sugarcane Research Center, Guneid; for three consecutive seasons, 2007/08, 2008/09 and 2009/10. Nine sugarcane genotypes namely, B 70531; B 79136; BJ 7451; BJ 7938; BJ 82105; BT 74209; COC 671; DB 75159 and TUC 75-3; were evaluated for their field reaction to borer infestation under natural conditions; the varieties CO 527, CO 997 and CO 6806 were included as checks. The trial was laid in a randomized complete block design with three replications. The mean percentages of bored joints were 1.68, 1.7 and 1.3 for the plant cane (PC); first ratoon (R1) and second ratoon (R2) crops respectively. Reaction of the test genotypes to borer infestation was not significant in the PC. However, significant differences were observed in the R1 and R2 crop cycles. Cane height (CHt), cane thickness (CTh) and number of nodes (NON), were significant in all crop cycles of PC, R1 and R2; no significant differences were detected in NON of R2. The mean numbers of dead hearts determined per plot of 15m^2 were 1.13, 1.49, 1.31, 0.84 and 1.05 for the successive counts from March to May; and significant differences were detected for sugar content (pol) and estimated recoverable sugar (ERS) of healthy and bored canes, other parameters exhibited no differences.

Keywords: Sugarcane, genotypes, borers, yield, natural conditions

INTRODUCTION

Sugarcane (inter-specific hybrids of *Saccharum* spp.)* is grown in over 115 countries and is the main source of global supply of sugar superseding sugar beet and other artificial sweeteners. With about 20.4 million ha in 2005 it provides close to 70% of the worlds sugar; and is a backbone of the economies of many developing countries (CIRAD, 2005). Sugarcane attained strategic status as an important agro-industrial crop in the Sudan in the last two decades. Currently, it contributes substantially to the national economy. However, the sugar productivity of this crop is adversely affected by a variety of diseases caused by bacterial, fungal, nematodes and viral pathogens worldwide and a variety of pests, (Solomon et al. 2000 and Ricaud et al. 1989). Under Indian conditions; Easwaramoorthy and David (2005) cited 20% loss in yield and Waraitch (1995) reported 15% loss in sugar recovery. However, Patil and Jain (2000) and Karla (1967) indicated that yield losses could be enormous depending on the crop cultivar, crop age disease and pest patho-systems involved and under epidemic conditions.

In Sudan smut disease incited by the fungus *Ustilago scitaminea* Sydow, (Nasr and Ahmed, 1974) and cane stalk borers are most important on sugarcane. Major borer species that are known to attack sugarcane and other members of the Poaceae in Sudan are (a) the pink borer *Sesamia cretica* Led. (Syn. *Sesamia inferens* Walker) [Lepidoptera: Noctuidae], and (b) the sugarcane stalk or (maize) borer *Crambus zonellus* Zeller; which Bleszynski (1965), revised to *Chilo partellus* (Swinhoe) [Lepidoptera: Pyralidae]. While, screening for smut resistance still continues to be a major activity; the disease is currently under some good control through the use of resistant or tolerant sugarcane genotypes such as CO 6806 and CO 997. However, the impact of cane stalk borers on sugarcane and their effects on yield and juice quality largely remains undetermined and unaccounted for. Therefore, the present work was undertaken objectively to assess the current levels of natural field infestation by the sugarcane borer complex under Sudan conditions and attempt to elucidate their effects on some yield parameters, juice quality and current economic status.

MATERIALS AND METHODS

The trials were conducted at the Sugarcane Research Center, Guneid; latitude 15^{o}N, longitude 33^{o}E, for three seasons namely, 2007/2008; 2008/2009 and 2009/2010. The objectives were to evaluate the field reaction of nine sugarcane genotypes to sugarcane moth borers under natural infestation conditions. The soil at the experimental site is heavy clay vertisols, with about 64% clay, 0.09% N and 2 - 8 ppm available P; and alkaline in reaction with pH of 8.2. Mean annual rainfall is about 112 mm falling mainly in July and August.

Sugarcane seed-bed and seed cane preparation

Cane seed bed was prepared according to standard practices of heavy disking, harrowing and ridging at 1.5 m row spacing. 9 introduced sugarcane genotypes namely, B 70531, B 79136, BJ 7451, BJ 7938, BJ 82105, BT 74209, COC 671, DB 75159 and TUC 75-3 were evaluated in a field trial against the borer complex under natural infestation conditions; varieties CO 527, CO 997 and CO 6806 were utilized as checks. Three eyed cane seed pieces were prepared from 8 to 10 month old field grown cane of each genotype and utilized as planting material. Plot size is 1 row of 10 m length and 15 to 20 cane setts were planted per row. The trial was executed in a randomized complete block design with three replications. Cane was harvested after 14 months for plant cane and 12 months for ratooncrops.

Borer incidence and damage evaluation

Borer incidence or infestation in young canes was determined based on counts of symptomatic plants with the characteristic ‘dead heart’ symptoms. Dead heart counts commenced starting from about 60-90 days after planting (DAP), for plant cane and immediately after ratoonestablishment in rations; and continued for 5 to 6 months. The trials were inspected at monthly intervals for the characteristic dead heart symptoms of dead spindles either ‘pullable’ (*Chilo* spp., *Sesamia* spp.) or ‘unpullable’ often associated with (*Scirpophaga excerptalis* Walker); and the mean number of dead hearts was expressed on a per unit area basis per plot of 15 m^2.

At harvest borer damage was determined by sampling 10 cane stalks at random from each plot and each stalk was inspected individually and number of borer holes (BH), or number of bored internodes (BIN), total number of nodes per stalk (NON) were recorded. The number of bored (joints) nodes/internodes was determined and expressed as a percentage to the total number of nodes/internodes per stalk. The data was subjected to square root transformation prior to analysis of variance; and Duncan’s multiple range test was used to locate differences between the genotypes.

Juice quality deterioration resulting from borer damage

Reductions in juice quality parameters was determined for the standard commercial variety CO 6806 by taking at random about 4 or 5 samples of 100 cane stalks each. The cane stalks in each sample was then inspected individually for borer damage, then grouped into (a) healthy (b) those with 1 to 2 borer holes/internodes BIN, and (c) those with more than 3 borer holes BIN. Juice was extracted from 10-15 stalk sub-samples taken from each category and the juice was analyzed for quality parameters namely; brix, pol, ERS purity and pH. This was then, subjected to an analysis of variance to determine significant differences due to borer activity.

RESULTS AND DISCUSSION

Data in table 1 show significant differences between the different sugarcane genotypes and their reaction to borer infestation expressed as percent bored joints (PBJ) in first ratoon (R1) and second ratooncrops (R2) respectively. Genotypic differences in plant canes (PC) were not significant. However, differences in their coefficients of variation percentage ranged from 21.3% to 47.37% an indication of real differences between the different sugarcane genotypes. Also, in table 1 some morphological and growth attributes of yield namely, number of nodes/stalk NON, cane thickness CTh and cane height CHt are presented. All these parameters were significant at ($P = 0.05$) in the different sugarcane genotypes in PC, R1 and R2 crop cycles respectively, only NON in the R1 did not exhibit any differences. The mean number of ‘dead heart’ symptoms or killed spindles due to borer activity calculated on unit area basis of 15 m^2 is given in table 2. The genotypic differences were significant at ($P = 0.05$) for all counts. However, no differences were detected for counts in May. Mean number of dead heart counts were 1.13, 1.49, 1.31, 0.84, and 1.05 starting from March through May. Quality losses from juice obtained from (a) healthy,

Table 1: Percentage bored joints, and some growth attributes in the different sugarcane genotypes and crop cycles.

Sugarcane genotype	Plant cane (2000/01)				Plant cane 2007/08				second ratoon 2009/10			
	PBJ	CTh (cm)	CHt (cm)	NON	PBJ	CTh (cm)	CHt (cm)	NON	PBJ	CTh (cm)	CHt (cm)	NON
B 70531	1.78	3.7a	274.4ab	32.0a	1.45 abcd	3.08ab	125.10e	20.67	1.07abcde	3.13a	140.3bc	24.4a
B 70531	1.57	3.1bc	248.8ab	25.5bc	2.28 ab	2.36c	151.13abcd	19.47	1.62 ab	2.73ab	170.0ab	21.5bc
BJ 7451	2.29	3.1bc	263.2ab	23.6bc	2.42 a	2.63cde	172.4a	18.03	1.52 abc	2.60abc	199.9a	20.7bc
BJ 7938	1.78	2.9bcd	251.4ab	26.9bc	1.97 abcd	2.50de	130.07de	19.17	1.24 abcde	2.70abc	138.0c	22.1abc
BJ 82105	1.32	3.3ab	268.5ab	28.0abc	1.42 bcd	2.54cde	163.87ab	19.33	1.73 a	2.69abc	164.7bc	22.7ab
BT 74209	1.19	3.2ab	270.4ab	27.6abc	1.07 d	2.85bc	141.03cde	18.97	0.71 e	2.82ab	152.5bc	21.0bc
COC 671	1.57	3.1bc	280.9a	28.1abc	1.40 bcd	2.77bcd	153.53abc	20.83	0.95 cde	2.69abc	131.2c	22.7ab
DB 75159	2.10	3.3ab	253.1ab	26.3bc	2.16 abc	3.23a	145.43bcde	19.47	1.57 abc	2.83ab	160.7bc	21.0bc
TUC 75-3	1.86	2.9bcd	257.7ab	26.4bc	1.64 abcd	2.50de	145.47bcde	18.63	1.47 abcd	2.64abc	163.0bc	22.5ab
CO 527	2.06	2.7cd	254.2ab	26.6bc	1.20 cd	2.58cde	140.83cde	20.13	1.03 abcde	2.33bc	154.8bc	20.6bc
CO 997	1.36	3.2b	235.8b	28.6abc	1.90 abcd	2.63cde	132.37cde	19.40	1.43 abcd	2.57bc	159.4bc	20.5bc
CO 6806	1.31	2.6d	269.5ab	24.7bc	1.56 abcd	23.1e	153.67abc	17.97	0.81 de	2.18c	159.3bc	19.4c
MEAN	**1.68**				**1.7**				**1.26**			
SE (±)	0.46	0.14	10.8	1.53	0.41	0.10	6.85	1.02	0.32	0.16	10.2	0.85
CV (%)	33.3	8.12	7.3	9.83	29.39	6.7	8.12	9.16	31.4	10.54	11.2	6.88

Figures in a column followed by the same letter(s) do not differ significantly at (P=0.05) according to DMRT, PBJ: Percentage bored joints; CTh: Cane thickness (cm); CHt: Cane height (cm); NON: Number of nodes; ns: = not significant

Table 2: Mean number of dead hearts in the different sugarcane genotypes in the second ration crop cycle per plot of 15 m^2.

Sugarcane genotype	Date of various counts				
	10 MAR	30 MAR	10 APR	10 MAY	30 MAY
B 70531	0.966 b	1.403 b	1.274 ab	0.84 a	0.84 a
B 70531	0.966 b	1.185 b	0.966 b	1.05 a	1.05 a
BJ 7451	1.314 ab	1.403 b	1.476 ab	0.71 a	1.05 a
BJ 7938	1.127 ab	1.654 a	0.998 b	0.84 a	0.97 a
BJ 82105	1.386 ab	1.538 b	1.387 ab	0.71 a	0.71 a
BT 74209	0.925 b	1.031 b	0.926 b	1.05 a	0.84 a
COC 671	0.925 b	1.055 b	1.217 ab	0.71 a	0.84 a
DB 75159	1.464 ab	1.71 ab	1.319 ab	1.05 a	1 22 a
TUC 75-3	1.736 a	2.31 a	1.998 a	0.84 a	1.36 a
CO 527	1.055 ab	1.61 ab	1.44 ab	0.71 a	0.93 a
CO 997	0.925 b	1.76 ab	1.217 ab	0.93 a	1.35 a
CO 6806	0.836 b	1.27 b	1.45 ab	0.71 a	1.48 a
MEAN	1.13	1.49	1.31	0.84	1.05
S.E. $\pm$	0.221	0.223	0.29	0.20	0.13
C.V. (%)	36.23	31.27	44.7	33.18	33.7

Data was transformed by $\sqrt{(X + 0.5)}$; Figures in a column followed by the same letter(s) do not differ significantly at (P = 0.05) according to DMRT.

Table 3: Effect of borer damage on cane juice quality and sugar recovery in sugarcane variety CO 6806.

Particulars	Brix	Pol	Purity	ERS	PH
Healthy canes	20.12	17.51	87.13	10.13	5.84
Bored canes					
1or 2 BIN*	20.30	16.54	81.29	9.40	5.81
3 or more BIN	18.91	15.53	78.55	8.42	5.97
Bored samples average	19.60	16.03	79.92	8.91	5.89
Decrease in comparison to healthy	0.52	1.48	7.21	1.22	- 0.05
Cane juice quality deterioration and losses due to cane borer damage in sugarcane variety CO 6806.					
Healthy canes	20.12a	17.51a	87.13a	10.13a	5.85a
Bored canes					
1- 2 BIN*	20.31a	16.54a	81.29a	9.40a	5.81a
> 3 BIN	18.88a	15.23b	78.55a	8.42b	5.98a
S.E. $\pm$	0.87	0.26	4.02	0.19	0.08
C.V. (%)	5.42	1.96	5.99	2.60	1.71

* BIN = bored internodes per stalk; ERS= Estimated recoverable sugar; Brix= total soluble solids in juice; Pol= Percent sucrose in juice. Figures within a column followed by the same letter(s) are not significantly different at (P = 0.05) according to Duncan's multiple range test.

(b) bored canes either; 1 to 2 bored internodes (BIN) or greater than 3 BIN are elucidated in table 3. All quality parameters namely, brix, pol, purity, ERS and pH showed marked reductions from that of healthy cane juice by 0.52, 1.48, 7.21, 1.22 and -0.05 units respectively. Also, in table 3 significant differences were detected for pol and estimated recoverable sugar (ERS) at P = 0.05. However, the other parameters did not show any significant differences.

These findings indicate that all tested cane genotypes were prone to infestation/attack by the borer pest; with a varying genotypic reaction since even the checks were attacked, but all at low intensities and therefore the amount of losses is little and hard to estimate. However, Easwaramoorthy (1995) reported a yield loss of 3.5% for every 5% increase in the level of borer incidence; utilizing this threshold it is evident that current borer incidences between 1.17% and 1.74% as given in table 2, should give losses of roughly under one ton per feddan (TCF) at an average production of 45 TCF.

Further, he stressed that under favorable conditions in certain geographical locations shoot borers could inflict mortality rates of up to 60% dead mother shoots and 6.4% primary tillers in plant cane and 20% shoots in rations. However, Earwaramoorthy and David (2005) pointed out that in spite of the excellent work of many workers, reduction in sucrose is extremely variable and difficult to assess '*per se'* as it depends entirely on the variety, age of crop, and the intensity of attack; henceforth, making it a formidably more difficult to estimate. They also showed that in Tamil Nadu losses amounted to 19.0, 16.3 and 8.6 tons per ha. When the mean percent damage was 40%, 42.9% and 55.4%; while in Reunion 20% of internodes with holes caused losses of up to 30 tones ha^{-1} in susceptible varieties (CIRAD, 2006). Mukunthan (1986) working in tropical India cited 4% yield loss at 10% incidence; and reported loss in sugar recovery to vary from 0.2-4.1 units. This result compares favorably and agrees to our finding of a loss of 1.22 units in sugar recovery (ERS) as elucidated in table 3.

Therefore, it is evident that from the mean percent damage or bored joints as given in table (2); under Sudan conditions the actual losses is bound to be little, often masked and goes undetected in the form of mill losses especially, for pol and ERS (table 3); in a hardy and vigorous crop as sugarcane. Karla (1968) cautioned that although shoot borers usually attack the shoot stage it is also sometimes found to attack and act as cane stalk borers. Furthermore, Karla (1967) demonstrated that if high temperatures and low relative humidity conditions prevail, *Chilo* spp. will behave as active shoot borers; but, under drought conditions and low rainfall and at temperatures of about 35 ^{0}C to 38 ^{0}C and 50 to 75% RH shoot borers will continue on as stalk borers. He further stressed that these conditions are, also favorable and apply for all other borer groups such as the root borer *Emmalocera depressella* Swinhoe. The behavior of these two borer groups *Chilo* spp. and *Sesamia* spp. under Sudan conditions as top borers by way of creating the characteristic bunchy top symptoms and appearance due to the formation of numerous side shoots resulting from a dead spindle in older canes has never been observed; although shot hole symptoms were occasionally encountered.

Therefore, it can be tentatively concluded that their current mode of damage is confined to mainly as shoot and stalk borers and quite rarely as top borers. Although both species can act either as shoot borers, stalk borers and top borers depending on the cane stage attacked, temperature and relative humidity; as stipulated by Karla (1967). Chemical control of borers has proved difficult due to the concealed habit of the borer larvae. Therefore, reliability had been on natural enemies, and agronomic practices which have been known to stabilize and maintain borer populations at below threshold levels. However, recently Kvedaras et al*.* (2005 and 2007) working in South Africa reported great success in this field by silicon applications in the form of calcium silicate with or without water stress (water stress increases susceptibility) which reduced infestation by reinforcing the barrier effect against larval penetration but without affecting tissue hardness and sugars contents, this therefore, is expected to greatly compliment future strategies of control.

CONCLUSION

Based on this study we can conclude that;

1) The percentage damage (bored joints); number of dead hearts per unit area and losses are quite low therefore no specific control measure is advised.

2) Emphasis should be directed towards well balanced agronomic/cultural practices to maintain the current balance.

3) Screening program should be initiated to identify and generate resistant and or tolerant sugarcane genotypes to the borer complex for future use.

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