EFFECT OF INFESTATION BY THE PURPLE- LINED BORER, *CHILO AGAMEMNON* BLEZYNSKI ON CHEMICAL COMPOSITION OF SUGARCANE VARIETIES

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INTRODUCTION

The purple-lined borer (PLB), *Chilo agamemnon* Blezynski (Pyralidae, Lepidoptera) is the most destructive and potentially chronic species that attacks sugarcane. It is a pest on graminaceous crops in tropical and subtropical regions and mainly attacks corn, sugarcane and rice (El-Sherif, 1962). Fletcher (1910) was the first to record it in Egypt under the synonym *C. simplex* Butl. Willcocks (1925) believed that *Chilo* sp. had been imported to Egypt in some sugarcane setts or straw packings from Japan.

Borer infestation causes reduction in cane weight due to internodes damage, in addition larval tunnel in the cane cause stalk breakage and lodging. Moreover, the larval entrance and moth holes offer entry points for red rot (Reagan and Flynn, 1985). Damage of this type of pathogens severly depends on the incidence of these pests, as well as on varietal susceptibility. The borer infestation and accompanied diseases complex cause serious deterioration in the quality and quantity of juice extract for sugar production and hence drastic threat to the sugar industry.

Numerous reports in the literature on observed differences among sugarcane varieties injury by stalk borer, whereas, screening for new resistant varieties is of paramount importance to both cane grower and industry. The sugarcane resistance to stalk borers my be due to the plant characters unfavorable for establishment of borers in the plant, which inhibit or render borer development (Mathes and Charpentier 1969).

The present study was initiated to elucidate the relationship between chemical composition of six new promising sugarcane varieties and infestation by the purple-lined borer (PLB). Also, to asses the changes in chemical juice quality associated with various noticeable sign of infestation.

MATERIAL AND METHODS

Six new promising sugar cane varieties were used in this study. These varieties were, Giza (G) 84-47, 85-37, 95-21, 95-21, Farmosa (F) 161 and PH (Philippine) 8013 in addition to the major commercial variety Giza-Taiwan (GT) 54-9 (95 % of the total sugarcane area) as a standard. Varieties were planted in Shandaweel Agricultural Research Station, Sohag governorate, Upper Egypt during the two successive seasons, 2000/2001 as plant cane and 2001/2002, first ratoon.

I- Effect of infestation on chemical composition:

The relationship between leaves fiber, fiber fractions, some nutrient elements and leaves protein content and the resistance of the used varieties to stalk borer were carried out in plant cane crop. Double leaves samples from four replicates for each variety after drying to a constant weight at 70 °C in electric oven was used as follows:

Fiber fractions were determined according to Georging and Van Soest (1975) using all dried green leaves (lamina and sheaths). Samples were analyzed as follows:

NDF (neutral detergent fiber) = Cellulose + Hemicellulose + Lignin

ADF (acid detergent fiber) = Cellulose + Lignin

Hemicellulose = NDF – ADF

Cellulose was determined as weight loss of ADF upon extraction with 72 % H_2SO_4.

Crude fiber analyzes was carried out according to A.O.A.C. (1990).

Lamina of the third to the sixth leaves counting from top downwards and their sheaths as described by Clements *et al.* (1968) were dried and used to determine some major elements *i.e.* Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Silica (Si) according to A.O.A.C. (1990).

The first leaves sample started after 60 days from planting date on April 20, 2000 (after complete eye-bud germination and beginning of tillering stage). The second leaves sample was after about 210 days (Sep. 15, 2000 and Oct. 15, 2001) for plant cane and first ratoon (during great cane elongation stage). While, the third one was at harvest time after 288 days from planting date (about 13 months) at March 15, 2001 for plant cane and after 365 days (12.5 months) at March 15, 2002 for first ratoon .

II- Effect of infestation on juice quality characteristics:

At harvest time for both plant cane and 1st ratoon, 25 stalks sample was selected from each plot (varieties × four replicates) comprised uninfested stalk (healthy stalks), bored, girdled and breakage stalks in addition to a stalk sample took randomly from each plot. Samples were brought immediately after cutting to the lab. for crushing and juice analysis after stripped and cleaned. Stalk components for each noticeable sign of infestation and sound cane as well *i.e.* stalk length, stalk diameter, stalk weight, No. of joints/stalk and average joints length were measured.

Each sample was weighted and then crushed through 5 roller mill lab. Crushed juice after filtration was weighted and juice extraction percentage was calculated:

$$\% \text{ JEP} = \text{juice weight} \times 100/\text{cane weight}$$

Cane stalks fiber percentage: determined according to Sugar and Integrated Industries Company producers using high speed cutter to slices the whole cane stalks and strong blender to separate fiber. Fibers were washed several times by lime water (Calcium hydroxide 1 %) to get rid of all other components. Fiber was weighted before and after drying at 105 °C.

Juice quality analysis was carried out according to Meade and Chen (1977) as follows:

1- Brix poids (Total Soluble Solids in 100 g juice) was determined using Brix hydrometer standardized at 20oC. Reading was corrected according to juice temperature.

2- Brix volume (Total Soluble Solids in 100 cc juice) and juice density were obtained directly from Scheibler's table corresponding to brix poids degrees.

3- Pol % (Sucrose in 100 cc clarified juice) was determined by direct polarization after clarification using saccharimeter apparatus.

4- Sucrose in 100 g juice = Pol % (Sucrose in 100 cc juice)/juice density.

5- Reducing sugars in 100 cc clarified juice was made by Fehling solution method.

6- Glucose ratio (GR) = Reducing sugars in 100 cc juice/sucrose in 100 cc juice.

7- Juice purity percentage = Sucrose in 100 cc. juice × 100/Brix in 100 cc juice

8- Sugar % Cane (Richness) = Sucrose in 100 g juice × [100- (Fiber % cane × 1.3) + 2.5] / 100

9- Extracted % Sugar (Recovery or rendement) = Sugar % cane (Richness) × purity %

10- Juice acidity:

a. Juice pH value using pH meter with quinhydrone electrode (electrometric method).

b. Tetrated acidity using the usual colorimetric titration with 0.1 normal sodium hydroxide to the first pink color with phenolphthalein as indicator.

11- Starch mg in 100 cc clarified juice: was estimated according to the methods described in A.O.A.C. (1990).

12- Dextran ppm in 100 cc clarified juice: was made according to Robert *et al.* (1983).

13- Non Sugars substance percentage = Brix volume – (Sucrose in 100 cc juice + reducing sugars in 100 cc juice + Ash %) according to Fort and Mckaig (1939) Formula.

14- Non Sugars substance/Sucrose ratio = Non Sugars substance in 100 cc juice/Sucrose in 100 cc juice

15- Nitrogen in mg/100 cc clarified juice: was determined according to Micro Kjeldahl methods as described in A.O.A.C. (1990).

16- Protein in mg/100 cc juice = Nitrogen in mg/100 cc juice × 6.25

17- Ash in 100 cc juice: Ash was determined by simple ignition in an electric muffle at a temperature approximately at 500°C using 50 cc of raw juice.

18- Ash/Sucrose ratio = Ash in 100 cc juice/Sucrose in 100 cc juice

RESULTS AND DISCUSSION

I- Effect of infestation on chemical composition:

1. Leaves crude fiber and fiber fractions:

Data in Table (1) show that, crude fiber and fiber fraction *i.e.* cellulose, hemicellulose and lignin in leaves of infested plant slightly decreased (statistically insignificant) as compared with healthy (uninfested) ones. Dealing with the used varieties, average leaves fiber and fiber fractions values differed significantly among the used varieties.

Data clear that there was a relationship between leaves crude fiber and lignin and the ability of *Chilo* insect to attack cane plants, meantime, leaves fiber and its fraction may be related to the varieties sensitivity to *Chilo* infestation. On the

TABLE (I)

Chemical composition of healthy (H) and infested (I) green leaves of some new promising sugarcane varieties.

Variety		GT 54-9	G 84-47	G 85-37	G 95-19	G 95-21	F 161	PH 8013	Aver.	L.S.D. 0.05
Crude fiber	**H**	31.10	32.68	31.85	30.87	31.35	32.08	31.39	31.61	0..30
	I	30.29	32.03	31.61	30.70	31.16	31.61	31.13	31.21	0.08
Cellulose	**H**	15.27	15.59	15.57	15.40	15.46	15.83	15.58	15.51	N.S.
	I	15.27	15.55	15.35	15.35	15.54	15.69	15.40	15.45	N.S.
Hemicellulose	**H**	13.23	14.12	13.77	13.35	13.40	13.99	13.58	13.68	0.19
	I	13.28	14.09	13.73	13.41	13.40	13.91	13.87	13.67	N.S.
Lignin	**H**	6.23	8.45	7.33	6.12	6.37	8.08	7.33	7.15	0.17
	I	6.15	8.18	6..04	6.32	7.94	7.25	7.13	7.00	0.04
Protein %	**H**	9.41	6.75	8.34	10.37	9.32	7.69	8.72	8.65	0.76
	I	9.81	7.22	9.16	11.63	9.85	8.03	9.15	9.22	0..22
Nitrogen %	**H**	1.55	1.08	1.33	1.66	1.49	1.23	1.40	1.38	0.12
	I	1.57	1.16	1.47	1.86	1.57	1.28	1.46	1.48	0.04
Potassium (K%)	**H**	1.90	1.96	1.91	1.87	1.85	1.82	1.97	1.90	0.05
	I	1.89	1.86	1.83	1.80	1.75	1.75	1.91	1.83	N.S.
Phosphorus (P%)	**H**	0.119	0.114	0.103	0.102	0.106	0.109	0.115	0.110	0.004
	I	0.109	0.106	0.098	0.097	0.099	0.097	0.104	0.101	0.002
Calcium (Ca %)	**H**	0.184	0.207	0.194	0.176	0.184	0.201	0.195.	0.192	0.012
	I	0.176	0.203	0.191	0.159	0.173	0.194	0.186	0.183	0.001
Silica (Si %)	**H**	5.38	5.75	5.66	5.20	5.32	5.67	5.53	5.48	0.24
	I	6.16	5.61	5.21	4.76	4.93	5.52	5.34	5.22	0.11

other hand, cellulose and hemicellulose were negatively but in-significantly correlated with affected *Chilo* attack ability. The obtained results may be partly emphasized by those of Rizk *et al.* (1986) who found that physical qualities of the tissues play a very important role in varietal resistance to *Chilo* sp. Kennedy and Nachiappan (1992) demonstrated that a thick sclerenchymatous layer of the leaf sheath is responsible for the resistance of the pyralid *Chilo infuscatellus*. Rutherford *et al.* (1993) stated that lignin as percentage of fiber showed no association to borer infestation unless it included fiber in multiple regressions. Coulibaly (1990) found that high negative and insignificant correlation was between fiber % and number of bored internodes. Beshay (2001) stated significant difference in green leaves crude fiber and its fractions among ten tested cane varieties.

2. Leaves protein and nitrogen percentages:

Leaves protein and nitrogen contents of the infested cane plants increased significantly as comparing with uninfested ones, meantime leaves protein and nitrogen contents decreased gradually as age of plants progressed up to harvest. Also, the ratio varied significantly among the used varieties. G 95-19 and

G 95-21 varieties had the highest leaves protein and nitrogen content, meantime highly attacked by stalk borer (*C. agamemnon*), while, G 84-47variety showed a vice versa trend in both leaves protein content and *Chilo* infestation.

The high protein and/or nitrogen content increased the sensitivity of cane to borer attack and this may be due to the reduction in fiber content accompanied with high nitrogen and hence protein content in cane tissues (Coulibaly, 1990). Padhi and Chatterji (1986) showed that the susceptibility of varieties had higher nitrogen content than the resistant ones. Beshay (2001) stated that crude protein content of green leaves varied significantly among cane varieties.

3. Leaves contents of potassium (K), phosphorus (P), calcium (Ca) and silica (Si):

Infested leaves content of K, P, Ca and Si decreased than those of the healthy leaves (Table 1), but reduction rate differed according to the elements and/or the plant age. Silica and Calcium exhibited the highest reduction (statistically significant). Such effect may be due to that borer infestation negatively affected absorption and/or the status of the elements inside plant tissues. In this connection, Sharma and Chatterji (1972) stated that *Chilo* resistance was not related to N, P, K, Si and iron.

The used cane varieties differed significantly in their leaves elements content of K, P, Ca and Si. Moreover, G 84-47 variety that had the highest leaves contents of K, P, Ca and Si was the less infested by stalk borer, while, G 95-19 variety exhibited the lowest leaves content of the P, Ca and Si followed by G 95-19 for the four elements meantime, both varieties were severely infested by stalk borer. Therefore, it appeared that cane varieties with low leaves content of K, P, Ca and Si were more susceptible to stem borer, while, high leaves content of the same elements gave a vice versa trend.

From the obtained results, it appears that calcium and silica in some cane varieties may play a vital role as a chemical resistance factor against stalk borer (PLB). Such effect may be due to that both elements greatly affected the hardness of cell wall of various plant tissues, which may be responsible for larval survival and development as reported by Ukwungwu and Odobiyi (1985). Furthermore, Abu-Dooh (1988) reported that phosphorus ratio plays an important role especially in the larval development. Soliman *et al.* (1997) found that silica decreased rice stem borer infestation with a negative correlation.

II- Effect of infestation on juice quality characteristics:

1. Effect on juice extraction percentage (JEP):

Data in Table (2, a) show that the infestation significantly reduced juice extraction percentage (JEP) in both plant cane and 1st ratoon. Such effect may be due to borer feeding on the juice and tissues of cane stalks (Schexnayder *et al.*, 2001). There was a slight reduction (statistically insignificant) in JEP among the used cane varieties in both plant cane and 1st ratoon. Such effect gives evidence that the susceptibility of the used cane varieties to *Chilo* infestation was nearly the same with respect to this trait. Rao *et al.* (1983) and recently, Ali *et al.* (2001) noticed a reduction in juice extraction percentage from damaged cane.

2. Effect on stalk fiber percentage:

The infestation increased significantly stalk fiber percentage as compared with healthy cane in plant cane and 1st ratoon (Table 2,a). Also, there was a significant variation in stalk fiber content among the used cane varieties in both plant cane and 1st ratoon. Mahmoud (2000) found that the highest percentage of breakeage occurred on the upper third of the stalk, therefore, the residual stalk parts after breakage under borer infestation are the middle and basal parts of stalks which were characterized by higher fiber content than those of the upper stalk part.

Cane variety G 95-19 seemed to be the most susceptible variety, which, recorded the highest *Chilo* infestation in both plant cane and 1st ratoon, meantime,

TABLE (II a)

Effect of infestation with *Chilo agamemnon* on juice characteristics of seven sugarcane varieties.

Variety			GT 54-9	G 84-47	G 85-37	G 95-19	G 95-21	F 161	PH 8013	Aver.	L.S.D. 0.05
Juice extraction %	**Plant cane**	**H**	60.92	59.43	61.39	62.35	61.89	61.26	61.84	61.30	0.45
		I	57.29	56.00	58.22	58.71	58.56	58.21	58.45	57.92	0.38
	1st ratoon	**H**	60.31	58.95	61.60	61.85	60.59	59.95	61.04	60.61	0.77
		I	56.67	55.72	58.27	58.20	56.99	57.07	57.68	57.23	0.65
Stalk fiber percentage	**Plant cane**	**H**	12.24	12.37	11.92	11.32	11.68	12.11	11.64	11.90	0.12
		I	12.61	12.69	12.28	11.77	12.07	12.48	12.06	12.28	0.11
	1st ratoon	**H**	12.95	13.21	12.84	12.23	12.56	12.62	12.78	12.74	0.11
		I	13.39	13.44	13.20	12.76	13.07	13.02	13.18	13.15	0.10
Brix volume (100 cc juice)	**Plant cane**	**H**	20.86	21.19	21.14	20.74	19.57	19.67	20.79	20.57	0.16
		I	20.03	20.51	20.40	19.89	18.69	18.93	20.15	19.80	0.13
	1st ratoon	**H**	21.35	21.98	21.52	21.14	20.20	20.15	21.37	21.10	0.13
		I	20.65	21.49	20.81	20.39	19.41	19.54	20.88	20.45	0.11
Brix poids (100 cc juice)	**Plant cane**	**H**	19.34	19.59	19.55	19.17	18.20	18.29	19.25	19.05	0.14
		I	18.60	19.01	18.91	18.47	17.43	17.64	18.70	18.40	0.12
	1st ratoon	**H**	19.73	20.27	19.87	19.55	18.74	18.70	19.75	19.51	0.12
		I	19.13	19.84	19.27	18.91	18.06	18.17	19.32	18.96	0.10
Juice density	**Plant cane**	**H**	1.0806	1.0817	1.0815	1.0798	1.0755	1.0759	1.0802	1.0793	0.0006
		I	1.0774	1.0791	1.0787	1.0767	1.0722	1.0731	1.0777	1.0764	0.0006
	1st ratoon	**H**	1.0823	1.0847	1.0830	1.0815	1.0779	1.0777	1.0824	1.0814	0.0006
		I	1.0796	1.0828	1.0803	1.0787	1.0749	1.0754	1.0805	1.0789	0.0003
Sucrose / 100 cc juice	**Plant cane**	**H**	17.48	17.90	17.16	17.29	15.83	16.12	17.44	17.03	0.14
		I	16.20	16.72	16.02	16.00	14.64	15.02	16.33	15.85	0.12
	1st ratoon	**H**	18.22	18.67	17.68	17.92	16.47	16.73	18.31	17.71	0.14
		I	16.83	17.45	16.39	16.53	15.17	15.58	17.13	16.44	0.12

Table II a continued

Sucrose / 100 gm juice	**Plant cane**	**H**	16.18	16.55	15.87	16.01	14,72	15.03	16.15	15.79	0.13
		I	15.05	15.50	14.85	14.86	13.65	14.01	15.20	14.73	0.11
	1st ratoon	**H**	16.84	17.14	16.33	16.57	15.28	15.52	16.92	16.37	0.13
		I	15.59	16.10	15.17	15.32	14.11	14.49	15.85	15.23	0.11
Glucose / 100 cc juice	**Plant cane**	**H**	0.84	0.77	1.20	1.01	1.03	0.96	0.76	0.94	0.06
		I	0.95	0.83	1.13	1.10	1.08	0.98	0.81	0.98	0.05
	1st ratoon	**H**	0.44	0.42	0.74	0.58	0.87	0.70	0.46	0.60	0.05
		I	0.70	0.60	1.07	0.91	1.29	0.98	0.66	0.89	0.05
Reducing sugar / Sucrose ratio	**Plant cane**	**H**	3.78	3.19	4.81	4.51	5.35	5.03	3.34	4.29	0.42
		I	5.94	5.00	7.14	6.95	7.47	6.58	5.00	6.30	0.35
	1st ratoon	**H**	2.41	2.26	4.19	3.23	5.27	4.19	2.51	3.44	0.37
		I	4.20	3.48	6.60	5.56	8.57	6.37	3.91	5.52	0.32
Purity percentage%	**Plant cane**	**H**	83.80	84.47	81.17	83.37	80.91	81.96	83.89	82.80	0.72
		I	81.29	81.48	78.51	80.39	78.27	79.28	81.24	80.07	0.61
	1st ratoon	**H**	85.35	84.95	82.17	84.74	81.54	83.03	85.67	83.92	0.50
		I	81.45	81.21	78.70	80.99	78.10	79.69	82.01	80.31	0.43

exhibited the lowest fiber content. On the other hand, cane variety G 84-47 was the lesser-affected variety by infestation where, the highest stalk fiber percentages in both plant cane and 1st ratoon have been observed. Allam and Abu-Dooh (1995) found inverse relation between fiber content and all degrees of susceptibility to *Chilo* spp.

3- Effect on brix degrees:

The infestation significantly reduced juice brix volume and poids in both plant cane and 1st ratoon as compared with sound canes and these degrees significantly differed among the used varieties (Table 2,a). The varieties PH8013, G 84-47 and F161 exhibiting the lowest reduction in juice brix degrees were more resistance to *Chilo* damage. On the contrary, the highest reduction in juice brix volume and poids in both plant cane and 1st ratoon was recorded by GT 54-9, G 95-19 and G 95-21; therefore, these varieties could be termed as susceptible varieties. Besheit *et al.* (1998) and Ahmed (2003) found that brix degree greatly varied among cane varieties.

4- Effect on Juice density:

Average values of the ratio between juice brix poids / juice brix volume is known as juice density. Juice density was significantly decreased by *Chilo* infestation and varied among the used varieties in both plant cane and 1st ratoon (Table 2, a). The reduction in juice density was negatively correlated with juice weight and hence, the quantities of juice total soluble solids and the quantity of recoverable sucrose. In this connection, early reports by Fort and Mckaig (1939) showed that juice with high apparent solids (high juice density) usually yields more sugar per ton of cane than a juice with low apparent solids (low juice density), the cost of production is also less.

PH8013 variety seemed to be more tolerant to *Chilo* damage in both plant cane and 1st ratoon recording the lowest percent of reduction in juice density, while, G 95-21 variety gave vice versa trend in plant cane only. Worthwhile to mention that, the relation of the used varieties, as indicated by average juice density was completely the same as juice brix poids noticed before, meantime, the used varieties characterized with high juice density showed high recoverable sucrose (will discussed later).

5- Effects on sucrose/100 cc juice (Pol) and Sucrose/100g juice:

Data in Table (2,a) indicate that sucrose/100 cc juice and 100g juice in attacked stalks in both plant cane and 1st ratoon were significantly decreased as compared to sound (healthy) ones. Such effect may be due to that loss in sucrose % in bored cane was due to the influence of the borer rot disease complex (Silva and

Moraes, 1977) and/or may be due to sucrose inversion to reducing sugar (glucose and fractose) accompained the germinate of lateral eye buds of the internodes and/or new tillers may be formed from the lower eye buds. Also, there were significant differences among the used varieties; this may be due to genetic causes. This is in agreement with El-Soghier and Beshiet (2003) who found that varieties differed significantly in sucrose content at harvest in either plant cane or 1st ratoon. The high sucrose content varieties (G 84-47, PH8013 and GT 54-9) resist more borer damage and verified high sugar content in spite of borer infestation. These results are in the same trend as reported by Abu-Dooh (1988) who found that varieties with high percentage of sucrose appeared to suffer more infestation by *C. agamemnon*.

6- Effect on reducing sugars:

The infestation significantly increased % juice reducing sugars in both plant cane and 1st ratoon (Table 2, a). The increase in juice reducing sugars of borer attacked cans may be due to some extend to borer larvae secretion which stimulate sucrose inversion and/or to various pathogens which attack cane stalks from larval entrance or moth exit holes of the insect which utilize sucrose in its feeding or change sucrose to reducing sugars and polysaccharide such as dextran. Soliman and Mihm (1997) found that the increase in reducing sugars and dextran accompanied PLB infestation is due to inversion of sucrose by enzymes to reducing sugars and/or the effect of bacteria which change sucrose to dextran, whereas, both reducing sugars and dextran depress juice quality and cause many problems during processing.

In general, the increase in levels of juice reducing sugars is considered as undesirable cane quality criteria because of its negative effect through out various steps of cane processing. Worth to mention, the healthy (uninfested) varieties showed nearly the same trend as mentioned above in both plant cane and 1st ratoon. The 1st ratoon seemed to be more susceptible to PLB damage than plant cane. Similar findings are obtained by Allam (1997).

7- Effect on reducing sugars/sucrose ratio (Glucose ratio):

Data in Table (2, a) show that, the infestation significantly increased reducing sugars/sucrose ratio which known as glucose ratio (GR) and varietal differences have been observed in both plant cane and 1st ratoon. These results could be attributed to the increase in juice reducing sugars and the decrease in sucrose content caused by PLB infestation recorded previously in this work. The increase in GR is positively proportional to the deterioration of bored cane juice quality which, cause technological problems during cane processing. GR of plant cane was significantly higher (6.30) than those of 1st ratoon (5.52). Such effect may be due that plant cane had higher values of reducing sugars and lower sugar content than 1st ratoon as mentioned before. These results indicate that juice of 1st ratoon was more deteriorated and hence more susceptible to borer damage than plant cane and this may be attributed to the higher values of infestation recorded in 1st ratoon than plant cane. The obtained results are in harmony with those reported by Viveiros *et al.* (1992).

8-Effect on purity percentage:

Juice purity percentage of *Chilo* attacked stalks was significantly decreased as compared with sound stalks in both plant cane and 1st ratoon (Table 2, a). Such effect may be due to the reduction in both juice brix degrees and sucrose content under the same infestation observed previously. These findings agree with those obtained by Chang and Wang (1995) who stated that juice purity was significantly lower for heavily, intermediately and lightly damaged internodes infested with sugar cane borers. Worth to mention, juice purity of the healthy stalks of the used varieties had the same arrangement as mentioned before. This gives evidence that the high pure varieties were more tolerant to borer damage and verified high purity in spite of borer infestation. Besheit *et al.* (1998) reported that, purity differed significantly among cane varieties.

9-Effect on Sugar % cane (Richness):

The infestation negatively affected sugar % cane in both plant cane and 1st ratoon. 1st ratoon suffered more loss in sugar % cane than that of plant cane (Table 2,b). Such effect may be due to that 1st ratoon suffered more damage by borer infestation than plant cane. Internode borer *e.g. Chilo agamemnon* feed mainly in the internode and also tunnel through the nodes (Schexnayder *et al.*, 2001). Severe attack causes rotting and death of tissues. Weakening of nodes often results in breakage (Williams, 1961). Furthermore, borer tunnels open the way to infection by bacteria, fungi and yeasts, which, increase the loss of sucrose to a significant extent (Soliman and Mihm, 1997).

10-Effect on extracted % sugar (Recovery or rendement):

Sugar recovery or rendement refer to actual extracted % sugar or final sugar % extracted during subsequent processing steps, therefore, this trait consider an important juice quality and/or technological feature of juice which had a vital role on the final product (sugar yield) during cane manufacture.

TABLE (II b)

Effect of infestation with *Chilo agamemnon* on juice characteristics of seven sugarcane varieties.

Variety			GT 54-9	G 84-47	G 85-37	G 95-19	G 95-21	F 161	PH 8013	Aver.	L.S.D. 0.05
Sugar % cane (Richness)	Plant cane	H	13.20	13.47	13.01	12.26	12.12	13.29	13.30	12.95	0.10
		I	12.21	12.55	12.12	12.22	11.17	11.39	12.40	12.01	0.09
	1st ratoon	H	13.51	13.77	13.20	13.52	12.41	12.59	13.69	13.24	0.11
		I	12.48	12.89	12.19	12.40	11.37	11.67	12.75	12.25	0.09
Extracted% sugar (Recovery)	Plant can	H	11.06	11.38	10.56	11.05	9.81	10.07	11.16	10.73	0.15
		I	9.94	10.21	9.53	9.84	8.76	9.05	10.08	9.63	0.12
	1st ratoon	H	11.59	11.70	10.84	11.56	10.12	10.45	11.72	11.14	0.13
		I	10.19	10.48	9.61	10.08	8.89	9.31	10.47	9.86	0.11
Juice acidity (pH)	Plant cane	H	5.15	5.17	5.11	5.04	5.02	5.07	5.17	5.10	0.07
		I	5.06	5.11	5.01	4.94	4.91	4.99	5.09	5.01	0.06
	1st ratoon	H	5.26	5.28	5.15	5.09	4.99	5.13	5.23	5.16	0.07
		I	5.16	5.22	5.03	5.01	4.88	5.03	5.17	5.07	0.06
Titratable acidity	Plant cane	H	2.25	2.30	2.45	2.55	2.60	2.70	2.25	2.44	0.11
		I	2.47	2.41	2.64	2.77	2.85	2.77	2.38	2.61	0.09
	1st ratoon	H	2.15	1.95	2.25	2.40	2.65	2.45	2.20	2.29	0.10
		I	2.16	2.04	2.62	2.66	2.89	2.62	2.13	2.45	0.09
Starch mg / 100 cc juice	Plant cane	H	14.75	13.00	15.00	22.00	23.00	21.00	17.00	17.96	1.59
		I	21.95	18.20	20.00	26.20	24.40	21.40	17.60	21.39	1.34
	1st ratoon	H	13.00	10.00	14.00	18.00	20.00	18.00	12.00	15.00	1.58
		I	19.40	14.60	17.80	21.80	21.60	18.00	15.60	18.40	1.33
Dextran ppm / 100 ml juice	Plant cane	H	198	189	200	195	204	208	191	198	10.47
		I	425	374	393	422	394	382	381	396	8.85
	1st ratoon	H	191	181	172	187	178	173	178	180	11.71
		I	379	347	335	393	360	340	349	357	4.90

Table II b continued

Non sugars substances percentage %	**Plant cane**	**H**	2.72	2.72	3.16	2.67	2.89	2.74	2.77	2.81	0.10
		I	2.89	2.97	3.24	2.80	2.97	2.94	2.97	2.97	0.09
	1st ratoon	**H**	2.69	2.89	3.10	2.64	2.86	2.72	2.60	2.79	0.12
		I	3.13	3.34	3.34	2.92	2.90	2.93	3.03	3.09	0.10
Non sugars substances / sucrose ratio	**Plant cane**	**H**	15.56	15.20	18.39	15.44	18.29	17.01	15.88	16.54	0.61
		I	17.97	17.85	20.29	17.58	20.39	19.70	18.20	18.85	0.52
	1st ratoon	**H**	14.80	15.47	17.54	14.85	17.38	16.26	14.20	15.79	0.72
		I	18.99	19.76	20.57	18.03	19.58	19.22	18.10	19.18	0.61
Nitrogen mg/100 cc juice	**Plant cane**	**H**	17.30	16.40	18.40	17.40	18.50	18.30	16.90	17.60	0.47
		I	22.20	20.34	21.56	23.29	21.76	20.20	19.02	21.20	0.40
	1st ratoon	**H**	17.50	18.40	20.00	18.30	20.50	19.80	17.80	18.90	0.45
		I	21.58	19.23	21.37	22.68	22.20	20.60	19.96	21.09	0.38
Protein mg/100 cc juice	**Plant cane**	**H**	108.13	102.00	115.00	108.78	115.63	114.40	105.65	109.94	2.92
		I	138.76	127.04	134.77	145.77	136.01	126.27	118.90	132.50	2.47
	1st ratoon	**H**	109.38	115.03	125.00	114.40	128.15	123.75	111.28	118.14	2.80
		I	134.89	120.21	133.54	141.76	138.76	128.78	124.76	131.81	2.37
Ash / 100 cc juice	**Plant cane**	**H**	0.58	0.53	0.57	6.60	0.69	0.64	0.56	0.60	0.04
		I	0.69	0.61	0.65	0.71	0.80	0.72	0.63	0.69	0.04
	1st ratoon	**H**	0.54	0.52	0.60	0.56	0.65	0.61	0.55	0.58	0.04
		I	0.63	0.60	0.68	0.65	0.77	0.69	0.62	0.66	0.04
Ash / sucrose ratio	**Plant cane**	**H**	3.33	2.96	3.32	3.47	4.36	3.97	3.22	3.52	0.29
		I	4.26	3.66	4.06	4.44	5.51	4.83	3.85	3.37	0.25
	1st ratoon	**H**	2.97	2.80	3.40	3.13	3.95	3.65	3.01	3.27	0.27
		I	3.77	3.43	4.16	3.96	5.13	4.46	3.66	4.08	0.23

Data in Table (2,b) show that, *Chilo* infestation significantly reduced sugar recovery in both plant cane and first ratoon as compared with sound cane. Such effect may be due to that *Chilo* infestation had the same effect on sugar % cane, sugar % juice and purity as already mentioned before, meantime, greatly influenced this trait. The obtained results are in accordence with those of Gupta and Singh (1997) and Ali *et al.* (2001) who reported that sugar recovery (rendement) in attacked stalk was lower than that of sound cane, and the rate of quality injure varied with the infestation level. Average sugar recovery of *Chilo* infestation varied significantly among the used varieties in both plant cane and 1st ratoon. This is agreed with those reviewed by Ahmed (2003) who found a wide variation in extracted % sugar among cane varieties and within and over seasons.

11-Effect on juice acidity:

Data in Table (2,b) cleare that *Chilo* infestation significantly decreased juice pH values (increased juice acidity) in both plant cane and 1st ratoon as compared with uninfested cane. Such effect indicated that, the infestation increased juice acidity or hydrogen-ion concentration and hence a significant increase in cubic centimeters of 0.1 normal alkalis (NaOH) needed to neutralize juice acidity (10 cc of juice). The same result was concluded by Ali *et al* (2001) who stated that various bored joints levels (>5, 5-10, <10%) decreased pH values.

The increase in juice acidity and corresponding low pH values associated with sucrose conversion to reducing sugars as first step and organic acid as second step cause many problems during sugar processing and finally reflected on high loss rate of recoverable sugars in molasses. In this connection, pH too far below 7 increases the activity of degradation enzymes and causes sucrose conversion to reducing sugars. Meanwhile, the increase in juice acidity may be attributed to the action of borer rot complex (Soliman and Mihm, 1997). The reduction in sucrose and purity and the increase in reducing sugars associated with *Chilo* infestation noticed before may be due to the same effect detected on pH and titrated acidity.The high acidity varieties recorded previously high juice reducing sugars and low juice sucrose content and purity %, while, the low acidity varieties had relatively low reducing sugar and high sucrose and purity percentages (Table 2, b).

12-Effect on starch mg/100 cc juice:

Starch is a polymer of D-glucose consists of a mixture of about 80% amylopectin and 20% of amylose and it is morphous substance and had non-sweet taste. The infestation increased starch content compared with healthy cane. Juice starch content in plant cane was significantly higher (21.39 mg/100 cc. juice) than the 1st ratoon (18.40 mg/100 cc. juice) (Table 2, b). Such effect may be due to that 1st ratoon at harvest time was high mature than plant cane.

The presence of starch in cane juice caused many problems during sugar processing such as increase in the syrup and molasses viscosity (Barnes, 1964). Gelatinize of starch especially in heated juice and dispersed in the liquid phase, gave hazy syrup (Smith and Reeves, 1981). Such effect increase costs of juice processing in addition to reducing the quantity of recoverable sucrose.

13-Effect on dextran:

Data in Table (2,b) show that certain noticeable signs of *Chilo* damage significantly increased juice dextran contents in both plant cane and 1st ratoon. In this connection, borer's tunnels open the way to the entry of fungi, bacteria and yeasts (Soliman and Mihm, 1997). Sugarcane has a distinctive epiphytic flora that is of significance in the role played by microorganisms in the manufacturing of raw sugar (Meade and Chen, 1977). A small amount of dextran causes increase in juice viscosity, slow crystallization, reduce sugar yield and produce needle grain crystals. Meantime, dextran reduces quality throughout processing and carries over into the refined sugar (Legendre and Richard, 1988). Contamination of cane plants is therefore possible, but generally requires prior damage to the rend of the cane stalks by storm, burning (Foster, 1979 and Foster *et al.*, 1980).

14-Effect on nonsugars substances:

Total nonsugars consist of both inorganic nonsugars (minerals or ash) and organic constituents. The average amount of nonsugars substances significantly differed among the used varieties in both plant cane and 1st ratoon. In such a way, a high nonsugar was obviously observed in relatively high sucrose varieties. Such effect may be due to that these varieties are characterized by high values of total soluble solids. Nonsugars substances of the 1st ratoon was significantly higher and suffered more in terms of percent of increase in nonsugars from *Chilo* damage than those of plant cane. Such effect may be due to that the 1st ratoon suffered more % bored joints, % girdled stalks and % breakage stalks than those of plant cane (Table 2, b).

Nonsugars substances prevent the crystallization of some of the sucrose, early studies estimated that nonsugars keep an equal quantity of sucrose from crystallizing; others found that only two parts of sucrose are kept in solution by three parts of nonsugars (Browne and Gamble, 1923).

15-Effect on nonsugars substances/sucrose ratio:

The infested stalks showed the more drastic increase in nonsugars / sucrose ratio in both plant cane and 1^{st} ratoon as compared with sound stalks. There were differences among varieties (Table 2, b). Sommer (1929) stated that, low nonsugars to sucrose ratio give best sucrose recovery.

16-Effects on nitrogen and protein in mg /100 cc juice:

Table (2, b) indicated that, borer infestation increased nitrogen and protein in mg / 100 cc. juice and varied between the different varieties in both plant cane and 1^{st} ratoon. Nirogen and / or nitrogen compouned present in the juice prevent crystallization of socrose and also contaminate sugar crystallize (Fort and Mckaig, 1939). Nitrogenous substances such as amino acids react with reducing sugars and form brownish compounds affected the syrup and sugar color (Mathur 1981). G 95-19 and GT 54-9 were the least tolerant varieties recording the highest increase in juice nitrogen and protein in plant cane and 1^{st} ratoon. Severity of *Chilo* damage depends largely on the variety of cane (Sardana, 1998).

17-Effect on ash % juice:

Data in Table (2,b) illustrate that infestation increased significantly juice ash content as compared with uninfested ones in both plant cane and 1^{st} ratoon. Such effect may be due to the wastes secreted by borer larvae and/or the pathogen infection.The used varieties significantly differed in their ash content in both plant cane and 1^{st} ratoon. In general, average over the two variables *i.e.* varieties and *Chilo* infestation cleared that plant cane had higher ash content (0.69%) than those of 1^{st} ratoon (0.66%)

In sugar production, high juice ash content negatively influences sugar extraction and the quality of the final product, such as, sugar, molasses or syrups (Fort and Mckaig, 1939). Moreover, Irvine (1977) stated that the mineral nutrients of greatest concern in processing are those dissolved as salts in the juice rather than those that are constituents of organic molecules.

18-Effect on ash/sucrose ratio:

The infestation significantly increased ash/sucrose ratio in plant cane and 1^{st} ratoon. G 95-21 is significantly higher in ash/sucrose ratio (5.51 and 5.13) than any other varieties in both plant cane and 1^{st} ratoon (Table 2, b). Moreover, GT 54-9 the main commercial variety is relatively low in ash/sucrose ratio in the 1^{st} ratoon only. Whereas, the other studied varieties G 85-37, G 95-19 and F161 could be considered as moderate ash/sucrose ratio. Such effect may be proportionally related to variety content of sucrose and ash, where, the low ash/sucrose ratio in varieties had high sugar and low ash content as already mentioned. The obtained results are in harmony with this reported by Ali *et al.* (2001).

SUMMARY

Six new promising sugar cane varieties were used in this study to investigate the effect of infestation by *Chilo agamemnon* on chemical composition of these varietes. Leaves fiber and fiber fractions correlated negatively with the ability of borer infestation. The infestation positively correlated with leaves protein and nitrogen percentages. Varieties with low leaves content of K, P, Ca and Si were more susceptible to borer. *Chilo* infestation significantly reduced juice extraction % (JEP) as compared with healthy cane in both plant cane and 1st ratoon.

Brix volume and poids negatively correlated with *Chilo* infestation. The percent of reduction in juice density among varities within *Chilo* infestation perform inconsistently in both plant cane and 1st ratoon. Borer infestation significantly and negatively affected sucrose/100 cc juice and sucrose/100 g juice in both plant cane and the first ratoon. The infestation significantly increased reducing sugar/100 cc juice and glucose ratio. Slight reduction in juice purity among the used varieties with infestation

Varieties exhibited different degrees of reduction in both sugar % cane and extracted % sugar in plant cane and 1st ratoon with infestation. The infestation significantly decreased juice pH values (increased juice acidity) in both plant cane and 1st ratoon. Also, titrated acidity was positively correlated with infestation. The infestation increased juice starch. The first ratoon suffered more damage than plant cane with respect to the average increase in starch content of infested stalks. The infestation exhibited the maximum and minimum juice dextran content in both plant cane and 1st ratoon.

Varieties perform inconsistently in both plant cane and 1st ratoon with respect to the effect of infestation on non sugars/sucrose ratio. The 1st ratoon was highly sensitive to borer damage with regard to non sugars substances and their ratio to sucrose than the plant cane. Non sugars substances correlated negatively with infestation.The infestation increased juice nitrogen and protein content. Juice ash content and their ratio to sucrose were increased in both plant cane and first ratoon. The varieties behave similarly with respect to their effect on ash and ash/sucrose ratio.

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