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Full-Length Research Paper

Impact of nitrogen fertilization on yield and quality for plant cane, ratoon crop and correlation analyses of some sugarcane varieties

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ABSTRACT: This study was conducted in 2018/2019 plant cane and first ratoon 2019/2020 in El-Mattana Research Station, (latitude of 25.18° N and longitude of 32.06° E), Luxor Governorate, Egypt to investigate the effect of nitrogen levels and nitrogen application number on yield and its components of some new sugar cane varieties. The field experiment included twenty-seven treatments that represented combinations of three application numbers [two, three, and four times], three nitrogen fertilization levels [180, 210, and 240 kg N/fed= 4200 m²], and three sugar cane varieties [G4, G.3, and G.T.54-9]. We used a split-split plot design with three replications. The number of applications (doses), nitrogen fertilization levels, and sugarcane varieties tested all showed significant differences in all traits studied. Millable canes/m², millable cane height, weight, cane yield/fed, and sugar yield/fed all increased significantly when nitrogen levels were increased from 180 to 240 kg N/fed. In plant cane only, the G.4 outperformed the other two varieties in millable cane height, diameter, weight, cane yield/fed., sugar yield/fed., and purity percentage. However, in terms of millable cane number in plant cane and first ratoon, the commercial variety G.T.54-9 outperformed the other two varieties. While G3 had the highest sucrose and sugar recovery percent in plant cane and first ratoon, brix percent and pol percentage were only in plant cane, but sugar recovery and purity percentage were only in first ratoon. In both seasons, planting the variety G.4 fertilized with 240 kg N/fed split into four doses resulted in the highest cane and sugar yields/fed. Data were collected on cane yield and its components, sugar yield and sugar quality traits. ANOVA correlation analysis was done. Analysis of variance revealed that cane yield had perfectly positive correlation ($r = 1.0$) and highly significant correlation ($P < 0.01$) with sugar yield. On the other hand sugar yield had very high positive correlation with sugar quality traits. The results illustrated that there are significant correlation coefficient ($P \le 0.05$) between each of cane yield and sugar yield with sugar recovery % was observed. Cane yield was more closely correlated with millable cane length followed by millable cane diameter and millable weight. This has important implications for selection of varieties to be used as parental material for crossing purposes. The present study in general found that there are negative correlation between agronomic characters and juice quality parameters. With regard to the biochemical characters in the present study, sucrose percent was closely correlated with sugar recover, pol%, brix% and purity%. This indicated that selection through pol%, brix% and purity% would produce varieties with high levels of sucrose recovery percent.

Keywords: Nitrogen fertilization, sugarcane, yield and quality

INTRODUCTION

Egypt is the world's leading producer of sugar and the fourth largest consumer of the commodity. However, there is a discrepancy between production and consumption, putting additional strain on the budget. To close the gap, sugar cane production must be increased by studying the factors that affect productivity, such as varieties, split applications, and nitrogen fertilization levels, among others. Sugar cane varieties are the foundation for increasing sugar output. Many researchers have reported the differences between yield varieties and their components (Ahmed and Khaled, 2008; Istmail and El-Sogheir, 2008; Bekheet, 2011; Ahmed, 2013; Mehareb et al. (2018) and Kamel 2020). Sugar Crops Research Institute has produced some promising types of sugarcane, which included G.4 and G.3. Nitrogen is essential for photosynthesis, protein synthesis, and enzyme action in sugar crops, resulting in increased plant growth and yield. Furthermore, exceeding the optimal nitrogen fertilizer levels and number of doses is either ineffective or harmful

(Nigade et al., 2006; Ahmed et al., 2008; Mokadem et al., 2008; Yousif et al., 2015 and Yousif, 2016). The primary goals of this study were to evaluate the effects of split applications and nitrogen levels on yield and its components in some sugar cane varieties. Tena *et al.* (2016) reported that study of correlations provides the information that how strongly traits are genetically associated with one another. Thus the estimates of correlations among yield components pave the basis for selection of superior genotypes from the diverse breeding populations. Also, Hussein *et al.* (2012) showed that correlation and the path analysis for number of cane stalks was the most important character with the highest direct and indirect effects on sucrose yield followed by sucrose% and stalk weight. Cane yield was found by Abdelmahmood *et al.* (2010) to be positively correlated with millable stalks, stalk height, internodes number per stalk, and single stalk weight. They, however, noted negative association of cane yield with stalk diameter, juice pol, and purity%.Many component analyses have been performed for complex traits based on morphological and physiological characterizations Petrasovits *et al.*(2007). Tena *et al.* (2016) stated it could be more effective that yield components were selected to increase yield because of lower heritability for yield and higher heritability for yield components. However, yield is correlated with yield components in complicated ways Darvasi and Pisanté-Shalomm (2002). Therefore, it is imperative to reveal the genetic relationship between yield and its component traits.

MATERALS AND METHODS

This study was conducted at El-Mattana Research Station in Luxor Governorate over two seasons (plant cane 2018/2019 and first ratoon 2019/2020) to investigate the effect of nitrogen fertilization levels and dose number on yield and its components of some new sugar cane varieties. Twenty-seven treatments were used in the field experiment, representing combinations of three application numbers [two, three, and four], and three nitrogen fertilization levels [180, 210, and 240 kg N/fed]. "feddan= 4200 m^2"), as well as three sugar cane varieties [G.4, G.3, and G.T.54-9]. The experimental design was a split–split plot with three replications, with the number of nitrogen fertilization doses allocated to the main plots and nitrogen levels randomly distributed in the sub-plots and sub-sub plots for the three sugar cane varieties. The plot was 35 m^2 in size, with five rows of 7 m length and 1 m width. Canes were planted using the dry method. Sugarcane was planted on February 20th in the spring season and harvested 12 months later in plant cane and first ratoon. After 60 days from planting, the first dose of nitrogen fertilizer was applied (after plant emergence was completed). In plant cane crop, the second dose of nitrogen fertilization was applied 90 days after planting, the third dose was applied 120 days after planting, and the fourth dose was applied 150 days after planting, whereas in first ratoon, the four N applications were carried out after 30, 60, 90, and 120 days from harvest. When compared to plant cane, three nitrogen fertilization levels increased 15 percent in the first ratoon. All other cultural practices were carried out in accordance with the guidelines. The soil type used in the experiment is clay loam. The experimental soil's chemical and physical properties are shown in (Table 1).

Recorded data

I Yield components

At harvest, the following traits were determined:
1- Number of millable canes/m^2. It was counted on one square meter base then converted into number/fed.
- A Sample of ten millable canes from each treatment was randomly taken to determine the following traits:
2- Millable cane length (cm): It was measured from land level up to the top visible dewlap.
3- Millable cane diameter (cm): It was measured at the middle part of cane stalk.
4- Millable cane weight (kg): It was determined by determining the millable cane weight of the sample then dividing it by its number.

II Yield

1- Cane yield (ton/fed) "fed= 4200 m^2": it was determined from the weight of the three middle guarded rows of each plot converted into value per fed.
2- Sugar yield (tons/fed.): was calculated according to the following equation described by Mathur (1981).
Sugar yield (ton/fed.) = cane yield (ton/fed) x sugar recovery %.

III Juice quality characteristics

A representative sample of twenty five millable canes from each plot was taken at random, stripped, cleaned and squeezed. The primary juice was extracted by electric pilot mill (Sabri 1966) screened and mixed thoroughly on liter juice was taken in glass cylinder for calculating the juice characters.

1- Brix percentage was determined in the laboratory using brix hydrometer standardized at 20°C.

Table 1: Mechanical and chemical properties of the upper 40 cm of the experimental soil sites.

Season		2018/2019
Mechanical analysis	Sand %	13.90
	Silt %	30.60
	Clay %	55.50
Soil texture		Clay loam
Chemical analysis	pH	7.75
	Total soluble- N (gm kg^{-1})	57.20
	Available- P (gm kg^{-1})	11.00
	Available-K(gm kg^{-1})	35.1
	Soluble cations(meq/L^{-1})	
	Na	5.30
	K	0.35
	Ca	4.00
	Mg	3.70
	Soluble anions(meq/L^{-1})	
	Cl	6.21
	SO_4	6.00
	HCO_3	1.14
	CO_3	0.00
	DTPA- extractable(gm kg^{-1})	
	Fe	4.10
	Mn	1.41
	Zn	0.82
	Cu	0.20
DTPA	Di-ethylene tri-amine penta acetic acid.	

2- Sucrose percentage was determined using Sacharemeter according to the method of Mead and Chen (1977).

3- Juice Purity percentage was calculated according to the following formula:

$$\text{Juice purity percentage} = \frac{\text{sucrose percentage}}{\text{Brix percentage}} \times 100$$

4- Pol percentage was calculated according to the formula:

Pol percentage = Pol %= {Brix% – (Brix%- sucrose %) 0.4) x 0.73} according the method of Satisha *et al.* (1996).

5- Sugar recovery percentage was calculated according to the following equation described by Yadav and Sharma (1980).

Sugar recovery % = [Sucrose % - 0.4(brix % - sucrose %)] x 0.73

Statistical analysis

The collected data were subjected to the proper statistical analysis according to the procedures outlined by Snedecor and Cochran (1981). The comparison among means was done using LSD at 0.05 level of probability.

RESULTS AND DISCUSSION

I Yield components

Number of millable canes/m^2

Nitrogen application doses had a significant influence on the number of millable canes/m^2 in plant cane and first ratoon crops, according to data in (Table 2). It was discovered that splitting N fertilizer into four applications resulted in 0.11 and 0.37 stalks more than applying N fertilizer three or two times, respectively. In the first season, 0.93 and 2.38 stalks correspond to the first ratoon. These findings could be explained by the fact that splitting nitrogen fertilizer doses ensures the presence of nitrogen element within the zone of the super facials root system of sugar cane plants for a longer period of time, rather than losing nitrogen beyond the root zone through irrigation to the water table. This result is consistent with the findings of Lakshmi et al., (2003), Mehar-Chand et al., (2004), and Nigade et al., (2006), who discovered that fertilization in four split doses, increased the number of millable canes per hectare. The data in (Table 2) revealed that N levels had a significant effect on the

Table 2: Number of millable canes/m^2 of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
Two doses	180	10.00	10.33	11.33	10.56	15.33	14.00	15.67	15.00
	210	11.00	11.67	12.00	11.56	15.67	15.33	16.67	15.89
	240	11.33	13.33	12.33	12.33	16.33	15.67	17.67	16.56
Mean		10.78	11.78	11.89	11.48	15.78	15.00	16.67	15.81
Three doses	180	10.00	11.00	11.33	10.78	17.00	15.00	16.67	16.22
	210	12.00	11.67	12.00	11.89	17.00	15.67	17.33	16.67
	240	12.67	11.67	13.33	12.56	17.33	18.67	20.67	18.89
Mean		11.56	11.44	12.22	11.74	17.11	16.44	18.22	17.26
Four doses	180	12.00	11.00	11.33	11.44	15.00	15.33	18.00	16.11
	210	12.00	11.00	11.33	11.44	17.33	18.00	19.67	18.33
	240	13.00	12.00	13.67	12.89	19.33	20.33	20.67	20.11
Mean		12.33	11.33	12.11	11.93	17.22	17.89	19.44	18.19
N levels	180	10.67	10.78	11.33	10.93	15.78	14.78	16.78	15.78
x	210	11.67	11.44	11.78	11.63	16.67	16.33	17.89	16.96
Varieties	240	12.33	12.33	13.11	12.59	17.67	18.22	19.67	18.52
Mean		11.56	11.52	12.07		16.70	16.44	18.11	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.133				0.500
Fertilization levels (B)					0.359				0.630
Varieties (C)					0.288				0.405
A x B					0.621				1.091
A x C					0.499				0.702
B x C					N.S				0.702
A x B x C					0.865				1.216

number of millable canes/m^2. The highest number of millable canes/m^2 was recorded when cane plants received 240 kg N/fed in plant cane and first ratoon crops. This result could be attributed to nitrogen's role in increasing the meristemic activity of plant tissues, which contributes to the formation of new organs, as well as its role in stimulating metabolic activity in plants, which contributes to an increase in metabolites, which are used in the formation of plant organs such as new tillers. El-Geddawy et al. (2004); Ismail and El-Sogheir, (2008); Ahmed et al., (2008); and Yousif et al., 2015 and Yousif (2016) discovered that increasing nitrogen fertilization levels resulted in the highest values of millable canes/m^2.
The results in (Table 2) revealed significant differences in the number of millable cane/m^2 in plant cane and first ratoon crops among the tested sugarcane varieties. The G.T. 54-9 variety produced the highest mean value of this trait in plant cane and first ratoon crops, while the G.3 variety produced the lowest. The variation in the number of millable cane/m^2 between varieties may be controlled by their genetic structure, which is reflected in their ability to produce more survival and millable cane tillers at harvest. Ismail and El-Sogheir (2008), Ahmed (2013), Mehareb et al. (2015), and Kamel (2016) all reported varietal differences in the number of millable canes/m2 (2020).
The interaction between nitrogen fertilization doses and levels had a significant effect on the number of millable cane /m^2 in plant cane and first ratoon crops. The highest value in this trait was obtained by increasing the number of N fertilizer application doses from two to four and feeding 240 kg N/fed. The interaction of nitrogen doses x cane varieties significantly affected the number of millable canes/m^2 in plant cane and first ratoon crops. Planting G.4 variety fertilized with four doses nitrogen yielded the highest number of millable cane/m^2 in plant cane crop. Furthermore, the commercial variety G.T. 54-9 produced significantly higher values of this trait when nitrogen fertilizer was applied in four doses in the first ratoon. The data showed that the interaction between fertilization levels and sugarcane varieties had a significant influence on the number of millable cane/m^2 at harvest in the first ratoon only. Planting G.T. 54-9 variety fertilized with 240 kg N/fed resulted in the highest number of millable cane/m^2. The interaction of the three factors studied had a significant impact on the number of millable cane/m^2 in plant cane and first ratoon crops. Planting G.T. 54-9 variety fertilized with 240 kg N/fed add to four doses resulted in the highest number of millable cane/m^2.

Millable cane length (cm)

Data in (Table 3) showed that the millable cane length (cm) was significantly affected by the number of fertilization doses. Height of millable cane was increased

Table 3: Millable cane length (cm) of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
Two doses	180	270.33	270.00	275.00	271.78	276.67	271.67	276.33	274.89
	210	281.67	274.00	281.67	279.11	283.33	276.00	283.33	280.89
	240	291.33	275.00	288.33	284.89	295.33	282.67	288.67	288.89
Mean		281.11	273.00	281.67	278.59	285.11	276.78	282.78	281.56
Three doses	180	284.00	273.33	280.00	279.11	285.00	275.00	282.33	280.78
	210	290.67	275.00	283.33	283.00	294.00	288.33	285.00	289.11
	240	298.00	277.33	290.33	288.56	310.67	295.00	299.33	301.67
Mean		290.89	275.22	284.56	283.56	296.56	286.11	288.89	290.57
Four doses	180	286.33	278.33	285.00	283.22	286.67	280.00	287.67	284.78
	210	294.67	280.00	288.33	287.67	296.33	283.33	290.00	289.89
	240	303.00	285.00	295.00	294.33	315.87	298.00	302.75	305.54
Mean		294.67	281.11	289.44	288.41	299.62	287.11	293.47	293.40
N levels x Varieties	180	280.22	273.89	280.00	278.04	282.78	275.56	282.11	280.15
	210	289.00	276.33	284.44	283.26	291.22	282.56	286.11	286.63
	240	297.44	279.11	291.22	289.26	307.29	291.89	296.92	298.70
Mean		288.89	276.44	285.22		293.76	283.33	288.38	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.371				1.305
Fertilization levels (B)					0.735				2.933
Varieties (C)					0.588				1.098
A x B					1.273				5.081
A x C					1.018				1.903
B x C					1.018				1.903
A x B x C					1.763				3.295

with increasing the number of fertilization doses from three up to four doses plant cane and first ratoon crops. Four doses produced the tallest millable cane length (cm) (288.41 and 293.40 cm) plant cane and first ratoon crops, respectively. The shortest millable cane length (278.59 and 281.56 cm) was produced by the two doses plant cane and first ratoon crops, respectively. Similar results were obtained by Nigade *et al*. (2006) and Mokadem *et al*. (2008). Also result in Table (3) cleared that increasing nitrogen fertilization levels form 180 kg/fed to 240 kg/fed increased the millable cane length significantly by 9.82 and 11.84 plant cane and first ratoon crops, respectively. As well as, it was noticed that the difference between each successive N levels on cane stalk length was significant. These results may be due to the role of nitrogen in the division of stalk cells. Similar finding were obtained by El-Geddawy *et al.* (2004); Pannerselvam and Durai, (2004); Nassar *et al.* (2005) and Yousif *et al* (2015) revealed that increasing nitrogen rate up increased millable cane length.

Results in (Table 3) cleared that millable cane length was significantly affected by cane varieties in the two seasons. G.4 variety had the tallest millable cane (288.89 and 293.76 cm), while the shortest millable cane (276.44 and 283.33 cm) were produced by G.3 in two seasons, respectively. This result may be due to the genetic differences among varieties. This result is line with those obtained by Ahmed and Khaled (2008); Kamel (2015); Mehareb *et al.* (2015), Abo Elenen et al, (2018) and Kamel, (2020). The interaction effect of number application x nitrogen levels on millable cane length was significant in plant cane and first ratoon crops. Data presented in (Table 3) show that the highest values obtained from applied 4 doses of nitrogen at 240 kg N/fed. The interaction effect between number applications of nitrogen x sugarcane varieties on millable cane length was significant in plant cane and first ratoon crops, the highest values obtained from using thesugarcane variety G.3 with four equal doses in plant cane and first ratoon crops. The interaction effect of nitrogen levels x sugarcane varieties on millable cane length was significant in plant cane and first ratoon crops. Data presented in (Table 3) show that the highest values obtained from sugarcane variety G.3 at 240 kg N/fed in plant cane and first ratoon crops. In respect to the interactions effects between the different combinations for the studied factors. it could be noted that millable cane length responded significantly to all possible interactions among the mean factors plant cane and first ratoon crops.

In general the tallest millable cane length (303.00 and 315.33 cm) was obtained from G.3 variety when fertilized with 240 kg N/fed split into four doses plant cane and first ratoon crops respectively.

Table 4: Millable cane diameter (cm) of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
Two doses	180	2.77	2.73	2.73	2.74	2.50	2.43	2.46	2.47
	210	2.72	2.70	2.73	2.72	2.45	2.38	2.43	2.42
	240	2.70	2.60	2.70	2.67	2.37	2.35	2.40	2.37
Mean		2.73	2.68	2.72	2.71	2.44	2.39	2.43	2.42
Three doses	180	2.76	2.67	2.73	2.72	2.48	2.42	2.45	2.45
	210	2.73	2.60	2.70	2.68	2.43	2.37	2.42	2.41
	240	2.67	2.53	2.68	2.63	2.40	2.34	2.37	2.37
Mean		2.72	2.60	2.71	2.68	2.44	2.37	2.42	2.41
Four doses	180	2.70	2.65	2.70	2.68	2.44	2.36	2.41	2.40
	210	2.67	2.63	2.62	2.64	2.43	2.34	2.40	2.39
	240	2.63	2.55	2.57	2.58	2.41	2.32	2.38	2.37
Mean		2.67	2.61	2.63	2.64	2.43	2.34	2.40	2.39
N levels	180	2.74	2.68	2.72	2.72	2.47	2.40	2.44	2.44
x	210	2.71	2.64	2.68	2.68	2.44	2.36	2.42	2.41
Varieties	240	2.67	2.56	2.65	2.63	2.39	2.34	2.39	2.37
Mean		2.71	2.63	2.69		2.43	2.37	2.42	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.005				0.003
Fertilization levels (B)					0.007				0.007
Varieties (C)					0.011				0.003
A x B					0.012				0.011
A x C					0.019				0.006
B x C					0.019				0.006
A x B x C					0.033				0.010

Millable cane diameter (cm)

Results in (Table 4) showed that the millable cane diameter was significantly affected by the number of fertilization doses. Two doses recorded the thicker millable cane (2.71 and 2.42 cm) in plant cane and first ratoon crops respectively, this result due to the decreased in the number and length of millable cane(Table 2, 3) While, the thinnest millable cane were obtained by the four doses in plant cane and first ratoon crops. The present results are agreed with those obtained by Pannerselvam and Durai (2004); and Saleem *et al*. (2012). Millable cane diameter was significantly affected by nitrogen levels in the plant cane and first ratoon crops. The highest value of millable cane diameter was obtained from plants received 180 kg N/fed. (2.72 and 2.44 cm) in the plant cane and first ratoon crops, respectively. This finding may be indicate to the excess application of nitrogen tended to affected on millable cane height than its effect on millable cane diameter. These results are in agreement with those obtained by Mohamed and Ahmed (2005); Ahmed and El-Shafai (2007); Ashraf *et al.* (2008) and Taha *et al*. (2008).

Also, the data revealed that millable cane diameter was significantly affected by sugarcane varieties. The thickest diameter (2.71 and 2.43 cm.) was obtained by G.4 variety followed by G.T.54-9 variety while the thinner stalk (2.63 and 2.37 cm.) was recorded by G.3 variety in plant cane and first ratoon crops, respectively. These results may be due to the more vigorous growth of plants of G.4 variety. This variety had less tillers which might account much in this respect this variety cane be characterized as having less stand density which increase the diameter of millable cane. This result is line with those obtained by Bekheet (2006); Ahmed and El-Shafai (2007); Ahmed *et al.* (2011) and Galal *et al.* (2015); Mehareb *et al.* (2017), Abo Elenen et al (2018), Mehareb *et al.* (2018), and Kamel (2020). The effect of all interaction was significant on millable cane diameter in plant cane and first ratoon crops. Generally the G.4 variety recorded the thickest stalk diameter (2.77 and 2.5 cm) when fertilized with 180 kg N/fed at two doses in plant cane and first ratoon crops, respectively.

Millable cane weight (kg)

Data presented in Table (5) exhibited significant differences in millable cane weight (kg/plant) in plant cane and first ratoon crops due to the number of nitrogen application. Applying four doses attained markedly the highest millable cane weight (1.57 and 1.31 kg/plant) in the plant cane and first ratoon crops, respectively, while applying two doses recorded the lowest millable cane

Table 5: Millable cane weight (kg) of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
Two doses	180	1.42	1.37	1.38	1.39	1.13	0.92	1.12	1.06
	210	1.45	1.42	1.45	1.44	1.26	0.99	1.25	1.16
	240	1.53	1.44	1.53	1.50	1.39	1.01	1.37	1.26
Mean		1.47	1.41	1.45	1.44	1.26	0.97	1.24	1.16
Three doses	180	1.43	1.39	1.45	1.42	1.29	0.93	1.27	1.17
	210	1.53	1.47	1.50	1.50	1.40	0.95	1.37	1.24
	240	1.56	1.52	1.56	1.55	1.41	1.04	1.41	1.29
Mean		1.50	1.46	1.50	1.49	1.37	0.97	1.35	1.23
Four doses	180	1.57	1.42	1.55	1.51	1.39	1.00	1.35	1.25
	210	1.64	1.51	1.55	1.57	1.44	1.05	1.43	1.31
	240	1.67	1.55	1.66	1.62	1.49	1.12	1.48	1.36
Mean		1.63	1.49	1.59	1.57	1.44	1.06	1.42	1.31
N levels x Varieties	180	1.47	1.39	1.46	1.44	1.27	0.95	1.25	1.16
	210	1.54	1.47	1.50	1.50	1.36	1.00	1.35	1.24
	240	1.59	1.50	1.58	1.56	1.43	1.06	1.42	1.30
Mean		1.53	1.46	1.51		1.35	1.00	1.34	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.007				0.007
Fertilization levels (B)					0.007				0.008
Varieties (C)					0.005				0.013
A x B					0.013				0.015
A x C					0.008				0.023
B x C					0.008				0.023
A x B x C					0.014				0.040

weight (1.44 and 1.16 kg/plant) in the plant cane and first ratoon crops, respectively. These results could be attributed to the superiority in number of millable canes/m^2 and height (Tables 2 and 3). Highly significant negative correlation between millable cane weight and number of millable cane was reported by Hogarth (1971). These results are in harmony with those reported by Pannerselvam and Durai (2004), Nigade *et al.,* (2006) and Yousif (2016). Data in (Table 5) showed that millable cane weight (kg/plant) was significantly affected by nitrogen fertilization levels at harvest in the plant cane and first ratoon crops. The highest values of millable cane weight (kg/plant) was obtained with the application of 240 kg N/fed for the plant cane and first ratoon crops. These results could be attributed to higher values of number of millable canes/m^{2}and height (Tables 2 and 3).These result are in agreement with those obtained by Mohamed and Ahmed (2005); Hussien, Omeima (2008); Dev *et al.* (2011) and Hemalatha (2015). Results given in (Table 5) showed that millable cane weight (kg/plant) was significantly affected by sugarcane varieties in plant cane and first ratoon crops. Sugar cane variety G.4 produced the highest millable cane weight (1.53 and 1.35 kg/plant), followed by G.T.54-9 variety (1.51 and 1.34).While G.3 variety had the lowest value of this trait (1.45 and 1.00) in plant cane and first ratoon crops, respectively. The superiority of G.4 over the other two sugarcane varieties in millable cane weight may be due to its superiority in millable cane diameter (Table 3). These results are in agreement with those obtained by El-Geddawy *et al.* (2012); El-Geddawy *et al.* (2015); Galal *et al.* (2015); Mehareb *et al.* (2016) Mehareb and Galal (2017) and Kamel (2020).

As for the interaction effects, in Table (5) cleared that the interaction between nitrogen doses x nitrogen fertilization levels affected significantly millable cane weight at harvest in in plant cane and first ratoon crops. The highest values obtained from applied 4 doses of nitrogen at 240 kg N/fed. Millable cane weight was significantly influenced by the interaction between nitrogen doses x sugarcane varieties at harvest in plant cane and first ratoon crops, the highest values obtained from using the sugarcane variety G.4 with four equal doses in plant cane and first ratoon crops. Millable cane weight was significantly affected due to the interaction between nitrogen fertilization levels x sugarcane varieties at harvest in plant cane and first ratoon crops. Data presented in Table (5) show that the highest values obtained from sugarcane variety G.4 at 240 kg N/fed. in plant cane and first ratoon crops.

Table 6: Cane yield (ton/fed.) of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019 G.4	G.3	G.T. 54-9	Mean	First ratoon 2019/2020 G.4	G.3	G.T. 54-9	Mean
	180	44.45	39.48	40.85	41.59	47.34	42.00	43.73	44.36
Two doses	210	45.37	39.55	41.48	42.13	47.20	43.58	45.43	45.40
	240	49.11	43.00	45.98	46.03	50.89	45.21	47.44	47.84
Mean		46.31	40.68	42.77	43.25	48.48	43.60	45.53	45.87
	180	45.26	40.34	41.25	42.28	47.66	42.33	43.56	44.52
Three doses	210	46.11	42.47	43.69	44.09	48.66	43.73	46.39	46.26
	240	50.35	44.16	46.33	46.95	52.56	45.61	50.41	49.53
Mean		47.24	42.32	43.76	44.44	49.63	43.89	46.79	46.77
	180	46.43	41.42	42.60	43.48	48.65	43.96	45.35	45.99
Four doses	210	47.23	42.58	44.11	44.64	51.17	44.64	48.05	47.95
	240	51.03	46.15	47.37	48.19	53.48	47.36	51.25	50.70
Mean		48.23	43.38	44.69	45.44	51.10	45.32	48.22	48.21
N levels	180	45.38	40.41	41.57	42.45	47.88	42.76	44.21	44.95
x	210	46.23	41.53	43.09	43.62	49.01	43.99	46.62	46.54
Varieties	240	50.16	44.44	46.56	47.05	52.31	46.06	49.70	49.36
Mean		47.26	42.13	43.74		49.73	44.27	46.85	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.202				0.227
Fertilization levels (B)					0.209				0.229
Varieties (C)					0.195				0.219
A x B					0.361				0.396
A x C					0.337				0.380
B x C					0.337				0.380
A x B x C					0.584				0.658

The interactions among the three studied factors were significantly affected on millable cane weight in plant cane and first ratoon crops. Generally, the highest millable cane weight (1.67 and 1.49 kg/plant) was obtained from G.4 variety fertilized with 240 kg N/fed and applied in four doses in plant cane and first ratoon crops, respectively.

II. Yield

Cane yield (ton/fed)

Data presented in Table (6) showed the differences between studied numbers of doses in cane yield (ton/fed) were significant in plant cane and first ratoon crops. Sugarcane inoculated with three and two number of doses produced 1.00 and 2.19 tons/fed lower than the four doses, respectively, in plant cane crop, and 1.44 and 2.34 tons/fed, in the first ratoon crop. The increase in cane yield as affected by the used four doses could be attributed to the increase in number of millable canes/m^2 and millable cane weight, (Tables 2 and 5) compared with other doses. Similar results were obtained by Ashraf *et al.* (2008); George *et al.* (2013) and McCray *et al.* (2014). They reported that cane yield/fed was gradually increased with increasing nitrogen application from 2 to 4 doses.

Data disclosed that increasing nitrogen fertilization level from 180 to 210 and to 240 kg N/fed resulted in an increase in cane yield/fed. of 4.60 and 3.43 tons/fed, in plant cane crop. The same trend was observed in the first ratoon crop, where an increase in cane yields of 4.41 and 2.82 tons/fed was obtained when N fertilization level was raised to 210 and 240 kg N/fed compared with that given by adding 180 kg N/fed., respectively. These results are probably due to the increase in millable cane length, diameter and number of millable canes/m^2/ at harvest (Tables 2, 3 and 4) respectively), which showed the need to increase N fertilization level for better growth of cane plants. These results are in agreement with thosereported by Tiwari *et al.* (2004); El-Sayed *et al.* (2005); Yahaya *et al.* (2010) and Hemalatha (2015).

The present results revealed significant differences in cane yield were found among the tested sugar cane varieties. Sugarcane variety G.4 out yielded G.T.54-9 and G.3 varieties in cane yield by 3.52 and 5.13 tons/fed in the plant cane crop respectively, meanwhile, 2.88 and 5.46 tons/fed in the first ratoon crop respectively. This superiority of G.4 variety in cane yield mainly attributed to its superiority in millable cane diameter and weight (Tables 4 and 5). These results are in agreement with those obtained by Abo El-Hamd *et al.* (2013); Galal *et al.* (2015); Mehareb *et al.* (2016) and Kamel (2020). Data presented in (Table 6) showed that the effects of the interactions between the studied factors were significant in plant cane and first ratoon crops. The greatest cane yield/fed (51.03 and 53.48 ton/fed) was obtained by planting variety G.4 fertilized with 240 kg nitrogen and applied in four equal doses in plant cane first ratoon crops

Table 7: Sugar yield (Ton/fed.) of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019 G.4	G.3	G.T. 54-9	Mean	First ratoon 2019/2020 G.4	G.3	G.T. 54-9	Mean
Two doses	180	4.69	4.13	4.32	4.38	5.36	4.84	5.01	5.07
	210	4.80	4.26	4.45	4.50	5.41	5.05	5.26	5.24
	240	4.83	4.27	4.52	4.54	5.57	5.14	5.35	5.36
Mean		4.77	4.22	4.43	4.47	5.45	5.01	5.21	5.22
Three doses	180	4.83	4.34	4.48	4.55	5.59	5.15	5.22	5.32
	210	5.01	4.75	4.84	4.87	5.75	5.33	5.57	5.55
	240	5.32	4.65	4.92	4.97	5.87	5.41	5.70	5.66
Mean		5.05	4.58	4.75	4.79	5.74	5.30	5.49	5.51
Four doses	180	5.32	4.75	4.92	5.00	5.69	5.21	5.37	5.42
	210	5.47	5.04	5.11	5.20	5.99	5.33	5.71	5.68
	240	5.56	5.12	5.32	5.33	6.03	5.42	5.82	5.76
Mean		5.45	4.97	5.12	5.18	5.90	5.32	5.63	5.62
N levels x Varieties	180	4.95	4.41	4.57	4.64	5.55	5.07	5.20	5.27
	210	5.09	4.68	4.80	4.86	5.72	5.24	5.51	5.49
	240	5.24	4.68	4.92	4.95	5.83	5.33	5.63	5.59
Mean		5.09	4.59	4.76		5.70	5.21	5.44	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.020				0.029
Fertilization levels (B)					0.023				0.028
Varieties (C)					0.022				0.025
A x B					0.040				0.049
A x C					0.038				0.044
B x C					0.038				0.044
A x B x C					0.065				0.076

respectively.

Sugar yield (ton/fed)

Data presented in (Table 7) showed that sugar yield ton/fed was affected by number of nitrogen fertilization doses in plant cane and first ratoon crops, the highest values of sugar yield ton/fed (5.18 and 5.62 ton/fed) were recorded from application nitrogen in four equal dose in plant cane and first ratoon crops, respectively. However, the lowest values of this trait (4.47 and 5.22 ton/fed) produced from application nitrogen on two equal doses in plant cane and first ratoon crops, respectively. The increase in sugar yield may be due to increase the yield and sugar recovery and sucrose percentages. The present results are in general agreement with those obtained by Saleem *et al*. (2012) and McCray *et al*. (2014). Concerning the effect of nitrogen fertilization levels on sugar yield ton/fed. results showed that increasing nitrogen application from 180 to 210 and to 240 kg N/fed. led to a significant increase in sugar yield by amounted by 0.31 and 0.15 in the plant cane crop, being 0.32 and 0.10 in first ratoon crop. This increase in sugar yield as affected by increasing nitrogen fertilization level is probably due to the gradual increase in cane yield Table (6). These results are in agreement with those obtained by Cabrera and Zuaznabar (2010); Shalaby *et al.* (2011) and Bologna-Campbell *et al.* (2013). Data exhibited a significant variance among the tested sugarcane varieties in sugar yield/fed in plant cane and first ratoon crops. Data showed the superiority of G.4 variety in sugar yield over the other two varieties, since it produced 0.33 and 0.50 ton of sugar/fed over those given by G.T.54-9 and G.3 varieties, respectively, in plant cane, while in first ratoon crop 0.26 and 0.49 ton of sugar/fed., respectively. These results could be attributed to cane yield given by the tested cane varieties (Table 6) where it is well known as a fact that the extractible sugar yield depends mainly on cane yield. The results obtained in the present study are in agreement with those obtained by Galal *et al.* (2015); El-Geddawy *et al.* (2015); Mehareb *et al.* (2018) and Kamel (2020).

Regarding the interaction effects, data in Table (7), cleared those sugars yield/fed was significantly affected by all the interactions in plant cane and first ratoon crops. The highest sugar yield/fed (5.56 and 6.03 ton/fed) was produced by G.4 variety fertilized with 240 kg N/fed and sprayed with four doses.

III. Juice quality characteristics

Data in Tables (8, 9, 10, 11and 12) show juice quality percentages differed significantly in plant cane and first

Table 8: Brix percentage of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
	180	19.50	20.40	19.81	19.90	19.07	18.58	19.28	18.98
Two doses	210	19.71	20.53	20.65	20.30	19.88	19.33	19.61	19.60
	240	19.80	20.80	20.36	20.32	20.08	19.41	19.71	19.73
Mean		19.67	20.58	20.27	20.17	19.68	19.10	19.53	19.44
	180	19.56	20.51	19.96	20.01	19.38	18.64	19.31	19.11
Three doses	210	19.93	20.89	20.71	20.51	19.57	19.47	19.50	19.51
	240	20.07	20.95	20.51	20.51	20.51	19.52	20.54	20.19
Mean		19.85	20.78	20.40	20.34	19.82	19.21	19.78	19.60
	180	19.83	20.32	19.81	19.99	19.72	19.21	19.47	19.47
Four doses	210	20.06	20.91	20.74	20.57	19.75	20.02	20.31	20.03
	240	20.45	21.00	20.64	20.70	20.67	20.39	20.66	20.57
Mean		20.11	20.74	20.40	20.42	20.05	19.87	20.15	20.02
N levels	180	19.63	20.41	19.86	19.97	19.39	18.81	19.35	19.19
x	210	19.90	20.77	20.70	20.46	19.73	19.61	19.81	19.71
Varieties	240	20.11	20.92	20.50	20.51	20.42	19.77	20.30	20.17
Mean		19.88	20.70	20.35		19.85	19.40	19.82	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.019				0.023
Fertilization levels (B)					0.018				0.014
Varieties (C)					0.009				0.014
A x B					0.031				0.025
A x C					0.015				0.024
B x C					0.015				0.024
A x B x C					0.026				0.042

Table 9: Sucrose percentage of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
	180	15.89	16.07	16.01	15.99	16.53	16.59	16.72	16.61
Two doses	210	15.98	16.39	16.40	16.26	16.90	16.85	16.93	16.89
	240	15.29	15.67	15.43	15.47	16.45	16.68	16.67	16.60
Mean		15.72	16.05	15.95	15.90	16.63	16.70	16.77	16.70
	180	16.04	16.39	16.33	16.25	17.02	17.23	17.24	17.16
Three doses	210	16.32	16.91	16.75	16.66	17.16	17.49	17.31	17.32
	240	16.08	16.30	16.25	16.21	16.79	17.19	16.93	16.97
Mean		16.14	16.53	16.45	16.37	16.99	17.31	17.16	17.15
	180	16.89	17.02	16.95	16.95	17.08	17.08	17.14	17.10
Four doses	210	17.06	17.55	17.27	17.29	17.10	17.41	17.42	17.31
	240	16.50	16.85	16.88	16.74	16.95	17.03	17.02	17.00
Mean		16.81	17.14	17.03	17.00	17.04	17.17	17.19	17.14
N levels	180	16.27	16.49	16.43	16.40	16.88	16.97	17.03	16.96
x	210	16.45	16.95	16.81	16.74	17.05	17.25	17.22	17.17
Varieties	240	15.95	16.27	16.19	16.14	16.73	16.96	16.88	16.86
Mean		16.23	16.57	16.48		16.89	17.06	17.04	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.012				0.005
Fertilization levels (B)					0.013				0.010
Varieties (C)					0.010				0.009
A x B					0.022				0.017
A x C					0.017				0.016
B x C					0.017				0.016
A x B x C					0.030				0.027

ratoon crops by the studied number of nitrogen doses, increasing the number of nitrogen applications from two to four nitrogen doses increased the values of juice quality percentages in plant cane first ratoon crops,

Table 10: Purity percentage of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	**G.3**	**G.T. 54-9**	**Mean**	**G.4**	**G.3**	**G.T. 54-9**	**Mean**
Two doses	180	81.47	78.76	80.82	80.35	86.64	89.27	86.72	87.54
	210	81.08	79.87	79.42	80.12	85.03	87.20	86.32	86.18
	240	77.23	75.33	75.82	76.13	81.91	85.92	84.61	84.15
Mean		79.93	77.97	78.68	78.86	84.53	87.46	85.88	85.96
Three doses	180	81.98	79.90	81.81	81.23	87.84	92.44	89.26	89.85
	210	81.91	80.97	80.90	81.26	87.68	89.86	88.78	88.77
	240	80.10	77.78	79.24	79.04	81.86	88.08	82.43	84.12
Mean		81.33	79.55	80.65	80.51	85.79	90.12	86.83	87.58
Four doses	180	85.15	83.75	85.59	84.83	86.59	88.94	88.04	87.86
	210	85.03	83.92	83.25	84.07	86.55	86.95	85.79	86.43
	240	80.67	80.25	81.80	80.91	81.97	83.52	82.39	82.63
Mean		83.62	82.64	83.54	83.27	85.04	86.47	85.41	85.64
N levels x Varieties	180	82.87	80.81	82.74	82.14	87.02	90.21	88.01	88.42
	210	82.67	81.59	81.19	81.82	86.42	88.00	86.96	87.13
	240	79.33	77.79	78.95	78.69	81.92	85.84	83.14	83.63
Mean		81.63	80.06	80.96		85.12	88.02	86.04	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.071				0.116
Fertilization levels (B)					0.097				0.068
Varieties (C)					0.064				0.076
A x B					0.168				0.117
A x C					0.110				0.132
B x C					0.110				0.132
A x B x C					0.191				0.228

Table 10: Purity percentage of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	**G.3**	**G.T. 54-9**	**Mean**	**G.4**	**G.3**	**G.T. 54-9**	**Mean**
Two doses	180	81.47	78.76	80.82	80.35	86.64	89.27	86.72	87.54
	210	81.08	79.87	79.42	80.12	85.03	87.20	86.32	86.18
	240	77.23	75.33	75.82	76.13	81.91	85.92	84.61	84.15
Mean		79.93	77.97	78.68	78.86	84.53	87.46	85.88	85.96
Three doses	180	81.98	79.90	81.81	81.23	87.84	92.44	89.26	89.85
	210	81.91	80.97	80.90	81.26	87.68	89.86	88.78	88.77
	240	80.10	77.78	79.24	79.04	81.86	88.08	82.43	84.12
Mean		81.33	79.55	80.65	80.51	85.79	90.12	86.83	87.58
Four doses	180	85.15	83.75	85.59	84.83	86.59	88.94	88.04	87.86
	210	85.03	83.92	83.25	84.07	86.55	86.95	85.79	86.43
	240	80.67	80.25	81.80	80.91	81.97	83.52	82.39	82.63
Mean		83.62	82.64	83.54	83.27	85.04	86.47	85.41	85.64
N levels x Varieties	180	82.87	80.81	82.74	82.14	87.02	90.21	88.01	88.42
	210	82.67	81.59	81.19	81.82	86.42	88.00	86.96	87.13
	240	79.33	77.79	78.95	78.69	81.92	85.84	83.14	83.63
Mean		81.63	80.06	80.96		85.12	88.02	86.04	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.071				0.116
Fertilization levels (B)					0.097				0.068
Varieties (C)					0.064				0.076
A x B					0.168				0.117
A x C					0.110				0.132
B x C					0.110				0.132
A x B x C					0.191				0.228

Table 11: Pol. percentage of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
Two doses	180	13.18	13.63	13.35	13.39	13.18	12.98	13.33	13.16
	210	13.30	13.78	13.83	13.64	13.64	13.39	13.53	13.52
	240	13.14	13.69	13.42	13.42	13.60	13.37	13.50	13.49
Mean		13.21	13.70	13.53	13.48	13.47	13.25	13.45	13.39
Three doses	180	13.25	13.77	13.51	13.51	13.46	13.20	13.49	13.38
	210	13.49	14.09	13.96	13.85	13.58	13.63	13.60	13.60
	240	13.49	13.94	13.73	13.72	13.89	13.57	13.94	13.80
Mean		13.41	13.93	13.74	13.69	13.64	13.47	13.68	13.59
Four doses	180	13.62	13.87	13.63	13.71	13.63	13.40	13.53	13.52
	210	13.77	14.28	14.13	14.06	13.64	13.85	13.98	13.83
	240	13.77	14.12	13.97	13.95	14.00	13.90	14.02	13.98
Mean		13.72	14.09	13.91	13.91	13.76	13.72	13.84	13.77
N levels	180	13.35	13.76	13.50	13.53	13.42	13.19	13.45	13.36
x	210	13.52	14.05	13.97	13.85	13.62	13.62	13.70	13.65
Varieties	240	13.46	13.91	13.71	13.70	13.83	13.61	13.82	13.75
Mean		13.45	13.91	13.73		13.62	13.48	13.66	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.010				0.009
Fertilization levels (B)					0.008				0.008
Varieties (C)					0.005				0.007
A x B					0.015				0.013
A x C					0.008				0.012
B x C					0.008				0.012
A x B x C					0.014				0.020

Table 12: Sugar recovery percentage of three sugarcane varieties as affected by number of nitrogen fertilization doses, levels and their interactions in plant cane and first ratoon crops.

N Doses	N levels Kg/fed.	Plant cane 2018/2019				First ratoon 2019/2020			
		G.4	G.3	G.T. 54-9	Mean	G.4	G.3	G.T. 54-9	Mean
Two doses	180	10.54	10.47	10.58	10.53	11.32	11.53	11.46	11.43
	210	10.58	10.76	10.73	10.69	11.47	11.58	11.57	11.54
	240	9.85	9.94	9.83	9.87	10.95	11.38	11.29	11.20
Mean		10.32	10.39	10.38	10.36	11.25	11.49	11.44	11.39
Three doses	180	10.68	10.76	10.86	10.77	11.74	12.17	11.98	11.96
	210	10.86	11.19	11.07	11.04	11.82	12.19	12.00	12.00
	240	10.57	10.54	10.62	10.58	11.17	11.87	11.31	11.45
Mean		10.70	10.83	10.85	10.79	11.58	12.08	11.76	11.80
Four doses	180	11.47	11.46	11.54	11.49	11.70	11.85	11.83	11.79
	210	11.57	11.83	11.59	11.66	11.70	11.95	11.88	11.84
	240	10.89	11.09	11.23	11.07	11.28	11.45	11.36	11.37
Mean		11.31	11.46	11.45	11.41	11.56	11.75	11.69	11.67
N levels	180	10.90	10.90	10.99	10.93	11.58	11.85	11.76	11.73
x	210	11.01	11.26	11.13	11.13	11.66	11.91	11.82	11.80
Varieties	240	10.43	10.52	10.56	10.51	11.13	11.56	11.32	11.34
Mean		10.78	10.89	10.89		11.46	11.77	11.63	
LSD at 0.05 level of significance									
Fertilization doses (A)					0.011				0.011
Fertilization levels (B)					0.014				0.010
Varieties (C)					0.011				0.010
A x B					0.024				0.017
A x C					0.019				0.017
B x C					0.019				0.017
A x B x C					0.033				0.030

Table 13: Correlation coefficients among 11 different characters in three sugarcane genotypes growing at Upper Egypt.

	No. Millable	Millable length	Millable diameter	Millable weight	Cane yield	Brix%	Sucrose%	Pol%	Purity%	SR%	Sugar yield
No. Millable	1.000										
Millable length	0.242 0.844	1.000									
Millable diameter	0.429 0.718	0.980 0.126	1.000								
Millable weight	0.552 0.628	0.943 0.216	0.990 0.090	1.000							
Cane yield	0.005 0.997	0.971 0.153	0.905 0.279	0.837 0.369	1.000						
Brix%	0.520 0.652	-0.702 0.504	-0.548 0.631	-0.425 0.720	-0.851 0.352	1.000					
Sucrose%	0.191 0.878	-0.906 0.278	-0.805 0.405	-0.713 0.494	-0.981 0.126	0.938 0.226	1.000				
Pol%	0.388 0.746	-0.800 0.410	-0.666 0.536	-0.554 0.626	-0.920 0.257	0.989 0.095	0.979 0.131	1.000			
Purity%	0.453 0.700	-0.975 0.144	-1.000 0.017	-0.994 0.072	-0.893 0.296	0.525 0.648	0.788 0.422	0.645 0.553	1.000		
SR%	0.065 0.958	-0.952 0.197	-0.873 0.324	-0.796 0.414	-0.998 0.045	0.886 0.307	0.992 0.081	0.945 0.212	0.860 0.341	1.000	
Sugar yield	0.015 0.991	0.974 0.147	0.909 0.273	0.842 0.363	1.000 0.006	0.846 0.358	0.979 0.132	0.916 0.263	0.898 0.290	0.997 0.051	1.000

respectively. Similar results were obtained by Nigade *et al*. (2006) and Bologna-Campbell *et al.* (2013). The results in (Tables 8, 9, 10, 11 and 12) pointed out that increasing nitrogen fertilization levels applied to sugarcane had a significant effect on juice quality percentages in plant cane and first ratoon crops. The highest value of sugar recovery percentage was obtained from nitrogen level 210 kg N/fed in plant cane and first ratoon crops. These results are in agreement with that reported by Ashraf *et al.* (2008); Taha *et al*. (2008) and Shalaby *et al.* (2011).

Data in Tables (8, 9, 10, 11and 12) cleared that the examined sugarcane varieties varied significantly in juice quality percentages in plant cane and first ratoon crops. The commercial G.T. 54-9 variety and G.3 variety showed the superiority over G.4 variety in juice quality percentages in plant cane crop, while G.3 gave the highest mean value of juice quality percentages in first ratoon crop. These results could be referred to that the commercial G.T. 54-9 variety and G.3 variety recorded the highest mean values of percentages, while G.4 variety showed the lowest values of this traits. The differences among sugarcane varieties were also reported Kamel (2015) and Mehareb *et al.* (2015). Concerning the interaction effects, the results showed that the interaction between number doses x nitrogen fertilization levels had a significantly affected on juice quality percentages at harvest in plant cane and first ratoon crops. Applied 210 kg N/fed at four doses of cane plants gave the highest values in plant cane crop, while in first ratoon crops applied 210 kg N/fed at three doses of cane plants gave the highest values percentages. The interaction between number doses x sugarcane varieties was affected on juice quality percentages at harvest in both seasons. The results showed that planting sugarcane varieties G.T. 54-9 and applied three doses nitrogen gave the highest values percentages in both seasons. The interaction between nitrogen levels x sugarcane varieties had a significant influence on juice quality percentages in plant cane and first ratoon crops. The interactions among the three studied factors affected juice quality percentages at harvest significantly in plant cane and first ratoon crops. G.3 variety recorded the highest values of juice quality percentages in plant cane crop when it was fertilized with 210 kg N/fed at the application of four and three doses in plant cane and first ratoon crops,.

Correlation

Correlation coefficients between the different pair of agronomic characters and juice quality parameters were calculated to find the relationship among the various characters studied. The values of correlation coefficient are presented in (Table 13). From Table 13 it can be seen that cane yield had perfectly positive correlation (r = 1.0) and highly significant correlation (P < 0.01) with sugar yield. Also it show very high negative correlation with sucrose% (r = - 0.981), pol% (r = - 0.920) and sugar recovery% (r = - 0.998), while very high positive correlation with millable cane length (r = 0.971) and diameter (r = 0.905). As well cane yield was high negative correlation with brix% (r = -0.851) and purity% (r =-0.893), while high positive correlation with millable weight (r = 0.837) except number of millable cane (r =0.005) which was negligible correlation.

On the other hand sugar yield had very high positive correlation with sugar quality traits such as Sucrose% (r =0.979), pol % (r = 0.916) and sugar recovery% (r = 0.997). Furthermore it was high positive correlation with brix% (r = 0.846) and purity % (r = 0.898). In addition to very high positive correlation with some agronomic characters like millable cane length (r =0.974) and diameter (r =0.909) as well high positive correlation with millable weight (r =0.842) except millable cane number (r =0.015) which was negligible correlation. The results illustrated that there are significant correlation coefficient (P ≤ 0.05) between each of cane yield and sugar yield with sugar recovery % was observed. Gadallah and Mehareb, 2020), they reported highly significant and positive correlation between cane yield, millable cane weight and number of millable canes, followed by cane yield and stalk height then cane yield and stalk diameter. Also, Mehareb and El-Mansoub (2020), they stated that Plant height and stalk diameter were positively correlated with cane yield. The present study in general found that there are negative correlation between agronomic characters and juice quality parameters. Tena *et al* (2016) reported that stalk diameter and brix percent had considerable negative direct effects and indirect positive effects through single cane weight on cane yield. Therefore, in view of their significant positive association with cane yield, indirect effects of stalk diameter and brix percent *via* single cane weight should be considered during selection. Shitahun Alemu *et al.* (2018) found also significant correlations between cane yield with plant height and sugar yield with recoverable sugar percent which revealed that cane yield was mainly affected by plant height while sugar yield is mainly affected by recoverable sugar percent.

In fact the very strong correlation of cane yield with sugar yield is expected as sugar yield is the product of cane yield and sugar percent. A positive and highly significant correlation between cane yield and its components *viz* single cane weight, stalk length and millable cane number was reported by (Tyagi and Lal, 2007) also observed highly significant positive correlation of cane yield with millable cane number, single cane weight, stalk height, and cane diameter.

In the present study cane yield was more closely correlated with millable cane length followed by millable cane diameter and millable weight. This has important implications for selection of varieties to be used as parental material for crossing purposes. The above information indicates that many of the characters affect cane yield but the degree at which each character affects yield is dependent upon the degree of association of that character to cane yield. In this case selecting for the character millable cane length and diameter would produce maximum yield as compared with any of the other characters. Rehman *et al*. (1992) and Khan *et al*. (2003) reported that increase in cane yield might be due to maximum plant height and cane diameter. Similarly, Javed *et al.* (2001) reported that cane yield tons per hectare depends upon number of stalks per hectare, stalk length and stalk girth. Similarly in the present study millable cane number existed a moderate positive correlation with stalk weight (r = 0.552), low positive correlation with millable cane diameter (r = 0.429) and negligible correlation with millable cane length (r = 0.242), (Table 13). Singh and Sharma (1983) reported that number of millable stalks per plot and stalk diameter were the most important components of cane yield. Chaudhary and Singh, (1994) also demonstrated that number of millable stalks and individual cane weight made the greatest direct contribution to cane yield, also mentioned millable cane number with purity percent had positive non-significant correlation. Similar in the present study association of millable cane number with other agronomic and sugar quality characters was positive but non-significant correlation. Khan, (1995) observed negative association of millable cane number with brix percent.

Knowledge of the association of various characters among themselves is important which ultimately gave the indication that selection for one trait will automatically change the other attributes. Therefore, to develop an understanding of association between the component characters is a necessary prerequisite to carry out an effective breeding program. The association between any two characters is dependent upon their inheritance. If they are inherited together, the relationship between them may be observed. The average between genes governing two or more characters, that is, location of genes on the same chromosome or chromosome governing particular character or pair is the cause for association between characters at phenotypic and genotypic levels.

With regard to the biochemical characters in the present study, sucrose percent was closely correlated with sugar recover (r = 0.992), pol% (r = 0.979), brix% (r = 0.938) and purity% (r = 0.788). Also, pol% and purity% was strongly correlated with sugar recover (r = 0.945) and (r = 0.860), respectively, while purity% was moderate correlated with pol% (r = 0.645). This indicated that selection through pol%, brix% and purity% would produce varieties with high levels of sucrose recovery percent. Tena *et al* (2016) suggested that genotypes should be selected on the basis of single cane weight and pol percent for getting higher cane and sugar yield.

Conclusion

The study led to the conclusion that the promising G.4 variety proved the superiority over the other tested ones in cane yield and sugar yield with 240 Kgs N/fed nitrogen and applied in four equal doses.

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