J. of Plant Production, Mansoura Univ.,Vol 12 (4): 413-422, 2021

Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Impact of Bio and Inorganic Potassium and Nitrogen Fertilization on Juice Quality and Sugar Yield of Promising Sugar cane Genotypes

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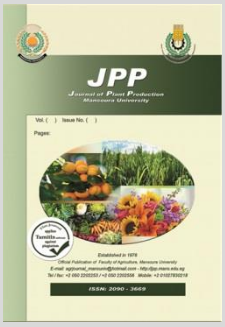

ABSTRACT

This work was carried out during 2018/2019 and 2019/2020 seasons at Kom-Ombo Agricultural Research Station (latitude of 24º 28′ N and longitude 32º 57′ E at an elevation108 m above sea level), Aswan Governorate. to assess juice quality and sugar yield of some promising sugar cane genotypes as affected by bio, inorganic fertilization rates of potassium and nitrogen. The study included 48 treatments, combinations of four genotypes (G.2006-6, G.2003-49, C.57-14 and G.T.54-9), three K rates (48 kg inorganic K_2O per fed, 40 kg inorganic K_2O + 400-gram bio K and 34 kg inorganic K_2O + 800 gram bio K /fed) and four N rates (210 kg inorganic N, 190 kg inorganic N + 300 gram bio N, 170 kg inorganic N + 600 gram bio N and 150 kg inorganic N + 900 gram bio N/fed). A split-split plot design with three replications was used. Results showed that 4 genotypes significantly differed in all studied traits except sugar yield in 1st season. Furthermore, K fertilization had a significant influence on some studied traits.Nitrogen levels had a significant effect on all the studied traits in the two seasons except purity%. Generally, supplying sugar cane G.006-6 and G.2003-49 genotypes, with 100% of the recommended inorganic potassium rate (48 kg K_2O /fed) integrated with 100% of the recommended inorganic N-rate (210 kg/fed), or 70% of the recommended inorganic potassium rate (34 kg K_2O + 800 gram bio K /fed) integrated with 70% of the recommended inorganic N-rate (150 kg inorganic N + 900 gram bio N fed), resulted in the highest sugar yield/fed in plant cane and its first ratoon crops, respectively.

Keywords: Sugar cane, genotypes, inorganic, Bio-fertilization potassium &nitrogen, juice quality, sugar yield.

INTRODUCTION

The juice sugar cane quality is one of the most important means for maximizing profitability in the sugar industry. It is indeed far more profitable to grind millable cane with a high sucrose percentage as this will reduce the cost per ton of sugar produced. In this respect juice sugar cane quality is important as it determines the maximum sugar yield, however sucrose content in sugar cane plants is affected primarily by planted varieties and fertilizers applied.

Increasing sugar production per unit area has become a national target to minimize the gap between sugar production and consumption, increase of sugar production can be achieved through the cane variety is the corner stone in sugar production. Commercial variety G.T.54-9 occupies most of the area planted with sugar cane in Egypt. Recently, Sugar Crops Research Institute released some promising varieties among them G.2003-49 and G.2006-6. Many investigators pointed out the important role of varieties in respect to their variation in juice quality (EL-Maghraby *et al.* 2009; Teama, *et al.* 2017; Abazied, 2018; Ali, *et al.* 2018; Ahmed *et al.* 2020 and Abazied and El-Laboudy, 2021).

Potassium is the most abundant cation in the cell of sugar cane; the functions of potassium in sugar cane are many. Among them, the main role of potassium as an enzyme activator in sugar cane plants metabolisms such as in photosynthesis, synthesis, and translocation of sugars. Many investigators cleared the role of inorganic and bio potassium fertilization in respect to its influence on yield and quality characteristics of sugar cane (Karthikeyan, and Shanmugam 2017; Ali, *et al.* 2018; Watanabe, *et. al.*, 2019 and Sasy and Abu-Ellail, 2021).

Nitrogen is vital for most plant metabolic processes and plays an important role in tillering and stalk elongation. In addition, N deficiency results in reduction of leaf area and thus, causes photosynthesis reduction which in turn leads to suppress in yield and quality. Many investigators pointed out the importance of the role of bio, inorganic nitrogen in respect to its influence on quality characteristics of sugar cane (Gosal, *et al.*, 2012; Hemalatha, 2015; Abazied, and El-Bakry 2018; Pene and Ouattara, 2019 and Zeng, *et al.* 2020)

Nitrogen and potassium fertilizers are essential for sugar cane plants development, but their industrial production requires a large amount of fossil energy. This means a high cost in terms of energy used and environmental impact, causing ecological problems and soil pollution. The use of bio fertilizers in sugar cane fertilization can contribute to overcome this problem, by reducing the need for chemical nitrogen and potassium fertilizers, with consequent cost saving.

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DOI: 10.21608/jpp.2021.169626

The objective of this work was to study the integrated nutrition of sugar cane with bio, inorganic fertilizers of nitrogen and potassium through the application of different proportions of the recommended doses from bio and inorganic sources to find out the best combination of them aiming the optimum quality and sugar yield.

MATERIALS AND METHODS

A field experiment was conducted at Kom-Ombo Agricultural Research Station, (latitude of 24° 28′ N and longitude of 32° 57′ E at an elevation108 m above sea level), Aswan Governorate, Egypt during 2018/2019 and 2019/2020 seasons to study the effect of bio, inorganic potassium and nitrogen fertilization rates on juice quality and sugar yield of some sugar cane genotypes. The study included 48 treatments, which were the combinations of four sugar cane genotypes (G.2006-6, G.2003-49, C. 57-14 and G.T.54-9 as a check), three rates of bio and inorganic potassium, i. e: K1, K2 and K3, and four bio and inorganic nitrogen rates, i. e: N1, N2, N3 and N4 (as shown in Table 1).

Split-split plot design with three replications was used. The genotypes were arranged in the main plots, while bio and inorganic potassium rates were randomly distributed in sub-plots and the sub-sub plots were assigned for bio and inorganic nitrogen rates. Plot area was 42 m^2 (including six ridges of seven meters in length and one meter apart). Sugar cane genotypes were planted in the 1^{st} week of March (plant cane). Harvesting date was done at age of twelve months for plant and ratoon cane crops. Some physical and chemical properties of the experimental soil according to Black (1965) and Ryan *et al.* (1996) are shown in Table (2).

The bio fertilizers used contain nitrogen fixed bacteria's: *Azotobacter* and *Azospirillum brasilense*, and potassium dissolving bacteria: *Bacillus circulans*. At the concentration 9^{10}colony forming unit/gram for each was used. The bio-fertilizers provided by the Unit of Bio-fertilizers production- Microbiology Research Department, Soils, Water and Environment Research Institute, Agricultural Research Center, Giza. Egypt.

Bio- potassium or/and nitrogen fertilizers were mixed with sand and manually thrown on cane cuttings in furrows at planting the plant cane crop, and irrigation was immediately practiced. In the 1^{st} ratoon crop, the two bio-fertilizers were applied before the 1^{st} dose of inorganic nitrogen fertilizer.

Table 1. A rates of potassium and nitrogen fertilizers tested.

potassium fertilizer rates		Nitrogen fertilizer rates	
Code	a dose Components /fed	Code	a dose Components /fed
K1	48 Kg inorganic K_2O/fed	N1	210 Kg inorganic N/fed
K2	40 Kg inorganic K_2O + 400 gram Bio	N2	190 Kg inorganic N+300 gram Bio
K3	34 Kg inorganic K_2O + 800 gram Bio	N3	170 Kg inorganic N+600 gram Bio-
		N4	150 Kg inorganic N+900 gram Bio

Inorganic N fertilizer was added in the form of Urea (46.5 % N) in three doses. In the plant cane, the 1^{st} nitrogen dose was applied after two months from planting. In the 1^{st} ratoon, the 1^{st} nitrogen dose was added after one month from harvesting. Meanwhile, second dose was followed after one month later as well as the third dose.

Inorganic Potassium fertilizer was applied in the form of potassium sulphate (48% K_2O) with the 2^{nd} N-dose, for the plant cane and 1^{st} ratoon cane. All plots received the usual agronomic practices as recommended for sugar cane.

Table 2. Some physical and chemical properties of the experiment soil before sowing.

Properties	Particle size distribution				OM %	CaCO3%	SP	pH	EC dSm^{-1}
	Sand %	Silt %	Clay %	Texture class					
Values	59.16	17.20	23.64	Sandy clay loam	0.48	2.4	58.0	7.95	1.39

	Soluble Cations and anions (meq/100 g soil)							Available Nutrients (mg kg^{-1})		
Properties	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{--}$	$HCO3^{-}$	Cl^{-}	$SO4^{--}$	N	P	K
Values	3.19	2.65	3.63	0.95	-	2.52	4.16	3.74	40	18	210

The recorded data:

At harvesting time, twenty-five millable canes from each plot were collected at random and cleaned. The primary sugar cane juice was extracted by using a three-roll squeezer, (Sabri, 1966) and the obtained juice were filtered and mixed thoroughly. One liter of juice was taken in glass cylinder to determine the following juice quality characteristics:

1.Brix percentage (total soluble solids, TSS %) was determined by using Brix Hydrometer according to A.O.A.C. (2005).

2.Sucrose percentage was determined by using Saccharemeter according to A.O.A.C. (2005).

3.Purity percentage was calculated according to the following formula of Singh and Singh (1998).

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

4..Richness percentage was calculated according to the following equation as described by E. S. I. I. C. (1981).

Richness % = (sucrose % gm juice x richness factor)/100.

Where:

Sucrose % gm juice= (sucrose % per cm^3 juice) / juice density.
Juice density was taken from Schibler's Tables.
Richness factor = 100 - (fiber % x 1.3).

5.Reducing sugars percentage: It was determined using Fehling method according to A.O.A.C. (2005).

6. Sugar recovery percentage was calculated according to the following equation as described by Yadav and Sharma (1980):

Sugar recovery percentage = [S % - 0.4(B% - S %) x 0.73]

Where:

S%= Sucrose percentage.
B%= Brix percentage
0.4 = each pound of non-sucrose solids in the juice will retain 0.4 of a pound of sucrose as outlined by Hebert (1973).
0.73= denote to a correction factor for actual milling condition in factories that depends on the overall mean fiber percentage cane during processing as outlined by Mathur (1997).

7.Sugar yield (tons/fed.): was calculated according to the following formula described by Mathur (1997).

Sugar yield (ton /fed) = cane yield (ton/fed) x sugar recovery %.

The collected data were statistically analyzed according to the method described by Snedecor and Cochran (1981). Treatment means were compared using LSD at 5% level of difference as outlined by Steel and Torrie (1980).

RESULTS AND DISCUSSIONS

1. Brix percentage:

Results in Table (3) showed significant differences among the examined sugar cane genotypes in Brix % in the plant cane and the 1st ratoon crops. The G.2006-6 genotype had the highest value (22.80) in the plant crop, followed by G.2003-49 (22.62). While in the 1st ratoon crop G.2003-49 genotype recorded the highest Brix percentage (22.38) followed by G.T. 54-9 (22.07) without significant difference. The difference among genotypes in total soluble solids may be due to the differences in growth and response to the surrounding environmental conditions prevailing during the formation of soluble solids in the plants. These results are in harmony with those reported by EL-Maghraby *et al.* (2009) and Ahmed *et al*. (2020). They found that significant differences among the examined sugar cane varieties in brix percentage.

The results revealed that brix % was significantly affected by the studied potassium fertilization treatment in both seasons. The highest mean values of brix % (21.93 and 21.85 %) were obtained from sugar cane plants which were fertilized by 48 kg mineral K2O/fed (K1) in 1st and 2nd Seasons , respectively. This result could be attributed to the important role of potassium fertilizer in physiological processes in sugar cane plants such as translocation of sugar and carbohydrate. These results are in harmony with those obtained by Ashraf, *et al.* (2009) and Sasy, and Abu-Ellail (2021) who found that applying 48 kg K_2O /fed resulted in a significant increase in brix %.

Table 3. Brix percentage as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop.

Season		Plant cane					First ratoon				
Genotypes	K. rates	Nitrogen rates					Nitrogen rates				
		N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
G.T.54-9	K1	22.30	21.81	21.73	20.22	21.51	22.52	22.55	22.02	21.99	22.27
	K2	21.23	20.52	21.06	21.08	20.97	21.24	21.68	21.95	22.09	21.99
	K3	21.02	20.59	21.16	21.05	20.96	22.24	22.50	22.31	21.81	21.96
	Mean	21.52	20.97	21.31	20.79	21.15	22.33	22.24	21.76	21.96	22.07
G.2006-6	K1	22.72	22.94	23.15	22.83	22.91	21.45	21.21	21.88	22.37	21.72
	K2	22.95	22.85	22.53	22.51	22.71	21.10	22.05	21.69	21.11	21.49
	K3	22.76	22.62	22.69	23.11	22.79	21.99	21.88	22.09	21.54	21.85
	Mean	22.81	22.80	22.79	22.81	22.80	21.51	21.71	21.88	21.64	21.69
G.2003-49	K1	22.68	22.74	23.04	22.93	22.84	22.69	22.44	22.54	22.23	22.47
	K2	22.96	22.62	22.22	22.55	22.59	22.04	22.43	22.59	22.05	22.27
	K3	21.81	22.20	23.18	22.50	22.42	22.72	22.49	21.89	22.44	22.38
	Mean	22.48	22.52	22.81	22.66	22.62	22.48	22.45	22.34	22.24	22.38
C. 57-14	K1	20.94	20.73	20.12	19.97	20.44	21.11	21.13	20.98	20.58	20.95
	K2	19.59	21.28	20.58	20.24	20.42	20.94	20.53	19.63	20.32	20.35
	K3	20.62	20.52	20.03	20.40	20.39	20.59	20.06	20.81	20.58	20.51
	Mean	20.38	20.24	21.24	20.20	20.42	20.88	20.58	20.47	20.50	20.60
B × C	K1	22.16	22.05	22.01	21.49	21.93	21.94	21.83	21.85	21.79	21.85
	K2	21.68	21.81	21.59	21.59	21.67	21.58	21.67	21.46	21.39	21.53
	K3	21.55	21.48	21.76	21.76	21.64	21.89	21.73	21.52	21.57	21.68
	Mean	21.80	21.78	21.79	21.61		21.80	21.74	21.61	21.58	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)		0.18						0.35			
Potassium rates (B)		0.15						0.21			
Nitrogen rates(C)		0.16						0.15			
A × B		0.30						0.42			
A × C		0.33						0.30			
B × C		0.29						0.26			
A× B × C		0.58						0.52			

Furthermore, the studied nitrogen fertilization rates had a significant influence on brix % in both seasons. The highest mean value of brix % (21.80 %) was achieved in both seasons from sugar cane plants under 210 kg inorganic nitrogen/fed. These results may be due to the fact that nitrogen increases the vegetative growth of plants and the increase in photo syntheses which lead to carbohydrate accumulation consequently resulted in more metabolites required for the formation of soluble solids. These results are in harmony with those reported by Hemalatha, (2015) and Pene and Ouattara (2019), they found that brix % was significantly affected by the tested nitrogen levels.

Data reveal that the first and second order interactions involved had a significant influence on brix percentage in both seasons. The highest average value of brix percentage (23.18 %) was detected by G.2003-49 genotype which was fertilized by 34 kg inorganic K_2O+ 800 g bio-K with 170 kg inorganic N + 600 g bio-N /fed in 1st season. While, the corresponding mean value in 2nd season (22.72 %) was recorded from G.2003-49 genotype which was fertilized by 34 kg inorganic K_2O+ 800 g bio-K with 210 kg inorganic N /fed.

2. Sucrose percentage

Data in Table (4) showed that the evaluated genotypes significantly differed in sucrose % in both seasons. The G.2003-49 genotype had the highest value of sucrose % followed by G.2006-6 and G. T. 54-9 in first and second seasons, respectively. Difference among tested genotypes in sucrose % may be their difference in gene make up effect. These results are agreement with those obtained by Teama, *et al.* (2017) and Ali, *et al.* (2018) who noted that among tested genotypes highly significant differences were observed for sucrose %.

Moreover, the illustrated data showed that sucrose percentage was significantly affected by studied potassium treatments in 1st season only. Sugar cane plants which fertilized by the highest potassium rate (K1:48 kg K_2O/fed as mineral fertilizer) gained the highest mean values. This can be explained by the role of potassium in translocation of more assimilates from source to sink. These findings are in a good line with those obtained by Ahmed, *et al.* (2008) and Karthikeyan and Shanmugam (2017), who reported that sucrose %, was significantly influenced by the applied potassium-rich bio stimulant.

Also , data revealed that nitrogen rates significantly affected sucrose % in both seasons. Application of N-rates; 210 kg N/fed (N1) and 190 kg mineral N + 300 g bio-N/fed (N2) produced the highest sucrose % (19.07-17.22) in the 1st and 2nd season, respectively without significant difference. These results are also in the same line with those found by Ahmed, *et al* (2003-b); Gosal, *et al.* (2012) and Zeng, *et al.* (2020) who found that sucrose % was influenced by the doses of nitrogen.

Sucrose % responded significantly to all interactions among the three studied factors in both seasons. Thus, the highest average value of sucrose % (20.75 and 20.52 %) was detected by G.2003-49 genotype which was fertilized by 34 kg inorganic K_2O+ 800 g bio-K with 170 kg inorganic N + 600 g bio-N /fed and 150 kg inorganic N + 900 g bio-N /fed in the first and second seasons, respectively.

Table 4. Sucrose percentage as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop.

Seasons		Plant cane					First ratoon				
Genotypes	K. rates	Nitrogen rates					Nitrogen rates				
		N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
G.T.54-9	K1	19.68	19.35	19.35	17.98	19.09	19.72	20.04	19.63	19.90	19.82
	K2	18.82	17.95	18.78	18.83	18.59	20.06	19.34	19.48	19.70	19.64
	K3	18.78	17.85	18.82	18.39	18.46	20.03	20.23	18.42	19.24	19.48
	Mean	19.09	18.36	18.98	18.40	18.71	19.94	19.87	19.17	19.61	19.65
G.2006-6	K1	19.83	19.87	19.90	19.40	19.75	18.34	18.29	19.12	19.32	18.76
	K2	19.77	19.82	19.38	19.24	19.55	17.82	19.33	18.93	18.19	18.56
	K3	19.74	19.27	19.50	20.08	19.65	19.09	18.87	19.49	18.97	19.10
	Mean	19.78	19.65	19.59	19.57	19.65	18.41	18.83	19.18	18.83	18.81
G.2003-49	K1	20.12	20.03	20.00	20.53	21.17	20.32	20.27	18.96	19.32	19.71
	K2	20.34	20.18	19.83	20.13	20.12	19.62	19.83	20.23	19.91	19.90
	K3	19.14	19.69	20.75	20.09	19.92	19.72	20.25	20.00	20.52	20.12
	Mean	19.87	19.96	20.19	20.25	20.07	19.88	20.11	19.73	19.91	19.91
C. 57-14	K1	18.06	17.80	17.03	16.90	17.45	19.49	18.30	17.61	17.83	18.30
	K2	16.58	18.38	17.67	17.50	17.53	18.17	18.11	17.37	17.78	17.86
	K3	18.04	17.86	17.49	17.34	17.68	17.19	17.81	17.66	17.44	17.52
	Mean	17.56	18.01	17.41	17.24	17.55	18.28	18.07	17.54	17.68	17.89
B × C	K1	19.42	19.26	19.07	18.70	19.11	19.46	19.22	18.83	19.09	19.15
	K2	18.87	19.08	18.91	18.92	18.95	18.91	19.15	19.00	18.89	18.99
	K3	18.93	18.66	19.14	18.98	18.93	19.01	19.29	18.89	19.04	19.06
	Mean	19.07	19.00	19.04	18.87		19.13	19.22	18.91	19.01	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)				0.23						0.42	
Potassium rates (B)				0.16						NS	
Nitrogen rates (C)				0.15						0.18	
A × B				0.32						0.42	
A × C				0.31						0.36	
B × C				0.27						0.31	
A× B × C				0.55						0.62	

3. Juice purity percentage:

High purity is considered an encouragement and careful factor for sugar production. Data in Table (5) indicated that the evaluated sugar cane varieties differed significantly in purity %. Genotypes of G.2003-49 and G.T.54-9 recorded the highest mean values followed by G.T.54-9 and G.2003-49 in the plant cane and first ratoon crops, respectively without significant difference. These results are probably referred to the same performance and tendency recorded by these Genotypes concerning brix% and sucrose % (Tables 3 and 4), where it is known that, high sucrose/brix ratio of cane juice, the highest purity%, and vice versa. These results are agreement with these obtained by EL-Maghraby *et al.* (2009) and Teama, *et al.* (2017). Differences among varieties in respect to juice purity percentage were significance in both growing seasons.

Furthermore, the presented data in the same table focus that the tested potassium fertilization rates had a significant effect on purity % in both seasons. Thus, the highest mean values of purity % (87.41 and 88.19 % in the plant cane and first ratoon crops, respectively) were recorded from sugar cane plants which were fertilized with 40 kg mineral K_2O + 400g bio-K/fed. ELamin, *et al.* (2007) and Ali, *et al.* (2018) they reported that potassium application significantly affected purity percentage.

Also, data in the same table denote that the studied nitrogen rates had a significant influence on the purity % in the first ratoon crop only. The maximum purity % (88.38 %) was obtained from first ratoon which were fertilized with 190 kg mineral N+ 300 g bio- N/fed.

Purity % was significantly affected by all possible interactions among the studied factors in both seasons. The highest value of purity % (89.50 % and 92.34 %) were detected by G.2003-49 genotype which was fertilized by 34 kg mineral K + 800 g bio- K/fed. with 1700 kg inorganic N + 600 g bio - N /fed and C.57-14 genotype which was fertilized by 48 kg inorganic K with 210 kg inorganic N /fed. in 1st and 2nd seasons, respectively. These results are in harmony with those obtained by Gosal, *et al.*, (2012) and Hemalatha, (2015) found that nitrogen fertilizer significantly affected purity

Table 5. purity percentage as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop.

Seasons		Plant cane					First ratoon				
Genotypes	K. rates	Nitrogen rates					Nitrogen rates				
		N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
G.T.54-9	K1	88.30	87.95	89.05	88.90	88.55	87.61	88.86	89.13	90.53	89.03
	K2	88.60	87.57	89.15	89.30	88.65	90.19	89.19	88.75	89.17	89.32
	K3	89.35	86.75	88.95	87.40	88.11	90.08	89.93	86.40	88.29	88.67
	Mean	88.75	87.42	89.05	88.53	88.44	89.29	89.32	88.09	89.33	89.01
G.2006-6	K1	87.30	86.65	86.00	84.95	86.22	85.49	86.23	87.41	86.38	86.38
	K2	86.10	86.75	86.00	85.45	86.07	84.38	87.66	87.30	86.19	86.38
	K3	86.75	85.20	85.95	86.90	86.20	86.82	86.25	88.21	88.47	87.44
	Mean	86.71	86.20	85.98	85.76	86.16	85.56	86.71	87.64	87.01	86.73
G.2003-49	K1	88.75	88.10	86.80	89.49	88.28	89.56	90.53	84.17	86.94	87.75
	K2	88.60	89.20	89.20	89.30	89.07	89.01	88.41	89.58	90.25	89.31
	K3	87.75	88.75	89.50	89.30	88.82	86.84	90.06	91.38	91.43	89.92
	Mean	88.36	88.68	88.50	89.36	88.72	88.47	89.61	88.37	89.54	89.00
C. 57-14	K1	86.20	85.85	84.70	84.60	85.33	92.34	86.63	83.94	86.59	87.75
	K2	84.65	86.40	85.90	86.45	85.85	86.79	88.19	88.52	87.51	87.75
	K3	87.50	87.05	85.80	84.95	86.32	83.59	88.82	84.99	84.72	85.53
	Mean	86.11	86.43	85.46	85.33	85.83	87.57	87.88	85.81	86.27	86.88
B × C	K1	87.63	87.13	86.63	86.98	87.10	88.75	88.01	86.16	87.61	87.63
	K2	86.98	87.48	87.56	87.62	87.41	87.59	88.36	88.53	88.28	88.19
	K3	87.83	86.93	87.55	87.13	87.36	86.86	88.76	87.74	88.22	87.89
	Mean	87.48	87.18	87.25	87.25		87.72	88.38	87.48	88.04	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)				0.32						0.67	
Potassium rates (B)				0.29						0.50	
Nitrogen rates (C)				NS						0.76	
A × B				0.59						1.00	
A × C				0.68						1.52	
B × C				0.59						1.32	
A× B × C				1.18						2.64	

4. Richness percentage

Data presented in Table (6) revealed that the tested sugar cane genotypes differed significantly in richness % in both seasons. The highest value of richness % (16.06 % and 16.23 %) was obtained from G.2006-6 and G.2003-49 genotypes in plant and its 1st ratoon crop, respectively. While, the lowest richness % (14.54 and 14.77%) was obtained from C.57-14 genotype in plant and 1st ratoon crops, respectively. The variation in richness % between genotypes could be correlated to their gene make up. These findings are in a good line with those obtained by Abazied, (2018) and Ahmed *et al.* (2020) who found that significant difference in richness percentage in the tested sugar cane varieties.

Also, the obtained data in the same table revealed that the studied potassium fertilization rates had a significant effect on richness % in the first season only. The highest value of richness percentage (15.42 %) was recorded from the sugar cane plants which were fertilized by 48 kg inorganic potassium/fed. These results are in the same line with those obtained by Ashraf, *et al.* (2009) and Watanabe, *et. al. (*2019) who found that richness percentage was markedly affected by tested K fertilization rates.

Moreover, nitrogen fertilization rates showed a significant influence on richness % in both seasons. Fertilized sugar cane plants by 190 kg inorganic nitrogen + 300 g bio-N /fed gained the maximum average values in the plan cane and first ratoon crops. This results were in agreement with those reported by Zeng, *et al.*(2020) who found that richness % was significantly affected by nitrogen fertilization.

Table 6. Richness percentage as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop

Seasons		**Plant cane**					**First ratoon**				
Genotypes	**K. rates**	**Nitrogen rates**					**Nitrogen rates**				
		N1	**N2**	**N3**	**N4**	**Mean**	**N1**	**N2**	**N3**	**N4**	**Mean**
G.T.54-9	K1	15.59	15.75	15.65	14.38	15.34	15.37	16.11	16.05	15.76	15.82
	K2	15.47	14.52	15.41	15.03	15.11	16.08	15.07	15.43	15.86	15.61
	K3	15.19	14.27	14.76	14.61	14.71	15.89	16.71	15.02	15.43	15.76
	Mean	15.41	14.85	15.27	14.67	15.05	15.78	15.96	15.50	15.68	15.73
G.2006-6	K1	15.76	16.33	16.15	15.79	16.00	15.35	15.07	16.15	15.93	15.62
	K2	16.43	16.60	15.83	15.71	16.14	15.23	16.05	15.84	15.24	15.59
	K3	16.30	16.19	15.24	16.43	16.04	16.01	15.94	16.36	16.07	16.09
	Mean	16.16	16.37	15.74	15.98	16.06	15.53	15.69	16.12	15.74	15.77
G.2003-49	K1	15.81	15.73	15.71	16.12	15.84	16.49	16.65	15.45	15.62	16.05
	K2	15.98	15.79	15.63	15.97	15.84	15.89	16.15	16.64	16.35	16.26
	K3	14.91	15.52	16.27	15.78	15.62	16.17	16.30	16.30	16.79	16.39
	Mean	15.56	15.68	15.87	15.96	15.77	16.18	16.36	16.13	16.25	16.23
C. 57-14	K1	15.34	14.37	14.16	14.11	14.49	16.14	15.35	14.49	14.55	15.13
	K2	13.57	15.35	14.78	14.47	14.54	14.94	14.81	14.24	14.79	14.69
	K3	14.83	14.89	14.17	14.43	14.58	14.29	14.73	14.54	14.30	14.46
	Mean	14.58	14.87	14.37	14.33	14.54	15.12	14.96	14.42	14.54	14.77
B × C	K1	15.62	15.54	15.41	15.10	15.42	15.84	15.79	15.53	15.46	15.66
	K2	15.36	15.56	15.41	15.29	15.41	15.53	15.52	15.54	15.56	15.54
	K3	15.30	15.21	15.11	15.31	15.23	15.59	15.92	15.55	15.64	15.68
	Mean	15.43	15.44	15.31	15.23		15.65	15.74	15.54	15.55	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)			0.18						0.36		
Potassium rates (B)			0.13						NS		
Nitrogen rates (C)			0.12						0.16		
A × B			0.26						0.33		
A × C			0.25						0.32		
B × C			0.22						0.28		
A× B × C			0.44						0.56		

Concerning the interaction effects, data reveal that all the first and second order interactions involved had a significant influence on richness % in both seasons. The highest value (16.60 % in the first season) was detected by G.2006-6 genotype which was fertilized by 40 kg inorganic K_2O+ 400 g bio-K with 190 kg inorganic N + 300 g bio - N /fed in the first season. While the corresponding mean value in the second season (16.79 %) was recorded from G.2003-49 genotype which was fertilized by 34 kg inorganic K_2O+ 800 g bio-K with 150 kg inorganic N + 900 g bio-N /fed.

5. Reducing sugars percentage:

Reducing sugars are one of the most important juice quality parameters which could be utilized to predict the loss in commercial cane sugar (Abazied, 2018).

Results in Table (7) showed that C.57-14 and G.2003-49 genotypes were considerably lower in reducing sugars contents (0.223% and 0.120%) than the other genotypes, on the other hand, G. 2006-6 and G.T.54-9 genotypes recorded the highest values of reducing sugars (0.526% and 0.366%) in plant and first ratoon crops, respectively. The differences among the studied genotypes in reducing sugars % are mainly due to their gene make-up. Differences among cane genotypes in this trait were also found by EL-Maghraby, *et al.* (2009) and Abazied (2018) who reported that sugar cane varieties significantly differed in reducing sugars in both seasons.

Data in same table showed that the effect of K fertilization treatments on reducing sugars were insignificant in both seasons.

The results revealed that reducing sugars was significantly responded to the applied N fertilization treatments. Application of 170 kg inorganic N + 300 g bioN /fed (N3) and 190 kg inorganic N + 600 g bio-N /fed (N2) produced the best (lowest) mean values (0.340 and.214). These results might be due to the enhanced role of nitrogen on vegetative growth which reflected negatively on juice quality. This result coincides with that reported by Rao *et al.* (2000) and Abazied, and El-Bakry (2018), they found that reducing sugars was significantly responded to the applied N levels.

Regarding the interaction effects in this respect, data illustrated that the first and second order interactions involved had a significant influence on reducing sugars percentage in both seasons. Generally, the lowest value (0.170 and 0.100) was detected by C.57-14 genotype which was fertilized by 34 kg inorganic K_2O + 800 g bio-K/fed with 170 kg inorganic N + 300 g bio-N /fed, and 190 kg inorganic N + 600 g bio-N /fed in the plant cane and first ratoon crops, respectively.

Table 7. Reducing sugars percentage as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop

Seasons		Plant cane crop,					First ratoon crop				
		Nitrogen rates					Nitrogen rates				
Genotypes	K. rates	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
G.T.54-9	K1	0.347	0.417	0.310	0.557	0.407	0.363	0.260	0.440	0.350	0.353
	K2	0.440	0.533	0.420	0.430	0.456	0.270	0.403	0.440	0.413	0.382
	K3	0.413	0.593	0.473	0.510	0.497	0.193	0.360	0.510	0.383	0.362
	Mean	0.400	0.514	0.401	0.499	0.454	0.276	0.341	0.463	0.382	0.366
G.2006-6	K1	0.523	0.527	0.527	0.610	0.547	0.403	0.320	0.363	0.390	0.369
	K2	0.560	0.450	0.550	0.560	0.532	0.390	0.273	0.373	0.363	0.350
	K3	0.460	0.527	0.527	0.480	0.498	0.337	0.313	0.260	0.300	0.303
	Mean	0.514	0.501	0.534	0.552	0.526	0.377	0.302	0.332	0.351	0.341
G.2003-49	K1	0.330	0.240	0.217	0.273	0.265	0.110	0.100	0.117	0.110	0.109
	K2	0.290	0.237	0.280	0.230	0.259	0.103	0.100	0.107	0.113	0.106
	K3	0.323	0.347	0.183	0.220	0.268	0.223	0.110	0.130	0.113	0.144
	Mean	0.314	0.274	0.227	0.241	0.264	0.146	0.103	0.118	0.112	0.120
C. 57-14	K1	0.187	0.247	0.207	0.220	0.215	0.100	0.113	0.110	0.230	0.138
	K2	0.303	0.200	0.220	0.240	0.241	0.270	0.113	0.110	0.110	0.151
	K3	0.220	0.180	0.170	0.280	0.213	0.197	0.100	0.123	0.183	0.151
	Mean	0.237	0.209	0.199	0.247	0.223	0.189	0.109	0.114	0.174	0.147
K × N	K1	0.347	0.357	0.315	0.415	0.359	0.244	0.198	0.258	0.270	0.242
	K2	0.398	0.355	0.367	0.367	0.372	0.258	0.223	0.257	0.250	0.247
	K3	0.354	0.412	0.338	0.372	0.369	0.238	0.221	0.256	0.245	0.240
Mean		0.366	0.375	0.340	0.385		0.247	0.214	0.257	0.255	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)						0.033					0.018
Potassium rates (B)						N.s					N.s
Nitrogen rates (C)						0.014					0.014
A × B						0.047					0.027
A × C						0.051					0.029
B × C						0.044					0.025
A× B × C						0.089					0.051

6. Sugar recovery percentage

Data illustrated in Table (8) show that the examined sugar cane genotypes significantly differed in sugar recovery % in both seasons. Thus, it is clear that genotypes G.2003-49 was superior on the other studied sugar cane genotypes in plant and first cane ratoon crops, in this respect. These results may be due to the genetic differences among genotypes. The differences between genotypes were reported by Ali, *et al.* (2018) and Ahmed *et al* (2020), they noted that sugar recovery was significantly affected by the sugar cane varieties.

Also, data revealed that sugar recovery % trait was not appreciably affected by the studied potassium levels in both seasons. Moreover, the exhibited data focus that nitrogen fertilization treatments had a significant influence on sugar recovery % trait in both seasons. Fertilized sugar plants by 210 kg inorganic nitrogen/fed produced the highest value of sugar recovery (13.13 %) while the plants which were fertilized by 150 kg inorganic nitrogen+900 g bio- N/fed recorded the minimum average value in this respect (12. 97 %). In the first ratoon, the highest mean value of sugar recovery (13.29 %) was recorded from sugar cane plants which were fertilized by 190 kg inorganic nitrogen + 300 g bio-N/fed. These findings are in line with those reported by Abazied, and El-Bakry (2018), they noted that richness % was significantly affected by nitrogen rates. Sugar recovery % responded significantly to all possible interactions among the three studied factors in both seasons. Generally, the highest value of sugar recovery % (14.44 % in the first season) was detected by G2003-49 genotype which was fertilized by 34 kg inorganic K_2O+ 800 g bio-K with 170 kg inorganic N + 600 g bio-N /fed in the first season. While the corresponding value in the second season (14.42 %) was recorded from 2003-49 genotype which was fertilized by 34 kg inorganic K_2O+ 800 g bio-K with 150 kg inorganic N + 900 g bio-N/fed.

7 – Sugar yield (Ton / Fed) :

Results in Table (9) indicate that the evaluated cane genotypes differed significantly in sugar yield in the first ratoon crop only. Sugar cane G.2003-49 genotype increased by 1.017, 0.803 and 1.477 ton/fed higher than that obtained from G.T. 54-9, G.2006-6 and C.57-14 genotypes, respectively. These results could be attributed to higher values of sugar recovery (Tables 7). This result is in accordance with that reported by EL-Maghraby *et al.* (2009) and Abazied and El-Laboudy, (2021) who reported the tested sugar cane varieties differed significantly in sugar yield in both seasons.

Table 8. sugar recovery % as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop.

Seasons		Plant cane crop					First ratoon crop				
Genotypes	K.rates	Nitrogenrates					Nitrogen rates				
		N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
G.T.54-9	K1	13.60	13.40	13.43	12.47	13.22	13.58	13.90	13.63	13.92	13.75
	K2	13.03	12.36	13.04	13.09	12.88	14.01	13.44	13.50	13.68	13.65
	K3	13.06	12.22	13.05	12.65	12.74	13.97	14.11	12.60	13.30	13.49
	Mean	13.23	12.66	13.17	12.73	12.95	13.85	13.81	13.24	13.63	13.63
2006-6	K1	13.63	13.62	13.58	13.16	13.50	12.47	12.49	13.15	13.22	12.83
	K2	13.50	13.58	13.23	13.09	13 .35	12.04	13.32	13.01	12.43	12.70
	K3	13.53	13.09	13.31	13.78	13.42	13.09	12.90	13.46	13.13	13.14
	Mean	13.55	13.43	13.37	13.34	13.42	12.53	12.90	13.21	12.92	12.89
2003-49	K1	13.94	13.83	13.71	14.28	13.94	14.14	14.16	12.80	13.25	13.58
	K2	14.08	14.01	13.78	13.99	13.96	13.61	13.72	14.08	13.91	13.83
	K3	13.20	13.64	14.44	13.96	13.81	13.52	14.13	14.05	14.42	14.03
	Mean	13.74	13.83	13.97	14.08	13.90	13.76	14.00	13.64	13.86	13.81
C. 57-14	K1	12.34	12.13	11.53	11.44	11.86	13.75	12.53	11.86	12.20	12.58
	K2	11.23	12.57	12.05	11.97	11.95	12.46	12.51	12.02	12.24	12.30
	K3	12.42	12.26	12.02	11.76	12.11	11.56	12.35	11.97	11.81	11.92
	Mean	11.99	12.32	11.86	11.72	11.97	12.59	12.46	11.95	12.08	12.27
A × B	K1	13.38	13.24	13.06	12.84	13.13	13.48	13.27	12.86	13.15	13.19
	K2	12.96	13.13	13.02	13.03	13.04	13.03	13.24	13.15	13.06	13.12
	K3	13.05	12.80	13.20	13.04	13.02	13.03	13.37	13.02	13.16	13.15
Mean		13.13	13.06	13.10	12.97		13.18	13.29	13.01	13.12	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)				0.18					0.33		
Potassium rates(B)				NS					NS		
Nitrogen rates(C)				0.12					0.16		
A × B				0.25					0.33		
A × C				0.24					0.33		
B × C				0.21					0.29		
A× B × C				0.42					0.58		

Table 9. Sugar yield (ton/fed) as affected by genotypes, bio, inorganic potassium and nitrogen fertilization rates in the plant cane and 1st ratoon crop.

Seasons		Plant cane crop					First ratoon crop				
Genotypes	K. rates	Nitrogen rates					Nitrogen rates				
		N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
G.T.54-9	K1	5.482	6.427	6.504	5.613	6.007	6.488	7.200	6.723	6.516	6.732
	K2	5.855	6.804	6.371	6.166	6.299	6.873	5.454	6.025	5.915	6.067
	K3	5.296	6.499	6.053	6.984	6.208	5.115	5.916	6.145	5.129	5.576
	Mean	5.544	6.577	6.309	6.254	6.171	6.159	6.190	6.298	5.854	6.125
2006-6	K1	7.804	6.481	5.768	6.562	6.654	5.403	5.384	5.470	6.116	5.593
	K2	5.086	5.995	6.647	5.852	5.895	6.362	6.286	6.419	7.204	6.568
	K3	6.355	6.324	6.397	5.251	6.081	7.126	6.368	6.921	7.003	6.854
	Mean	6.415	6.267	6.270	5.888	6.210	6.297	6.013	6.270	6.774	6.339
2003-49	K1	5.093	7.063	5.545	6.088	5.947	7.772	7.022	7.081	6.274	7.037
	K2	6.591	6.203	6.945	5.821	6.390	6.924	7.134	7.401	6.612	7.018
	K3	5.338	6.119	6.146	4.924	5.632	6.589	7.264	7.403	8.224	7.370
	Mean	5.674	6.462	6.212	5.611	5.990	7.095	7.140	7.295	7.037	7.142
C. 57-14	K1	5.998	5.325	5.166	6.205	5.674	6.345	5.677	5.590	6.146	5.939
	K2	5.703	6.733	5.925	5.803	6.041	5.832	5.391	6.281	5.715	5.805
	K3	5.840	6.842	6.665	5.981	6.332	4.780	5.542	5.054	5.629	5.251
	Mean	5.847	6.300	5.919	5.996	6.016	5.652	5.536	5.642	5.830	5.665
A × B	K1	6.094	6.324	5.746	6.117	6.070	6.502	6.321	6.216	6.263	6.325
	K2	5.809	6.434	6.472	5.911	6.156	6.498	6.066	6.531	6.362	6.364
	K3	5.707	6.446	6.315	5.785	6.063	5.902	6.272	6.381	6.496	6.263
Mean		5.870	6.401	6.178	5.938		6.301	6.220	6.376	6.374	
LSD.at 0.05 level for:											
Sugar cane genotypes (A)						NS					0.283
Potassium rates (B)						0.073					NS
Nitrogen rates (C)						0.124					0.124
A × B						0.147					0.448
A × C						0.248					0.248
B × C						0.215					0.215
A× B × C						0.430					0.430

Furthermore, the obtained data in the same table show that the effect of potassium levels on sugar yield was significant in the first season only. Applying of 40 kg inorganic K_2O +400g bio-K/fed resulted in the highest sugar yield (6.156 and 6.364 ton/fed) in plant cane and ratoon crops, respectively. The effective role of potassium on sugar yield was reported by Sasy and Abu-Ellail (2021), they found that tested K fertilization doses had significantly affected in sugar yield.

Also, reveal that sugar yield (ton/fed) was significantly affected by the studied nitrogen levels in both seasons. The highest mean values of sugar yield (6.401 and 6.376 ton/fed.) were obtained with application of N2 and N3 nitrogen treatment in in the plant cane and first ratoon, respectively. These results are in a good line with those obtained by Rao *et al*. (2000) and Pene and Ouattara (2019) who found that nitrogen fertilizer application improved sugar yield and the difference between N application and non-nitrogen application was significant.

Concerning the interaction effect between studied factors was significant in both seasons. Generally, maximum sugar yield /fed (7.804 and 8.224 ton/fed,) was obtained from genotypes G006-6 and G.2003-49 supplying with 48 kg K_2O /fed, integrated with 210 kg/fed and 34 kg K_2O + 800 gm bio-K /fed integrated with 150 kg inorganic N + 900 gm bio-N/ fed in plant cane and its first ratoon crops, respectively.

CONCLUSION

Under conditions of the present work, supplying sugar cane G006-6 and G.2003-49 genotypes, with 100% of the recommended inorganic potassium rate (48 kg K_2O /fed) integrated with 100% of the recommended inorganic N-rate (210 kg/fed), or 70% of the recommended inorganic potassium rate (34 kg K_2O + 800 gram bio-K/fed) integrated with 70% of the recommended inorganic N-rate (150 kg inorganic N + 900 gram bio-N/fed), resulted in the highest sugar yield/fed in plant cane and its first ratoon crops, respectively.

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تأثير التسميد الحيوي وغير العضوي بالبوتاسيوم والنيتروجين على جودة العصير ومحصول السكر للتراكيب الوراثية المبشره لقصب السكر

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تم إجراء هذا الدراسة خلال موسمى 2019/2018 و 2020/2019 بمزرعة محطة البحوث الزراعية بكوم أمبو (دائرة عرض 24,28 شمالاً و خط طول 57,32 شرقاً ، على إرتفاع 108 متراً فوق سطح البحر) بمحافظة أسوان لدراسة تأثير استخدام التسميد الحيوى و غير العضوى البوتاسى و النيتروجينى على محصول السكر وجودة العصير لبعض التراكيب الوراثية الواعدة لقصب السكر. وقد إشتملت الدراسة على ثمانى وأربعون معاملة هى جملة التوليفات بين أربعة تراكيب و ارثية من قصب السكر(جيزة 2006-6 , جيزة 2003-49, كوبا 57-14 ، جيزة تايوان 54-9 كمقارنة) و ثلاثة مستويات من التسميد البوتاسى الحيوى وغير العضوى(48 كجم غير عضوى للفدان, 40 كجم غير عضوى +400 جم سماد حيوى و 34 كجم سماد غير عضوى+800 جم سماد حيوى)؛ و أربعة مستويات من السماد النيتروجينى الحيوى و غير العضوى (210 كجم غير عضوى للفدان, 190 كجم غير عضوى + 300جم حيوى,170 كجم نتروجين غير عضوى +600 جم حيوى و 150 كجم غير عضوى+900 جم حيوى للفدان) ، و قد تم إستخدام نظام تصميم القطع المنشقة مرتين. أظهرت النتائج أن التراكيب الوراثية الأربعة لقصب السكر إختلفت معنويا في جميع الصفات المدروسة في كلا الموسمين بإستثناء محصول السكر في الموسم الأول. علاوة على ذلك ، كان للتسميد بالبوتاسيوم تأثير معنوي على بعض الصفات المدروسة ، بينما لم يكن هذا التأثير معنوياً في بعض الصفات الأخرى مثل صفة السكريات المختزلة وناتج السكر(%) في كلا الموسمين؛ هنا أيضًا كان لمستويات التسميد بالنيتروجين المختبرة تأثير معنوي على جميع الصفات المدروسة في محصول الغرس ومحصول الخلفة الأولى باستثناء صفة نقاوة العصير في محصول الغرس .معاملة التركيب الوراثى جيزة 2006 / 6 فى محصول الغرس بنسبة 100 ٪ من معدل البوتاسوم غير العضوي الموصى به مع 100 ٪ من النتروجين غير العضوي الموصى به أعطت أعلى محصول من السكر للفدان بينما معاملة التركيب الوراثى جيزة 2003 / 49 فى محصول الخلفة الأولى بنسبة 70 ٪ من معدل البوتاسوم غير العضوي الموصى به + 800 جم من البوتاسيوم الحيوى + 150 كجم من النتروجين غير العضوي + 900 جم من النتروجين الحيوى للفدان أعطت أعلى محصول من السكر للفدان .