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Crop Assessment and Phenotypic Correlation and Stability of New Sugarcane Genotypes under Different Seed Rates

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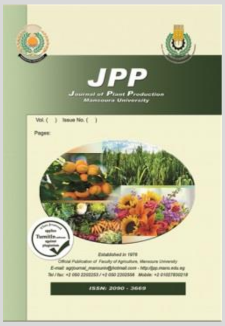

ABSTRACT

Two field experiments were conducted at Shandaweel Agric. Res. St. (latitude of 26.33° N and longitude of 31.41° E), Sohag Governorate, Egypt in 2017/2018 and 2018/2019 seasons to assess the yield and quality of the new sugarcane varieties *viz.* (G.2003-47 and G.2004-27) and G.2005-47 promising genotype, compared to the commercial variety GT.54-9 as affected by three seed rates (1.0, 1.5 and 2.0 drills of three-budded cane cuttings). A split plot design was used. Planting sugarcane using 2.0 drills of cuttings improved most of the studied traits. Significant improvements in brix%, sucrose% and sugar recovery% (SR%) were recorded in case of growing using 1.0 drill, while using 1.5 drill resulted in the highest millable cane (MC) weight. The commercial GT.54-9 variety was superior in most of the studied traits. Variety G.2003-47 was superior in brix%, sucrose% and SR%, meanwhile, variety G.2004-27 attained the highest number of MC/fed. The interaction between the studied factors markedly affected all the studied traits, except MC height, in both seasons. Millable cane weight exhibited positive and high significant correlation with MC height and diameter. However, it was negative correlation between number of MC/fed with MC diameter, brix and sucrose%. Variety G.2004-27 showed broader adaptability for all studied seeding rates. Based upon the previous results, planting sugar cane variety GT.54-9 using 2.0 drills cutting seed setts could be recommended to attain the highest cane yield, while, planting variety G.2003-47 using 1.5 drill is recommended to get the maximum sugar yield under conditions of the present work.

Keywords: Sugarcane, genotype, seed rate, quality, correlation, stability.

INTRODUCTION

Many researchers in Egypt and most countries of the world showed that cane yield increase with increasing seeding rate, probably due to the maximum utilization of growth factors as solar radiation, water and nutrients by an optimal number of cane plants, which will reflected in more photosynthesis and dry matter accumulation in cane stalks. Hasan *et al.* (2009) found that stalk height, diameter, brix, sucrose, sugar recovery, cane and sugar yields/fed differed significantly, as a result of planting sugarcane using 1.5, 2.0 and 2.5 drills of cane cuttings/fed Shalaby *et al.* (2011) found that seed rates 2.0 drills (50400 buds/fed) recorded the highest values significantly of stalk height, sucrose%, sugar recovery%, millable cane/fed, cane and sugar yields/fed, while, seed rate 1.5 drill (37800 buds/fed) recorded the highest values of stalk diameter and brix%. While, El-Geddawy - Dalia *et al.* (2015) showed that drilling sugarcane by 2.0 drills significantly attained length, diameter, weight/ stalk, number of millable canes/fed, cane and sugar yields/fed, as well as brix% and sucrose% in both seasons, while, sugar recovery% was significant in the 1st seasons only. Also, Bekheet and Abd El-Aziz - Rania (2016) indicated that increasing seed rate from 1.5 drill (37800 buds/fed) to 2 drills (50400 buds/fed) produced increases significantly in height and stalk diameter, number of millable canes, cane and sugar yields, as well as brix% and sucrose%. However, Makhlouf *et al.* (2016) found that planting sugarcane by seeds rate 1.5 drill (37800 buds/fed) attained a significant increase in stalk diameter and stalk fresh weight compared with planting by 50400 buds/fad, while, seeds rate 2.0 drills (50400 buds/fed) attained brix% and sugar recovery%, number of millable cane/fed, cane and sugar yields/fed. Gadallah (2020) resulted that planting sugarcane by seeds density rate 2.0 drills (50400 buds/fed) gives improvement of millable cane height, number of millable canes/fed, cane and sugar yields/fad, while, had a significant improvement on diameter and weight/millable cane, as well as brix, sucrose and sugar recovery% by reducing seed rates to 1.0 drill (25200 buds/fad).

In Egypt, the commercial cane variety GT.54-9, occupies most of the area were planted with sugarcane. Recently, Sugar Crops Research Institute developed a lot of promising varieties of sugarcane, as G.2003-47 and G.2004-27 in addition to G.2005-47 genotypes. The newly bred varieties showed variable response to different agronomic practices.

Makhlouf *et al.* (2016) found that sugarcane variety GT.54-9 over passed the two promising varieties (G.2003-47 and G.2003-49) in length, diameter and fresh weight/stalks, while, the two promising varieties over passed in brix, purity, sugar recovery% and number of millable canes/fed, however, G.2003-47 variety gave the highest sugar yield/fed. Fahmy *et al.* (2017) showed that sugarcane variety GT.54-9 and G.2003-47 was surpassed the other two varieties (Phil 8013 and C. 57-14) in number of millable canes/fed, cane and sugar yields/fed. El-Bakry

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(2018) revealed that the promising sugarcane variety G.2003-47 showed the significant superiority in juice quality traits. Galal *et al*. (2018) found that sugarcane variety G.2003-47 had a significant superiority in the number of millable canes/ha and quality traits. The promising sugarcane G.2004-27 variety surpassed the other ones in stalk length, stalk weight as well as cane and sugar yields/ha in the plant cane and 1stratoon. Ali *et al.* (2019) showed that sugarcane varieties G.T. 54-9 and C. 57-14 were superior over the other varieties in cane and sugar yields/fad. Gadallah and Abd El-Aziz - Rania (2019) showed that sugarcane variety GT.54-9 superior on the other varieties in stalk height and cane yield/fed, while, G.2003-47 variety was superior in stalk diameter, brix, sucrose, sugar recovery and sugar yields/fed in both seasons, however, G.2004-27 variety attained the highest values of number of millable canes/fed.

Sugarcane breeders interested to produce new varieties with high cane and sugar yields and desirable agronomic traits. Modification of plant architecture offer possibilities for developing more efficient plants with increased cane and sugar yield potential. Consequently, identifying the interrelationships between cane and sugar yield and the related traits influencing of yield are important. All possible correlation among yield components and (or) juice quality were studied by several researchers (El-Hinnawy *et al.,* 2001 and Mohamed, 2007). On the other hand, Puneet-Jain *et al.* (2002) reported that significant correlation were detected between juice quality traits and each of cane yield and its components, but the interrelationships between quality traits were high and positive.

The development of cultivars or varieties, which are adapted to a wide range of diverse environments, is the ultimate goal of plant breeders in any crop improvement program. The adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is planted. Genotype by environment (G x E) interaction complicates selection and testing desirable genotypes. Measuring G x E interaction is important in order to determine an optimum strategy for selecting genotypes with adaptation to target environments (Annicchiarica, 1997). Several statistical methods have been developed for the analysis of G x E interaction, the deviation from regression mean squares (S^2_d) has been termed stability index by Eberhart and Russell (1966) and it was considered a true measure of production stability by Langer *et al.* (1979). In this respect, Backer *et al*. (1982) regarded deviation mean square from regression to be the most appropriate criterion for measuring phenotypic stability in an agronomic sense because this parameter measures the predictability of genotypic reaction to environments. In addition, Lin *et al.* (1986) cleared that type 2 stability (w_i and σ^2_i) is a relative measure that is dependent on the genotypes included in the test. According to Pham and Kang (1988), this type of relative measure is acceptable to plant breeder.

The objectives of the present study were to evaluate mean performance of some new promising sugarcane genotypes under different seeding rate for some agronomic and technological traits and to study the phenotypic correlation among these traits of the evaluated genotypes under six environments representing the combinations between three seed rates and two years, as well as to study the effectiveness of biometric models in estimating stability parameters of sugarcane genotypes for cane yield.

MATERIALS AND METHODS

Two field experiments were conducted at Shandaweel Agricultural Research Station (latitude of 26.33° N , longitude of 31.41° E and altitude of 69m), Sohag Governorate, Egypt in 2017/2018 and 2018/2019 seasons to evaluate the performance of new sugarcane varieties viz. [G.2003-47 (Giza 3) and G.2004-27 (Giza 4)] and G.2005-47 promising genotype, compared to the commercial variety GT.54-9 (C 9) planted with three rates of seeds [1.0, 1.5 and 2.0 drills of 3-budded cane cuttings (25200, 37800 and 50400 buds/fed obtaind by planting 8400,12600 and 16800 of three- budded seed setts/fed.)]. Sugarcane was planted in the last week of February and harvested after 12 months, in both seasons. A split plot design with three replications was used. Seed rates were allocated in the main plots, while sugarcane varieties were randomly distributed in the sub plots. Each plot area was 35 m^2 including 5 rows of 7 m in length and 1.0 m apart. Chemical and physical properties of the experimental soil are presented in Table (1).

Table 1. Chemical and physical properties of the upper 40-cm of the experimental soil

Seasons		2017/2018	2018/2019
Physical analysis	Sand%	56.34	59.20
	Silt%	28.44	24.30
	Clay%	15.22	16.50
Soil texture		Sandy loam	Sandy loam
Chemical analysis	Available N (ppm)	0.20	0.24
	$CaCO_3$%	1.20	1.47
	CO_3 meq/100 g	-	-
	HCO_3 meq/100 g	0.30	0.33
	Cl^- meq/100 g	0.89	0.89
	SO_4^{--} meq/100 g	1.02	1.13
	Ca^{++}meq/100 g	0.53	0.54
	Mg^{++}meq/100 g	0.27	0.35
	Na^+meq/100 g	1.25	1.31
	K^+meq/100 g	0.16	0.15
	EC, dS/m (1:5)	0.24	0.26
	pH	7.5	7.3

Nitrogen fertilizer was applied as urea (46% N) at the rate of 200 kg N/fed, which was split into two equal doses; after the 1st and 2nd hoeing, *i.e.* (60 and 90 days from planting). Phosphorus fertilizer was added once during seed-bed preparation as calcium super phosphate (15% P_2O_5) at the rate 30 kg P_2O_5/fed. Potassium fertilizer was added once as potassium sulfate (48% K_2O) at the rate of 48 kg K_2O/fed with the 2nd dose of N fertilizer. The other agricultural practices were done as recommended by Sugar Crops Research Institute.

The recorded data:

A: The following data were recorded at harvest from 20 random millable canes for each treatment:

1. Millable cane height (cm) was measured from soil surface to the top visible dewlap.
2. Millable cane diameter (cm) was measured at the middle part of stalks.
3. Net millable cane weight (kg).

B: The harvested sugarcanes of the middle three rows of each experimental unit were cut, topped, cleaned up from trash, weighed and counted to estimate the following traits:

1. Number of millable canes/plot was counted and converted in to thousands/fed.
2. Cane yield/fed (ton), which was determined from the fresh weight (kg) of millable canes of each plot, which was converted into tons/fed.
3. Sugar yield/fed (ton), which was estimated according to the following equation:

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

C: At harvest, a sample of 20 millable canes from each treatment was collected at random, cleaned and crushed to extract the juice, which was analyzed to determine the following quality traits:

1. Brix% (TSS: total soluble solids of juice), which was determined using "Brix Hydrometer" according to A.O.A.C. (2005).
2. Sucrose% was determined using “Sacharemeter” according to A.O.A.C. (2005).
3. Sugar recovery% was calculated according to Yadav and Sharma (1980) as follows:

Sugar recovery % = [sucrose % - 0.4 (brix % - sucrose %) × 0.73].

Statistical analysis:

The collected data were statistically analyzed according to Gomez and Gomez (1984) using the computer "MSTAT-c" statistical analysis package described by Freed, *et al*. (1989). The least significant differences (LSD) at 0.05 level of probability was calculated to compare the differences among means of treatments according to Snedecor and Cochran (1981).

Simple phenotypic correlation coefficients (r) between all characters studied were calculated as shown by Cardinal and Burton (2007). All factors used in this study were assumed as fixed factors. The combinations between the two years and three seeding rates were considered as six different environments.

D: The following stability statistics were estimated for cane and sugar yields:

1. The linear regression coefficient (bi) of genotypes mean on environmental index and the deviation mean square from regression (S^2_d) according to method of Eberhart and Russell (1966).
2. The ecovalence stability index (W_i) was estimated as developed by Wricke (1962).

RESULTS AND DISCUSSION

1. Millable cane height:

Data in Table 2, showed that the used seed rates significantly affected millable cane height, in both seasons. Planting sugarcane using 2.0 drills of cane cuttings (50400 buds/fed) increased millable cane height by 11.75, 5.50, 12.08 and 3.08 cm, compared to that planted with 1.0 and 1.5 drills of 3-budded setts in the 1st and the 2nd seasons, respectively. These results may be due to that increasing seed rate resulted in an increase in plant population density, causing mutual shading among plants, and consequently, the competition directed plants searching for solar radiation to increase their height (Chang, 1974). Similar results were given by Shalaby, *et al.* (2011), El-Geddawy - Dalia, *et al.* (2015), Bekheet and Abd El-Aziz - Rania (2016) and Gadallah (2020).

Table 2. Effect of seed rates on millable cane height, diameter and weight of some promising sugarcane genotypes in 2017/2018 and 2018/2019 seasons

Treatments		Millable cane height (cm)		Millable cane diameter (cm)		Millable cane weight (kg)	
		2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
Seed rate/fed (A)							
1.0 drill (25200 buds/fed)		328.83	318.92	2.60	2.59	1.383	1.352
1.5 drill (37800 buds/fed)		335.08	327.92	2.57	2.56	1.392	1.363
2.0 drills (50400 buds/fed)		340.58	331.00	2.54	2.54	1.375	1.348
LSD at 0.05		1.27	1.74	0.02	0.01	0.001	0.002
Sugarcane genotypes							
G.2003-47 (G1)		333.00	324.22	2.57	2.57	1.374	1.348
G.2004-27 (G2)		337.11	326.89	2.57	2.56	1.390	1.367
GT. 54-9 (G3)		339.89	331.56	2.58	2.58	1.424	1.392
G.2005-47 (G4)		329.33	321.11	2.56	2.54	1.344	1.310
LSD at 0.05		1.79	1.24	0.01	0.01	0.001	0.003
Interaction							
1.0 drill (25200 buds/fed)	(G1)	327.33	318.00	2.59	2.60	1.381	1.347
	(G2)	329.67	319.67	2.60	2.60	1.389	1.362
	(G3)	333.00	324.00	2.61	2.61	1.419	1.384
	(G4)	325.33	314.00	2.59	2.57	1.342	1.315
1.5 drill (37800 buds/fed)	(G1)	332.00	326.00	2.57	2.57	1.379	1.361
	(G2)	338.33	327.67	2.57	2.56	1.405	1.381
	(G3)	341.00	335.00	2.59	2.58	1.431	1.402
	(G4)	329.00	323.00	2.55	2.54	1.350	1.309
2.0 drills (50400 buds/fed)	(G1)	339.67	328.67	2.54	2.54	1.361	1.388
	(G2)	343.33	333.33	2.55	2.53	1.377	1.358
	(G3)	345.67	335.67	2.55	2.55	1.423	1.390
	(G4)	333.67	326.33	2.53	2.51	1.338	1.307
LSD at 0.05		NS	NS	0.02	0.02	0.002	0.005

NS: insignificant difference.

The results in Table 2, the commercial variety GT.54-9 gave the highest millable canes in both seasons. Also, insignificant difference in this trait was observed between GT.54-9 and promising G.2004-27 variety in this trait, in the1stseason. Meanwhile, it was found that G.2005-47 genotype had the shortest millable canes, in the 1stand 2ndseasons. Similar trends were reported by Makhlouf *et al.* (2016), Fahmy *et al.*(2017) and Gadallah and Abd El-Aziz - Rania (2019).

Millable cane height was insignificantly affected by the interaction between the studied seed rates and sugarcane genotypes in both seasons.

2. Millable cane diameter:

Data in Table 2, indicated that reducing the used planting material to 1.0 drill of cane cuttings (25200 buds/fed) significantly resulted in producing the thickest millable cane diameter, compared to those obtained in case of planting with 1.5 and 2.0 drills of cane sets (37800 and 50400 buds/fed, successively), in both seasons. These results may be attributed to the lower inter-plant competition among plants for light and nutrients, as well as little mutual shading in case of planting with the lowest seeding rate, which resulted in the lowest plant population, in comparison to the other higher seed rates. These results are in harmony with those reported by Shalaby *et al.* (2011), Makhlouf *et al.* (2016) and Gadallah (2020).

The tested sugarcane varieties varied significantly in stalk diameter in both seasons. The commercial variety GT.54-9 had the thickest stalks, while G.2005-47 genotype recorded the lowest value of this growth character. The variance among cane varieties in these traits may be due to their gene make-up. These findings coincide with those obtained by Makhlouf *et al.* (2016) and Fahmy *et al.* (2017).

Millable cane diameter was significantly affected by the interaction between seed rate and sugarcane genotypes, in the 1st and 2nd seasons. Insignificant variance in cane stalk diameter was detected in case of planting sugarcane G.2003-47 and G.2005-47 varieties using 1.0 and/or 2.0 drills of cane cuttings. However, the difference between these two varieties in this trait was appreciable when they were grown using 1.5 drills of setts, in the 1st season. In the 2nd one, insignificant difference was recorded between sugarcane varieties *viz.* G.2004-27 (G2) and the check GT.54-9 in cane diameter, when they were planted using 1.0 drill of cane cuttings, with a statistical variance between the two varieties in this trait, in case of growing them using the other two higher seeding rates.

The thickest millable canes were obtained by the commercial cultivar GT.54-9 planted with 1.0 drill of cane seeds, in both seasons.

3. Millable cane weight:

Data in Table 2, illustrate that planting seed rate 1.5 drill of cane cuttings (37800 buds/fed) significantly increased millable cane weight by (0.009 and 0.017 kg) and (0.011 and 0.015 kg), compared to those obtained in case of planting sugarcane with 1.0 and 2.0 drills of cane setts (25200 and 50400 buds/fed, in the1st and 2nd season, successively. These results may be attributed to that growing sugar cane under conditions of the middle seeding rate of 1.5 drill ensured appropriate growth conditions compared to that of higher plant populations under 2.0 drills of cane cuttings, which ultimately led to highest fresh weight of canes. These results are in conformity with those of Makhlouf *et al.* (2016) and Gadallah (2020).

The results cleared that the commercial variety GT.54-9 had the highest millable cane weight, where it exceeded G.2003-47, G.2004-27 and 2005-47 by (0.050, 0.034 and 0.080 kg) and (0.044, 0.025 and 0.082 kg), in the 1st and 2nd season, respectively (Table 2). The variance among cane varieties in these traits may be due to their gene make-up. The same finding was reported by Makhlouf *et al.* (2016).

Millable cane weight was significantly affected by the interaction between seed rates and sugarcane genotypes, in the 1st and 2nd seasons. In the 1st one, the variance between GT.54-9 and G.2005-47 in stalk weight became more distinguished (0.077, 0.081 and 0.085 kg) as the used seed rate increased from 1.0 to 1.5 and 2.0 drills of cane setts, respectively. In the second season, the difference between G.2003-47 and the GT.54-9 in millable cane weight was insignificant under conditions of the two lower seeding rates. However, statistical variance between them was recorded at the highest seed rate.

The highest millable cane weight was obtained when GT.54-9 cultivar was planted with 1.5 drills of seeds, in both seasons.

4. Brix %:

Data in Table 3, revealed that decreasing seed rate to 1.0 drill of cane cuttings (25200 buds/fed) significantly increased brix compared to that planted with 1.5 or 2.0 drills of setts (37800 and 50400 buds/fed, respectively), in the 1st and 2nd season. These results may be due to the great competition among plants for light and nutrients as well as mutual shading compared in case of using high rate of seeds for planting. Solar radiation has an effect on brix% and sucrose% (Chang, 1974). These results are in agreement with those mentioned by Shalaby *et al.* (2011) and Makhlouf *et al* (2016).

The tested sugarcane genotypes differed markedly in brix. The results in Table 3, manifested that G.2003-47 sugarcane variety had the highest values of brix. On the contrary, variety G.2004-27 recorded the lowest values in both seasons. The differences between the studied varieties in brix may be due to the variations among varieties in gene make-up. These results are in accordance with that obtained by Makhlouf *et al.* (2016), Fahmy *et al* (2017), El-Bakry (2018) and Gadallah and Abd El-Aziz - Rania (2019).

Brix was significantly affected by the interaction between sugarcane genotypes when planted by different seed rates in both seasons. The highest values of brix were obtained by G.2003-47 variety as 1.0 drill planted of seeds, as shown in Table 3.

Table 3. Effect of seed rates on brix, sucrose and sugar recovery percentages of some promising sugarcane genotypes in 2017/2018 and 2018/2019 seasons

Treatments		Brix%		Sucrose%		Sugar recovery%	
		2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
Seed rate/fed							
1.0 drill (25200 buds/fed)		20.48	20.47	17.18	17.17	11.68	11.66
1.5 drill (37800 buds/fed)		20.30	20.23	16.96	16.92	11.52	11.48
2.0 drills (50400 buds/fed)		19.90	19.76	16.70	16.60	11.35	11.30
LSD at 0.05		0.15	0.10	0.08	0.08	0.10	0.08
Sugarcane genotypes							
G.2003-47 (G1)		21.36	21.23	18.00	17.94	12.28	12.28
G.2004-27 (G2)		18.66	18.55	15.39	15.31	10.33	10.68
GT.54-9 (G3)		19.92	19.85	17.05	17.01	11.82	11.82
G.2005-47 (G4)		20.98	20.98	17.38	17.34	11.66	11.60
LSD at 0.05		0.08	0.13	0.07	0.11	0.06	0.09
Interaction							
1.0 drill (25200 buds/fed)	(G1)	21.63	21.67	18.19	18.23	12.39	12.42
	(G2)	18.81	18.77	15.49	15.46	10.33	10.27
	(G3)	20.25	20.27	17.48	17.50	12.23	12.24
	(G4)	21.24	21.18	17.56	17.49	11.76	11.70
1.5 drill (37800 buds/fed)	(G1)	21.43	21.38	18.11	18.07	12.40	12.38
	(G2)	18.75	18.57	15.44	15.27	10.30	10.17
	(G3)	20.05	19.95	17.05	17.02	11.75	11.76
	(G4)	20.97	21.00	17.33	17.33	11.61	11.59
2.0 drills (50400 buds/fed)	(G1)	21.00	20.63	17.69	17.51	12.07	12.03
	(G2)	18.42	18.31	15.26	15.18	10.24	10.19
	(G3)	19.45	19.31	16.61	16.52	11.49	11.45
	(G4)	20.73	20.77	17.23	17.18	11.60	11.52
LSD at 0.05		0.14	0.23	0.12	0.819	0.11	0.15

5. Sucrose%:

Data in Table 3, revealed that decreasing seed rate to 1.0 drill of cane cuttings (25200 buds/fed) for sugarcane planting seed rates significantly increased sucrose% compared to that planted with 1.5 or 2.0 drills of setts (37800 and 50400 buds/fed, respectively), in the 1st and 2nd season. These results are in line with that shown by Shalaby *et al.* (2011) and Makhlouf *et al.* (2016).

The results indicated that G.2003-47 new variety gave the highest sucrose% as compared with the other genotypes. However, variety G.2004-27 recorded the lowest values in the 1st and 2nd season. Such varietal differences among cane genotypes in sucrose% were reported by Makhlouf *et al.* (2016), Fahmy *et al.* (2017), El-Bakry (2018), Galal *et al.* (2018) and Gadallah and Abd El-Aziz - Rania (2019).

Sucrose% was significantly affected by the interactions between seed rates x sugarcane genotypes in the 1st and 2nd season. The highest sucrose% was recorded by planted of sugarcane variety G.2003-47 by using 1.0 drill of 3-budded cane setts for plant in both seasons.

6. Sugar recovery%:

Data in Table 3, revealed that decreasing seed rate to 1.0 drill of cane cuttings (25200 buds/fed) used in sugarcane planting significantly increased sugar recovery% as compared to that planted with 1.5 or 2.0 drills of setts (37800 and 50400 buds/fed, respectively), in the 1st and 2nd seasons. Increasing of brix and sucrose% (Table 3) resulted in increased sugar recovery%. These results are in agreement with those mentioned by Hasan *et al.* (2009) and Gadallah (2020).

Sugar recovery% differed significantly by the tested sugarcane genotypes; G.2003-47 new variety recorded the highest sugar recovery% value, in both seasons. However, sugarcane variety G.2004-27 gave the lowest value of this trait in both seasons. Such varietal differences among cane genotypes in Sugar recovery% were reported by Makhlouf *et al.* (2016) and Gadallah and Abd El-Aziz - Rania (2019).

Sugar recovery% was significantly affected by the interaction between seed rates x sugarcane genotypes in both seasons. The highest sugar recovery% was recorded by planted sugarcane variety G.2003-47 by using 1.5 in the first season and 1.0 drill in the second season.

7. Number of millable canes/fed:

Results in Table 4, cleared that the used seed rates significantly affected number of millable canes/fed, in both seasons. Planted of sugarcane using 2.0 drills of cane cuttings (50400 buds/fed) increased number of millable canes/fed by 2.524 and 1.336 thousand/fed, compared to that planted with 1.0 and 1.5 drills of setts (25200 and 37800 buds/fed, respectively), in the 1st season and being 2.587 and 1.361 thousand/fed in the 2nd one. The increase of number of millable cane/fed may be due to the increase in population of cane plants emerged and utilized the available growth factors as space, sun light, water and nutrients. These results are in harmony with those reported by Shalaby *et al.* (2011), El-Geddawy - Dalia *et al.* (2015), Bekheet and Abd El-Aziz - Rania (2016), Makhlouf *et al.* (2016) and Gadallah (2020).

The tested sugarcane varieties differed significantly in the number of millable canes. In both seasons the results in Table 4, cleared that the new sugarcane variety viz. G.2004-27 significantly surpassed the other varieties in millable cane number/fed. Moreover, it can be noticed that the difference between G.2004-27 variety and G.2005-47 genotype in this trait was insignificant, in the 2nd season.

These results are similar with those obtained by Gadallah and Abd El-Aziz - Rania (2019).

Number of millable canes/fed was significantly affected by the interaction between seed rates x sugarcane genotypes in both seasons. Planted of sugarcane variety G.2004-27 by using 2.0 drill of 3-budded cane setts had the highest number of millable canes/fed (46.070 and 45.767 thousand/fed) in the 1st and 2nd seasons, respectively.

Table 4. Effect of seed rates on number of millable canes, cane and sugar yields of some promising sugarcane genotypes in 2017/2018 and 2018/2019 seasons

Treatments		Number of millable cane (thousand/fed)		Millable cane yield (ton/fed)		Sugar yield (ton/fed)	
		2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
Seed rate/fed							
1.0 drill (25200 buds/fed)		42.934	42.667	57.127	55.514	6.667	6.495
1.5 drill (37800 buds/fed)		44.122	43.893	59.068	57.613	6.796	6.631
2.0 drills (50400 buds/fed)		45.458	45.254	60.066	58.731	6.811	6.655
LSD at 0.05		0.062	0.079	0.091	0.095	0.057	0.038
Sugarcane genotypes							
G.2003-47 (G1)		43.613	43.350	57.618	56.259	7.077	6.931
G.2004-27 (G2)		44.681	44.261	59.747	58.258	6.147	5.972
GT.54-9 (G3)		44.051	43.903	60.419	58.903	7.137	6.982
G.2005-47 (G4)		44.339	44.238	57.230	55.724	6.671	6.489
LSD at 0.05		0.099	0.133	0.134	0.128	0.041	0. 053
Interaction							
1.0 drill (25200 buds/fed)	(G1)	42.377	42.113	56.323	54.583	6.977	6.807
	(G2)	43.437	42.868	58.058	56.217	5.997	5.797
	(G3)	42.703	42.623	58.362	56.823	7.136	6.982
	(G4)	43.220	43.062	55.763	54.433	6.558	6.393
1.5 drill (37800 buds/fed)	(G1)	43.507	43.250	57.727	56.667	7.158	7.041
	(G2)	44.537	44.147	60.223	58.738	6.203	5.998
	(G3)	44.040	43.840	60.720	59.258	7.135	6.997
	(G4)	44.403	44.337	57.603	55.790	6.688	6.490
2.0 drills (50400 buds/fed)	(G1)	44.957	44.687	58.803	57.527	7.096	6.947
	(G2)	46.070	45.767	60.960	59.820	6.240	6.120
	(G3)	45.410	45.247	62.323	60.627	7.142	6.967
	(G4)	45.395	45.317	58.323	56.950	6.768	6.586
LSD at 0.05		0.171	0.230	0.232	0.221	0.072	0.092

8. Cane yield/fed:

Data in Table 4, showed that the used seed rates significantly effected on cane yield/fed, in both seasons. Planted sugarcane genotype using 2.0 drills of cane cuttings (50400 buds/fed) increased cane yield by 2.939 and 0.998 tons/fed as compared to that planted with 1.0 or 1.5 drills of setts (25200 and 37800 buds/fed, successively), in the 1st season, corresponding to 3.217 and 1.118 tons of canes/fed, in the 2nd one. These results could be due to the increased in number of millable canes/fed. These results are in accordance with those reported by Shalaby *et al.* (2011), El-Geddawy - Dalia *et al.* (2015), Bekheet and Abd El-Aziz - Rania (2016), Makhlouf *et al.* (2016) and Gadallah (2020).

Cultivated sugarcane variety GT.54-9 exhibited the superiority in cane yield recording significant increases amounted to 2.801, 0.672 and 3.189 tons/fed higher than those produced by G.2003-47, G.2004-27 varieties and G.2005-47 genotype, respectively, in the 1st season, as same as in 2nd season 2.644, 0.645 and 3.179 tons/fed. Although, the data in Table 4, cleared that the differences in this trait between (GT.54-9 with G.2004-27 varieties) and (G.2003-47 variety with G.2005-47 genotype) were minimal in both seasons. These results are in a line with those reported Ali *et al.* (2019) and Gadallah and Abd El-Aziz - Rania (2019).

Results revealed that cane yield was significantly affected by the interaction between seed rates x sugarcane genotypes in both seasons. Planted of sugarcane variety G.2004-27 by using 2.0 drill of 3-budded cane setts had the highest cane yield/fed (62.232 and 60.627 tones/fed) in the 1st and 2nd season, respectively.

9. Sugar yield/fed:

Data in Table 4, manifested that planted of sugarcane using 2.0 drills of cane cuttings (50400 buds/fed) significantly increased sugar yield/fed by 0.144 and 0.160 tons/fed as compared to that planted with 1.0 drill of cane cuttings (25200 buds/fed) in the 1st and 2nd seasons, respectively. However, the difference in this trait between 1.5 and 2.0 drills of setts (37800 and 50400 buds/fed) was insignificant, in both seasons. The increase in sugar yield/fed was associated with the increase in number of millable canes and millable cane yield/fed, which is considered the main component of sugar yield. These results are in accordance with those reported by Hasan *et al.* (2009), Shalaby *et al.* (2011), El-Geddawy - Dalia *et al.* (2015), Bekheet and Abd El-Aziz - Rania (2016), Makhlouf *et al.* (2016) and Gadallah (2020).

Cultivated sugarcane variety GT.54-9 exhibited the superiority in sugar yield/fed recording significant increases amounted to 0.060, 0.990, and 0.466 tons/fed higher than those produced by G.2003-47, G.2004-27 varieties and G.2005-47 genotype, respectively, in the 1st season, corresponding to 0.051, 1.010 and 0.493 tons/fed in 2nd season. However, the difference in this trait between GT.54-9 and G.2003-47 varieties was insignificant, in the 2nd season. The increase in sugar yield/fed was associated with the increase in millable cane yield/fed and millable cane weight, which is considered the main component of sugar yield. Such varietal differences were reported by Makhlouf *et al.* (2016), Fahmy *et al.* (2017), El-Bakry (2018), Galal *et al*. (2018), Ali *et al.* (2019) and Gadallah and Abd El-Aziz - Rania (2019).

Sugar yield was significantly affected by the interactions between seed rates and sugarcane genotypes in both seasons. The highest sugar production/fed was obtained by planted of new sugarcane variety viz. G.2003-47 using 1.5 drill of 3-budded cane seeds, in both seasons. However, the differences in sugar yield/fed between new sugarcane variety viz. G.2003-47 and cultivated commercial variety GT.54-9 was insignificant when they were planted by 1.5 drills and/or 2.0 drills in the 1st and 2nd season.

- Phenotypic correlation:

The correlation coefficient was computed for the different genotypes on pooled data over years and seed rates in plant cane crops.

The results in Table 5, showed that sugar yield exhibited positive and high significant correlations with brix reading, sucrose% and sugar recovery%, while cane yield had positive and high significant correlation with each of millable cane height, millable cane weight and number of millable cane/fed. Furthermore, cane yield had a high significant negative correlation with each of brix reading and sucrose%. This means that selection for one or more of these traits; millable cane height, millable cane weight and number of millable cane/fed simultaneously may be effective in improving cane yield. The rest of studied traits were not significantly correlated with cane yield and can't be used as an efficient selection for cane yield. Many investigators studied the association between cane and/or sugar yield with each of yield components (stalk number, weight, diameter and …*etc*) and juice quality (sucrose%, purity% and …*etc*). Puneet-Jain *et al.*(2002), Mohamed (2007) and El-Hinnawy *et al.* (2001), reported that cane yield was positively and significantly correlation with each of stalk length, stalk number, stalk diameter, sucrose%, purity%, sugar recovery% and sugar yield in plant cane. Ebid *et al.* (2008), found that sugar yield exhibited positive and significant correlations with all studied traits except brix reading and plant height, while cane yield showed positive and significant correlation with each of stalk weight, number of plants/m^2 and stalk diameter.

Sugar recovery % had positive and high significant correlation with each of brix reading and sucrose % (Table 5). Meantime, sucrose % showed positive and high significant correlation with brix reading. The remainder of traits had lesser and insignificant correlation with sugar recovery %. The results suggested that highest sucrose and sugar recovery percentage could be achieved by selection for high brix reading.

Among main yield components, millable cane weight exhibited positive and high significant correlation with millable cane height and diameter. The number of millable cane/fed exhibited significant and positive correlation with millable cane height, but it was negatively correlated with millable cane diameter, brix reading and sucrose%.

Table 5 . Diallel Correlation coefficient between cane and sugar yields and other seven studied components at cane crop

Traits	Millable caneheight (cm)	Millable cane diameter (cm)	Millable cane weight (kg)	Brix %	Sucrose %	Sugar recovery %	Millable cane No./fed	Millable cane yield (ton/fed)	Sugar yield (ton/fed)
Millable cane height (cm)	1	-0.272	0.640**	-0.423*	-0.309	-0.197	0.647**	0.938**	0.285
Millable cane diameter (cm)		1	0.419*	0.050	0.128	0.182	-0.848**	-0.270	0.046
Millable cane weight (kg)			1	-0.413*	-0.219	-0.050	-0.029	0.681**	0.312
Brix %				1	0.965**	0.889**	-0.445*	-0.645**	0.606**
Sucrose %					1	0.977**	-0.459*	-0.521**	0.771**
Sugar recovery%						1	-0.443*	-0.391*	0.868**
Millable cane No./fed							1	0.680**	-0.110
Millable cane yield (ton/fed)								1	0.116
Sugar yield (ton/fed)									1

****. Correlation is significant at the 0.01 level (1-tailed).**
***. Correlation is significant at the 0.05 level (1-tailed).**

- Stability analysis:

Pooled analysis of variance in Table 6, revealed the presence of highly significant differences among the four sugarcane genotypes in cane yield. Similar findings were found by Ahmed (2000), highly significant genotype x environment interaction was detected, including linear environmental effect concerning this trait. A large sum of squares of environments indicates that the environments were diverse, with large differences among environmental means causing most of the variation in cane yield. The highly significant mean squares due to environments (linear) point to differences between the environments and their considerable influences on this trait. The significance of environments mean squares led to the conclusion that the performance of sugarcane genotypes regarding this trait differed from one environment to another under the conditions of this study.

Table 6. Stability analysis of variance for cane yield of the tested sugarcane genotypes and GT.54-9 check cultivar over 6 different environments

Source of variation	Df	Mean squares
Genotypes (G)	3	57.68**
Environments (Env.) + (G x Env.)	20	10.70**
Env. (linear)	1	208.53**
G x Env. (linear)	3	1.12
Pooled deviation	16	0.13
Pooled error	54	0.732

**** denote to the significance at 0.01 level of probability.**

It is worthy to note that the estimates of stability parameters should be done when G x E interaction is significant. Mean cane yield of the four studied sugarcane genotypes and their estimates of different stability parameters are given in Table 7. According to Eberhart and Russell's (1966) model, a desirable stable genotype is that one having mean yield higher than the average yield of all genotypes under study, a regression coefficient close to unity and small deviation from regression possibly close to zero. Genotypes with b_i values greater than unity would be adapted to more favorable environments (below average stability), while those with b_i values less than unity would be adapted to poor environments (above average stability).

The mean values for cane yield ranged from 56.48 to 59.66 tons/fed. The cultivar GT.54-9 and the promising variety G.2004-27 were significantly superior to the rest of genotypes for cane yield.

The regression coefficients of the sugarcane genotypes ranged from 0.87 to 1.18 for cane yield. The large variation in the regression coefficients indicated that genotypes had different environmental responses. The cultivar GT.54-9 appeared to be more responsive to favorable environments than the other genotypes as indicated by the relatively high regression coefficient value and high cane yield in higher yielding environments. The genotype G.2005-47 was less responsive to environmental change, as indicated by the lower regression coefficient for cane yield. In higher yielding environments, this genotype lacked the ability to respond to the favorable conditions, whereas G.2004-27 variety, which had high mean yield, b_i value higher and very close to 1 and S^2_d value more close to zero, was more stable than other genotypes.

Table 7. Estimates of environment stability statistics for cane yield/fed (ton) of the tested sugarcane genotypes grown under 6 environments

Genotypes	Stability parameters				
	Mean	b_i	S_{di}^2	σ_i^2	W_i^2
G.2003-47	56.94	0.89	0.011	0.05	0.23
G.2004-27	59.00	1.06	0.015	0.01	0.15
GT.54-9	59.66	1.18*	0.020*	0.18	0.57
G.2005-47	56.48	0.87*	0.029*	0.13	0.43
Mean	58.02				
LSD (0.05)	0.07				

*** denote to the significance at 0.05 level of probability.**
 # b_i denote to the regression coefficient.

The results in Table 7 indicate that S^2_d values significantly differed from zero for the cultivated GT.54-9 variety and G.2005-47 genotype, indicating that they could be classified as being unstable. Since stability of a genotype is inversely proportioned to covalence stability index (w_i) and stability variance (σ^2_i), a stable genotype should have relatively low values for these parameters. Consequently, the most stable genotypes would be judged as the varietyG.2004-27 for w_i and σ^2_i in regard to cane yield.

Based on the different stability analyses, the promising variety G.2004-27 was the most stable in cane yield across environments tested showing broader adaptability for all studied seeding rates.

CONCLUSION

Under conditions of this work (Shandaweel Agricultural Research Station, Sohag Governorate, Egypt), planting sugar cane variety GT.54-9 using 2.0 drills cutting seed setts (50400 buds/fed) could be recommended to attain the highest cane yield, while, planting variety G.2003-47 using 1.5 drill (37800 buds/fed) could be recommended to get the maximum sugar yield/fed. Variety G.2004-27 showed broader adaptability for all studied seeding rates.

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التقييم المحصولي والارتباط والثبات المظهري لتراكيب وراثية جديدة من قصب السكر تحت معدلات تقاوي مختلفة

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أقيمت تجربتان حقليتان في محطة بحوث شندويل للبحوث الزراعية بمحافظة سوهاج (دائرة عرض 26.33° شمالاً وخط طول 31.41°شرقاً) خلال موسمي 2018/2017 و 2019/2018 لتقييم أداء صنفين جديدين هما (جيزة 3 وجيزة 4) وتركيب وراثي واحد مبشر هو (جيزة 2005-47) من قصب السكر وذلك بالمقارنة مع الصنف التجاري (جيزة-تايوان 54-9) ، وقد زرعت هذه التراكيب الوراثية كلها بثلاث معدلات من التقاوي (صف واحد و1,5 صف وصفين) لتحديد مدي تأثر صفات المحصول والجودة، وذلك في تصميم قطع منشقة مرة واحدة وثلاث مكررات. أظهرت النتائج أن معدل التقاوي صفين حقق زيادة ملحوظة في معظم الصفات المدروسة. حقق معدل التقاوي صف واحد زيادة معنوية في صفات البركس والسكروز% وناتج السكر%، بينما حقق معدل التقاوي 1,5 صف اعلي القيم في متوسط وزن العود. تفوق الصنف التجاري في معظم الصفات المدروسة. تفوق الصنف (جيزة 3) في البركس والسكروز% وناتج السكر% بينما الصنف (جيزة 4) أعطى اعلي عدد للعيدان القابلة للعصر/فدان. تأثرت كل الصفات معنويا بالتفاعل بين معدلات التقاوي والتراكيب الوراثية ما عدا صفة طول العود التي لم تتأثر معنوياً وذلك في كلا الموسمين.أوضحت دراسة الارتباط وجود ارتباط موجب وعالي المعنوية بين صفات طول وقطر العود وبين وزن العود. بينما كان الارتباط سالباً بين عدد العيدان القابلة للعصر/فدان وبين قطر العود والبركس والسكروز%. كما اظهر تحليل الثبات أن الصنف الجديد (جيزة 4) كان الأكثر ثباتاً في محصول العيدان مما يظهر قابلية أوسع لزراعته بمعدلات التقاوي المختلفة محل الدراسة. من نتائج هذه الدراسة يوصى بزراعة الصنف التجاري بمعدل تقاوي صفين للحصول على أعلى محصول عيدان بينما زراعة الصنف (جيزة 3) بمعدل تقاوي صف ونصف للحصول على أعلى محصول سكر.