RESEARCH ARTICLE

COMPARATIVE PERFORMANCE OF SUGARCANE GENOTYPES FOR RATOONABILITY IN EARLY CLONAL SELECTION STAGES

Eid M. Mehareb[1], Salah Fatouh Abou-Elwafa[2*] and Mohamed. O.A. Galal[1]

Abstract

Sugarcane plays a crucial role in the economics of farmers and in the survival of the ever-expanding sugar industry in Egypt. Eighteen promising genotypes and two commercial varieties were evaluated at two locations in middle and southern Egypt during 2010 (plant cane), 2011 (first ratoon) and 2012 (second ratoon). Significant differences among evaluated genotypes for all measured traits across all crop cycles were observed. Stalk diameter of 12 genotypes decreased with older crop cycles whereas stalk length of 10 genotypes increased with older crop cycles. Stalk weight of 15 genotypes decreased from plant cane to first ratoon. Cane yield of genotypes G99-103 and G2004-121 exceeded the control variety GT54-9 significantly across all crop cycles. Generally, cane yield decreased significantly in the second ratoon by 4.36% compared to first ratoon. Genotype G2004-136 produced high cane and sugar yields in the second ratoon indicating superiority in ratoonability.

Key words: *Saccharum*, sugarcane, genotypes, clonal selection, crop cycle, cane yield, sugar yield, ratoonability.

Introduction

Sugarcane (*Saccharum officinarum* L.) is a major sugar crop in tropical and sub-tropical countries. In Egypt, sugarcane is an important cash crop as it plays a crucial role in the economics of farmers and provides the mainstay to sugar industry in southern Egypt and also raw material to many allied industries. Ratoonability in sugarcane is the ability to maintain yield as the number of ratoon crops increases and is a desirable character because it improves the economics of sugarcane production. Ratoonability is a cane yield related trait and is defined as the ratio of cane yield in the second ratoon crop relative to that in plant cane and is associated with stalk numbers, bud viability, vigorous root formation and biomass production (Chapman 1988; Milligan et al. 1996; Sundara 1989). Ratooning of sugarcane is a common practice throughout the world and ratoon occupies almost 50 per cent of the total area under sugarcane cultivation (Sundara 2008). A variety may be considered to have good ratoonability if it can maintain yield and/or has a high yield potential in the plant crop followed by high cane yield in the ratoon crop. The plant characteristics of sugarcane associated with ratoonability were studied for possible use as selection criteria in breeding (Ferraris et al. 1993; Matsuoka and Stolf 2012). The major cane growing countries normally take two or more ratoons (Bashir et al. 2013; Singh and Dey 2002; Yadav 1991). Ratoon crop yields usually decrease with age and, hence, limit the economic production of sugarcane (Johnson et al. 1993; Mirzawan and Sugiyarta 1999; Ricaud and Arceneaux 1986). The

Eid M. Mehareb[1], Salah Fatouh Abou-Elwafa[2*] and Mohamed. O.A. Galal[1]
[1]Sugar Crops Research Institute, Agricultural Research Center (ARC), Cairo, Egypt
[2]Agronomy department, College of Agriculture, Assiut University, 71526 Assiut, Egypt
*Email : elwafa75@aun.edu.eg

average yield gap between plant and ratoon crop is 20-25% (Gomathi et al. 2013). At early selection stage of sugarcane, stalk diameter and stalk weight decreased with older crops, while stalk number, cane yield, juice quality traits and sugar yield increased with older crops (Milligan et al. 1990). Bissessur et al. (2000) evaluated the performance of four sugarcane families including 154 clones at two sites and reported significant differences among families and environments for stalk height, stalk diameter, recoverable sucrose% and cane yield. The family x environment interaction was significant for stalk height, stalk number, stalk diameter, sucrose content, cane and sugar yields per hectare whereas it was not significant for Brix reading either in plant or ratoon crops.

Selection of the best families based on their mean performance and further selection of individual clones based on their sugar yield in early stages would improve the efficiency of selection and increase heritability (Shanthi et al. 2008). Furthermore, family selection has been shown to be superior to individual selection in terms of gains from selection, resource efficiency and cost of operation. Family selection has also been shown to provide a superior method for estimating the breeding value of parent clones (Stringer et al. 2010).

Reports on the relative performance of sugarcane genotypes for ratoonability and other associated traits in early selection stages are limited. Competition due to high tiller density in the early growth phase of ratoon crop resulted in reduced weight of the cane (Chapman et al. 1992; Hunsigi 1982). Characters such as cane yield and its components, i.e., stalk length, stalk diameter, stalk number and stalk weight have been suggested as being indicative of better ratooning varieties (Milligan et al. 1996).

The objectives of this study were to evaluate the performance of 18 promising sugarcane genotypes and two local controls (GT54-9 and Ph8013) grown under different crop cycles (years) and locations for ratoonability and associated traits at early clonal selection stages.

Materials and methods

Plant material and experimental conditions

The study was carried out at two locations, i.e. Mallawi Agricultural Research Station, El-Minya Governorate, Egypt (lat 28° 10' N, long 30° 75' and alt 55m ASL) and Mattana Agricultural Research Station, Luxor Governorate, Egypt (lat 25° 17' N, long 32° 33' and alt 76 m ASL) during 2010, 2011 and 2012 harvesting seasons. Eighteen sugarcane genotypes (*Saccharum* spp.), representative of selections from early stages in the sugarcane breeding program in Egypt, constituted the study material and two commercial varieties, namely GT54-9 and Ph8013 were used as control. Each sugarcane genotype was planted in three rows of 5 m length and 90 cm width in randomized complete block design with three replications at each of the two locations during first week of March, 2009. Seed rate of 25 three - budded setts per row was adopted. The field was irrigated right after planting and all other agronomic practices were carried out as recommended. In order to study the crop cycle effects on ratoonability, plant crop was ratooned for two consecutive years. Harvest of plant crop took place 12 months after planting. The crop raised from the stubble of the first plant crop represented first ratoon crop and regrowth from first ratoon crop was considered the second ratoon crop.

Phenotypic evaluation

Data were recorded on cane yield and juice quality traits. A sample of 10 stalks was used to measure stalk length and diameter. A sample of 20 stalks was crushed and juice was analyzed to determine quality traits. Stalk length (cm) was measured from soil surface to the visible dewlap and stalk diameter (cm) was measured at mid-stalk with no reference to the bud groove. Stalk weight (kg) was calculated by dividing cane yield per plot by the number of stalks per plot and cane yield was converted to t/ha values. Brix (per cent soluble solids) was measured using hydrometer and sucrose percentage of clarified juice was determined using automated Sacharimeter according to AOAC (1980). Juice purity was calculated as:

Purity (%) = (Sucrose % / Brix) x 100

Sugar recovery % (SR) was calculated according to the formula described by Yadav and Sharma (1980) as:

SR = [Sucrose % - 0.4 (Brix - Sucrose %)] x 0.73

Sugar yield (t/ha) was estimated by multiplying net cane yield (t/ha) by sugar recovery %.

Statistical analysis

Analysis of variance (ANOVA) and *t*-tests were performed using SAS 9.1 TS level 1M3 (SAS 2008). Sample groups with signiûcantly different means were further analyzed using Fisher's least signiûcant difference (LSD) test at a 5% probability level. Two models were used for data analysis. The full model included crop effect and crop interaction effect. The reduced model did not include crop or crop interaction effect and was analyzed for each crop. The full model used was:

$$T_{ijklm} = \mu+Y_i+L_j+YL_{ij}+R_{k(ij)}+C_m+YC\text{-}_{im}+LC_{jm}+YLC_{ijm}+G_l+YG_{il}+LG_{jl}+CG_{ml}+YLG_{ijl}+YCG_{iml}+LCG_{jml}+YLCG_{ijml}+E_{ijkml}$$

where

T_{ijklm} is observation *k*, year *i*, in location *j*, in crop *m*, of genotype *l*;

μ	is overall mean;
Y_i	is year *i*;
L_j	is location *j*;
YL_{ij}	is year *i* in location *j*;
$R_{k(ij)}$	is replication *k* in year *i* and location *j*;
C_m	is crop *m*;
YC_{im}	is crop *m* in year *i*;
LC_{jm}	is crop *m* in location *j*;
YLC_{ijm}	is crop *m* in year *i* and location *j*;
G_i	is the genotype *l*;
YG_{il}	is the genotype *l* in year *i*;
LG_{jl}	is the genotype *l* in location *j*;
$CG\text{-}_{ml}$	is the genotype *l* in crop *m*;
YLG_{ijl}	is the genotype *l* in year *i* and location *j*;
YCG_{iml}	is the genotype *l* in year *i* and crop *m*;
LCG_{jml}	is the genotype *l* in location *j* and crop *m*;
$YLCG\text{-}_{ijml}$	is the genotype *l* in year *i*, location *j* and crop *m*;
E_{ijkml}	is the residual.

Analysis of variance and variance component estimates were performed for each crop (reduced model) and over crops (using the full model). Except for specific crop, all factors (genotype, replicate and interaction) were considered random. Variance components were calculated by equating appropriate mean squares to their expectations and solving for the components.

Cane ratoonability (RA) was estimated as:

CRA = (SR/PC) x 100

where CRA of the genotype was expressed as the percent yield (or the mean of other traits) of second ratoon crop (SR) to the yield (or the mean of other traits) of plant crop (PC) for each clone (Milligan et al. 1996).

Results and discussion

Crop cycle effects on cane yield traits

The genotypes exhibited significant differences for stalk diameter and stalk length in plant cane (PC), first ratoon (FR), second ratoon (SR) and across crop cycles (CC) (Table 1). The genotype by crop cycle interaction revealed significant effects on all traits studied, indicating that genotype performed differently among the crop cycles. Milligan et al. (1990) and Orgeron et al. (2007) reported that genotype by crop interaction was important in determining sugarcane yield and its component traits.

Among the 20 genotypes, the control variety Ph8013 registered the highest stalk diameter of 3.12 cm and 2.93 cm in plant and first ratoon crop, respectively. The test genotype G2004-140 was the most inferior clone with 1.88 and 1.87 cm stalk diameter in the

Table 1. Mean performance of 20 sugarcane genotypes for stalk diameter and stalk length in plant cane (PC), first ratoon (FR), second ratoon (SR) and across crop cycles (CC)

Genotype	Stalk diameter (cm)				Stalk length (cm)			
	PC	FR	SR	CC	PC	FR	SR	CC
GT54-9	2.74	2.52	2.23	2.50	281.68	277.50	273.33	277.50
Ph8013	3.12	2.93	2.88	2.98	250.39	276.67	179.17	35.41
G99-103	3.01	2.47	3.17	2.88	271.51	260.00	227.50	253.00
G2004-102	2.29	2.03	2.37	2.23	221.74	220.00	199.17	213.63
G2004-103	2.50	2.23	2.65	2.46	239.05	238.33	270.83	249.41
G2004-104	2.08	1.93	1.82	1.94	222.06	235.83	276.67	244.85
G2004-106	2.18	2.12	1.93	2.08	216.58	221.67	231.67	223.30
G2004-116	2.50	2.27	2.52	2.43	213.50	215.00	256.67	228.39
G2004-117	2.37	2.20	1.95	2.17	209.01	233.33	256.67	233.00
G2004-119	2.37	2.25	2.30	2.31	209.77	217.50	280.83	236.03
G2004-121	2.61	2.52	2.22	2.45	265.19	275.83	275.83	272.28
G2004-122	2.13	2.05	1.98	2.05	247.09	260.00	232.50	246.53
G2004-124	2.32	2.12	2.08	2.17	209.40	228.33	295.00	244.24
G2004-131	2.31	2.28	1.78	2.12	208.95	227.50	265.00	233.82
G2004-132	2.16	2.12	1.72	2.00	202.66	234.17	253.33	230.05
G2004-133	1.97	2.28	1.70	1.99	271.06	270.00	225.00	255.35
G2004-136	2.04	2.13	1.88	2.02	177.94	174.17	220.00	190.70
G2004-140	1.88	1.87	1.70	1.81	194.50	181.67	224.17	200.11
G2004-144	2.44	2.05	3.02	2.50	258.58	250.83	267.50	258.97
G2004-147	2.35	2.13	1.97	2.15	179.17	200.00	237.50	205.56
Mean	2.37	2.23	2.19	2.26	227.49	234.92	247.42	236.61
LSD at 5%								
Genotype (G)	0.053	0.053	0.13		4.63	2.93	2.36	
Crop (C)		0.11				4.79		
G x C		0.19				8.3		

plant and ratoon crop, respectively. In the second ratoon crop, stalk diameter varied from 1.70 cm (G2004-133, G2004-140) to 3.17 (G99-103) (Table 1). Across crop cycles, average stalk diameter varied from 1.81 cm for G2004-140 to 2.98 cm for Ph8013. Stalk diameter of 10 genotypes (G2004-104, G2004-106, G2004-117, G2004-121, G2004-122, G2004-124, G2004-131, G2004-132, G2004-140 and G2004-147) and two control varieties GT54-9 and Ph8013 decreased in older crop cycles whereas in the remaining eight genotypes (G 99-103, G2004-102, G2004-103, G2004-116, G2004-119, G2004-133, G2004-136 and G2004-144) it fluctuated among crop cycles which is in accordance with the results of Milligan et al. (1990).

Stalk length varied from 281.68 and 277.50 cm for the control variety GT54-9 to 177.94 and 174.17cm for the genotype G2004-136 in plant and ratoon crops respectively. In the second ratoon crop, stalk length ranged from 295 cm (G2004-124) to 199.17 cm (G2004-102) (Table 1). Across crop cycles, while the control variety GT54-9 was superior in stalk length (277.50 cm), G2004-136 produced the shortest stalks (190.70 cm). In general, stalk length increased with older crop cycles in most of the test genotypes as compared to the plant crop (G2004-104, G2004-106, G2004-116, G2004-117, G2004-119, G2004-121, G2004-124, G2004-131, G2004-132 and G2004-147) whereas it decreased in three genotypes (G99-103, G2004-102 and G2004-133) and control variety (GT54-9). Five genotypes (G2004-103, G2004-122, G2004-136, G2004-140 and G2004-144) and one control variety Ph8013 exhibited a fluctuating trend for stalk length trait across crop cycles.

Among the 18 test genotypes, G99-103 recorded the highest mean stalk weight of 0.83 kg across crop cycles with 0.90, 0.75 and 0.83 kg in plant cane, first ratoon and second ratoon crop, respectively (Table 2). The genotype G2004-140 registered the lowest mean single cane weight of 0.22 kg with 0.19, 0.25 and 0.23 kg in the plant crop, first ratoon and second ratoon crop, respectively. The superiority of G99-103 for stalk weight could be attributed to high mean values for both stalk diameter and stalk length across crop cycles. The genotype G2004-140 which produced the lowest stalk weight (0.22 kg) was found to be inferior for both stalk diameter (1.81 cm) and stalk length (224.17 cm) across crop cycles. Fifteen genotypes exhibited a decreasing trend for stalk weight from plant cane to first ratoon, which was in agreement with previous results (Chapman et al. 1992; Hunsigi 1982) where a reduction in stalk weight in the ratoon crop was observed.

Cane yield of two genotypes, i.e., G99-103 and G2004-121 was significantly higher than that of the two controls (GT54-9 and Ph8013) across crop cycles. Cane yield increased significantly in the first ratoon by 8.5% and in the second ratoon by 3.8% compared to the plant cane (Table 2). Cane yield in plant cane, first ratoon and across crop cycles varied from 202.38 , 219.00 and 200.14 t/ha, respectively for G2004-121 to 62.62 , 85.12 and 77.21 t/ha, respectively for G2004-136; in the second ratoon it ranged from 182.88 t/ha for genotype G99-103 to 68.62 t/ha for genotype G2004-140. In contrary to the moderate values observed for both stalk diameter and length in G2004-106 across crop cycles, it was found to be the poorest in cane yield among the test genotypes under evaluation. The genotype G2004-121 was the top cane yielder due to its taller and thicker stalks. Cane yield of four genotypes (G99-103, G2004-124, G2004-132, G2004-144 and the control (GT54-9) registered an increasing trend with older crop cycles, while 15 test genotypes fluctuated for cane yield with older crop cycles. GT54-9 was the best among the control varieties for cane yield ratoonability (117.61). Three genotypes, viz. G99-103, G2004-136 and G2004-147 were found to be

Table 2. Mean performance of 20 sugarcane genotypes for stalk weight and cane yield in plant cane (PC), first ratoon (FR), second ratoon (SR), across crop cycles (CC) and cane ratoonability (CRA)

Genotype	Stalk weight (kg)				Cane yield (t/ha)				
	PC	FR	SR	CC	PC	FR	SR	CC	CRA
GT54-9	0.700	0.600	0.660	0.653	120.74	123.17	142.00	128.64	117.61
Ph8013	0.762	0.673	0.727	0.721	144.43	145.67	130.98	151.69	90.69
G99-103	0.898	0.753	0.832	0.828	155.31	158.74	182.88	165.64	117.75
G2004-102	0.433	0.397	0.422	0.417	122.67	124.67	121.60	122.98	99.13
G2004-103	0.497	0.462	0.485	0.481	138.50	140.50	122.26	133.76	88.28
G2004-104	0.322	0.317	0.328	0.322	91.52	100.76	92.67	94.98	101.25
G2004-106	0.352	0.312	0.340	0.334	73.00	75.00	74.29	74.10	101.76
G2004-116	0.335	0.337	0.345	0.339	75.05	82.62	73.67	77.10	98.16
G2004-117	0.343	0.33	0.348	0.341	93.76	96.93	96.64	95.76	103.07
G2004-119	0.425	0.405	0.422	0.417	136.64	139.31	127.31	134.40	93.17
G2004-121	0.800	0.728	0.748	0.759	202.38	219.00	179.05	200.14	88.47
G2004-122	0.415	0.407	0.42	0.414	95.10	97.76	96.02	96.29	100.98
G2004-124	0.445	0.367	0.415	0.409	84.36	84.86	96.26	88.50	114.11
G2004-131	0.312	0.302	0.317	0.310	85.26	87.93	89.64	87.60	105.14
G2004-132	0.398	0.353	0.385	0.379	91.57	92.40	104.45	96.14	114.07
G2004-133	0.320	0.392	0.367	0.359	94.12	124.86	106.24	108.40	112.88
G2004-136	0.357	0.443	0.407	0.402	62.62	85.12	83.90	77.21	133.99
G2004-140	0.192	0.248	0.228	0.223	66.40	90.57	68.62	75.19	103.33
G2004-144	0.428	0.397	0.422	0.416	92.64	96.31	97.83	95.60	105.60
G2004-147	0.272	0.338	0.310	0.307	70.67	108.76	89.33	89.60	126.42
Mean	0.45	0.428	0.446	0.442	104.83	113.74	108.79	109.69	103.77
LSD at 5%									
Genotype (G)	0.06	0.02	0.03		1.26	0.59	4.11		
Crop (C)	0.05				3.51				
G x C	0.09				6.07				

superior to the best control GT54-9 for cane yield ratoonability.

Crop cycle effects on juice quality traits

Significant differences were observed among the 20 genotypes for total soluble solids (Brix), sucrose percentage, juice purity, sugar recovery and sugar yield. Brix ranged from 19.40% (G2004-121) to 22.88% (G2004-140) in the plant crop, from 20.41% (G2004-121) to 23.41% (G2004-147) in the first ratoon crop and from 19.43% (G99-103) to 24.02% (2004-147) in the second ratoon crop (Table 3). Across crop cycles, Brix varied from 20.37% (G99-103) to 23.31% (G2004-147). Juice Brix increased in older crop cycles in eight genotypes and one control variety (GT54-9) whereas it fluctuated among crop cycles in 11 genotypes.

Sucrose varied from 14.74% (G2004-121) to 18.14% (Ph8013) in plant crop and from 15.82% (G2004-147) to 17.95% (G2004-124) in first ratoon (Table 3). However, the control variety Ph8013 was the best for juice sucrose (%) in the second ratoon crop that registered a maximum of 19.71%. Across crop cycles, none of the test genotypes performed better than the control variety Ph8013 (18.16%) for juice sucrose.

Juice purity ranged from 72.01% (G2004-136) to 86.22% (G2004-132) in the plant crop whereas it ranged from 68.25% (G2004-147) to 84.22% (G2004-132) in first ratoon (Table 4). The control variety Ph8013 was found to be the best in the second ratoon crop with the highest juice purity of 87.39%. Across crop cycles, mean juice purity ranged from 84.62% (G2004-124) to 71.03% (G2004-147).

Table 3. Mean performance of 20 sugarcane genotypes for Brix percentage and sucrose percentage in plant cane (PC), first ratoon (FR), second ratoon (SR) and across crop cycles (CC)

Genotype	Brix				Sucrose (%)			
	PC	FR	SR	CC	PC	FR	SR	CC
GT54-9	21.44	21.48	22.46	21.79	17.73	17.54	17.69	17.65
Ph8013	22.21	21.45	22.56	22.07	18.14	16.63	19.71	18.16
G99-103	20.65	21.02	19.43	20.37	15.84	16.34	16.70	16.29
G2004-102	21.34	21.99	21.77	21.70	17.31	17.70	18.94	17.98
G2004-103	21.17	22.32	21.56	21.68	15.83	16.11	17.45	16.46
G2004-104	21.66	22.59	22.16	22.14	15.85	15.89	17.20	16.31
G2004-106	21.82	22.50	22.64	22.32	16.54	16.57	18.13	17.08
G2004-116	20.75	22.26	22.85	21.95	15.38	15.98	18.16	16.50
G2004-117	19.82	22.56	20.50	20.96	14.31	17.59	16.73	16.21
G2004-119	21.11	21.91	21.73	21.59	15.32	15.02	15.76	15.37
G2004-121	19.40	20.41	21.68	20.49	14.74	16.13	16.70	15.85
G2004-122	22.14	22.37	23.70	22.74	16.81	15.86	17.99	16.89
G2004-124	20.61	21.56	21.54	21.24	17.47	17.95	18.33	17.91
G2004-131	21.88	22.07	19.63	21.19	16.66	17.70	16.91	17.09
G2004-132	21.04	21.47	20.42	20.97	17.98	17.86	16.43	17.42
G2004-133	21.05	22.59	21.40	21.68	17.06	16.73	17.40	17.06
G2004-136	22.16	22.39	23.76	22.77	15.88	16.02	18.07	16.66
G2004-140	22.88	23.07	23.72	23.22	17.51	17.26	18.28	17.68
G2004-144	20.35	21.64	21.70	21.23	16.98	15.93	18.71	17.20
G2004-147	22.50	23.41	24.02	23.31	16.14	15.82	17.42	16.46
Mean	21.30	22.05	21.96	21.77	16.47	16.63	17.63	16.91
LSD at 5%								
Genotype (G)	0.34	0.25	0.35		0.4	0.22	0.31	
Crop (C)	0.46				0.44			
G x C	0.79				0.76			

Sugar recovery ranged from 8.84% (G2004-117) to 12.24% (G2004-132) in plant crop (Table 4). In the first ratoon crop, while G2004-124 was the best clone that recorded the highest sugar recovery (12.05%), G2004-119 was the poorest with a low sugar recovery of 8.95%. In the second ratoon, sugar recovery varied from 9.76% (G2004-119) to 13.56% (Ph8013). Across crop cycles, the control variety Ph8013 registered the highest mean sugar recovery of 12.12%. Out of the 20 clones tested, the test genotype G2004-119 was found to be the poorest over crop cycles with a low sugar recovery of 9.40%.

In general, the crop cycles had no effect on the juice quality traits of the 18 test genotypes evaluated

Table 4. Mean performance of 20 sugarcane promising genotypes for purity percentage and recovery percentage in plant cane (PC), first ratoon (FR), second ratoon (SR) and across crop cycles (CC)

Genotype	Purity (%)				Sugar recovery (%)			
	PC	FR	SR	CC	PC	FR	SR	CC
GT54-9	82.70	81.77	78.92	81.13	11.86	11.66	11.52	11.68
Ph8013	81.68	78.00	87.39	82.36	12.06	10.74	13.56	12.12
G99-103	76.71	77.82	85.90	80.14	10.16	10.56	11.39	10.71
G2004-102	81.22	80.89	87.00	83.03	11.46	11.67	12.99	12.04
G2004-103	74.81	72.44	80.89	76.05	10.00	9.95	11.54	10.50
G2004-104	73.28	70.36	77.67	73.77	9.88	9.64	11.10	10.21
G2004-106	75.99	73.75	80.15	76.63	10.53	10.36	11.92	10.94
G2004-116	74.31	71.83	79.48	75.21	9.66	9.83	11.88	10.46
G2004-117	72.06	77.94	81.70	77.23	8.84	11.39	11.11	10.45
G2004-119	72.39	68.71	72.51	71.20	9.50	8.95	9.76	9.40
G2004-121	75.94	78.97	77.28	77.40	9.40	10.52	10.74	10.22
G2004-122	76.28	71.37	75.97	74.54	10.72	9.68	11.47	10.62
G2004-124	84.91	83.50	85.44	84.62	11.83	12.05	12.44	12.11
G2004-131	76.04	80.26	86.18	80.83	10.63	11.64	11.55	11.28
G2004-132	86.22	84.22	81.19	83.88	12.24	11.99	10.83	11.68
G2004-133	81.33	74.29	81.39	79.00	11.28	10.50	11.53	11.11
G2004-136	72.01	71.94	76.21	73.38	9.76	9.83	11.53	10.37
G2004-140	76.77	75.04	77.16	76.32	11.21	10.90	11.76	11.29
G2004-144	83.42	73.77	86.18	81.12	11.41	9.96	12.79	11.38
G2004-147	72.16	68.25	72.70	71.03	9.93	9.33	10.79	10.01
Mean	77.28	75.75	80.56	77.87	10.62	10.56	11.61	10.93
LSD at 5%								
Genotype (G)	2.3	1.49	1.48		0.4	0.25	0.29	
Crop (C)	2.39				0.43			
G x C	4.15				0.75			

for ratoonability in the present study. Chapman (1988) reported that older crop cycles tend to mature earlier than younger crops but final sucrose concentration and its component traits, viz. Brix, juice purity and sugar recovery are generally not influenced by crop age. However, EL-Hinnawy and Masri (2009) reported that crop cycles significantly affected juice quality traits.

Significant differences were observed among the test genotypes for sugar yield in plant, first ratoon and second ratoon crops. Sugar yield in plant cane varied from 6.31 t/ha for G2004-136 to 18.43 t/ha for G2004-121 whereas it ranged from 7.90 t/ha for G2004-106 to 21.57 t/ha for G2004-121 in first ratoon (Table 5). In the second ratoon, sugar yield ranged from 8.12 t/ha for G2004-140 to 20.74 for G99-

Table 5. Mean performance of 20 sugarcane promising genotypes for sugar yield in plant cane (PC), first ratoon (FR), second ratoon (SR) and over crop cycles (CC) and sugar ratoonability (SRA)

Genotype	Sugar yield (t/ha)				
	PC	FR	SR	CC	SRA
GT54-9	14.45	14.43	16.24	15.05	112.36
Ph8013	17.29	15.67	15.45	16.14	89.40
G99-103	15.64	16.55	20.74	17.64	132.64
G2004-102	13.98	14.50	15.79	14.76	112.91
G2004-103	13.24	13.52	13.95	13.57	105.47
G2004-104	9.07	9.71	10.24	9.67	113.09
G2004-106	8.02	7.90	9.00	8.31	112.23
G2004-116	7.26	8.17	8.71	8.05	120.22
G2004-117	8.10	11.29	10.74	10.02	132.50
G2004-119	12.29	12.19	12.31	12.26	100.19
G2004-121	18.43	21.57	19.17	19.71	104.01
G2004-122	10.76	9.88	11.17	10.60	103.88
G2004-124	9.93	10.29	11.79	10.67	118.58
G2004-131	9.05	10.24	10.29	9.86	113.68
G2004-132	11.21	11.10	11.31	11.21	101.00
G2004-133	10.50	13.14	12.33	12.00	117.29
G2004-136	6.31	8.79	10.07	8.38	159.50
G2004-140	7.71	10.19	8.12	8.67	105.22
G2004-144	10.57	9.57	12.55	10.88	118.66
G2004-147	8.12	10.19	9.93	9.40	122.30
Mean	11.10	11.93	12.83	11.95	116.74
LSD at 5%					
Genotype (G)	0.22	0.15	0.48		
Crop (C)	0.44				
G x C	0.76				

103. Among the two control varieties, Ph8013 recorded higher mean sugar yield (16.14 t/ha) over crop cycles than the other control GT54-9 (15.05 t/ha). The two test genotypes G99-103 and G2004-121 recorded significantly higher sugar yield than the best control GT54-9 in plant, first ratoon and second ratoon crops.

GT54-9 was the best local control for sugar yield ratoonability (112.36). Eleven test genotypes performed better than GT 54-9 for sugar yield ratoonability. Of these, four clones (G99-103, G2004-117, G2004-136 and G2004-147) were found to be significantly better than the control GT54-9 for sugar yield ratoonability across crop cycles (Table 5). Considering the overall performance of the 18 genotypes for cane yield, sugar yield and other associated traits, three test genotypes, viz. G99-103, G2004-136 and G2004-147 were found to be promising for ratoonability over crop cycles.

References

AOAC (1980) Official Methods of Analysis. Association of Official Analytical Chemists. Washington, D.C., USA. 642.

Bashir S, Hassan M, Fiaz N, Khan Z, Ali Z (2013) Ratooning potential of different promising sugarcane genotypes at varying harvesting dates. J Agric Biol Sci 8: 437-440.

Bissessur D, Tileny-Bassett RAE, Chong LCYLS, Domaingue R, Julien MER, Shin C (2000) Family × environment and genotype x environment interactions for sugarcane across two contrasting marginal environments in Mauritius. Exp Agric 36: 101-114.

Chapman LS (1988) Constraints to production in ratoon crops. Proc Australian Soc Sugar Cane Technol Meeting: 189-192.

Chapman LS, Ferraris R, Ludlow MM (1992) Ratooning ability of cane varieties: yield and yield components. Proc Australian Soc Sugar Cane Technol Meeting: 130-138.

EL-Hinnawy HH, Masri, MI (2009) Crop cycle effects on genetic variability, heritability and yield of sugarcane. J Agric Sci Mansoura Univ 34: 6755-6767.

Ferraris R, Chapman LS, Ludlow MM (1993) Ratooning ability of cane varieties: interception of light and efficiency of light use. Proc Australian Soc Sugar Cane Technol Meeting: 316-322.

Gomathi R, Rao PNG, Rakkiyappan P, Sundara BP, Shiyamala P (2013) Physiological studies on ratoonability of sugarcane varieties under tropical Indian condition. Am J Plant Sci 4: 274-281.

Hunsigi G (1982) Ratooning of sugarcane in India. Prabhat Printers, Mysuru 97p.

Johnson JL, Heagler AM, Zapata HO, Ricaud R (1993) The impact of succession planting and a third ratoon crop on economic efficiency in sugarcane production in Louisiana. Am Soc Sugar Cane Technol 13: 28-32.

Matsuoka S, Stolf R (2012) Sugarcane tillering and ratooning: key factors for a profitable cropping. In: Sugarcane: Production, Cultivation and Uses, (JF Goncalves, KD Correia, eds), pp.137-157. Nova Publishers, New York, USA.

Milligan SB, Gravois KA, Bischoff KP, Martin FA (1990) Crop effects on broad-sense heritabilities and genetic variances of sugar cane yield components. Crop Sci 30:344-349.

Milligan SB, Gravois KA, Martin FA (1996) Inheritance of sugarcane ratooning ability and relationship of younger crop traits to older crop traits. Crop Sci 36: 45-50.

Mirzawan PDN, Sugiyarta E (1999) Ratooning ability in sugarcane: Direct *vs* indirect selection based on clonal performance in younger crops. Proc Int Soc Sugar Cane Technol 23: 467-475.

Orgeron AJ, Gravois KA, Bischoff KP (2007) Planting rate effects on sugarcane yield traits. J Am Soc Technol 27: 23-34.

Ricaud R, Arceneaux A (1986) Some factors affecting ratoon cane yield and longevity in Louisiana. Proc Int Sugar Cane Technol 19: 18-24.

SAS (2008) SAS/STAT® 9.2 user's guide. SAS Institute Inc., Cary, NC, USA.

Shanthi RM, Bhagyalakshmi KV, Hemaprabha G, Alarmelu S, Nagarajan R (2008) Relative performance of the sugarcane families in early selection stages. Sugar Tech 10: 114-118.

Singh RK, Dey P (2002) Genetic variability in plant and ratoon of sugarcane genotypes grown under saline conditions. Indian Sugar LI (10): 725-727.

Stringer JK, Cox MC, Atkin FC, Wei X, Hogarth DM (2010) Family selection improves the efficiency and effectiveness of selecting original seedlings and parents. Proc Int Soc Sugar Cane Technol 27: 1-9.

Sundara B (1989) Improving sugarcane productivity under moisture constraints and through cropping systems. In: Proc Int Symp Sugarcane Varietal Improvement - Present and Future Strategies, (KM Naidu, TV Sreenivasan, MN Premachandran, eds), pp. 221-256. Sugarcane Breeding Institute, Coimbatore, India.

Sundara B (2008) Sugarcane ratoons, their importance and establishment. In: Ratoon Management in Sugarcane, (TR Shanthy, DP Prathap, eds), pp. 6-11. Sugarcane Breeding Institute, Coimbatore, India.

Yadav RL (1991) Sugarcane Production Technology: Constraints and Potentialities. Oxford and IBH Publishing Co. (Pvt.) Ltd., Bombay

Yadav RL, Sharma RK (1980) Effect of nitrogen levels and harvesting dates on quality traits and yield of four sugar cane genotypes. Indian J agric Sci 50: 581–589.