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CROP CYCLE EFFECTS ON GENETIC VARIABILITY, HERITABILITY, AND YIELD OF SUGARCANE

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ABSTRACT

Ten promising sugarcane *(Saccharum spp.)* genotypes; G84/47, G150/99, G103/99, G26/99, G87/98, G24/98, G217/99, G208/99, G193/99 and G28/99 as well as two check cultivars; PH 8013 and GT 54/9 were laid in a randomized complete block design with three replicates to be evaluated at Kom-Ombo Agricultural Research Station, Aswan Governorate for three different crop cycles; plant cane (PC), first ratoon (FR) and second ratoon (SR) crops during 2005/2008 seasons. The objectives of this study were to investigate the effect of crop cycle on sugar yield and its components, as well as its effect on broad-sense genetic and genotype by crop interaction variance components of stalk length, stalk diameter, stalk weight, stalks number and cane yield, as well as juice quality traits; Brix, sucrose%, purity%, sugar recovery% and sugar yield.

Results indicated that stalk length of studied genotypes fluctuated among crop cycles. Stalk diameter and stalks weight decreased for all evaluated genotypes in older crops. Stalk number over the evaluated genotypes significantly increased in FR by 22.6 % and in SR by 21.6 % compared to plant cane with insignificant difference between FR and SR crops. Cane yield of the evaluated genotypes fluctuated between PC and FR crops. However, for most evaluated genotypes it decreased in SR crop. Over studied genotypes it varied from 57.02 tons in FR crop to 43.23 tons in SR crop. Brix, sucrose content, Juice purity, and sugar recovery are generally not affected by crop age. Sugar yield followed the same trends as in cane yield and varied significantly among genotypes within each crop cycle and among crop cycles from 7.49 tons in FR crop to 5.60 tons in SR crop.

Genotypic variance, heritability, and genotypic coefficient of variation (GCV) decreased from plant cane crop to second ratoon crop for stalk weight, stalk number, cane yield, juice purity, and sugar yield, while increased slightly for stalk diameter, sucrose content, and sugar recovery. The values of GCV and heritability of stalk number and cane yield indicated that the population offered considerable potential for improvement by selection, especially in plant cane. Analysis across crops showed that heritability, and GCV estimates for stalk length, stalk diameter, stalk weight, stalk number, cane yield, and sugar yield were smaller than of individual crops for the same traits, this is because the interaction variance (δ^2gc) was the predominant determining of phenotypic variance for these traits. Little change was observed in GCV for juice quality traits. The GCV values estimated in this study suggest selection to improve a particular crop's yield component value is most effective when performed within that crop and commonly shows the most potential for improvement in the younger crops.

Keywords: *Saccharum spp*, crop cycle, broad-sense genetic variance, genotype by crop interaction variance (δ^2gc).

INTRODUCTION

Sugarcane is a clonally propagated crop and in Egypt it is typically harvested for plant cane and a number of ratoon crops. Unfortunately, yields of younger crops fail to adequately predict subsequent ratoon yields (Ramdoyal *et al.,* 1986). First ratoon yields commonly equal plant cane yields but yield decline is often severe in second ratoon crops. Hence, selection for high second ratoon yielding ability requires testing through this crop. Because second ratoon yield potential is an essential cultivar characteristic, a study investigating crop effects should include the second ratoon crop to be meaningful.

Breeding program decisions commonly rely on knowledge of the underlying genetic structure of the breeding population and an understanding of the relative importance of GE interactions. Such knowledge includes accurate estimates of the genetic variances and covariances of pertinent traits. Using these estimates in a breeding program may increase efficiency through optimization of available resources, development of selection plans and indices, and predictions of the most fruitful parental combinations (Skinner, 1971; Henderson, 1984; Milligan et al., 1990 a; Chaudhary, 2001and Masri, 2004).

The clonally nature of sugarcane suggests broad- sense genetic estimates of variance and covariance are the relevant genetic estimates for predictive use between clonal stages. Genetic variance estimates are usually applicable only to the specific population and range of tested environments (Falconer, 1989). Estimating genetic variances under a limited range of environmental conditions may lead to biased genetic variance estimates (Dudley and Moll, 1969). Kang *et al.* (1984) reported that sugarcane genetic variance estimates obtained from a single year and/or location, would cause the GE variance estimates be possibly biased or not estimable.

Milligan *et al.* (1990 a) and Masri (2004) found that at early selection stage of sugarcane, that stalk diameter, and stalk weight decreased with older crops , while stalk number , cane yield, juice quality traits and sugar yield increased with older crops . However, Orgeron *et al.* (2007) reported that at final selection stages, cane yield and sugar yield decreased from plant cane to third ratoon crop, while stalk number increased from plant cane to first ratoon crop, but decreased from first ratoon to third ratoon crop.
Bhatnagar *et al*. (2003) reported that sugarcane clones vary in their ability to survive and produce a profitable ratoon crop. Since the ratooning behavior of sugarcane variety is the function of genotype and environment interaction, a good ratooning genotype may not necessarily be a good ratooner if grown in another situation. It is, therefore, necessary to identify availability of genotypes with good ratooning ability for specific conditions.

Reported genetic studies with sugarcane have used a wide range of populations and environments (Hogarth *et al*., 1981; kang *et al.,* 1983 and kang et al., 1984). They reported large estimates of heritability for sugarcane yield and its components. They also reported the least potential for selection gain existed for Brix and purity, followed by stalk length and stalk diameter, however, they found stalk weight and sucrose concentration to offer the largest potential for gain. While Milligan *et al*. (1990 a) found stalk number and cane yield to offer the most potential.

The objectives of this study were (i) to evaluate the performance of some sugarcane genotypes under three different crop cycles; plant cane (PC), first ratoon (FR), and second ratoon crops (SR) and (ii) to estimate broad–sense genetic and GC (genotype by crop interaction) variance components.

MATERIALS AND METHODS

Ten promising sugarcane genotypes; G84/47, G150/99, G103/99, G26/99, G87/98, G24/98, G217/99, G208/99, G193/99, and G28/99 as well as two check cultivars (PH 8013 and G T 54/9) were grown in 7m x 5 ridges plot. Distance between ridges was 1.0 m, thus plot size was 35 m^2 (1/120 fed.). A randomized compete block design with three replications was used. Planting was done during first week of March 2005 season at Kom-Ombo Agricultural Research Station, Aswan Governorate. Planting was achieved by placing fifteen 3-budded cane pieces in each ridge. Field was irrigated right after planting and all other agronomic practices were carried out as recommended. Plant cane was allowed to ratoon (first and second ratoons). Harvest took place after 12 months from planting or harvest plant cane or harvest first ratoon.

At harvest, the following traits were measured:

A- cane yield and its contributing traits:

Sample of twenty stalks from each plot was removed to measure stalk length, and stalk diameter.

1- Stalk length (cm) was measured from soil surface to the visible dewlap.

2-Stalk diameter (cm) was measured at midstalk with no reference to the bud groove.

3-Number of millable stalks/fed was calculated on plot basis

4-Stalk weight (kg) was calculated by dividing cane yield per plot by number of stalks per plot

5-Cane yield (ton/fed) was calculated by multiplying plot yield x 120.

B-Juice quality traits and sugar yield:

Juice of the twenty stalk sample taken from each plot was crushed and juice was analyzed to determine the following traits:

1- Brix (percent soluble solids) was determined with a hydrometer.

2-Sucrose percentage of clarified juice was determined by using automated sacharimeter according to A.O.A.C. (1980).

3-Purity was calculated as: [(Sucrose / Brix) x 100].

4-Sugar recovery% (rendment) was calculated according to the formula described by Yadav and Sharma (1980): **SR**= [Sucrose % - 0.4 (Brix – Sucrose %)] x 0.73

5-Sugar yield (ton/fed) was estimated by multiplying net cane yield (ton / fed) by sugar recovery %.

Collected data were subjected to normal statistical analysis as shown by Snedecor and Cochran (1989). Comparisons between treatment means were made using least significant difference at 5% level of probability.

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:

$T_{ijk} = M + G_i + C_j + GC_{ij} + R_{k(ij)} + E_{ijk}$

where

T_{ijk} is the observation k, in crop j, of genotype i;

M is the over all mean;

G_i is the genotype effect;

C_j is the crop effect;

GC_{ij} is the genotype i in crop j;

$R_{k(ij)}$ is the replication effect;

E_{ijk} is the residual.

Analysis of variance and variance component estimates were performed for each crop (reduced model) and across 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.

Heritability within crop was estimated as:

$H = \delta^2 g / (\delta^2 g + \delta^2 e/r)$

where, $\delta^2 g$ and $\delta^2 e$ refers to genotypic and error variance, respectively. The divisor r refers to number of replications.

Heritability estimate using variance components from the full model analysis were calculated as: **H** $= \delta^2 g / (\delta^2 g + \delta^2 gc/c + \delta^2 e/rc)$

where, $\delta^2 gc$ refers to genotype by crop interaction variance. The divisor c refers to number of crops.

Genetic coefficient of variation (GCV) provide a unitless measure of a trait's genetic variance relative to its mean. The GCV facilitate comparisons among traits with different units and scales, and give perspective to the variability to be potentially exploited for genetic gain. Genetic coefficient of variation as: **GCV %** = (δg / general mean) x 100

RESULTS AND DISCUSSION

All studied traits; stalk length, stalk diameter, stalk weight, stalks number, cane yield, Brix, sucrose%, purity%, sugar recovery and sugar yield were significantly ($P = 0.05$) different among genotypes in plant cane (PC), first ratoon (FR), and second ratoon (SR) crops (Tables 1, 2, 3, and 4). Cane yield and its components as well as sugar yield were significantly affected by crop age. The genotype by crop cycle interaction was significant for all studied traits, indicating that genotype performance differ among the crop cycles. Milligan *et al*. (1990a), and Orgeron et al. (2007) reported that genotype by crop interaction was important for sugarcane yield and its component traits.

Data presented in Table 1, revealed that stalk length of five genotypes; pH 8013, G84/47, G 103/99, G 87/98, and G 28/98 decreased in older crops, while stalk length of other genotypes fluctuated among crops. On the other hand stalk length of the studied genotypes significantly increased in the first ratoon crop by 7.7 %, while it decreased in the second ratoon crop by 12.8 % and 19 % compared to plant cane and first ratoon, respectively. Stalk diameter for most tested genotypes decreased with older crops, while stalk weight decreased for all genotypes with advancing crops. Stalk weight of two genotypes; pH 8013, and G 217/99 was significantly greater than stalk weight of the commercial (check) cultivar GT 54/9 in plant cane and first ratoon crops, but the difference was insignificant in the second ratoon crop. Stalk length, diameter, and weight over evaluated genotypes varied significantly between plant cane, first ratoon, and second ratoon crops. It is worthy to mention that means of stalk diameter and stalk weight in plant cane were significantly higher than those in first and second ratoon crops. Similar results were reported by Milligan et al. (1990a).

Table 1: Mean performance of twelve sugarcane genotypes for Stalk length, stalk diameter,and stalk weight in plant cane (PC), first ratoon(FR), and second ratoon (SR) crops.

characters	Stalk length (cm)			Stalk diameter (cm)			Stalk weight (kg)		
Genotype	**PC**	**FR**	**SR**	**PC**	**FR**	**SR**	**PC**	**FR**	**SR**
GT 54/9	291.67	313.00	276.33	2.680	2.607	2.400	1.160	1.133	0.953
PH8013	314.67	309.33	244.33	3.000	2.380	2.493	1.543	1.300	0.910
G84/47	304.00	311.00	291.67	2.750	2.233	2.113	1.347	1.093	0.777
G 150/99	241.33	267.33	217.00	3.000	2.820	2.380	1.107	1.187	0.860
G 103/99	316.00	264.33	191.67	2.870	2.490	2.520	1.313	0.840	0.753
G 26/99	160.67	296.67	246.67	2.740	2.513	2.233	0.917	0.880	0.767
G 87/98	298.67	293.67	226.00	2.560	2.293	2.033	1.487	0.980	0.700
G 24/98	276.00	304.33	239.33	2.830	2.367	2.213	1.460	1.083	0.877
G 217/99	256.00	262.67	214.33	2.610	2.433	2.467	1.357	1.413	0.850
G 208/99	195.00	283.67	213.33	2.780	2.567	2.120	1.677	1.157	0.913
G 193/99	242.33	251.00	192.33	2.960	2.347	2.337	1.053	1.000	0.800
G 28/98	289.00	276.00	224.00	2.610	2.367	2.433	1.220	1.147	0.860
Mean	**265.45**	**286.08**	**231.42**	**2.783**	**2.451**	**2.312**	**1.303**	**1.101**	**0.835**
LSD at 5%									
Genotype(G)	**20.16**	**17.92**	**14.61**	**0.293**	**0.240**	**0.262**	**0.142**	**0.120**	**0.107**
Crop (C)	**7.17**			**0.077**			**0.048**		
G x C	**17.05**			**0.258**			**0.115**		

Stalks number of seven genotypes; pH 8013, G 84/47, G 150/99, G 24/98, G 208/99 and G 193/99 increased significantly with older crops (Table 2). While stalk number of five genotypes; GT 54/9, G 26/99, G 87/98, G 217/199, and G 28/98 increased in the first ratoon crop and decreased in the second ratoon crop. Stalk number of G 84/47, and G 87/98 was significantly greater than stalk number of the check cultivar GT 54/9 across all crop cycles. Stalk number over the evaluated genotypes significantly increased in first ratoon by 22.6 % and in second ratoon by 21.6 % compared to plant cane with insignificant difference between the first and second ratoon crops.

Of the 12 genotypes examined in this study, cane yield of the genotype; G87/98 declined significantly in advancing crops, since it decreased from 72.70 ton in plant cane to 63.44 ton (12.5%) in first ratoon and 39.25 ton (46%) in second ratoon crop. Cane yield of two genotypes; GT 54/9 and G 150/99 increased significantly from plant cane (46.72 and 45.00 ton) to the first ratoon (56.66 and 52.38 ton) then declined in second ratoon (45.34 and 43.30 ton, respectively). However, difference between plant cane and second ratoon crop was insignificant. Yield of three genotypes; pH 8013 , G 26/99 and G 28/98 was nearly the same in both plant cane and first ratoon crop, then it decreased significantly in second ratoon crop by 23.35 , 40.49 , and 34.06%, respectively compared to their yield in plant cane. Yield of two genotypes; G 84/47, and G 217/99 increased significantly from plant cane (62.29 and 52.04 ton) to the first ratoon (68.87 and 68.82 ton), but significantly decreased drastically in the second ratoon crop (49.62 and 33.86 ton, respectively). Yield of two genotypes; G 24/98 and G 208/99 significantly decreased in older crops, but with insignificant difference between first and second ratoon crops. Although three genotypes; pH 8013, G 84/47, and G 87/98 recorded the high mean value of cane yield over crops (59.1, 60.3 and 58.5 ton, respectively), yet their yield was inconsistent across crop cycles, since the yield significantly decreased in the older crop. The genotype, G 103/99 was more consistent in its yield across crops with an average of 45.4 ton over crops. Insignificant difference between this genotype and the widely grown commercial cultivar (GT 54/9) in both plant cane and second ratoon crops was observed. Therefore, G 103/99 genotype may show more consistent performance in more advancing crops, hence saving costs of replanting of new sugar cane fields. Over examined genotypes, cane yield varied significantly among crops from 57.02 ton in the first ratoon crop to 43.33 ton in the second ratoon crop.

Table 2: Mean performance of twelve sugarcane genotypes for Stalk number, and cane yield in plant cane (PC), first ratoon(FR), and second ratoon (SR) crops.

characters	Stalk number/fed x 10^3			Cane yield (ton/fed)		
Genotype	PC	FR	SR	PC	FR	SR
GT 54/9	40.20	50.00	47.60	46.72	56.66	45.34
PH8013	42.00	48.40	54.60	64.74	62.91	49.62
G84/47	46.20	63.00	63.80	62.29	68.87	49.62
G 150/99	40.80	44.20	50.40	45.00	52.38	43.30
G 103/99	35.20	54.60	58.80	46.27	45.63	44.22
G 26/99	61.80	63.00	44.00	56.70	55.37	33.74
G 87/98	49.00	64.80	56.20	72.70	63.44	39.25
G 24/98	40.80	45.60	53.60	59.58	49.41	47.11
G 217/99	38.40	48.80	40.00	52.04	68.82	33.86
G 208/99	37.40	41.60	54.80	62.56	48.03	49.93
G 193/99	32.20	52.20	54.40	33.82	52.00	43.58
G 28/98	49.00	53.00	45.60	59.37	60.72	39.15
Mean	**42.75**	**52.43**	**51.98**	**55.15**	**57.02**	**43.23**
LSD at 5%						
Genotype(G)	**3.57**	**3.92**	**4.82**	**4.32**	**4.78**	**6.66**
Crop (C)	**1.18**			**1.80**		
G x C	**3.98**			**5.15**		

Although stalks number for most studied genotypes significantly increased from plant cane to second ratoon, yet this increase did not compensate for the reduction in cane yield especially in second ratoon cycle. This is because of the reduction in stalk length, diameter and weight. Stalk weight seems to be the predominant determining of cane yield in this population (Masri et al., 2008).

Table 3: Mean performance of twelve sugarcane genotypes for Brix, Sucrose% and purity% in plant cane (PC), first ratoon(FR), and second ratoon (SR) crops.

Genotype	Bix			Sucrose %			Purity %		
	PC	**FR**	**SR**	**PC**	**FR**	**SR**	**PC**	**FR**	**SR**
GT 54/9	22.04	22.91	22.24	19.60	20.14	19.20	88.90	87.93	86.30
PH8013	21.54	22.13	21.44	18.37	19.10	18.09	85.27	86.27	84.36
G84/47	21.88	23.31	23.15	18.98	20.58	20.56	86.80	88.20	88.83
G 150/99	22.63	23.90	21.85	19.52	20.37	18.52	86.27	85.23	84.73
G 103/99	21.90	21.38	21.44	18.09	18.37	17.61	82.57	85.90	82.12
G 26/99	23.45	20.62	22.03	19.18	17.90	18.86	81.77	86.83	85.56
G 87/98	22.57	22.37	22.55	19.20	18.89	19.27	85.03	84.23	85.45
G 24/98	21.69	22.19	23.10	18.89	19.71	20.38	87.03	88.83	88.20
G 217/99	23.03	22.31	22.13	19.97	19.73	18.99	86.73	88.47	85.83
G 208/99	24.16	22.32	23.14	20.50	19.63	20.26	84.83	87.93	87.53
G 193/99	20.28	19.09	20.15	16.69	16.45	17.08	82.27	86.20	84.78
G 28/98	23.63	21.63	21.74	20.47	18.43	18.57	86.63	85.17	85.42
Mean	**22.40**	**22.01**	**22.08**	**19.12**	**19.11**	**18.95**	**85.34**	**86.77**	**85.76**
LSD at 5%									
Genotype(G)	**1.28**	**0.69**	**0.99**	**1.22**	**0.82**	**1.19**	**1.70**	**1.54**	**1.78**
Crop (C)	**n.s**			**n.s**			**n.s**		
G x C	**0.98**			**1.05**			**1.62**		

Data in Tables 3 and 4 revealed that evaluated genotypes varied significantly within and among crop cycles for total soluble solids (Brix), sucrose percentage, juice purity and sugar recovery. Over studied genotypes, crop age had no effect on juice quality traits. Chapman (1988) reported that older crops tend to mature earlier than younger crops, but final sucrose concentration and its components, Brix, sucrose content, Juice purity, and sugar recovery are generally not affected by crop age. Sugar yield varied significantly among genotypes within each crop cycle and among crop cycles. Sugar yield for all studied genotypes followed the same trends as in cane yield. Sugar yield of the genotype G84/47 (8.11, 9.81 and 7.06 ton) was significantly greater than yield of the check cultivar GT 54/9 (6.35, 7.87 and 5.94 ton), in plant cane, first ratoon, and second ratoon crop, respectively. Five genotypes; G26/99, G87/98, G24/98, G208/99 and G28/98 recorded the high mean value of sugar yield in plant cane (7.23, 9.47 , 7.73 , 8.69 and 8.32 ton, respectively) and all of them were significantly superior than the check cultivar GT 54/9 that yielded 6.35 tons in plant cane. Thereafter their yield decreased with the older crops. However, the difference between them and the check cultivar GT 54/9 was insignificant. Genotype G26/99 was significantly lower than the check cultivar, while G28/98 was significantly superior to the check cultivar GT 54/9 in the second ratoon crop. The superiority of genotypes in sugar yields is firstly due to their superiority in cane yield. Milligan *et al*. (1990b), El- Hinnawy *et al*. (2001), and Masri *et al*. (2008) reported that cane yield was the predominant in determining sugar yield. Therefore, further improvement of sugar yield could be obtained through selection for high cane yield and its component traits.

Table 4: Mean performance of twelve sugarcane genotypes for sugar recovery,and sugar yield in plant cane (PC), first ratoon(FR), and second ratoon (SR) crops.

characters	Sugar recovery %			Sugar yield (ton/fed.)		
Genotype	PC	FR	SR	PC	FR	SR
GT 54/9	13.59	13.89	13.12	6.347	7.873	5.943
PH8013	12.48	13.05	12.23	8.077	8.213	6.067
G84/47	13.01	14.23	14.25	8.110	9.807	7.060
G 150/99	13.34	13.83	12.54	5.997	7.247	5.430
G 103/99	12.09	12.53	11.74	5.593	5.723	5.193
G 26/99	12.75	12.26	12.84	7.227	6.790	4.327
G 87/98	13.03	12.77	13.11	9.473	8.103	5.143
G 24/98	12.97	13.66	14.08	7.730	6.753	6.670
G 217/99	13.69	13.65	12.95	7.123	9.393	4.387
G 208/99	13.89	13.61	13.95	8.687	6.553	6.960
G 193/99	11.13	11.24	11.58	3.753	5.850	5.033
G 28/98	14.02	12.52	12.63	8.323	7.607	4.943
Mean	**13.00**	**13.10**	**12.92**	**7.203**	**7.493**	**5.596**
LSD at 5%						
Genotype(G)	**0.90**	**0.66**	**0.93**	**0.692**	**0.809**	**1.006**
Crop (C)	**n.s**			**0.248**		
G x C	**0.81**			**0.815**		

The relative influence of genotypic variance (δ^2g) in determining the phenotypic variance was more important than error variance (δ^2e) for stalk length and stalk weight. However, it came in second place to error variance for stalk diameter at each crop cycle (Table 5). Genotypic variance, and G CV, decreased from plant cane crop to second ratoon crop for stalk length and stalk weight, while increased slightly for stalk diameter. Crop cycle effects did not appear to affect heritability for stalk length especially in second ratoon crop because of decreasing error variance. Heritability increased for stalk diameter with older crops, while it decreased for stalk weight. Although error variance for stalk weight decreased two times in magnitude in second ratoon crop compared to error variance in plant cane, but genotypic variance decreased about 12 times and this explains the reduction of heritability for stalk weight in second ratoon crop.

Table 5: Variance components, mean, heritability (H%), and genetic coefficient of variation (GCV%) for stalk length, stalk diameter, and stalk weight for each crop cycle.

Parameter	Stalk length (cm)				Stalk diameter (cm)				Stalk weight (kg)		
	PC	FR	SR		PC	FR	SR		PC	FR	SR
δ^2 g	2322.58	426.27	895.95		0.014	0.019	0.019		0.047	0.025	0.004
δ^2e	141.81	112.05	74.40		0.030	0.021	0.024		0.006	0.006	0.003
Mean	265.45	286.08	231.42		2.780	2.450	2.310		1.300	1.100	0.840
H%	98.01	91.94	97.31		58.33	73.08	70.37		95.92	92.59	80.00
GCV	18.16	7.217	12.93		4.256	5.626	5.967		16.68	14.37	7.529

Table 6: Variance components, mean, heritability (H%), and genetic coefficient of variation (GCV%) for stalk number, and cane yield for each crop cycle.

Parameter	Stalk No /fed x 10^3				Cane yield (ton/fed)		
	PC	FR	SR		PC	FR	SR
δ^2 g	60.65	57.17	42.48		112.66	59.84	27.35
δ^2e	4.224	5.364	8.088		6.498	7.959	15.453
Mean	42.75	52.43	51.98		55.15	57.02	43.23
H%	97.73	96.97	94.03		98.11	95.75	84.15
GCV	18.22	14.42	12.54		19.25	13.57	12.10

Genotypic variance and GCV for stalk number and cane yield decreased with older crops (Table 6). Error variance played a smaller role in influencing the phenotypic variance for stalk number and cane yield at each crop cycle, therefore effect of crop cycle on heritability was negligible for stalk number and cane yield except for cane yield in second ratoon, in which genotypic variance was decreased in magnitude 4 times and error variance increased about 2.5 times compared to plant cane crop. The values of GCV and heritability of stalk number and cane yield indicated that the population offered considerable potential for improvement by selection, especially in plant cane. The genotypic variance, heritability, and GCV for Brix fluctuated among crop cycles, with the lowest values in the older crop (Table 7). Genotypic variance and GCV for sucrose percentage were little affected by crop age, while were decreased for purity in advancing crops. Sugar recovery variances and GCV were apparently affected by crop age (Table 8), on the other hand sugar yield genetic variance, heritability, and GCV decreased with older crops. For sugar recovery and sugar yield, the genotypic variance was the largest source of phenotypic variance, ranging in magnitude from two to fourteen times the error variance.

Table 7: Variance components, mean, heritability (H%), and genetic coefficient of variation (GCV%), for Brix, sucrose %, and purity % for each crop cycle.

Parameter	Brix				Sucrose %				Purity %		
	PC	FR	SR		PC	FR	SR		PC	FR	SR
δ^2 g	0.954	1.530	0.637		0.961	1.323	1.006		4.427	1.961	2.926
δ^2e	0.573	0.165	0.339		0.516	0.234	0.489		1.011	0.822	1.110
Mean	22.40	22.01	22.08		19.12	19.11	18.95		85.34	86.77	85.76
H%	83.32	96.53	84.93		84.82	94.43	86.06		92.93	87.74	88.77
GCV%	4.360	5.619	3.614		5.128	6.020	5.294		2.465	1.614	1.994

Table 8: Variance components, mean, heritability (H%) and genetic coefficient of variation (GCV%), for sugar recovery %, and sugar yield for each crop cycle.

Parameter	Sugar recovery %				Sugar yield (ton/fed.)		
	PC	FR	SR		PC	FR	SR
δ^2 g	0.582	0.701	0.643		2.414	1.545	0.765
δ^2e	0.279	0.153	0.303		0.168	0.228	0.354
Mean	13.00	13.10	12.92		7.200	7.490	5.596
H%	86.22	93.22	86.42		97.73	95.31	86.64
GCV	5.868	6.391	6.206		21.58	16.60	15.63

A crop like sugar cane in which a single superior genotype once identified can be multiplied clonally. Therefore, estimates of broad sense heritability are more relevant to the breeder than those of narrow sense heritability. The previous results indicated high heritability estimates for all studied traits within each crop except for stalk diameter, since it ranged from 58.33 for stalk diameter in plant cane to 98.01 for stalk length in plant cane. High heritability with high GCV was observed for stalk length, stalk weight, stalk number, cane yield, and sugar yield, suggesting the possibility of improvement of those traits through selection. Although heritability of Brix, sucrose percentage, juice purity, and sugar recovery were relatively high, lack of remaining variability at this stage left little potential for more gain. However estimates of heritability within a crop under one environment are somewhat considered biased estimates, where the environmental effects are known to be significant in sugarcane (Hogarth et al.,1981 and Schnell and Nagai, 1992). Bias in heritabilities estimated under restricted environmental conditions was discussed by Dudley and Moll (1969).

Examination of variance components calculated from the full model analysis across crops showed the important contributions of genotypic by crop interaction variance (δ^2gc) in determining the phenotypic variance for stalk length, stalk diameter, stalk weight, stalk number and cane yield (Table 9). The error variance was, however, the lowest source of variation for stalk length, stalk diameter and stalk number. Heritability, and GCV estimates for cane yield and its component traits were smaller than the average of individual crops for the same traits because of the interaction variance was the predominant determining of phenotypic variance. Therefore, it is necessary to use more than one year and one location to estimate the components of variance if the genotype X year, genotype X location, or genotype X year X location interaction is of importance (Dudley and Moll, 1969). The relative influence of genotypic variance (δ^2g) in determining the phenotypic variance was primary to genotype by crop interaction variance (δ^2gc) for sucrose percentage and sugar recovery, but was secondary to δ^2gc for sugar yield (Table 10). However, δ^2g and δ^2gc for Brix and purity played similar role in detecting phenotypic variance. Little change was observed in GCV for juice quality traits. However, heritability, and GCV for sugar yield were smaller than the average of individual crops.

The GCV values estimated in this study suggest selection to improve a particular crop's yield component value is most effective when performed within that crop and commonly shows the most potential for improvement in the younger crops. The different potential improvement among traits results at least in part from selection program's methodology prior to this selection stage (Breaux, 1972). Selection program in Egypt tend to concentrate on sucrose quality and stalk diameter in its early stages. Therefore, genetic variability for this trait may be limited (Gravois, 1988 and Milligan, 1988).

Table 9: Variance components, mean, heritability (H%), and genetic coefficient of variation (GCV%) for stalk length, stalk diameter, stalk weight, stalk number and cane yield over crops.

Parameter	Stalk				Cane yield (ton/fed.)
	length (cm)	diameter (cm)	weight (kg)	no/fed.x 103	
δ^2 g	354.78	0.008	0.008	11.51	9.949
δ^2 gc	860.15	0.009	0.017	41.93	56.67
δ^2e	109.44	0.027	0.009	5.958	9.972
Mean	260.98	2.515	1.080	49.06	51.80
H%	54.28	57.19	54.55	44.02	33.22
GCV %	7.217	3.556	8.282	6.915	6.089

Table 10: Variance components, mean, heritability (H%), genetic coefficient of variation (GCV%) for Brix, sucrose %, purity %, sugar recovery% and sugar yield over crops.

Parameter	Brix	Sucrose	Purity	Sugar recovery	Sugar yield (ton/fed.)
		%			
δ^2 g	0.533	0.769	1.657	0.477	0.534
δ^2 gc	0.506	0.328	1.448	0.165	1.041
δ^2e	0.360	0.414	0.981	0.243	0.252
Mean	22.16	19.06	85.96	13.01	6.764
H%	71.88	83.20	73.69	85.33	58.75
GCV %	3.295	4.601	1.497	5.309	10.80

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تأثير المرحلة العمرية على التباين الوراثى و كفاءة التوريث و المحصول في قصب السكر

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تم تقييم عشرة تراكيب وراثية واعدة من قصب السكر هي: جيزة ٤٧/٨٤ ، جيزة ٩٩/١٥٠ ، جيزة ٩٩/١٠٣ ، جيزة ٩٩/٢٦ ، جيزة ٩٨/٨٧ ، ٩٨/٢٤ ، جيزة ٩٩/٢١٧ ، جيزة ٩٩/٢٠٨ ، جيزة ٩٩/١٩٣ جيزة ٩٩/٢٨ بالاضافه إلى الصنفين التجاريين جيزة تايوان ٩/٥٤ وPh 80/13 في محطة أبحاث كوم امبو الزراعية بمحافظة أسوان ، وذلك لمحاصيل الغرس و الخلفة الأولى و الخلفة الثانية بداية من موسم ٢٠٠٥ /٢٠٠٦ وحتى موسم ٢٠٠٧ /٢٠٠٨. وقد نفذت التجربة في تصميم القطاعات الكاملة العشوائية في ثلاث مكررات. وكان الهدف من الدراسة هو معرفة تأثير العمر المحصولى على المحصول ومكوناته بالإضافة إلى تأثيره على التباين الوراثى وكفاءة التوريث لصفات طول و سمك و متوسط وزن الساق ، عدد العيدان الصالحة للعصير للفدان ، محصول العيدان للفدان وصفات جودة العصير متمثلة في نسبة المواد الصلبة الذائبة الكلية (البركس) ، نسبة السكروز ، نسبة النقاوة للعصير ، نسبة السكر المستخلص ومحصول السكر للفدان.

أظهرت نتائج الدراسة تباين في سلوك التراكيب الو راثية بين الغرس والخلف بالنسبة لصفة طول الساق ، حيث زادت هذه الصفة لبعض التراكيب بينما انخفضت للبعض الأخر.كما حدث انخفاض ملحوظ في سمك الساق ومتوسط وزن الساق مع التقدم في العمر لجميع التراكيب الو راثية تحت الدراسة. بغض النظر عن التراكيب الو راثية زاد عدد العيدان في محصول الخلفة الأولى بنسبة ٢٢,٦ % بينما زاد في محصول الخلفة الثانية بنسبة ٢١,٦ % وذلك مقارنة بمحصول الغرس. تباينت التراكيب الو راثية في محصول العيدان بين الغرس والخلفة الأولى، حيث زاد محصول العيدان لبعض التراكيب الو راثية بينما انخفض لبعض التراكيب الأخرى في حين لم يتأثر سلوك باقي التراكيب الو راثية ، ولكن بصفة عامة حدث انخفاض ملحوظ في محصول العيدان لمعظم التراكيب الو راثية تحت الدراسة في الخلفة الثانية. بغض النظر عن التراكيب الو راثية فقد تباين محصول العيدان من ٥٧,٠٢ طن في الخلفة الأولى إلى ٤٣,٢٣ طن في الخلفة الثانية . لم تتأثر صفات جودة العصير (البركس ، نسبة السكروز ، نقاوة العصير ، ناتج السكر) بالعمر المحصولى ، حث أنه لم يكن هناك فرق معنوي بين جميع التوافيق الثنائية للأعمار الثلاثة بالنسبة لصفات الجودة. تأثر محصول السكر معنويا بالأصناف داخل كل عمر محصولي وكذلك تأثر معنويا بالعمر المحصولى ، فقد تباين محصول السكر من ٧,٤٩ طن في الخلفة الأولى إلى ٥,٦٠ طن في الخلفة الثاني

أظهرت النتائج حدوث انخفاض في قيم التباين الوراثى ، كفاءة التوريث ، معامل الاختلاف الوراثى لصفات وزن الساق ، عدد العيدان ، محصول العيدان ، نقاوة العصير، محصول السكر وذلك بالتقدم في العمر من الغرس إلى الخلفة الثانية. بينما حدثت زيادة طفيفة في هذه التقديرات بالنسبة لصفات سمك الساق ، نسبة السكروز ، ناتج السكر مع التقدم في العمر. أشارت تقديرات، كفاءة التوريث ، معامل الاختلاف الوراثى ، التقدم الوراثى في ظل الانتخاب لصفتي عدد العيدان ، محصول العيدان إلى وجود إمكانية للتحسين بالانتخاب في هذا المجتمع تحت الدراسة. أدى تحليل التباين على مستوى الأعمار الثلاثة إلى انخفاض قيم كفاءة التوريث ، معامل الاختلاف الوراثى لصفات طول الساق ، وزن الساق ، عدد العيدان ، محصول العيدان ، نقاوة العصير، محصول السكر مقارنة بالقيم المناظرة لها والناتجة من التحليل الفردي لكل عمر محصولي، مما يشير إلى أهمية التفاعل بين التراكيب الو راثية والعمر المحصولى . أشارت نتائج تقدير معامل الاختلاف الوراثى إلى أن الانتخاب للمحصول ومكوناته يكون أكثر فاعلية داخل كل عمر محصولي على حده ، كما أن الانتخاب للمحصول ومكوناته يكون أكثر فاعلية في الأعمار المبكرة (الغرس أو الخلفة الأولى) مقارنة بالعمر المتأخر (الخلفة الثانية).