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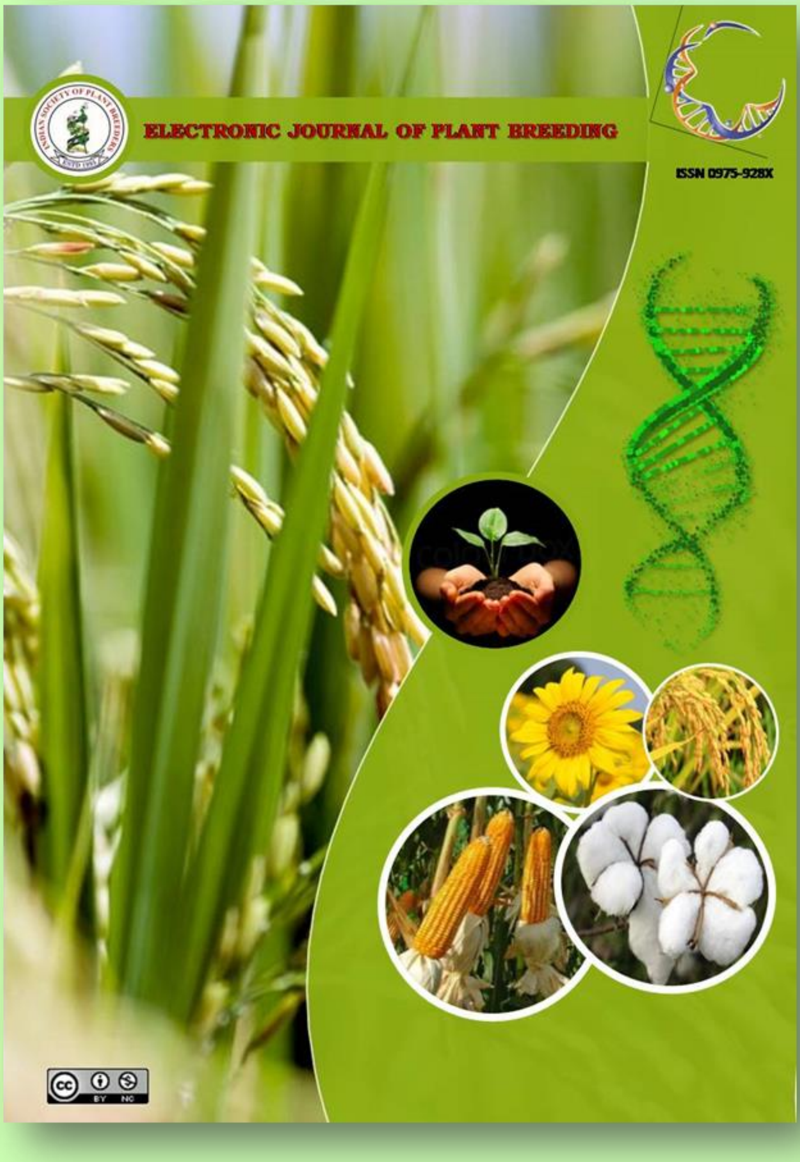

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Research Article

Assessment of ratooning ability and genetic variability of promising sugarcane varieties under middle Egypt conditions

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Abstract

Poor ratooning ability was a major cause for rejection of sugarcane varieties in the breeding program because of the decline in cane yield associating the advance in the crop cycle. Seven sugarcane-promising varieties (G.2010-26, G.2011-82, G.84-47, G.2003-47, G.2006-6, G.99-103, and G.2010-7) along with one check commercial cultivar (G.T.54-9) were evaluated for ratooning ability (RA) and genetic variability. The experiment was planted in the randomized complete block design with three replications in a crop cycle included plant cane (PC), 1st ratoon (FR), and 2nd ratoon (SR) during 2016-2019 growing seasons at Mallawi Agricultural Research Station, El-Minya Governorate, Egypt (latitude of 28° 10' N, longitude of 30° 75' E and altitude of 55m above sea level). Varieties x crop cycles interaction showed highly significant effects on all traits except for purity %, indicating that variety performed differently among cane crops within the crop cycle. The evaluated varieties showed significant differences in RA% for all studied traits. Sugarcane G.2003-47 and G.2010-7 varieties exhibited higher ratooning ability recording higher cane and sugar yields in SR, compared to G.2011-82 and G.2010-26, which had poor performance concerning the same traits in SR. The overall mean of cane and sugar yields for the tested varieties significantly decreased by 3.38 and 0.59 tons in FR, being 13.9 and 1.7 tons in SR, respectively, compared to PC. Highest genotypic and phenotypic coefficients of variation were exhibited by single stalk weight, sugar yield and cane yield in both plant and ratoon crops. High heritability and genetic advance % estimates across crops were recorded for single cane weight (85.27% and 34.97%), cane yield (96.93% and 36.44%), Brix %(89.82% and 28.08%) and sugar yield (94.81% and 41.76%). These results suggest that a simple selection for these traits would be effective. In addition, selection in ratoon crops should be based on yield contributing traits having high PCV, GCV, heritability and genetic advance along with mean value.

Keywords
Genetic variability, Heritability, Ratooning ability, Screening, Sugarcane, Yield traits

Introduction

In Egypt, sugarcane is an important cash crop; it is being grown on 133.8 thousand ha with the total annual production of 15.3 million tons (Annual Report of Sugar Crops Council, 2019). Mallawi is one of the most important sugarcane growing tracts of Egypt, which lies, between latitude of 28° 10' N, and longitude of 30° 75' E with an altitude of about of 55m above sea level. The climate in Mallawi is called a moderate climate with the average annual temperature is 20.8 °C; there is virtually about 3 mm of precipitation falls annually. Mallawi has the extreme type of climatic conditions, with an average of 27.1 °C, July is the warmest month. At 10.9 °C on average, January is the coldest month of the year. Therefore, as ratoon crop failure is the major problem of the cane growers in Mallawi. Good ratooning in sugarcane is beneficial for the farming community as its production costs lower than the plant crop. However, during the last few years, ratoon crop of sugarcane has shown a declining tendency in yield. The ratooning ability was defined as the ratio between yields of the 2nd ratoon crop relative to the plant crop (Milligan *et al.*, 1996). The major cane growing countries normally take two or more ratoons (Bashir *et al.*, 2012). Abu-Ellail *et al.*, (2018) found that crop cycles had a negative effect on cane and sugar yields, it is important to study the characteristics of sugarcane associated with a ratooning ability for use them as selection criteria in breeding programe. Sugarcane genotypes greatly differ in ratooning capacity and to produce profitable ratoon crops (Srivastava, 1993); moreover, the selection in ratoon crops was effective in identifying elite sugarcane clones with acceptable cane yield. The yield of ratoon cane generally is not the same as that of the plant crop; also less ratoon cane yield is common with complex causes. The development of ratoon crops depends upon the sprouting of underground buds that stay behind after harvesting of plant crop (Hunsigi and Krishna, 1998). Genotypes with poor ratooning ability were characterized mostly by a sharp decline in cane yield especially between the plant cane and the 1st ratoon crop, whereas those with good ratooning ability had the highest yield decline between the 1st and 2nd ratoon crops reported by Olaoye (2005). Testing ratooning ability only on a plant crop may be satisfactory because, sugarcane clones varied in their ability to survive and produce a profitable ratoon crop (Bhatnagar *et al.,* 2003). Ratoon ability 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; it is due to genetic variation among sugarcane genotypes for ratooning potential has previously been reported by Rafiq *et al.,* (2006). Heritability estimates along with expected genetic gain from selection and genotypic coefficients of variation are very essential to improve traits of sugarcane and select best genotypes because this would help in knowing whether or not the desired objective can be achieved from the material (Tyagi and Singh, 1998). Selection of the best genotype based on their sugar yield would improve the efficiency of selection and increase heritability (Shanthi *et al.,* 2008). Genetic variability and heritability are useful parameters that can help in crop improvement (Anshuman *et al.,* 2002). The study of the genetic coefficient of variation along with heritability estimate as necessary to obtain the true picture of the heritable variations in the population handled (Burton, 1952), furthermore, the most important function of heritability in genetic studies of quantitative traits is its prediction value that could be used as a guide to the breeding value and selecting superior clones for the on-going sugarcane industry. Abu-Ellail *et al.,* (2017) found that significant genotypic effects indicated the existence of genetic variability among the genotypes and the possibility of utilizing them in genetic improvement. The objectives of this study were (i) to investigate the ratooning ability and the yield performance of seven sugarcane promising varieties along with check cultivar (G.T.54-9) grown under crop cycles; plant cane (PC), 1st ratoon (FR), and 2nd ratoon crops (SR) , and (ii) to estimate broad–sense heritability, genetic potential gain and genetic variability.

Materials and Methods

Seven sugarcane promising varieties of *Saccharum hybrid Spp viz.,*G.2010-26, G.2011-82, G.84-47, G.2003-47, G.2006-6, G.99-103, and G.2010-7 along with check cultivar (G.T.54-9) were investigated for the ratooning ability under middle Egypt conditions at Mallawi Agricultural Research Station, El-Minya Governorate, Egypt (latitude of 28° 10' N, longitude of 30° 75' E and altitude of 55m above sea level) during 2016-2019 seasons. Soil type of experimental site is silty clay. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Three rows of each variety per replication with the row length of 6 m and the distance between rows were 1.0 m, thus plot area was 18 m^2. Planting was done during the third week of March 2016 season. Planting was achieved by placing twenty-five 3-budded cane pieces in each row was adopted. The field was irrigated immediately right after planting and all agronomic and plant protection measures were kept uniform. Plant crop was harvested on 12 months and kept as ratoon for the first and second year. At harvest, data were recorded for the three crop years following planting; plant cane (PC), 1st ratoon (FR), and 2nd ratoon (SR).

A sample of twenty stalks from each plot was removed to measure the following five traits:

1. Stalk length (cm) was measured from the soil surface to the visible dewlap.
2. Stalk diameter (cm) was measured at mid-stalk with no reference to the bud groove.
3. Stalk weight (kg) was calculated by dividing cane yield per plot by the number of stalks/plot.
4. Number of millable stalks/feddan (fed) (one fed = 4200 m^2) was calculated on a plot basis.
5. Cane yield (ton/fed) was calculated on the plot basis.

Twenty stalks from each plot were crushed and juice was analyzed to determine the following five traits:

1. Brix (percent soluble solids) was determined with a hydrometer.
2. Sucrose percentage of clarified juice was determined by using automated saccharometer according to A.O.A.C. (1995).
3. Purity was calculated as [(Sucrose / Brix) x 100].
4. Sugar recovery% (a rendment) was calculated according to the formula described by Yadav and Sharma (1980) which is given: SR= [Sucrose % - 0.4 (Brix – Sucrose %)] x 0.73
where: 0.4 = each pound of non-sucrose solids in the juice will retain 0.4 of a pound of sucrose as outlined by Herbert (1973), and 0.73 is a correction factor for actual milling conditions in factories that depends on the overall mean cane fiber percentage during processing .
5. Sugar yield (ton/fed) was estimated by multiplying net cane yield (ton/fed) by sugar recovery percentage.

Ratooning ability (RA) was estimated as:

$$RA_i = 100\ SR_i / PC_i$$

where RA of trait *i* is defined as the ratio of 2nd ratoon crop (SR) yield for trait *i* to the plant-cane crop yield (PC) for trait *i* expressed as a percent according to Milligan *et al.,* (1996).

The collected data were statistically analyzed using MSTATC; version 1.2 (Freed, 1990) and least significant difference test (LSD) was applied to compare the treatment means (Steel *et al.*, 1997). The separate analysis data for each crop and combined analysis of variance for across crops cycles were done. Variance components were calculated by equating appropriate mean squares to their expectations and solving for the components. Broad-sense heritability (H %) on variety mean basis was estimated using variance components following the formula according to Johnson *et al.*, (1955): $H= \sigma^2g/ (\sigma^2g + \sigma^2e /r + \sigma^2gc /rc)$, where, (σ^2g) and (σ^2e) refers to genotypic and error variance, respectively. The divisor (r) refers to the number of replications; σ^2gc refers to variety by crop interaction variance. The divisor c refers to number crops. Genetic coefficients of variance (GCV) provide the measure of traits genetic variation relative to its mean estimated according to Burton and Devance (1953). The GCV facilitates comparisons among traits with different units and scales and gives perspective to the variation as GCV% = $(\sigma^2g/\text{general mean}) \times 100$. Expected genetic gains as % of the mean (GA %) from the individual selection were calculated according to Falconer (1989): $GA = K \times H \times \sigma_P$. (GA as % of mean) = (GA / general mean) × 100, where, K = 1.756 for 10% selection intensity in standard deviation units, □g is within family genetic variances and □p is the phenotypic standard deviation.

Results and Discussion

In plant cane (PC), 1st ratoon (FR), 2nd ratoon (SR) and across crop cycles (AC), the studied traits showed highly significant (P = 0.05) differences among sugarcane varieties in their ratooning ability for all traits. Furthermore, the crop cycles were highly significant for all studied traits, except for purity%, as well as the varieties by crop cycle interaction revealed significant effects on all studied traits except for purity% , indicating that variety performed differently among the crop cycles in agreement with the results obtained by Abu-Ellail *et al*., (2017 and 2018); Olaoye (2005); and El-Hinnawy and Masri (2009), reported that genotype by crop interaction was important in determining sugarcane yield and its component traits, therefore, necessary to identify genotypes with the good ratooning ability for specific conditions.

Results in Table .1 reveal that the evaluated sugarcane varieties differed substantially in stalk length along the crop cycle (plant, 1st and 2nd ratoon cane crops). In the plant cane, G.99-103 showed the significant superiority in stalk length hover the other cane varieties, while G.2010-26 variety had the shortest stalks. Meanwhile, insignificant variance in this growth trait was detected among G.2011-82, G.84-47, and G.2006-6 as well as between G.2003-47 and G.2010-7. In the first ratoon; G.84-47 had the tallest canes, without a significant difference with those of G.2010-7. Meantime, insignificant variance in this trait was observed between G.2010-26, which had the shortest stalks, and G.2006-6. In the 2nd ratoon, G.99-103 recorded the highest mean value of stalk length, but G.2010-26 had the lowest record of this trait, with insignificant variance with that given by G.2006-6. Moreover, the promising varieties namely G.2011-82, G.2003-47, and G.2010-7 were not markedly different in their cane length. The mean values of the studied sugarcane crop cycle manifested that stalk length of the evaluated varieties decreased gradually as crop cycle advanced with age from the plant cane, up to the 2nd ratoon crop. Stalk length was significantly influenced by the interaction of cane varieties x crop cycle. It was found that the difference in stalk length between G.2010-7 and G.2003-47, grown as plant cane or 2nd ratoon, was insignificant. However, in the 1st ratoon, G.2010-7 surpassed G.2003-47 significantly in this growth character. The promising variety of viz. G.84-47 had the best ratooning ability of stalk length, while the lowest value of this criterion was recorded by G.2006-6. These results were similar with those reported by Sundra (1989), who recorded a significant reduction in stalk height in ratoon crop compared to that of the plant cane and referred the reduction in ratoon crop to the interference of differential ratooning capacity of genotypes studied.

Regardless of the crop cycle, the tested cane varieties varied significantly. It was found that G.99-103 had the biggest stalk diameter of 3.65 cm, 3.01cm, 2.82 cm and 3.16 cm in plant cane, 1st and 2nd ratoon crops and across crops, respectively (Table 1)., while the tested variety G.2011-82 was the most inferior varieties with 2.53, 2.03 cm and 2.33m stalk diameter in the plant cane, 2nd ratoon crop and across crops, respectively. However, in the 1st ratoon, the lowest stalk diameter was recorded by (G.84-47) 2.33 cm. The highest RA value for stalk diameter was recorded by the variety G.2003-47 (87.69%) followed by the varieties G.2010 -26 (85.66%), and G.2010-7 (82.44%) significantly stable in their performance but not exceed the check cultivar GT. 54-9 (87.79%). Stalk diameter of all promising varieties was decreased in older crop cycles which are in accordance with the results of Milligan *et al.*, (1996) who found that stalk diameter have been suggested as being indicative of better ratooning cultivars.

Significant differences were observed among the seven varieties for stalk weight, the promising variety G99-103 recorded the highest mean stalk weight in the plant crop, 1st ratoon and across crop cycles, with 1.21, 1.15 and 1.13 kg respectively (Table 2). The variety G.84-47 registered the lowest mean single cane weight of kg with 0.83, 0.73 and 0.77 kg in the plant crop 2nd ratoon and across crop cycles, respectively, while, the variety G.2010-7 recorded the lowest stalk weight (0.71kg) in the 1st ratoon. 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. Five varieties exhibited a decreasing trend for stalk weight from plant cane to the second ratoon, which was in agreement with previous results (Chapman *et al.,* 1992) where a reduction in stalk weight in the ratoon crop was observed may be due to decline in nutritional status of soil due to exhaustive crop in nature . The highest RA value (91.59 %) for stalk weight was recorded by the check variety G.T.54-9, indicating the superiority of stalk weight in 2nd ratoon crop, while the lowest RA value (83.16%) for stalk weight was recorded by the variety G.2010-26, indicating the high reduction in yield in the 2nd ratoon crop. The ratooning ability was related to stalking weight and biomass produced by the crop (Sundara, 1989), and the ratooning ability is usually considered as cane yield-related character.

Results in Table 2, revealed that sugarcane varieties differed substantially in the number of millable cane along the crop cycle (plant, 1st and 2nd ratoon cane crops). The promising variety; G.2003-47 recorded the highest number of millable cane (51.24 and 43.26 respectively) significantly surpassed the commercial cultivar G.T.54-9 during the plant crop and 2nd ratoon crops, but the control variety recorded the highest number of millable cane in the 1st ratoon and across crops (58.80, 50.26, respectively). The lowest numbers of millable cane were recorded by G.99-103 (38.52, 34.86, 31.92, 35.01, respectively) at plant cane, first, second ratoons and across crops. One variety; G.99-103 were decreased with older crops, while the other varieties either increased with older crops or fluctuated among crops. Only three of them; G.2006-6 (87.10%), G.2003-47 (84.43 %) and G.84-47 (83.74%) were good ratooner varieties and near the unit exceeded the check cultivar G.T.54-9 (80.99%). On other hands, the G.2011-82 recorded the lowest ratoon ability percentage (74.48 %). These results are in line with Singh and Dey, (2002) noticed the varying response of different sugarcane genotypes for sprouting, millable canes to ratooning. Reduced plant population due to gaps and poor sprouts, the poor establishment of plant crop or stubble damage during harvesting and haulage of farm types of equipment and the infection of pests and diseases were blamed to be responsible to the poor yield in ratoon crop.

Data in Table 3 showed that the promising varieties varied significantly within and among crop cycles for total soluble solids (Brix). In plant-cane, Brix percentage ranged from 19.50 % (G.99-103) to 22.25 % (G.2006-6). In 1st ratoon and across crop cycles, the trait of Brix ranged from the lowest percentage 17.97 and 18.74 % (G.2010-26) to the heights percentage 20.71 and 20.58% (G.2003-47). Most of the promising varieties were decreased in older crop cycles. Although the tested varieties differ significantly in their ratooning ability for Brix trait, the RA% of Brix value ranged from 84.91 % for variety (G.2011-82) to 93.26% for variety (G.2003-47) , indicated little change between plant cane and 2nd ratoon crop for most promising varieties are in agreement with the results reported by El- Hinnawy and Masri (2009); Chapman (1988) reported that older crops tend to mature earlier than younger crops, but final Brix concentration is generally slightly affected by crop age.

Overall mean, sucrose percentage of the evaluated varieties was decreased in the first and 2nd ratoon crops by 1.01 % and 1.33 % compared to plant cane crop. Sucrose percentage in plant cane ranged from 14.81 % for the variety G.2010-26 to 18.31 % for the variety G.84-47 (Table 3), while in 1st ratoon it varied from 14.00 % for the variety G.2010-26 to 17.01 % for the check-variety GT.54-9. However, in the 2nd ratoon and across crop cycles it ranged from 13.10, 14.14% for the variety G.2011-82 to 17.03, 17. 26 % for the check-G.T.54-9. The highest RA value (98.62 %) for sucrose percentage was recorded by the variety G.2010-7, also five varieties had RA value equal or more than 90%, indicating the stable of sucrose percentage in 2nd ratoon crop led to high ratooning ability. Sucrose percentage of most promising varieties beside the check cultivar G.T.54-9 were slightly decreased or showed consistency with the older crops in agreement with the results observed by Masri and Amen (2015) found that crop age had no significant effect on juice quality traits.

In plant cane, sugar recovery ranged from 9.26 % for the variety G.2010-26 to 12.29 % for the variety G.84-47 (Table 4). In the 1st and 2nd ratoons and across crop cycles, the lowest value of sugar recovery was recorded by the variety G.2011-82 (8.82, 8.25 and 8.89 % respectively) while; the check- G.T.54-9 recorded the highest values (11.80, 11.85 and 11.86% respectively). In general, crop cycle across studied varieties had slight effects on sugar recovery trait. El-Hinnawy and Masri (2009) found that crop cycles significantly affect juice quality traits. The highest RA value for sugar recovery% was recorded by the variety of G.2010-7 (103.46 %) that significantly exceeded the check cultivar G.T.54-9 (99.39%). Overall mean, sugar recovery% of the studied varieties was decreased in the 1st and 2nd ratoon crops by 0.55 %, 0.72 % compared to plant cane crop in agreement with the results obtained by Bhoj (1971) recorded that ratoon crop gives lower cane yield with better juice quality than the plant cane. Abu-Ellail (2015) who found significant differences among varieties and the interaction between varieties, however, insignificant differences existed between crop-year for sugar recovery percentage.

Purity percentage in plant cane ranged from 73.57 % for the variety G.2010-26 to 83.19 % for the variety G.84-47(Table 4), while in the 1st ratoon crop it ranged from 73.93% for the variety G.2003-47 to 88.92% for the check- G.T.54-9. In the 2nd ratoon and across crops, however, it varied from 74.39 and 74.22% for the variety G.2011-82 to 89.49 and 87.25 % for the check-G.T.54-9. Purity percentage of most varieties decreased with older crops or fluctuated among crops. Five of tested varieties; G.2010-26, G.2011-82, G.84-47, G.2003-47, G.99-103, and G.2010-7, were good ratooner varieties and exceeded the unit. However, the highest value of RA% was recorded by the variety G.2010-7 (108.57 %) are in line with Abu-Ellail *et al.*,(2018) who found significant differences among genotypes and the interaction between genotypes and crop-year for purity percentage.

Data in Table (5) show a significant variance among the evaluated varieties in cane and sugar yields/fed. The mean values of cane and sugar yields of varieties across crop cycle pointed to the superiority of the check commercial variety G.T.54-9 over the other ones in the cane and sugar yields/fed, followed by the promising G.2003-47, which recorded 7.02 and 1.54 tons, respectively less than G.T.54-9. On the contrary, the lowest cane and sugar yields were given by G.2006-6 and G.2011-82, respectively, which produced 20.2 and 3.03 tons, respectively lower than that of G.T.54-9. In addition, insignificant variance in cane and sugar yields/fed can be noticed be between G.2010-26, G.2011-82, G.84-47, G.2006-6, and G.2010-7. The results manifested that the check commercial variety G.T.54-9 had the highest percentage of ratooning ability for cane yield, followed by G.2003-47, however, the highest percentage of ratooning ability for sugar yield was given by the variety G.2010-7. While 2010-26 and G.2011-82 occupied the last rank in cane and sugar yields/fed, respectively, compared with the other tested cane varieties. The results in Table 5 indicate that the interaction of cane varieties x crop cycle had a significant influence on cane and sugar yields/fed. It was noticed that the difference between G.2011-82 and G.84-47 in cane yield was insignificant when they were grown as a plant or first ratoon cane crop. However, the difference between them in sugar yield was significant. Meantime, the G.84-47 out-yielded G.2011-82 substantially, in the 2nd ratoon. Abu-Ellail *et al.*, (2018) found significant differences among genotypes and insignificant interaction between varieties and crop-year for sugar yield (ton/fed). Concerning crop cycle, a significant difference in cane yield/fed was detected in case of growing sugarcane in ratoon crops. However, the harvestable cane yield/fed was decreased by 3.38 and 13.90 tons of canes per fed, in comparison with that given by the plant cane, successively. On the other side, the sugar yield/fed was decreased by 0.59 and 1.7 tons of sugar per fed, in comparison with that given by the plant cane. The general tendency of decreasing cane and sugar yields/fed associated aging of crop cycle was observed. These results are in accordance with those reported by Gomathi, *et al*. (2013), Mirzawan, and Sugiyarta (1999), who mentioned that ratoon crop yields usually decrease with age, and hence, limit the economic production of sugarcane. They pointed out that the average yield gap between plant and ratoon cane yield is 20-25%. Milligan *et al*., (1996), 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.

The highest of GCV (%) and PCV (%) values were observed for sugar yield, cane yield, stalk diameter, and single stalk weight in the plant can and ratoon crops. Low values of GCV and PCV in plant cane and ratoon crops (Fig. 1) was recorded for characters viz., the number of millable cane (fed), stalk length and juice quality such as Brix%, sucrose%, purity%, and sugar recovery. Stalk height registered low heritability coupled with low GCV, PCV and genetic advance as percent of mean suggesting selection will be less effective for these traits. Abu-Ellail *et al.,* (2017) reported that phenotypic and genotypic coefficient of variation decreased from plant cane to the 1st ratoon for the traits, stalk diameter, cane yield, Brix% and the number of stalks/fed. Bhatnagar *et al.*, (2003) had found that high value of genotypic and phenotypic coefficients of variation was exhibited by the number of stalks, single stalk weight, sugar yield and cane yield in both plant and ratoon crops. The selection for yield contributing characters with the high genotypic and phenotypic coefficient of variability and low depression in ratoon crop will be more effective for development of genotypes with ratoon ability (Gowda *et al.,* 2016).

The genotypic coefficient of variations is not a correct measure to know the heritable variation present and should be considered together with heritability estimates. In this study, high heritability (broad sense) estimates (Fig.2) at plant cane, first, second ratoons and across crops were recorded for sugar recovery% (99.53 %), purity% (99.43 %) and cane yield (96.93 %), respectively. While, the lowest heritability was recorded by number of millable cane (fed) (60.18%) at plant cane and stalk length (cm) (65.72, 62.87, 63.08 %) at first, second ratoons and across crops, respectively. In addition, the results reported high estimates of broad sense heritability and expected genetic advance for cane and sugar yield. High heritability and genetic advance % estimates at across crops were recorded for single cane weight, cane yield, stalk diameter and Brix %; this suggests that simple selection for these traits would be effective. Xie *et al.,* (1989) and Walker (1965) who reported that number of millable cane and stalk weight are the most useful traits to consider when selection imposed for high cane yield where, millable cane is a reasonable selection criterion for high cane yield. Abu-Ellail *et al*., (2017) and Abu-Ellail (2015) who reported that heritability decreased from plant cane to 1st ratoon for the traits, stalk diameter, cane yield and Brix%, while, they increased slightly for number of stalks/fed and purity%. The significant genotypic effects indicated existence of genetic variability among the genotypes and the possibility of utilizing them in genetic improvement.

The effectiveness of selection depends not only on heritability but also on genetic advance. Genetic advance was high for sugar yield, cane yield, single stalk weight, number of millable cane and Brix% for plant cane, 1st and 2nd ratoon crops. High heritability coupled with high genetic advance indicated that these traits were controlled by additive gene action. Hence, phenotypic selection could be effective in improvement of such traits. However, the genetic advance was low for stalk length in plant, 1st and 2nd ratoon crops. In general, characters *viz*., stalk length (cm), number of millable cane (fed), cane yield (ton/fed), Brix%, and sucrose% showed depression in ratoon crop as compared to plant crop, are in line with Johnson *et al.,* (1955), who found higher heritability estimate along with higher genetic advance, was more useful than heritability alone in predicting the resultant effect of selection. Reduction in cane length and thickness, generally the heritability values for the important stalk characters studied were high to moderate paving the way for improvement of these characters through simple selection. Knowledge of variability and heritability of characters is essential for identifying those amenable to genetic improvement through selection (Vidya *et al.,* 2002).

The study led to the conclusion that higher number of millable cane, single cane weight, stalk diameter endowed with better sugar yield are the important characters which should be considered while selection to be made for higher ratoon ability in sugarcane varieties grown in Mallawi (Egypt). Therefore, it brings more economic return not only to the farmers but also for the sugar industry. This paper reports a simulation study on sugarcane clone selection for ratooning ability based on the performance of younger crop traits. The promising variety G2003-47 seems to be the ideal one because of its significant superiority in cane yield and its acceptable juice quality traits during the three crop cycles, indicating that evaluation of sugarcane clones for cane and sugar yield in many locations should identify superior clones.

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Table 1. Mean performance and ratooning ability (RA %) of seven sugarcane varieties for stalk length and stalk diameter in plant cane (PC), 1st ratoon (FR), 2nd ratoon (SR) and across crops (AC).

Varieties	**Stalk length (cm)**					**Stalk diameter (cm)**				
	PC	**FR**	**SR**	**AC**	**RA%**	**PC**	**FR**	**SR**	**AC**	**RA%**
G.2010 -26	238.40	219.20	218.34	225.31	91.59	2.72	2.44	2.33	2.50	85.66
G.2011-82	296.70	264.00	241.50	267.40	81.40	2.53	2.42	2.03	2.33	80.24
G.84-47	295.20	306.00	275.30	292.17	93.26	2.65	2.33	2.13	2.37	80.38
G.2003-47	314.92	269.06	245.73	276.57	78.03	2.68	2.54	2.35	2.52	87.69
G.2006-6	294.42	223.78	219.74	245.98	74.63	2.74	2.40	2.20	2.45	80.29
G.99-103	374.43	293.33	287.02	318.26	76.66	3.65	3.01	2.82	3.16	77.26
G.2010-7	316.92	299.35	244.33	286.87	77.10	2.79	2.61	2.30	2.57	82.44
Check- G.T.54-9	294.34	247.36	254.76	265.49	86.55	3.03	2.71	2.66	2.80	87.79
Mean	303.17	265.26	248.34	272.26	82.40	2.85	2.56	2.35	2.59	82.58
L.S.D at 5%										
Varieties (V)	8.91	5.20	6.61	8.57		1.06	0.45	0.14	0.16	
Crop cycle (C)				8.85					0.47	
V x C				9.47					0.16	

Table 2. Mean performance and ratooning ability (RA %) of seven sugarcane varieties for number of millable cane and stalk weight in plant cane (PC), 1st ratoon (FR), 2nd ratoon (SR) and across crops (AC)

Varieties	**Number of millable cane x 10^3 /fed.**					**Stalk weight (Kg)**				
	PC	**FR**	**SR**	**AC**	**RA%**	**PC**	**FR**	**SR**	**AC**	**RA%**
G.2010 -26	42.84	50.40	32.34	41.86	42.84	0.95	0.83	0.79	0.86	83.16
G.2011-82	46.24	47.50	34.44	42.73	46.24	0.92	0.81	0.78	0.84	84.78
G.84-47	49.56	51.03	41.50	47.36	49.56	0.83	0.74	0.73	0.77	87.95
G.2003-47	51.24	54.60	43.26	49.70	51.24	1.07	0.88	0.91	0.95	85.05
G.2006-6	39.06	40.74	34.02	37.94	39.06	0.98	0.88	0.81	0.89	82.65
G.99-103	38.26	34.86	31.92	35.01	38.26	1.21	1.15	1.02	1.13	84.30
G.2010-7	45.78	55.44	37.80	46.34	45.78	0.91	0.71	0.77	0.80	84.62
Check- G.T.54-9	50.82	58.80	41.16	50.26	50.82	1.17	0.96	1.03	1.05	88.03
Mean	45.48	49.17	37.06	43.90	45.48	1.01	0.87	0.86	0.91	85.07
L.S.D at 5%										
Varieties (V)	4.12	5.12	5.73	2.73		0.14	0.08	0.07	0.05	
Crop cycle (C)				3.54					0.40	
V x C				3.00					0.07	

Table 3. Mean performance and ratooning ability (RA %) of seven sugarcane varieties for brix% and sucrose% in plant cane (PC), 1st ratoon (FR), 2nd ratoon (SR) and across crops (AC).

Varieties	Brix%					Sucrose%				
	PC	FR	SR	AC	RA%	PC	FR	SR	AC	RA%
G.2010 -26	20.13	17.97	18.11	18.74	89.97	14.81	14.00	13.90	14.24	93.86
G.2011-82	20.74	18.82	17.61	19.06	84.91	15.31	14.01	13.10	14.14	85.56
G.84-47	22.01	20.11	19.32	20.48	87.78	18.31	16.33	16.71	17.12	91.26
G.2003-47	21.23	20.71	19.80	20.58	93.26	16.43	15.31	15.22	15.65	92.64
G.2006-6	22.25	19.41	19.50	20.39	87.64	16.61	14.81	13.90	15.11	83.68
G.99-103	19.50	18.92	18.11	18.84	92.87	16.21	16.01	15.11	15.78	93.21
G.2010-7	20.40	19.60	18.53	19.51	90.83	15.21	15.11	15.00	15.11	98.62
Check- G.T.54-9	21.30	19.13	19.03	19.82	89.34	17.75	17.01	17.03	17.26	95.94
Mean	20.95	19.33	18.75	19.68	89.58	16.33	15.32	15.00	15.55	91.85
L.S.D at 5%										
Varieties (V)	0.59	0.53	0.54	0.30		0.41	0.29	0.22	0.17	
Crop cycle (C)				1.20					1.25	
V x C				1.01					0.66	

Table 4. Mean performance and ratooning ability (RA %) of seven sugarcane varieties for sugar recovery% and purity% in plant cane (PC), 1st ratoon (FR), 2nd ratoon (SR) and across crops (AC)

Varieties	Sugar recovery%					Purity%				
	PC	FR	SR	AC	RA%	PC	FR	SR	AC	RA%
G.2010 -26	9.26	9.06	8.92	9.08	96.33	73.57	77.91	76.75	76.08	104.32
G.2011-82	9.59	8.82	8.25	8.89	85.98	73.82	74.44	74.39	74.22	100.77
G.84-47	12.29	10.82	11.44	11.51	93.08	83.19	81.20	86.49	83.63	103.97
G.2003-47	10.59	9.60	9.77	9.99	92.27	77.39	73.93	76.87	76.06	99.33
G.2006-6	10.48	9.47	8.51	9.49	81.23	74.65	76.30	71.28	74.08	95.49
G.99-103	10.87	10.84	10.15	10.62	93.39	83.13	84.62	83.43	83.73	100.37
G.2010-7	9.59	9.72	9.92	9.74	103.46	74.56	77.09	80.95	77.53	108.57
Check- G.T.54-9	11.92	11.80	11.85	11.86	99.39	83.33	88.92	89.49	87.25	107.39
Mean	10.57	10.02	9.85	10.15	93.14	77.95	79.30	79.96	79.07	102.53
L.S.D at 5%										
Varieties (V)	0.22	0.44	0.26	0.18		1.58	1.46	2.45	1.02	
Crop cycle (C)				0.81					9.34	
V x C				0.50					4.50	

Table 5. Mean performance and ratooning ability (RA %) of seven sugarcane varieties for cane and sugar yields/fed in the plant cane (PC), 1st ratoon (FR), 2nd ratoon (SR) and across crops (AC).

Varieties	Cane yield /fed (ton)					Sugar yield /fed (ton)				
	PC	FR	SR	AC	RA%	PC	FR	SR	AC	RA%
G.2010 -26	40.70	41.83	25.55	36.03	62.78	3.77	3.79	2.28	3.28	60.47
G.2011-82	42.54	38.48	26.86	35.96	63.14	4.08	3.39	2.22	3.23	54.32
G.84-47	42.13	37.76	30.30	36.73	71.92	5.18	4.09	3.47	4.24	66.93
G.2003-47	53.83	48.05	39.37	47.08	73.14	5.70	4.61	3.85	4.72	67.47
G.2006-6	38.28	35.85	27.56	33.90	72.00	4.01	3.40	2.35	3.25	58.46
G.99-103	46.30	40.09	32.56	39.65	70.32	5.03	4.35	3.30	4.23	65.67
G.2010-7	41.66	39.36	29.11	36.71	69.88	4.00	3.83	2.89	3.57	72.27
Check- G.T.54-9	59.46	56.45	46.39	54.10	78.02	7.09	6.66	5.02	6.26	70.88
Mean	45.61	42.23	31.71	39.85	69.52	4.82	4.23	3.12	4.06	64.79
L.S.D at 5%										
Varieties (V)	5.80	4.50	6.41	3.04		1.264	0.37	0.35	0.42	
Crop cycle (C)				6.05					0.361	
V x C				3.32					0.54	

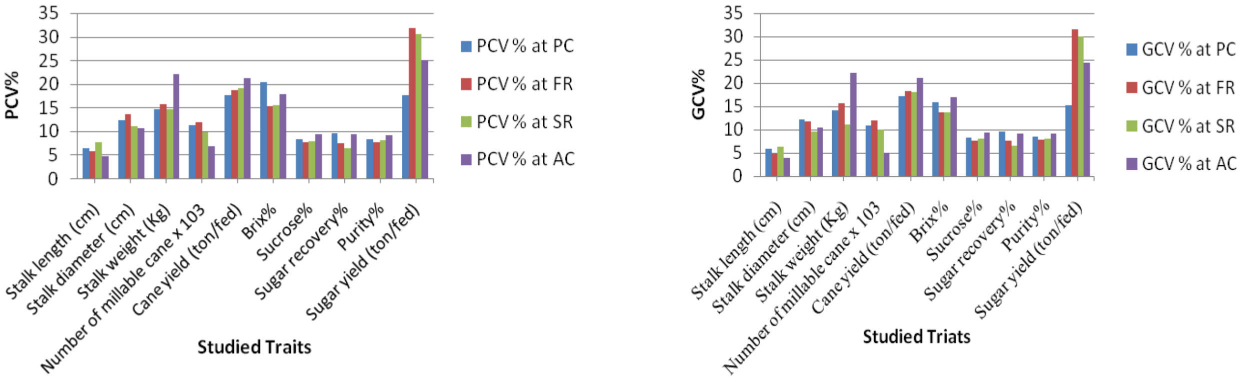


Fig.1 Phenotypic (PCV %) and genotypic coefficient of variance (GCV %) for all studied traits

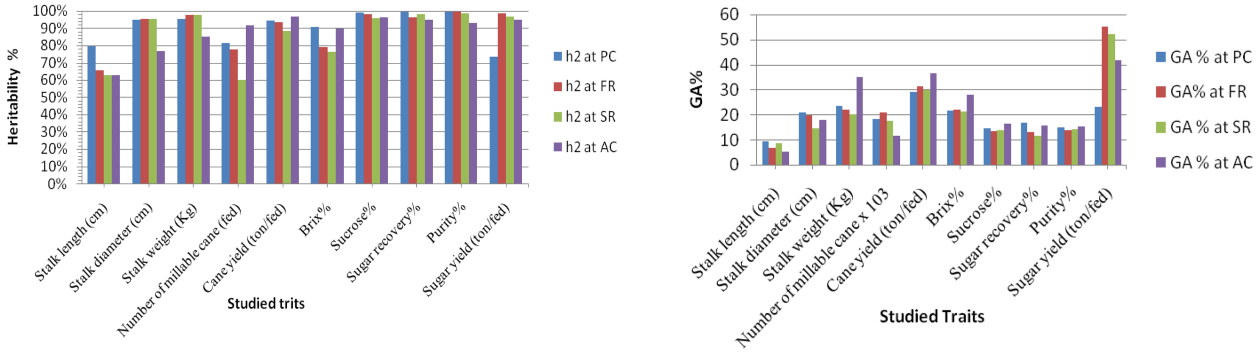
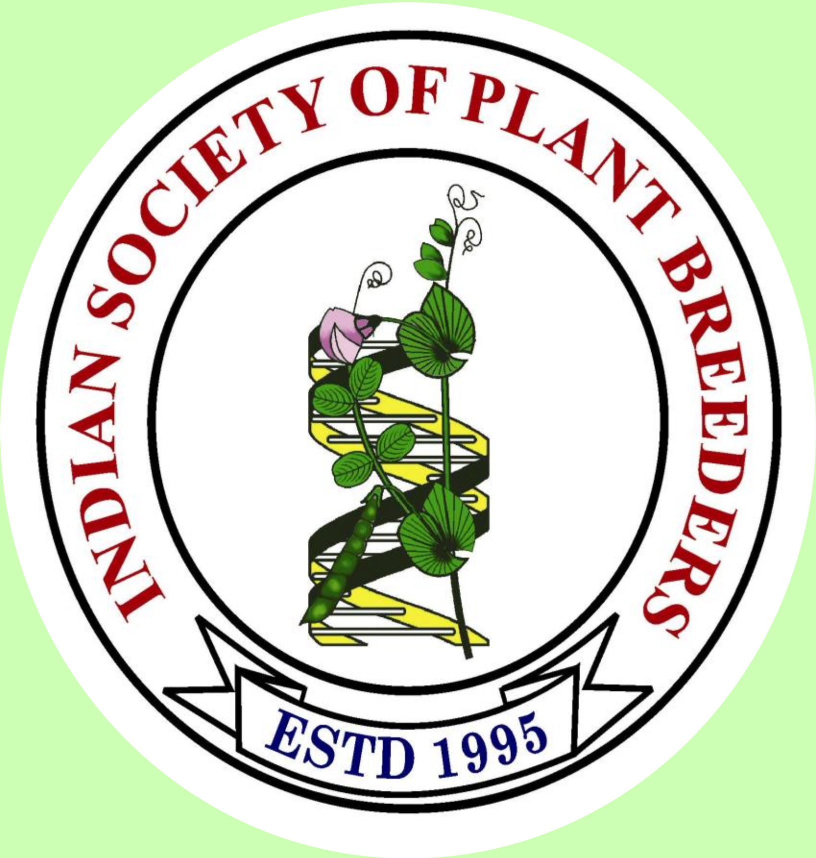


Fig.2 Broad sense heritability (H %) and genotypic advance% of mean (GA %) for all studied traits



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