Estimation of Genetic Variance and Broad Sense Heritability of Sugar Cane (*Saccharum* Spp. L.)

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ABSTRACT

The present investigation was carried out at the Sabahia Agricultural Research Station; Alexandria, Egypt as planted crop in the two spring seasons 2004/2005, 2005/2006, on ten sugar cane varieties. The objectives of this study were to determine means, ranges, coefficient of variability, variance components and broad sense heritability for some important characters in a population of ten sugar cane varieties. The studied characters are stalk length; stalk diameter, number of internodes, stalk weight, total soluble solid % (Brix), sucrose% and purity%. The ten varieties used in the present study were obtained from different countries. They were used as parents of the important varieties and as promising Egyptian ones. These varieties are Co.312, Co.421, from India; CP.44-101 from U.S.A., N.Co.310, from South Africa; Ph. 8013, from Philippine; and G.74-96, G.75-368, G.84-47, G.85-37, G.T.54-9, from Egypt. The variety Co.312 was one of the two parents of NCo.310, which had been used as pistil parent for G.T.54-9, G.85-37, G.84-47, G.74-96 and G.75-368. The variety, Cp.44-101, has been used as male parent of G.75-368. Highly significant differences were recorded for the tested varieties in all examined traits. The results indicated that, G.T.54-9, Ph.8013, G.85-37, G.75-368, varieties gave a good performance for the studied characters over both seasons. The studied estimates of coefficient of variability, genotype and phenotype were proven to be less than 10% for all studied characters except for the stalk weight. The genetic variance calculated for the different characters was essential in determining the phenotypic variance, which ranged from 0.0513 for stalk diameter to 8775.39 for stalk weight. The genetic variance for all studied characters was higher than that the environmental variance. Broad sense heritability estimates for sucrose percent was the largest one it recorded (96%), followed by stalk length (95%), stalk weight (94%), total soluble solids percent (93%), number of internodes (92%), purity present (89%) and stalk diameter (88%). This study suggests that genetic variance was the largest source of total variation for studied characters; therefore, the improvement of cane varieties will have more genetic progress and more effective through the seven studied characters. This result indicates that a significant improvement of stalk weight for new lines of sugar cane could be achieved. The chance would be capable to raise sugar cane varieties with good characters.

INTRODUCTION

Sugar cane flowering is highly affected by environmental conditions more than by genetic factors. In Egypt, specially after the success of sugar cane flowering naturally in Sabahia, Alexandria, Rao *et al.* (1973), this has facilitated breeding and developing sugar cane varieties through crossing methods, and evaluation the delivered clones in upper Egypt, where commercial sugar cane is produced.

Heritability in a broad sense is meaningful, in asexually propagated crops such as sugar cane, since all genetic variability is usable between asexual generations of selection. Estimating the heritability provides a measure of the effectiveness with which selection can be expected to exploit the genetic variability. Many quantitative inheritance studies have been conducted recently in order to obtain information on the inheritance of the important characters of sugar cane. Allam *et al*(1977) reported that a highly significant difference among clones was noted for cane yield and sugar yield, within all three cane types (plant, first-stubble and second-stubble).They reported that heritability estimates were (0.78, 0.83, 0.75) for plant cane, (0.87, 0.86, 0.82) for first- stubble, and (0.90, 0.89, 0.87) for second stubble. The heritability estimates were increased from type to type cane for all traits. Their high heritability values are of particular interest to the sugar cane breeder as they estimate the latitude for gain through selection. Although the total genetic variance component may contain dominance and epistatic effects, the expected gain from selection based on a broad sense heritability estimate should be appropriate since sugar cane is asexually propagated. Singh and Singh (1981) stimated high heritability for number of internodes per stem, height, number of green leaves per stem and Brix. Kang *et al.* (1983) estimated high broad sense heritability in two biparental crosses for various traits which were 84% for plant height, 94% for stalk diameter, 93% for stalk weight, and 91% for sucrose content. El Manhaly *et al* (1987), studied sugar cane flowering and seed setting under Alexandria condition. He reported that the flowering percentage varied between and within varieties from less than 40% to more than 70%. Milligan *et al.* (1990), mentioned that the phenotypic variance was similar to error variance for stalk weight in plant

crop and the estimates of stalk weight heritability was among the largest observed of all traits. However, the heritability of sucrose concentration and Brix was relatively high. Chang (1996) estimated 0.955, 0.944 and 0.965 broad sense heritability for Brix, purity and sugar content, respectively. Chang (1997) found that the broad sense heritability of Brix is similar to that of sugar content during the whole maturity stages. Younan *et al* (1997) found that the broad sense heritability ranged from 61.3% for number of green leaves to 85.32% for number of internodes. The genetic variance calculated for the different characters was essential in determining the phenotypic variance, which ranged from 0.0148 for stalk weight to 123.626 for stalk length. The variance due to the interaction of genotype X environment was secondary to genetic variance, while the error variance which refers to the environmental variance was the smallest part of the phenotypic variance. El Taib *et al* (2005)evaluated some selected genotypes of sugar cane. They found significant differences between environment and genotype interaction for stalk weight, number of millable cane, net cane yield (t/fed), theoretical sugar recovery%, and sugar yield (t/fed). Ghura (2005) found that the broad sense hertability ranged from 90%for stalk diameter and sucrose percent to 78% for purity percent. The genetic variance ranged from 0.209 for stalk diameter to 93.51 for stalk length. The genotypic coefficient of variability (GCV %)for the studied characters ranged from 9.27% calculated for total soluble solids percent (Brix) to 32.7% for stalk weight. The phenotypic coefficient of variability (PCV %)ranged from 10.02% to 35.14% for total soluble solids percent (Brix) and stalk weight respectively.

The objectives of this work were to estimate genetic and environmental variance components for some important characters of sugar cane, to determine the relative importance of genetic and environmental variances in influencing the phenotypic variance, and to estimate broad sense heritability for some important characters of ten sugar cane varieties to produce seed setting every year and have been used as parents in the breeding program.

MATERIALS AND METHODS

The present investigation was carried out at the Sabahia Agricultural Research Station; Alexandria, Egypt as planted crop in the two spring seasons 2004/2005, 2005/2006, on ten sugar cane varieties used to reach complete flowering at Sabahia area during the last twenty years. They are characterized with high cane stalk weight, good thickness, tall and high sugar content. Because of their good characteristics, they have been chosen to be as start for breeding programs for

developing promised sugar cane varieties for Egypt and other similar countries.

A randomized complete block design with four replications in a factorial experiment was used in this study. Cuttings of the ten varieties were planted at the end of march and the beginning of April of the two seasons respectively, as spring planting. Each variety was sown in plots containing 7 ridges 1.5 meter in width and 5 meters in length. The distance between cuttings was 30cm. Each cutting contained two buds. The plot area was 52.5m2 (10.5m x 5.0m). All recommended agricultural practices needed for growing sugar cane crop were applied in both seasons. In each season, harvest took place ten months after planting. Thirty plants were randomly taken from each plot to study the following characters: stalk length, stalk diameter, number of internodes, stalk weight, total soluble solid % (Brix), sucrose % and purity %.

Analysis of variance components was performed for each character. Variance components were calculated by equating appropriate mean squares to their expectation, according to Steel and Torrie (1980). The treatment means were compared by using the least significant differences (L.S.D.) test by Waller and Duncan, 1969 at 5% and 1% levels of probability. The homogeneity tests of error variances of both seasons indicated that error terms were homogenous then the combined analysis was used for the traits measured at both seasons. Broad sense heirtability (h2) estimates were calculated on a plots mean, according to Hogarth (1977), with the formula:

$$h^2 = \sigma^2 g / \sigma^2 ph$$

Where:

$\sigma^2 g$ = the genetic variance was calculated from the formula

$$= \frac{MS_V - MS_{Vy}}{r.y}$$

$\sigma^2 ph$ = the phenotypic variance = $\sigma^2 g + \sigma^2 g\, y + \sigma^2 e/ry$

Where:

MS_v = the mean square of the varieties

$MS_{v\,xy}$ = variance due to interaction of variety X year.

$\sigma^2 g\, y$ $\left\{ \begin{array}{l} \text{= The mean squares of the interaction} \\ \quad \text{of varieties and years.} \\ \text{= (} MS_{vy} - MS_e \text{) / r} \end{array} \right.$

R   = number of replicates

Y   = number of years

$\sigma^2 e$ = the error variance

The components $\sigma^2 ph$ and $\sigma^2 g$ are used for estimation of other statistics such as :-

Phenotypic coefficient of variation (P.C.V.) =

$$\sqrt{\frac{\sigma^2ph}{\bar{X}}} \text{ x100}$$

Genotypic coefficient of variation (G.C.V.) =

$$\sqrt{\frac{\sigma^2g}{\bar{X}}}\text{x100}$$

RESULTS AND DISCUSSION

Analysis of variance for the seven studied quantitative characters (stalk length, stalk diameter, number of internodes, stalk weight, total soluble solids, sucrose percentage and purity percentage) for the ten tested sugar cane varieties are presented in Table(1). Highly significant differences were noticed for the tested varieties in all examined traits. With regard to the interaction between varieties and years, highly significant differences were found for stalk length, stalk weight, total soluble solids, sucrose percentage and purity percentage, significant differences was found for number of internodes, no significant differences in stalk diameter had achieved. Mean values for different characters of ten sugar cane varieties for the two seasons are presented in Table(2). The data show that, G.T. 54-9 variety had the highest values in stalk length, stalk diameter, stalk weight and total soluble solids percentage. Ph.8013, variety had the highest values in number of internodes, sucrose percentage and purity percentage. These increased values have no significance, compared to G.T.54-9 variety. While, CP.44-101variety had the lowest values in stalk weight, total soluble solids percentage, sucrose percentage and purity percentage. Varieties X year's interactions were apparent in the rankings of the varieties in the two examined years. The evaluation of the studied varieties indicated that G.T. 54- 9, Ph. 8013, G.85-37, and G.75-368 varieties gave a good performance for the seven studied characters over both seasons.

Means, ranges, coefficients of variability percent (genotypic and phenotypic), variance components (genotypic and phenotypic), and broad sense heritability for the seven studied characters, of a population of ten varieties of sugar cane are tabulated in table(3). As shown from this table considerable variations in range among varieties are found. The values of stalk length ranged from 205.75 to 299.75 cm., with mean value equal to 231.97 cm. The value of stalk diameter ranged from 3.17 to 5.16 cm, with mean value = 3.83 cm. The value of number of internodes ranged from 11.14 to 16.46 nodes, with mean value = 14.01 nods. The range and mean of stalk weight (g.) ranged from 433.5 to 939.5 with mean value = 734.6 g. The values of (T.S.S.

%) and sucrose (%) ranged from 17.8% to 21.83% and 12.24 to 15.28% with mean value equal 20.10% and 14.1% respectively. The values of purity (%) ranged from 64.59% to 79.73% with mean value equal 73.4%.The studied results for coefficient of variability percent (genotypic and phenotypic) were less than 10%, for all characters, except for the stalk weight. On the other side, variance components and broad sense heritability for the seven studied characters are shown in the same table. As shown in this table the genetic variance for all studied character was higher than the environment and the interaction variances. So when estimated broad sense heritability for sucrose percent was the largest one it recorded (96%), followed by stalk length (95%), stalk weight (94%), total soluble solids (93%), number of internodes (92%), purity percent (89%), and stalk diameter (88%). This is due to the high genetic variance obtained for the seven characters compared to the other two variances. This study suggested that genetic variance was the largest source of total variation for studied characters. These results are in good agreement with those reported by several authors (e.g. Gaber *et al* 1990; Tawfic *et al* 1997; Younan *et al* 1997, Ghura 2005 and Saleh *et al* 2006). Therefore, the improvement of cane varieties will have more genetic progress and more effective through the seven studied characters.This result indicated that a significant improvement for new lines could be achieved, and the chance will be to raise new varieties of sugar cane clones in Egypt characterised with good characters.

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الملخص العربي

تقدير التباين الوراثى ومعامل التوريث بالمعنى الواسع لنبات قصب السكر

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اجريت هـذه الدراسـة فى محطة البحـوث الزراعيـة بالصبحية بالاسكندرية خلال مـوسمى الزراعة الربيعى لزراعة القصب الغرس فى مـوسمين متتـاليين همـا موسم الزراعة الربيعى لغرس 2004/2005 وموسم الزراعة الربيعى لغرس 2005/2006.

الهدف من اجراء هذا البحث هو تقدير بعض المقاييس والثوابت الاحصائية مثل المتوسط والمدى ومعامل الاختلاف الـوراثى والبيئى ودراسة مكونات التباين وتقدير درجة توريث الصفة بالمعنى الواسع وذلك لدراسة الصفات الاتية: طول العود، سمك العود، عدد العقل، وزن العود نسبة المواد الصلبة الذائبة، نسبة السكروز واخيرا درجة النقاوة، وقد اجريت الدراسة فى عشيرة مكونة مـن عشـرة اصناف قصب السكر ربيت فى مناطق وخطوط عرض مختلفة وهذه الأصناف تمثل اصناف تجارية او اباء تربية. من هذه الاصناف كوامباتور312 وكوامباتور 421 مـن الهنـد، والصنف كـانال بويت 44–101مـن الولايات المتحدة ، وصنف ناتال كوامباتور 310 من جنوب افريقيا والصنف الفلبينى 8013 امـا الاصنـاف التاليـة الخمسة تم استنباطها مـن مصر وهى جيـزة تايوان54–9 ، جيـزة 85–37، جيـزة 84– 47، وجيـزة 75–368واخـيرا جيـزة 74–96فقـد كـان الصنف كوامباتور 312 احـد اباء الصنف التجـارى، ناتال كوامباتور310 وهذا الاخير هو الاب المؤنث للاصناف المصرية جيزة تايوان 54–9 ، جيـزة 85–37، وجيـزة 84–47وجيـزة 74–96 واخـيرا جيـزة 75–368.امـا الصنف كـانال بوينت 44–101 فقـد كـان الاب المذكر لجيزة 75–368.

اوضحت النتائج وجود اختلافات عالية المعنوية فى جميع التجارب التى اجريت وقد اظهرت النتائج ان الاصناف جيزة

تايوان54–9 والصـنف الفلبينى 8013 والاصناف المصرية جيزة 37–85، جيزة 74–368،كانت متفوقة للصفات السبع المدروسة خلال موسمى الزراعة.

وقد اظهرت الدراسة ان معامل الاختلاف الوراثى والمظهرى كانا اقل من10%وذلك لجميع الصفات المدروسة ماعدا صفة وزن العود.

عند تقدير التباين الوراثى والمظهرى للصفات المدروسة فقد كانت قيمـة التباين المظهـرى مـا بـين0.0513 لصفة سمك العـود الى 8775.39 لصفة وزن العود ، وكان معامل التباين الوراثى اعلى من معامل التباين البيئى لجميع الصفات المدروسة . امـا بالنسبة لدرجة التوريث بالمعنى الواسع فكانت(96%) لصفة النسبة المئوية للسكروز، ثم تلى ذلك صفة طول العود وكانت درجة توريثه (95%)ثم صفة وزن العود كانت درجة توريثه (94%)، ثم صفة النسبة المئوية للمواد الصـلبة الذائبـة فكانـت(93%)ثم صـفة عـدد العقـل فى العـود فكانـت(92%) يلى ذلك صفتى درجة النقاوة ثم سمك العود فقد سجلا نسبة (89%)، (88%)على التوالى.

ومن هذا يتضح ان معامل التوريث للصفات تحت هذه الدراسة كان مرتفعا، وان التباين الوراثى كان له دور اساسى فى تحديد التباين المظهرى، وبالتـالى فالتباين الخـاص بالتفاعـل بـين التركيب الجينى والظروف البيئية كان ثانويا لمعظم الصفات تحت الدراسة. وعليه فانه يؤخذ فى الاعتبار فى برامج تربية قصب السكر، ان التحسين سوف يكون مـا يكون لصفات وزن العـود والنسبة المئوية للسكروز وللمـواد الصـلبة الذائبـة وبذلك سـتكون الفرصـة متاحـة لاستنباط اصناف وتراكيب وراثيـة جديدة مـن قصب السكر تتصف بارتفاع المحصول تحت الظروف المصرية.