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Selection Indices for CCS yield in Sugarcane (*Saccharum* spp.)

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ABSTRACT: *Seventy seven genotypes of sugarcane were evaluated in second clonal stage. Selection indices were formulated considering CCS yield and eleven of its component characters which showed high correlation with cane yield. Among twelve characters, commercial cane sugar yield (X_1) was considered as dependent character while, other characters viz., shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), brix per cent (X_5), sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8), total sugars per cent (X_9), fibre yield (X_{10}), theoretical yield of alcohol (X_{11}) and cane yield (X_{12}) were considered as independent variables. From the results it was evident that all the selection indices included cane yield which indicated that cane yield was the most important character for commercial cane sugar yield. For indirect selection, the index based on shoot population at 240 DAP (X_2), number of millable canes (X_3), fibre yield (X_{10}) and cane yield (X_{12}) exhibited high relative efficiency of 1686.17 coupled with high genetic advance of 54.39.*

INTRODUCTION

Sugarcane is an important cash crop and raw material for sugar industry which is the second largest agro based industry of India. It assumes an important position in the economy of the country. Its contribution to agricultural GDP is 10% which is significant as the crop is grown in only 2.57% of the gross cropped area in the country (SBI, 2011). Sugarcane crop serves as the major source for a variety of products such as sugar, jaggery, molasses, bagasse, filter cake, out of which sugar and jaggery are meant for daily use as consumable products while other byproducts have industrial significance.

Sugarcane is grown in an area of 17.53 M ha worldwide producing 1286.67 M t of cane with a productivity of 73.40 t ha^{-1} (FAOSTAT, 2011). In India sugarcane is cultivated in an area of 5.03 M ha producing 342.19 M t of cane with an average productivity of 68.1 t ha^{-1} (Sugar India, 2012). In India sugarcane is grown in both tropical and sub tropical regions. Uttar Pradesh, Maharastra, Karnataka, Tamil Nadu, Gujarat and Andhra Pradesh are the major cane growing states. In Andhra Pradesh it is grown in an area of 1.8 lakh ha producing 140.4 lakh tonnes of sugarcane with an average productivity of 78.0 t ha^{-1} (Sugar India, 2012). In India 24.39 M t of sugar is produced, but the projected requirement of sugar by 2030 is 36 M t which has to be achieved from the existing cane area through improved varieties for cane yield and sugar recovery as further expansion in area is not possible.

The main objective of a selection programme is to shift the mean to a new peak by directional selection. Continuous selection in one character may result in a loss or gain in the other characters, which are also of equal importance. On the other hand, if selection is made for a number of characters, the efficiency of selection would be reduced. So the plant breeder will have to base his selection on a combination of a few important characters related to the main character under consideration in the form of a selection index by appropriate weightages assigned to the phenotypic values of each character so that the genetic gain in the character under consideration will be maximum without any loss in other important characters. Selection indices provide the means for making use of correlated characters for higher efficiency in selection for characters of low heritability. Selection index is a tool, which breeder can use successfully for selection on several characters

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simultaneously by discriminating the desirable ones on the basis of phenotypic performance.

MATERIAL AND METHODS

The present investigation was carried out at Agricultural Research Station, Perumallapalle (Acharya N. G. Ranga Agricultural University), situated in the Southern Agro-climatic Zone of Andhra Pradesh with seventy seven genotypes of sugarcane that were planted in a randomized block design with two replications during April, 2011. Each entry was planted in 2 rows of 5 m length spaced at a distance of 80 cm between rows with 4 three budded setts per meter as seed rate.

Observations were recorded on each entry for the traits viz., no. of tillers at 120 DAP, shoot population at 180, 240 DAP, NMC at harvest, no. of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane (kg), internode number, internode length (cm), stalk length (cm), stalk diameter (cm), stalk volume (cm^3), single cane weight (kg), fibre content (%), Brix (%), sucrose (%), CCS (%), juice purity (%), pol % cane, juice extraction (%), total sugars (%), fibre yield (tha^{-1}), CCS yield (tha^{-1}), theoretical yield of alcohol (g/100ml) and cane yield (tha^{-1}).

The technique of Discriminant function developed by Fisher (1936) was adopted to know the true genotypic worth of yield and its components and to have computational formulae for construction of selection indices which when applied to select plants can bring about effective improvement in yield compared to straight selection for yield. Smith (1936) has illustrated the use of discriminant function in plant selection. A number of different selection indices are constructed using 2, 3,……, n combination of characters. The expected genetic advance based on the composition of characters that was included for formulation of the various selection indices was calculated as per the formula of Robinson *et al.* (1951). The relative efficiency of each selection index formulated was evaluated by comparing with yield alone which is considered as 100 per cent efficient as given by Brim *et al.* (1959).

RESULTS AND DISCUSSION

Selection indices were formulated for commercial cane sugar yield considering eleven of its component characters which showed high correlation with commercial cane sugar yield in second clonal generation. Among twelve characters, commercial cane sugar yield (X_1) was considered as dependent character while other characters viz., shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), brix per cent (X_5), sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8), total sugars per cent (X_9), fibre yield (X_{10}), theoretical yield of alcohol (X_{11}) and cane yield (X_{12}) were considered as independent variables. Selection indices showing higher relative efficiencies based on different character combinations along with their genetic advance and relative efficiency over straight selection for commercial cane sugar yield are presented in Table 1.

Higher relative efficiency of 1828.82 coupled with high genetic advance (59.00) was exhibited by the combination involving all the twelve traits viz., commercial cane sugar yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), single cane weight (X_4), brix per cent (X_5), sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8), total sugars per cent (X_9), fibre yield (X_{10}), theoretical yield of alcohol (X_{11}) and cane yield (X_{12}) followed by eleven character combination excluding commercial cane sugar per cent (X_7); ten character combination excluding single cane weight (X_4) and commercial cane sugar per cent (X_7); nine character combination excluding sucrose per cent (X_6), commercial cane sugar per cent (X_7), pol per cent cane (X_8).

Among single characters, cane yield (X_{12}) was highly efficient with relative efficiency of 861.95 and high genetic advance of 27.81, compared to the direct selection based on commercial cane sugar yield (X_1). Whereas among two character combinations, maximum relative efficiency of 1234.09 was observed for the combination of number of millable canes (X_3) and cane yield (X_{12}) with high genetic advance of 39.81. However, in case of three character combinations, the combination involving shoot population at 240 DAP (X_2), number of millable canes (X_3) and cane yield (X_{12}) exhibited high relative efficiency of 1580.55 coupled with high genetic advance of 50.99.

Among four character combinations, selection index based on shoot population at 240 DAP (X_2), number of millable canes (X_3), fibre yield (X_{10}) and cane yield (X_{12}) exhibited high relative efficiency of 1686.17 coupled with high genetic advance of 54.39. This selection index could be used for indirect selection of commercial cane sugar yield. All the other combinations which showed higher relative efficiency and genetic advance included commercial cane sugar yield.

Whereas among five character combinations, maximum relative efficiency of 1765.98 was observed

Table 1
Discriminant Functions, their Genetic Advance (GA) and Relative Efficiency (RE) over Straight Selection for Commercial Cane Sugar Yield

S.No	*Discriminant function*	*GA*	*RE*
1	Y= 0.92X1	3.23	100.00
2	Y= 0.92X2	14.49	449.32
3	Y= 0.91X12	27.81	861.95
4	Y= 0.81X1 + 0.92X12	30.55	946.90
5	Y= 0.99X2 + 0.91X12	38.12	1181.81
6	Y= 0.77X3 + 1.01X12	39.81	1234.09
7	Y= 0.83X1 + 1.00X2 + 0.91X12	40.66	1260.47
8	Y= 1.02X1 + 0.80X3 + 0.98X12	42.59	1320.17
9	Y= 1.09X2 + 0.73X3 + 0.99X12	50.99	1580.55
10	Y= 1.14X1+ 1.09X2 + 0.75X3 + 0.96 X12	53.56	1660.27
11	Y= 1.11X2 + 0.76X3 + 0.78X10 + 0.99X12	54.39	1686.17
12	Y= 1.14 X1+ 1.11X2 + 0.79X3 + 0.75 X10 + 0.96X12	56.97	1765.98
13	Y= 1.14X1 + 1.11X2 + 1.70X3 + 70.55X4 + 0.82X10 +0.31X12	57.13	1770.89
14	Y= 1.15X1+ 1.11X2 + 0.78X3 + 1.05X9 + 0.72 X10 +0.97X12	57.72	1789.24
15	Y= 1.15X1+ 1.12X2 + 1.70X3 + 71.11 X4 + 1.05 X9 +0.79X10 + 0.31X12	57.88	1794.07
16	Y= 1.22X1+ 1.11X2 + 0.79X3 + 0.95X9 + 0.74X10 +1.09X11 + 0.96X12	58.17	1803.10
17	Y= 1.20X1 + 1.11X2 + 1.73X3 + 72.91X4 + 0.88X9 +0.82X10 + 1.23X11 + 0.28X12	58.32	1807.98
18	Y= 0.79X1 + 1.11 X2 + 0.78X3 + 1.36X5 + 1.01 X9 +0.72X10 + 1.04X11 + 1.00X12	58.33	1808.29
19	Y= 0.57X1 + 1.12X2 + 1.75X3 + 74.40X4 + 1.54X5 +0.95X9 + 0.79X10 + 1.18X11 + 0.33X12	58.49	1813.22
20	Y= 0.65X1 + 1.12X2 + 1.74X3 + 74.14X4 + 1.54X5 +0.91X6 + 0.98X9 + 0.79X10 + 1.17X11 + 0.33X12	58.63	1817.53
21	Y= 0.52X1+ 1.12X2 + 1.74X3 + 74.19X4 + 1.37X5 +1.19X8 + 0.96X9 + 0.82X10 + 1.18X11 + 0.34X12	58.65	1818.06
22	Y= 0.65X1 + 1.12X2 + 0.77X3 + 1.26X5 - 3.56X6 +6.54X8 + 1.09X9 + 1.47X10 + 0.99X11 + 0.91X12	58.72	1820.23
23	Y= 0.46X1 + 1.12X2 + 1.72X3 + 73.16X4 + 1.29X5 -0.87X6+ 3.50X8 + 1.00X9 + 1.13 X10 + 1.16X11+ 0.31X12	58.87	1824.96
24	Y= -1.13X1+ 1.11X2 + 1.83X3 + 81.76X4 + 2.21X5 - 4.78X6 + 5.21X7 + 5.02X8 + 1.11X9 + 1.30X10 +1.05X11 + 0.38X12	59.00	1828.82

X1 = Commercial cane sugar yield
X2 = Shoot population at 240 DAP
X3 = Number of millable canes
X4 = Single cane weight
X5 = Brix percent
X6 = Sucrose percent
X7 = Commercial cane sugar percent
X8 = Pol % cane
X9 = Total sugars percent
X10 = Fibre yield
X11 = Theoretical yield of alcohol
X12 = Cane yield

Table 2
Top Ranking Genotypes (10%) based on the Best Selection Index for CCS Yield in Sugarcane
Commercial Cane Sugar yield
(t ha^{-1})

Rank	*Genotype*	*Mean*	*Index score*
1	2010T-115	17.41	675
2	2010T-146	18.91	652
3	2010T-103	17.75	626
4	2010T-72	16.00	614
5	2010T-347	13.89	610
6	2010T-4	20.73	598
7	2010T-229	14.32	589
Mean of the above seven genotypes		17.00	
Population mean		12.02	
%gain over Population mean		141.40	

for the index based on commercial cane sugar yield (X_1), shoot population at 240 DAP (X_2), number of millable canes (X_3), fibre yield (X_{10}) and cane yield (X_{12}) with high genetic advance of 56.97. When total sugars per cent (X_9) was included to this selection index the relative efficiency was 1789.24 with genetic advance of 57.72. To this selection index, inclusion of theoretical yield of alcohol (X_{11}) resulted in a relative efficiency of 1803.10 and genetic advance of 58.17. Among seven character combinations inclusion of brix per cent (X_5) further increased the relative efficiency to 1808.29 and genetic advance to 58.33 among eight character combination.

Scoring of sugarcane genotypes for commercial cane sugar yield based on the best selection index is

depicted in Figure 1. Selection of top ten percent of the genotypes (Table 2) based on the best selection index has shown 141.40% gain over population mean.

From the results it was evident that all the selection indices included cane yield which indicated that cane yield was the most important character for commercial cane sugar yield. Similar kind of results were reported by Miller *et al.* (1978) and Singh and Khan (2003).

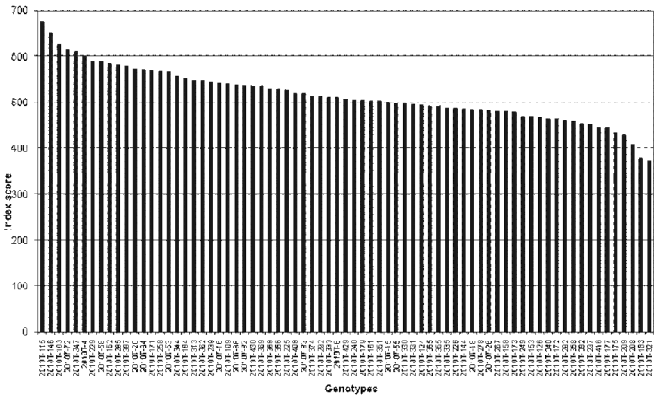

Figure 1: Selection Index Score of Sugarcane Genotypes for Commercial Cane Sugar Yield

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