



## Selection Indices at Three Stages of Selection in Sugarcane

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### ABSTRACT

Selection indices were constructed in a study comprising 38 biparental crosses and 18 GCs in seedling and clonal stages. Weighing coefficient values estimated were observed to be high for single cane weight in all the three stages of selection. Expected genetic advance and relative efficiency were found low, when the characters were studied individually over direct selection for cane yield alone. A progressive increase in genetic advance and relative efficiencies were noted when the number of characters included were increased. Among the parameters studied, shoot population at 120 DAP, NMC, cane length, cane diameter, single cane weight and brix per cent were found relatively more important. Selection indices involving more than one character resulted in higher genetic gain and relative efficiency. Sequential selection indices constructed indicated that genetic advance and relative efficiency were increased linearly with simultaneous inclusion of component characters viz., cane yield, sugar yield, number of green leaves, leaf area index, shoot population at 120 DAP, NMC, single cane weight, cane length, cane diameter, brix, sucrose, CCS and purity per cent in a combination suggesting that multi trait selection may be useful in bringing improvement in cane and sugar yields.

**Key words :** Genetic advance, Relative efficiency, Selection indices, Weighing coefficient Sugarcane.

Cane yield is a highly complex quantitative character influenced by several component characters, hence direct selection is not reliable. Discriminate function developed by Smith (1936) helps to discriminate undesirable clones on the basis of phenotypic performance and formulate selection indices. Selection indices are useful in understanding the extent of improvement in yield that can be achieved by a combination of characters. Studies on selection indices in sugarcane are limited. Hence, an attempt was made to identify the combination of characters that are more effective than direct selection for cane yield alone and to construct selection indices for cane yield based on simultaneous selection of component characters.

### MATERIAL AND METHODS

The experimental material comprising of 38 biparental crosses and 18 GCs were transplanted in an augmented design (Federer, 1956) in 18 blocks along with four standards viz., Co 6907, 87A 298 (early), Co 7219 and Co 86249 (mid late) in 10 meter row length at 80 x 40 cm spacing during April, 2007. Five hundred and twenty genotypes were selected in seedling stage and planted during 2008-09 in two rows of 2.5 meter row length spaced at 80 cm apart in ARCBD along with four standards. One hundred and fourteen genotypes were selected in the first

clonal stage for further study in second clonal generation. Each clone was planted in four rows of five meter row length spaced at 80 cm during the third week of April, 2009 in ARCBD with four standards. Data on number of canes per clump at harvest, single cane weight, cane length, cane diameter, cane yield, HR brix per cent and cane volume in seedling nursery and number of green leaves, leaf area index and shoot population at 120 DAP, number of millable canes at harvest, cane yield, CCS yield, single cane weight, cane length, cane diameter, brix per cent, sucrose per cent, CCS per cent and purity per cent were recorded / estimated in first and second clonal generations.

Twenty seven clones were selected based on number of millable canes, cane length, cane diameter, single cane weight, juice quality parameters viz., brix, sucrose per cent and desired morphological characters at second clonal generation. Selections were made based on the selection criteria mentioned in Table 1.

The expected genetic advance was calculated by constructing discriminant functions and relative efficiency of each discriminant function and was estimated according to Robinson *et al.* (1951). The relative efficiency index was expressed as the percentage ratio of genetic gain by the index to the genetic gain by the direct selection. The relative

Table 1. Selection criteria of the clones.

Sl. No.	Character(s)	Selection Criteria (per plot basis)
1	Number of millable canes	> 100.00
2	Cane length (cm)	> 225.00
3	Cane diameter (cm)	> 2.20
4	Single cane weight (kg)	> 1.10
5	Brix per cent	> 18.00
6	Sucrose per cent	> 16.00

Table 2. Economic weights (a.i.) and weighing coefficients ( $\beta_i$ ) in seedling and clonal stages in Sugarcane.

Variable(s)	Economic weight (a.i.)	Weighing coefficients ( $\beta_i$ )		
		Seedling nursery	Settling nursery	Selection nursery
No. of green leaves 120 DAP	1.00	—	5.98	8.50
Leaf area index at 120 DAP	1.00	—	-27.31	-24.05
Shoot population at 120 DAP	1.00	—	0.47	0.67
Number of millable canes plot <sup>-1</sup>	1.00	0.88	-4.48	-1.57
Cane yield (kg plot <sup>-1</sup> )	1.00	8.64	14.20	-0.58
CCS yield (kg plot <sup>-1</sup> )	1.00	—	-57.11	32.75
Single cane weight (kg)	1.00	71.71	905.25	273.83
Cane length (cm)	1.00	0.30	0.23	0.65
Cane diameter (cm)	1.00	47.40	46.07	27.35
Brix (%)	1.00	0.63	-41.11	22.98
Sucrose (%)	1.00	—	160.41	66.09
CCS (%)	1.00	—	-87.57	-169.01
Purity (%)	1.00	—	1.43	14.20
Cane volume	1.00	11.84	—	—
HR Brix (%)	1.00	0.63	—	—

efficiency of direct selection for cane and sugar yield was considered as 100%.

Sequential selection index was calculated using the formula given by Singh and Chaudhary (1985). Six indices were constructed at the seedling stage taking combinations of characters. Cane yield was taken as the final product and equal weightage was given to all components and twelve indices were constructed for the clonal stages.

In order to determine the relative efficiency (%) of various selection indices, the expected genetic advance was expressed as per cent of genetic advance expected from selection on the basis of cane yield alone. Expected genetic advance at 5% selection intensity and relative efficiency of cane yield alone was taken as 100% and relative efficiency of other functions were estimated with reference to cane yield.

## RESULTS AND DISCUSSION

Cane yield was taken as the final product and equal weightage was given to all components. Economic weight was taken as 1.00 for all characters since the method will give more weight to small values as compared to larger values and also equal importance to all characters. The economic weight (a) values allotted for each character along with weighting coefficient (b) values estimated in seedling and clonal stages are presented in Table 1.

Single cane weight (71.71) showed higher weighing coefficient value followed by cane diameter (47.40), cane volume (11.84), stalk yield (8.64), number of canes per clump (0.88), HR brix per cent (0.63) and cane length (0.30) in seedling nursery.

Single cane weight recorded higher weighing coefficient value (905.25) followed by sucrose per cent (160.41), cane diameter (46.07), cane yield

Table 3. Sequential selection indices in seedling nursery based on characters combinations in Sugarcane.

Character(s)	Economic weight (a.i.)	Genetic advance	Relative efficiency (%)
Cane yield	1.00	0.27	100.00
Single cane weight	1.00	1.54	565.25
Cane length	1.00	22.38	8217.40
Cane yield + cane length	1.00	23.91	8781.25
Cane yield + single cane weight + cane length	1.00	24.12	8857.81
Cane yield + Single cane weight + Cane length + cane diameter	1.00	24.18	8881.48
Cane yield + single cane weight + cane length+ cane volume	1.00	24.37	8948.81
Cane yield + single cane weight + cane length + cane diameter + cane volume	1.00	24.88	9137.95

(14.20), number of green leaves 120 DAP (5.98), purity per cent (1.43), shoot population at 120 DAP (0.47) cane length (0.23), CCS per cent (-87.57), CCS yield (-57.11), brix per cent (-41.11) leaf area index at 120 DAP (-27.31), number of millable canes per plot (-4.48) in first clonal stage (Table 2).

In second clonal stage, single cane weight showed higher weighing coefficient value (273.83) followed by sucrose per cent (66.09), CCS yield (32.75), cane diameter (27.35) brix per cent (22.98), purity per cent (14.20), number of green leaves at 120 DAP (8.50), shoot population at 120 DAP (0.67), cane length (0.65), CCS per cent (-169.01), leaf area index at 120 DAP (-24.05), number of millable canes (-1.57) and cane yield (-0.58) (Table 2).

In the present study, higher weighing coefficient values were observed for single cane weight in all the three generations followed by cane diameter in seedling and per cent juice sucrose in clonal stages. The cross combinations *viz.*, 86A146 x Co86011, 81V48 x CoT8201, 87A380 x Co87268, 86A146 x CoH107, Co8371 x 89V74, 87A298 x Co94008, 81V48 x CoA7602, CoC85061 x MS6847, 87A298 x 89V74 and 81V48 x Co94008, recorded maximum selection criterion values in seedling nursery when selection indices were constructed based on number of canes per clump, single cane weight, cane length, cane diameter, cane volume, HR brix and cane yield.

In the first clonal stage, out of 520 clones studied 114 clones were selected for evaluation in second clonal stage. Out of 114 clones, 27 clones *viz.*, 2008A15, 2008A73, 2008A74, 2008A104,

2008A105, 2008A112, 2008A113, 2008A120, 2008A124, 2008A154, 2008A159, 2008A160, 2008A171, 2008A187, 2008A234, 2008A236, 2008A241, 2008A357, 2008A380, 2008A387, 2008A465, 2008A419, 2008A427, 2008A458, 2008A440, 2008A257 and 2008A470 recorded higher selection criterion values and were located on top 50 clones in first clonal stage and in the top 35 clones the second clonal stage. Selection indices when constructed with the inclusion of number of green leaves, leaf area index, shoot population at 120 DAP, number of millable canes per plot, cane length, cane diameter, single cane weight, brix per cent, sucrose per cent, purity per cent, CCS per cent, cane yield and CCS yield were found superior over direct selection in both the clonal stages. The present findings are in agreement with the findings of Doule and Balasundaram (2006), Kumar *et al.* (2007), Sahu *et al.* (2008) and Sirisha *et al.* (2010) in sugarcane.

Construction of sequential selection indices revealed an increase in genetic advance and relative efficiency due to increase in number of characters over straight selection based on cane yield alone.

Selection indices constructed with the inclusion of more than one character gave higher genetic advance suggesting the utility of selection indices for effective improvement of several characters. A combination involving five characters *viz.*, length of millable canes, diameter of cane, single cane weight, number of canes per clump and cane volume in seedling nursery showed highest genetic advance as well as relative efficiency over straight selection based on yield alone (Table 3).

Table 4. Sequential selection indices based on character combinations in first clonal stage in Sugarcane

Sl. No.	Character(s)	Genetic advance	Relative efficiency
1	X1	8.84	100.00
2	X2	20.57	232.81
3	X1 + X2	30.68	347.22
4	X1 + X3 + X2	32.77	370.91
5	X1 + X2 + X4	41.72	472.21
6	X1 + X3 + X2 + X4	44.74	506.37
7	X1 + X3 + X5 + X2 + X4	46.29	523.93
8	X1 + X3 + X2 + X4 + X6	47.91	542.23
9	X1 + X3 + X5 + X2 + X4 + X6	49.38	558.87
10	X1 + X3 + X2 + X4 + X6 + X7	49.57	561.00
11	X1 + X3 + X2 + X4 + X6 + X8	50.22	568.36
12	X1 + X3 + X5 + X2 + X4 + X6 + X9	50.53	571.81
13	X1 + X3 + X5 + X2 + X4 + X6 + X7	51.09	578.19
14	X1 + X3 + X5 + X2 + X4 + X6 + X8	51.65	584.53
15	X1 + X3 + X2 + X4 + X6 + X9 + X7	51.87	587.06
16	X1 + X3 + X2 + X4 + X6 + X9 + X10	52.16	590.34
17	X1 + X3 + X2 + X4 + X6 + X7 + X10	52.74	596.83
18	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X8	52.93	599.00
19	X1 + X3 + X5 + X2 + X4 + X6 + X9 + X7	53.28	602.97
20	X1 + X3 + X5 + X2 + X4 + X6 + X9 + X10	53.45	604.90
21	X1 + X3 + X5 + X2 + X4 + X6 + X7 + X10	54.02	611.32
22	X1 + X3 + X2 + X4 + X6 + X12 + X7 + X10	54.20	613.44
23	X1 + X3 + X5 + X13 + X2 + X4 + X6 + X7 + X10	54.60	617.96
24	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X7 + X10	55.03	622.75
25	X1 + X3 + X5 + X2 + X4 + X6 + X12 + X7 + X10	55.35	626.39
26	X1 + X3 + X5 + X2 + X4 + X6 + X9 + X7 + X10	55.40	628.67
27	X1 + X3 + X5 + X2 + X4 + X6 + X12 + X9 + X7 + X10	55.61	629.30
28	X1 + X3 + X5 + X13 + X2 + X4 + X6 + X12 + X7 + X10	56.01	633.90
29	X1 + X3 + X5 + X13 + X2 + X4 + X6 + X9 + X7 + X10	56.02	633.94
30	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X12 + X7 + X10	56.19	635.95
31	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X9 + X7 + X10	56.40	638.32
32	X1 + X3 + X5 + X2 + X4 + X6 + X12 + X9 + X7 + X10	56.73	642.05
33	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X12 + X7 + X10	56.78	642.60
34	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X9 + X7 + X10	56.91	644.06
35	X1 + X3 + X5 + X13 + X2 + X4 + X6 + X12 + X9 + X7 + X10	57.39	649.47
36	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X10	57.54	651.22
37	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X9 + X7 + X8 + X10	57.70	653.04
38	X1 + X3 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X8 + X10	57.78	653.96
39	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X10	58.12	657.81
40	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X12 + X7 + X8 + X10	58.13	657.88
41	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X9 + X7 + X8 + X10	58.23	659.05
42	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X8 + X10	58.86	666.16
43	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X8 + X10	59.47	673.05

Details of characters:

X1 : Cane yield

X2 : Shoot population at 120 DAP

X3 : CCS yield

X4 : Number of millable canes per plot

X5 : Number of green leaves at 120 DAP

X6 : Cane length

X7 : Sucrose per cent

X8 : CCS per cent

X9 : Brix per cent

X10 : Purity per cent

X11 : Single cane weight

X12 : Cane diameter

X13 : Leaf area index at 120 DAP

Table 5. Sequential selection indices in second clonal stage based on character combinations in Sugarcane.

Sl. No.	Character(s)	Genetic advance	Relative efficiency
1	X1	20.96	100.00
2	X2	38.71	184.74
3	X1 + X2	51.39	245.23
4	X1 + X3 + X2	53.76	256.56
5	X1 + X5 + X2	53.90	257.19
6	X1 + X2 + X4 + X6	65.42	312.18
7	X1 + X3 + X2 + X6	67.93	324.16
8	X1 + X2 + X4 + X6	68.54	327.09
9	X1 + X3 + X5 + X2 + X6	69.52	331.74
10	X1 + X3 + X2 + X4 + X6	71.04	338.99
11	X1 + X3 + X5 + X2 + X4 + X6	72.80	347.43
12	X1 + X3 + X5 + X13 + X2 + X4 + X6	72.84	347.61
13	X1 + X3 + X5 + X2 + X4 + X11 + X6	73.06	348.66
14	X1 + X3 + X5 + X2 + X4 + X6 + X12	73.07	348.70
16	X1 + X3 + X5 + X2 + X4 + X6 + X9	73.36	350.09
17	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X9	73.54	350.93
18	X1 + X3 + X5 + X2 + X4 + X6 + X12 + X9	73.59	351.19
19	X1 + X3 + X5 + X2 + X4 + X6 + X9 + X7	73.82	352.27
20	X1 + X3 + X5 + X2 + X4 + X6 + X9 + X10	73.89	352.61
21	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X9 + X7	74.03	353.28
22	X1 + X3 + X5 + X2 + X4 + X6 + X12 + X9 + X7	74.14	353.80
23	X1 + X3 + X5 + X2 + X4 + X6 + X9 + X7 + X8	74.14	353.80
24	X1 + X3 + X5 + X13 + X2 + X4 + X6 + X12 + X9 + X7	74.25	354.34
25	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X12 + X9 + X7	74.33	354.72
26	X1 + X3 + X5 + X2 + X4 + X6 + X12 + X9 + X7 + X8	74.48	355.40
27	X1 + X3 + X5 + X13 + X2 + X4 + X6 + X12 + X9 + X7 + X8	74.61	356.05
28	X1 + X3 + X5 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X8	74.65	356.21
29	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X8	74.78	356.83
30	X1 + X3 + X5 + X13 + X2 + X4 + X11 + X6 + X12 + X9 + X7 + X8 + X10	74.92	357.51

## Details of characters:

- X1 : Cane yield
- X2 : Shoot population at 120 DAP
- X3 : CCS yield
- X4 : Number of millable canes per plot
- X5 : Number of green leaves at 120 DAP
- X6 : Cane length
- X7 : Sucrose per cent
- X8 : CCS per cent
- X9 : Brix per cent
- X10 : Purity per cent
- X11 : Single cane weight
- X12 : Cane diameter
- X13 : Leaf area index at 120 DAP

A combination of two component characters *i.e.*, cane yield and shoot population at 120 DAP compared to a single character *i.e.*, shoot population at 120 DAP when taken into consideration, there is an increase in the genetic advance and relative efficiency over straight selection in both the clonal generations. Inclusion of cane yield, shoot population at 120 DAP and NMC at harvest in first clonal stage and cane yield, shoot population at 120 DAP and cane length in second clonal stage resulted in an increase in genetic advance and relative efficiency.

The increase in genetic advance and relative efficiency were comparatively low in a combination of ten characters *viz.*, cane yield, CCS yield, number of green leaves, leaf area index and shoot population at 120 DAP, number of millable canes, cane length, cane diameter, sucrose and purity per cent than selection indices constructed based on the ten characters excluding leaf area index at 120 DAP and inclusion of brix per cent (Table 4). A slight increase in genetic advance and relative efficiency was noted when brix per cent was included as eleventh character. A combination of 13 characters *viz.*, Cane yield, CCS yield, number of green leaves, leaf area index, shoot population at 120 DAP, number of millable canes, single cane weight, cane length, cane diameter, brix per cent, sucrose per cent, CCS per cent, purity per cent resulted in higher genetic advance and relative efficiency over a combination of ten, eleven and twelve characters, respectively. Selection indices constructed with the above character combinations in second clonal stage also revealed similar trend as that of first clonal generation (Table 5).

In the present investigation, genetic advance and relative efficiency were increased progressively with the inclusion of more number of characters in the index along with cane yield per plot. The positive correlation among the component characters with cane yield may be the probable reason for higher genetic advance and relative efficiency. These results are in conformity with the findings of Miller *et al.* (1978), Punia and Hooda (1982), Kumar and Singh (2005), Doule and Balasundaram (2006), Kumar *et al.* (2007), Sahu *et al.* (2008) and Sirisha *et al.* (2010) in sugarcane.

The results obtained from the present study demonstrated that selection based on selection indices was more efficient in seedling and clonal stages than direct selection on cane yield alone. A linear increase in genetic advance and relative efficiency was noted with the inclusion of more number of characters *viz.*, CCS yield, number of green leaves, leaf area index, shoot population at

120 DAP, number of millable canes, single cane weight, cane length, cane diameter, brix per cent, sucrose per cent, CCS per cent and purity per cent in sequential index along with cane yield.

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