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Restriction Selection Indices in Sugarcane (*Saccharum officinarum* L.)

M Sireesha, K Prasada Rao, C Panduranga Rao and V Srinivasa Rao
Department of Genetics and Plant Breeding, Agricultural college, Bapatla 522101, Andhra Pradesh

ABSTRACT

Twelve diverse pre-released genotypes of sugarcane obtained from Sugarcane Research Station, Vuyyur were evaluated for 14 characters *viz.,* shoot population at 120 DAP, shoot population at 240 DAP, shoot population at 270 DAP, length of millable cane, diameter of cane, single cane weight, number of internodes cane^{-1}, number of millable canes, brix per cent at 300 days, sucrose per cent at 300 days, purity per cent at 300 days, cane yield (kg plot^{-1}) and CCS yield (kg plot^{-1}) during 2007-08 crop season. The restricted selection indices using single and double case restriction of each or two character/s were studied. In both single and double case restriction selection indices highest genetic advance values were recorded by cane yield when each character / two characters were restricted separately. Therefore, simultaneous selection for all those traits dependent on cane yield would be better over selection for cane and CCS yields, directly.

Key words : Restriction Selection Indices, Sugarcane

Sugarcane (*Saccharum officinarum* L.) contributes about 60 percent to the world sugar production. It is the cheapest source of sweetening agent. Direct selection is not effective for quantitatively inherited characters which have low heritability. Construction of selection indices will be helpful for making selection on several characters (Venkateswara Rao, 1985; Basavaraj and Sheriff, 1992).

MATERIAL AND METHODS

The present investigation was conducted at Sugarcane Research Station, Vuyyur during 2007-2008 crop season. The experimental material consisted of twelve sugarcane genotypes, grown in randomized block design with three replications. Each clone was accommodated in plots having 8 rows of 8 meter length of 80 cm apart.

Under certain situations the breeder like to effect change in the means of some characters while keeping the means of other characters unchanged. When a character was restricted *i.e.,* the genetic gain is zero (G= 0), the maximization of the correlation between genetic worth (H) and another function (I) based on the phenotypic performance of various characters was obtained. A solution to this problem of index constriction was given by Kempthorne and Nordskog (1959) by using log range multiplier. Using single and double restriction cases, in respect of all the 14 characters in single case and 9 characters in double case restriction selection indices were constructed in the present study and genetic advance was calculated for other characters in each restriction according to Singh and Chaudhary (1977).

RESULTS AND DISCUSSION

Single case restriction

The character-wise genetic advance (Gi) values in case of single character restricting are embodied in Table 1.By restricting shoot population at 120 DAP, highest value of genetic advance was observed for cane yield (39.61) and low value for stalk population at 270 DAP (-1.33). By restricting stalk population at 240 DAP, highest value of genetic advance was observed for cane yield (37.97) and low value for diameter of cane (0.03). By restricting stalk population at 270 DAP, highest value of genetic advance was observed for cane yield (39.49) and low value for stalk population at 240 DAP (-2.85). By restricting length of millable cane, highest value of genetic advance was observed for cane yield (32.45) and low value for stalk population at 240 DAP (-1.55). By restricting diameter of cane, highest value of genetic advance was observed for cane yield (35.20) and low value for stalk population at 240 DAP (-2.55).

By restricting single cane weight, highest value of genetic advance was observed for cane yield (22.56) and low value for diameter of cane (-0.03). By restricting number of internodes per cane, highest value of genetic advance was observed for cane yield (36.35) and low value for stalk population at 270 DAP (-0.62). By restricting number of millable canes plot^{-1}, highest value of genetic advance was observed for cane yield (39.00) and low value for stalk population at 270 DAP (-2.03). By restricting brix per cent at 300 days, highest value of genetic advance was observed for cane yield (41.65) and low value for stalk population at 240 DAP (-0.18). By restricting juice sucrose per cent at 300 days, highest value of genetic advance was observed for cane yield (43.48) and low value for purity per cent at 300 days (-0.002). By restricting per cent purity at 300 days, highest value of genetic advance was observed for cane yield (45.12) and low value for stalk population at 240 DAP (-1.92). By restricting CCS per cent at 300 days, highest value of genetic advance was observed for cane yield (43.73) and low value for brix per cent and juice sucrose per cent at 300 days (-0.02). By restricting cane yield per plot, highest value of genetic advance was observed for shoot population at 120 DAP (11.37) and low value for diameter of cane (-0.05). By restricting CCS yield per plot, highest value of genetic advance was observed for shoot population at 120 DAP (31.34) and low value for CCS per cent at 300 days (-0.40).

In single case restriction, the character cane yield showed high genetic advance in all the cases except when that character and CCS yield per plot were under restriction.

Double case restriction

The character-wise genetic advance (Gi) values in case of double character restriction are embodied in Table 2.

By restricting length of millable cane and diameter of cane, highest value of genetic advance was observed for cane yield (33.32) and low value for single cane weight (0.08). By restricting length of millable cane and single cane weight, highest value of genetic advance was observed for cane yield (21.08) and low value for diameter of cane (-0.04). By restricting length of millable cane and number of internodes cane^{-1}, highest value of genetic advance was observed for cane yield (34.17) and low value for diameter of cane (0.03). By restricting length of millable cane and number of millable canes, highest value of genetic advance was observed for cane yield (33.31) and low value for number of internodes cane^{-1} (-0.07). By restricting length of millable cane and brix per cent, highest value of genetic advance was observed for cane yield (34.47) and low value for juice sucrose per cent (-0.06). By restricting length of millable cane and juice sucrose percent, highest value of genetic advance was observed for cane yield (35.77) and low value for diameter of cane (0.08).

By restricting length of millable cane and cane yield, highest value of genetic advance was observed for CCS yield (4.07) and low value for diameter of cane (-0.03). By restricting length of millable cane and CCS per cent, highest value of genetic advance was observed for cane yield (20.74) and low value for brix per cent (-0.28). By restricting diameter of cane and single cane weight, highest value of genetic advance was observed for cane yield (27.93) and low value for brix per cent (0.24). By restricting diameter of cane and number of internodes cane^{-1}, highest value of genetic advance was observed for cane yield (35.0) and low value for number of millable canes (-0.08). By restricting diameter of cane and number of millable canes, highest value of genetic advance was observed for cane yield (35.45) and low value for number of internodes cane^{-1} (0.05). By restricting diameter of cane and brix per cent, highest value of genetic advance was observed for cane yield (34.91) and low value for single cane weight (0.07). By restricting diameter of cane and juice sucrose per cent, highest value of genetic advance was observed for cane yield (31.50) and low value for single cane weight (0.08). By restricting diameter of cane and cane yield, highest value of genetic advance was observed for CCS yield (3.46) and low value for number of internodes per cane (-0.50). By restricting diameter of cane and CCS yield, highest value of genetic advance was observed for cane yield (10.37) and low value for brix per cent (-0.07). By restricting single cane weight and number of internodes cane^{-1}, highest value of genetic advance was observed for cane yield (19.42) and low value for diameter of cane (-0.05).

By restricting single cane weight and number of millable canes, highest value of genetic advance was observed for cane yield (20.35) and low value for diameter of cane (-0.03). By restricting single cane weight and brix per cent, highest value of genetic advance was observed for cane yield (30.68) and low value for diameter of cane (0.01). By restricting single cane weight and juice sucrose per cent, highest value of genetic advance was observed for cane yield (31.68) and low value for brix per cent (-0.01). By restricting single cane weight and cane yield, highest value of genetic advance was observed for CCS yield (4.82) and low value for diameter of cane (-0.06). By restricting single cane weight and CCS yield, highest value of genetic advance was observed for cane yield (23.70) and low value for brix per cent (-0.43). By restricting number of internodes cane^{-1} and number of millable canes, highest value of genetic advance was observed for cane yield (38.82) and low value for diameter of cane

Table 1. Genetic advance (Δ Gi) values in single case restricted selection indices in 12 genotypes of sugarcane (*Saccharum officinarum* L.).

Character	Shoot population at 120 DAP	Stalk population at 240 DAP	Stalk population at 270 DAP	Length of millable cane	Diameter of cane	Single cane weight	Number of internodes cane^{-1}	Number of millable canes	Brix per cent at 300days	Sucrose per cent at 300 days	Purity per cent at 300 days	CCS per cent at 300 days	Cane yield (kg plot^{-1})	CCS yield (kg plot^{-1})
Shoot population at 120 DAP	0.00	11.15	7.94	10.30	8.86	8.91	7.76	3.38	14.10	13.40	9.85	13.47	11.37	31.34
Shoot population at 240 DAP	-4.05	0.00	-2.85	-1.55	-2.55	3.61	-3.64	-4.65	-0.18	-0.45	-1.92	-0.36	1.67	8.73
Shoot population at 270 DAP	-1.33	2.39	0.00	1.85	0.68	5.58	-0.62	-2.03	3.03	2.65	0.99	2.64	2.72	9.95
Length of millable cane	4.17	3.44	3.88	0.00	3.07	1.32	2.61	4.32	5.22	5.40	4.90	5.40	-4.24	0.90
Diameter of cane	0.02	0.03	0.02	0.01	0.00	-0.03	0.01	0.03	0.05	0.05	0.05	0.06	-0.05	0.05
Single cane weight	0.13	0.12	0.14	0.12	0.11	0.00	0.14	0.15	0.14	0.14	0.15	0.14	0.01	0.06
Number of internodes cane^{-1}	0.35	0.44	0.36	0.23	0.28	0.49	0.00	0.36	0.62	0.59	0.45	0.59	-0.06	0.61
Number of millable canes	1.44	4.44	2.93	4.04	3.78	7.12	3.10	0.00	4.18	4.22	3.75	4.32	3.25	7.64
Brix per cent at 300 days	0.35	0.21	0.28	0.36	0.35	0.31	0.38	0.31	0.00	-0.01	0.12	-0.02	0.48	-0.43
Sucrose per cent at 300 days	0.49	0.34	0.41	0.52	0.54	0.54	0.51	0.44	0.05	0.00	0.12	-0.02	0.83	-0.51
Purity per cent at 300 days	0.78	0.68	0.72	0.94	1.06	1.30	0.82	0.78	0.24	-0.02	0.00	-0.07	2.01	-0.57
CCS per cent at 300 days	0.42	0.30	0.36	0.44	0.47	0.46	0.44	0.39	0.07	0.02	0.11	0.00	0.72	-0.40
Cane yield (Kg plot^{-1})	39.61	37.97	39.49	32.45	35.20	22.56	36.35	39.00	41.65	43.38	45.12	43.73	0.00	16.55
CCS yield (kg plot^{-1})	7.07	6.25	6.71	6.28	6.74	5.25	6.70	6.84	5.56	5.48	5.98	5.41	3.75	0.00

Table 2. Genetic advance (ΔGi) values in double case restricted selection indices in 12 genotypes of sugarcane (*Saccharum officinarum* L.).

Character	Restriction with length of millable cane							
Length of millable cane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diameter of cane	0.00	-0.04	0.03	0.03	0.08	0.08	-0.03	0.11
Single cane weight	0.08	0.00	0.15	0.15	0.16	0.17	0.06	0.15
Number of internodes cane^{-1}	0.09	0.15	0.00	-0.07	0.25	0.14	-0.42	0.11
Number of millable canes	6.08	3.90	0.64	0.00	2.83	1.98	-7.60	-1.05
Brix per cent	0.35	0.55	0.44	0.48	0.00	0.10	0.64	-0.28
Per cent juice sucrose	0.46	0.77	0.52	0.56	-0.06	0.00	0.91	-0.56
Cane yield	33.32	21.08	34.17	33.31	34.47	35.77	0.00	20.74
CCS yield	5.99	5.87	6.39	6.42	4.01	4.31	4.07	0.00

Character	Restriction with diameter of cane							
Length of millable cane	0.00	4.23	3.57	3.94	7.57	6.43	-3.49	3.26
Diameter of cane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Single cane weight	0.08	0.00	0.12	0.12	0.07	0.08	0.09	0.08
Number of internodes cane^{-1}	0.09	0.63	0.00	0.05	0.50	0.80	-0.50	0.37
Number of millable canes	6.08	3.71	-0.08	0.00	4.27	5.21	-7.10	0.11
Brix per cent	0.35	0.24	0.53	0.51	0.00	0.46	0.59	-0.07
Per cent juice sucrose	0.46	0.35	0.68	0.66	0.10	0.00	0.79	-0.23
Cane yield	33.32	27.93	35.00	35.45	34.91	31.50	0.00	10.37
CCS yield	5.99	4.99	7.19	7.22	4.96	5.23	3.46	0.00

Character	Restriction with single cane weight							
Length of millable cane	0.00	4.23	0.83	3.86	6.43	6.47	-2.90	6.21
Diameter of cane	-0.04	0.00	-0.05	-0.03	0.01	0.01	-0.06	0.07
Single cane weight	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of internodes cane^{-1}	0.15	0.63	0.00	0.30	0.82	0.81	-0.37	0.93
Number of millable canes	3.90	3.71	2.78	0.00	5.36	5.46	-2.68	3.98
Brix per cent	0.55	0.24	0.63	0.52	0.00	-0.01	0.77	-0.43
Per cent juice sucrose	0.77	0.35	0.86	0.74	0.08	0.00	1.11	-0.67
Cane yield	21.08	27.93	19.42	20.35	30.68	31.68	0.00	23.70
CCS yield	5.87	4.99	6.01	5.74	4.28	3.97	4.82	0.00

Character	Restriction with number of internodes cane^{-1}							
Length of millable cane	0.00	3.57	0.83	3.11	3.92	4.00	-0.70	2.48
Diameter of cane	0.03	0.00	-0.05	0.03	0.07	0.07	-0.02	0.10
Single cane weight	0.15	0.12	0.00	0.16	0.20	0.19	0.03	0.17
Number of internodes cane^{-1}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of millable canes	0.64	-0.08	2.78	0.00	-0.45	-0.95	-5.80	-3.02
Brix per cent	0.44	0.53	0.63	0.42	0.00	0.13	0.48	-0.26
Per cent juice sucrose	0.52	0.68	0.86	0.48	-0.11	0.00	0.78	-0.56
Cane yield	34.17	35.0	19.42	38.82	35.83	38.74	0.00	21.18
CCS yield	6.39	7.19	6.01	6.76	3.86	4.60	3.70	0.00

Character	Restriction with number of millable canes							
Length of millable cane	0.00	3.94	3.86	3.11	7.29	6.73	-6.11	4.75
Diameter of cane	0.03	0.00	-0.03	0.03	0.08	0.07	-0.06	0.12
Single cane weight	0.15	0.12	0.00	0.16	0.17	0.17	0.02	0.15
Number of internodes cane^{-1}	-0.07	0.05	0.30	0.00	0.53	0.45	-0.57	0.45
Number of millable canes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brix per cent	0.48	0.51	0.52	0.42	0.00	0.07	0.72	-0.48
Per cent juice sucrose	0.56	0.66	0.74	0.48	-0.06	0.00	1.04	-0.80
Cane yield	33.31	35.45	20.35	38.82	45.33	45.70	0.00	28.60
CCS yield	6.42	7.22	5.74	6.76	5.44	5.65	4.48	0.00

Character	Restriction with brix per cent							
Length of millable cane	0.00	7.57	6.43	3.92	7.29	7.25	-0.06	-0.10
Diameter of cane	0.08	0.00	0.01	0.07	0.08	0.07	0.04	0.08
Single cane weight	0.16	0.07	0.00	0.20	0.17	0.16	0.10	0.14
Number of internodes cane^{-1}	0.25	0.50	0.82	0.00	0.53	0.56	-0.02	-0.26
Number of millable canes	2.83	4.27	5.36	-0.45	0.00	0.50	-6.63	-5.45
Brix per cent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Per cent juice sucrose	-0.06	0.10	0.08	-0.11	-0.06	0.00	0.13	-0.27
Cane yield	34.47	34.91	30.68	35.83	45.33	44.01	0.00	12.22
CCS yield	4.01	4.96	4.28	3.86	5.44	5.62	1.02	0.00

Character	Restriction with per cent juice sucrose							
Length of millable cane	0.00	6.43	6.47	4.00	6.73	7.25	-1.00	-2.40
Diameter of cane	0.08	0.00	0.01	0.07	0.07	0.07	0.06	0.06
Single cane weight	0.17	0.08	0.00	0.19	0.17	0.16	0.13	0.13
Number of internodes cane^{-1}	0.14	0.80	0.81	0.00	0.45	0.56	-0.21	-0.47
Number of millable canes	1.98	5.21	5.46	-0.95	0.00	0.50	-8.39	-7.28
Brix per cent	0.10	0.46	-0.01	0.13	0.07	0.00	0.02	0.14
Per cent juice sucrose	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cane yield	35.77	31.50	31.68	38.74	45.70	44.01	0.00	1.77
CCS yield	4.31	5.23	3.97	4.60	5.65	5.62	0.19	0.00

Character	Restriction with cane yield							
Length of millable cane	0.00	-3.49	-2.90	-0.70	-6.11	-0.06	-1.00	-1.88
Diameter of cane	-0.03	0.00	-0.06	-0.02	-0.06	0.04	0.06	0.07
Single cane weight	0.06	0.09	0.00	0.03	0.02	0.10	0.13	0.13
Number of internodes cane^{-1}	-0.42	-0.50	-0.37	0.00	-0.57	-0.02	-0.21	-0.36
Number of millable canes	-7.60	-7.10	-2.68	-5.80	0.00	-6.63	-8.39	-8.22
Brix per cent	0.64	0.59	0.77	0.48	0.72	0.00	0.02	0.08
Per cent juice sucrose	0.91	0.79	1.11	0.78	1.04	0.13	0.00	0.01
Cane yield	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCS yield	4.07	3.46	4.82	3.70	4.48	1.02	0.19	0.00

Character	Restriction with CCS yield							
Length of millable cane	0.00	3.26	6.21	2.48	4.75	-0.10	-2.40	-1.88
Diameter of cane	0.11	0.00	0.07	0.10	0.12	0.08	0.06	0.07
Single cane weight	0.15	0.08	0.00	0.17	0.15	0.14	0.13	0.13
Number of internodes cane^{-1}	0.11	-0.37	0.93	0.00	0.45	-0.26	-0.47	-0.36
Number of millable canes	-1.05	0.11	3.98	-3.02	0.00	-5.45	-7.28	-8.22
Brix per cent	-0.28	-0.07	-0.43	-0.26	-0.48	0.00	0.14	0.08
Per cent juice sucrose	-0.56	-0.23	-0.67	-0.56	-0.80	-0.27	0.00	0.01
Cane yield	20.74	10.37	23.70	21.18	28.60	12.22	1.77	0.00
CCS yield	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(0.03). By restricting number of internodes per cane and brix per cent, highest value of genetic advance was observed for cane yield (35.83) and low value for juice sucrose per cent (-0.11). By restricting number of internodes $cane^{-1}$ and juice sucrose per cent, highest value of genetic advance was observed for cane yield (38.74) and low value for number of millable canes (-0.95). By restricting number of internodes $cane^{-1}$ and cane yield highest value of genetic advance was observed for CCS yield (3.70) and low value for diameter of cane (-0.02). By restricting number of internodes $cane^{-1}$ and CCS yield highest value of genetic advance was observed for cane yield (21.18) and low value for brix per cent (-0.26).

By restricting number of millable canes and brix per cent, highest value of genetic advance was observed for cane yield (45.33) and low value for per cent juice sucrose (-0.06). By restricting number of millable canes and per cent juice sucrose, highest value of genetic advance was observed for cane yield (45.70) and low value for brix per cent and diameter of cane (0.07). By restricting number of millable canes and cane yield, highest value of genetic advance was observed for CCS yield (4.48) and low value for diameter of cane (-0.06). By restricting number of millable canes and CCS yield, highest value of genetic advance was observed for cane yield (28.60) and low value for brix per cent (-0.48). By restricting brix per cent and per cent juice sucrose, highest value of genetic advance was observed for cane yield (44.01) and low value for diameter of cane (0.07). By restricting brix per cent and cane yield, highest value of genetic advance was observed for CCS yield (1.02) and low value for number of internodes per cane (-0.02). By restricting brix per cent and CCS yield, highest value of genetic advance was observed for cane yield (12.22) and low value for length of millable cane (-0.10). By restricting per cent juice sucrose and cane yield, highest value of genetic advance was observed for CCS yield (0.19) and low value for number of internodes per cane (-0.47). By restricting cane yield and CCS yield, highest value of genetic advance was observed for single cane weight (0.13) and low value for number of internodes per cane (-0.36).

In each double restriction case, the character cane yield showed high genetic advance in all the restriction cases except when cane yield was under restriction. When cane yield was under restriction CCS yield showed high genetic advances in all the restriction cases.

In both single and double restriction cases, we can conclude that cane yield showed high genetic advances in all the restriction cases. Cane yield is important as it directly influences CCS yield and hence, can be selected using restriction selection indices.

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