RESEARCH PAPER

EVALUATION OF SUGARCANE TOPS OF Co CLONES FOR FODDER QUALITY TRAITS

Bakshi Ram*, S.K. Tomar and R. Karuppaiyan

Abstract

Twenty four sugarcane clones were evaluated for two years in one plant crop and one ratoon crop, to assess the magnitude of variability for sugarcane tops related traits at eighth, 10th and 12th month after planting/ratooning and to find out correlations among morphological and biochemical traits of sugarcane tops. High variability at phenotypic and genotypic levels was observed for top weight, top/cane ratio, fat content and crude fibre content; moderate variability for leaf length, leaf width, top length, crude protein content, ash content and silica content and low variability for dry matter content, neutral detergent fibre (NDF) and acid detergent fibre (ADF) fraction of fibre were observed. Most of the biochemical (fodder quality) traits did not exhibit significant correlations with morphological traits of sugarcane except the negative association between crude protein content and cane yield or CCS yield; ash content and cane yield or CCS yield. On the basis of biochemical compositions of SCT, the clone Co 05011 was rated as the best for dry matter content (33.03%), Co 0118 (7.27%) and CoJ 64 (6.85%) for crude protein content, Co 0237 (3.67%), Co 07023 (3.67%) and Co 0238 (3.62%) for crude fat content, Co 0424 (19.12%) and Co 0118 (21.39%) for low crude fibre content and CoS 8436 for low silica content (2.49%).

Key words: *Sugarcane tops, variability, correlation and fodder quality.*

Bakshi Ram, R. Karuppaiyan
Sugarcane Breeding Institute Regional Centre
Karnal - 132 001, Haryana, India
e-mail: headsbirc@dataone.in
S.K. Tomar
National Dairy Research Institute
Karnal - 132 001, Haryana, India

Introduction

Sugarcane tops (SCT) are the left-over crown portions of canes after harvesting the crop..Cane top comprises green leaves, leaf bundle sheaths and some portion of immature canes. A study conducted at the Sugarcane Breeding Institute Regional Centre, Karnal, has revealed that SCT form about 26% weight of stripped cane on fresh weight basis. If sugarcane production in India is considered 350 million tonnes/year, then an estimated 91 million tonnes of SCT are available every year in the country. Assuming about 25% losses of SCT on account of drying, flowering and other reasons, at least 68 million tonnes of SCT will be available per year which can be fed to animals for about 4-5 months. The subtropical states like Bihar, Haryana, Punjab, Uttar Pradesh and Uttarakhand are estimated to have 42.74 million buffalo and 37.01 million cattle (GoI 2007). In northern India, green fodder shortage is acute especially during winter and early summer (November to March). During this period, the livestock heavily depends on sugarcane tops for fodder. Despite its low nutrient content and digestibility, sugarcane tops are extensively used in northern India as fodder.

The yield and fodder quality of SCT were found to vary considerably among the varieties of sugarcane, age of harvest, growing condition and management practices but hardly few studies on these aspects were made earlier. Hence the present study was undertaken at the Sugarcane Breeding Institute, Regional Centre, Karnal, in collaboration with the National Dairy Research Institute, Karnal, to find out whether varietal differences existed for morphological and biochemical traits of sugarcane tops, to find whether there is any association between fodder quality traits of sugarcane tops and morphological traits of sugarcane and to look for any temporal (November to March) and crop type (plant and ratoon) effects on the proximate principles of sugarcane tops.

Materials and methods

Twenty one sugarcane clones evolved at the Sugarcane Breeding Institute Regional Centre, Karnal namely, Co 0118, Co 0124, Co 0237, Co 0238, Co 0239 Co 0240, Co 0241, Co 0424, Co 05009, Co 05011, Co 06033, Co 06034, Co 06035, Co 06036, Co 07022, Co 07023, Co 07024, Co 07025, Co 07026, Co 89003 and Co 98014 were evaluated along with three standards *viz.*, Co 1148, CoS 8436 and CoJ 64 for two years *i.e.* as one plant crop and one ratoon crop from 2009 to 2011 in randomized block design (RBD) with three replications and a plot size of two 6 m rows per clone; the inter-row spacing was 0.9 m. Recommended dose of NPK (150:50:50 kg NPK/ha) was applied and other cultural operations were followed as and when necessary. Observations on morphological traits of tops such as leaf length, leaf width, top length, top weight and top/cane ratio were recorded. Juice quality traits such as Brix, pol %, purity % and commercial cane sugar percentage (CCS %) were estimated for each clone at eighth (November), 10th (January) and 12th month (March) after planting / ratooning. For the estimation of proximate principles of sugarcane tops, three randomly selected canes from each variety were chosen, their tops were harvested at eighth (November), 10th (January) and 12th month (March) after planting, chopped into small pieces and oven dried at 80^{o}C. The processed top samples were subjected to estimation of dry matter content, crude protein content, ether extract (crude fat content), silica content (acid insoluble ash) and total ash content as per AOAC manual (2002). The crude fibre content and its fraction *viz.*, neutral detergent fibre (NDF) and acid detergent fibre (ADF) were estimated as per Van Soest *et al.* (1991). The data were analyzed year-wise as well as combining both the year data (plant crop and ratoon crop) through combined RBD procedures. To assess the variability for top morphological traits, the phenotypic coefficient of variation (PCV %) and genotypic coefficient of variation (GCV %), and phenotypic correlation coefficient amongst biochemical and morphological traits of sugarcane tops were worked out as per Singh and Chaudhary (1985). The broad sense heritability (h^2) was calculated as per the method of Burton and DeVane (1953) while the expected genetic advance was worked out as per Singh and Chaudhary (1985).

Results and discussion

The analysis of variance showed significant differences due to clones, crop type (plant and ratoon), clone x plant type interaction for traits like leaf length, leaf width, top length, top weight and top/cane ratio indicating that these traits varied with variety, plant type and interaction.

Variability of sugarcane clones for tops related traits

The length of leaf in 24 clones varied from 105.72 cm to 143.95 cm with an average of 131.36 cm

(Table 1). The mean leaf length of plant crop was significantly shorter (121.17 cm) than the mean leaf length of ratoon crop (141.54 cm). Four clones *viz.,* Co 0238, Co 0239, Co 0241, and Co 05011 exhibited significantly longer leaves than the best standard Co 1148. The minimum leaf width observed in the study was 2.93 cm (Co 89003), the maximum was 4.49 cm (Co 06036) and the mean was 3.68 cm (Table 1). Significantly narrower leaves than the pooled mean were present in Co 89003 and Co 98014, whereas broader leaves were observed in Co 0118, Co 05011, Co 06035 and Co 06036. Midrib width was in the range of 0.43 cm (Co 06033) to 0.67 cm (Co 0424) with the mean value of 0.54 cm. Clones such as Co 0424 and Co 0241 exhibited significantly wider midrib than the general mean. Length of tops varied from 136.61 cm in Co 07022 to 189.22 cm in Co 05011. The pooled mean of plant and ratoon crop was 165.08 cm. Among the standards, Co 1148 recorded the longest tops (163.78 cm); three 'Co clones' namely, Co 06036, Co 0238 and Co 05011 were significantly superior to it. The top weight of plant crop was significantly lower (0.22 kg) than that of the ratoon crop (0.26 kg). The pooled mean of plant and ratoon crops was 0.24 kg; the lowest top weight/cane was 0.12 kg recorded in Co 07022 and the highest (0.33 kg) in Co 06036. Three clones *viz.*, Co 06036, Co 0118 and Co 05011 had significantly higher top weight than the best standard Co 1148 (0.24 kg). The top/cane ratio on weight basis varied from 0.17 in Co 98014 to 0.34 in Co 0124 and Co 05009, the pooled mean being 0.26. The values of tops/cane ratio were significantly different in plant and ratoon crop. The ratoon crop exhibited higher tops/cane ratio (0.34) than the plant crop (0.21). The clones Co 98014, Co 07022, Co 0237 and Co 0240 exhibited significantly lower tops/cane ratio than the general mean (0.26) and are desirable for increasing stalk yield; the clones Co 0124, Co 05009 and Co 0424 recorded significantly higher top/cane ratio than the general mean as well as the best standard CoJ 64 (0.21) indicating higher fodder yield. The mean value of tops/cane ratio reported in the study was similar to the value (0.28) reported by Thi Mui *et al*. (1997) but higher than the ratio (0.15-0.20) reported by Gendley *et al.* (2002).

Table 1. Means, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance (GA) as percentage of mean for sugarcane tops related traits on the basis of average of plant and ratoon crops

Sl. No.	Clone	Leaf length (cm)	Leaf width (cm)	Midrib width (cm)	Tops length (cm)	Tops weight (kg)	Tops/Cane Wt Ratio
1	Co 0118	124.44	4.36	0.52	167.28	0.30	0.24
2	Co 0124	129.39	3.57	0.53	150.56	0.24	0.34
3	Co 0237	126.11	3.33	0.53	158.67	0.19	0.19
4	Co 0238	153.94	4.17	0.50	187.56	0.29	0.24
5	Co 0239	141.89	4.28	0.64	168.89	0.27	0.23
6	Co 0240	137.56	3.56	0.65	165.17	0.19	0.20
7	Co 0241	142.39	3.87	0.64	178.39	0.28	0.28
8	Co 0424	126.06	3.73	0.67	161.05	0.24	0.32
9	Co 05009	134.56	3.53	0.59	172.22	0.29	0.34
10	Co 05011	142.22	4.36	0.60	189.22	0.30	0.28
11	Co 06033	123.94	3.26	0.43	161.06	0.23	0.24
12	Co 06034	131.72	3.61	0.59	166.33	0.23	0.28
13	Co 06035	138.78	4.37	0.50	171.83	0.28	0.28
14	Co 06036	122.00	4.49	0.57	181.67	0.33	0.31
15	Co 07022	105.72	3.58	0.59	136.61	0.12	0.17
16	Co 07023	136.95	3.02	0.54	172.00	0.24	0.24
17	Co 07024	130.83	3.78	0.51	158.83	0.20	0.24
18	Co 07025	134.83	3.54	0.59	175.06	0.27	0.29
19	Co 07026	126.11	3.14	0.47	151.50	0.17	0.25
20	Co 1148	129.17	3.47	0.47	163.78	0.25	0.29
21	Co 89003	128.78	2.93	0.58	156.11	0.21	0.25
22	Co 98014	138.11	2.99	0.52	170.61	0.17	0.17
23	CoJ 64	120.08	3.18	0.44	141.22	0.19	0.21
24	CoS 8436	127.00	4.08	0.43	156.39	0.26	0.29
Mean (plant crop)		121.17	3.60	0.53	149.4	0.22	0.21
Mean (ratoon crop)		141.54	3.75	0.56	181.02	0.26	0.34
Pooled Mean		131.36	3.68	0.54	165.08	0.24	0.26
CD at 5%		11.14	0.68	0.16	17.69	0.04	0.34
PCV %	13.49	19.00	20.75	14.52	29.34	30.66	
GCV %	11.28	15.08	9.00	12.93	26.63	28.96	
h^2 (Broad sense)		0.70	0.63	0.19	0.79	0.82	0.89
GA	19.43	24.64	8.04	23.70	49.80	56.35	

The magnitude of variability for traits related to SCT was classified as low (0-10%), moderate (10-20%) and high (>20%). PCV was high for characters such as midrib width, top weight and top /cane ratio and moderate for leaf length, leaf width and tops length. The high PCV for midrib width was contributed mainly by the environment as evident from its low GCV and low heritability. The high GCV combined with high heritability observed for traits such as top weight and top/cane ratio suggested ample scope for selection and the expected genetic advance would be 49.80% for top weight and 56.35% for top/cane ratio. Leaf width was positively correlated with cane yield and stalk thickness. The heritability of leaf width in the present study was high, therefore, by selecting thicker canes it would be possible to improve both cane yield as well as fodder yield.

Variability of proximate principles and fibre content of SCT

The dry matter (DM) content of sugarcane tops of the 24 clones varied from 27.84% in Co 06036 to 33.03% in Co 05011 and the mean of plant and ratoon crop was 30.51% (Table 2). The clones having higher DM content being desirable, Co 05011 was rated as the best clone (33.03%) since its DM content was significantly higher than the general mean (30.51%). DM content estimated in earlier works showed some variation: 26% in sugarcane varieties of Natal (Barnes 1974), 30.66% in Co 419 (Kutty and Prasad 1980), 30% in Co 740 (Rangnekar 1988), 29% in sugarcane cultivar grown in Mauritius (Naseeven 1988), 18-21% in Vietnam cultivar (Thi Mui *et al.* 1997) and 42.60% in the experimental clones grown in Maharashtra (Patil *et al.* 1999).

The crude protein content of sugarcane tops of 24 clones was in the range of 4.78% in Co 07026 to 7.27% in Co 0118. The pooled mean of plant and ratoon crop was 5.77% (Table 2). The plant crop exhibited significantly higher crude protein content than the ratoon crop. However, interaction effect between clones and crop type (plant or ratoon) was not significant. Since protein is required for the growth and development of animals, varieties having higher protein are preferred. Two clones *viz.*, Co 0118 and CoJ 64 showed significantly higher crude protein than the general mean. Since Co 0118 is gaining popularity as an early maturing variety, its cultivation would benefit farmers to reap twin benefits of high sugar, high yield and earliness coupled with protein rich tops as fodder for better animal growth. Earlier workers like Prabhu *et al.* (2007) and Rangnekar (1988) have identified high protein cultivars such as 9847115 and Co 740 (6.3% and 6.2% protein respectively). The crude protein content reported in the present study corroborated with the earlier reports of 6.2% by Rangnekar (1988), 5.9% by Naseeven (1988), 4.1-5.1% by Thi Mui *et al.* (1997) and 5.96% by Patil *et al.* (1999).

Ether extract is an indication of crude fat content in animal feed. The ether extract of sugarcane tops varied from 1.10% (Co 06035) to 3.67% (Co 0237 and Co 07023). Contrary to crude protein content, the tops of ratoon crop had higher ether extract than the plant crop. Six clones such as Co 0237, Co 07023, Co 0238, Co 1148, Co 07025 and Co 07024 showed values superior to the general mean. The values of ether extract estimated in the present study were lower than that (5%) reported by Rangnekar and Joshi (1978) in Co 740 but higher than that (0.38-2.0%) reported by Kutty and Prasad (1980), Rangnekar (1988), Naseeven (1988), Patil *et al.* (1999) and Prabhu *et al.* (2007).

The crude fibre content of sugarcane tops varied from 19.12% in Co 0424 to 40.78% in Co 0239 with a general mean of 25.07%. Ratoon crop exhibited significantly higher fibre than the plant crop. Low fibre percentage in tops or stalk would increase animal digestibility and increase sucrose accumulation. Hence, varieties having less crude fibre are preferred (Pate, 1981). Accordingly, six clones Co 0424, Co 0118, Co 06034, CoJ 64, Co 0240 and Co 07022 were identified as good for low crude fibre content. The neutral detergent fibre accounted for 66.57% of the total fibre in sugarcane tops, in contrast to 43.23% of the acid detergent fibre. The crude fibre content of SCT estimated by earlier workers (Patil *et al.* 1999 and Rangnekar 1988) was slightly higher (30.9%) than in the present report. But the NDF and ADF fractions of fibre estimated in the present study were similar to those reported by Kutty and Prasad (1980) (NDF=67.92%; ADF=40.10%) and Kevelenge *et al.* (1983) (NDF=63.3%; ADF=43.1%).

Organic matter content in the sugarcane tops ranged from 89.80% in Co 06036 to 92.67% in Co 07024 with a mean of 91.34% (clone-wise data not shown). The clones viz. Co 05011, Co 0331, Co 0241, CoS 8436, Co 0124, Co 06035, Co 1148, Co 07025, Co 07026, Co 06034, Co 0241, Co 98014, Co 0122 and Co 07024 exhibited higher OM content (91.55 - 92.67%) than the general mean. This was in agreement with earlier estimates of 92.25% (Gendley *et al.* 2002) and 92.25% (Kevelenge *et al.* 1983). Ash content of tops varied between 7.06% in Co 07025 and 8.50% in Co 06036 with an average value of 7.85%, similar to the earlier reports by Naseeven (1988) and Prabhu *et al.* (2007). No clone was significantly superior to general mean for ash content although ratoon crop exhibited higher ash content than plant crop. The acid insoluble ash (silica content) of sugarcane tops varied from 2.49% in CoS 8436 to 4.32% in CoJ 64 and the pooled mean was 3.50%. The SCT of plant and ratoon crop did not show significant differences for silica content and there was no interaction effect between clones x crop type (plant or ratoon crop). Kutty and Prasad (1980) analyzed the silica content of SCT in the variety Co 419 which was higher (4.62%) than that of CoJ 64 (4.32%) estimated in the study. The silica content estimated in the present study was similar to the value (3.25%) reported by Gendley *et al.* (2002).

The phenotypic coefficient of variation was high for fat and crude fibre; moderate for crude protein, ash and silica content; low for dry matter content, and NDF and ADF fractions of fibre. Barring crude fibre content and ether extract, the GCV of other biochemical traits such as crude protein content, silica content, ash content, NDF and ADF fractions of fibre did not exhibit high variability suggesting lack of variability among sugarcane clones. Traits like DM content, crude protein and silica content exhibited low heritability (0.30-0.43). Hence simple selection based on content of these proximate principles may not bring improvement. Earlier study by Prabhu *et al.* (2007) showed low heritability for crude protein and silica content, high GCV for crude fat and medium GCV for crude fibre content.

3. Comparison of SCT with other green fodders

A comparison of the nutritive values of SCT estimated in the study with those of other commonly available green fodders reported by Banerjee (2009) indicated that crude protein content SCT appeared to be (5.77%) on par with 2nd year napier grass (5.99%) but inferior to bajra at dough stage (8.80%), berseem (17.3%), lucerne (20.2%), jowar (7.6-12%) and young maize (12.1%). For ether extract (fat content), sugarcane tops (3.00%) can be rated on par with cowpea (3.00%) and superior to maize (0.9-1.50%) and second year napier grass (1.11%). For (low) crude fibre content, sugarcane tops (25.07%) is on par with berseem (25.90%), better than second year napier grass (28.00%) but inferior to bajra at dough stage (24.90%). Kevelenge *et al.* (1983) reported that SCT contained higher NDF and ADF fractions of fibre than maize stalk. Thi Mui *et al.* (1997) reported that SCT contains less crude protein and higher DM content than that of guinea grass. Hence SCT was recommended as the best source of roughage for milking goat. Although SCT is highly palatable with good intake characteristics (Gendley *et al.* 2002), due to its low protein content, poor mineral content and low level of digestibility of nutrients, Joshi et al. (1995) and Patil et al. (1999) suggested using SCT as a source of roughages in the diet of ruminants after supplementation. The results of the study supported the views of earlier workers.

4. Temporal and crop type effects on proximate principles of sugarcane tops

The biochemical composition of sugarcane tops estimated at eighth, 10th and 12th month after planting in plant and ratoon crops of 24 clones showed that that the dry matter content and crude fibre content of SCT increased with the age of crop (Fig 1). On the other hand, crude protein content decreased with crop age. The crude fat content and silica content were not drastically affected by the age of the crop. Total ash content of SCT decreased during winter *i.e.* from eighth month (November) to 10th month (January) and then increased from January to March. The data presented by Rangnekar (1988) indicated increasing trend of crude fibre and ash and decreasing trend of crude protein and ether extract with the age (6th and 12th month) of sugarcane cultivar Co 740. SCT of plant and ratoon crops did not exhibit significant differences for dry matter content and silica content (Table 2). However, SCT of plant crop had relatively higher crude protein content than the ratoon crop. Moreover, higher ash content and crude fibre were recorded in SCT of ratoon crop than plant crop.

5. Association among traits

The phenotypic correlation coefficients computed on the basis of mean data of two years amongst morphological, economic and biochemical (fodder quality) traits of sugarcane tops are shown in Table 3. Among the morphological traits, leaf length and leaf width were positively associated with top length and top weight. Top length showed positive association with tops weight and tops/cane ratio. Top weight was positively correlated with

Table 2. Analysis of sugarcane tops for fodder quality traits

Sl. No.	Clone	Dry matter (%)	Crude Protein (%)	Ether Extract (%)	Total Ash (%)	Silica (%)	Crude Fibre (%)	NDF (%)	ADF (%)
1	Co 0118	30.07	7.27	2.67	8.09	3.39	21.39	64.86	45.02
2	Co 0124	32.61	6.04	3.15	8.00	3.55	24.04	66.05	45.62
3	Co 0237	31.27	5.57	3.67	8.20	3.81	25.28	65.24	41.88
4	Co 0238	29.37	6.13	3.62	7.96	3.88	23.18	67.77	44.27
5	Co 0239	29.50	5.93	3.24	8.25	3.20	40.78	67.30	43.11
6	Co 0240	28.15	5.77	2.98	8.42	3.75	21.71	66.96	43.08
7	Co 0241	28.95	6.28	2.24	7.56	3.19	24.31	65.51	44.74
8	Co 0424	29.38	6.36	2.18	8.10	3.62	19.12	65.76	42.57
9	Co 05009	30.54	5.42	2.89	8.06	3.00	26.63	64.48	43.84
10	Co 05011	33.03	5.84	2.93	8.01	3.57	24.81	69.30	45.06
11	Co 06033	29.74	5.08	3.06	7.96	3.92	25.25	68.77	45.36
12	Co 06034	30.92	6.04	2.74	7.69	4.04	21.56	67.49	43.87
13	Co 06035	30.74	5.46	1.10	7.63	3.16	23.79	67.10	40.67
14	Co 06036	27.84	6.37	2.84	8.50	3.63	26.53	67.13	44.99
15	Co 07022	28.89	5.86	3.08	7.96	3.96	22.34	65.83	43.58
16	Co 07023	31.96	5.28	3.67	8.14	3.68	23.59	67.98	43.48
17	Co 07024	30.86	5.77	3.46	7.34	3.74	25.50	65.92	43.79
18	Co 07025	29.82	5.59	3.56	7.06	3.51	39.46	68.46	39.36
19	Co 07026	30.80	4.78	2.82	7.51	3.40	23.19	64.05	43.89
20	Co 1148	31.98	5.46	3.60	7.27	3.18	26.78	67.63	40.56
21	Co 89003	31.25	5.10	3.31	7.62	3.08	23.29	66.13	43.05
22	Co 98014	31.89	5.28	3.25	7.27	3.09	24.74	67.12	41.08
23	CoJ 64	31.88	6.85	3.09	8.22	4.32	21.63	65.27	43.23
24	CoS 8436	30.88	5.07	2.78	7.50	2.49	22.76	65.64	41.53
Mean of plant crop (2010-11 trial)		30.22	6.32	2.89	7.09	3.51	23.59	67.12	42.50
Mean of ratoon crop (2009-10 trial)		30.80	5.23	3.11	8.60	3.50	26.55	66.03	43.97
Pooled Mean		30.51	5.77	3.00	7.85	3.50	25.07	66.57	43.23
CD at 5%2.36		0.99	0.37	0.66	0.65	2.46	1.97	2.57	
PCV % 8.27		19.85	21.71	14.16	19.43	23.46	3.71	6.78	
GCV % 4.77		12.97	20.29	12.05	10.61	21.84	2.65	4.38	
h^2 (Broad sense)		0.33	0.43	0.87	0.73	0.30	0.87	0.51	0.42
GA as % of mean		5.67	17.46	39.07	21.13	11.94	41.89	3.903	5.823

GCV - genotypic coefficient of variation; PCV - phenotypic coefficient of variation; h^2 – heritability;

GA - genetic advance as percentage of mean

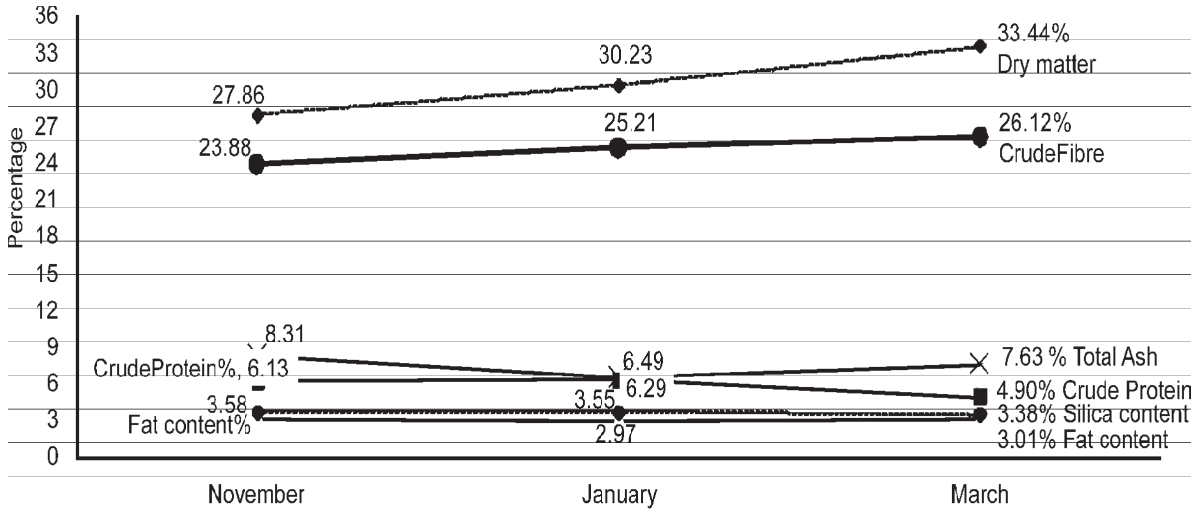

Fig 1. Changes in proximate principles of SCT with age of crop

tops/cane ratio. Therefore, improvement in any of the above traits would simultaneously improve the correlated traits. However, improvement in top/cane ratio, would reduce cane yield, CCS yield and crude protein content in tops as the correlations among these were negatively significant. Hence, for increasing cane yield and CCS yield, lower top/cane ratio is desirable. Lowering the top/cane ratio would concomitantly increase crude protein content in tops. It may be noted that the cane yield and CCS yield *per se* showed positive but non-significant association with crude protein and therefore, increasing cane yield need not always result in remarkable increase in crude protein in tops. At the same time, high yielding variety viz Co 0118 is having added advantages like higher crude protein. Total ash content showed significant positive correlation with leaf length, top length, top weight and top/cane ratio.

All the juice quality traits showed high positive correlations amongst them. However juice quality traits were not associated with cane and CCS yields. All these economic traits did not show significant association with any of the fodder quality traits, except negative association of total ash content with both cane and CCS yields. High ash content is a desirable trait but the results of the study have indicated that increase in the cane yield or CCS yield would reduce total ash content in the tops. However increase in ash content would also increase the silica content in tops which is undesirable. Therefore, moderate ash content may be looked as optimum so as to have a balance between cane yield and CCS yield *versus* silica content. Association of crude protein with both cane and CCS yields was positive but not significant. Amongst fodder quality traits, crude protein showed significant negative association with total ash content, which was positively correlated with silica content. Fat content showed positive correlation with crude fibre %.

Conclusion

The results of the study have revealed the extent of variability in sugarcane clones and association among morphological and biochemical traits of sugarcane tops. The information will be useful for sugarcane breeders while selecting high yielding clones for areas where animal husbandry is given due importance. The best clones for various fodder quality traits were identified: Co 05011 was the best for dry matter content (33.03%); Co 0118 (7.27%) and CoJ 64 (6.85%) for crude protein content; Co 0237 (3.67%), Co 07023 (3.67%) and Co 0238 (3.62%) for crude fat content; Co 0424 (19.12%) and Co 0118 (21.39%) for (low) crude fibre content; and CoS 8436 for (low) silica content (2.49%). The clones such as Co 0118, Co 0238, CoS 8436 and CoJ 64 are already in cultivation and therefore, farmers can reap the benefits of high sugar, high yield and earliness coupled with high protein / high fat / low silica tops of these varieties by using them as fodder for better animal growth.

Table 3. Correlations amongst sugarcane morphological and tops biochemical (fodder quality) traits

Trait	Leaf width	Midrib width	Tops length	Tops weight	Tops/ cane ratio	Brix% at 10th month	Pol% in juice	Purity% 10th month	Cane yield	CCS% 10th month	CCS yield	Dry Matter content of tops	Crude Protein	Fat content	Total Ash	Silica content	Crude Fibre
Leaf length	0.27	0.17	0.82**	0.44**	0.37	-0.04	-0.01	0.07	0.00	0.00	0.01	0.06	-0.26	0.07	0.43**	-0.02	0.24
Leaf width		0.27	0.35*	0.65**	0.16	-0.13	-0.13	-0.15	0.33*	-0.13	0.11	-0.14	0.16	-0.24	0.21	-0.09	0.12
Midrib width			0.15	0.15	0.06	0.15	0.16	0.14	-0.01	0.16	0.04	-0.19	0.09	-0.17	0.01	-0.06	0.19
Tops length				0.60**	0.46**	-0.17	-0.10	0.02	0.00	-0.07	-0.01	0.06	-0.29	0.06	0.49**	-0.06	0.26
Tops weight					0.59**	-0.21	-0.16	-0.11	0.19	-0.15	0.17	0.03	-0.03	-0.09	0.30*	-0.19	0.22
Tops/ cane ratio						-0.13	-0.07	0.00	-0.37*	-0.05	-0.37*	0.15	-0.31*	-0.05	0.42**	-0.10	0.23
Brix% at 10th month							0.93	0.82	-0.17	0.89	0.05	0.02	0.14	0.11	-0.05	0.10	0.04
Pol% in juice								0.90	-0.18	0.99	0.07	0.03	0.07	0.11	0.01	0.08	0.04
Purity% 10th month									-0.20	0.90	0.04	0.11	-0.02	0.09	0.11	0.09	0.03
Cane yield										-0.18	0.96	-0.16	0.21	-0.04	-0.36*	-0.01	0.08
CCS% 10th month											0.08	0.04	0.04	0.11	0.03	0.07	0.04
CCS yield												-0.13	0.21	-0.01	-0.36*	0.01	0.10
Dry matter													-0.23	0.17	-0.11	-0.10	-0.04
Crude Protein														-0.28	-0.28*	0.14	-0.27
Fat content															0.12	0.10	0.33*
Total Ash																0.30*	0.13
Silicacontent																	-0.11

*, ** refer to significance at 5% and 1% level, respectively

References

AOAC (2002) Official Methods of Analysis Association of Official Analytical Chemists (17th ed.). Association of Official American Chemists, Maryland, USA.

Banerjee GC (2009) *A Text Book of Animal Husbandry* (8th ed.). Oxford and IBH Publishing Co, New Delhi: 235-236.

Burton GW, De-Vane FH (1953) Estimating heritability in tall fescue (*Fascutata arundinaceae*) from replicated clonal material. Agron. J. 45: 478-481.

Barnes AC (1974) The Sugarcane (2nd ed.). Leonard Hill Books, London.

Gendley MK, Singh P, Garg AK (2002) Performance of crossbred cattle chopped green sugarcane tops and supplemented with wheat bran or lentil chuni liquid diet. Asian Aust. J. Anim. Sci. 15(10):1422-1427.

GoI (2007) 18th Livestock Census 2007. All India report based on quick tabulation plan village level totals (Provisional). Department of Animal Husbandry, Dairying and Fisheries. Govt. of India, New Delhi. Available at http://dahd.nic.in/dahd/upload/ 18th Livestock Census2007Software/LS_Hindi.pdf.

Joshi AL, Rangnekar DV, Singh M, Kundu SS, Ambedkar SR, Bendigeri AV (1995) Sugarcane tops: Feeding of ruminants on fibrous crop residues. ICAR, New Delhi.

Kevelenge JEE, Said AN, Kiflewahid B (1983) The nutritive value of four area farm byproducts commonly fed to daily cattle by small scale farmers in Kenya. I. Organic structural components and in vitro digestibility. Tropical Anim. Prod. 8:162-170.

Kutty KPA, Prasad DA (1980) Studies on improving nutritive value of sugarcane tops with urea or dried poultry waste by ensiling technique. Indian J. Anim. Sci. 50:189-193.

Naseeven R (1988) Sugarcane tops as animal feed. In: Sugarcane as Feed (Sansoucy R, Aarts G and Preston TR (eds)) FAO Animal Health and Production Paper No.72, 106-122. Accessed at http://www.fao.org/docrep/003/s8850e/S8850E10.htm.

Pate FM (1981) Fresh chopped sugarcane in growing–finishing steer diets. J. Anim. Sci. 53:881-888.

Patil NV, Kharadi VB, Desai PM, Desai BM (1999) Comparative nutritional value of fresh and sun dried sugarcane tops in buffalo calves. Indian J. Anim. Nutr. 16:259-266.

Prabhu DA, Vijayakumar G, Jayakumar J (2007) Variability studies of quality characters in sugarcane (*Saccharum* spp) for cane and fodder yield. Indian Sugar 56(9): 49-53.

Rangnekar DV (1988) Integration of sugarcane and milk production in Western India. In: Sugarcane as Feed (Sansoucy R, Aarts G and Preston TR (eds)) FAO Animal Health and Production Paper No. 72, 106-122. Accessed at http://www.fao.org /docrep/003/s8850e/S8850E17.htm.

Rangnekar DV, Joshi AL (1978) Sugarcane as potential fodder for cattle. Proc. Seminar on Stabilization of Sugarcane Production, Kanpur, India.

Singh RK, Chaudhary BD (1985) Biometrical Methods in Quantitative Genetic Analysis (3rd ed.). Kalyani Publishers, New Delhi.

Thi Mui N, Preston TR, van Binh D, Ly LV, Ohlsson I (1997) Effect of management practices on yield and quality of sugar cane and on soil fertility. Livestock Res. Rural Dev. 8(3):51-60.

Van Soest PJ, Robertson JB, Lewis BA (1991) Methods for dietary fibre, neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.