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Characterisation of sugarcane soils of Karnataka

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Sugarcane is one of the most important commercial crops grown over an extent of 2.82 lakh ha in Karnataka spreading in different agro-climatic regions and wide range of soils. The productivity of the crop ranges from 52 to 132 t ha^{-1} in different cane growing areas of the state (FAI, 1999-2000). The best rooting medium for sugarcane should be loam to clay loam soils, more than 1 metre deep with CEC greater than 15 c mol (p+) kg^{-1} (Blackburn 1984). The favourable pH range for good cane growth is 6-8. (Hunsigi 1993). The cane root and stem growth is poorer in clayey soils. Inadequate drainage condition decreases the intake of irrigation water and reduce root growth which will result in reduced cane growth (Humbert 1968). The desired depth of well-drained zone is 60-90 cm as cane roots were not able to penetrate beyond 75 cm (Escolar and Allison 1976). The threshold limits of soluble salts found to have no adverse effects on cane growth are EC<2d Sm^{-1} (Mehrad 1968) and ESP<15% (Valdivia 1977). Presence of lime in soils by more than 8.5% induce chlorotic symptoms (Tandon and Srivastava 1981). There is a paramount need to characterize sugarcane soils in different cane growing tracts of the state to identify soil-related constraints for sustained cane production.

Nearly 86 per cent of sugarcane area is confined to the districts of Belgaum, Bijapur, Bidar and Dharward (Northern tracts), Mandya, Mysore and Shimoga (Southern tracts). Ten pedons representing extensive cane growing tracts were studied, analysed for physical and chemical properties (Jackson 1958; Sarma *et al.* 1987) and taxonomically classified (Soil Survey Staff 1994). In light of optimum soil requirements of sugarcane (Clements 1940; Mehrad 1968; Humbert 1968; Valdivia 1977 and Blackburn 1984) the studied soils were interpreted for their potentials and limitations to grow sugarcane.

The brief description of morphology, physical and chemical characteristics of the dominant cane growing soils in northern and southern tracts of Karnataka are given in Tables 1 and 2.

Belgaum soils are very deep (>150 cm), well drained valley soils, clayey in texture with 10 to 60% quartz gravels in subsurface horizon. They are slightly acidic in reaction (pH 6.2) with low cation exchange capacity (<10.8 c mol (p+) kg^{-1}). The soil characteristics viz., depth, drainage and neutral reaction are found as congenial for surgarcane crop. On the contrary, fine texture, gravelly rooting medium and poor

fertility status (low CEC) are some of the soil-related constraints affecting the cane production.

Khanapur soils are deep (>100 cm), moderately well drained valley soils clayey in texture with 15% fine gravels in subsurface horizons, developed on colluvio-alluvium of laterites occurring on 0-3% slopes. They are non-calcareous, neutral in reaction with medium cation exchange capacity. The soil characteristics such as depth, neutral reaction and fertility status are in favourable range to suit crop requirement. Over all, heavy texture, improper drainage, presence of lime and soluble salts are found as important soil related constraints affecting the cane productivity.

Chikodi soils are very deep (>150 cm), moderately well drained shrink-swell soils, clayey in texture (clay 48.7%), with fine gravels (5 to 20%) that increase with depth. They are calcareous, moderately alkaline (pH 8.3) in reaction with high cation exchange capacity. The soils are developed from basaltic alluvium and occur on nearly level valleys. The soil characteristics such as depth and fertility status are in favourable range to suit crop requirement. Over all, heavy texture, improper drainage, presence of lime and soluble salts are found as important soil related constraints.

Jamkhandi soils are very deep (>150 cm), moderately well drained heavy cracking clayey soils developed on basaltic alluvium on nearly level valleys. They are strongly alkaline (pH> 8.5) in reaction, calcareous ($CaCO_3$ 12.99%) in nature with high cation exchange capacity (64.3 c mol (p+) kg^{-1}). The soil characteristics viz., depth and fertility status are in favourable range to suit crop requirement. On the other hand, heavy texture, moderately well drained conditions, presence of lime and soluble salts are found as soil related constraints.

Indi soils are deep (>100 cm), moderately well drained cracking clayey soils with 10-15% fine gravels in subsurface horizon developed on basaltic alluvium occuring on 0-1% slopes. They are calcareous, strongly alkaline in reaction (pH>8.5) with high cation exchange capacity. The soil characteristics viz., depth and fertility status are in favourable range to suit crop requirement. On the other hand, heavy texture, moderately well drained conditions, presence of lime and sodium salts are found as soil related constraints.

Hangal soils are moderately deep (<100 cm) well drained gravelly red soils with 60-70% gravels in subsoil, loamy in texture, developed on granite gneiss on undulating lands. They are neutral in reaction (pH 6.5) with low cation exchange capacity (8.0 c mol (p+) kg^{-1}). The soil characteristics viz., drainage, neutral reaction are found congenial for sugarcane crop. On the contrary, moderate depth, gravelly rooting medium and poor fertility status (low CEC) are some of the soil-related constraints.

Table 1 : Physical & chemical characteristics of sugarcane soils of northern tracts

Horizon depth (cm)	Particle size class (mm) Sand (2.0–0.05)	Silt (0.05–0.002)	Clay (<0.002)	Organic Carbon	Colour (moist)	Coarse fragments (%)	$CaCO_3$ (%)	pH (1:2.5)	EC (dS m^{-1})	ESP (%)	CEC (c mol (p+)/kg $^{-1}$)
Belgaum soils : Fine, kaolinitic, isohyperthermic, Rhodic Paleustalfs											
0-20	62.0	14.5	23.5	0.75	5YR4/6	10.0	-	6.1	0.07	0.50	8.5
20-48	62.4	12.1	25.5	0.65	5YR4/6	60.0		6.2	0.08	0.50	8.7
48-76	48.5	10.0	41.5	0.64	2.5YR3/4	20.0	-	6.1	0.07	0.60	10.2
76-100	52.3	6.4	41.3	0.49	2.5YR3/4	10.0	-	6.1	0.07	0.50	10.7
100-130	50.5	6.5	43.0	0.35	2.5YR3/4	15.0		6.1	0.06	0.30	10.8
130-151	51.7	6.0	42.3	0.33	2.5YR3/4	10.0	-	6.0	0.57	0.20	9.8
Khanapur soils : Fine, montmorilionitic, isohyperthermic, Vertic Ustropepts											
0-19	54.8	18.9	26.3	0.38	10YR5/3	15.0		6.5	0.09	4.90	17.8
19-38	48.0	14.5	37.5	0.37	10YR4/3	15.0	-	7.1	0.08	3.10	20.5
38-62	30.9	15.7	53.4	0.31	10YR3/1		-	7.3	0.07	1.10	22.3
62-90	29.4	17.0	53.6	0.19	10YR3/1	-	-	7.4	0.05	1.00	22.9
90-120	33.8	13.4	52.6	0.18	10YR3/1	-		7.5	0.06	0.90	20.7
120-150	Quartz parent meterial										
Chikodi soils : Fine, montmorillonitic, isohyperthermic, calcareous, Vertic Ustropepts											
0-12	28.6	22.1	49.3	0.84	10YR3/3	5.0	6.00	8.2	0.62	4.00	21.0
12-32	31.1	19.4	49.5	0.72	10YR3/3	5.0	20.50	8.2	0.45	3.00	25.7
32-46	31.1	18.9	50.0	0.69	10YR3/3	10.0	23.40	8.4	0.33	2.30	37.5
46-58	40.4	9.3	50.3	0.38	10YR3/4	10.0	24.50	8.3	0.35	2.00	41.0
58-74	24.4	27.0	48.6	0.39	10YR3/1	20.0	30.10	8.6	0.33	2.0	43.5
74-102	23.1	32.4	44.6	0.35	10YR3/3	5.0	28.50	8.2	0.35	1.80	44.0
102-150	26.8	23.2	50.0	0.33	10YR3/3	5.0	26.00	8.4	0.36	1.80	45.7

Jamkhandi soils : Very fine, montmorilionitic, isohyperthermic, calcareous, Typic Haplusterts

0-18	15.4	20.2	64.4	0.70	10YR3/3	<5.0	14.50	8.7	0.15	9.70	58.5
18-45	10.2	20.2	69.6	0.65	10YR3/3	<5.0	13.10	8.9	0.16	9.80	63.1
45-78	10.4	15.8	73.8	0.49	10YR3/3	<5.0	12.50	8.6	0.17	9.60	65.6
78-107	11.0	14.5	75.5	0.45	10YR3/2	<5.0	12.80	8.7	0.15	9.60	64.5
107-150	8.0	12.1	79.9	0.30	10YR3/2	<5.0	12.80	8.6	0.16	9.20	66.1

Indi soils : Fine, montmorilionitic, isohyperthermic, calcareous, Vertic Ustropepts

0-16	38.8	21.2	40.0	0.82	10YR4/2	10.0	15.50	9.0	0.40	10.90	24.3
16-36	22.5	27.5	50.0	0.75	10YR3/2	10.0	19.10	9.3	1.20	16.18	25.3
36-56	16.0	29.0	55.0	0.76	10YR3/2	10.0	18.80	8.9	2.60	8.47	40.1
56-78	18.4	26.6	55.0	0.72	10YR3/3	10.0	19.20	8.7	5.20	9.22	37.7
78-95	18.5	26.0	55.5	0.60	10YR3/2	13.0	20.70	8.8	5.50	8.10	36.8
95-130	Basalt mixed with lime										

Bidar Soils : Fine, kaolinitic, isohyperthermic, Rhodic Paleustalfs

0-14	49.9	16.4	33.7	0.56	5YR3/3	60.0	-	6.4	-	0.40	10.8
14-30	36.6	11.1	52.3	0.47	205YR3/4	60.0	-	6.6	-	0.40	9.3
30-55	13.4	18.4	68.2	0.45	2.5YR3/4	10.0	-	6.6	-	0.60	9.0
55-80	15.5	23.9	60.6	0.38	2.5YR3/4	15.0	-	6.7	-	0.50	9.1
80-113	16.1	24.3	39.6	0.35	2.5YR3/6	-	-	6.7	-	0.40	9.2
113-125	Hard laterite										

Hangal soils : Loamy, skeletal, mixed, isohyperthermic, Typic Rhodustalfs

0-10	48.5	24.0	27.5	0.71	2.5YR 4/4	10.0	-	6.3	0.80	0.00	8.0
10-36	47.3	27.0	25.7	0.52	2.5YR4/6	40.0	-	6.40	0.08	0.5	9.50
36-62	44.6	24.7	30.7	0.42	2.5YR4/6	60.0	-	6.4	0.04	0.50	9.9
62-91	37.8	31.5	30.7	0.39	2.5YR3/6	70.0	-	6.4	0.04	0.50	10.6
91-113	Schist										

Table 2. Physico-chemical characteristics of sugarcane soils of southern tracts

Horizon	Particle size class (mm)			Organic	Colour	Coarse fragments $CaCO_3$		pH	EC	ESP	CEC
depth (cm)	Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Carbon (%)	(moist)	(%)	(%)	(1:2.5)	(dS m^{-1})	(%)	(c mol (p+) kg^{-1})
Bhadravathi soils : Fine loamy, mixed, isohyperthermic, Typic Tropaquepts											
0-12	46.7	23.3	30.0	0.74	10YR5/2	10.0	-	6.4	0.38	3.90	12.0
12-28	45-8	24.2	30.0	0.63	10YR5/1	10.0	-	7.4	0.23	3.90	12.9
28-56	44.1	20.9	35.0	0.59	2.5YR4/2	10.0	-	7.7	0.19	3.10	13.2
56-86	44.8	18.2	35.0	0.28	2.5YR4/2	10.0	-	7.7	0.17	2.60	15.7
86-110	49.6	17.3	33.1	0.16	10YR4/2	10.0	-	8.3	0.22	2.80	13.5
Mandya soils : Fine-loamy, mixed, isohyperthermic, Typic Ustropepts											
0-16	68.5	8.5	23.0	0.35	7.5YR3/3	-	5.20	8.6	0.20	5.90	12.1
16-34	68.6	7.2	24.2	0.35	10YR3/3	-	4.00	8.8	0.23	5.90	12.7
34-66	70.7	4.4	24.9	0.34	10YR3/3	-	4.40	8.8	0.29	6.20	12.9
66-91	58.5	13.0	28.5	0.31	10YR4/2	-	5.60	9.0	0.20	5.90	14.5
91-126	60.6	10.2	29.3	0.27	10YR4/2	-	4.50	9.1	0.25	6.00	15.1
Nanajanagud soils : Fine, montmorillontic, isohyperthermic, calcareous, Vertic Ustropepts											
0-9	65.6	12.3	22.1	0.55	10YR4/2	-	6.30	9.0	0.32	8.50	18.7
9-26	41.0	16.7	42.3	0.23	10YR3/2	-	16.40	9.4	0.49	12.28	35.0
26-67	36.1	17.6	46.3	0.13	10YR3/2	-	10.00	9.7	0.76	11.33	38.1
67-95	20.4	22.6	57.0	0.09	10YR3/2	-	23.00	9.8	1.20	12.03	47.3
95-124	19.5	21.9	58.6	0.04	10YR4/2	-	10.90	9.5	1.50	10.74	49.5
124-150	23.6	19.9	56.5	0.01	10YR4/1	-	11.50	9.7	1.65	10.63	48.6

Bidar soils are deep (>100 cm), well-drained gravelly red clayey soils developed on plateaus of laterites. They are slightly acid to neutral in reaction (pH 6.6) with low cation exchange capacity (9.3 c mol (p+) kg^{-1}). They are highly gravelly soils with gravel content (60 to 10%) that decrease with depth. The soil characteristics viz. drainage, neutral reaction are found congenial for sugarcane crop. On the contrary, fine texture, gravelly rooting medium and poor fertility status (low CEC) are some of the soil-related constraints limiting the cane production.

Nanjangud soils are very deep (>150 cm), moderately well drained cracking clayey soils occuring on nearly level valleys developed on colluvio-alluvium of granite gneiss. They are calcareous in nature, very strongly alkaline in reaction (pH>9.0) with high cation exchange capacity (35.0 cmol (p+) kg^{-1}). The soil characteristics viz., depth and fertility status are in favourable range to suit crop requirement. On the other hand, heavy texture, moderately well drained conditions, presence of lime and sodium salts are found as soil related constraints affecting the cane production.

Mandya soils are deep (>100 cm), well drained sandy clay loam soils developed on colluvio-alluvium of granite gneiss on nearly level valleys. The soils are strongly alkaline in reaction (pH>8.6) in isolated patches especially at low-lying areas, whereas large extent of Mandya soils which are on slightly upper reaches are neutral in reaction (pH 7.3, clay 26.7% and CEC 10.95 c mol (p+) kg^{-1}) (ISSC 1982). The soil characteristics like depth, drainage and loamy texture are highly desirable range for sugarcane crop. The important soil related constraints in general are low CEC and presence of soluble salts especially in low lying areas.

It is concluded from the present study that the soil related constraints are varying from place to place. Shrink swell clay (fine, montmorillonitic, calcareous, Vertic Ustropepts/very fine, Typic Haplusterts), lateritic soils (fine, kaolinitic, Rhodic Paleustalfs) are extensive in northern tracts. Soil characteristics such as fine texture, improper drainage, presence of lime and soluble salts in shrink swell soils and gravelly sub-soils, low fertility in lateritic soils are major constraints limiting cane production. Loamy soils (fine-loamy, mixed Typic Ustropepts/Typic Tropaquetps) are dominant in southern tracts with major soil fertility limitations.

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