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Research Article

Nutrient status of sugarcane growing soils of Theni district, Tamil Nadu- A soil series based study

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Summary

Sugarcane is the most important commercial crop of Tamil Nadu and Theni district of this state produces on an average about 4.67 lakh tonnes every year. The three major soil series in which sugarcane is cultivated are taken as a basis for organizing the survey and collection of soil samples and farmers data during 2012-13 to diagnose the potentials and constraints of soils and to assess the fertility and cane productivity. About 400 soil samples collected from 0-30 cm depth were subjected to physical, physico-chemical and chemical analysis adopting standard analytical procedures. Correlation was worked out between important soil parameters. The study indicated that the average yield of cane in this district was 70-75 t ha^{-1}, however extreme yields of 154 t ha^{-1} and 45 t ha^{-1} are also being obtained in some packets of the district. Variations in yield were assessed and soil series based nutrient survey indicated that the low organic matter content and available N status along with increasing deficiency of available sulphur in cane growing soils were the major limitations in achieving the maximum cane yield. Among the soil series, the Palaviduthi series registered average available higher N, P, K, S and Zn contents of 209, 56, 540, 20 kg ha^{-1} and 1.60 mg kg^{-1}, respectively indicating the better prospects of higher yields of sugarcane in the soils of this series. The low available S status (less than 10 mg kg^{-1}) in 52 per cent of soil samples of this series has to be managed for achieving higher cane productivity. However, the results of the study showed invariably higher P and K status in all the sugarcane growing soils of the district necessitating the need for refinement of P and K fertilizer schedule in this dominant sugarcane zone of Tamil Nadu.

Key words : Sugarcane, Fertility, Productivity, Deficiency, Tamil Nadu

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Introduction

India is the world's largest producer of sugarcane. Sugarcane is cultivated in about 5.10 million ha producing about 357.70 million tonnes of cane with an average productivity of 70 tonnes/ha. The prime concern of cane growers and the sugar industry is to achieve higher sugarcane productivity and high sugar recovery both of which support maximum economic returns. The wider spatial and temporal variations in soil characteristics are the major constraint for achieving the maximum cane productivity. Tamil Nadu one of the leading states in sugarcane production and productivity is of no exception. Theni district, which is located at the foot of Western Ghats comprises of about 11, 000 acres of sugarcane involving about 4500 cane farmers. The average production of sugarcane in this district is 4.67 lakh tonnes with an average cane productivity of 65 to 70 tonnes per ha. Inventory of the physico-chemical properties, available macro and micronutrients status of the soils help in demarcating areas where the application of particular nutrient is needed for profitable crop production (Singh, 2010). Also, it is already well known that the properties of a soil are the basic attributes that influence directly the soil response to any specified use (Sood *et al*., 2009). Though sporadic information is available on characterization and classification of soils in Theni district, no detailed and systematic investigation on the properties of soils has been taken up so far. Hence, the present study was taken up in the major sugarcane growing soil series of Theni district with an objective to understand and update the knowledge on the potentials and limitations of these soils in

enhancing the productivity of sugarcane to a minimum level of 100 tonnes per hectare.

Resource and Research Methods

Soil sampling, processing and analysis :

Soil survey was taken up in the dominant soil series of Theni district *viz.,* Palaviduthi comprising of 26,876 ha (9.3 % of total area), Somayyanur comprising of 24, 644 ha (8.5% of total area) followed by Irugur series encompassing 23, 670 ha (8.2% of total area). Based on the extent of distribution of sugarcane crop, variation in physiography and previous crop yields the number of soil samples in each of the series was determined. A total number of about 400 soil samples were collected in the initial phase during 2012 before planting of sugarcane crop in the major sugarcane growing soil series *viz.,* Palaviduthi (159 samples), Somayyanur (146 samples) and Irugur series (95 samples) from the plough layer of soils (0-30 cm depth).Soil samples were air dried and ground to pass through a 2mm sieve. The pH and EC was measured with glass electrode in a 1:2.5 soil/water suspension (Jackson, 1973), organic carbon estimation was done by Walkley and Black (1934), available nitrogen by Subbaiah and Asija (1956), available phosphorus by Olsen's extractant of 0.5M $NaHCO_3$ as described by Olsen's *et al.* (1954) and available potassium was extracted with neutral 1N NH_4OAc and then measured by flame photometer (Jackson, 1973). The available sulphur in the soil was extracted with 0.15 per cent $CaCl_2.2H_2O$ solution as described by Williams and Steinberg's (1959) and the DTPA extractable micronutrients *viz.,* iron, manganese, zinc and copper was estimated using atomic absorption spectrophotometer (Lindsay and Norwell, 1978). The mean values for each soil property, standard deviation (SD) and co-efficient of variance (CV) was calculated as suggested by Panse and Sukhatme (1967).

Research Findings and Discussion

The findings of the present study as well as relevant discussion have been presented under following heads :

Physico-chemical properties :

The soil series based analytical results of the sugarcane growing regions of Theni district are presented in Table 1. The soil reaction (pH) of these soils ranged from 4.7 to 9.2 *i.e.,* slightly acidic to alkaline reaction. Among the soil series, the average soil pH of 7.76 was recorded in the Somayyanur series followed by 8.03 in the Palaviduthi series and 7.98 in Irugur series. Among the three major soil series, 73% of the soil samples from Irugur followed by 60% and 59% from Somayyanur and Palaviduthi series, respectively exhibited moderate alkalinity. With the increase of pH, the availability of micronutrients decreased, which probably might be due to alkaline nature of soils (Rakesh Kumar *et al.,* 2009). This was confirmed by correlation studies that showed the soil pH had significant and negative correlation with available iron (r = -0.3565**; -0.4986**; -0.2996*) in respect to Palaviduthi, Somayyanur and Irugur series, respectively. The soils

Table 1 : Characterization of soils in the dominant sugarcane growing soil series of Theni district, Tamil Nadu

	pH	EC	OC	N	P_2O_5	K_2O	$CaCO_3$	S	Fe	Mn	Zn	Cu
		(dS/m)	(g/kg)	kg/ha			(%)		mg/kg			
Palaviduthi series (No. of samples 159)												
Max.	9.12	1.6	13.5	326	183	1820	3.8	89.75	152.1	38.36	9.85	11.13
Min.	5.97	0.05	0.7	91	11	85	0.2	1.02	1.44	1.18	0.16	0.64
Mean	8.03	0.26	5.6	209.74	55.83	539.16	0.98	19.73	13.77	7.46	1.60	2.43
S.D.	0.56	0.19	0.27	37.75	28.68	354.25	0.80	16.74	22.39	4.89	1.45	1.59
C.V.	7.03	70.79	48.20	18.00	51.37	65.70	81.92	84.85	162.63	65.56	90.45	65.43
Somayyanur series (No. of samples 146)												
Max.	9.11	1.25	14.6	449.00	142.00	2010.00	4.83	98.30	139.30	38.52	12.78	7.83
Min.	4.70	0.04	0.4	69.00	13.00	83.00	0.10	1.16	1.76	1.20	0.12	0.72
Mean	7.76	0.24	5.3	208.36	62.63	535.59	1.42	18.52	12.41	8.74	1.45	2.43
S.D.	0.72	0.19	0.29	50.13	29.22	380.58	1.26	19.96	21.66	7.28	1.38	1.30
C.V.	9.23	77.27	55.26	24.06	46.65	71.06	89.26	107.77	174.51	83.28	95.28	53.70
Irugur series (No. of samples 95)												
Max.	9.2	1.64	12.1	320	157	1501	3.8	87.06	186	45.1	9.73	4.81
Min.	6.13	0.03	0.4	88	9	93	0.2	4.68	2	0.98	0.16	0.52
Mean	7.98	0.28	5.3	201.82	48.17	437.15	0.83	22.30	17.28	8.34	1.53	2.41
S.D.	0.52	0.27	0.26	38.02	31.86	291.01	0.66	16.71	34.54	6.87	1.49	1.08
C.V.	6.58	95.63	49.21	18.84	66.13	66.57	79.58	74.95	199.83	82.38	97.67	44.95

analyzed for pH in Palaviduthi series had a significant and negative correlation with available Zn (r= -0.3489*) and available Cu (r= -0.4671**).

The total soluble salts expressed as electrical conductivity (EC) varied from 0.03 to 1.64 dS m^{-1} in almost all the soils were analysed. Invariably all the soils samples collected from the three series of sugarcane growing areas recorded an EC of less than 2 dSm^{-1} indicating that the soils are free from salinity. The ranges of organic carbon content of each series and the distribution of the soils under low, medium and high based on soil organic content are furnished in the Table 1. The highest mean value of OC was found in Pulaviduthi series (mean 5.6 g kg^{-1}) while, the lowest was observe in the soil samples from Somayyanur and Irugur series with the mean organic carbon content of 5.3 g kg^{-1} each.

About 50, 47 and 46% of the soils from Irugur, Palaviduthi and Somayyanur series, respectively were found to have low organic carbon status (<0.5 %). However, about 21% of the soils from Palaviduthi series were found to have higher organic carbon content. All the soils from the three soil series were observed to be non – calcareous nature, where the ranges were between 0.1 and 3.8 per cent.

Available macronutrients :

The available nitrogen content of the soil samples varied from 69 to 449 kg ha^{-1} with a mean N status of 209 kg ha^{-1} (Palaviduthi), 208 kg ha^{-1} (Somayyanur) and 201 kg ha^{-1} (Irugur) in the sugarcane growing areas of Theni district. On an average 95% of the soils of all the three series recorded low nitrogen status and remaining five percentage soils were found to have medium status of available nitrogen. The low levels may be ascribed to lower organic carbon content and N loss through various mechanisms like NH_3 volatilization, nitrification, succeeding denitrification, leaching, run off and high pH (De Datta and Buresh, 1989). Soil available nitrogen had significant and positive correlation with Organic Carbon content (r = 0.4826**; 0.3852**; 0.4247**) (Fig. 1) in Palaviduthi, Somayyanur and Irugur series, respectively. These findings are related with those of Dhale and Prasad (2009).

The available phosphorus content of soil samples exhibited extreme variation between 9 and 183 kg ha^{-1}. About 80 to 96 per cent of sugarcane growing soils of the major soil series of Theni district were found to be high in available phosphorus status (> 22 kg ha^{-1}). The invariably high P status of the soil may be due to continuous application of phosphatic fertilizer (DAP), bio- compost and rock phosphate enriched compost as recorded in the farm survey conducted before the preliminary soil survey for assessment of soil properties. Similar results were reported by Venkatakrishnan and Ravichandran (2012).

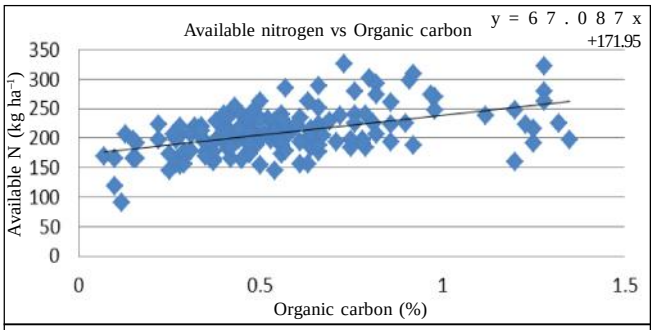

Fig. 1 : Relation between available N and OC in Palaviduthi series

The available potassium content of soil samples ranged from 83 to 2010 kg $ha^{-1}$with the highest mean value of 539 kg ha^{-1} recorded in Palaviduthi soil series. About 79%, 70% and 67% of soils from Palaviduthi, Somayyanur and Irugur series, respectively, recorded high status of available potassium (> 280 kg ha^{-1}). The Somayyanur series of soils of available K had a significant positive correlation with OC (r=0.4254**) and available S (r= 0.4514). However, the soils of Palaviduthi series had significant positive correlation with available N (r= 0.3321*). Medium to high available K in these soils may be attributed to the prevalence of K rich minerals. Bhangu and Sidhu, (1991) also observed that the soils of Punjab are medium to high in available potassium and significantly increased with increase in available N status.

The average available sulphur content in the soil samples varied from 1.02 to 98.3 ppm. Considering 10 ppm as critical limit for available sulphur, 45%, 26% and 24% of soils from Somayyanur, Palaviduthi and Irugur series, respectively registered low available sulphur content. However, 50 per cent of soils of the sugarcane growing areas of the district are found to be adequate in sulphur availability. It may be

Table 2 : Correlation between different soil properties

Palaviduthi series		Somayyanur series		Irugur series	
pH vs Av. Fe	r= - 0.3565**	pH vs Av. N	r= -0.2215*	pH vs Av. Fe	r= -0.2996*
pH vs Av. Zn	r= -0.3489*	pH vs $CaCO_3$	r= 0.2607*	pH vs Av. Mn	r= -0.2765*
EC vs Av. S	r= 0.6042**	pH vs Av. Fe	r= -0.4986**	EC vs Av. S	r= 0.4639**
OC vs Av. N	r= 0.4826**	pH vs Av. Mn	r= -0.6552**	OC vs Av. N	r= 0.4247**
OC vs Av. Fe	r= 0.3566**	OC vs Av. N	r= 0.3852**	Av. N vs Av. Cu	r= 0.3472*
Av. P vs Av. Zn	r= -0.2529*	OC vs Av. S	r= 0.3200*	-	-
Av. P vs Av. Fe	r= -0.2196*	Fe vs $CaCO_3$	r= 0.2357**	-	-

* and ** indicates significance of values at P= 0.01 and 0.05, respectively

attributed due to the low content of organic carbon in the soil which is the integral part of sulphur (Sharma *et al*., 2010). This was confirmed through the significant and positive correlation exhibited by available sulphur and organic carbon (r = 0.3200*) in the soils of Somayyanur series and had positive correlation with electrical conductivity (r= 0.6042**) in Palaviduthi series (Fig. 2).

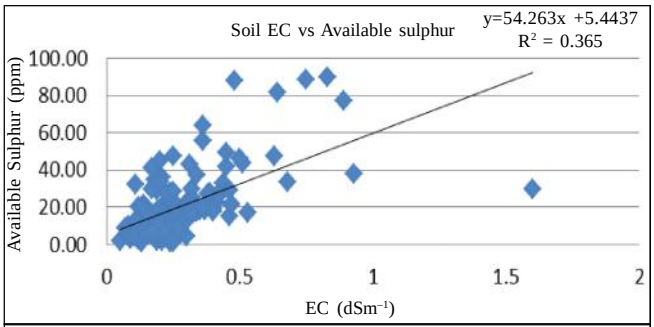

Fig. 2 : Relation between available S and EC in Palaviduthi series

Available micronutrients :

The available iron content of soil samples varied from 1.44 (Palaviduthi series) to 186 mg kg^{-1} (Irugur series). The highest mean Fe content of 17.28 mg kg^{-1} was observed in Irugur series, while the lowest mean Fe content was found in Somayyanur series (12.41 mg kg^{-1}). Considering 3.7 mg kg^{-1} as a critical limit, 16% 13% and 6% of Irugur, Somayyanur and Palaviduthi series, respectively recorded iron deficiency. The low Fe and Mn contents of the soils were possibly due to alkaline nature in most of the soils series which resulted to oxidation of divalent cations in Uttar Pradesh (Sharma *et al*. 2010). This can be confirmed through the significant and negative correlation of soil pH with available iron (r=-0.3565**; -0.4986**; -0.2996*) in all the three series of Palaviduthi, Somayyanur (Fig. 3) and Irugur.

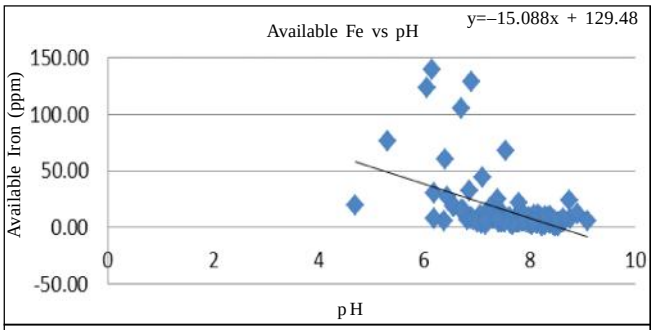

Fig. 3 : Relation between available Fe and pH in Palaviduthi series

The available manganese content of soil samples ranged from 0.98 to 45.10 mg kg^{-1} from the sugarcane growing Irugur series. The highest and lowest mean values of available Mn content were 8.74 and 7.46 mg kg^{-1}, respectively in Somayyanur and Palaviduthi series. Almost all the soil samples from these series recorded sufficiency in available Mn status. However, available Mn had significant and negative correlation with soil pH (r= -0.6552**) in Somayyanur series Table 2. The Mn bearing minerals in the parent material of these soils might be the reason for higher Mn content. Similar observation has been made in Chittoor district of Andhra Pradesh by Selvaraj and Naidu (2012).

The available zinc content of the soils ranged from 0.12 to 12.78 mg kg^{-1}. About 60% of soils from Irugur series, 53 per cent of Somayyanur soil series and 46% of soils from Palaviduthi registered deficiency in available iron status. Poor Zn status may be due to low organic carbon content and high pH in these soils. Similar trend was also reported by Singh *et al*. (2001) in soils of central Uttar Pradesh. Zinc is one of the most important components of the recommended package in most of the sugarcane growing soils of this district. However, 54 per cent of soil samples were observed to be sufficient (>1.2 mg kg^{-1}) in Palaviduthi series. The higher content of organic carbon and finer fractions of soils lead to increase in the surface ion exchange properties thus contributing to more DTPA – Zn content in these soils. The available Zn of soil samples showed positive correlation with OC (r= 0.2873*). A significant negative correlation with pH (r= - 0.3489*) indicated the availability of Zn decreased with increase in soil pH.

The available copper content of soil samples from all the series ranged from 0.52 to 11.13mg kg^{-1}. Almost all the soil samples from the major sugarcane growing soil series recorded sufficient status of available copper. The availability of Cu showed a significant and positive correlation with organic carbon in (r= 0.3391*) Palaviduthi series and r= 0.4227 (Irugur series) while a non-significant positive correlation was recorded (r = 0.2668*) in Somayyanur series of the sugarcane growing soils of Theni district.

Conclusion :

The analysis of sugarcane growing soils of Theni district spread in the three major soil series *viz.*, Palaviduthi, Somayyanur and Irugur indicated the wide variation in pH and organic carbon content of the soils. However, 80 percentages of the soils analyzed for available nitrogen indicated low status of less than 280 kg ha^{-1} irrespective of the soil series. Invariably higher status of available P and K in the sugarcane growing soils of Theni district has necessitated the need for refinement of P and K fertilization schedule in terms of quantity and time of application of nutrients to the sugarcane crop. On the contrary the increasing deficiency of sulphur and zinc in these soils is of much concern and soil test based application of sulphur and zinc has to be taken up for sustaining the soil fertility status and enhancing the sugarcane crop productivity in theses soils.

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