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Original Research Article

Geo-referenced Spatial Distribution of Available Sulphur and Micronutrients in surface soils of Sugarcane growing Area of Jalna (Maharashtra)

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A B S T R A C T

In order to evaluate available sulphur and micronutrients in geo-referenced surface soils of sugarcane growing area of Jalna, total sixty representative GPS-referenced soil samples were randomly collected based on preliminary survey covering Ambadtaluka. All the collected soil samples were analyzed for physico-chemical properties (pH, EC, Org. Carbon, $CaCo_3$, exchangeable cations), available major nutrients (N, P_2O_5, K_2O), available sulphur (S) and DTPA-extractable micronutrients (Fe, Mn, Zn and Cu). The data obtained from analysis were interpreted and discussed based on jurisdiction area from sugarcane growing area of Samarth Co- operative industries, Jalna as a whole after statistical analysis. Considering 60 soil samples from entire jurisdiction area of one sugar industries of Jalna were considered, it was observed that overall soil available N ranged from 128.57 to 297.92 kg ha^{-1} i.e. from very low to medium with mean value of 223.56 kg ha^{-1}. Available P_2O_5 ranged widely from 1.14 to 30.55 kg ha^{-1} i.e. from very low to medium with mean value 8.65 kg ha^{-1}. Available K_2O ranged from 110.88 to 776.4 kg ha^{-1} with mean of 415.95 kg ha^{-1}, high K-status in major soils probably because of higher K- bearing minerals. Available sulphur ranged from 5.81 to 77.01 ppm i.e. from low to high with mean of 29.39 ppm. Exchangeable Ca^{++} ranged from 11.5 to 77.01 c mol (p^+) kg^{-1} with mean of 22.59 c mol (p^+) kg^{-1} i.e. from high status in major soils. Exchangeable Mg^{++} ranged from 7.7 to 28.4 c mol (p^+) kg^{-1} with mean of 17.08 c mol (p^+) kg^{-1} i.e. from high status in major soils. In case of micronutrient distribution was concerned, DTPA-Fe ranged from 3.28 to 12.44 ppm (mean of 12.44 ppm i.e. high status), DTPA-Mn from 4.22 to 16.98 ppm (mean of 8.05 ppm i.e. medium), DTPA-Zn ranged from 0.11 to 2.06 ppm (mean of 0.60 ppm i.e. medium), DTPA-Cu ranged from 0.26 to 2.96 ppm (mean of 1.79 i.e. high status).

Keywords

Geo-referenced, spatial distribution, sugarcane

Introduction

Sugarcane (*Saccharum spp*.) is the main sugar producing crop that contributes more than 75 per cent to the total sugar pool at the global level. Area, production and productivity of sugarcane in India are 5.32 million ha, 356.7 million tones and 70.8 tones ha^{-1}. India in Maharashtra ranks second in sugarcane cultivation and production. Though a small area is under sugarcane cultivation, the yield per hectre is very high. Maharashtra has only 9% of India's total area under sugarcane. Jalna district is located in the central part of Maharashtra state in the Marathwada region. It lies between 19^o 1' to 20^o 3' North latitudes and 75^o 4' to 76^o 4' East longitudes. The district is bound on the north by Jalgaon district on the east by district

Parbhani and Buldhana, on the south by district Beed and on the west by Aurangabad district of Maharashtra state. The Jalna district has a sub-tropical climate in which the bulk of rainfall is received from south west monsoon during June to September.

Soil physico-chemical properties mainly depend on cropping pattern and soil management practices over a period of time which may often modify the soil properties. Sugarcane is annual exhaustive crop and requires large amount of nutrients during its different stages of growth (Gaikwad*et.al*. 2016). A large number of elements are required for the growth and reproduction of plants. Sulphur when applied in field, it helps in activation of enzymes, which aid in bio-chemical reactions within the plant, hence play its key role in yield and quality improvement of sugarcane and its available status in soil. (Sakal *et al.,* 2002) reported the continuous use of high analysis sulphur (S)-free fertilizers in recent years throughout the world coupled with decreased atmospheric input of S from burning of fossil fuels has led to a marked increase in the incidence of S- deficiencies in crops. The deficiency of S in plants manifests itself as chlorosis of leaves, poor yield and delayed maturity and sugarcane (*Saccharum spp*) is not an exception to these symptoms. In S-deficient soils, sugarcane crop showed good response to S in medium black soils of Maharashtra and Madhya Pradesh. Most of the Indian soils are deficient in available sulphur and about 250 districts of India were reported to be around the critical limit (10 mg kg^{-1}) of sulphur Tandon *et al.,* (2007). The advent of information technology tools like, GPS and GIS help in collecting a systematic set of geo-referenced samples and generating spatial data about the distribution of nutrients and also help to monitor changes in nutrient status over a period of time. Little work has been done recently on the available status of S, Fe, Mn, Zn and Cu in surface soils of the sugarcane growing area, so a study has been undertaken in this area. Further, GPS for sample collection being new technique would be utilized for present research work. So this study was undertaken to delineate the sulphur and micronutrients status of sugarcane growing soils of Jalna.

Materials and Method

Soils from sugarcane growing area of Ambadtaluka of Jalna encompassing the jurisdiction area of Samarth co-operative sugar industry, Dist. Jalnawas taken into consideration under the present research study. Total sixty representative GPS-referenced soil samples were randomly collected based on preliminary survey covering Ambadtaluka. All the collected soil samples were analyzed for physico-chemical properties (pH, EC, Org. Carbon, $CaCo_3$, exchangeable cations), available major nutrients (N, P_2O_5, K_2O), available sulphur (S) and DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) following standard procedure. The data obtained from analysis were interpreted and discussed based on jurisdiction area from sugarcane growing area of Samarth Co- operative industries, Jalna as a whole after statistical analysis.

Results and Discussion

Soil pH in sugarcane growing area was ranged from 6.5 to 8.6. Generally, 95 per cent soil samples were alkaline and only 5 per cent soil samples were neutral in soil reaction. Soil EC in sugarcane growing area was ranged from 0.15 to 0.68 dS m^{-1}. Electrical conductivity of 100 percent study area was normal. These soils were categorized as normal in respect of electrical conductivity. Similar results for South Gujarat were also reported by Gaikwad *et*

al., (2016). Organic carbon content in sugarcane growing soils was ranged from 0.31 to 0.82 g kg^{-1} with (29%) low organic carbon and (25%) medium to (6%) high Majority of these soils were low in organic carbon content. The free $CaCO_3$ content in sugarcane growing soils was ranged from 2.2 to 4.8 %. Generally, all soil samples were non-calcareous. These soils were categorized as non-calcareous in nature. Similar results were also reported for South Gujaratby Gaikwad *et al.,* (2016).

Available nitrogen content in sugarcane growing soils was ranged from 128.57 to 297.92 kg ha^{-1}. While, the sugarcane growing soils were low in available nitrogen content to the tone of (70%) and (30%) soils was medium available N content. The soils in sugarcane growing area was ranged from 1.14 to 30.55 kg ha^{-1} in available phosphorus content. 75 percent, soils were low in phosphorus content. The medium phosphorus content was observed in 25 percent sugarcane growing soils study area. The available potassium content in sugarcane growing soils was varied from 110.88 to 776.4 kg ha^{-1}. 12 percent area was under low, 20 percent area under medium and 68 percent under high status of available potassium.

Status of available S, exchangeable Ca^{++} and Mg^{++}

Sulphur plays an important role in the plant's metabolism, synthesis of amino acids, proteins photosynthesis. Additional application of sulphur had profound effect on sugarcane yield, sugarcane quality. Further, sugarcane exhibits luxury consumption and removes a considerable quantity of S (about 47.6 kg $S0_4$/100 T cane) from the soil.

The data on status and characterization of available S and exchangeable Ca^{++}, Mg^{++} of sugarcane growing soils are presented in table 3.The available S content in sugarcane growing soils was ranged from 5.81 to 77.01 mg kg^{1}. The exchangeable Ca^{++} and Mg^{++} content in these soils were 11.5 to 32.7 Cmol (P^{+}) kg^{-1} and 7.7 to 28.4 Cmol (P^{+}) kg^{-1} respectively, all sugarcane growing soils from Samarth sugar co-operative industry Jalna were high in exchangeable Ca^{++} and Mg^{++} content. Similar results were also reported by Gaikwad *et al.,* (2016) for South Gujarat.

As shown in Table No.01,10.00 percent of soils exhibit low S content, 21.66 percent under medium where as 68.33 percent under high status of available S. Soils having sulphur status below critical level are required to be replenished improved to meet the demand of S in sugarcane crop. Organic matter plays a major role (Gaikwad *et al.,* 2016 and Kaur and Jalaji, 2008) in generating different forms of sulphur including available Sin soils. Sulphur removal by different crop ranges from 5 to 46 kg ha^{-1} and it rises to 78 to 80 kg ha^{-1} under intensive crop rotation.

Table.1 % categorization of soil S under sugarcane growing area of Jalna

S (ppm)		Sample no	No. of samples	% soil samples
Less than10	Low	3, 4, 14, 34, 38, 45	6	10.00 %
10-20	Medium	1, 2, 6, 8, 11, 12, 18, 19, 21, 23, 31, 44, 54	13	21.66 %
More than 20	High	5, 7, 9, 10, 13, 15, 16, 17, 20, 22, 24, 25, 26, 27, 28, 29, 30, 32, 33, 35, 36, 37, 39, 40, 41, 42, 43, 46, 47, 48, 49, 50, 51, 52, 53, 55, 56, 57, 58, 59, 60	41	68.33 %

Table.2 Global positioning system (GPS) information of sugarcane growing soils of Samarth sugar co-operative industry, Jalna

Sample No	Village	Elevation	North	East
1	SukhapuriShivar	468.3 m	$19^0$32.146'	$075^0$46.122'
2	Sukhapuri	467.9 m	$19^0$31.937'	$075^0$47.208'
3	Belgaon	466.0 m	$19^0$30.776'	$075^0$49.625'
4	Rui	446.0 m	$19^0$29.457'	$075^0$51.486'
5	KhaperkhedaHiwra	444.7 m	$19^0$27.881'	$075^0$53.720'
6	Bhardi	443.1 m	$19^0$27.510'	$075^0$26.964'
7	Ghugrdi	454.7 m	$19^0$26.964'	$075^0$50.157'
8	GhugrdiHadgao	448.0 m	$19^0$27.039'	$075^0$50.073'
9	Karnjala	444.5 m	$19^0$27.658'	$075^0$48.697'
10	KaranjalaShivar	439.2 m	$19^0$27.187'	$075^0$48.631'
11	Bhangjalgao	434.8 m	$19^0$26.630'	$075^0$48.961'
12	Bhangjalgao	437.6 m	$19^0$25.927'	$075^0$48.741'
13	Godi	432.8 m	$19^0$25.466'	$075^0$48.406'
14	GodiShivar	425.8 m	$19^0$24.988'	$075^0$47.011'
15	PathrvalaBudruk	425.6 m	$19^0$24.458'	$075^0$46.382'
16	PathrvalaBudruk	438.6 m	$19^0$23.239'	$075^0$44.956'
17	PathrvalaKhurd	447.8 m	$19^0$22.533'	$075^0$43.564'
18	PathrvalaKhurd	448.0 m	$19^0$22.573'	$075^0$43.094'
19	Vasantnagar	468.0 m	$19^0$32.177'	$075^0$45.751'
20	VadiBudruk	451.9 m	$19^0$27.050'	$075^0$42.636'
21	VadiBudruk	448.9 m	$19^0$26.655'	$075^0$42.780'
22	Gahinath Nagar	439.2 m	$19^0$25.328'	$075^0$42.593'
23	Mahakala	450.8 m	$19^0$24.255'	$075^0$42.121'
24	Surmapuri	454.3 m	$19^0$25.125'	$075^0$40.341'
25	Dahala	457.2 m	$19^0$25.563'	$075^0$39.727'
26	Dahala	450.3 m	$19^0$26.109'	$075^0$38.477'
27	Bhamberi	447.5 m	$19^0$26.332'	$075^0$37.500'
28	Bhamberi	439.1 m	$19^0$26.055'	$075^0$37.417'
29	BhamberiShivar	436.2 m	$19^0$25.573'	$075^0$37.420'
30	Bhamberi	437.2 m	$19^0$25.573'	$075^0$37.420'
31	Balegao	443.4 m	$19^0$23.226'	$075^0$36.890'
32	Balegao	447.0 m	$19^0$25.573'	$075^0$37.420'
33	Apegao	447.9 m	$19^0$23.282'	$075^0$39.064'
34	SashtiPimpalgao	447.7 m	$19^0$22.999'	$075^0$39.919'
35	SashtiPimpalgao S	444.8 m	$19^0$22.768'	$075^0$40.639'
36	MahakalaShivar	448.7 m	$19^0$23.924'	$075^0$42.598'
37	Mahakala	442.1 m	$19^0$24.420'	$075^0$42.641'
38	Mahakala	444.2 m	$19^0$24.936'	$075^0$42.710'
39	MahakalaShivar	436.3 m	$19^0$25.653'	$075^0$42.789'

40	MahakalaShivar	445.2 m	$19^0$26.249'	$075^0$42.869'
41	VadigodriShivar	448.6 m	$19^0$26.674'	$075^0$42.981'
42	Vadigodri	449.0 m	$19^0$27.187'	$075^0$43.169'
43	VadigodriShivar	449.7 m	$19^0$27.615'	$075^0$43.439'
44	Dhakalgao	469.0 m	$19^0$29.711'	$075^0$44.534'
45	Dandegao	456.7 m	$19^0$30.364'	$075^0$45.065'
46	Dandegao	459.7 m	$19^0$30.795'	$075^0$45.184'
47	Sevalal Nagar D.	462.3 m	$19^0$31.051'	$075^0$45.440'
48	Zimpi	465.1 m	$19^0$31.476'	$075^0$45.939'
49	AmbadShivar	489.2 m	$19^0$33.433'	$075^0$46.721'
50	AmbadShivar	498.7 m	$19^0$36.324'	$075^0$47.579'
51	Mathpimpalgao	480.1 m	$19^0$42.959'	$075^0$49.752'
52	Mathpimpalgao	483.9 m	$19^0$43.795'	$075^0$49.975'
53	Pangarkheda	478.7 m	$19^0$34.296'	$075^0$50.412'
54	Pangarkheda	496.3 m	$19^0$35.219'	$075^0$48.670'
55	Tadasgao	463.3 m	$19^0$33.442'	$075^0$51.393'
56	Tadasgao	473.2 m	$19^0$33.655'	$075^0$51.804'
57	TadasgaoShivar	472.6 m	$19^0$32.620'	$075^0$48.493'
58	Gaudgao	470.4 m	$19^0$32.937'	$075^0$48.813'
59	Gaudgao	481.3 m	$19^0$33.143'	$075^0$47.250'
60	GaudgaoShivar	474.2 m	$19^0$33.253'	$075^0$46.980'

Table.3 Status of available micronutrients in sugarcane growing soils from Samarth sugar co-operative industry, Jalna

Sample No	Village	S (ppm)	Ca^{++} c mol (p^+) kg^{-1}	Mg^{++} c mol (p^+) kg^{-1}	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
1	SukhapuriShivar	14.36	18.7	8.5	3.28	4.38	1.48	1.96
2	Sukhapuri	18.11	26.5	11.2	5.15	4.64	0.92	2.85
3	Belgaon	5.81	21.3	8.6	4.89	8.56	0.52	0.30
4	Rui	7.24	15.5	10.5	6.12	5.32	1.18	2.32
5	KhaperkhedaHiwra	48.29	18.2	17.9	4.36	6.30	0.15	1.84
6	Bhardi	16.31	25.7	12.4	8.98	5.92	1.21	1.26
7	Ghugrdi	23.31	21.8	9.8	5.22	4.54	0.11	0.72
8	GhugrdiHadgao	14.71	17.1	16.2	8.26	6.92	0.18	0.98
9	Karnjala	25.47	28.6	12.4	3.45	8.94	0.16	2.22
10	KaranjalaShivar	26.56	21.8	9.8	4.73	7.28	0.43	2.96
11	Bhangjalgao	14.88	11.5	17.2	8.84	10.88	1.14	1.78
12	Bhangjalgao	12.73	32.4	22.2	3.92	10.18	0.46	1.24
13	Godi	21.62	18.7	28.4	9.13	11.78	0.42	0.86
14	GodiShivar	9.61	31.4	9.6	10.26	8.92	0.12	2.34
15	PathrvalaBudruk	24.81	29.6	19.2	9.18	12.82	0.22	1.84
16	PathrvalaBudruk	26.58	19.3	13.2	8.88	4.22	0.68	1.72

17	PathrvalaKhurd	47.42	16.5	17.6	6.62	5.94	0.28	2.74
18	PathrvalaKhurd	13.45	18.8	27.8	8.14	5.28	0.22	1.78
19	Vasantnagar	19.13	25.5	20.2	8.72	6.52	0.28	1.68
20	VadiBudruk	39.37	14.8	19.4	6.33	4.44	2.06	0.26
21	VadiBudruk	19.85	22.3	22.4	4.22	4.58	1.20	2.22
22	Gahinath Nagar	39.72	29.4	18.8	6.28	6.10	1.10	2.42
23	Mahakala	18.06	16.9	20.2	5.64	8.62	0.32	1.64
24	Surmapuri	46.12	25.9	17.4	9.80	11.26	0.36	0.92
25	Dahala	66.01	18.5	20.3	10.46	15.28	0.86	1.14
26	Dahala	72.14	11.5	19.2	12.44	12.98	0.54	2.82
27	Bhamberi	24.75	21.6	16.6	9.32	8.12	0.48	2.42
28	Bhamberi	60.32	21.7	21.2	6.23	7.74	0.34	2.16
29	BhamberiShivar	25.87	26.4	21.6	8.62	8.44	0.28	2.94
30	Bhamberi	53.72	12.5	21.2	8.44	9.24	0.56	0.82
31	Balegao	16.24	14.8	23.4	9.93	10.92	0.94	1.24
32	Balegao	28.72	16.6	13.6	7.13	12.68	0.42	2.42
33	Apegao	38.72	12.6	9.8	8.92	16.98	0.42	1.32
34	SashtiPimpalgao	8.48	18.5	23.2	5.24	8.24	0.54	2.32
35	SashtiPimpalgao S	28.91	14.2	9.4	8.84	9.94	0.84	2.84
36	MahakalaShivar	30.5	30.5	19.2	10.7	6.78	0.98	1.30
37	Mahakala	29.43	32.5	15.6	5.37	8.88	0.26	2.36
38	Mahakala	7.81	16.6	20.2	8.35	6.28	0.16	1.84
39	MahakalaShivar	60.32	32.7	22.4	9.26	9.12	0.12	2.48
40	MahakalaShivar	37.25	20.7	23.2	5.22	4.68	0.28	1.32
41	VadigodriShivar	24.32	26.4	7.7	9.58	6.22	1.02	2.82
42	Vadigodri	77.01	18.3	13.6	9.36	11.10	0.30	2.44
43	VadigodriShivar	25.53	17.7	21.2	10.08	8.18	0.32	2.46
44	Dhakalgao	18.93	30.7	21.4	4.76	9.76	0.22	1.82
45	Dandegao	8.34	28.5	21.2	8.24	8.44	0.16	1.32
46	Dandegao	34.08	32.6	21.4	5.34	6.90	0.80	2.84
47	Sevalal Nagar D.	24.66	14.6	16.2	6.49	8.22	0.84	1.28
48	Zimpi	28.36	16.5	22.2	7.82	5.05	0.84	2.22
49	AmbadShivar	23.31	22.5	20.8	9.52	6.17	0.26	1.44
50	AmbadShivar	37.46	32.6	15.6	5.14	7.22	0.94	1.32
51	Mathpimpalgao	27.01	31.4	16.2	7.74	6.98	0.70	0.44
52	Mathpimpalgao	26	32.5	11.2	4.76	4.74	1.82	0.74
53	Pangarkheda	21.28	28.4	24.4	5.84	7.32	0.30	1.22
54	Pangarkheda	18.93	26.6	10.2	7.42	8.38	0.74	2.63
55	Tadasgao	41.16	22.2	24.2	4.56	6.42	0.58	0.82
56	Tadasgao	54.52	32.5	12.4	8.84	10.18	0.50	2.84
57	TadasgaoShivar	22.63	18.4	13.4	6.32	8.68	0.44	1.55
58	Gaudgao	35.13	24.4	11.2	8.74	9.27	0.84	0.74
59	Gaudgao	24.19	26.6	15.4	8.42	7.38	0.72	2.32
60	GaudgaoShivar	48.16	22.3	14.2	6.44	6.34	0.42	1.82
	Average	29.39	22.59	17.08	7.33	8.05	0.60	1.79
	Maximum	77.01	32.7	28.4	12.44	16.98	2.06	2.96
	Minimum	5.81	11.5	7.7	3.28	4.22	0.11	0.26
	STDV	16.42	6.41	5.22	2.13	0.72	0.42	2.72

So, to tide over problems of low to medium available S, addition of organic/ inorganic fertilizers, sulphonated compost and biocomposts or gypsum or sulphur solubilizing microbes in requisite quantity would be must in these soils for enhancement of available S. Increase in available S content in the post-harvest soils was found with increasing levels of S application (Gaikwad *et al.,* 2016 and Singh *et al.,* 2007).

The data revealed that the available S content of these soils were ranged from 5.81 to77.01 mg kg^{-1} with an average value of 29.39 mg kg^{-1}. The lower value of S was recorded in soils of Belgaon (Sample No.3) while higher value of S was recorded in soils of Vadigodri (Sample No.42) along with STDV value 16.42. From the above data it is clearly noticed that surface soils were rich in available sulphur. This might be due to higher amount of organic matter in surface layers. The results are in confirmatory with the results reported by Mali and Syed (2002).The available sulphur content in sugarcane growing soils was 5.81 to 77.01 ppm. These soils were categorized as 10 percent low, 22 percent medium and 68 percent high in sulphur content it was observed in (10%), (22%) and (68%) respectively. The exchangeable Ca^{++} content in sugarcane growing soils were ranged from 11.5 to 32.7 cmol (P^{+}) kg^{-1}. Sugarcane growing soils of Samarth sugar co-operative industry Jalna were high (100%) in exchangeable Ca^{++}. The exchangeable Mg^{++} content in sugarcane growing soils ranged from 7.7 to 28.4 cmol (P^{+}) kg^{-1}. These soils were found high (100%) in exchangeable Mg^{++}. Similar results were also reported by Gaikwad *et al.,* (2016) for South Gujarat.

The DTPA Fe content in sugarcane growing soils was ranged from 3.28 to 12.44 mg kg^{-1} with percentage of medium iron (5%) and 95% high in DTPA-Fe. The DTPA Mn content in sugarcane growing soils was ranged from 4.22 to 16.98 mg kg^{-1}. Generally, sugarcane growing soils were medium to high content of Mn. The DTPA zinc content in sugarcane growing soils was ranged from 0.11 to 2.06 mg kg^{-1}. Hence, these soils were categorized as medium to high in DTPA zinc content. The low zinc content was observed 85% and high 15%.The DTPA copper content in sugarcane growing soils was ranged from 0.26 to 2.96 mg kg^{-1}. Majority of these soils were high in DTPA Cu content. Similar results were also reported by Gaikwad *et al.,* (2016) for South Gujarat.

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