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Soil Characterization, Leaf Nutritional Status and Fruit Quality of Acid Lime Orchards in Patur Block of Akola District, Maharashtra

Priya S. Gadge[1], S. N. Ingle[1*], M. M. Raut[1], N. M. Konde[1], D. V. Mali[1], N. R. Dange[1] and D. N. Nalge[1]

[1]Department of Soil Science and Agrilcultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola - 444104, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation on "Soil characterization, leaf nutritional status and fruit quality of Acid Lime orchards in Patur block of Akola district" was undertaken during the year 2018-19. Twenty healthy lime orchards were selected on the basis of their yield performance and visual observations from five locations of Patur block viz., Wadegaon, Sasti, Patur, Mazod and Goregaon. The study was framed to evaluate the soil characteristics, leaf nutritional status and fruit quality of Acid Lime. Twenty soil samples were collected from 0-30 and 30-60 cm depth in randomly selected acid lime orchards. Similarly, the leaf and fruit samples were collected and analyzed for quality parameters. The results indicated that, the soil reaction was neutral to slightly alkaline with pH value varied from 7.35 to 8.14, EC ranges from 0.23 to 0.32 dS m^{-1} indicating the non-saline nature of these soils. Free calcium carbonate varied from 5.63 to 9.42%, Organic carbon showed decreasing trend with soil depth and having medium to moderately high in organic carbon. The available nitrogen was found to be low to medium, phosphorus was low, potassium was high to very high and sulphur was low to moderate. The DTPA extractable micronutrients in soil were moderately high in zinc, iron,

**Corresponding author: E-mail: sagarsoils26@gmail.com;*

copper and manganese. The leaf nutrient status was found to be low to optimum in total nitrogen, phosphorus and micronutrient and optimum to high in potassium. Fruits of acid lime were found to be of good quality. Since, the correlations obtained in the present studies did not show any consistent trend.

Keywords: Soil characterization; acid lime; Patur; leaf nutrient.

1. INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) is the third important citrus fruit crop in India next to mandarin and sweet orange and it is native of India and belongs to Rutaceae family. It is generally grown under both tropical and subtropical climatic conditions in the plains and up to above 1200 m MSL. Citrus is globally one of the leading fruit crop with a total production of 112.8 million tonnes (Mt), the maximum production 32.6 Mt is noted in Asia, followed by 25.8 Mt in South America [1]. Brazil tops the list with a total production of 19.9 Mt, followed by USA and India (Srivastava and Singh, 2008). The highest global citrus production comes from soils represented by order Alfisol, Ultisols, Entisols and Inceptisol [2,3,4]. In India, citrus is grown on 5.63 lakh hectare area with a total production of 56.8 lakh tonnes and productivity 10.1 tonnes/ha [5].

Citrus is considered as highly nutrient responsive crop. Nutrient responsiveness of citrus is evaluated through nutrient diagnosis based on leaf analysis, soil analysis, juice analysis, enzyme function and deficiency symptoms. Out of these, deficiency symptom is mostly used, although with minimum practical implications on the orchard performance. Relying solely on deficiency symptoms will be too late for timely diagnosis of nutrient constraints unless complemented with both leaf and soil analysis data. Occurrence of multiple nutrient deficiencies makes the redressal of such nutrient deficiencies is very complex exercise. Site specific nutrient management studies find a greater weightage over the conventional fertilization response studies. Simultaneously, use of integrated strategies viz., soil application of macronutrients (NPKS) and foliar application of micronutrients (Fe, Mn, Zn and B); fertigation and integrated nutrient management (INM) using rationale use of organic manures fortified with microbial consortium. The integration of microbial cultures through isolation and characterization of native and dual purpose microbes and inorganic fertilizers have produced encouraging responses to improve production dividends underlying their undeniable utility [6]. Maintaining orchards with trees at optimal leaf nutrient concentrations is one of the key issues for maximizing yields [7].

The soils of Patur bock of Akola district are moderately shallow to deep black categorised under Vertisols, have major problems of poor hydraulic conductivity, high degree of swell-shrink potential, compact and dense soil fabric. While considering the importance of plant nutrition in determining production and quality of acid lime and lack of information regarding the optimum range of nutrients in soil, particularly for maintaining the yield potential of quality fruits of acid lime, the present investigation has been attempted.

2. MATERIALS AND METHODS

The study area of present investigation lies between 20026’60.00” North Latitude and to 76055’48.00” East with an area of 737.09 square Km in Akola district of Maharashtra. The location map of the study area is given in Fig. 1. The investigation area is lies in subtropical region, dry sub-humid with ustic soil moisture regime and hyperthemic soil temperature regime. The average rainfall is 718 mm which is received mostly from south-west monsoon. The 20 acid lime orchards were selected for the present study. The soil samples in all the twenty orchards were collected from the depth of 0-30 and 30-60 cm. The analysis of collected soil samples was carried out using standard procedures [8,9,10] Similarly About 50 leaves from 4-7 month old flush from non-fruiting terminals, preferably 2nd, 3rd and 4th leaf at the height of 1.5 – 1.8 m from ground were collected randomly from all the side of plants. [2]. The total analysis of leaf nutrient properties of collected samples were carried out using standard procedures [11,9,12]. While in Fruit analysis the physical and chemical properties were carried out using standard procedures by Lacey [13]. The coefficient of correlation between dependent and independent soil variables and the regression equations were worked out as per procedure described by Gomez and Gomez [14].

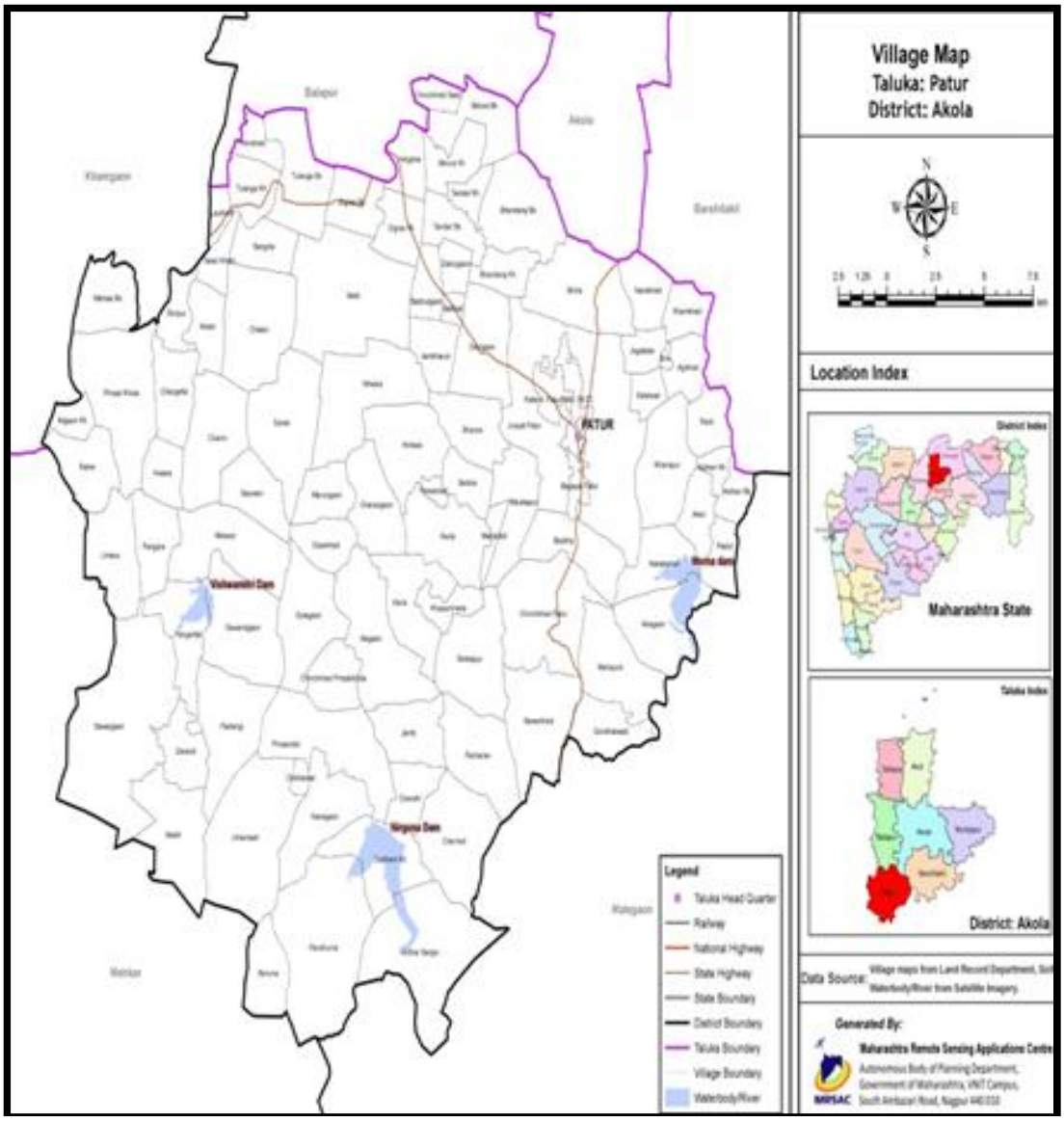

Fig. 1. Location map of Patur block

3. RESULTS AND DISCUSSION

3.1 Chemical Properties of Soil

The soil reaction was neutral to slightly alkaline with pH value varied from 7.35 to 8.41, presented in (Table 1). it slightly increased with depth and varied from 7.53 to 8.14 at 30-60 cm depth. Electrical conductivity ranges from 0.23 to 0.32 dS m^{-1} indicating the non-saline nature of these soils [11]. The free calcium carbonate varied from 5.63 to 9.42 % which qualify them to class as moderately calcareous to calcareous. Calcium carbonate content below 10 per cent is supposed to be safe for cultivation of lime [6]. Similar result were closely pointed out by Punekar et al. [17]. The organic carbon has a strong cascading effect on most of the soil physico-chemical properties [2]. The organic carbon content in soils of healthy acid lime orchards varied from 4.4 to 6.8 g kg^{-1}. Whereas, it has shown decreasing trend with soil depth These soil profiles displayed a medium to moderate soil organic carbon content, especially in their rhizosphere soil. The results were in conformity with the findings of Punekar et al. [17].

Table 1. Chemical properties of soils of acid lime orchards

Sample No.	Depth (cm)	pH	EC (dS m^{-1})	CaCO3 (%)	Org. C (g kg^{-1})
Location : Wadegaon					
Orchard 1	0-30	7.89	0.258	7.65	5.3
	30-60	7.92	0.274	8.28	4.4
Orchard 2	0-30	7.45	0.298	7.39	6.1
	30-60	7.53	0.324	8.71	5.9
Orchard 3	0-30	8.01	0.274	7.96	5.6
	30-60	8.12	0.302	8.54	4.2
Orchard 4	0-30	7.69	0.276	6.14	4.6
	30-60	7.74	0.298	7.65	4.2
Location : Sasti					
Orchard 5	0-30	7.35	0.286	7.02	6.8
	30-60	7.41	0.312	8.32	5.0
Orchard 6	0-30	8.08	0.234	6.01	5.4
	30-60	8.14	0.248	7.35	4.4
Orchard 7	0-30	7.61	0.264	7.85	5.6
	30-60	7.72	0.282	8.01	4.0
Orchard 8	0-30	7.63	0.278	8.96	4.6
	30-60	7.78	0.298	9.42	4.0
Location : Patur					
Orchard 9	0-30	7.91	0.283	7.96	5.2
	30-60	8.02	0.314	8.63	4.1
Orchard 10	0-30	7.84	0.267	7.12	4.8
	30-60	7.97	0.282	8.51	4.1
Orchard 11	0-30	8.02	0.234	7.56	4.4
	30-60	8.14	0.248	8.43	4.0
Orchard 12	0-30	7.58	0.291	6.12	5.1
	30-60	7.62	0.321	7.03	4.6
Location : Mazod					
Orchard 13	0-30	8.01	0.261	7.26	5.3
	30-60	8.10	0.278	8.31	4.5
Orchard 14	0-30	7.65	0.268	7.21	5.4
	30-60	7.78	0.281	8.08	4.9
Orchard 15	0-30	8.01	0.288	6.69	5.1
	30-60	8.08	0.311	7.42	4.9
Orchard 16	0-30	7.65	0.295	7.84	4.4
	30-60	7.74	0.321	8.25	4.0
Location : Goregaon					
Orchard 17	0-30	7.58	0.257	7.22	4.8
	30-60	7.63	0.271	8.67	4.1
Orchard 18	0-30	7.44	0.234	7.85	5.6
	30-60	7.56	0.252	8.50	4.4
Orchard 19	0-30	8.00	0.287	5.63	4.8
	30-60	8.12	0.302	6.45	4.2
Orchard 20	0-30	8.04	0.261	6.08	5.5
	30-60	8.13	0.278	6.74	4.8

3.2 Soil Nutrient Status of Acid Lime Orchards

The collected soil samples were analyzed for various nutrients and the generated results are placed in (Tables 2 and 3). It was observed that the available nitrogen in surface soils varied from 198.91 to 291.68 kg ha^{-1} in acid lime orchards. Whereas, it varied from 179.29 to 264.47 kg ha^{-1} with different depths. From the data, it is indicated that, the available nitrogen content was decreasing with depth in all the soil profile. Similar findings were reported by Kuchanwar et al. [18]. While available phosphorus varied from 18.12 to 22.85 kg ha^{-1}. The available phosphorus content showed a decreasing trend with depth in all the soil profile. Similar observations was also recorded by Srivastava and Singh [3] and Rahman et al. [19] The available potassium in surface soils of acid lime orchard ranged from

330.28 to 394.45 kg ha^{-1}. All soils of acid lime orchards were under high to very high in available potassium content. Similar result were reported by Kuchanwar et al. [18]. The available sulphur in surface soils of acid lime orchards ranged from 10.14 to 12.87 mg kg^{-1}.The result showed that the distribution of sulphur was not uneven with depth of the soil. Amongst the available micro-nutrient status in soils of acid lime orchards, the available Fe- 4.87-7.94 $mgkg^{-1}$, Mn-6.34-11.18 $mgkg^{-1}$, Cu-3.14-3.98 $mgkg^{-1}$ and Zn- 0.61-0.81 mg kg^{-1} were registered Similar finding were also reported by Khokhar et al. [20].

Table 2. Soil nutrient status of acid lime orchards

Sample No.	Depth (cm)	N	P	K	S
			(kg ha^{-1})		(mg kg^{-1})
Location : Wadegaon					
Orchard 1	0-30	236.82	22.85	394.45	11.22
	30-60	197.13	21.62	352.84	9.92
Orchard 2	0-30	272.95	20.63	365.41	12.62
	30-60	264.47	18.14	320.02	9.24
Orchard 3	0-30	251.54	21.25	354.32	11.84
	30-60	188.21	20.52	321.22	8.95
Orchard 4	0-30	207.39	21.21	371.65	11.28
	30-60	188.65	20.12	322.52	9.12
Location : Sasti					
Orchard 5	0-30	291.68	19.38	360.82	12.22
	30-60	223.89	18.14	302.02	11.01
Orchard 6	0-30	244.85	20.63	340.50	10.85
	30-60	199.36	19.47	310.51	9.02
Orchard 7	0-30	252.43	18.36	380.65	11.54
	30-60	180.18	17.08	323.84	9.11
Orchard 8	0-30	207.39	19.63	342.54	12.87
	30-60	179.29	18.85	310.92	11.52
Location : Patur					
Orchard 9	0-30	233.25	18.28	350.36	10.28
	30-60	183.75	17.25	326.63	8.27
Orchard 10	0-30	214.97	19.51	380.59	11.71
	30-60	183.30	18.02	342.28	9.81
Orchard 11	0-30	198.91	20.46	362.25	12.31
	30-60	181.96	19.43	313.21	11.96
Orchard 12	0-30	228.35	18.49	364.39	11.14
	30-60	207.39	17.76	311.82	10.02
Location : Mazod					
Orchard 13	0-30	238.16	20.48	354.64	10.51
	30-60	204.26	19.61	304.58	8.44
Orchard 14	0-30	243.51	18.85	365.36	11.56
	30-60	219.87	17.32	301.01	10.42
Orchard 15	0-30	228.35	18.12	364.28	11.20
	30-60	220.32	17.55	318.84	9.04
Orchard 16	0-30	199.36	19.54	362.81	11.21
	30-60	180.18	18.18	302.43	10.84
Location : Goregaon					
Orchard 17	0-30	216.31	19.22	340.28	10.74
	30-60	185.53	18.67	312.71	9.22
Orchard 18	0-30	251.54	19.52	345.55	11.65
	30-60	199.36	18.58	310.32	8.37
Orchard 19	0-30	215.41	18.82	350.84	10.36
	30-60	187.76	17.04	329.67	9.21
Orchard 20	0-30	248.42	19.82	330.28	10.14
	30-60	214.97	18.98	314.62	9.22

Table 3. Micronutrient status of soils of acid lime orchards

Sample No.	Depth (cm)	Fe	Mn	Cu	Zn
			(mg kg^{-1})		
Location : Wadegaon					
Orchard 1	0-30	6.23	11.23	3.21	0.73
	30-60	7.11	8.24	2.68	0.59
Orchard 2	0-30	5.31	13.23	3.57	0.66
	30-60	5.82	10.35	3.01	0.44
Orchard 3	0-30	4.69	10.01	3.41	0.71
	30-60	5.01	7.22	2.74	0.62
Orchard 4	0-30	6.47	9.21	3.52	0.76
	30-60	7.02	7.13	2.83	0.61
Location : Sasti					
Orchard 5	0-30	5.54	12.02	3.72	0.61
	30-60	6.03	9.94	3.02	0.55
Orchard 6	0-30	6.44	10.42	3.83	0.79
	30-60	5.48	7.58	2.97	0.62
Orchard 7	0-30	4.32	12.54	3.77	0.65
	30-60	4.87	8.23	3.10	0.58
Orchard 8	0-30	4.84	10.56	3.2	0.71
	30-60	5.22	6.34	2.35	0.62
Location : Patur					
Orchard 9	0-30	5.36	11.24	3.76	0.68
	30-60	7.24	7.52	3.14	0.51
Orchard 10	0-30	4.57	12.41	3.98	0.78
	30-60	5.98	8.53	3.23	0.64
Orchard 11	0-30	4.84	9.54	3.67	0.69
	30-60	5.42	7.01	3.01	0.58
Orchard 12	0-30	6.52	9.57	3.84	0.72
	30-60	7.02	7.12	3.22	0.68
Location : Mazod					
Orchard 13	0-30	5.15	13.84	3.43	0.67
	30-60	6.85	9.93	2.84	0.59
Orchard 14	0-30	4.98	12.01	3.21	0.80
	30-60	5.52	8.13	2.39	0.71
Orchard 15	0-30	4.45	14.02	3.74	0.79
	30-60	5.91	10.91	3.11	0.66
Orchard 16	0-30	6.35	12.36	3.14	0.69
	30-60	7.70	9.12	2.54	0.61
Location : Goregaon					
Orchard 17	0-30	5.74	13.54	3.64	0.81
	30-60	6.31	9.22	2.95	0.76
Orchard 18	0-30	5.74	13.11	3.90	0.74
	30-60	6.01	9.42	3.31	0.69
Orchard 19	0-30	4.72	12.42	3.45	0.71
	30-60	5.23	8.51	2.82	0.65
Orchard 20	0-30	6.57	14.06	3.78	0.74
	30-60	7.94	11.18	3.20	0.68

3.3 Leaf Nutrient Status of Acid Lime Orchards

The leaf assessment was also followed during the investigation. The generated data is placed in (Table 4). The nitrogen content in leaves of acid lime ranged from 2.21 to 2.41%, the similar variation of nitrogen content in kagzi lime was also observed by Shrivastava and Singh (2001). Similar findings were also reported by Kuchanwar et al. [18] who reported that nitrogen content in leaves of mandarin orchards in Warud tahsil of Amravati district were ranged from 2.22 to 2.43% with a mean value of 2.29%. The total phosphorus concentration in the leaves of acid lime orchards ranged from 0.09 to 0.16%. The

low concentration of phosphorus might be due to low available phosphorus status in soil and inadequate use of phosphatic fertilizers. Similar findings were also reported by Kuchanwar et al. [18]. Total potassium content in the leaves of acid lime orchards varied from 0.79 to 1.96%. The micro-nutrient status was optimum in leaf samples of lime. The iron content was varied from 84.65-102.01 ppm, the maximum value of Fe in leaves was found in orchards of Sasti Wadegaon (102.01 ppm) and minimum in Goregaon (84.65 ppm). The manganese was ranges from 38.28-42.09 ppm, copper 4.65-6.92 ppm and Zinc was in the range of 23.18-30.65 ppm. The similar findings were reported by Kuchanwar et al. [18].

3.4 Fruit Quality of Acid Lime Orchards

The data regarding juice content in the fruits of acid lime is presented in (Table 5). The juice content in acid lime orchards varied from 40.65 to 49.57 per cent with an average of 45.01 per cent. Similar observations in respect of juice content were recorded by Survase *et al.* (2016). The total soluble solids content in fruit juice of acid lime orchards ranged between 7.12 to 8.52 with an average of 7.64 per cent. Similar observations in respect of total soluble soilds was recorded by Shirgure and Srivastava [21]. The ascorbic acid content in fruit juice ranged from 24.24 to 31.43 mg 100 ml^{-1}. The higher value of vitamin C was observed in juice acid lime collected from Wadegaon. The results are in conformity with the findings of Reddy et al. [22].

3.5 Correlation Co-efficient between Soil Properties and Leaf Nutrient Status

The correlation between different soil properties with nutrient content in leaves is placed in (Table 6). It observed that, the significant positive correlations between soil organic carbon with leaf nitrogen (r=0.421**), phosphorous (r=0.435**), iron (r=0.487**) manganese (r=0.454**) and zinc (r=0.402*). Similarly, significant positive correlations of available nitrogen with leaf nitrogen (r=0.504**), phosphorous (r=0.328*), manganese (r=0.474**), and zinc (r=0.318*). This indicates that the optimum availability of nitrogen in soil increases uptake of other nutrients. Significant positive correlations of available P with leaf nitrogen (r=0.496**), phosphorous (r=0.361*), iron (r=0.432**), zinc (r=0.469**).

Table 4. Leaf nutrient status of acid lime orchards

Sample No.	N	P	K	Fe	Cu	Mn	Zn
	%			ppm			
Location : Wadegaon							
Orchard 1	2.35	0.12	1.15	95.31	5.64	41.09	30.01
Orchard 2	2.38	0.16	1.43	102.01	6.61	40.66	28.78
Orchard 3	2.40	0.13	1.09	86.36	5.90	39.14	29.15
Orchard 4	2.29	0.11	1.24	100.02	5.41	40.09	28.74
Location : Sasti							
Orchard 5	2.30	0.11	1.32	85.32	4.92	41.01	26.65
Orchard 6	2.41	0.12	1.14	96.24	4.65	39.06	23.46
Orchard 7	2.26	0.10	0.90	95.41	5.22	42.09	27.08
Orchard 8	2.24	0.14	0.94	102.01	5.48	40.02	23.47
Location : Patur							
Orchard 9	2.33	0.11	0.96	88.32	5.63	39.01	24.82
Orchard 10	2.28	0.12	1.82	96.32	4.91	38.66	26.23
Orchard 11	2.26	0.14	1.96	88.22	5.12	41.16	27.54
Orchard 12	2.32	0.13	1.74	96.14	5.54	40.06	29.58
Mazod							
Orchard 13	2.36	0.12	1.24	94.71	5.82	39.41	27.01
Orchard 14	2.32	0.11	1.83	88.21	5.96	39.44	26.66
Orchard 15	2.24	0.09	1.01	96.14	6.36	38.28	27.15
Orchard 16	2.28	0.12	0.96	100.85	6.41	40.08	23.18
Location : Goregaon							
Orchard 17	2.21	0.14	1.84	84.65	6.92	41.12	27.54
Orchard 18	2.23	0.11	1.21	97.33	5.86	39.22	30.65
Orchard 19	2.28	0.13	0.79	88.52	5.73	41.18	26.23
Orchard 20	2.22	0.10	1.35	94.32	5.67	38.85	24.25

Table 5. Fruit quality of acid lime orchards

Sample No.	Juice (%)	TSS (%)	Ascorbic acid (mg 100 ml^{-1})
Location : Wadegaon			
Orchard 1	48.32	8.25	31.43
Orchard 2	47.85	7.77	28.53
Orchard 3	49.44	8.52	29.12
Orchard 4	49.57	7.46	28.32
Location : Sasti			
Orchard 5	44.33	7.83	27.54
Orchard 6	41.58	7.66	25.64
Orchard 7	41.55	7.45	24.24
Orchard 8	43.54	7.81	31.41
Location : Patur			
Orchard 9	40.65	7.21	30.22
Orchard 10	41.05	7.77	27.82
Orchard 11	43.84	8.02	27.69
Orchard 12	44.28	7.33	30.01
Location : Mazod			
Orchard 13	47.35	7.18	28.74
Orchard 14	44.93	7.41	27.61
Orchard 15	45.17	7.12	30.82
Orchard 16	43.52	7.44	31.08
Location : Goregaon			
Orchard 17	47.63	7.15	28.59
Orchard18	49.12	8.04	27.85
Orchard 19	42.85	8.12	29.51
Orchard 20	43.65	7.37	30.02

Table 6. Correlation co-efficient between soil properties and leaf nutrient status

Correlation co-efficient between soil properties and leaf nutrient status							
Soil properties	**Leaf nutrient content**						
	N	**P**	**K**	**Fe**	**Mn**	**Cu**	**Zn**
pH	0.044	0.014	-0.093	0.018	0.360	0.354	0.098
EC	-0.377	-0.132	0.081	0.329	-0.367	-0.456	-0.190
$CaCO_3$	-0.188	-0.047	-0.381	0.298	-0.167	-0.126	-0.453
OC	0.421**	0.435**	0.197	0.487**	0.454**	-0.029	0.402**
N	0.504**	0.328*	-0.073	-0.340	0.474**	0.217	0.318*
P	0.496**	0.361*	0.296	0.432**	0.120	0.144	0.469**
K	0.007	0.357	0.385	-0.389	0.167	0.429	0.302
S	-0.050	0.320	0.427	-0.334	0.163	0.244	0.126
Zn	0.472**	0.322*	-0.178	0.343*	0.414**	0.352*	0.438**
Cu	-0.010	-0.178	-0.613	0.495	-0.297	-0.432	-0.047
Mn	0.506**	0.317*	-0.279	0.459	-0.104	0.374*	0.456**
Fe	0.328*	0.316*	0.739	0.511**	0.592*	0.026	0.476**

The availability of micronutrients in soil significantly influences the content of nutrient in leaves. The significant positive correlation of DTPA-Fe was recorded with nitrogen (r=0.328*), phosphorus (r=0.316*), iron (r=0.511**), manganese (r=0.592**), zinc (r=0.476**). DTPA-Mn significantly and positively correlated with leaf nitrogen (r=0.506**), phosphorus (r=0.317*), copper(r=0.374*), zinc (r=0.456**). DTPA-Zn was significantly and positively correlated with, leaf nitrogen (r=0.472**) phosphorus (r=0.322*), Iron (r=0.343*), Manganese (r=0.414**), Cu (r=0.352*), Zn (r=0.438**).

This indicated that, the increasing availability micro-nutrients in soils support to enhance content of nutrients in leaves. The DTPA-Cu did not show any correlation with nutrient content in leaves this might be due to the high content of copper in leaves and also might be due to the high content of copper in soil due to heavy use of

copper in pasting the trunk of acid lime trees and Bordeaux mixture for spraying.

4. CONCLUSION

It can be concluded that fertility of soils is a result of presence of essential plant nutrients in adequate amounts and in available forms to the plant. The present result thus, reflect that the soils of the region are suitable for acid lime. There is a need to increase in the content of organic carbon, available nitrogen, available phosphorus, DTPA extractable Zn, which increases the content of nutrients in leaves which turns into yield of acid lime orchards.The studies further confirm that the soil analysis in conjunction with leaf analysis can be effective in predicting the nutrient status as well as the effects on yields in citrus, since the correlations obtained in the present studies do not show any consistent trends.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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