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Studies on soil nutrient status of acid lime orchards in Western Vidarbha

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ABSTRACT
A survey of 70 acid lime orchards were made to evaluate the soil nutrient status of acid lime orchards in western Vidarbha region of Maharastra state. Acid lime orchards were classified in high yielding and low yielding group for evaluation of soil nutrient content. Soil samples were collected, processed as per the standard procedure and analyzed for their nutritional content. The average nitrogen content in soil was 398.57 kg ha^{-1} and 270.12 kg ha^{-1}, phosphorus 43.47 and 35.98 kg ha^{-1}, potassium 328.30 and 227.92 kg ha^{-1}, calcium 23.50 and 21.58 cmol(p^{+})kg^{-1}, magnesium 12.94 and 10.43 cmol(p^{+})kg^{-1}, sulphur 17.32 and 15.77 kg ha^{-1}, iron 8.49ppm and 7.86ppm, manganese 20.79ppm and 19.26ppm, zinc 1.19ppm and 0.87ppm, copper 9.78ppm and 7.31ppm in high and low yielding orchard respectively. The average range of different nutrients content in different orchard soil viz. nitrogen 266.56-611.52 and 141.12-454.72 kg ha^{-1}, phosphorus 17.47-64.06 and 19.71-53.76 kg ha^{-1}, potassium 118.92-662.18 and 114.40-465.13 kg ha^{-1}, calcium 16.38-32.65 and 16.16-29.08 cmol(p^{+})kg^{-1}, magnesium 4.64-19.20 and 5.68-13.62 cmol(p^{+})kg^{-1}, sulphur 12.43-19.66 and 11.31-19.99 kg ha^{-1}, iron 5.00-12.73ppm and 3.53-11.65ppm, manganese 11.25-37.73ppm and 9.25-27.13ppm, zinc 0.62-2.23ppm and 0.55-1.29ppm, copper 4.68-17.93ppm and 4.65-9.85ppm in high and low yielding orchard respectively.

Key words : Soil nutrients, Orchards, Vidarbha.

INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) is locally known as *Kagzi lime* or *Nimboo*. Acid lime plant requires judicious supply of plant nutrients for proper growth and yield of high quality fruits. Improper and inadequate nutrition is one of the major cause of citrus decline in India. Studies on the decline of Mandarin in Kerala showed that poor nutrient status of soil and negligence in manuring are the causal factors (Iyer and Iyengar, 1956, Ramakrishna, 1954) in Chennai. Deterioration and unthrifty growth of citrus trees was reported due to lack of adequate nutrients in Punjab (Nijjar and Singh, 1966 and Singh and Bakhshi, 1958). Determination of nutritional need of acid lime orchard and then application of nutrients as per their requirement is an essential step and operation for proper growth and optimum yield of high quality fruits. However, to ensure high economic productivity and to sustain the available soil nutrient status of desirable levels correct dose of manures and fertilizers must be applied by using reliable diagnostic tools.

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 in Western Vidarbha region, the present investigation was undertaken to evaluate the soil nutrient status for optimum production of acid lime and to decide the requirement of nutrient for acid lime.

MATERIALS AND METHODS

Soil samples of acid lime from the selected 70 orchards were collected and processed as per the standard procedure and analyzed for their nutritional contents. The circular band 30 to 40 cm wide under beneath the perimeter of that tree from which leaf sample were to be collected for the soil sampling. The surface soil (0-30cm) samples were taken from the said circular band 30 to 40cm away from stem and were kept separately. The collected soil samples were kept separately according to orchard high or low yielding sub population. These samples were air dried in shade, ground gently by wooden pestle and mortar sieved through 2mm sieve for determination of available nutrients and through 0.2mm sieve for organic carbon and free calcium carbonate estimation. Thus processed samples of 2 mm and 0.2mm size were duly labeled and stored in clean polyethylene bags for further analysis.

The processed samples were analyzed for different soil characteristics, macro and micro-nutrients viz. Soil pH(pH meter), Electrical conductivity (dSm^{-1}) (conductivity meter), Calcium carbonate (%)(rapid titration method), Organic carbon (%)(Walkley and Black method), nitrogen (Kjeldahl method), phosphorus (Vanadomolybdate yellow colour method), potassium (Flame photometry method), calcium and magnesium (EDTA method), sulphur (Turbidimetry method), zinc, iron, manganese and copper (Atomic Absorption Spectrophotometer).

RESULTS AND DISCUSSION

Characteristics of soil

The data presented in Table 1 and 2 indicated that soil are moderate alkaline to alkaline in reaction with the pH value ranging from 7.54-8.91 with mean pH value (8.25) in high yielding orchards during 2002-03 and 7.87-8.63 with mean pH value in (8.08) during 2003-04 which is slightly decreasing in order. The average range of pH value for two year was 7.75 - 8.77 with mean pH value of 8.16, which was moderate to alkaline in nature in high yielding orchards. Similar trends were observed in low yielding orchards during both the years of investigation. Kanwar and Randhawa (1960), Dhingra and Kanwar (1963) and Kanwar *et al*., (1965) reported that the pH of soils should not be more than 8.5 for the successful growth of citrus. Dhawan *et al*. (1957) reported similarity in their findings that the safe limit of pH was 7.0 to 8.5 for citrus. In the present investigation, the results have conformity with the findings of Patil and Malewar (1998) who reported that the soils of acid lime in Western Vidarbha are moderately alkaline in reaction (pH 7.9 to 8.3)

The soil electrical conductivity is a measure of soluble salt concentration in soil. Higher amount of salt in soils (higher EC) restrict the nutrient uptake and thus affect plant growth. EC of Acid lime orchards soil ranging from 0.05-0.27 dSm^{-1} with mean EC value (0.13 dSm^{-1}) in high yielding orchards during 2002-03 and 0.09-0.25 dSm^{-1} with mean value (0.15 dSm^{-1}) during 2003-04 which is slightly increasing in order. The average range of EC for two year was 0.07-0.17 dSm^{-1} with mean EC value (0.15 dSm^{-1}) in high yielding orchards (Table 1). As regard the low yielding orchard, EC was ranging from 0.04– 0.24 dSm^{-1} with mean EC value (0.17 dSm^{-1}) during 2002-03 and 0.10-0.25 dSm^{-1} with mean value (0.18 dSm^{-1}) during 2003-04, which was slightly increasing in order. The average range of EC for two year was 0.09-0.24 dSm^{-1} with mean (0.17 dSm^{-1}) in low yielding orchards (Table 2). Cooper and Peyando (1959) reported decrease in growth of young and old lime trees when treated with salts. Joolka and Singh (1979) reported inhibitory effects of salts on the growth of citrus roots and sweet orange. Patil (1979) suggested that EC should not exceed (3 dSm^{-1}) for orange fruit crop. The shoot growth, number of leaves and the leaf area of Nagpur mandarin were adversely affected as salinity levels increased in the soil (Khanna and Kumar, 1990). However, EC of acid lime orchards under study was within safe limits (<0.25 dSm^{-1}).

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Soil organic matter content in the soil indicates its general health. It helps in granulation of soil separates and maintain conductive acid water ratio in soil. Comparatively, higher organic carbon content in high yielding orchards soil than the low yielding orchards during both the years of investigation. Organic carbon content in the soil of high yielding orchards was ranging from 0.38-1.25% with mean of 0.68 during first year and it was 0.34-0.97% with the mean of 0.62% during second year of investigation. Average organic carbon content in the soil ranging from 0.40-1.1% with the mean of 0.65% which was optimum for soil health (Table 1). Whereas, the organic carbon content in the low yielding orchards soil, it was ranging from 0.3-0.89% with mean of 0.53% and 0.23-0.64% with mean of 0.45% during first and second year of investigation respectively. Average range organic carbon was found 0.33%- 0.75% with mean (0.49%), which was slightly, nearer to optimum level (Table 2). Raina (1988) observed the similar trend of organic carbon in the soils of citrus growing belts of Dhaulkuan district in Himachal Pradesh.

Table 1 : Soil characteristics and available nutrient status of high yielding acid lime orchards in Western Vidarbha

Sr. No.	Soil characters and nutrients	High yielding population								
		1st year			IInd Year			Average		
		Range	Mean	SE (m) ±	Range	Mean	SE (m) ±	Range	Mean	SE (m) ±
1	pH	7.54-8.91	8.25	0.04	7.87-8.63	8.08	0.03	7.75-8.77	8.16	0.03
2	EC (dSm^{-1})	0.05-0.27	0.13	0.01	0.09-0.25	0.15	0.01	0.07-0.17	0.14	0.01
3	Organic carbon (%)	0.38-1.25	0.68	0.03	0.34-0.97	0.62	0.03	0.40-1.1	0.65	0.02
4	CC (%)	1.60-13.76	7.54	0.63	2.45-16.92	6.86	0.55	2.56-14.38	7.20	0.55
5	N (kg ha^{-1})	219.52-595.84	367.00	17.52	313.6-627.20	530.14	19.12	266.56-611.52	398.57	17.01
6	P_2O_5 (kg ha^{-1})	16.13-73.47	42.28	2.53	16.13-68.10	44.65	2.68	17.47-64.06	43.47	2.31
7	K_2O (kg ha^{-1})	105.37-698.45	290.92	23.72	132.46-734.58	365.67	27.56	118.92-662.18	328.30	23.66
8	Ca (c mol $(p^+)kg^{-1}$)	17.38-31.14	23.83	0.56	13.08-34.15	22.18	0.82	16.38-32.65	23.50	0.64
9	Mg (c mol $(p^+)kg^{-1}$)	4.35-18.96	13.06	0.50	4.93-19.55	12.81	0.49	4.64-19.20	12.94	0.47
10	S (kg ha^{-1})	10.42-21.06	18.12	0.37	10.98-19.82	16.52	0.32	12.43-19.66	17.32	0.27
11	Fe (ppm)	4.40-14.65	8.61	0.44	4.20-13.90	8.37	0.42	5.00-12.73	8.49	0.40
12	Mn (ppm)	10.20-40.95	21.23	1.33	12.00-37.40	20.36	1.14	11.25-37.73	20.79	1.23
13	Zn (ppm)	0.46-1.87	1.25	0.08	0.49-2.84	1.12	0.07	0.62-2.23	1.19	0.06
14	Cu (ppm)	4.6-19.65	9.98	0.65	4.70-16.75	9.57	0.57	4.68-17.93	9.78	0.60
15	Yield (fruits/tree)	750-1900	1101	50.66	800-2500	1477	83.78	850-2100	1289	57.50

Free calcium carbonate content in high yielding orchards soil was lower as compare to the low yielding orchards during both the years of investigation. Average calcium carbonate content was recorded in the soil ranging from 2.56-14.38% with the mean of 7.20% in high yielding orchards (Table 1). Whereas the average calcium carbonate content in low yielding orchard was comparatively wide range was found i. e. 1.76-22.63% with mean of 8.15%, which was slightly, higher than the high yielding orchards (Table 2). Patil and Malewar (1988) reported similar results in mandarin soils of Amravati district of Western Vidarbha. Kanwar and Randhawa (960) and Dhingra and Kanwar (1963) reported that high $CaCO_3$ content in citrus soils of Punjab was an important factor towards decreased availability of iron and zinc in these soils. Nilangekar and Patil (1981) reported harmful effects of excessive accumulation of $CaCO_3$ on citrus. Kharkar *et al*., (1991) reported that free lime content in soil adversely affecting availability of macro and micronutrients. Besides, its affect on soil physical condition particularly aeration (Randhawa *et al*., 1966) and Kankal (2000) reported 3.01-19.73 per cent $CaCO_3$ in soil of Nagpur mandarin orchard.

Primary available nutrient status

Available nitrogen content in high yielding orchards soil was higher as compare to the low yielding orchards during both the years of investigation. Average available nitrogen content was recorded in the soil ranging from 266.56-611.52 kg ha^{-1} with the mean of 398.57 kg ha^{-1} in high yielding orchards (Table 1). Whereas, average available nitrogen content in low yielding orchard was found from 141.12-454.72 kg ha^{-1} with mean of 270.12 kg ha^{-1}, which was comparatively much lower than the high yielding orchards (Table 2). These results are in close conformity with the research findings of Awasthi *et al*., (1984) who studied mineral nutrient status of mandarin orchards in Nurpur area of Himachal Pradesh. Similar observations were also reported by Kharkar *et al.,* (1991) while studying nutritional status of healthy and declining citrus orchards in Vidarbha region. Nijjar and Singh (1971) also reported similar trend of nitrogen in citrus orchard soils in Amritsar district of Punjab. Kankal (2000) reported soil nitrogen status (73.76-219.96 kg ha^{-1}) in low yielding Nagpur mandarin orchard.

Average available phosphorus content was recorded in the soil ranging from 17.47-64.06 kg ha^{-1} with the mean of 43.47 kg ha^{-1} in high yielding orchards (Table 1). Whereas, Average available phosphorus content in low yielding orchard was found ranged from 19.71-53.76 kg ha^{-1} with mean of 35.98 kg ha^{-1}, which was comparatively lower than the high yielding orchards (Table 2). Relatively high content of available phosphorous in high yielding acid lime orchards of this region may be attributed to the intermittent application organic manure with applied dose of phosphorus which helps in build up of high level of phosphorus Similar results has been reported by (Malewar *et al.*, 1978) and Kharkar *et al.*, (1991). Organic manure produced in decomposition due to organic acids, which might make native phosphorus available and keeps it in available form by reducing its fixation. By and large the soil samples from low yielding orchard contained less available P than in the high yielding or healthy orchard. The results are in accordance with the findings of Singh and Tripathi (1983) and Kankal (2000).

Average available potassium content was recorded in the soil ranging from 118.92-662.18 kg ha^{-1} with the mean of 328.30 kg ha^{-1} in high yielding orchards (Table 1). Whereas, the average available potassium content in low yielding orchard was ranged from 114.40-465.13 kg ha^{-1} with mean of 227.92 kg ha^{-1} (Table 2), which was comparatively lower than the high yielding orchards. Potassium serves metabolic functions in the growth and cell division of young tissues. It improves fruit quality. It regulates water requirement in tress and greatly increases citrus yields not in term of number but in fruit size (Rajput and Sri Haribabu, 1995). Potassium is rather a regulatory nutrient maintaining nutrient balance in plants. Awasthi et al., (1984) observed similar result in healthy and declined mandarin orchards in Himachal Pradesh and Kharkar *et al.*, (1991) and Kankal (2000) in

Nagpur mandarin in Vidarbha region.

Secondary available nutrient status

Average available calcium content was recorded in the soil ranging from 16.38-32.65 c mol (p^+) kg $^{-1}$ with the mean of 23.50 c mol (p^+) kg $^{-1}$ in high yielding orchards of acid lime in Western Vidarbha (Table 1), Whereas, the average available calcium content in low yielding orchard was ranged from 16.16-29.08 c mol (p^+) kg $^{-1}$ with mean of 21.58 c mol (p^+) kg $^{-1}$, which was comparatively lower than the high yielding orchards (Table 2). These results are in conformity with the finding of Nilangekar and Patil (1981 and 1982), Kalbande et al., (1983), Awasthi et al. (1984) and Kankal (2000). This variation might have been due to the presence of free calcium carbonate in soils (Bhargava and Ragupathi, 1996).

Average available magnesium content was recorded in the soil ranging from 4.64-19.20 c mol (p^+) kg $^{-1}$ with the mean of 12.94 c mol (p^+) kg $^{-1}$ in high yielding orchards (Table 1). Whereas, the average available magnesium content in low yielding orchard was recorded from 6.65-13.62 c mol (p^+) kg $^{-1}$ with mean of 10.43 c mol (p^+) kg $^{-1}$, which was comparatively lower than the high yielding orchards (Table 2). Magnesium is a constituent of chlorophyll and also an enzyme activator. It helps in synthesis of organic acids e.g. citric and malic acid. However, usually soil containing less than 1 me exchangeable mg/100 g soil are considered deficient (Biswas *et al*.1985). Available magnesium content in high yielding orchards soil was higher as compare to the low yielding orchards during both the years of investigation. Nilangekar and Patil (1981 and 1982) also observed that exchangeable magnesium were some what low in chlorotic than that of in the profile of normal citrus garden.

Average available sulphur content was recorded in the soil ranging from 12.43-19.66 kg ha^{-1}with the mean of 17.32 kg ha^{-1} in high yielding orchards (Table 1). However, the available sulphur content in the low yielding orchards soil was ranging from 11.31-19.99 kg ha^{-1} with mean of 15.77 kg ha^{-1}, which was comparatively lower than the high yielding orchards (Table 2). High yielding orchards are probably well cared and manured by cultivators. Sulphur is also supplemented though super phosphate and micronutrient preparations containing sulphate. Thus properly fertilized and manured orchards are well supplied with available sulphur to sustain high yield. Sulphur deficiency some what resemble N deficiency, but new growth is much yellow than old leaves (Rajput and Sri Haribabu, 1995).

Available micronutrient status

Micronutrients play an important physiological role in plant growth and development ant it participated in enzyme system. Results obtained in this investigation are presented in Table 1 and 2.

It is clearly indicated that the available iron content in high yielding orchards soil was higher as compare to the low yielding orchards during both the years of investigation. Average available iron content was recorded in the soil ranging from 5.00-12.73ppm with the mean of 8.49ppm in high yielding orchards (Table 1). Whereas, average available iron content in low yielding orchard was found i.e. 3.53-11.65ppm with mean of 7.86 ppm , which was comparatively lower than the high yielding orchards (Table 2). Similar pattern of iron distribution was reported by Chauhan et al. (1984). Irregular distribution of iron may be because of impeded drainage conditions and differences in the degree of weathering (Nair and Cottenie, 1971). Deficiency of iron is reduced by calcium carbonate resulting chlorosis is called by "lime induced chlorosis".

Average available manganese content was recorded in the soil ranging from 11.25-37.73ppm with the mean of 20.79ppm in high yielding orchards (Table 1). However, the available manganese content in the low yielding orchards soil was ranging from 9.25-27.13ppm with mean of 19.26ppm, which was comparatively lower than the high yielding orchards (Table 2). These results are in close with the findings of Nijjar and Singh (1977), Malewar et al. (1978) and Awasthi et al. (1984) in case of healthy and declined condition of citrus. Manganese seems to be the essential for photosynthesis, respiration and nitrogen metabolism.

Average available zinc content was recorded in the soil was ranging from 0.62-2.23ppm with the mean of 1.19ppm in high yielding orchards (Table 1). However, the average available zinc content in low yielding orchard was found i.e. 0.55-1.29ppm with mean of 0.87ppm, which was comparatively lower than the high yielding orchards (Table 2). The similar results were also recorded by Nijjar and Singh, (1971) and Chauhan *et al*. (1984) while studying the citrus growing soil of Punjab and Haryana respectively Low availability of available zinc may partly attributed to low organic carbon and partly attributed to high phosphorus built up Malewar *et al*. 1978). Zinc plays a role in protein synthesis and formation of some growth hormones like auxins and in the reproductive process of certain plants.

Average available copper content was recorded in the soil ranging from 4.68-17.93ppm with the mean of 9.78ppm in high yielding orchards (Table 1). Whereas, the average available copper content in the low yielding orchards soil was ranging from 4.65-9.85ppm with mean of 7.31ppm, which was comparatively lower than the high yielding orchards (Table 2). These results are accordance with the findings of Malewar *et al,*. (1978), Singh and Tripathi (1983) and

Table 2 : Soil characteristics and available nutrient status of low yielding acid lime orchards in Western Vidarbha

Sr. No.	Soil characters and nutrients	Low yielding population								
		1st year			IInd Year			Average		
		Range	Mean	SE (m) ±	Range	Mean	SE (m) ±	Range	Mean	SE (m) ±
1	pH	7.78-8.61	8.25	0.04	7.90-8.35	8.07	0.02	7.86-8.45	8.16	0.03
2	EC (dSm^{-1})	0.04-0.24	0.17	0.01	0.10-0.25	0.18	0.01	0.09-0.24	0.17	0.01
3	Organic carbon (%)	0.3-0.89	0.53	0.02	0.24-0.61	0.45	0.02	0.33-0.75	0.49	0.02
4	CC (%)	1.44-25.28	8.69	1.09	0.59-19.98	7.62	0.88	1.96-22.63	8.15	0.95
5	N (kg ha^{-1})	124.44-439.04	273.69	14.00	156.80-470.40	266.56	15.40	141.12-454.72	270.12	14.23
6	P_2O_5 (kg ha^{-1})	18.82-51.97	35.35	1.81	17.92-59.14	36.60	1.80	19.71-53.76	35.98	1.63
7	K_2O (kg ha^{-1})	99.35-370.30	202.48	13.29	120.42-562.97	253.36	21.34	114.4-465.13	227.92	14.87
8	Ca (c mol (p^+)kg^{-1})	15.66-31.60	22.41	0.62	15.21-31.20	21.55	0.64	16.16-29.08	21.58	0.56
9	Mg (c mol (p^+)kg^{-1})	4.74-16.19	10.48	0.41	6.28-15.82	10.37	0.41	5.68-13.62	10.43	0.35
10	S (kg ha^{-1})	10.42-20.61	16.61	0.42	10.53-20.38	14.93	0.41	11.31-19.99	15.77	0.36
11	Fe (ppm)	3.50-12.25	7.80	0.48	3.15-11.05	7.92	0.35	3.53-11.65	7.86	0.41
12	Mn (ppm)	9.55-28.95	19.65	0.91	8.95-29.75	18.87	0.89	9.25-27.13	19.26	0.88
13	Zn (ppm)	0.46-1.64	0.88	0.05	0.43-1.17	0.86	0.04	0.55-1.29	0.87	0.03
14	Cu (ppm)	4.75-10.60	7.39	0.29	4.85-9.30	7.24	0.24	4.65-9.85	7.31	0.24
15	Yield (fruits/tree)	250-520	427	11.73	250-550	429	15.08	275-525	428	10.76

Malewar (1977). Copper is involved in both photosynthesis and respiration. Copper and iron are capable of acting as "electron careers" in enzyme systems that bring about oxidation-reduction reactions in plants.

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