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RESEARCH PAPER

Assessment of fertility status of soils of acid lime (*Citrus aurantifolia* Swingle) orchards of Vijayapur district, Karnataka

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Abstract: A survey was conducted during 2018-19 covering acid lime (*Citrus aurantifolia* Swingle) orchards of Indi and Sindagi talukas in Vijayapur district, Karnataka state. Asurface (0-22.5 cm) soil samples (n=85) were collected and analysed for soil properties and extractable nutrients. Soil pH (1:2.5 suspensions of soil water) varies from 7.20 to 8.52 with an average value of 8.01. The electrical conductivity ranged from 0.13 to 1.87 dSm^{-1} with mean value of 0.36 dS m^{-1}. The organic carbon content ranged from 0.50 to 1.13% with an average value of 0.81%. The mean values of Alkaline $KMnO_4$ N, Olsen's P and Neutral 1N ammonium acetate (NH_4OAc) K were 315.60, 14.89 and 246.46 kg ha^{-1}, respectively. The mean values of neutral 1N ammonium acetate (NH_4OAc) of Ca and Mg, and $CaCl_2$ (0.15 %) extractable S content of soil were 21.77 and 9.40 cmol (P^+) kg^{-1} and40.42 mg kg^{-1}, respectively. The mean values of extractable DTPA Fe, Mn, Zn and Cu were 7.35, 23.66, 1.33 and 5.39 mg kg^{-1}, respectively. The water-soluble B in soils ranged from 0.18 to 1.66 mg kg^{-1} with a mean value of 0.70 mg kg^{-1} soil. As per the calculated nutrient index values, soils of lime orchards of Indi were low in N, medium in P, K and Fe and high in S, Mn, Zn, Cu and B. The soils of Sindagi were low in N and P, medium in K and Fe and high in S, Mn, Cu, Zn and B. The relationship between soil properties, extractable soil nutrients and fruit yield/plant/year was also studied.

Key words: Acid lime, Extractable soil nutrients, Fruit yield, Nutrient index, Soil fertility

Introduction

Citrus is considered to be one of the most remunerative fruit crops of India, having a lasting niche in the international trade and world finance (Lakshmi *et al.,* 2014). The most commonly cultivated citrus species in India are *Citrus reticulata* (mandarin), *Citrus sinensis* (sweet orange), *Citrus aurantifolia* Swingle (acid lime). Among them acid lime popularly known as Kagzi lime or Neebu belongs to the family Rutaceae. The word Kagzi being derived from the word Kagaj meaning paper, as the rind of the fruit is very thin. It is a profusely branched thorny shrubs or small tree. Kagzi lime is an indigenous fruit of our country widely distributed in tropical and subtropical zones. In India acid lime is cultivated in an area of 2.75 lakh hectares by producing 27.64 lakh tonnes with a productivity of 10.05 tonnes per hectare (Anon., 2014a). Karnataka state ranks 5th position in acid lime production with 2.83 lakh tonnes accounting to 12,150 hectares of area (Anon., 2014a). In Vijayapur district, acid lime is unique remunerative fruit crop grown on commercial scale in an area of 6,499 hectares, with a production of 1.62 lakh tonnes and productivity of 25 tonnes per hectare (Anon., 2014b). Indi taluk having major area of 4,059 ha, with a production 1,01,475 tonnes with a productivity of 25 tonnes per hectare. Indi region from the Karnataka state is known for good quality of acid lime.

Fruits used in preparing delicious and refreshing drinks and pickles (Goramnagar *et al.,* 2018), citric acid is used in pharmaceuticals and cosmetics industry. Acid lime fruit yield is low because of excessive vegetative growth due to late winter and heavy N application. Major area of this region comes under saline soil due to this the deficiency of Fe, and poor availability of Zn, Mn, Cu, and B will further limit the fruit yield by restricting flower setting and subsequent development of fruits. The causes of deterioration in acid lime crop are many, few to be enlisted are non-availability of genuine and quality planting material, improper use of the fertilizer, poor water quality used in irrigation, majority of acid lime growers use saline water for irrigation purpose and lack of facilities for post harvesting technology, *etc*.

Due to various uses and the increasing consumer awareness, the demand for acid lime fruits is constantly increasing. To fulfil this demand, large scale plantations are coming up particularly in Vijayapura district of Karnataka state specially Indi and Sindagi talukas. The nutritional need of acid lime is unique and differs from other fruit crops as it has continuous flowering and heavy fruiting habit. To stabilize fruit production and quality, it is necessary to supply the right amount of water and fertilizer at different growth stages not only for enhancing the growth of acid lime trees, but also for improvement yield and fruit quality (Shirgure *et al*., 2000).

Acid lime is a nutrient sensitive and responsive fruit crop and requires adequate nutrition for proper growth and development (Musmade *et al.,* 2010). Thus, soil tests are the most practical way of measuring the nutrient-supplying power of the soil and determining if manure, fertilizer and/or amendments are needed *i.e.* roots extract nutrients from the soil in a manner comparable to chemical soil extractants and direct relationship between the levels of extractable nutrients in soil and their uptake by plants (Bhargava and Chadha, 1993). To attain this goal, it is necessary to assess the availability of

nutrients in soils of acid lime orchards. In the light of above facts, the present study was undertaken with the objective of assessing the fertility status of soils in acid lime orchards of Indi and Sindagi talukas ofVijayapur district.

Material and methods

Aregional survey was conducted during 2018-19 in the acid lime growing area of Indi and Sindagi taluks of Vijayapur district for collection of soil samples to assess soil nutritional status of acid lime orchards. The data on yield, amount of fertilizers, manures added to the acid lime plants and other management practices were also collected from each orchard during the survey.

Four composite soil samples representing each orchard were collected from 0-22.5 cm depth in between four plants for each orchard during the survey. Each soil sample was formed from the composite of six randomly drawn samples at each orchard (Jackson, 1973). The soil samples were dried in shade at ambient temperature, passed through 2mm sieve and stored for analysis of pH, EC, soil extractable nutrients. An aliquot of 2 mm sieved soil was ground using agate pestle and mortar to pass through 0.2 mm sieve for determination of organic carbon of soil.

The wet digestion method (Walkley and Black, 1934) was followed to determine the organic carbon (OC) content. Available nitrogen (N) was determined by alkaline potassium permanganate method as described by Sabhiah and Asija (1956). Available phosphorous (P0 was determined by Olsen's method (Olsen, 1954). Available K in the soil extracted with neutral N ammonium acetate and K was determined by flame photometer as described by Schollenberger and Siman (1945). The available iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) in soil samples were estimated by atomic absorption spectrophoto meter following DTPA extraction method (Lindsay and Norvell, 1978). The calcium chloride extraction (Williams and Steinbergs, 1959) was followed for estimation of S. Hot water soluble method (Tandon, 2005) was followed for determination of soil boron (B).

The soils were classified in low, medium and high categories of nutrient status using standard soil nutrient rating values for each nutrient. Nutrient index value calculated from the proportion of soils under low, medium and high available nutrient categories for each taluk.

The following equation was used to calculate nutrient index value:

$$\text{Nutrient index value} = (Nl \times 1) + (Nm \times 2) + (Nh \times 3)/Nt$$

Where, Nl = Number of samples falling in low category of nutrient status.

Nm = Number of samples falling in medium category of nutrient status.

Nh = Number of samples falling in high category of nutrient status.

Nt = Total number of samples analysed for a nutrient in any given area.

Ramamoorthy and Bajaj (1969) had categorized these values as less than 1.67 being indicative of low fertility status, between 1.67 to 2.33 as medium and more than 2.33 to classify as high. Soil samples of each taluk were classified based on nutrient index values as per the criteria of Ramamoorthy and Bajaj (1969).

Results and discussion

Soil properties and fertility status

The range and mean values of soil properties and nutrient status of various acid lime orchards (n=85) shown in Table 1. The soil reaction (pH) varied from 7.20 to 8.52 with an average value of 8.01. The soils electrical conductivity ranged from 0.13 to 1.87 dS m^{-1}. The organic carbon content ranged from 0.50 to 1.13 per cent with an average value of 0.81 per cent. Kirankumar and Hundekar (2018) found the similar results of soils of the Hittnalli micro-watershed area of Vijayapur, Karnataka where the soils were moderately saline to alkaline in reaction (7.89 to 8.95) with a mean pH of 8.42. Shreekanth *et al*. (2018) reported the similar soil pH range in soils of grape orchards of Vijayapur district. Bhandari *et al*. (2018) reported the electrical conductivity (0.48, dS m^{-1}), organic carbon content of 0.94 percent. Alkaline $KMnO_4$ N, Olsen's P and Neutral 1N ammonium acetate (NH_4OAc) K ranged from 75.44 to 589.74, 4.38 to 54.43 and 148.39 to 356.91 kg ha^{-1}, respectively with mean values of 315.60, 14.89 and 246.46 kg ha^{-1}. Similar results were reported by Bhandari *et al*. (2018) with Olsen's P of 14.7 kg ha^{-1}. Srivastava and Shirgure (2018) reported similar result for soil extractable K in *Khashi* mandarin orchards. Neutral 1N ammonium acetate (NH_4OAc) Ca and Mg ranged from 15.53 to 28.58 and from 3.18 to 16.60 cmol (p^+) kg^{-1} with average concentration 21.77 and 9.40 cmol (p^+) kg^{-1} soil, respectively. The $CaCl_2$ (0.15 %) extractable S content of soil varies from 11.33 to 74.00 mg kg^{-1} with an average of 40.42 mg kg^{-1}. Shreekanth *et al*. (2018) reported the similar status of Ca, Mg and S in the soils of grape orchards of Vijayapur.

The DTPA extractable Fe in soils ranged from 4.64 to 14.27 mg kg^{-1} with a mean value of 7.35 mg kg^{-1} and soil Mn ranged from 7.5 to 40 mg kg^{-1} with a mean value of 23.66 mg kg^{-1}. The

Table 1. Soil properties and soil fertility status in different lime orchards of Vijayapur district

Property	Range	Mean
pH (1:2.5 soil water suspension)	7.20-8.52	8.01
EC (dS m^{-1})	0.13-1.87	0.36
Organic carbon (%)	0.50-1.13	0.81
Alkaline $KMnO_4$hydrolysable N (kg ha^{-1})	75.44-589.74	315.60
Olsen's P (kg ha^{-1})	4.38-54.43	14.89
Neutral 1N NH_4Oac K(kg ha^{-1})	148.39-356.91	246.46
Neutral 1N NH_4Oac Ca (cmol (p^+) kg^{-1})	15.53-28.58	21.77
Neutral 1N NH_4Oac Mg (cmol (p^+) kg^{-1})	3.18-16.60	9.40
0.15% $CaCl_2$ extract S (mg kg^{-1})	11.33-74.00	40.42
DTPA extractable Fe (mg kg^{-1})	4.64-14.27	7.35
DTPA extractable Mn (mg kg^{-1})	7.50-40.00	23.66
DTPA extractable Zn (mg kg^{-1})	0.71-2.20	1.33
DTPA extractable Cu (mg kg^{-1})	3.02-8.80	5.39
Hot water soluble B (mg kg^{-1})	0.18-1.66	0.70
Fruit yield (Fruits/plant/year)	300-4200	1665

DTPA extractable Zn and Cu status ranged from 0.71 to 2.20 mg kg^{-1} and 3.02 to 8.80 mg kg^{-1}, respectively with mean values of 1.33 and 5.39 mg kg^{-1}. Shreekanth *et al*. (2018) reported the similar results of Fe, Mn, Zn and Cu in soils of grape orchards of Vijayapura, where 100 percent soil samples indicated Mn and Zn as high. Somasundaram *et al*. (2011) reported the similar values of DTPA extractable Mn, Fe, Zn, and Cu in surface soils of citrus. Hot water soluble B in soils ranged from 0.18 to 1.66 mg kg^{-1} with a mean value of 0.70 mg kg^{-1}. Fruit yields of acid lime ranged from 300 to 4200 kg/plant/year with a mean fruit yield of acid lime of 1665 kg/plant/year.

Soil fertility status and nutrient indices for acid lime orchards of Indi taluk

The proportion of soil samples falling in low, medium and high categories for different nutrients and the calculated values of nutrient indices are presented in Table 2. For available N, samples were 50, 48, and 2 percent, respectively in low, medium, and high categories. In available P, 45, 33 and 22 percent samples were in low, medium and high categories, respectively, whereas in medium and high categories for available K 70 and 30 percent samples, respectively. For S, samples in medium and high categories were 13 and 87 percent, respectively. It is apparent from the data that all (100 %) soil samples were high in Mn and Cu. For Fe, 68 and 32 percent samples were medium and high categories, respectively. For Zn, samples in medium and high categories were 43 and 57 per cent, while for B, samples in medium and high categories were 8 and 92 percent, respectively. As per the calculated values of nutrient index, soils of acid lime orchards of Indi taluk of Vijayapur were low in N, medium in P, K and Fe, and high in S, Mn, Cu, Zn, and B. According to Ramamoorthy and Bajaj (1969), nutrient index value less than 1.67 indicated low fertility status, while between 1.67 to 2.33 as medium as and more than 2.33 was rated as high. Kiran and Hundekar (2018) reported that nutrient index values, soils were predominantly low in available N (1.00), medium in available P (1.60) in Vijayapur. The soils of Indi taluk showing low in available N and medium in availability of P, K and Fe content while soils showing high content of S, Mn, Zn, Cu and B.

Soil fertility status and nutrient indices for acid lime orchards of Sindagi taluk

The percentage of soil samples falling in low, medium and high categories for different nutrients and the calculated values of nutrient indices for Sindagi taluk are presented in Table 2. It is apparent from the data that all 36 and 64 per cent soil samples were low and high for available N. For available P, 60, 32 and 8 per cent samples were in low, medium and high categories, respectively. In case of K, 68 and 32 per cent samples were in medium and high categories, respectively. For S, 100 per cent samples were in high categories. Among the micronutrients, 92 and 8 per cent samples were in medium and high categories, respectively for Fe. In case of Mn and Cu all (100 %) soil samples were falling under high category. For Zn, 36 and 64 per cent samples were in medium and high categories, respectively while 8, 32 and 60 per cent samples were in low, medium and high categories, respectively for B. As per the calculated values of nutrient index, soils of acid lime orchards of Sindagi taluk were low in N and P, medium in K and Fe and high in S, Mn, Cu, Zn and B.

Table 2. Essential nutrients and nutrient index value of lime orchards

Nutrient	Low	Medium	High	Nutrient Index Value (NIV)
Indi taluka				
N	30 (50)	29 (48)	1 (2)	1.52 (L)
P	27 (45)	20 (33)	13 (22)	1.77 (M)
K	0	42 (70)	18 (30)	2.3 (M)
S	0	8 (13)	52 (87)	2.87 (H)
Fe	0	41 (68)	19 (32)	2.32 (M)
Mn	0	0	60 (100)	3 (H)
Zn	0	26 (43)	34 (57)	2.57 (H)
Cu	0	0	60 (100)	3 (H)
B	0	5 (8)	55 (92)	2.92 (H)
Sindagi taluka				
N	9 (36)	16 (64)	0	1.64 (L)
P	15 (60)	8 (32)	2 (8)	1.48 (L)
K	0	17 (68)	8 (32)	2.32 (M)
S	0	0	25 (100)	3 (H)
Fe	0	23 (92)	2 (8)	2.08 (M)
Mn	0	0	25 (100)	3 (H)
Zn	0	9 (36)	16 (64)	2.64 (H)
Cu	0	0	25 (100)	3 (H)
B	2 (8)	8 (32)	15 (60)	2.52 (H)

Relationship between soil properties and soil extractable nutrients

Simple correlation assessment between soil properties and extractable nutrients content in soil samples is shown in Table 3. The pH of the soil was significant and negative correlation with Olsen's P, DTPA (pH 7.3) extractable Fe, hot water soluble (significant at p = 0.05) and highly significant and negative correlation with neutral 1N NH_4OAc exchangeable Ca (significant at p = 0.01). Soil organic carbon content had a significant and highly negative correlation with Neutral 1N NH4Oac extractable K (significant at p = 0.01) whereas significant and negative correlation with Neutral 1N NH_4Oac extractable Mg (significant at p = 0.05).

Relationship between soil extractable soil nutrients and fruit yields of acid lime

Simple correlation analysis was performed between extractable soil nutrients and acid lime fruit yields and the values of simple correlation coefficients are presented in Table 3. Fruit yields of acid lime showed a significant and positive correlation with Neutral 1N NH_4OAc K, Hot water-soluble B (significant at p = 0.05) and highly significant and positive correlation with 0.15 per cent $CaCl_2$ extractable S (significant at p = 0.01). Savita *et al.* (2017) also reported similar results that they concluded that the soil pH of litchi orchards had a significant and significant negative correlation with, Olsen's P, Neutral 1N NH_4Oac K, DTPA (pH 7.3) extractable Fe, (significant at p = 0.01). Savita *et al.,* (2017) reported that similar results that the litchi fruit yields showed a significant and positive correlation with Neutral 1N NH_4Oac K (significant at p = 0.05).

Table 3. Correlation coefficients (r) between soil properties and soil extractable nutrients

Extractable nutrients	pH	Electrical conductivity(dS m^{-1})	Organic carbon (%)	Yield (Fruits/ plant/year)
Alkaline $KMnO_4$ hydrolysable N (kg ha^{-1})	-0.059	-0.094	0.129	0.00
Olsen's P (kg ha^{-1})	-0.215*	-0.038	-0.005	0.21
Neutral 1N NH_4OAc K (kg ha^{-1})	-0.097	0.169	-0.360**	0.222*
Neutral 1N NH_4OAc Ca (cmol (p^+) kg^{-1})	-.319**	0.095	0.048	0.021
Neutral 1N NH_4OAc Mg (cmol (p^+) kg^{-1})	-0.027	0.074	-0.217*	0.076
0.15% $CaCl_2$ extract S (mg kg^{-1})	-0.154	-0.045	0.11	0.309**
DTPA extract Fe (mg kg^{-1})	-0.254*	-0.014	-0.186	0.083
DTPA extract Mn (mg kg^{-1})	-0.114	-0.008	-0.044	0.205
DTPA extract Zn (mg kg^{-1})	-0.081	-0.197	0.099	0.173
DTPA extract Cu (mg kg^{-1})	-0.115	-0.032	0.142	-0.01
Hot water-soluble B (mg kg^{-1})	-0.227*	0.084	0.112	0.220*

**Significant at p<0.01, *Significant at p<0.05.

Conclusion

Thus, soils of acid lime orchards, of Vijayapur district were perpetually low supply in N and P. As per the nutrient index values, the soils of acid lime orchards of Indi were low in N, medium in P, K, Fe and high in S, Mn, Zn, Cu and B. The soils of Sindagi were low in N and P, medium in K and Fe and high in S, Mn, Cu, Zn and B. The pH of the soil had a significant and negative correlation with Olsen P, DTPA (pH 7.3) extractable Fe and Hot water soluble B. The pH of the soil was highly significant but negative correlation with Neutral 1N NH_4OAc Ca whereas, organic carbon content was highly significant and negative correlated with Neutral 1N NH_4OAc K and significant and negative correlated with Neutral 1N NH_4OAc Mg. General soil properties have performed influence on the availability of nutrients and fruit yield of acid lime was positively correlation with Neutral 1N NH_4OAc K and Hot water-soluble B and highly significant and positive correlation with 0.15 % $CaCl_2$ extractable S.

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