Depth-wise fertility status of soil under high yielding citrus orchards in medium deep black soils of Madhya Pradesh

ABSTRACT

Soil fertility is one of the important components for better citrus fruit production and produce quality. Soil with lower fertility status imposed a big threat to achieving higher citrus productivity. In this regard, the management of major and micronutrients is essential for the sustainable productivity of citrus in high-yield orchards. Thus, measurement of soil fertility status can provide an efficient way to develop strategies for citrus production. Therefore, the present study was conducted to assess the macro and micronutrient status in the citrus-producing area in medium black soils of Madhya Pradesh. For this purpose, a high-intensity survey was conducted and 65 soil samples at depths of 0-20 and 20-40 cm were collected from well-established orchards and analyzed for soil pH, EC, organic carbon content, N, P, K, Ca, Mg, Zn, Cu, Fe, Mn and B content. Descriptive statistics were calculated for exploratory analysis of data. Results showed that in depth of 0-20 cm, soil pH ranged from 6.83 to 8.84 with a mean value of 7.70, EC varied from 0.07-0.34 dS m^{-1} (0.18 dSm^{-1}), organic carbon (OC) 0.13-0.89% (0.45%), available nitrogen N102-288 kg ha^{-1} (mean 186 kg ha^{-1}), available P 7-76 kg ha^{-1} (mean 29.7 kg ha^{-1}), available K 259-775 kg ha^{-1} (mean 474 kg ha^{-1}), Ex Ca 1406-4568 mg kg^{-1} (mean 2784 mg kg^{-1}),Ex Mg 461-1799 mg kg^{-1}(Mean 1033 mg kg^{-1}), available S 5.6-30 mg kg^{-1} (Mean 16.7 mg kg^{-1}). Meanavailable Zn, Fe, Mn, Cu, and B were 0.95, 16.6, 11.3, 1.12, and 0.75 mg kg^{-1}, respectively. At the lower depth (20-40 cm), soil pH was slightly higher while soil EC and SOC was slightly lower compared to the upper depth. All the major and micronutrients were lower in subsurface (20-40 cm) as compared to surface depth (0-20 cm) except Ex Ca content which was higher in subsurface depth. Correlation analysis revealed that soil pH was negatively and significantly correlated with available P, Ex. Mg, available Zn, Fe and Mn while soil EC was positively correlated with available P, Zn, and Cu. Orchard soils were found to be suboptimal for available N, K, Zn, Cu,andMn.So, for attaining high production and sustainable production integrated nutrient management practices should be opted .

Keywords:Citrus,EC, pH, Macronutrients, Micronutrients,

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1.INTRODUCTION

Globally, citrus is grown in more than 150 nations as one of the most important perennial fruit crops .India is the third-highest citrus producer in the world after China and Brazil Kumar et al., (2023). India contributes about 7–8% of the global citrus production. Citrus ranks third in the country after mango and banana and is cultivated in 10.86 lakh hectares with an annual production of 142.62 lakh tonnes

(NHB,2019). Madhya Pradesh, Punjab, Maharashtra, Rajasthan, and Haryana are the top-ranking states with the highest area under cultivation and production in the country. In fact, Madhya Pradesh alone contributes over 32 percent to the total production in the country. The districts of Chhindwara, Agar Malwa, Shajapur and Rajgarh are the important orange clusters in the state. The yield of citrus crops depends on soil fertility, crop management and environmental factors (rainfall, temperature and disease incidence etc.). The nutrient status of orchards is directly related to the orchard health and longevity of the orchard. Orchard soil health is very important to sustain yield of crops.

Healthy soils have been shown to support more stable, yields up to more extent, by increasing our understanding of the biological and physical as well as chemical properties of soil to increase root health, moderate nutrient and water stress, and increase the yield potential of orchards (DuPont, 2020). Soil physico-chemical characteristics and soil nutrient status influence the requirement of different nutrients by the crop the proper knowledge of soil nutrient status is very helpful along with plant nutrient content in understanding tree health status and production. Soil factors like soil organic carbon (SOC), soil pH, and electrical conductivity (EC) are important factors that affects nutrient availability. Soil organic carbon is obtained from soil organic matter (SOM). The decomposition of SOM releases many cations and anions along with organic acids which influence soil nutrient availability (Tisdale et al., 1985). pH of Soil solution influences nutrient solubility and phyto-availability, because hydrogen ion or H+ ions on soil surface occupy the negatively charged spaces by displacing the nutrient ions . Soil EC is related to several soil properties influencing nutrient availability and crop productivity (Behera and Shukla, 2015; Asbin et al., 2022). Macro and micronutrient deficiency decreased the yield and the quality of citrus fruit. It is the need of the hour to measure soil fertility status under well-established high yielding orchards in medium-black soils (Ahmad et al., 2022). Low availability of both macro and micro nutrients and their inefficient management affects crop production in different parts of the world (Alloway, 2008; Jones et al., 2013). Understanding orchard nutrition status can facilitate the proper management of orchards for higher fruit yield and quality (Chen et al., 2022; Bhardwaj et al., 2024). The phyto-availability of nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), and boron (B) in soil depends upon various soil, environmental, and plant factors (Schjoerring et al., 2019). Yield of citrus is known to be influenced by soil characteristics up to a depth of 40 cm (Srivastava and Singh ,2002). Thus, surface and subsurface soil samples were collected to assess the fertility status of soil for optimum citrus yield. Identification of optimum fertility limit has been repeatedly emphasized for sustained productivity of citrus orchards, besides helps to minimize the occurrence of the alternate bearing of fruiting cycle. There is a dearth of information about orchards nutrient status of Rajgarh district. This study aimed to understand the nutritional status of established high-yielding citrus orchards in medium black soil and establish relationships of soil attributes at the surface and subsurface depth with citrus yield.

2. MATERIALS AND METHOD

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2.1 Description of Study Area And Calculation of Cutoff Yield

The study area was located under Rajgarh District of Madhya Pradesh state .It represents Northern region of Malwa Plateau. Study area extends between the parallels of Latitude 23 27′ 12″ North and 24 17′ 20″ North and between the meridians of Longitude 76 11′ 15″ and 77 14′ East. A high-intensity survey was conducted to calculate the cutoff yield based on the yield of each well-established orchards. As per the literature and citrus grower response during the survey, a cutoff yield was selected as 50 kg per tree (Srivastava et al.,2016) and healthy orchards were selected having a high yield that was more than or equal to cutoff yield.

2.2 Collection of Soil Samples

In present study, soil samples were collected from 65 highyielding citrus orchard sites. Soil samples were collected at the depth of 0-20 and 20-40 cm depth beneath trees and sampling points at specified locations were recorded with GPS (Fig 1). Collected soil samples were processed at laboratory and used for soil fertility evaluation.

2.3Soil Fertility Evaluation

Soil pH was measured in 1:2.0 soil-to-water ratio and supernatant obtained from soil pH measurement was utilized for the determination of electrical conductivity using a conductivity meter (Jackson, 1973). Chromic acid oxidation method was used for the determination of organic carbon content in soil (Walkley and Black, 1934).Available nitrogen (AN) was estimated by following standard procedure under Kjeldahl method of Subbiah and Asija (1956) in which distillation followed by titration method. Available phosphorus (AP) was measured by Olsen's method in which intensities of blue color were measured with spectrophotometer to estimate phosphorus content (Olsen et al., 1954). Available potassium (AK) was determined by ammonium acetate method (Hanway and Heidel, 1952). Exchangeable calcium (Ex. Ca) and exchangeable magnesium (Ex. Mg) in soil samples were determined by extracting soil samples with neutral normal ammonium acetate (1N) solution then required aliquote was taken and calcium and magnesium concentrations in aliquot measured by using atomic absorption spectrophotometer (AAS) (Shukla et al., 2019). Available sulfur (AS) in samples was measured by a turbidimetric (Williams and Steinbergs, 1959). Micronutrients in soil samples were analyzed for Available zinc (Zn) (AZn), available copper (Cu) (ACu), available iron (Fe) (AFe), and available manganese (Mn) (AMn)] after soil samples extracted by DTPA extractant and estimated using AAS (Lindsay and Norvell, 1978). Available boron was estimated by hot-water extraction (Gupta, 1967).

2.4 Calculation of Nutrient Index

The Nutrient Index Value was determined by assessing the distribution of soils across low, medium, and high categories of available nutrients. The nutrient index was calculated as given in equation 1.

$$\text{Nutrient index (NI)} = \frac{(\text{NL x1}) + (\text{NM x2}) + (\text{NH x3})}{\text{NT}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \textit{equation } 1$$

Nutrient index in both surface and sub surface soil for nitrogen, phosphorus and potassium were calculated according to formula suggested by Parker (1951), NI indicated nutrient index for a particular nutrient under consideration, NL were number of samples under lower category, NM were number of samples under medium category, NH were number of samples under high category and NT were total number of samples.

2.5 Statistical Analysis

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The datasets obtained after laboratory analysis of soil variableswere subjected to descriptive statistics parametersviz. minimum, maximum, mean, standard deviation (SD), coefficient of variation (CV), skewness, and kurtosis using SAS software (SAS, 2011). Pearson's correlation coefficient was computed to visualize relationships between soil fertility status and citrus yield.

3. RESULTS AND DISCUSSION

3.1 Yield of Citrus Orchards

Results from this study revealed that from survey of high yielding citrus orchards of Rajgarh district of Madhya Pradesh that observed yield ranged between 50 kg tree^{-1} to 240 kg tree^{-1} with mean observed mean yield of 117 kg tree^{-1} with coefficient of variation 47.1 % for the particular study area.

3.2 Nutrient Status of Citrus Orchards At Surface And Subsurface Depth

Results showed that in depth of 0-20 cm, soil pH ranged from 6.83 to 8.84 with a mean value of 7.72, EC varied from 0.07-0.34 dS m^{-1} (mean EC 0.18 dSm^{-1}), organic carbon (OC) ranged from 0.13-0.89% (mean SOC 0.45%) (table 1). The CV were 4.89, 27.2 and 46.4% for pH, EC and SOC, respectively. Available N 102-288 kg ha^{-1} (mean 186 kg ha^{-1}), available P 7-76 kg ha^{-1} (mean 29.7 kg ha^{-1}), available K 259-775 kg ha^{-1} (mean 474 kg ha^{-1}). The CV value for available N, P and K were 20.0,53.5 and 27.8%, respectively. Exchangeable Ca in orchard soils was ranged from 1406 to 4568 mg kg^{-1} while Ex. Mg varied from 461 to 1799 mg kg^{-1}. Average plant available S was 16.7 mg kg^{-1}. The CV value for secondary nutrients ranged between 31 to 34%. Available Fe in study sites varied from 7.21 to 30.3 mg kg^{-1}with an average value of 16.6 mg kg^{-1}. Average plant available Zn,Mn, Cu and B were 0.95, 11.3, 4.55, 0.75 mg kg^{-1}, respectively. The corresponding values of CV were 53.7, 48.2, 44.8 and 29.6% (table 1).

Nutrient distribution at 20-40 cm soil depth was presented in Table 2. For subsurface depth of 20 to 40 cm, the mean value of soil attribute viz. pH, EC and SOC were 7.90, 0.16 dSm^{-1} and 0.27 %, respectively, while CV was 4.54, 23.1, and 55.2 % respectively. It was observed that pH was higher while lower SOC content was observed in subsurface depth than surface layer. Available N varied from 72 to 258 kg ha-1 with a mean value of 148 kg ha-1 which was found to be less than surface depth (0-20 cm). Mean value of available P for subsurface layer was 22.3 kg ha-1. Available K ranged between 191 to 597 kg ha-1. The CV among primary nutrients was highest for available P (54.7%) whereas it was 24.5 and 26.4 % for available N and available K, respectively. For secondary nutrients, it was observed that the mean exchangeable Ca content was 3150 mg kg-1 which was higher than surface depth, thus a decreasing trend was observed from surface to subsurface depth. Exchangeable Mg ranged from 328 to 1860 mg kg-1. Mean available S in soil was 17 mg kg-1. Among micronutrients, it was observed that the concentration of micronutrients was lower than their surface layer (table 1 and 2). The mean value of available Zn, Cu, Fe and Mn were 0.67, 0.84, 15.1 and 8.95 mg kg-1, respectively. Similar to the depth of 0-20 cm, the highest CV was observed for soil Zn in the depth of 20-40 cm. Available boron content ranged from 0.08 to 1.24 mg kg-1 with a mean of 0.26 mg kg-1 and CV value was 50.2%. Soil pH of study area was near neutral to alkaline in range. Similar to the findings of Sharma et al., (2001) who reported that pH of arable land of Rajgarh was 7.9 and EC 0.2. Accordingly, Behera et al (2022) reported that farm lands of Bhopal, Madhya Pradesh is near neutral to alkaline in nature. The higher pH of soils in the medium black soil might be due to higher Ca and Mg content in soil which is also observed in this soil. With the depth, soil pH was increased,this is in line with the findings ofSurwase et al., (2016) and Singh et al.,(2022) mentioned that increased pH with soil depth under citrus orchards and optimum pH for better citrus crop growth is ranged from pH 7.6 to 8.5 (Dahule, 2020; In our study mean value of EC were found

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to be < 0.2 dSm^{-1} our results were similar to findings of Kanwar and Randhawa (1960) and Dahule (2020) that soil EC below 0.50 dSm^{-1} as safe limit for citrus.The SOC value was (0.13 to 0 .89%) with a mean 0.45% in surface depth indicating a lower SOC rating as established for crop production in India. Many reports suggested that SOC content decreased with soil depth in orchards of Madhya Pradesh (Singh et al., 2022) and Nagpur mandarin (Surwase et al., 2016). The variation in soil properties was measured with coefficient of variation (CV), In present study we found <10% CV for soil pH and other properties values ranged between 10-100 indicating low variability and moderate variability, respectively.Bogunovic et al. (2017) reported low, medium, and high variability for pH, organic matter and EC respectively in soils of Rasa River valley of Croatia. Low variability for pH and EC while moderate variability for SOC content in Indian acid soils confirmed by Behera and Shukla (2015). Similarly, low variability for pH and medium for EC and organic matter in soils of Alequeva reservoir of Portugal reported by Ferreira et al.,(2015). Our results for higher available iron content in surface layer than subsurface layer were in confirmation with reports of Reddy and Rao (1991) in sweet orange orchards of Rayalaseema region in Andhra Pradesh and Ratnam et al. (2001) in sapota growing soils of Andhra Pradesh that surface soils had significantly higher available iron content as compared to the sub-surface soils which might be due to the higher organic matter content in the surface soils further, this decrease in the available iron with depth might be also due to absorption of iron from lower layers and their deposition in surface layer by leaf shedding. Similarly in case of available copper the trend of decrease in available copper with depth was also reported in citrus orchards of the Jammu region(Gupta et al., 2004).

For determining soil suitability criteria for citrus, optimum available nutrient ranges forP, K and Zn were 4 to 10 ppm, 60-150 ppm and 0.6 to 1.0 ppm, respectively, while critical limit of Fe,Mn and Cu were suggested as 4.0 ppm, 2.8 ppm and 0.5 ppm respectively suggestedfor citrus (Srivastava and Kohi, 1997). In another study by Srivastava et al. (2022) reported optimal soil fertility norms for Nagpur mandarin incentral India for N, P, K, Ca, Mg, as 94.8-154.8 for (N), 6.6-15.9 (P), 146.8-311.9(K) , 408.1-616.0 (Ca) , 85.2-163.3(Mg), 10.9-25.2(Fe) , 7.,5-23.2 (Mn), 2.5-5.1(Cu) and 0.59-1.26 (Zn). Further Srivastava and singh (2002) reported optimum soil fertility limits for available N, P, K, Fe, Mn, Cu, and Zn were 118.8, 10.1, 241.2, 14.8, 13.4, 1.3, and 1.2 mg kg^{-1} , respectively, at 0–15 cm depth for an optimum yield of 16.2 tons ha-1 . While for 15–30 cm, were obtained as 100.1, 8.4, 268.0, 10.1, 8.8, 0.96, and 0.88 mg kg^{-1}, N, P, K, Fe, Mn, Cu, and, Zn, respectively.

Based on the above criteria an attempthas been made to classify surface soil and subsurface soil fertility, results revealed that as per the limits of Srivastava et al.,(2022) for surface depth available nutrients viz .N,P,K,Ca,MgZn,Fe,Cu and Mnrange (mean) varied from 45.5-128 (83.03),3.12-33 (13.25),115-345 (211),1406-4568(2784), 461-1799(1033) ,0.34-2.29 (0.95),0.21-30.3 (16.6) ,0.29-2.4(1.12) and 4.55-26.3 (11.3) mg kg-1 respectively, corresponding value For subsurface depth was 32.1-115 (Mean 66.07) ,3.03-24.1 (9.90) ,85.3-265 (164), 1806-4900 (3158), 328-1860 (990) ,0.21-1.66 (0.672),7.58-25.8 (15.1) ,0.22-1.92 (0.84) ,and 3.65-19.82 (8.95) mg kg-1 respectively.For surface depth nutrient ranges were suboptimal for available nitrogen, potassium and copper were suboptimal according to optimum fertility norms of Srivastava et al., (2022). Inboth depths mean values of nutrients according to optimal soil fertility limits of Srivastava and Singh (2002) in available N,AvailableK,availableZn,availableCu were found to be suboptimal whereas Mn was suboptimal in surface soil .

3.3 Nutrient Index In Orchard Soils

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Nutrient index (NI) of macronutrients was calculated for study area. Results revealed that NI value for plant available N, P and K at depth 0-20 cm was 1.06, 2.46 and 2.96, respectively. The rating of NI indicated that low fertility levels for nitrogen and high fertility level for available P and available K was recorded. Similarly. For subsurface layer (20-40 cm) the nutrient index values were 1.00,2.27and 2.83 for available N, available P and available K respectively, revealing that low, medium and high fertility levels were recorded for available N, P and K respectively. Nutrient index rating defined as < 1.67, 1.67-2.33, >2.33 for low, medium and high fertility rating by Parker et al. (1951) while Ramamoorthy and Bajaj (1969) redefine the NI rating as <1.5, 1.5 -2.5 and >2.5 for low, medium and high fertility. Based on the above ratings, most deficient nutrient in soil was Nfollowed by P and K. our findings are in conformity with Gehlotet,el (2019 ,2023) that nutrient index for nitrogen and phosphorus indicated low and medium fertility respectively for soils of Ujjain Tehsil of Madhya Pradesh

3.4 Relationships Among Soil Properties And Citrus Yield

In the present study, at the depth of 0-20 cm, soil pH was negatively correlated with P (r =-0.37**), Ex.Mg (r =-0.42**), available Zn (r= -.40**), available Fe (r =-0.60**), available Cu(r = -0.38**) and available Mn (r = -0.62**). Soil EC was positively correlated with available P (r =0.26**), available Zn (r =0.32**), available Cu (r =0.30**). SOC was positively correlated with available P (r =0.31*) and available K (r =0.33**). Citrus yield is significantly andpositively correlated with soil properties and available nutrient content in soils (table 3). Similar to the depth of 0-20 cm, in subsurface (20-40 cm), soil pH was negatively correlated with available P (r =-0.41**) and with micronutrient Zn (r =-0.46**), Fe (r =-0.56**), Mn (r =-0.69**) and Cu (r=-0.43**). EC is the only positively and significantly correlated with available N (r =0.33**).SOC was significantly and positively correlated with available P (r = 0.30*).Yield was positively and significantly correlated with EC (r =0.29*) and available N (r =0.41**) (Table 4)similar findings reported by Srivastava (2013) for significant positive correlation of citrus fruit yield with available Nitrogen.The extent of correlation was higher in subsurface than surface soil for soil pH with available Fe and Available Mn while correlation was higher for surface soil in rest of the micronutrient. The extent of correlation with yield and EC, SOC, N and P was higher in surface soil than subsurface soil. Behera et al. (2022) reported significant negative correlation of soil pH with available P, available Zn, available Fe, available Mn in farmland of Bhopal Madhya Pradesh. Similar results were reported in soils of Hardadistrct of Madhya Pradesh (Tagore , et al., 2017), citrus orchard soil for Layahh district of Pakistan (Ahmad et al., 2022). The negative relationship observed between soil pH and the availability of cationic micronutrients in our research underscores that variations in soil pH directly impact the levels of these micronutrients in the soil (Shukla et al., 2018, Mishra et al., 2019). Lindsay (1979) indicates that for every incremental increase in soil pH within the range of 4 to 9, the solubility of zinc (Zn), copper (Cu), and manganese (Mn) decreases by 100-fold, while for iron (Fe), the reduction is even more significant, at 1000-fold. Positive correlation of SOC with available nutrients might be due tothe fact that SOC is a fundamental component of soil organic matter (SOM). Soil organic matter facilitates the availability of nutrients to crop plants by releasing organic acids, and, upon mineralization, release nutrients into pools accessible to plants.

The relationship obtained in our results were supported by findings of Ramana Murthy and Srivastava (1994) who observed that positive and significant correlation of EC with available phosphorus.

In our findings yield is positively and significantly correlated with available nitrogen are similar with reports of Srivastava and Singh (2002). Negative and significant correlation of pH and DTPA extractable Fe,Cu and Mn . Positive correlation of soil organic carbon with available Sulphur, Zinc ,Copper and Boron are in confirmation in our results are similar with findings of Chouhan et al.,(2012) for medium black soils of Dewas district of Madhya Pradesh .

4. CONCLUSIONS

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Thisstudy concluded that the soils under high yielding orchards of citrus were having neutral to slight alkaline pH ,EC was <0.5 dSm^{-1} which indicated good condition for citrus cultivation . Mean value of SOC content <0.5% indicated lower SOC content of soil.based on nutrient index rating macronutrient status as per nutrient index value reflected that N was low in both the depth whereas P and K was higher in surface soil .Citrus fruit yield had significant positive correlation of with available Nitrogen.Based on suitability criteria, available N,P,K, Zn, Cu and Mn were in suboptimal level . Therefore for optimum production and maintenance of soil fertility one should opt integrated nutrient management practices to improve soil health as well as sustainability in citrus production in which organic manure ,macronutrient should be applied in optimal manner.

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Fig 1: Study area and sampling points

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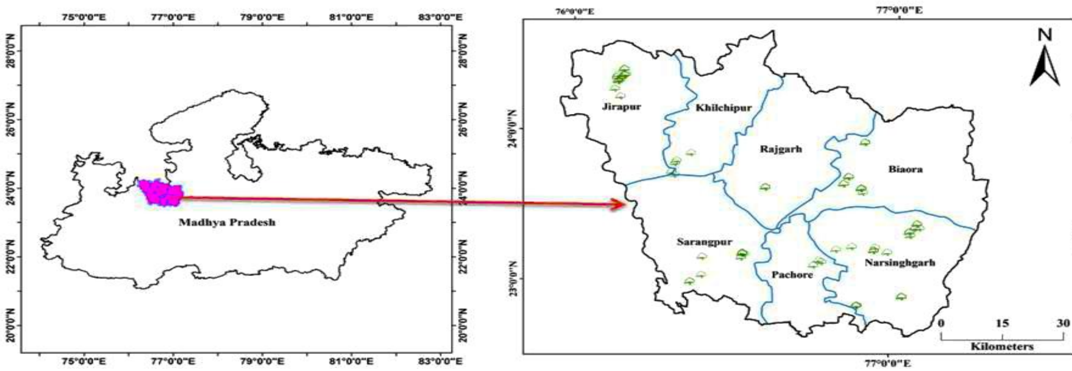

Table 1: Descriptive statistics of soil variable in high yielding orchards of citrus for 0-20 cm soil depth (n=65)

0-20 cm	Mean	Minimum	Maximum	SD	CV%	Skewness	Kurtosis
pH	7.72	6.83	8.84	0.38	4.89	0.192	0.794
EC (dSm^{-1})	0.18	0.07	0.34	0.05	27.2	0.691	1.15
SOC (%)	0.45	0.13	0.89	0.21	46.4	0.346	-1.01
N (kg ha^{-1})	186	102	288	37	20.0	1.028	1.459
P (kg ha^{-1})	29.7	7	76	15.9	53.5	0.812	0.333
K(kg ha^{-1})	474	259	775	132	27.8	0.698	-0.184
Ca (mg kg^{-1})	2784	1406	4568	862	31.0	0.383	-0.881
Mg (mg kg^{-1})	1033	461	1799	351	34.0	0.508	-0.628
S (mg kg^{-1})	16.7	5.6	30.0	5.2	31.0	0.393	-0.005
Zn (mg kg^{-1})	0.95	0.34	2.29	0.51	53.7	1.28	0.955
Fe(mg kg^{-1})	16.6	7.21	30.3	6.01	36.2	0.49	-0.543
Cu(mg kg^{-1})	1.12	0.29	2.4	0.49	44.2	0.96	0.199
Mn(mg kg^{-1})	11.3	4.55	26.3	5.43	48.2	1.06	0.411
B(mg kg^{-1})	0.75	0.30	1.22	0.22	29.6	0.20	-0.702

Table 2 : Descriptive statistics of soil variable in high yielding orchards of citrus for 20-40 cm soil depth (n=65)

20-40 cm	Mean	Minimum	Maximum	Standard Deviation	CV%	Skewness	Kurtosis
pH	7.90	7.16	8.55	0.36	4.54	-0.20	-0.90
EC (dSm^{-1})	0.161	0.08	0.24	0.04	23.1	0.18	-0.40
SOC %	0.271	0.03	0.56	0.15	55.2	0.49	-1.13
N ($kg\ ha^{-1}$)	148	72.0	258	36.1	24.5	0.73	1.28
P($kg\ ha^{-1}$)	22.3	6.72	54.2	12.2	54.7	1.01	0.28
K($kg\ ha^{-1}$)	369	191	594	97.6	26.4	0.63	0.04
Ca ($mg\ kg^{-1}$)	3158	1806	4900	826	26.2	0.33	-0.90
Mg ($mg\ kg^{-1}$)	990	328	1860	370	37.4	0.53	-0.10
S ($mg\ kg^{-1}$)	17	8.13	29.5	4.84	29.2	0.49	0.05
Zn ($mg\ kg^{-1}$)	0.672	0.21	1.66	0.379	56.4	1.09	0.365
Fe($mg\ kg^{-1}$)	15.1	7.58	25.8	5.07	33.5	0.50	-0.78
Cu($mg\ kg^{-1}$)	0.84	0.22	1.92	0.39	46.5	1.15	0.81
Mn($mg\ kg^{-1}$)	8.95	3.65	19.82	4.40	49.1	1.03	0.07
B($mg\ kg^{-1}$)	0.528	0.08	1.24	0.265	50.2	0.82	0.213

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Table 3: Correlation of soil nutrient with soil properties and yield (0-20 cm soil depth)

Soil variables	pH	EC	SOC	Yield
pH	1	-	-	.17
EC	0.13	1	-	.33**
SOC	0.08	0.23	1	.17
N	-0.06	0.16	.22	.42**
P	-0.37**	0.26*	.31*	.10
K	-0.16	-.03	.33**	.11
Mg	-0.42**	-.09	.02	-.07
S	-0.11	.20	.05	.16
Ca	0.2	.08	-.13	-.19
Zn	-.40**	.32**	.14	.02
Fe	-.60**	-.18	-.01	-.30*
Cu	-0.38**	.30*	.17	.02
Mn	-0.62**	-.21	-.10	-.05
B	0.03	-.01	.05	-.2

***** Correlation is significant at the 0.01 level (2-tailed)***

**** Correlation is significant at the 0.05 level (2-tailed)***

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Soil variables	pH	EC	SOC	Yield
pH	1	-	-	0.07
EC	0.40**	1	-	0.29*
SOC	-0.24	-0.15	1	0.01
N	0.04	0.33**	-0.051	0.41**
P	-0.41**	0.14	0.30*	0.1
K	-0.12	0.09	-0.07	0.12
Mg	-0.45**	-0.08	0.2	-0.05
S	-0.08	0.16	-0.12	0.19
Ca	0.22	-0.02	-0.01	-0.19
Zn	-0.46**	0.1	0.04	0.06
Fe	-0.56**	-0.18	0.07	-0.2
Cu	-0.43**	0.11	0.04	0.1
Mn	-0.69**	-0.12	0.07	-0.05
B	-0.13	-0.004	-0.1	0.15
***** Correlation is significant at the 0.01 level (2-tailed)*** **** Correlation is significant at the 0.05 level (2-tailed)***				

Table 4: Correlation of soil nutrient with soil properties and yield (20-40 cm soil depth)

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