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Effect of Soil Nutrient Status on Yield and Quality of Sweet Orange (*Citrus sinensis* (L.) Osbeck) in YSR District of Andhra Pradesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author ARR designed and executed the study by collecting and analyzing soil and plant (fruit) samples, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BRR assisted in statistical analysis. Authors PVMR and VM provided required laboratory facilities and helped in draft preparation. Authors PS and KV managed the literature searches and subsequent draft proofing. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to determine the effect of soil nutrient status on fruit yield and quality of sweet orange (*Citrus sinensis* (L.) Osbeck) in YSR district of Andhra Pradesh, India. To carry out this investigation fifty sweet orange orchards aged between 12 to 13 years were selected and soil samples were collected from these orchards at 0-30 cm and 30-60 cm depth. Majority of the soils of the study area were deficit in available nutrients such as Zn, Fe, N, P and Mn, but Ca, Mg, S, K and Cu were in optimum to high range.

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The soil mineral nutrients like N, P and K influenced the fruit weight significantly and positively (r = 0.469**, r = 0.446** and r = 0.415**, respectively), but fruit yield and fruit juice per cent had significant positive relation with soil N (r = 0.519** and r = 0.353*) and P (r = 0.409** and r = 0.364**) only. Soil P had a significant positive correlation with TSS (r = 0.438**). Soil Fe and Mn had a significant negative correlation with titrable acidity (r = -0.371** and r = -0.292*, respectively). Soil Mn had a significant negative correlation with fruit TSS (r = -0.311*).

Keywords: Sweet orange; soil macro nutrients; soil micro nutrients; fruit yield; fruit quality; YSR District.

1. INTRODUCTION

Sweet orange (*Citrus sinensis* (L.) Osbeck) occupies a prominent position in the fruit industry of the world, as well as in India. The area under sweet orange in India during 2015 was 2.78 lakh hectares with production of 45.26 lakh tones [1].

In Andhra Pradesh, the chief sweet orange production areas are Prakasam, YSR, Ananthapur and SPSR Nellore districts with an area of nearly 0.94 lakh ha and production of 13.16 lakh tonnes during 2014–15 [1]. In YSR district, area under sweet orange is 0.11 lakh ha with production of 1.54 lakh Mt [2].

At present, among various citrus cultivars being grown in India, the sweet orange is the leading citrus cultivar with 70% share of the total citrus production. Productivity of sweet orange depends on many abiotic (climate, site, soil, nutrition & irrigation management) and biotic (rootstock, cultivar, insect pest & disease management) factors. Among them adequate supply of plant nutrients is a very important factor to produce the good quality fruits.

The application of macro-nutrients particularly nitrogen (N), phosphorus (P) and potassium (K) plays important role in yield, as well as fruit quality [3]. The fruit size, weight, yield and quality (TSS, juice percent, acidity and ascorbic acid) are directly related to nutritional status of plant and soil of the orchard [4].

Sweet oranges, when used in combination with rough lemon (*Citrus jambhiri* Lush) rootstock, may be more prone to various nutritional disorders than mandarins (*Citrus reticulata* Blanco), especially for micronutrients. Studies addressing the contribution of different soil fertility and plant nutritional factors are comparatively limited. Absence of a suitable soil and plant test norm in relation to optimum fruit yield further jeopardized the timely diagnosis of causes for malnutrition of premier *Citrus sinensis* cultivar Mosambi in India. Such conditions are highly conducive to gradual improvisation in orchard efficiency, especially with advancing orchard age [5].

Therefore, the present study was conducted to investigate the relationship of soil nutrient status with fruit yield and quality of sweet orange in YSR district of Andhra Pradesh, India.

2. MATERIALS AND METHODS

For studying the effect of soil nutrient status on fruit yield and quality of sweet orange in the YSR district, during 2014, fifty sweet orange orchards aged between 12 to 13 years were selected (Fig. 1) in different mandals and in each orchard, two pits were dug at random and composite soil samples were separately collected at two depths *viz*., 0 – 30 and 30 – 60 cm with geo reference by taking location co-ordinates and collected samples were processed for laboratory analysis. Available nitrogen in soil was determined by alkaline permanganate method [6]. Available phosphorus was extracted from soil with 0.5 M sodium bi-carbonate [7] as an extracting agent and determined using double beam US-VIS spectrophotometer. The available 'K' was extracted with the neutral normal ammonium acetate determined using Flame photometer [8]. Calcium and magnesium were determined by versanate titration method [9], available S was estimated by extracting the soil sample with 0.15% calcium chloride [10] and S content in the extract was determined by turbidimetric method [11], available micronutrients *viz*., iron, manganese, zinc and copper in soil were extracted with 0.005 M DTPA extractant (1:2 ratio) [12] and contents were estimated by using Atomic Absorption spectrophotometer (Agilent, 200 Series AA).

Fully ripened and matured fruits were selected and harvested for fruit quality analysis. Fruit quality parameters such as, total soluble solids were estimated by using digital hand

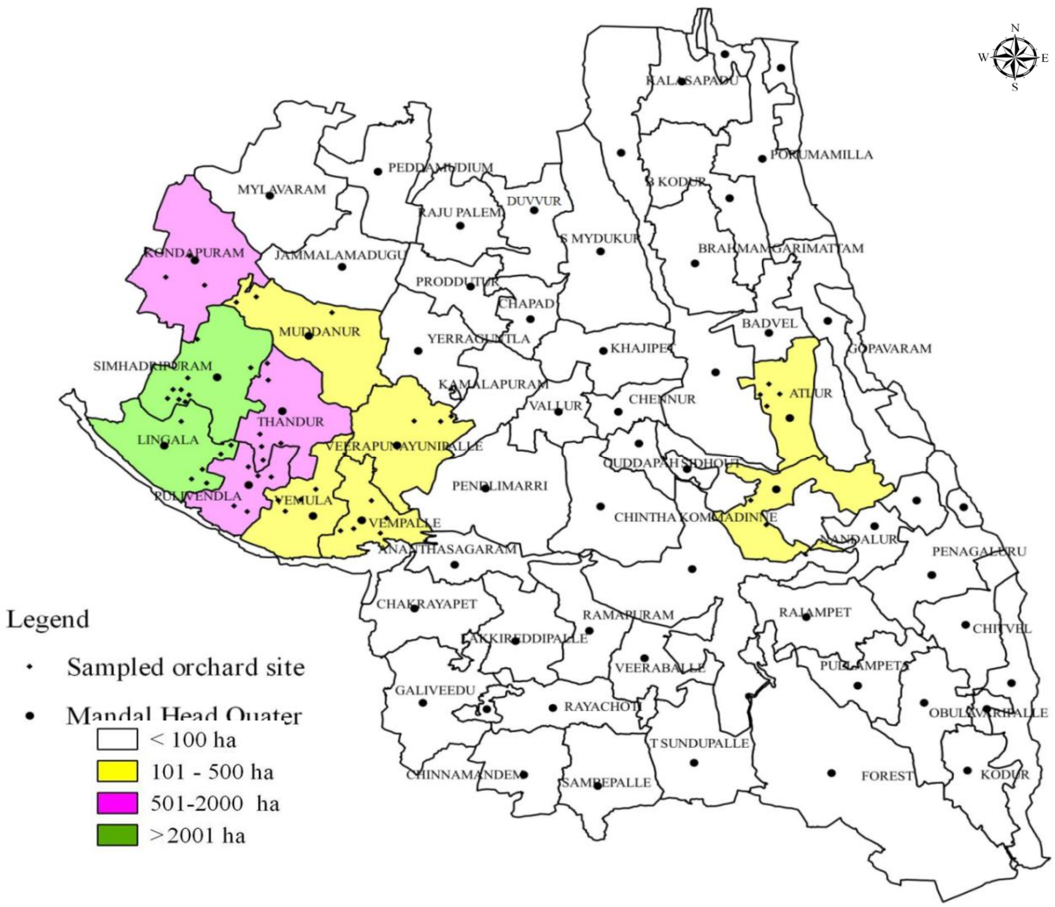

Fig. 1. Map showing area wise distribution of Sweet orange and sampled sites in different mandals of YSR district

refractometer (ATAGO Co. Ltd., Japan), Juice percentage, Acidity percentage, Ascorbic acid contents were determined by following the standard procedures [13].

Fruit yield was estimated by weighing total number of fruits harvested per plant and expressed as yield per tree (kg). Fruit yield per hectare for season was estimated depending upon the spacing adopted in the orchard and expressed in t ha^{-1}.

2.1 Statistical Analysis

Results were analyzed in SPSS 20.0 using Pearson correlation coefficient matrix to know the significant variations between the soil nutrient status with fruit yield and fruit quality parameters of sweet orange. Descriptive statistics were calculated using Microsoft Excel (Microsoft, WA, USA) spread sheet.

3. RESULTS AND DISCUSSION

3.1 Nutrient Status of the Sweet Orange Orchards

3.1.1 Major nutrients (N, P and K)

The soil available N content ranged from 125.26 to 307.33 kg ha^{-1}, with a mean value of 224.31 kg ha^{-1} at 0-30 cm and at 30 to 60 cm it ranged from 82.72 to 220.69 kg ha^{-1}, with a mean value of 150.79 kg ha^{-1} (Table 1 and Fig. 2).

The available P content of soil showed a variation of 5.26 to 39.54 kg ha^{-1} and 2.13 to 25.07 kg ha^{-1} with a mean values of 17.79 kg ha^{-1} and 11.16 kg ha^{-1} in surface and sub-surface soils, respectively (Table 1 and Fig. 2).

The available K content of the surface soils was differed from 116.14 to 955.92 kg ha^{-1}, with a mean value of 365.00 kg ha^{-1}. In the sub-surface soils of sweet orange orchards in study area, the available K content was varied from 69.66 to 554.51 kg ha^{-1}, with a mean value of 258.54 kg ha^{-1} (Table 1 and Fig. 2).

As per the soil nutrient ratings [14], out of all the soils of sweet orange orchards studied, 82% were deficit in N and 18% were medium in N, 20% were deficient in P, 60% were medium in P and 20% were high in P, but in case of available K, 32% were in medium range and 68% were in high range (Table 2 and Fig. 3). Similar results with regard to soil N, P and K was reported in citrus growing soils of Sahiwal district [15].

3.1.2 Secondary nutrients (Ca, Mg and S)

The exchangeable calcium (Ca) content of surface soils was ranged from 8.50 to 45.25 cmol(p^+)kg^{-1} with a mean value of 27.13 cmol(p^+)kg^{-1} and in sub-surface soils the exchangeable calcium content ranging from 6.00 to 46.50 cmol(p^+)kg^{-1} with a mean value of 29.52 cmol(p^+)kg^{-1} in sweet orange growing orchards of the study area (Table 1 and Fig. 2).

The exchangeable magnesium (Mg) content of soil showed a variation of 2.25 to 41.50 cmol(p^+)kg^{-1} and 2.75 to 22.50 cmol(p^+)kg^{-1} with mean values of 13.48 cmol(p^+)kg^{-1} and 10.51 cmol(p^+)kg^{-1} in surface and sub-surface soils, respectively (Table 1 and Fig. 2).

The available sulphur (S) content of surface soils was differed from 14.37 to 73.41 mg kg^{-1}, with a mean value of 30.12 mg kg^{-1}. In sub-surface soils of sweet orange orchards of study area, the available S content was varied from 8.35 to 29.16 mg kg^{-1}, with a mean value of 16.58 mg kg^{-1} (Table 1 and Fig. 2).

The higher exchangeable calcium status observed in all the orchards both in the surface and subsurface soils and were above critical limit of <1.50 cmol(p^+)kg^{-1} [16]. Similar trend was observed with respect to exchangeable magnesium status as that of exchangeable calcium. As per the critical limit of Mg <1.00 cmol(p^+)kg^{-1} [16].

The available S content was higher in surface soils than sub-surface soils of the study area. It might be due to application of organic manures and sulphur containing fertilizers on surface layers. As per the S critical limit (<10 mg kg^{-1}) [17], all the surface soils of the study area were sufficient in S content. Similar results were reported in sweet orange soils of Jalna district [18].

3.1.3 Micro nutrients (Fe, Cu, Mn and Zn)

The available Fe, Zn, Mn and Cu content of surface soils was ranged from 1.05 to 5.12, 0.08 to 1.23, 0.52 to 9.73 and 0.37 to 2.87 mg kg^{-1}, with mean values of 2.67, 0.37, 4.05 and 1.33 mg kg^{-1}, respectively in the sweet orange growing orchards of the study area (Table 1 and Fig. 2).

In the sub-surface soils of study area, the available Fe, Zn, Mn and Cu content was varied from 0.67 to 3.95, 0.01 to 1.19, 0.59 to 9.00 and 0.42 to 2.60 mg kg^{-1}, with a mean value of 1.58, 0.26, 2.93 and 0.92 mg kg^{-1} , respectively (Table 1 and Fig. 2).

Out of all the soils of sweet orange orchards studied, 24% and 78% samples were very low in available Fe and Zn, respectively. Low in available Fe, Zn and Mn contents to an extent of 68%, 18% and 8%, respectively. Medium in available Fe, Zn Mn and Cu were 8%, 4%, 38% and 18%, respectively. High in available Mn (36%) and Cu (82%), but very high in available Mn (18%) (Table 2 and Fig. 3). Sweet orange growing soils of Jalana district also reported that the maximum soil samples were deficient in Fe and Zn irrespective of soil depth [18].

The variation in the available micronutrient contents of soils might be due to variation in organic carbon content of the soils and micronutrient containing minerals. Similar results were also reported [19,20,21] with regard to available micronutrient concentration and distribution in different soils.

3.1.4 Fruit yield

From the Table 3, it could be noticed that the fruit yield of the sweet orange ranged from 6.00 to 25.50 t ha^{-1} with a mean yield of 12.32 t ha^{-1}. The yield of sweet orange orchards of the study area was classified [22], accordingly, 52% of the orchards were poor yielders, 32% low yielders and 16% optimum yielders.

3.1.5 Fruit quality

Fruit quality parameters like fruit weight, juice per cent, juice pH, titrable Acidity (%), total soluble solids (TSS) and vitamin C (ascorbic acid) were analyzed and the mean values are presented in Table 3.

Table 1. Soil mineral nutrient content of the sweet orange growing soils of YSR district

Parameter	Total samples	0 – 30 cm			30 – 60 cm		
		Range	Mean	SD	Range	Mean	SD
Available N (kg ha^{-1})	50	125.26- 307.33	224.31	51.05	82.72 - 220.69	150.79	40.04
Available P (kg ha^{-1})	50	5.26 - 39.54	17.79	9.095	2.13 - 25.07	11.16	6.08
Available K (kg ha^{-1})	50	116.14 - 955.92	365.00	169.34	69.66 - 554.51	258.54	95.59
Ex. Ca (cmol(p$^+$)kg^{-1})	50	8.50 - 45.25	27.13	8.47	6.00 - 46.50	29.52	8.83
Ex. Mg (cmol(p$^+$)kg^{-1})	50	2.25 - 41.50	13.48	8.97	2.75 - 22.50	10.51	4.86
Available S (mg kg^{-1})	50	14.37 - 73.41	30.12	13.19	8.35 - 29.16	16.58	4.51
DTPA-Fe (mg kg^{-1})	50	1.05 - 5.12	2.67	0.92	0.67 - 3.95	1.58	0.72
DTPA-Zn (mg kg^{-1})	50	0.08 - 1.23	0.37	0.25	0.01 - 1.19	0.26	0.20
DTPA-Mn (mg kg^{-1})	50	0.52 - 9.73	4.05	1.98	0.59 - 9.00	2.93	2.03
DTPA-Cu (mg kg^{-1})	50	0.37 - 2.87	1.33	0.53	0.42 - 2.60	0.92	0.41

(Ex. = Exchangeable)

Table 2. Distribution of the mineral nutrients in the sweet orange growing soils of YSR district

Parameter	Total samples	Very low		Low		Medium		High		Very high	
		Number of samples	%	Number of samples	%	Number of samples	%	Number of samples	%	Number of samples	%
Available N (kg ha^{-1})	50	–	–	41	82.00	9	18.00	–	–	–	–
Available P (kg ha^{-1})	50	–	–	10	20.00	30	60.00	10	20.00	–	–
Available K (kg ha^{-1})	50	–	–	–	–	16	32.00	34	68.00	–	–
DTPA-Fe (mg kg^{-1})	50	12	24.00	34	68.00	4	8.00	–	–	–	–
DTPA-Zn (mg kg^{-1})	50	39	78.00	9	18.00	2	4.00	–	–	–	–
DTPA-Mn (mg kg^{-1})	50	–	–	4	8.00	19	38.00	18	36.00	9	18.00
DTPA-Cu (mg kg^{-1})	50	–	–	–	–	9	18.00	41	82.00	–	–

** Soil nutrient indices were referred to [12,14]*

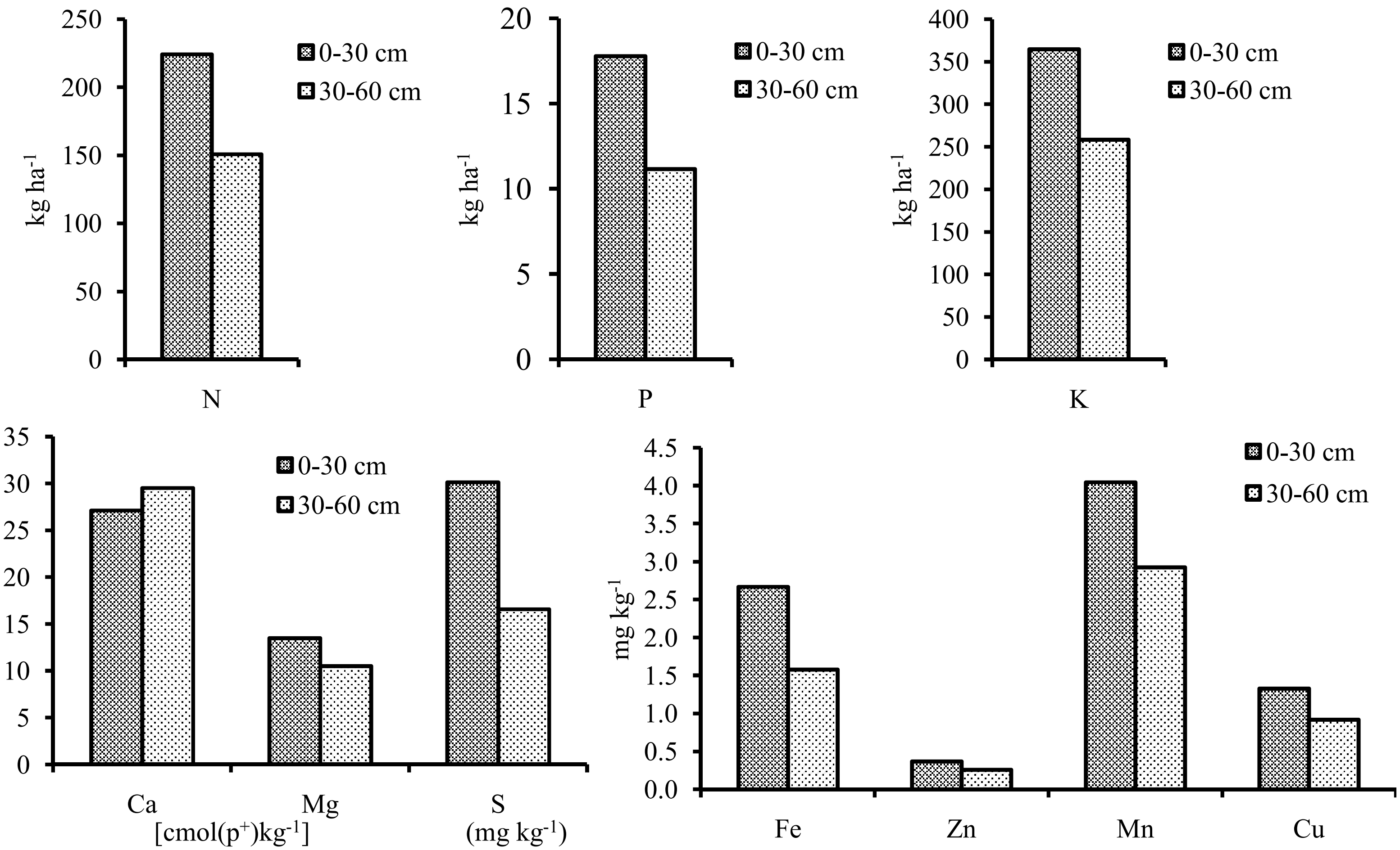

Fig. 2. Mean soil nutrients content of the sweet orange growing soils in YSR district

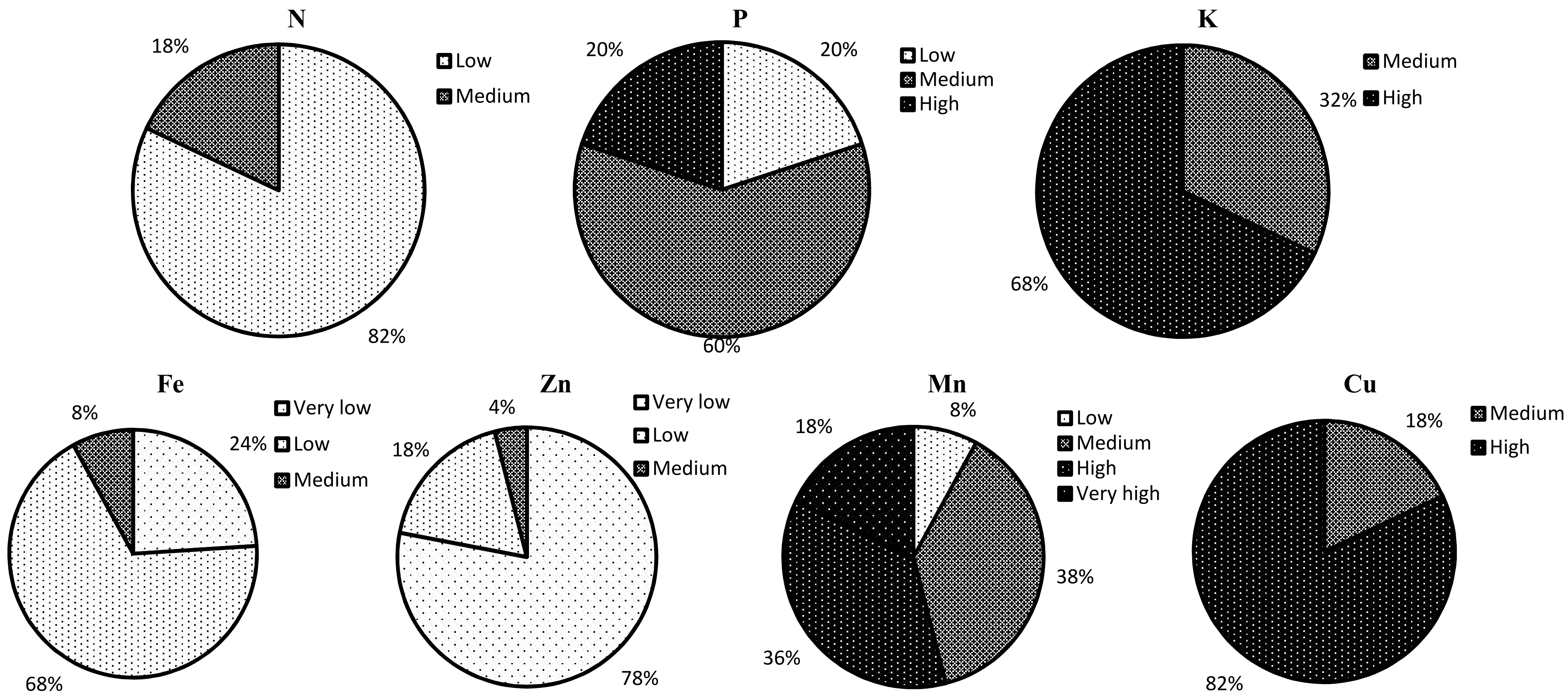

Fig. 3. Nutrients distribution in the soils of sweet orange orchards of YSR district

Table 3. Mean fruit yield and fruit quality parameters of the study area

Parameter	Total samples	Range	Mean	SD
Fruit weight (g)	50	155.20 - 218.38	180.11	19.52
Juice %	50	24.34 - 38.20	31.62	3.48
Juice pH	50	3.30 - 4.10	3.62	0.18
Titrable Acidity (%)	50	0.70 - 1.14	0.87	0.10
TSS (^{o}Brix)	50	7.40 - 13.60	10.77	1.70
Vit.-C (mg $100ml^{-1}$)	50	26.24 - 40.16	32.08	3.82
Yield (t ha^{-1})	50	6.00 - 25.50	12.32	4.98

Table 4. Correlation coefficient matrix between soil mineral nutrients and fruit yield, fruit quality parameters

	N	P	K	Ca	Mg	S	Fe	Zn	Cu	Mn
Fruit weight	0.469**	0.446**	0.415**	0.155	0.019	-0.204	-0.004	-0.134	-0.179	-0.117
% juice	0.353*	0.364**	0.147	-0.023	-0.068	-0.077	-0.028	-0.035	-0.008	-0.110
Juice pH	0.090	0.054	0.097	-0.067	0.212	0.024	-0.196	0.043	-0.024	-0.259
Titrable acidity	0.012	0.042	0.028	-0.262	-0.090	-0.093	-0.371**	-0.058	0.098	-0.292*
TSS %	0.267	0.438**	0.192	0.037	0.068	-0.032	-0.193	-0.199	-0.047	-0.311*
Vit.-C	0.437**	0.516**	0.398**	0.018	-0.042	-0.052	-0.058	-0.052	-0.178	-0.113
Yield	0.519**	0.409**	0.249	0.136	-0.043	-0.067	-0.049	-0.048	-0.168	-0.104

** and ** indicate a significant difference at P < 0.05 and P < 0.01, respectively*

The fruit weight, fruit juice per cent, juice pH, titrable acidity, TSS and vitamin C of the sweet orange fruits were ranged from 155.20 to 218.38 g, 24.34 to 38.20%, 3.30 to 4.10, 0.70 to 1.14%, 7.40 to 13.60 ^{o}Brix and 26.24 to 40.16 mg 100 ml^{-1} with an average value of 180.11 g, 31.62%, 3.62, 0.87%, 10.77 ^{o}Brix and 32.08 mg 100ml^{-1}, respectively.

The juice per cent of sweet orange orchards obtained from all the orchards in the study was lower when compared with the standards (>42% juice) prescribed [23]. The variation in the fruit juice per cent in all the orchards studied might be due to increased mobilization of sugars by manganese and potassium and probably due to more accumulation of sugars in fruits [24].

The results indicated that titrable acidity of the sweet orange fruits was more (0.7 to 1.14%) in all the orchards studied, when compared to the standards (0.4 to 0.7 % acidity) [23].

Most of the vitamin C (ascorbic acid) values registered in the study were below the level of standards (44 mg 100 ml^{-1}) [23].

3.1.6 Correlation of soil nutrient status with fruit yield and fruit quality

As per the correlation matrix presented in the table 4, the soil mineral nutrients like N, P and K influenced the fruit weight significantly and positively (r = 0.469**, r = 0.446** and r = 0.415**, respectively), showing their importance in regulating the quantum of fruit weight, but fruit yield and fruit juice per cent had significant positive relation with soil N (r = 0.519** and r = 0.353*) and P (r = 0.409** and r = 0.364**) only. Earlier studies demonstrated the similar positive correlation of soil available N and P with fruit yields of Nagpur mandarin [25] and *Kinnow* mandarin [26]. Soil P had a significant positive correlation with TSS (r = 0.438**).

Soil Fe and Mn had a significant negative correlation with titrable acidity (r = -0.371** and r = -0.292*, respectively). Soil Mn had a significant negative correlation with fruit TSS (r = -0.311*).

The soil Ca, Mg, S, Zn and Cu content showed no significant correlation with either fruit yield or any of the fruit quality parameters.

4. CONCLUSIONS

Majority of the soils of the study area were deficit in available nutrients such as Zn, Fe, N, P and Mn, but Ca, Mg, S, K and Cu were in optimum to high range. Fruit yield and fruit weight was positively and significantly influenced by soil organic carbon content, N and P. Fruit juice per cent had significant positive relation with soil N and P. Soil P had a significant positive correlation with TSS. Soil Fe and Mn had a significant negative correlation with titrable acidity. Soil Mn had a significant negative correlation with fruit TSS.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Horticultural Statistics at a Glance. Horticulture Statistics Division, Ministry of Agriculture and Farmers Welfare, Government of India, 2016. Oxford University Press. New Delhi 110001, India. 2015;17.
2. CPO (Chief Planning Officer). YSR District statistical database. YSR District, Andhra Pradesh; 2015.
3. Srivastava AK, Singh S. Citrus decline: Soil fertility and plant nutrition. Journal of Plant Nutrition. 2009;32(2):197-245.
4. Huchche AD. Studies on the biochemical and physiological aspects of citrus decline. Ph.D. Thesis, Haryana Agriculture University, Hisar. 1999;171.
5. Srivastava AK, Singh S. Recent trends in production research. Souvenir: International Symposium on Citriculture. Organized by Indian Society of Citriculture, and Central Citrus Research Institute (Formerly National Research Center for Citrus), Nagpur, at Nagpur, Maharashtra. 1999;174-191.
6. Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. Current Science. 1956;25:259-260.
7. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture, Circular No. 939; 1954.
8. Jackson ML. Soil chemical analysis. Oxford and IBH Publishing House, Bombay. 1973;38.
9. Vogel AI. A text book of quantitative inorganic analysis. Richard Clay, The Chances Press Ltd., Britain; 1978.

10. Williams CH, Steinbergs A. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian Journal of Agricultural Research. 1959;10: 340-352.
11. Chesnin L, Yien CH. Turbidimetric determination of available sulphates. Proceedings of Soil Science Society of America. 1951;15:149-151.
12. Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 1978;42:421-428.
13. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw Hill Publishing Company Ltd., New Delhi. 1986;881.
14. Muhr GR, Datta NP, Shankarasubromoney H, Leley VK, Donahue RL. Soil testing in India. USAID, New Delhi. 1965;52-56.
15. Ranjha AM, Akram M, Mehendi SM, Sadiq M, Sarfraz M, Hasan G. Nutritional status of citrus in Sahiwal district. Online Journal of Biological Sciences. 2002;2(7):453-458.
16. Tandon HLS. Secondary and micro nutrient recommendation for soils and crops. A Guide Book. 1989;22.
17. Tandon HLS. Sulphur research and agricultural production in India, 3rd Edition. The Sulphur Institute, Washington DC. 1991;140.
18. Chaudhari SR, Gawate AB, Chaudhari RS. To study the effect of different soil depth in relation to yield of sweet orange of Jalna District. International Journal of Horticultural and Crop Science Research. 2016;6(1):15-20.
19. Khokhar Y, Singh HR, Singh WD, Dhillon, Singh G, Singh PG. Soil fertility and nutritional status of Kinnow orchards grown in aridisol of Punjab, India. African Journal of Agricultural Research. 2012;7(33):4692-4697.
20. Noor Y, Subhanullah, Shah Z. Spatial variability of micronutrients in citrus orchard of North Western Pakistan. Sarhad Journal of Agriculture. 2013;29(3): 387-394.
21. Surwase SA, Kadu PR, Patil DS. Soil micronutrient status and fruit quality of orange orchards in Kalmeshwar Tahsil, District Nagpur (MS). Journal of Global Biosciences. 2016;5:3523-3533.
22. Srivastava AK, Singh S, Tiwari KN. Diagnostic tools for citrus: Their use and implications in India. Better Crops- India. 2007;26-29.
23. Satyanarayana G, Ramasubba Reddy M. Citrus cultivation and protection. Wiley Eastern Ltd., Hyderabad. 1994;4-24.
24. Kazi SS, Ismail S, Joshi KG. Effect of multi-micronutrient on yield and quality attributes of the sweet orange. African Journal of Agricultural Research. 2012;7(29):4118-4123.
25. Srivastava AK, Singh S. Soil properties influencing yield and quality of Nagpur Mandarin (*Citrus reticulata* Blanco). Journal of the Indian Society of Soil Science. 2001;49(1):226-229.
26. Dhillon WS, Dhatt AS. Nutrient status and productivity of Kinnow mandarin in Ferozpur district. Punjab Horticulture Journal. 1988;29(1&2):7-13.

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