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M Balakrishna
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

T Giridhara Krishna
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

KV Nagamadhuri
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

P Sudhakar
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

B Ravindra Reddy
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

KM Yuvaraj
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

Corresponding Author
M Balakrishna
Department of Soil Science and Agricultural Chemistry, Acharya N.G. Ranga Agricultural University, S.V. Agriculture College, Tirupati, Andhra Pradesh, India

Soil fertility and leaf nutrient status of mango orchards in YSR district of Andhra Pradesh

M Balakrishna, T Giridhara Krishna, KV Nagamadhuri, P Sudhakar, B Ravindra Reddy and KM Yuvaraj

Abstract
Two fifty soil and leaf samples from selected mango (*Mangifera indica* L.) orchards were collected in twelve mandals of YSR district of Andhra Pradesh to evaluate Physical, Physico chemical and chemical properties of soils and mango leaves during 2019-20. The soil textural classes identified were sandy loam (42.8%), sandy clay loam (38%) loamy sand (12.4%),, sandy clay (4.4%) and clay loam (2.4%) of the study area The pH of soils varied from 6.72 to 8.62 Electrical conductivity of the soils ranged from 0.13 to 0.34 dS m^{-1} and OC varied from 0.30 to 0.72 percent. The available nitrogen, phosphorus, potassium, sulphur, Calcium and magnesium of the soils ranged from 125 to 388 kg ha^{-1}, 5 to 70 kg $ha^{-1,}$ 74 to 666 kg $ha^{-1}$and 5.36 to 27.76 mg kg^{-1} 3.87- to 36.75 and 2.16 to 22.50 cmol (p+) kg^{-1} respectively. The values of total N, P, K were 0.98 to 1.60, 0.03-0.51, 00.35 to 1.33 per cent, respectively. The dominant soil textural class was sandy loam. The mean concentration of nitrogen (1.27%) and Phsosphorus (0.12%) and potassium (0.60%) in the leaf samples were in optimum levels. The overall fertility status of the soils of YSR district mandals in relation to mango cultivation is moderate.

Keywords: fertility status, leaf nutrition, mango orchards

Introduction
Mango (*Mangifera indica* L.) has become a major fruit crop of the tropics and subtropics, particularly in Asia, the most important fruit crop and where it has always been considered the king of fruits (Litz, 2009). India produces about 50 per cent of world mango production with largest area. In India, mango is cultivated in more than 40 per cent of total fruit area. The area occupied by Mango in India is 22.58 lakh hectare, where the annual production and productivity is 218.22 lakh MT and 9.7 MT/ ha respectively as against a higher productivity of 30 MT/ ha in Israel. Andhra Pradesh leads in area of mango cultivation occupying 3.63 lakh hectare followed by Uttar Pradesh occupying 2.65 lakh hectare whereas Uttar Pradesh leads in production of 45.51 lakh MT followed by Andhra Pradesh producing 43.73 lakh MT and Rajasthan leads in productivity of 17.58 MT/ ha followed by Punjab of 16.9 MT/ ha (NHB, 2019-20). In YSR district of Andhra Pradesh mango is in dominant area with other fruit crops like banana, papaya, sweet orange etc. The domain of the present research work is YSR district is a part of Southern tract and identified as horticulture district of Andhra Pradesh. The district tropical climate with medium rainfall (Average annual rainfall of 763 mm, latitude of 14.280 to 14.666 N and longitude 78.490 to 78.816 E. Here, mango is grown on plain to slightly hilly areas under irrigated to rainfed conditions

The productivity of mango is hampered due to imbalanced use of fertilizers and pesticides (Sultana *et al.* 2018) [20]. Nutrition of fruit plants depends upon inherent ability of soils to supply nutrient elements. The key to mineral nutrition of the plants is the judicious use of fertilizers based on soil testing. Plant analysis is also used to confirm the suspected deficiencies and toxicities of nutrients and also to assess the efficacy of fertilizer doses (Sharma *et al.* 2018) [21]. Therefore, it is very important to focus on the soil nutrients availability and other properties pertaining to nutrients if mango production is to be increased. Total nitrogen, phosphorus, potassium sulphur, calcium and magnesium content in soils and their availability to the plants are vital properties of soil fertility. Soil nutrient of mango is an important part of orchard management practices (Ravishankar *et al.* 2010) [15]. Essential nutrients have specific role in the plant and their presence is must for the plant to complete its life cycle. Information on mineral nutrient status helps in diagnosis of nutritional problems and estimation of the fertilizer needs of the fruit trees (Sharma *et al.* 2018) [21]. To ascertain these, both soil and plant analyses are necessary as these are complementary to each other and one

supplies the information that the other may not. The information on nutritional status of both soil and plant helps to understand about adequate fertilization of the orchards. Practically, no systematic work has been done on the nutritional status of mango orchards in YSR district of Andhra Pradesh. The results obtained here may help in formulation of future nutritional status and in working out accurate fertilizer recommendations in the above mentioned regions.

The present experiment was undertaken to evaluate some physical, physico-chemical and chemical properties of mango growing soils of selected mandals of YSR district of Andhra Pradesh and also leaf nutrient concentrations of mango plants.

2. Materials and Methods

The fertility status of selected mango orchard soils as well as leaf nutrient contents in. Sambepalle, Rayachoty, Chinnamandem, Galiveedu, Chakrayapeta, Lakkireddypalle, Ramapuram, Veeraballe, T. Sundupalle, Penagaluru, Koduru and Chitvel mandals of YSR district were evaluated. Two fifty soil samples (0 - 30 cm depth) and two fifty leaf samples were collected. Soil samples were air-dried, visible roots and debris were discarded, massive aggregates were broken by using a wooden hammer, ground and sieved using 2 mm sieve. Samples were kept in polyethylene bags with proper labeling. Two hundred fifty leaf samples were collected comprising of 25-30 leaves (latest mature flush from middle of the terminal growth) were collected from 8-10 randomly selected trees in each selected orchard as per the sampling time at random covering 10 trees per hectare in an orchard to represent the nutrients. The leaves from trees were collected covering all four directions *viz*., North, South, East and West preferably at 2 to 2.5 m from ground level

The leaf samples were washed with ordinary water and then with 0.1N HCL followed by washing with distilled water. They were dried in an oven at 60 + 5 ºC for 72 hours. The dried samples were ground in stainless steel grinder to facilitate proper mixing of plant material and stored in paper bags for subsequent analysis (Chapman, 1964) [8]

Particle size distribution (mechanical composition) of the soils was determined by the Bouyoucos hydrometer method as described by Bouyoucos (1962). Based on particle size distribution, soil texture was classified by using *nomograph* (textural diagram) of USDA Hand Book 60. Soil reaction expressed as pH was determined in 1:2.5 soil water suspension using Systronics pH meter model-361 with a glass electrode as described by Jackson (1973) [9, 10]. The electrical conductivity of the soil was determined in 1:2.5 soil water extract with help of Systronics digital electrical conductivity meter model-306 as described by Richards (1954) [5] and was expressed in dS m^{-1}. The organic carbon content in the 0.2 mm sieve soil sample was estimated by Walkley and Black wet oxidation (1934) [1] method as outlined by Jackson (1973) [9, 10] and was expressed in percentage.

Soil available nitrogen was estimated by alkaline permanganate method as described by Subbiah and Asija (1956) [7] and was expressed in kg ha^{-1}. Soil available phosphorus was extracted by using 0.5 M $NaHCO_3$ adjusted to pH 8.5 (Olsen *et al.*, 1954) [3] and color intensity was read in spectrophotometer at 660 nm and was expressed in kg ha^{-1}. Soil available potassium was extracted with neutral normal ammonium acetate and the content was estimated as per procedure out lined by Jackson (1973) [9, 10] using flame photometer and was expressed in kg ha^{-1}.

Available sulphur in soil was determined by extracting the soil sample with 0.15% calcium chloride (Williams and Steinbergs, 1959) [6] and S content in the extract was determined by turbidimetric method (Chesnin and Yien, 1951) [4] using spectrophotometer at 420 nm and was expressed in mg kg^{-1} of soil. Exchangeable calcium and magnesium were determined in neutral normal ammonium acetate extract and the contents were determined by following versanate titration method (Vogel, 1978) [11] and were expressed in cmol (p^+) kg^{-1} of soil.

The total nitrogen content of leaf sample was estimated by Micro-kjeldahl method (A.O.A.C., 1970) and expressed in percentage. One gram of oven dry leaf sample was digested with 10 ml of di-acid mixture (Nitric acid and Perchloric acid in 10:4 ratio). The digested leaf samples were diluted to known volume with double distilled water and filtered (Jackson, 1973) [9, 10]. This filtrate was used for the estimation of P, KThe phosphorus concentration in di-acid extract was determined by Vanadomolybdo phosphoric yellow colour method by using spectrophotometer (Jasco V-530 UV visible spectrophotometer) at 470 nm wavelength (Jackson, 1973) [9, 10] and expressed in percentage. The concentration of potassium in di-acid extract was determined using the flame photometer (Jackson, 1973) [9, 10] and expressed in percentage.

3. Results and Discussion

The per cent sand, silt and clay contents ranged from 12.25 to 95.08, 2.00 to 48.50 and 2.92 to 74.36 with mean values of 69.95, 11.14 and 18.91 per cent, respectively. The soil textural classes identified were sandy loam (42.8%), sandy clay loam (38%), loamy sand (12.4%), sandy clay (4.4%) and clay loam (2.4%) of the study area. (Table.1) The variation in soil texture might be due to difference in topographic position, nature of parent material, *in situ* weathering, translocation of clay and age of soils. From this study, it was known that the mango growing satisfactorily in the range of light textured sandy loam to fine textured sandy clay loams. The results are in accordance to the findings of Salunkhe *et al.* (2021) [24] while characterizing the mango growing soils of Rathnagiri district of Konkan region of Maharastra and observed that the soils texture varied from sandy loam to loamy sand. The sand/silt ratio in the soils of ranged from 2.57 – 9.57 and the average silt/clay ratio varied from 2.32 – 5.66.It was reported that well drained sandy loam to loam soils provide the best environment for mango production (Sys *et al*. 1998).

The pH of soils varied from 6.72 to 8.62 with a mean value of 7.66 and standard deviation of 0.24 and CV of 3.15 per cent. In Sambepalle, Rayachoty, Chinnamandem, Galiveedu, Chakrayapeta, Lakkirddypalle, Koduru, Chitvel soil reaction was slightly alkaline whereas in Ramapuram, Veeraballe, T. Sundupalle mandals it was moderately alkaline in Penagaluru mandal. The lower pH of surface soil might be due to the presence of more amount of organic matter, which resulted in the release of organic acids during its decomposition. Probably this might have brought down the pH of surface soils. The higher pH showed in the sub-surface soils might be due to low organic matter and leaching of exchangeable bases to lower horizons. The higher pH values in orchard soils could be attributed to comparatively less leaching of bases in fine textured soils like sandy clay and sandy clay loam. Similar results were reported by Chetna and Prasad (2011) [16] and Surwase *et al*. (2016) [18]. Adak *et al.* (2019) [23].

Electrical conductivity of the soils in the study area ranged from 0.13 to 0.34 dS m^{-1} and the soils were non-saline, with a mean value of 0.20 and standard deviation of 0.06 and CV of 13.59 per cent (Table.2). In almost all the mandals EC was within the normal range and soils were free from salinity problem because of good drainage condition leading to leaching of salts to lower horizons. The orchards were non-saline in nature as the EC of these soils was far below 4.0 dS m^{-1}. The normal electrical conductivity (<0.5 dS m^{-1}) observed from this study was favourable for satisfactory plant growth.

The Organic carbon (OC) content of soils of all mandals falls under low to medium range. The OC content of soils varied from 0.30 to 0.72 per cent, with a mean of 0.52 per cent.

The available nitrogen content of the soils varied from 125 to 388 kg ha-1, with a mean value of 229.65 kg ha-1 and standard deviation of 20.14 and CV of 8.77 per cent The soils of Chitvel mandal recorded the highest mean value for (267.79 kg ha-1) while the soils of Chinnamandem mandal had the lowest mean value of 204.05 kg ha-1. this variation in N contents might be due to a number of reasons such as difference in natural fertility, variation in cultural practices and variation in the N applied fertilizers. Nitrogen contents in surface was higher as compared to the lower depths of soil, which might be due to presence of more organic matter in surface than sub-surface soil. Similar results were reported by (Joshi *et al.* 2015) [17]. The available phosphorus status of study area soils of YSR district was low to high and ranged from 5 to 70 kg ha-1, with a mean value of 21.28 kg ha-1 and standard deviation of 2.68 and CV of 12.58 per cent. The soils of Chinnamandem mandal recorded the highest mean value for (26 kg ha-1) while the soils of Galiveedu mandal had the lowest mean value of 15.48 kg ha-1. It might be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external source *i.e.* fertilizers. The lower P content in sub-surface compared to surface soil was due to the fixation of released P by clay minerals and oxides of iron and aluminum. Similar results were reported by Joshi *et al.* 2015 [17].

The available potassium content of study area soils of YSR district ranged from 74 to 666 kg ha-1, with a mean value of 264.1149 kg ha-1 and standard deviation of 118.47 and CV of 44.86 per cent. Soils of all twleve mandals were medium to high in available potassium. The soils of Ramapuram mandal recorded the highest mean value (444.73 kg ha-1) followed by Chitvel (428.94 kg ha-1) and Galiveedu (363.10 kg ha-1) mandals. Soils of Veeraballe mandal had the lowest mean value of 119.49 kg ha-1.This might be due to more intense weathering, release of liable K from organic residues, application of K fertilizers and upward translocation of K from lower depths along with capillary rise. The available sulphur content of soils of study area soils of YSR District varied from 5.36 to 27.76 mg kg-1, with a mean value of 12.46 mg kg-1(Table.2). The soils twleve mandals, recorded mean values under sufficient range (>10 mg kg-1) of available sulphur content except koduru under deficit range (<10 mg kg-1) as per the S critical limit (<10 mg kg^{-1}) prescribed by Tandon (1991) [12]. Similar results were reported by Chaudhari *et al.* (2016) [19]. The available calcium and magnesium content of study area varied from 3.87- to 36.75 and 2.16 to 22.50 cmol (p+) kg-1 with mean values of 12.38 and 5.90 cmol (p+) kg-1, The soils of all the mandals were above critical limit in both calcium and magnesium contents. The exchangeable calcium and magnesium status observed in all the orchards both in the surface soils were above critical limit of <1.50 cmol(p^+) kg^{-1} as established by Tandon (1989).

Leaf samples showed that the total nitrogen content ranged from 0.98 to 1.60 per cent with an average of 1.27% The phosphors content of the leaf samples ranged from 0.03-0.51 per cent with an average of 0.12. The potassium concentration of leaf samples of study area of YSR District varied from 0.35 to 1.33 per cent, with a mean value of 0.60 (Table.3)All the values are in medium range as established by Tandon (1989).

Table 1: Particle size distribution in selected soils of mango orchard sites at different mandals of YSR district

Mandal name	No. of soil samples	% sand	% silt	% clay	Textural class	Sand/silt ratio	Silt/clay ratio
Sambepalle	20	55.40-85.08 (71.56)	3.56-24.77 (9.42)	8.64-33.36 (19.02)	sl	7.59	3.76
Rayachoty	22	12.25-80.36 (57.49)	4.28-48.50 (17.83)	11.28-46.46 (24.68)	scl	3.22	2.32
Chinnamandem	21	20.36-85.08 (62.84)	4-37.28 (11.43)	7.00-60.08 (25.72)	scl	5.49	2.44
Galiveedu	21	53.52-83.36 (70.80)	3.56-23.4 (10.15)	8.64-30.92 (19.14)	sl	7.03	3.69
Chakrayapeta	21	11.92-95.08 (77.28)	2-23.13 (9.08)	2.92-25.92 (13.64)	sl	7.60	5.66
Lakkireddypalle	20	20.36-84.06 (63.90)	4-25.88 (24.82)	10.92-23.57 (11.28)	sl	2.57	5.66
Ramapuram	21	12.92-82.08 (70.03)	5-24.82 (9.86)	5.28-32.24 (16.84)	sl	9.37	4.15
Veeraballi	21	55.08-83.36 (74.13)	3.56-14.28 (7.18)	8.64-36.92 (18.40)	sl	9.91	4.02
T.Sundupalle	23	61.18-84 (70.96)	3.64-17.38 (9.31)	8.64-32.36 (19.71)	sl	7.60	3.60
Penagaluru	21	24.92-91.25 (70.61)	3.64-14.28 (7.10)	5.05-67.08 (22.29)	scl	9.94	3.16
Koduru	19	18.73-90.04 (73.86)	3.56-40.56 (9.24)	5.06-32.92 (16.9)	sl	7.99	4.37
Chitvel	20	64.08-81.08 (72.39)	4-13.3 (8.26)	7.92-23.36 (19.35)	sl	8.76	3.74

Sl: sandy loam, scl: sandy clay loam

Table 2: Physico chemical and chemical properties in selected soils of mango orchards at different mandals of YSR district.

Mandal Name	No. of soil samples	pH	EC (dS m-1)	Organic carbon (%)	Available Nitrogen (kg ha-1)	Available Phosphorus (kg ha-1)	Available potassium (kg ha	Available Sulphur (mg kg-1)	Available Ca	Available Mg
									cmol (p+) kg-1)	
Sambepalle	20	6.95-8.15 (7.44)	0.11-0.27 (0.18)	0.30-0.53 (0.38)	156 -295 (219.99)	10-36 (19.46)	78-160 (119.93)	5.74-18.94 (11.41)	4.58-18.21 (9.96)	2.95-7.45 (4.76)
Rayachoty	22	7.1-8.25 (7.71)	0.18-0.31 (0.24)	0.29-0.53 (0.42)	175–275 (228.22)	13-39 (23.11)	98-186 (134.3)	6.86-19.02 (12.7)	5.07-13.79 (8.46)	3.03-9.22 (4.84)
Chinnamandem	21	7.15-8.25 (7.70)	0.16-0.37 (0.28)	0.27-0.55 (0.44)	161 -231 (204.05)	18 -38 (26)	110-186 (143.27)	8.95-18.87 (12.53)	7.05-17.69 (11.75)	2.18-5.25 (3.56)
Galiveedu	21	7.35-8.5 (7.82)	0.18-0.41 (0.31)	0.25-0.57 (0.41)	166 - 269 (206.02)	9 - 28 (15.48)	145 - 610 (363.10)	9.75-21.46 (13.46)	7.25-18.24 (11.13)	3.05-7.78 (5.13)
Chakrayapeta	21	6.72-8.35 (7.50)	0.11-0.58 (0.28)	0.27-0.72 (0.48)	183 -388 (257.97)	10 - 39 (22.26)	118 - 426 (276.96)	7.98-27.76 (13.38)	3.87-18.55 (8.96)	2.16-6.41 (3.81)
Lakkireddypalle	20	6.75-8.25 (7.60)	0.17-0.48 (0.32)	0.27-0.52 (0.38)	137-300 (237.14)	8- 38 (20.15)	177 - 384 (300.27)	6.97-19.11 (11.53)	4.33-20.15 (8.05)	3.23-9.98 (4.42)
Ramapuram	21	7.78-8.45 (8.15)	0.12-0.66 (0.32)	0.23-0.63 (0.40)	198 -321 (255.76)	12 - 35 (23.13)	348 – 666 (444.73)	7.26-18.45 (12.23)	8.68-14.01 (11.06)	7.89-13.24 (9.94)
Veeraballi	21	7.28-8.54 (7.88)	0.17-0.67 (0.40)	0.13-0.51 (0.35)	139 - 307 (225.36)	7 - 44 (19.80)	74 -188 (119.49)	5.58-23.99 (15.03)	15.5-31.25 (23.21)	5.50-22.5 (12.86)
T.Sundupalle	23	7.57-8.62 (7.92)	0.14-0.68 (0.27)	0.2-0.49 (0.34)	125 - 307 (214.42)	5 -39 (19.11)	86 -531 (154.37)	8.48-26.69 (15.58)	6-36.75 (24.61)	2.75-18.75 (8.00)
Penagaluru	21	6.8-7.7 (7.26)	0.12-0.56 (0.26)	0.27-0.72 (0.52)	175-277 (227.04)	9 - 70 (24.10)	250-436 (345.90)	7.86-17.75 (11.46)	4.69-15.59 (9.84)	3.29-6.65 (4.43)
Koduru	19	6.9-7.9 (7.42)	0.16-0.28 (0.21)	0.26-0.69 (0.41)	159 - 290 (212.14)	10 - 41 (22.60)	205 -458 (338.06)	5.36-15.8 (9.95)	5.15-15.95 (10.61)	2.16-6.3 (4.27)
Chitvel	20	7.2-8.0 (7.53)	0.13-0.34 (0.20)	0.3-0.72 (0.52)	213 - 316 (267.79)	9 – 44 (20.20)	246 - 616 (428.94)	6.36-16.34 (10.37)	6.33-17.11 (10.95)	3.77-6.21 (4.86)
	Range	6.72 - 8.62	0.11-0.68	0.13-0.72	125-388	5- 70	74 -666	5.36 - 27.76	3.87-36.75	2.16-22.50
	Mean	7.66	0.27	0.42	229.65	21.28	264.11	12.46	12.38	5.90
	SD	0.24	0.06	0.06	20.14	2.68	118.47	1.63	5.27	2.74
	CV%	3.15	21.71	13.59	8.77	12.58	44.86	13.09	42.61	46.45

Table 3: The concentration of N, P and K in mango leaves of selected mandals of YSR district

Mandal name	No.of soil samples	Nitrogen%	Phosporus%	Potassim%
Sambepalle	20	0.99-1.51 (1.22)	0.07-0.22 (0.13)	0.42-0.73 (0.55)
Rayachoty	22	1.09-1.36 (1.24	0.12-0.15 (0.13)	0.45-0.67 (0.57)
Chinnamandem	21	0.97-1.45 (1.20)	0.04-0.20 (0.11)	0.41-0.78 (0.59)
Galiveedu	21	1.01-1.44 (1.19)	0.03-0.21 (0.14)	0.44-0.73 (0.60)
Chakrayapeta	21	1.09-1.51 (1.30)	0.04-0.18 (0.11)	0.35-0.74 (0.58)
Lakkireddypalle	20	1.16-1.45 (1.32)	0.09-0.18 (0.13)	0.43-1.33 (0.84)
Ramapuram	21	1.04-1.60 (1.25)	0.07-0.18 (0.12)	0.39-0.93 (0.56)
Veeraballi	21	1.14-1.57 (1.37)	0.04-0.18 (0.13)	0.35-0.89 (0.61)
T.Sundupalle	23	1.19-1.45 (1.34)	0.03-0.45 (0.11)	0.38-0.79 (0.60)
Penagaluru	21	1.06-1.46 (1.29)	0.03-0.15 (0.12)	0.41-0.78 (0.59)
Koduru	19	0.98-1.51 (1.30)	0.05-0.51 (0.21)	0.43-0.77 (0.56)
Chitvel	20	1.08-1.42 (1.21)	0.03-0.14 (0.10)	0.48-0.7 (0.61)
	Range	(0.98-1.60)	0.03-0.51	0.35-1.33
	Mean	1.27	0.12	0.60
	SD	0.06	0.03	0.08
	CV%	4.65	22.00	12.68

Note: Figures in parenthesis indicate mean values of corresponding mandals)

4. Conclusions

The present study was conducted to study the physical, physiochemical and chemical properties of soils of Mango orchards of YSR district at 0-30 cm depth by using standard analytical methods. The results show that sand content was higher than clay content. Majority of the soil textural class was sandy loam (42.8%) followed by sandy clay loam (38%). Organic carbon was found as low to medium, soil pH was neutral to moderately alkaline in reaction, EC of the soils was normal in condition where as available nitrogen was low, available phosphorus was medium to high in range and in all the mandals an average recorded medium to high available potassium content except Sambepalle and veeraballi where available potassium content was in low to medium range. In all the mandals recorded sufficient calcium, magnesium and sulphur contents. N,P and K values of leafs were in medium range from mango fields of YSR district.

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