International Journal of Advanced Biochemistry Research 2025; SP-9(9): 191-196

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(9): 191-196
www.biochemjournal.com
Received: 16-07-2025
Accepted: 19-08-2025

RN Punse
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Maharashtra, India

Dr. RN Katkar
Professor, Soil Science Section, Dr. P.D.K.V, Akola, Maharashtra, India

Dr. RL Isal
Associate Professor, Department of Agronomy, Dr. P.D.K.V, Akola, Maharashtra, India

Nishigandha R Mairan
Soil Science Section, College of Agriculture, Nagpur, Maharashtra, India

Dr. SS Balpande
Associate Professor, Soil Science Section, College of Agriculture, Nagpur, Maharashtra, India

Yashashri P Gajbhiye
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Maharashtra, India

Shreya Singh
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Maharashtra, India

Corresponding Author:
RN Punse
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Maharashtra, India

Development of Dris norms for sweet orange grown in Narkhed tehsil, Nagpur district

RN Punse, RN Katkar, RL Isal, Nishigandha R Mairan, SS Balpande, Yashashri P Gajbhiye and Shreya Singh

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i9Sc.5513

Abstract
An investigation entitled "Development of Dris norms for sweet orange grown in Narkhed Tehsil, Nagpur district" was conducted during 2024-25 to evaluate the soil and leaf nutrient status in black soils. 27 soil and plant samples (0-30 cm) from 6 to 8 year old orchards were analyzed. Soil samples were tested for fertility status, while leaf samples were assessed for nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, iron, manganese, zinc, copper and boron content. Fruit yield and quality parameters were recorded in November 2024. Soil properties varied with pH ranging from 7.08 to 8.01, EC ranging from 0.156 to 0.290 dS m^{-1}, OC ranging from 4.31 to 5.82 g kg^{-1}, and $CaCO_3$ ranging from 2.1 to 4.3%. Macronutrient availability in soil ranged as follows: N (250.08-348.05 kg ha^{-1}), P (16.4-28.8 kg ha^{-1}), K (400.1-433.9 kg ha^{-1}), S (7.6-14.8 mg kg^{-1}), Ca (20.01-38.24 cmol ($p^{+)}$ kg^{-1}) and Mg (5.68-14.88 cmol ($p^{+)}$ kg^{-1}). Micronutrient levels were Fe (3.13-5.76 mg kg^{-1}), Mn (5.21-9.45 mg kg^{-1}), Zn (0.18-0.92 mg kg^{-1}), Cu (0.30-1.52 mg kg^{-1}) and B (0.23-0.93 mg kg^{-1}). Leaf nutrient content varied with macronutrients N (1.38-2.67%), P (0.11-0.35%), K (1.38-1.84%), S (0.17-0.29%), Ca (1.44-1.98%) and Mg (0.34-0.58%) and micronutrients Fe (72.4-128.4 mg kg-1), Mn (34.4-79.2 mg kg-1), Zn (13.5-23.8 mg kg^{-1}), Cu (5.8-9.6 mg kg^{-1}) and B (19.8-31.9 mg kg^{-1}). The yield of sweet orange orchards ranged from 8.0 to 23.6 t ha^{-1}, with fruit acidity and TSS ranging from 0.31 to 0.45% and 8.2 to 9.5% respectively.

Keywords: Sweet orange orchards, DRIS, Soil fertility norms, DRIS indices

Introduction
Sweet orange (*Citrus sinensis* L. Osbeck), a commercially important fruit crop, is widely cultivated in tropical and subtropical regions and is increasingly preferred in Vidarbha over Nagpur mandarin due to better market potential, longer orchard life, and dependable flowering. Despite its rising popularity, declining productivity in mature orchards is a growing concern, often linked to imbalanced fertilization particularly the neglect of micronutrients which affects both yield and fruit quality. Conventional fertilizer recommendations, based on outdated soil test ratings (Muhr *et al*., 1965), do not cater to specific nutrient requirements of citrus cultivars (Srivastava and Singh, 2001c), while leaf tissue analysis has been proven to better reflect plant nutritional status (Srivastava and Singh, 2002). DRIS (Diagnosis and Recommendation Integrated System), developed by Beaufils (1973) [1] and further refined by Walworth and Sumner (1986) [31], is considered a more comprehensive approach as it uses nutrient ratios to detect deficiencies, imbalances, and excesses. Although research has been conducted on soil fertility and citrus nutrition, studies correlating leaf nutrient status with fruit yield and quality using DRIS are limited, especially in black soils of Vidarbha. Hence, the present investigation was undertaken to assess the soil and leaf nutrient status of sweet orange orchards and to develop DRIS-based norms for optimizing yield and quality in Narkhed tehsil, Nagpur district.

Materials and Methods
The present investigation, "Development of Dris norms for sweet orange grown in Narkhed Tehsil, Nagpur district" was undertaken during the year 2024-25 to assess the nutrient status of soil, leaf, fruit quality and yield of sweet orange from different orchards in the mentioned area. Surface soil samples (0-30 cm) were collected, avoiding any metallic contamination, with the help of wooden Khurpi and scoop.

These soil samples were collected from 27 sweet orange orchards in Narkhed tehsil of Nagpur district. The samples were taken from the peripheral area of each tree per orchard, depending upon the area. The samples were placed in clean cloth bags, properly labeled, and brought to the laboratory. After drying in the shade, the soil samples were ground using a wooden mortar and pestle, passed through 2 mm sieves and kept in clean polythene bags with proper labeling. Similarly, leaf samples from the same orchards were also collected.

The soil pH and electrical conductivity were determined in 1:2.5 soil: water suspension (Jackson, 1973) [7] respectively and analysis of organic carbon (Walkley and Black, 1934) [34] and free calcium carbonate (Piper, 1966) [16]. Soil fertility analyses consisted of alkaline potassium permangate ($KMnO_4$) distillation for available N (Subbiah and Asija, 1956) [28], sodium bicarbonate ($NaHCO_3$) (pH 8.5) extractable P as Olsen-P, 1 N neutral ammonium acetate (NH_4OAc) extractable-K, Ca and Mg (Piper, 1966) [16], available sulphur (Chesnin and Yien, 1951) and 1 N (pH 7.3), diethylenetriamine-pentaacetic acid (DTPA)-calcium chloride ($CaCl_2$) extractable Fe, Mn, Cu and Zn (Lindsay and Norvell, 1978) [11] and available boron (Gupta, 1979) [6].

The leaf samples were thoroughly washed, ground using Willey grinding machine to obtain homogenous samples and subsequently digested in tri-acid mixture of perchloric acid ($HClO_4$) : nitric acid (HNO_3): sulfuric acid (H_2SO_4) in 2:5:1 (Chapman and Pratt, 1961) [3]. Analyses made consisted of N by auto-nitrogen analyzer (Model-Perkin Elmer-2410, Perkin Elmer, Waltham, MA), P using vanadomolybdo-phosphoric acid method, K flame photometrically, Ca, Mg titrimetrically (versenate titration), sulphur using turbidimetric method, micronutrients (Fe, Mn, Cu and Zn) by atomic absorption spectrophotometer (Model GBC-908) and boron by dry ashing method.

Six well developed and mature fruits were randomly selected from each sweet orange orchards and were used for quality parameter analysis. After harvesting of the orchards, yield data was collected from the farmers in the month of November 2024. The titratable acidity was estimated by titrating juice with 0.1 N NaOH by using the method as suggested by Ranganna, 2001 [18]. The total soluble solids (TSS) of Sweet orange fruit juice was recorded by using hand refractometer.

The whole population, i.e. total number of orchards were divided into two groups based on yield as low yielding and high yielding sub-population as per principle of third quartile method (Nageshwara Rao, 1983) [13]. From selected 54 orchards, 46 orchards were classified as low yielding, whereas 8 orchards were classified as high yielding. The procedure of DRIS norms initially developed by Beaufils (1973) [1] and modified by Bhargava (2002) [2] was used through a PC based program. DRIS norms for soils were calculated as per procedure developed by Filho (2004) [5]. The norms for optimum level of nutrients in soils were derived using them as mean of high yielding orchards as the mean for optimum. The range of optimum was the value derived from mean-4/3 to + 4/3 standard deviation. As such, new five-tier system of classification of soil characteristics has been established as new ratings for soil fertility, viz. deficient, low, optimum, high and excess for each soil parameter.

Results and Discussion

Based on the data of nutrient composition of the leaf samples for the nutrients N, P, K, S, Fe, Mn, Zn, Cu and B, all possible combinations/expressions for each pair of nutrients (eg.: N/P, P/N) were calculated for all the eight nutrients. The mean, variance and CV for all these expressions were calculated separately for low and high yielding populations as per methodology described. Only those expressions, which have high variance ratio between low and high yielding populations, were selected for inclusion in the indices under DRIS. The corresponding mean values of selected forms of expression of high yielding population were considered as DRIS norms and are utilised in calculating the DRIS indices. The forms of expressions along with norms are given table 1.

Based on the nutrient ratios selected (Table 1) and using the data of their means, CV and functional values, the nutrient indices were calculated using equations for different nutrients for all the orchards and the data are presented in table 2. Nutritional imbalance index were also given based on DRIS indices.

For any given orchard, the more negative the index, the more the requirement of a particular nutrient it represents, relative to other nutrients used in diagnosis. Alternatively, the more the positive value for nutrient index indicates that the corresponding nutrient is present in relatively excess quantity. The nutrient indices were prioritized and arranged in order of their requirement for all the orchards under study (Table 2).

The absolute sum values of the nutrients indices generate an additional index denominated Nutritional Imbalance Index (NIBI). This index can be useful to the plant nutritional status indication, without however, hinting their causes. The higher the sum value, the larger will be the indication of plant nutritional unbalance and therefore, the lower will be the yield.

Use of DRIS with soil data provides an advantage of taking into account, the nutrient balance and ranking nutrients in terms of abundance relative to optimal levels. The concept of an optimum soil nutrient balance is promoted as the basic cation saturation ratio (McLean, 1977) [12] advocating the use of specific fractional level of nutrient saturation of cation exchange capacity rather than nutrient ratios. Optimizing soil fertility has recently emerged as a new field of investigation which ensures maximum yield under a wide range of soil conditions. According to DRIS norms, the adequate range of available soil nutrients N, P, K and S were found in the range of 248.2 to 317.7, 16.4 to 29.9, 400.4 to 431.2 and 9.5 to 15.5 (kg ha^{-1}) with a mean of 287.3, 24.66, 417.9 and 13.09 (kg ha^{-1}) respectively. The adequate range of micronutrients Fe, Mn, Zn, Cu and B were found in the range of 3.13 to 5.57, 5.58 to 9.37, 0.22 to 0.79, 0.32 to 1.50 and 0.40 to 0.93 (mg kg^{-1}) with a mean of 4.37, 7.42, 0.47, 0.96 and 0.61 (mg kg^{-1}) respectively. (Table 3).

Table 1: Selected forms of expressions or norms for different nutrients in sweet orange

Sr. No.	Nutrient norms	Low yield orchards (n=46)			High yield orchards (n=8)			Variance ratio (VL/VH)
		Mean	Variance (VL)	CV (%)	Mean	Variance (VH)	CV (%)	
1	N/P	9.47	40.00	66.81	9.63	74.94	89.91	0.53
2	N/K	1.41	8.47	206.39	1.35	29.74	402.66	0.28
3	N/S	9.39	120.99	117.14	9.08	121.05	121.14	1.00
4	N/Fe	0.02	0.0008	121.88	0.02	0.0196	120.19	1.46
5	N/Mn	0.04	0.0011	94.33	0.03	0.0346	84.12	1.39
6	N/Zn	0.13	0.02	118.56	0.11	0.01	104.17	1.73
7	N/Cu	0.28	0.13	128.82	0.25	0.36	236.48	0.35
8	N/B	0.08	0.01	115.02	0.08	0.01	106.55	1.11
9	P/K	0.15	0.21	308.94	0.14	0.40	447.85	0.53
10	P/S	0.99	3.02	175.35	0.94	1.62	134.73	1.87
11	P/Fe	0.0024	2.0491	182.44	0.0020	2.05	133.68	2.7416
12	P/Mn	0.0038	2.9299	141.20	0.0036	2.93	93.56	2.5803
13	P/Zn	0.01	0.00056	177.46	0.01	0.00017	115.87	3.24
14	P/Cu	0.03	0.0031	192.82	0.03	0.0047	263.03	0.66
15	P/B	0.01	0.0023	172.17	0.01	0.0038	118.51	2.08
16	K/S	6.66	14.29	56.76	6.71	4.07	30.08	3.51
17	K/Fe	0.02	0.00010	59.05	0.01	0.0145	29.85	0.48
18	K/Mn	0.03	0.00014	45.70	0.03	2.8613	20.89	1.00
19	K/Zn	0.09	0.0027	57.44	0.08	0.00043	25.87	6.08
20	K/Cu	0.20	0.0027	62.41	0.19	0.0120	58.73	1.24
21	K/B	0.06	0.0020	55.73	0.06	0.0114	26.46	3.90
22	S/Fe	0.0024	6.4908	104.04	0.0021	4.6272	99.22	4.52
23	S/Mn	0.0038	9.2807	80.53	0.69	7.0297	69.44	0.90
24	S/Zn	0.01	0.00017	101.21	0.01	0.00010	86.00	0.08
25	S/Cu	0.03	0.0010	109.97	0.03	0.0029	195.22	0.35
26	S/B	0.01	0.0040	98.19	0.01	0.0064	87.96	2.13
27	Fe/Mn	1.55	1.44	77.40	1.76	1.52	69.99	0.95
28	Fe/Zn	5.38	27.42	97.27	5.55	23.18	86.68	1.18
29	Fe/Cu	11.76	154.40	105.69	12.86	639.90	196.76	0.24
30	Fe/B	3.35	10.01	94.37	4.09	13.17	88.65	0.76
31	Mn/Zn	3.47	18.98	125.68	3.15	15.26	123.84	1.24
32	Mn/Cu	7.57	106.90	136.56	7.30	421.21	281.13	0.25
33	Mn/B	2.16	6.93	121.94	2.32	8.67	126.67	0.80
34	Zn/Cu	2.18	5.63	108.66	2.31	27.61	227.01	0.20
35	Zn/B	0.62	0.37	97.02	0.74	0.57	102.28	0.64
36	Cu/B	0.29	0.06	89.29	0.32	0.02	45.06	3.15

Table 2: DRIS indices and nutritional imbalance index (NIBI) for selected sweet orange orchards

Orchards	N	P	K	S	Fe	Mn	Zn	Cu	B	NIBI
1	0.23	2.58	2.25	8.64	1.39	-3.38	-5.36	6.88	11.1	24.33
2	2.21	-1.89	1.25	5.61	-3.83	2.87	-3.81	1.45	-0.41	3.45
3	-2.52	2.73	7.82	-1.32	-1.54	1.99	4.87	6.91	-4.4	14.54
4	-2.32	0.45	9.32	-2.21	4.97	3.89	5.56	-9.95	0.91	10.62
5	1.21	-1.44	-4.21	8.52	1.62	4.47	-3.78	11.2	3.41	21
6	0.26	2.93	3.34	3.33	-5.55	-7.76	4.56	-2.34	6.79	5.56
7	1.83	3.56	1.23	2.19	-3.96	-8.56	5.89	-4.56	9.71	7.33
8	-4.58	0.28	3.67	2.76	2.88	1.67	-7.78	4.67	8.39	11.96
9	0.04	3.71	-6.87	-7.51	3.38	10.7	1.34	-5.98	0.07	-1.12
10	3.94	-7.65	2.34	6.56	2.47	12.5	-9.45	1.11	5.14	16.96
11	1.57	0.34	-8.71	5.67	1.37	-6.89	2.56	3.31	3.34	2.56
12	-0.39	4.42	10.1	-1.47	6.53	15.9	4.65	-6.34	7.51	40.91
13	0.05	1.67	-7.23	3.91	2.28	7.85	6.87	-5.42	-0.57	9.41
14	1.38	-3.98	6.21	4.76	-3.39	3.74	9.34	-10.3	0.86	8.62
15	3.96	1.23	1.21	-1.68	4.87	6.78	-16.9	5.87	4.48	9.82
16	-1.89	-0.33	2.92	4.56	-8.56	-9.98	18.5	8.87	4.88	18.97
17	4.87	2.56	-1.45	0.5	3.35	10.4	-12.6	9.91	-1.79	15.75
18	1.34	-2.23	3.13	1.89	-5.16	-4.46	2.77	0.66	-1.42	-2.15
19	1.79	3.56	-2.71	2.78	2.22	3.58	-1.87	-4.87	-0.09	3.06
20	2.44	-2.12	4.65	5.11	10.7	2.96	0.48	2.77	-2.82	24.17
21	-0.32	1.23	0.15	-2.12	2.85	1.34	3.54	1.77	5.42	13.86
22	3.74	0.45	-5.43	4.87	0.76	-0.36	1.78	-6.88	-3.08	-4.15
23	1.44	5.67	4.9	1.88	-3.67	6.67	-6.98	3.71	-0.61	13.01
24	2.89	-2.13	9.91	-0.49	3.54	3.81	9.89	4.49	4.41	36.32
25	-2.54	4.21	2.34	1.32	-0.37	-7.89	5.51	1.41	-0.54	3.45
26	3.66	5.53	7.78	3.91	-3.98	11.3	-6.68	-0.67	-0.28	20.57
27	5.78	2.34	-2.34	2.87	2.72	15.9	12.7	-4.72	3.62	38.87
28	6.12	3.97	1.19	-1.49	-4.41	4.61	15.1	2.56	-5.3	22.35
29	3.25	-1.82	2.35	1.57	2.51	-1.23	8.89	3.78	-3.78	15.52
30	-1.11	4.67	1.75	-0.35	0.78	5.91	-4.46	6.44	4.81	18.44
31	3.32	5.77	-3.59	5.13	-4.34	12.8	0.99	2.79	0.27	23.14
32	5.45	-0.68	1.57	6.33	6.65	-6.81	3.38	-5.13	-3.72	7.04
33	-0.19	0.27	2.92	0.14	1.47	0.32	0.80	0.15	4.52	10.4
34	4.21	1.30	3.00	2.22	-1.55	-5.45	9.75	-0.76	5.81	18.53
35	1.25	0.45	-0.15	1.42	-1.10	-4.68	8.42	-1.008	-7.71	-3.108
36	1.58	2.70	-2.22	1.20	0.85	0.11	3.32	-0.75	0.05	6.84
37	-1.68	-0.62	0.21	-4.70	0.83	-1.53	5.10	0.109	-9.39	-11.67
38	3.81	-0.81	-1.31	-1.38	0.03	1.09	3.39	-0.012	2.51	7.31
39	-0.20	3.55	3.71	1.94	1.41	-0.20	7.55	-1.62	0.17	16.31
40	-0.56	6.79	2.82	1.47	0.05	1.59	-2.27	0.96	6.82	17.67
41	2.00	-0.06	1.37	1.97	1.18	5.76	4.88	0.69	9.29	27.08
42	-1.01	1.06	2.45	0.23	-0.72	0.52	4.52	0.49	-0.43	7.11
43	-8.02	3.19	7.34	-0.49	0.65	-1.56	4.93	1.72	18.47	26.23
44	-0.67	1.99	1.01	1.93	1.48	1.89	-1.83	-0.31	-0.68	4.81
45	-0.46	0.27	-0.84	-0.03	1.76	0.73	-2.35	0.68	2.72	2.48
46	0.07	-1.14	0.51	0.06	3.30	-3.75	-1.46	0.39	-0.57	-2.59
47	0.20	0.81	4.37	2.16	-0.19	0.03	-2.79	0.97	0.42	5.98
48	2.51	-1.23	0.31	1.41	-2.14	-1.76	5.48	-1.17	3.5	6.91
49	-1.64	1.84	0.72	-3.64	0.94	0.01	-3.02	-0.53	1.72	-3.6
50	-2.65	3.69	4.56	-3.99	1.72	0.82	6.36	1.52	-6.93	5.1
51	0.33	-0.15	1.93	-1.01	-0.01	1.76	4.38	0.19	9.83	17.25
52	0.05	-0.85	-3.46	-0.25	-2.06	-3.43	-1.73	-0.66	0.57	-11.82
53	6.28	3.32	-5.38	3.91	0.42	1.94	2.016	-1.26	-6.62	4.62
54	0.73	0.36	-1.73	0.56	-1.06	-1.34	3.69	-0.73	12.67	13.15
No. of orchards deficient	11	10	14	12	16	17	18	15	12	-
No. of orchards optimum	16	16	7	10	13	9	3	18	17	-
No. of orchards excess	27	28	33	32	25	28	33	21	25	-

Table 3: Adequate range of available soil nutrient derived from DRIS based analysis

Nutrients	Range	Mean	*Critical limit
N (kg ha^{-1})	248.2-317.7	287.3	280
P (kg ha^{-1})	16.4-29.9	24.66	30
K (kg ha^{-1})	400.1-431.2	417.9	180
S (mg kg^{-1})	9.5-15.5	13.09	10
Fe (mg kg^{-1})	3.13-5.57	4.37	4.5
Mn (mg kg^{-1})	5.58-9.37	7.42	2.5
Zn (mg kg^{-1})	0.22-0.79	0.47	0.6
Cu (mg kg^{-1})	0.32-1.50	0.96	0.2
B (mg kg^{-1})	0.40-0.93	0.61	-

***Critical limit of six-tier approach (Ramamoorthy and Bajaj,1969)

Table 4: Adequate range of leaf nutrient derived from DRIS based analysis

Nutrients	Range	Mean	*Optimum level
N (%)	1.38-2.78	2.15	1.98-2.57
P (%)	0.11-0.34	0.22	0.091-0.17
K (%)	1.41-1.83	1.58	1.33-1.72
S (%)	0.21-0.30	0.25	-
Fe (mg kg^{-1})	79.3-122.9	97.53	69.5-137.1
Mn (mg kg^{-1})	36.8-81.3	61.62	42.2-87.0
Zn (mg kg^{-1})	15.8-23.2	19.16	11.6-28.7
Cu (mg kg^{-1})	6.1-8.5	7.9	6.6-15.8
B (mg kg^{-1})	19.8-29.8	24.68	-

***** Optimum level suggested earlier (Srivastava and Singh 2003[a]; 2004[b]) [22, 23, 24]

It was noticed that according to DRIS norms, the adequate range of leaf nutrients N, P, K and S were found in the range of 1.38 to 2.78, 0.11 to 0.34, 1.41 to 1.83 and 0.21 to 0.30% percent respectively. The adequate range of leaf nutrients Fe, Mn, Zn, Cu and B were found in the range of 79.3 to 122.9, 36.8 to 81.3, 15.8 to 23.2, 6.1 to 8.5 and 19.8 to 29.8 (mg kg^{-1}) respectively (Table 4).
It was observed that the earlier optimum ranges suggested for leaf nutrients by Srivastava and Singh (2003[a]; 2004[b]) [22, 23, 24] was required to be modified for the sweet orange yields.

Conclusion
It was concluded that the evaluation of soil nutrient status and leaf nutrient content in various sweet orange orchards revealed significant variation and nutrient imbalance. Out of 54 sweet orange orchards studied with DRIS norms, the leaf nutrient content showed the imbalance of macronutrients in 39 orchards and micronutrients in 42 orchards.
Therefore, the optimum soil and leaf nutrient content norms derived from DRIS indices are better guide for balance nutrient management in orchards.

Acknowledgement
I am sincerely thankful to Dr. R. N. Katkar, Associate Dean, L.A.E., Dr. P.D.K.V, Akola and Chairman of advisory committee, I extent my sincere gratitude to Dr. W. P. Badole, Head of Soil Science Department, College of Agriculture, Nagpur for their timely advice and laboratory assistance for soil and plant sample analysis.

Reference
1. Beaufils ER. Diagnosis and Recommendation Integrated System (DRIS). Soil Sci Bull. 1973;1:1-132. University of Natal, South Africa.
2. Bhargava BS. Leaf analysis for nutrient diagnosis, recommendation and management in fruit crops. J Indian Soc Soil Sci. 2002;50(4):352-373.
3. Chapman HD, Pratt PF. Methods of analysis for soils, plants and water. Berkeley: University of California; 1961. p. 60-179.
4. Chesnin L, Yien CH. Turbidimetric determination of available sulphate. Soil Sci Soc Am Proc. 1951;15:149-151.
5. Filho FAA Muraro. DRIS concept and applications on nutritional diagnosis in fruit crops. Sci Agric. 2004;61(5):311-316.
6. Gupta UC. Some factors affecting the determination of hot-water soluble boron from podzol soils using Azomethine-H. Can J Soil Sci. 1979;59:241-247.
7. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India; 1973. p. 498-512.
8. Jadhav VH. Assessment of fertility status of soils under sweet orange (*Citrus sinensis* Osbeck) in Nanded district [MSc thesis]. Parbhani: Vasantrao Naik Marathwada Krishi Vidyapeeth; 2007.
9. Jibhakate SB, Raut MM, Bhende SN, Kharche VK. Micronutrient status of soils of Katol tahsil in Nagpur district and their relationship with some soil properties. J Soils Crops. 2009;19(1):143-146.
10. Kankal DS, Damre SR. New soil fertility norms for Nagpur mandarin from summer flush using DRIS. Asian J Soil Sci. 2010;5(1):109-113.
11. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci Soc Am J. 1978;42:421-428.
12. McLean EO. Fertilizer and lime recommendations based on soil tests, good but could they be better? Commun Soil Sci Plant Anal. 1977;8:441-464.
13. Nageshwara Rao G. Statistics for agricultural sciences. New Delhi: Oxford and IBH Publishing Co.; 1983.
14. Olsen SR, Sommers LE. Phosphorus. In: Page AL, editor. Methods of soil analysis. Part 2. Madison: Soil Sci Soc Am; 1982. p. 403-430.
15. Pawar PS, Rukadikar MV, Bhite BR. Studies on use of micronutrients in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi. Pharma Innov J. 2022;11(6):601-603.
16. Piper CS. Soil and plant analysis. Bombay: Hans Publishers; 1966. p. 368.
17. Ramamoorthy B, Bajaj JC. Soil fertility map of India. New Delhi: Indian Agricultural Research Institute; 1969.
18. Ranganna R. Handbook of analysis and quality control for fruit and vegetable products. 2nd ed. New Delhi: Tata McGraw Hill; 2001. p. 860.
19. Rathod SM, Sable PB, Jagtap PS. Studies on soil nutrient status in relation to yield attributes of sweet orange (*Citrus sinensis* L.) cv. Nucellar. Int J Agric Sci. 2016;54(8):2877-2880.
20. Reddy AR, Munnaswami V, Munireddy PV, Reddy BR, Sudhakar P. Leaf nutrient status vis-à-vis fruit yield and quality of sweet orange (*Citrus sinensis* Osbeck). Int J Plant Soil Sci. 2019;31(3):1-8.
21. Srivastava AK, Kohli RR. Soil suitability criteria for VL/VH citrus-An appraisal. Agric Rev. 1997;18(3):134-146.
22. Srivastava AK, Singh S. Soil plant nutrient limits in relation to optimum fruit yield of sweet orange (*Citrus*

sinensis) cultivar Mosambi. Indian J Agric Sci. 2003;73(4):209-211.
23. Srivastava AK, Singh S. Plant and soil diagnostic norms for optimum productivity of Nagpur mandarin (*Citrus reticulata* Blanco). Fertil News. 2003;48(2):47-63.
24. Srivastava AK, Singh S. Leaf and soil nutrient guide in citrus-A review. Agric Rev. 2004;25(4):235-251.
25. Srivastava AK, Singh S. Citrus nutrition research in India: Problems and prospects. Indian J Agric Sci. 2008;78(1):3-16.
26. Srivastava AK, Singh S. DRIS norms and their field validation in Nagpur mandarin (*Citrus reticulata* Blanco). J Plant Nutr. 2008;31(6):1091-1107.
27. Srivastava AK. Global citrus nutrition research: An incisive analysis. Curr Hort. 2014;2(1):3-5.
28. Subbiah BV, Asija GL. A rapid procedure for determination of available nitrogen in soil. Curr Sci. 1956;25:259-260.
29. Venkataramana KT, Laxmi LM, Gopal K, Krishna VNP, Nagalakshmi, Sankar TG. Nitrogen and potassium based fertigation response on plant growth, yield and quality of sweet orange (*Citrus sinensis* Linn. Osbeck) cv. Sathgudi. Res Rev J Agric Allied Sci. 2014;3(2):22-28.
30. Walkley AJ, Black AI. Estimation of organic carbon by chromic acid titration method. Soil Sci. 1934;25:255-259.
31. Walworth JL, Sumner MW. The diagnosis and recommendation integrated system (DRIS). Adv Soil Sci. 1987;6:149-188.