Vol. 19, No. 1, pp. 91-99 (2019)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Developing Soil Nutrient Index in Indigenously Grown 200 Mango Orchards of Ecological Importance

TARUN ADAK*, S RAJAN AND G. PANDEY

ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101, Uttar Pradesh

ABSTRACT

Malihabad region of UP, India is famous for diversified mango cultivation; most of the species are indigenously grown. The area is having ecological importance from view point of livelihood and nutritional security of millions of growers. To sustain the productivity, soil fertility status in turn soil nutrients have immense role. Thus, 200 mango orchards soils were undergone to develop soil nutrient index (SNI), an index for soil sustainability. Individual nutrients in each orchard were tabulated to show the vast changes in its contents, a source of farmers led nutrient variance. It was found that Zn, P and K, the essential nutrients for producing quality fruits were rated as low while Cu, Fe and Mn showed medium ratings. SNI and fertility ratings showed need for proper precision management of orchards for long-term sustainability of the ecologically dependent mango growing areas.

Key words: Indigenously grown mango, Soil nutrient index, Soil sustainability, Precision management options

Introduction

Mango growing areas of Malihabad, Lucknow, Uttar Pradesh, India is best known for ecosystem service to the farming population by ensuring the profitability of mango cultivation. The areas are thus having immense potential for ecological importance in terms of mango fruit production and were well known for indigenously grown Dashehari fruit. However, over the decades or more, the continuous farming might have an impact on soil fertility which in turn may reflect on quality production (Ganeshamurthy *et al*., 2016; Adak *et al*., 2018a). The extension and communication system enables growers and end users of business community for time bound adoption of key management practices needed to be updated over time. The sensitization workshop and scientist-farmers interaction meet helps in sensitizing and motivating for the role of one or more depleted nutrients to the added productivity (Adak *et al*., 2018c). Soil nutrient index, an index for showing the status of soil nutrients through development of fertility ratings indicates the orchard soil health and is essential component in ecological profiling of sustainable fruit production system. It ensures growers benefit via adoption of precision farming technologies on real time basis for ensuring better profitability *vis-a-vis* long-term fertility sustainability. Since, no such information over the century was available in this aspect or developed over the time periods, the present study was conducted in 200 mango orchards of Malihabad region of Lucknow, UP, India to develop soil nutrient index for orchard sustainability.

*Corresponding author,
Email: tarunadak@gmail.com

Materials and Methods

The current study was completed in 10 villages *viz*., Gulabkhera, Dugauli, Mujasa,

Mehmoodnagar, Mandauli, Naibasti, Sanyasibag, Habibpur, Sahilamau and Allupur covering 200 mango orchards in the GI status areas of Malihabadi Dashehari fruit. Growers practiced standard management protocol for soil and tree canopy, pest and weed controls. Soil samples from each of the orchard were collected, from four different locations randomly indentified within the orchards and tree basins at a depth of 0-30 cm in the months of September to February during 2018 to 2019 aged between 30 to 40 yrs. A sum of 200 soils was thus collected representing the composite soils for 200 mango orchards. Soils were undergone standard procedural practices for laboratory analysis. Soil pH was recorded in each orchard of ecological niche area; P, K, Zn, Cu, Mn and Fe were estimated (Jackson, 1973; Olsen *et al*., 1954; Lindsay and Norvell, 1978). Soil fertility ratings were developed after calculating the soil nutrient index values following Amara *et al.* (2017). The outcome was then discussed in detailed.

Results and Discussion

Nutrient distribution and productivity analysis

The distribution pattern of soil nutrients in 200 mango orchards were tabulated in the Table 1 to 4. Variations across these orchards were noted. Likewise, Cu, Mn and Fe were also observed in a range of 0.46 to 3.34, 3.62 to 19.82 and 4.46 to 19.36 mg kg^{-1} respectively. Soil available P was ranged between 1.72 to 35.70 mg kg^{-1}, whereas, K from 60.45 to 213.10 mg kg^{-1} across composite soil samples from 200 mango orchards. Soil pH had 6.11 to 8.47 ranges; some of the orchards (68) had greater pH values over 7.5. Big data analysis showed fertility variations in the mango orchards; these might be the resultant effect of farmers own practice of their orchard with different nutrient management modules. The productivity level when compared, it was found that orchards in general had <10.0t ha^{-1}. To further categorize, lower percentage (18%) in the range of 6.1 to 10.0 t ha^{-1} was recorded. Productivity data concluded that 51% was in the range of 4.1 to 6.0 t ha^{-1} with 31% orchards had 1.0 to 4.0 t ha^{-1} respectively. Growers' way of farm management had immense impact on the nutrient transformations and availability content. Many a times, perception varies across growers based on socio-economic and knowledge level. For small and marginalized farmers, obtaining the sustainable fruit production becomes questionable over depleted nutrients in soil. For this purpose, site based precision farming modules needs to be developed and disseminated to growers. It was found that the soil resources in different ecologically importance fruit growing system do vary over a vast range of issues from cultivation practices to post harvest protocols. Production measurement in sustainability becomes vulnerable under non-synchronized way of production practice over an ecological niche area. In many parts of the world, it was noticed that farm sustainability was in question (Hansen *et al*., 1997). Therefore robust research avenues may improve the situation (Akohoue *et al*., 2018) and advanced land based management options may provide economic ecosystem services (Keesstra *et al.,* 2018).In the present study, lower soil fertility is responsible for lower productivity suggesting need for adoption of hi-tech horticultural intervention for better input use efficiency and to sustain livelihood of growers as well. Of course, biotic interactions are important for quantifying the soil nutrient dynamics (Van Der Heijden *et al*., 2008; Larsen *et al*., 2015) and successful soil analysis report vests on precise sampling in perennial crops (Nelson *et al*., 2015; Singha *et al.*, 2016). Joshi *et al*. (2015) recorded the micronutrient status in mango orchard soils of Ratnagiri district and also develop relationship. During 2018b, Adak *et al*. observed the significant difference in soil properties in mango orchards of different villages and actual status indicated the need for precise management of key nutrients whereas Reddy *et al.* (2000) suggested positive response of N, P and K on Totapuri mango. Satisha and Ganeshamurthy (2015) nicely described the role of soil fertility *vis-a-vis* productivity in mango while Talang *et al*. (2017) concluded for inclusion of both inorganic and organic sources for economical yield attenuation. The canopy management within the tree

Table 1. DTPA extractable Zn and Cu (mg kg^{-1}) contents across 200 mango orchards of Lucknow region, UP, India

Orchard number	Zn(Cu)	Orchard number	Zn(Cu)	Orchard number	Zn	Orchard number	Zn	Orchard number	Zn	Orchard number	Zn	Orchard number	Zn	Orchard number	Zn(Cu)
1	0.58(1.04)	26	0.72(1.72)	51	0.46(1.96)	76	0.34(1.18)	101	0.46(1.62)	126	0.56(1.82)	151	0.42(1.84)	176	0.62(2.12)
2	0.44(1.22)	27	0.66(1.98)	52	0.42(2.04)	77	0.40(1.24)	102	0.38(1.46)	127	0.34(1.94)	152	0.46(1.62)	177	0.68(2.28)
3	0.42(1.14)	28	0.64(1.56)	53	0.56(2.14)	78	0.36(1.08)	103	0.56(1.72)	128	0.50(1.80)	153	0.4(2.04)	178	0.58(1.90)
4	0.32(0.96)	29	0.68(1.68)	54	0.38(1.82)	79	0.30(1.30)	104	0.58(1.94)	129	0.38(1.28)	154	0.56(1.56)	179	0.840(0.82)
5	0.30(1.28)	30	0.60(1.84)	55	0.48(1.68)	80	0.32(1.16)	105	0.64(1.64)	130	0.36(1.78)	155	0.54(2.04)	180	0.56(1.68)
6	0.26(0.56)	31	0.62(1.42)	56	0.40(1.72)	81	0.46(1.34)	106	0.48(1.56)	131	0.48(2.94)	156	0.48(1.86)	181	0.54(1.92)
7	0.28(0.98)	32	0.48(1.64)	57	0.54(1.78)	82	0.38(1.56)	107	0.44(1.38)	132	0.32(2.04)	157	0.42(1.28)	182	0.66(2.68)
8	0.34(1.06)	33	0.58(1.34)	58	0.56(1.86)	83	0.56(1.88)	108	0.42(1.32)	133	0.28(1.62)	158	0.46(1.38)	183	0.52(2.24)
9	0.30(1.24)	34	0.84(1.72)	59	0.50(2.28)	84	0.82(1.98)	109	0.46(1.42)	134	0.40(1.86)	159	0.84(1.76)	184	0.54(1.94)
10	0.66(1.56)	35	0.66(1.50)	60	0.44(1.92)	85	0.58(1.84)	110	0.66(1.52)	135	0.46(2.24)	160	0.48(1.02)	185	0.64(2.72)
11	0.46(1.44)	36	0.50(1.26)	61	0.46(1.54)	86	0.48(1.68)	111	0.58(2.84)	136	0.54(2.96)	161	0.56(1.80)	186	0.56(1.92)
12	0.52(1.66)	37	0.68(1.62)	62	0.36(0.62)	87	0.62(1.96)	112	0.7(2.72)	137	0.42(1.76)	162	0.44(1.28)	187	0.5(1.84)
13	0.48(1.16)	38	0.54(1.76)	63	0.28(1.28)	88	0.44(1.42)	113	0.48(2.02)	138	0.48(3.22)	163	0.52(2.44)	188	0.58(2.32)
14	0.32(0.84)	39	0.90(1.86)	64	0.34(0.46)	89	0.5(1.72)	114	0.78(2.92)	139	0.40(1.90)	164	0.76(1.66)	189	0.64(2.16)
15	0.38(1.08)	40	0.94(1.78)	65	0.48(1.44)	90	0.48(1.84)	115	0.42(1.74)	140	0.34(1.84)	165	0.54(2.56)	190	0.48(2.86)
16	0.40(1.02)	41	0.98(1.92)	66	0.44(0.56)	91	0.52(1.6)	116	0.38(1.66)	141	0.50(1.74)	166	0.38(0.78)	191	0.54(1.90)
17	0.46(1.48)	42	0.80(1.64)	67	0.38(1.38)	92	0.42(1.52)	117	0.4(1.72)	142	0.48(2.06)	167	0.54(1.62)	192	0.46(2.42)
18	0.42(1.38)	43	0.74(1.96)	68	0.42(1.82)	93	0.40(1.7)	118	0.36(1.48)	143	0.42(1.58)	168	0.36(0.96)	193	0.52(2.04)
19	0.50(1.64)	44	0.82(1.88)	69	0.36(0.92)	94	0.68(2.32)	119	0.38(1.78)	144	0.38(1.66)	169	0.42(1.14)	194	0.40(1.10)
20	0.64(1.82)	45	1.06(1.98)	70	0.58(0.58)	95	0.42(1.74)	120	0.56(1.98)	145	0.36(1.60)	170	0.40(1.08)	195	0.48(2.28)
21	0.46(1.36)	46	1.12(1.84)	71	0.52(1.86)	96	0.46(1.44)	121	0.42(1.68)	146	0.54(2.08)	171	0.78(3.34)	196	0.56(2.16)
22	0.82(1.58)	47	0.86(1.68)	72	0.44(1.24)	97	0.36(2.44)	122	0.54(1.96)	147	0.52(1.92)	172	0.42(1.18)	197	0.38(2.34)
23	0.52(1.14)	48	0.76(1.94)	73	0.38(2.36)	98	0.42(2.08)	123	0.38(2.04)	148	0.62(2.14)	173	0.68(2.76)	198	0.46(1.14)
24	0.44(1.28)	49	1.22(1.80)	74	0.32(1.32)	99	0.66(2.14)	124	0.82(2.86)	149	0.56(1.68)	174	0.74(1.88)	199	0.48(1.22)
25	0.76(1.90)	50	0.84(1.96)	75	0.36(1.74)	100	0.52(2.24)	125	0.42(1.70)	150	0.52(1.64)	175	0.70(2.06)	200	0.74(1.76)

Table 2. DTPA extractable Mn and Fe (mg kg^{-1}) contents across 200 mango orchards of Lucknow region, UP, India

Orchard number	Mn (Fe)	Orchard number	Mn (Fe)	Orchard number	Mn	Orchard number	Mn (Fe)	Orchard number	Mn	Orchard number	Mn	Orchard number	Mn	Orchard number	Mn (Fe)
1	5.30(8.56)	26	12.86(14.98)	51	7.44(12.02)	76	11.78(7.08)	101	8.96(10.62)	126	10.28(7.92)	151	11.86(6.52)	176	13.58(14.56)
2	7.68(11.34)	27	15.08(16.28)	52	8.16(12.36)	77	8.66(5.84)	102	8.32(9.74)	127	7.36(6.96)	152	12.12(6.64)	177	14.04(15.48)
3	7.90(10.76)	28	16.44(13.76)	53	9.02(13.94)	78	8.02(6.02)	103	8.42(8.28)	128	8.88(8.10)	153	14.24(11.58)	178	13.91(15.78)
4	6.76(10.38)	29	17.28(14.74)	54	7.44(11.52)	79	7.98(7.88)	104	7.72(12.68)	129	9.36(6.56)	154	14.48(7.16)	179	12.96(11.62)
5	7.30(4.66)	30	15.82(15.30)	55	8.56(12.44)	80	9.78(5.68)	105	6.76(7.22)	130	8.1(13.62)	155	17.02(13.4)	180	13.58(15.34)
6	3.62(5.28)	31	14.54(14.22)	56	8.32(12.10)	81	8.28(7.78)	106	9.06(14.92)	131	9.28(10.04)	156	16.36(13.04)	181	15.62(9.64)
7	6.60(8.34)	32	12.72(16.46)	57	9.36(12.78)	82	6.98(7.50)	107	6.16(6.44)	132	7.38(7.34)	157	8.32(11.76)	182	12.28(16.36)
8	6.62(10.56)	33	15.96(15.48)	58	9.54(14.28)	83	13.06(14.16)	108	7.48(7.74)	133	8.22(7.44)	158	8.76(10.72)	183	12.64(9.14)
9	7.92(5.94)	34	17.54(15.72)	59	7.92(9.58)	84	8.04(11.24)	109	5.92(6.36)	134	9.76(7.26)	159	12.58(11.8)	184	14.36(9.3)
10	8.96(12.68)	35	15.68(19.36)	60	7.34(7.84)	85	7.36(9.14)	110	8.48(8.28)	135	9.64(8.16)	160	6.28(9.54)	185	12.06(15.38)
11	10.24(12.04)	36	17.26(14.34)	61	7.78(7.48)	86	8.26(6.82)	111	12.54(14.48)	136	10.32(10.62)	161	9.121(13.42)	186	13.76(9.72)
12	11.92(14.22)	37	18.14(15.16)	62	6.16(5.84)	87	13.16(13.48)	112	14.16(16.24)	137	7.54(7.28)	162	8.54(8.98)	187	9.92(7.96)
13	12.02(14.86)	38	15.64(16.28)	63	8.08(6.22)	88	8.36(7.36)	113	8.36(14.12)	138	10.02(10.44)	163	15.36(14.16)	188	13.94(16.12)
14	9.04(10.28)	39	13.98(16.76)	64	6.22(5.14)	89	7.06(6.84)	114	14.88(16.52)	139	8.84(6.72)	164	13.98(9.30)	189	13.76(15.96)
15	8.52(13.86)	40	14.16(15.22)	65	7.68(6.90)	90	6.68(8.28)	115	8.18(13.1)	140	7.72(6.34)	165	16.52(14.42)	190	14.14(11.08)
16	7.84(10.16)	41	15.18(15.64)	66	4.36(5.16)	91	5.42(7.34)	116	6.54(8.36)	141	7.56(6.48)	166	6.56(8.88)	191	11.12(9.62)
17	6.94(12.32)	42	18.42(13.88)	67	6.94(6.34)	92	7.88(8.46)	117	6.72(8.02)	142	8.46(8.32)	167	8.28(11.44)	192	11.82(7.92)
18	6.82(13.72)	43	17.66(16.18)	68	5.12(7.90)	93	6.46(7.44)	118	6.46(7.84)	143	8.5(7.40)	168	6.4(9.26)	193	15.68(9.54)
19	12.34(14.24)	44	16.54(14.82)	69	5.62(5.82)	94	12.82(14.32)	119	6.52(7.92)	144	9.04(8.48)	169	7.82(10.56)	194	6.72(10.12)
20	11.84(15.28)	45	18.06(15.76)	70	4.44(4.46)	95	6.44(6.88)	120	10.96(15.28)	145	8.76(6.76)	170	7.94(9.72)	195	12.1(7.94)
21	13.28(13.92)	46	16.22(16.32)	71	9.62(7.34)	96	6.74(6.56)	121	6.62(8.34)	146	8.18(8.54)	171	12.42(10.62)	196	12.46(11.76)
22	14.3214.48)	47	19.34(14.20)	72	7.14(6.96)	97	7.68(7.44)	122	8.44(9.64)	147	13.96(6.98)	172	7.84(11.14)	197	7.92(10.84)
23	14.66(15.64)	48	17.16(13.86)	73	6.76(7.38)	98	7.6(7.94)	123	7.60(7.98)	148	14.52(12.26)	173	13.68(9.68)	198	12.741(15.48)
24	12.56(14.52)	49	19.82(15.44)	74	7.74(7.12)	99	5.66(10.36)	124	13.78(16.12)	149	12.58(7.62)	174	13.54(14.72)	199	8.66(14.02)
25	16.08(13.62)	50	19.16(15.94)	75	6.96(6.76)	100	6.42(12.52)	125	7.56(8.48)	150	13.86(7.44)	175	14.64(14.08)	200	11.88(12.64)

Table 3. Available P and K (kg ha^{-1}) contents across 200 mango orchards of Lucknow region, UP, India

Orchard number	P (K)	Orchard number	P (K)	Orchard number	P (K)	Orchard number	P (K)	Orchard number	P (K)	Orchard number	P (K)	Orchard number	P (K)	Orchard number	P (K)
1	11.80(145.55)	26	9.70(64.70)	51	21.50(173.85)	76	8.80(94.90)	101	13.40(83.65)	126	11.20(98.50)	151	9.60(86.65)	176	31.30(84.35)
2	18.60(154.60)	27	19.60(88.05)	52	19.30(183.35)	77	12.20(83.70)	102	10.20(95.40)	127	8.60(150.75)	152	8.80(84.80)	177	27.80(87.75)
3	10.40(160.70)	28	11.30(83.60)	53	24.90(172.55)	78	9.50(85.30)	103	11.70(91.05)	128	9.20(126.90)	153	18.60(84.10)	178	12.90(94.50)
4	9.60(139.50)	29	9.60(104.20)	54	13.90(180.05)	79	12.40(133.25)	104	12.90(84.35)	129	9.90(97.80)	154	10.70(97.75)	179	23.80(89.90)
5	8.90(142.40)	30	11.40(84.80)	55	12.40(169.25)	80	14.10(93.15)	105	9.10(85.50)	130	13.80(83.20)	155	15.60(90.60)	180	14.60(91.05)
6	9.60(133.05)	31	9.80(98.25)	56	14.90(205.60)	81	15.80(97.95)	106	13.20(93.15)	131	10.50(143.35)	156	14.90(96.30)	181	10.40(112.35)
7	12.50(144.60)	32	9.30(70.05)	57	16.70(171.85)	82	19.00(88.60)	107	9.60(88.35)	132	8.70(97.20)	157	11.50(85.20)	182	8.80(108.15)
8	7.70(123.30)	33	8.90(69.15)	58	22.40(213.10)	83	34.90(141.65)	108	8.80(158.25)	133	22.90(93.15)	158	9.40(81.40)	183	15.90(104.25)
9	25.20(97.45)	34	15.20(105.10)	59	11.30(152.20)	84	29.80(95.70)	109	9.40(141.90)	134	10.60(94.70)	159	21.90(84.55)	184	28.70(120.90)
10	17.30(77.00)	35	21.50(90.90)	60	13.30(149.65)	85	27.20(91.35)	110	10.60(93.85)	135	11.90(93.60)	160	20.70(74.20)	185	20.60(97.60)
11	11.60(84.80)	36	9.30(60.45)	61	14.40(113.90)	86	21.30(93.05)	111	27.40(92.45)	136	12.40(99.40)	161	18.80(75.45)	186	11.30(128.40)
12	14.10(95.35)	37	11.20(84.85)	62	13.80(109.90)	87	29.80(144.95)	112	24.90(95.65)	137	9.70(90.35)	162	19.20(72.35)	187	8.90(105.20)
13	12.90(113.15)	38	8.30(67.20)	63	10.50(122.35)	88	17.30(89.30)	113	22.70(94.75)	138	10.10(123.00)	163	17.60(145.60)	188	16.40(94.40)
14	14.10(72.70)	39	1.72(104.90)	64	15.00(119.30)	89	21.60(90.75)	114	29.30(101.20)	139	9.80(95.55)	164	29.40(86.20)	189	12.10(98.70)
15	16.90(80.40)	40	18.90(108.85)	65	22.70(130.90)	90	13.60(80.35)	115	23.80(82.80)	140	11.40(98.25)	165	16.10(142.80)	190	13.40(161.70)
16	17.70(65.55)	41	10.10(111.70)	66	12.20(97.40)	91	20.90(80.55)	116	17.50(77.85)	141	8.90(90.30)	166	12.70(84.95)	191	10.90(134.05)
17	20.70(73.35)	42	12.60(114.95)	67	11.50(101.20)	92	13.80(90.15)	117	13.30(88.00)	142	12.30(89.35)	167	19.00(85.05)	192	11.20(109.60)
18	13.60(67.40)	43	19.90(87.90)	68	10.40(92.80)	93	15.50(79.45)	118	12.10(82.55)	143	8.40(79.70)	168	15.30(93.10)	193	9.90(124.15)
19	10.60(71.10)	44	10.80(117.25)	69	7.80(96.90)	94	30.90(141.75)	119	11.80(84.80)	144	11.00(84.05)	169	16.60(81.65)	194	8.40(99.95)
20	15.70(92.15)	45	20.90(122.35)	70	11.00(99.35)	95	13.00(82.40)	120	9.30(85.10)	145	9.60(78.40)	170	18.20(78.80)	195	13.30(102.45)
21	12.10(66.80)	46	16.40(111.70)	71	14.70(134.00)	96	15.50(79.70)	121	19.20(81.65)	146	13.70(82.65)	171	26.30(80.55)	196	9.20(149.80)
22	9.20(64.50)	47	12.00(99.50)	72	10.50(109.70)	97	11.50(80.10)	122	14.40(87.90)	147	10.20(95.10)	172	15.80(86.95)	197	16.60(92.90)
23	11.80(96.05)	48	12.60(93.85)	73	16.60(134.85)	98	20.40(83.30)	123	10.80(111.55)	148	12.90(91.55)	173	29.90(88.40)	198	13.40(88.70)
24	12.80(68.05)	49	20.10(109.45)	74	11.50(99.10)	99	24.00(77.05)	124	27.70(100.35)	149	11.40(92.60)	174	32.80(97.70)	199	25.60(156.30)
25	18.00(93.35)	50	22.90(96.30)	75	10.50(121.20)	100	35.70(74.30)	125	26.10(86.40)	150	14.30(89.80)	175	30.20(91.30)	200	18.40(103.95)

Table 4. Soil reaction (pH) contents across 200 mango orchards of Lucknow region, UP, India

Orchard number	pH	Orchard number	pH	Orchard number	pH	Orchard number	pH	Orchard number	pH	Orchard number	pH	Orchard number	pH	Orchard number	pH
1	7.73	26	7.54	51	7.71	76	7.53	101	7.18	126	7.16	151	7.23	176	7.54
2	7.48	27	7.63	52	7.59	77	7.64	102	7.37	127	7.09	152	7.09	177	7.48
3	7.42	28	7.48	53	7.42	78	7.71	103	7.46	128	7.14	153	6.92	178	7.19
4	7.49	29	8.19	54	7.46	79	7.42	104	7.43	129	7.21	154	6.86	179	7.12
5	7.72	30	7.81	55	7.31	80	7.54	105	7.39	130	7.23	155	6.79	180	7.34
6	7.61	31	7.67	56	7.34	81	7.48	106	7.44	131	7.34	156	6.97	181	7.31
7	7.58	32	7.64	57	7.26	82	7.44	107	7.53	132	7.36	157	7.08	182	7.42
8	7.02	33	7.58	58	7.29	83	7.23	108	7.36	133	7.47	158	7.29	183	7.63
9	6.11	34	7.69	59	7.41	84	7.26	109	7.58	134	7.51	159	7.21	184	7.59
10	7.44	35	7.56	60	7.36	85	7.42	110	7.38	135	7.43	160	7.27	185	7.38
11	7.52	36	7.65	61	7.47	86	7.48	111	6.84	136	7.46	161	7.39	186	7.48
12	7.38	37	7.68	62	8.26	87	7.18	112	6.55	137	7.57	162	7.46	187	7.44
13	7.41	38	7.56	63	7.88	88	7.36	113	6.91	138	7.49	163	7.34	188	7.29
14	7.47	39	7.39	64	8.47	89	7.49	114	6.38	139	7.52	164	7.18	189	7.26
15	7.32	40	7.36	65	8.07	90	7.51	115	6.97	140	7.44	165	7.07	190	7.24
16	7.26	41	7.42	66	8.38	91	7.42	116	7.08	141	7.40	166	7.28	191	7.31
17	7.39	42	6.96	67	8.06	92	7.39	117	7.34	142	7.54	167	7.19	192	7.42
18	7.30	43	7.44	68	8.36	93	7.64	118	7.41	143	7.43	168	7.36	193	7.34
19	7.44	44	7.47	69	8.22	94	7.55	119	7.54	144	7.51	169	7.30	194	7.27
20	7.52	45	7.52	70	8.27	95	7.38	120	6.88	145	7.45	170	7.42	195	7.38
21	7.71	46	7.33	71	7.72	96	7.47	121	7.31	146	7.41	171	7.68	196	7.43
22	7.64	47	7.49	72	7.87	97	7.54	122	7.43	147	7.18	172	7.87	197	7.55
23	7.68	48	7.53	73	7.72	98	7.63	123	7.39	148	7.06	173	7.83	198	7.21
24	7.57	49	7.44	74	7.61	99	7.58	124	6.48	149	7.02	174	7.66	199	7.18
25	7.49	50	7.31	75	7.66	100	7.54	125	7.04	150	6.97	175	7.43	200	6.98

ecosystem (Wen *et al*., 2018) as well as yield response was also dependent on water availability (Moriana *et al*., 2003). Thus, participatory rural approaches and knowledge sharing are key issue for securing immortal soil resources and betterment of farming community (Stoate *et al.,* 2019; Shaban *et al*., 2017).

Soil nutrient index and fertility ratings

Soil nutrient index value for each nutrient was calculated and results concluded that nutrients falls in the category of low and medium ratings (Table 5). Zn, P and K had low ranked SNI values of 1.415, 1.600 and 1.165 respectively. Cu, Mn and Fe had medium ranked SNI values of 1.995, 1.995 and 2.000 respectively. Soil fertility ratings are therefore pivotal for ranking the nutrient limitations (Table 6). The percentage of such nutrients in sufficiency or deficiency levels indicates the soil condition. The present study showed wide variations in percentages of low, medium and high categories, 55.5, 43.0 and 1.5 for Zn. For P, the corresponding values were 18% in low and 71% in medium categories while for K, 83.5% in Medium and only 16.5% in high category respectively. Hundred percent of Fe was in medium category and 100% of Cu in low category while 99.5% Mn in medium category. The exiting scenarios of soil in 200 orchards are vital for growers' livelihood and nutritional security. The SNI value is thus should be considered as top priority index for correlating soil sustainability with overall productivity in any agri-horti ecosystem. Researchers from all over the world emphasized for the betterment of fruit produces in a way for future generations while also keeping the soil healthy and safe. Accurate measurement of problematic soils and their management may further enhance the economic yield and profitability. Reduction of erosion, both soil and water, and conservation practices either *in-situ* or on vast regions of sloppy lands, arid, semi-arid, humid, coastal in tropical or sub-tropical fruits provides an opportunity for making farm sustainable. Organic production is also considered for betterment of profitable fruit business and harnessing optimization of soil organic resources. Avoidance of stress complexes and its identification, management is the best option in present day quality fruit production system. In the current study, lower SNI values indicated the immediate need for resource optimization. Literature suggested for increasing input use efficiency. Natural resource may sometimes influence the phenolic compounds in mango (Ribeiro *et al*., 2008), therefore accuracy in its management is pivotal. Bhupal Raj and Prasad Rao (2006) developed yield limiting nutrient array for correlating mango productivity. Critical phenological stage wise irrigation may improve the productivity in mango (Wei *et al*., 2017). Detection of water stress is very crucial for making farm productivity sustainable (Ballester *et al*., 2013; De la Rosa *et al*., 2015). Sometimes, saline water management enhances the required yield (Durán *et al.,* 2004; Romero-Trigueros *et al*., 2014). Knowledge on sap flow is another aspect for getting best response in precise irrigation scheduling from fruit farming (Fernandez *et al*., 2008). Growers may invest less attention on the conservation practices (Gao *et*

Table 5. Soil nutrient index and fertility ratings in 200 mango orchards

	SNI Values	Fertility ratings
Zn	1.415	Low
Cu	1.995	medium
Mn	1.995	medium
Fe	2.000	medium
P	1.600	Low
K	1.165	Low

Table 6. Percentage of nutrients in sufficing or deficiency level

	Low	Medium	High
Zn (mg kg^{-1})	0-0.5	0.5-1.0	>1.01
Per centages	55.5	43.0	1.5
Cu (mg kg^{-1})	<4.5	4.5-5.5	>5.5
Per centages	100.0	-	-
Mn (mg kg^{-1})	4	>4	
Per centages	0.5	99.5	-
Fe (mg kg^{-1})	<2.0	>2.01	
Per centages	-	100	-
P (kg ha^{-1})	<22	22-54	>54
Per centages	18.0	71.0	11.0
K (kg ha^{-1})	<123	123-293	>296
Per centages	-	83.5	16.5

al., 2018) but investment in organic production may help in economic benefit (Tzouramani *et al*., 2013). Thus, consideration of physical, micro-nutrients and other soil indicators become obvious for precised fruit productivity (Adak *et al.,* 2016). All these aspects suggest for decision support system to growers for improving SNI in turn soil sustainability.

Conclusion

In the current study, soil nutrients in 200 mango orchards grown indigenously by the farmers of famous Malihabad region of Uttar Pradesh were documented. Soil nutrient index was calculated and a fertile rating was allotted. Big data analysis concluded that micronutrient like Zn and Major nutrient like K was rated as low and needs utmost attention for soil or foliar application for producing quality fruits. Nutrients in medium ratings also asked for special attention in terms of management requirement. Scientific interactions with growers on regular basis should be the immediate solutions for keeping soil productive and ensuring growers' profit.

References

Adak, T., Singh, V.K. and Pandey, G. 2018. Soil physico-chemical and biological properties vis-à-vis yield gap analysis in mango cv. Langra orchards in Lucknow. *Journal of Agricultural Physics* **18**(2): 246-252.

Adak, T., Kumar, K. and Singh, Vinod Kumar. 2016. Variations in some soil physical properties, micronutrient distribution and its stock under high density guava orchard ecosystem. *Journal of Soil and Water Conservation* **15**(2): 141-147.

Adak, T., Pandey, G. and Kumar, K. 2018a. Site Specific Nutrient Management in Mango - A Cursory Look. *In*: Soil and Water Conservation Bulletin, Mishra, P.K., Singh, L., Kumar, A., Mandal, D., Kaushal, R., Kumar, G. and Roy, T. (Eds), 2018. Indian Association of Soil and Water Conservationists, Dehradun, Uttarakhand, No 3 pages 52-59.

Adak, T., Pandey, G., Pandey, D., Garg, N., Ram Kumar, Singh, S.R., Chandra, S. and Kumar, A. 2018c. Scientist-Farmers interaction for enhancing farmers' income through nutrient management, crop diversification, value addition and other horticultural technologies. In: *National Conference on Strategies & Challenges on Doubling Farmers' Income through Horti-cultural Technologies in Subtropics*, held during June 21-22, 2018 at CISH, Lucknow, pp. 115.

Akohoue, F., Segnon, A. and Achigan-Dako, E. 2018. Diversity in smallholder citrus orchards and cultivation bottlenecks: research avenues for improved production in Benin, West Africa. *Experimental Agriculture* **54**(5): 641-654.

Amara, D.M.K., Patil, P.L., Kamara, A.M. and Saidu, D.H. 2017. Assessment of soil fertility status using nutrient index approach. *Academia Journal of Agricultural Research* **5**(2): 028-038.

Ballester, C., Jiménez-Bello, M.A., Castel, J.R. and Intrigliolo, D.S. 2013. Usefulness of thermo-graphy for plant water stress detection in citrus and persimmon trees. *Agricultural and Forest Meteorology* **168**: 120-129.

Bhupal Raj, G. and Prasad Rao, A. 2006 Identification of Yield Limiting Nutrients in Mango through DRIS Indices. *Communications in Soil Science and Plant Analysis* **37**: 1761-1774.

De la Rosa, J.M., Domingo, R., Gómez-Montiel, J. and Pérez-Pastor, A. 2015. Implementing deficit irrigation scheduling through plant water stress indicators in early nectarine trees. *Agricultural Water Management* **152**: 207-216.

Denis, M.K.A., Parameshgouda, L.P., Augustine, M.K. and Daniel, H.S. 2017. Assessment of soil fertility status using nutrient index approach. *Academia Journal of Agricultural Research* **5**(2): 028-038.

Durán, Z.V.H., Martínez, R.A. and Aguilar, R.J. 2004. Impact of salinity on the fruit yield of mango (*Mangifera indica* L. cv. Osteen). *European Journal of Agronomy* **21**: 223-234.

Fernandez J.E., Green S.R., Caspari H.W., Diaz-Espejo A. and Cuevas M.V. 2008. The use of sap flow measurements for scheduling irrigation in olive, apple and Asian pear trees and in grape-vines. *Plant and Soil* **305**: 91-104.

Ganeshamurthy, A.N. Satisha, G.C., Kumar, K. and Adak, T. 2016. Soil Fertility and Crop Nutrition in Mango: Delineation, Deficiencies and Manage-ment of Nutrients. Technical Bulletin: ICAR-Indian Institute of Horticultural Research, Bengaluru.

Gao, L., Zhang, W., Mei, Y., Sam, A.G., Song, Y. and Jin, S. 2018. Do farmers adopt fewer conservation practices on rented land? Evidence

from straw retention in China. *Land Use Policy* **79**: 609-621.

Hansen, J., Knapp, E. and Jones, J. 1997. Determinants of sustainability of a Colombian Hillside Farm. *Experimental Agriculture* **33**(4): 425-448.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Private Ltd., New Delhi, India.

Joshi, N.S., Vaidya, K.P. and Pawar, C.D. 2015. DTPA extractable micronutrient status of soil from mango orchards of Ratnagiri district and their relationship with soil properties. *Plant Archives* **15**(1): 61-66.

Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalantari, Z. and Cerdà, A. 2018. The superior effect of nature based solutions in land management for enhancing ecosystem services. *Science of the Total Environment* **610-611**: 997-1009.

Larsen, J., Jaramillo-López, P., Nájera-Rincon, M. and Gonzaléz-Esquivel, C.E. 2015. Biotic interactions in the rhizosphere in relation to plant and soil nutrient dynamics. *Journal of Soil Science and Plant Nutrition* **15**(2): 449-463.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**: 421-428.

Moriana, A., Orgaz, F., Pastor, M. and Fereres, E. 2003. Yield response of a mature olive orchard to water deficit. *Journal of American Society of Horticultural Science* **184**: 425-431.

Nelson, P.N., Banabas, M., Goodrick, I., Webb, M.J., Huth, N.I. and O'Grady, D. 2015. Soil sampling in oil palm plantations: a practical design that accounts for lateral variability at the tree scale. *Plant and Soil* **394** (1-2): 421-429.

Olsen S.R., Cole C.V., Watnabe F.S. and Dean L.A. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. U.S. Department of Agriculture Circular, pp. 939.

Reddy, Y.T.N., Kurian, R.M., Kohli, R.R. and Singh, G. 2000. Effect of nitrogen, phosphorus and potassium on growth, yield and fruit quality of 'Totapuri' mango (*Mangifera indica*). *Indian Journal of Agricultural Sciences* **70**: 475-478.

Ribeiro, S.M.R., Barbosa, L.C.A., Queiroz, J.H., Knodler, M. and Schieber, A. 2008. Phenolic compounds and antioxidant capacity of Brazilian mango (*Mangifera indica* L.) varieties. *Food Chemistry* **110**: 620-626.

Romero-Trigueros, C., Nortes, P.A., Pedrero, F., Mounzer, O., Alarcón, J.J., Bayona, J.M. and Nicolás, E. 2014. Assessment of the variability of using saline reclaimed water in grapefruit in medium to long term. *Spanish Journal of Agriculture Research* **12**(4): 1137-1148.

Satisha, G.C. and Ganeshamurthy, A.N. 2015. Optimizing soil fertility and foster productivity of mango: An appraisal on soil fertility status and development of nutrient delineation maps of India. *Current Advances in Agricultural Sciences* **7**(1): 33-36.

Shaban, N., Bistrichanov, S., Kadum, E. and Tityanov, M. 2017. Sustainable Development in Education of Horticulture. *Bulgarian Journal of Soil Science* **2**(1): 75-82.

Singha, A., Adak, T. and Kumar, K. 2016. Spatio-temporal Variations of Dehydrogenase Activity and Some Soil Physical Parameters in High Density Guava Orchard. *Journal of Agricultural Physics* **16** (1&2): 86-97.

Stoate, C., Jones, S., Crotty, F., Morris, C. and Seymour, S. 2019. Participatory research approaches to integrating scientific and farmer knowledge of soil to meet multiple objectives in the English East Midlands. *Soil Use and Management* **35**: 150-159.

Talang, H.D., Dutta, P., Mukhim, C. and Patil, S. 2017. Effect of Integrated Nutrient Management on Mango (*Mangifera indica* L.) cv. Himsagar. *Journal of Horticultural Science* **12**(1): 23-32.

Tzouramani, I., Liontakis, A., Sintori, A. and Alexopoulos, G. 2013. Exploring organic cherry investment opportunities for Greek farmers. *Outlook in Agriculture* **42**(1): 41-46.

Van Der Heijden, M.G.A., Bardgett, R.D. and Van Straalen, N.M. 2008. The unseen majority: soil microbes as drivers of plant diversity and productivity in terrestrial ecosystems. *Ecology Letters* **11**: 296-310.

Wei, J., Liu, G., Liu, D. and Chen, Y. 2017. Influence of irrigation during the growth stage on yield and quality in mango (*Mangifera indica* L.). *PLoS ONE* **12**: e0174498-e0174498.

Wen, Y., Su, S.C., Ma, L.Y., Yang, SY., Wang, Y.W. and Wang, X.N. 2018. Effects of canopy microclimate on fruit yield and quality of Camellia oleifera. *Scientia Horticulturae* **235**: 132-141.

Received: February 12, 2019; Accepted: April 21, 2019