OnLine Journal of Biological Sciences 2 (7): 453-458, 2002
ISSN 1608-4127

Nutritional Status of Citrus Orchards in Sahiwal District

[1]A.M. Ranjha, [1]M. Akram, S.M. Mehdi, M. Sadiq, M. Sarfraz and G. Hassan
Soil Salinity Research Institute, Pindi Bhattian, Punjab, Pakistan
[1]University of Agriculture, Faisalabad, Pakistan

Abstract: A total of 100 soil and 75 plant samples were collected for determination of nutritional status of citrus orchards in Sahiwal. The results showed that 8% soil samples were deficient in N, 4% in P, no one in K, 100% in Zn and no one in Cu, Fe and Mn. The extent of nutrients belonging to low category has been found as 88% in N, 56% in P, no one in K, 84% in Cu and no one in Fe and Mn. In sufficiency range, 4% soil samples were sufficient in N, 24% in P, 64% in K, 16% in Cu and 100% in Fe and Mn contents. Among high range of nutrients only 16% soil samples in P and 35% in K were found. In case of leaf samples, 40% were deficient in N, 28% in Zn, no one in P, K, Fe, Cu and Mn while 24% were low in N, 60% in K, 68% in Zn and no one in P, Cu, Fe and Mn and 32% were sufficient in N, 68% in P, 40% in K, 4% in Zn, 100% in Cu, Fe and Mn contents while 4% were high in N and 32% in P. Soil pH had a non significant negative correlation with leaf N, P, K, Zn, Fe and Mn and nonsignificant positive correlation with Cu. Soil organic matter had a highly significant positive correlation with leaf N and nonsignificant negative correlation with K, Cu and Mn and non significant positive correlation with P, Ca+Mg, Zn and Fe contents. Clay contents had a significant positive correlation with K and non-significant positive correlation with P, Ca+Mg, Zn and negative correlation with N, Cu, Fe and Mn but non significantly. A positive significant correlation was also found between soil N, Ca+Mg, Fe content and leaf N, Ca+Mg and soil P, K, Zn and Mn also had positive correlation with leaf P, K, Zn and Mn but non significantly. Soil Cu had negative correlation with leaf Cu but non-significantly.

Key words: Citrus orchards, macro and micronutrients, Sahiwal

Introduction

Citrus is a very common nutritious fruit of Pakistan. It is grown on an area of 0.17 X 10^6 ha with an annual production of 1.58 X 10^6 tones of fruit (Anonymous, 1989-90). Major part of citrus area is in Punjab, which is 0.16 X 10^6 ha, which is 94% of the total citrus area of Pakistan. Citrus production is declining and the reasons for its decline are not properly known. However Lipas (1986) analyzed soil samples collected from 98 citrus orchards. He found that all the nutrients both macro and micro were lower than those recommended for soils under citrus orchards. Which may cause the citrus decline. Similarly, Munir (1990) examined 80 soil samples and 60 associated leaf samples collected from orchards of Sargodha district. He found that 15% soil samples were deficient in N, 10% in P, 80% in Zn, 40% in Cu, 100% in Fe and 10% in Mn contents. He also reported that 25% leaf samples were deficient in N, 30% in K, 70% in Zn and no one in P, Cu, Fe and Mn. Deficiency symptoms of N and Zn were noted on leaves. Tuzcu *et al.* (1986) also found than N and Zn contents were deficient in leaves of Mediterranean region of Turkey. Zhuang *et al.* (1985) noticed that with increasing soil pH, N was decreased while P and K were increased in the respective soil. Lal and Sharma (1985) found a positive correlation between soil organic matter and leaf N contents while there is a negative correlation between clay contents and plant (leaf) nutrients (Tuzcu *et al.*, 1986). Hiroce *et al.* (1984) found a highly positive correlation between soils N, P and K with leaf N, P and K contents. Keeping all this in view present survey was carried out for a broad enquiry into citrus declined to fill the gap to gain better yield of citrus.

Materials and Methods

A survey was carried out to investigate the causes of citrus deterioration in Sahiwal district. Twenty-five citrus orchards were selected and 100 soil samples were collected from them. Four sites were selected in each garden; each site was a crossing point of four plants. From each site sampling was done upto 90 cm depth in the order of 0-15, 15-30, 30-60 and 60-90 cm. The samples were so composited that four samples were taken from each garden upto 90 cm. These soil samples were brought to laboratory, air-dried, ground and passed through a 2 mm sieve and analyzed for physical, chemical characteristics and various nutrient levels were determined. The citrus leaves were collected from 5-7 months old spring flush immediately above the node, from the same orchards from where in soil samples were collected. A total of 75 samples were collected. Each plant sample was a composite of three subsamples. Leaves were collected from 8-10 plants haphazardly from an orchard and a total of 50 leaves were taken from each sample. All the leaves were sampled from non-fruiting twigs 3-6 feet above the ground level. No citrus plant was sampled from the borderlines. Leaf samples were washed with distilled water and oven dried at 60-70°C to a constant weight. The oven dried plant samples were ground and analyzed for various nutrients. All the analysis were done according to methods described in hand book No.60 (U.S.Salinity Lab. Staff, 1954) except texture by Moodie *et al.* (1959), total N in soil and plant by Jackson (1962), available P in soil by Watanabe and Olsen (1965), Zn, Cu, Fe and Mn in soil and plant by Lindsay and Norvell, (1978) and Cottenie *et al.* (1979). The correlation between pH, organic matter, clay contents and the plant nutrient elements i.e. N, P, K Ca + Mg, Zn, Cu, Fe and Mn were determined. Relationship between soil nutrients status and plant nutrient contents (leaf analysis) were also determined by using simple linear correlation technique (Steel and Torrie, 1980).

Results and Discussion

Among soil physical, chemical and nutritional status of citrus orchards in Sahiwal district, the pH of soil ranged between 7.3-8.3, organic matter content of soil was very low (0.32-1.04%), calcium carbonate ranged from 4 to 8.40% while clay content of soil varied from 15 to 39%. Total nitrogen in soil varied from 0.01 to 0.06% upto 90 cm depth (Tables 1, 2). This variation in N contents might be due to a number of reasons such as difference in natural fertility; variation in cultural practices like sowing of berseem in some gardens, variation in the N applied fertilizers. Moreover N contents in surface were higher as compared to the lower depths of soil profiles, which is due to presence of more organic matter in surface than sub soil. According to the quantitative standards suggested by Jackson (1962), for soil N, 8% of soil samples analyzed were deficient in total N, 88% were low and 4% had sufficient N contents.

The leaf analysis value indicated that total N ranged between 1.3 to 2.8% (Table 3). According to standards suggested by Chapman (1960) for citrus leaf N, 40% of the leaf samples analyzed were deficient, 24% has low, 32% had sufficient and 4% had high leaf N for normal fruit production. Similar findings regarding soil and

Corresponding Author: Mr. Muhammad Sarfraz, Soil Salinity Research Institute, Pindi Bhattian, Punjab, Pakistan

Table 1: Soil analysis data of surveyed, non-fruit bearing citrus orchards in Sahiwal district

		Soil attributes				Macronutrients							
Orchard/ garden No.	Sampling depth (cm)	pH	Organic matter (%)	Clay (%)	$CaCO_3$ (%)	Total N (%)	Available P (ppm)	Extractable K (ppm)	Soluble Ca+Mg (mel^{-1})	Available macronutrients			
										Zn	Cu	Fe	Mn
1.	0-15	7.8	0.99	29	4.5	0.05	5.9	221	11.3	1.03	1.70	23.5	27.6
	15-30	7.8	0.83	23	4.8	0.04	4.8	205	7.2	0.81	1.30	23.4	27.3
	30-60	7.6	0.70	20	4.5	0.04	2.2	180	8.8	0.68	1.20	17.2	21.2
	60-90	7.4	0.65	20	4.2	0.03	1.0	152	10.4	0.35	1.10	14.1	15.0
2.	0-15	8.1	1.00	39	5.6	0.05	9.4	210	5.6	0.72	1.90	26.2	53.0
	15-30	8.0	0.72	36	5.4	0.03	4.2	189	9.8	0.76	1.50	18.1	57.2
	30-60	8.0	0.71	21	5.7	0.03	2.4	155	16.2	0.53	1.40	16.2	65.0
	60-90	7.8	0.50	21	5.9	0.02	2.0	140	26.2	0.21	1.20	13.0	82.3
3.	0-15	8.3	0.76	33	5.6	0.04	9.6	186	5.6	0.73	1.78	25.0	25.3
	15-30	8.2	0.63	27	5.4	0.04	3.8	156	7.6	0.51	1.34	24.4	21.7
	30-60	8.1	0.50	25	5.8	0.02	1.7	132	8.2	0.32	1.20	18.2	18.2
	60-90	8.0	0.32	15	6.2	0.02	1.1	120	10.0	0.29	1.90	13.7	15.0
4.	0-15	8.1	1.00	31	6.5	0.06	2.0	242	6.5	0.80	1.57	27.0	44.6
	15-30	8.0	0.80	26	4.3	0.03	7.4	231	27.3	0.75	1.41	20.0	45.2
	30-60	8.0	0.80	26	4.8	0.03	3.1	205	18.0	0.53	1.20	18.3	33.4
	60-90	8.0	0.70	21	5.6	0.03	4.3	175	13.6	0.31	1.00	14.1	27.2
5.	0-15	8.3	0.81	15	7.6	0.05	4.7	225	9.5	0.64	2.30	25.7	48.2
	15-30	8.3	0.70	17	6.4	0.04	5.1	185	14.2	0.53	2.00	23.2	38.4
	30-60	8.2	0.50	16	6.8	0.02	1.9	133	16.4	0.37	1.80	18.4	59.3
	60-90	8.0	0.48	15	7.0	0.02	2.1	125	20.4	0.31	1.50	13.2	42.1
6.	0-15	8.1	0.73	26	8.4	0.06	3.7	201	6.3	0.86	2.60	23.2	26.4
	15-30	8.0	0.52	26	7.3	0.03	6.2	183	12.3	0.78	2.40	22.1	25.3
	30-60	7.9	0.51	24	6.9	0.03	2.3	168	14.6	0.53	2.00	19.3	20.3
	60-90	7.8	0.38	20	7.1	0.01	2.1	140	17.8	0.33	1.70	16.7	14.2
7.	0-15	8.1	0.70	33	7.2	0.04	7.4	264	6.7	0.59	2.60	25.6	21.7
	15-30	8.2	0.50	25	7.5	0.03	4.3	180	18.3	0.40	2.40	23.4	1.4
	30-60	8.0	0.48	25	7.3	0.03	3.1	165	13.6	0.29	1.50	19.2	17.3
	60-90	7.7	0.32	20	7.6	0.02	2.3	135	27.0	0.28	1.30	17.3	12.1
8.	0-15	8.1	1.00	33	5.6	0.05	12.0	250	14.7	0.71	2.50	21.5	23.6
	15-30	8.1	1.00	33	5.3	0.05	9.8	184	12.4	0.63	2.20	18.3	23.2
	30-60	8.0	0.62	29	5.7	0.03	8.2	143	13.6	0.41	1.70	16.2	19.5
	60-90	8.0	0.53	22	6.2	0.02	6.0	122	20.4	0.34	1.40	13.1	15.2
9.	0-15	8.0	1.00	27	8.0	0.06	11.3	272	21.7	1.00	1.71	25.6	18.4
	15-30	8.1	0.81	25	7.8	0.04	8.7	236	11.5	1.00	1.53	21.5	18.0
	30-60	8.2	0.62	24	7.5	0.03	8.2	207	14.0	0.81	1.30	19.2	17.2
	60-90	7.6	0.51	17	7.3	0.02	4.0	139	39.2	0.63	1.10	13.7	14.3
10.	0-15	8.3	0.82	27	5.6	0.04	13.5	227	7.5	0.64	1.67	27.7	44.1
	15-30	8.1	0.62	27	5.5	0.03	2.1	205	8.2	0.56	1.46	19.2	36.4
	30-60	8.0	0.60	24	5.1	0.03	2.0	189	10.4	0.39	1.29	16.3	28.7
	60-90	7.7	0.55	18	5.3	0.02	2.2	145	17.7	0.28	1.10	14.2	39.2
11.	0-15	8.3	1.04	23	6.2	0.05	5.7	230	5.6	0.97	1.35	24.8	43.9
	15-30	8.2	1.00	20	6.0	0.05	2.1	195	9.7	0.94	1.25	15.0	42.8
	30-60	8.2	0.70	20	6.5	0.03	2.3	176	10.2	0.73	1.20	17.0	39.6
	60-90	8.0	0.63	15	6.8	0.02	2.1	132	12.4	0.45	1.13	13.6	32.3
12.	0-15	8.2	1.19	21	5.7	0.06	10.1	278	6.7	0.56	2.80	23.2	21.0
	15-30	8.0	1.03	17	4.8	0.05	5.8	265	7.2	0.53	2.50	19.0	21.5
	30-60	8.0	0.88	17	4.8	0.04	3.1	192	12.4	0.37	2.00	16.0	18.4
	60-90	7.8	0.59	15	4.5	0.03	2.1	133	18.2	0.25	1.50	13.7	15.2
13.	0-15	8.2	0.94	30	7.5	0.05	7.0	248	5.8	1.75	2.30	26.0	16.4
	15-30	8.3	0.78	19	7.8	0.04	4.1	219	5.0	0.58	1.76	26.6	17.3
	30-60	7.8	0.61	18	7.2	0.03	2.6	190	24.0	0.43	1.63	19.3	14.2
	60-90	7.7	0.53	18	7.0	0.03	2.5	141	27.3	0.35	1.41	14.2	12.4
14.	0-15	8.1	0.88	21	6.9	0.05	6.6	291	7.4	0.99	2.50	27.4	23.5
	15-30	8.2	0.75	18	7.1	0.04	6.3	279	7.3	0.81	2.10	24.2	23.2
	30-60	7.9	0.60	18	6.5	0.03	8.2	215	19.2	0.75	1.81	19.2	33.4
	60-90	7.6	0.39	18	6.3	0.01	4.0	185	31.3	0.51	1.63	17.3	18.2
15.	0-15	8.0	0.71	29	7.8	0.04	5.0	265	6.4	0.86	1.90	26.7	27.8
	15-30	8.1	0.61	25	7.9	0.03	2.8	212	12.1	0.78	1.70	23.6	29.6
	30-60	7.8	0.61	25	7.5	0.03	2.7	187	14.3	0.55	1.60	29.4	17.2
	60-90	7.8	0.55	21	7.6	0.03	2.7	132	14.6	0.41	1.30	15.2	16.1
16.	0-15	8.2	1.00	23	4.2	0.05	9.3	195	6.6	0.84	2.30	21.3	20.5
	15-30	8.2	0.70	23	4.3	0.04	4.2	183	7.8	0.67	1.90	19.8	20.6
	30-60	8.3	0.60	18	4.8	0.03	7.0	152	5.5	0.51	1.30	17.6	25.2
	60-90	7.9	0.43	18	4.5	0.02	2.3	131	23.2	0.32	1.20	14.3	13.2
17.	0-15	8.2	0.99	25	7.6	0.05	4.7	248	7.4	1.15	1.80	22.5	26.7
	15-30	8.2	0.80	23	7.5	0.04	5.1	229	7.7	1.01	1.23	20.3	26.0
	30-60	8.2	0.72	21	7.5	0.04	2.0	192	7.0	0.86	1.00	18.3	23.1
	60-90	8.2	0.65	20	7.7	0.03	1.6	161	7.8	0.62	0.80	16.2	14.2

Table 1: Continue

Orchard/ garden No.	Sampling depth (cm)	Soil attributes pH	Organic matter (%)	Clay (%)	$CaCO_3$ (%)	Macronutrients Total N (%)	Available P (ppm)	Extractable K (ppm)	Soluble Ca+Mg (mel^{-1})	Available macronutrients (ppm) Zn	Cu	Fe	Mn
18.	0-15	8.3	0.91	25	6.8	0.04	10.2	244	6.4	0.91	2.60	25.4	29.3
	15-30	8.3	0.91	25	6.7	0.04	6.8	181	4.5	0.88	2.00	18.2	28.7
	30-60	8.2	0.83	23	6.8	0.04	3.6	170	14.0	0.71	1.60	17.3	22.2
	60-90	8.0	0.60	20	7.0	0.02	2.7	125	16.3	0.52	0.91	14.2	17.8
19.	0-15	8.1	1.04	33	7.4	0.05	9.9	320	9.7	1.00	2.30	27.8	26.6
	15-30	8.0	0.73	25	7.5	0.04	4.8	250	12.4	0.93	2.10	25.3	26.4
	30-60	7.8	0.53	23	7.3	0.03	2.2	207	21.0	0.76	1.60	21.4	25.2
	60-90	7.8	0.50	22	7.5	0.03	2.3	175	32.3	0.47	0.72	17.3	15.0
20.	0-15	8.0	0.91	18	7.2	0.04	8.5	260	11.7	0.51	2.60	22.4	23.3
	15-30	8.1	0.75	18	7.6	0.04	4.2	206	10.7	0.37	2.40	19.5	23.5
	30-60	7.8	0.63	19	7.5	0.03	3.7	195	18.3	0.31	1.70	16.4	32.2
	60-90	7.8	0.60	18	7.0	0.02	2.4	135	19.9	0.23	1.40	13.3	19.4
21.	0-15	8.2	1.00	30	7.2	0.05	8.2	219	6.4	0.70	1.90	20.0	26.5
	15-30	7.9	0.85	29	7.4	0.05	5.8	207	11.7	0.68	1.30	18.7	26.8
	30-60	7.7	0.52	31	7.5	0.03	4.1	185	17.8	0.51	1.00	15.4	24.2
	60-90	9.0	0.48	31	7.8	0.02	3.5	163	26.1	0.38	0.92	13.2	17.3
22.	0-15	8.1	0.96	30	5.2	0.05	9.6	264	18.0	0.61	2.40	27.4	28.7
	15-30	8.0	0.83	23	5.5	0.04	5.7	256	22.2	0.50	2.00	23.5	28.6
	30-60	8.1	0.64	18	6.6	0.02	3.0	185	19.5	0.39	1.80	18.4	20.2
	60-90	7.3	0.51	17	6.2	0.02	2.1	131	31.2	0.31	1.00	14.3	18.0
23.	0-15	8.0	0.84	29	6.9	0.04	6.3	272	18.6	0.72	1.80	21.4	25.5
	15-30	7.8	0.52	30	5.3	0.02	4.1	205	12.7	0.59	1.50	18.3	21.2
	30-60	7.7	0.52	20	4.8	0.02	3.5	167	22.3	0.50	1.20	12.4	15.3
	60-90	7.6	0.50	18	4.0	0.02	3.5	138	35.4	0.31	1.00	10.2	12.3
24.	0-15	8.2	1.00	22	7.8	0.03	9.4	255	7.4	0.87	2.60	17.5	50.4
	15-30	8.2	0.70	38	7.9	0.03	5.6	216	7.7	0.80	1.80	14.3	44.6
	30-60	8.1	0.70	30	7.5	0.02	6.1	183	10.5	0.73	1.50	10.2	45.2
	60-90	8.0	0.61	29	6.9	0.04	3.4	144	13.3	0.61	1.00	9.4	44.2
25.	0-15	8.3	0.82	34	8.2	0.03	5.7	270	5.4	0.61	2.10	16.9	57.4
	15-30	8.2	0.51	32	7.8	0.02	4.0	251	7.8	0.58	1.90	14.5	53.0
	30-60	7.8	0.40	32	7.3	0.02	2.5	213	14.3	0.41	1.30	12.3	48.3
	60-90	7.8	0.36	31	7.0	0.01	2.0	176	16.2	0.27	0.98	11.1	38.6

Table 2: Ranges and means of physical, chemical and nutritional properties of soil collected from citrus orchards in Sahiwal district

Properties	Range	Mean
pH	7.3–8.3	8.00
Organic matter (%)	0.32–1.04	0.70
Clay (%)	15.0–39	23.83
$CaCO_3$ (%)	4.0–8.4	6.48
Total nitrogen (%)	0.01–0.06	0.03
Available phosphorus (ppm)	1.0–13.5	4.78
Extractable potassium (ppm)	120.0–320	193.46
Soluble Ca+Mg (me l^{-1})	4.5–39.2	13.79
DTPA extractable		
Zn (ppm)	0.21–1.75	0.61
Cu (ppm)	0.92–2.8	1.66
Fe (ppm)	9.4–27.4	19.46
Mn (ppm)	12.1–59.3	25.58

plant N were reported by Tuzcu *et al.* (1986). Similarly there was much variation in soil available P. It ranged between 1.0 to 13.5 mg Kg^{-1} soil to a depth of 90 cm (Table 1). Like N, P in soil was also highest in surface soil, which can be attributed to the applied phosphatic fertilizers or more organic matter. On the basis of standards laid down by Watanabe and Olsen (1965), 4% of the soil samples were deficient in available P, 56% had low, 24% sufficient and 16% had highest P for normal citrus growth. Phosphorus concentration in leaves ranged between 0.19 to 0.35% of dry matter of leaf (Table 3). According to Chapman (1960) standards for P in citrus leaves, 68% of the leave samples analyzed had sufficient and 32% had highest P contents indicating that soils were well supplied with phosphatic fertilizers as well as good uptake by the plant from the deep profiles. Similar findings were reported by Sharma and Reddy (1986) regarding P in soil and citrus leave.

As for as extractable K is concerned, no sample indicated its deficiency, 64% had sufficient and 36% had highest extractable K because it ranged in soil between 120-320 mg kg^{-1} soil (Table 1). On the other hand citrus leaves had K contents between 0.78-1.71% (Table 3) and according to Chapman (1960) standards 60% of the leaf samples were low in K and 40% had sufficient K. Similar findings were reported by Reddy and Swamy (1986).

In case of micronutrients 100% soil samples analyzed were deficient in Zn, in case of Cu 84% had low and 16% had sufficient while all samples had sufficient Fe contents probably due to presence of Fe chelates in soil. In case of Mn, all samples analyzed had high amount of Mn. The critical limits for micronutrients in soil and plants are presented in Table 7. All these micronutrients were more in surface soil and gradually decreased with the depth might be due to decrease of organic matter with depth. Sharma *et al.* (1986) also found similar results.

The citrus leaves analyzed for micronutrients indicated that 28% were deficient in Zn, 68% had low and 4% had satisfactory Zn content. While majority of the leaf samples analyzed has sufficient level of Cu which indicate a negative correlation between soil and leaf Cu content. The decreasing Cu content of leaf might be attributed to the immobility of this element in leaves with the consequence of accumulation in the leaves. All the leaf samples analyzed had highest Fe contents. The range of Fe in leaves was between 204 to 400 ppm. Similarly Mn contents were sufficient in all leaves samples. Liu *et al.* (1984) also reported similar results.

Correlation between soil pH and leaf nutrient contents: There was a negative non-significant correlation between soil pH and citrus leaf P, K, Zn, Fe and Mn and a positive but non-significant correlation between soil pH and leaf N, Ca, Mg and Cu contents (Table 5). The above findings might be due to alkaline and calcareous nature of soils due to which Ca+Mg dominates on exchange sites resulting in P, K, Zn, Fe and Mn decrease in citrus leaf. Similar results were reported by Birriel *et al.* (1984). Zn may

Table 3: Leaf analysis data of surveyed, non-fruit bearing citrus orchards of Sahiwal district

Orchard/ garden No.	Total macronutrients				Total macronutrients			
	N	P	K	Ca+Mg	Zn	Cu	Fe	Mn
	% dry matter of leaf				ppm dry matter of leaf			
1	1.6	0.34	1.00	2.8	17	5	378	58
2	1.4	0.26	0.87	3.6	15	8	308	45
3	1.8	0.29	0.79	3.4	20	7	395	52
4	2.1	0.22	0.86	3.1	21	9	334	51
5	2.0	0.22	0.83	3.3	16	6	307	58
6	2.3	0.29	0.79	3.5	16	12	400	41
7	2.1	0.32	1.15	3.0	18	16	204	48
8	1.3	0.34	1.10	4.2	17	9	388	58
9	1.5	0.28	0.93	3.6	21	6	247	47
10	1.7	0.22	0.78	3.8	12	10	325	79
11	2.2	0.26	0.97	3.7	15	8	235	67
12	2.1	0.21	0.86	3.8	20	8	301	55
13	2.8	0.26	0.81	3.2	13	5	263	63
13	1.6	0.29	1.71	2.8	18	6	301	49
15	2.0	0.22	0.94	3.5	31	7	323	54
16	1.8	0.21	1.40	3.3	16	9	336	79
17	2.4	0.28	1.13	3.4	19	12	333	67
18	2.6	0.32	0.91	3.6	21	14	316	83
19	1.8	0.29	1.30	3.6	14	22	302	47
20	1.5	0.19	1.40	3.2	17	13	314	54
21	2.4	0.32	1.00	3.4	13	11	313	44
22	2.2	0.31	0.81	3.8	15	16	273	39
23	2.0	0.26	1.23	4.2	26	12	240	43
24	2.3	0.26	0.88	3.2	23	12	298	51
25	2.5	0.35	0.93	2.3	17	14	281	60

Table 4: Ranges and means of nutrient contents in dry matter of citrus leaf, collected from orchards in Sahiwal district

Nutrients	Unit	Range	Mean
N	%	1.3 – 2.8	2.0
P	%	0.19 – 0.35	0.27
K	%	0.78 – 1.71	1.01
Ca+ Mg	%	2.3 – 4.2	3.41
Zn	ppm	12.0 – 26	18.04
Cu	ppm	5.0 – 22	10.28
Fe	ppm	204.0 – 400	295.44
Mn	ppm	39.0 - 79	55.28

Table 5: Correlation coefficient (r) between soil attributes and nutrients status of citrus leaves (Sahiwal)

Soil attributes	Plant nutrients							
	N (%)	P (%)	K (%)	Ca+Mg (%)	Zn (ppm)	Cu (ppm)	Fe(ppm)	Mn (ppm)
pH	0.077	-0.038	-0.186	0.156	-0.174	0.171	-0.160	-0.139
Organic matter	0.541**	0.345	-0.147	0.215	0.055	-0.148	0.029	-0.153
Clay	-0.067	0.165	0.485**	0.225	0.113	-0.213	-0.193	-0.121
Calcium carbonate	-0.022	0.105	0.300	0.538**	0.211	0.146	0.071	-0.107

Table 6: Correlation coefficient (r) between nutrient status of soil and citrus leaf (Sahiwal)

Soil nutrients	Plant nutrients							
	N	P	K	Ca+Mg	Zn	Cu	Fe	Mn
N	0.629**							
P		0.203						
K			0.232					
Ca+ Mg				0.557**				
Zn					0.286			
Cu						-0.135		
Fe							0.55**	
Mn								0.008

*Significant at 5% level, ** Significant at 1% level.

Table 7: Critical limits for macro and micronutrients in soil and plants

Elements	Form	Deficient	Low range	Satisfactory range	High range	Author
Soils						
N (%)	Total	< 0.028	0.03-0.04	0.049	> 0.05	Jackson (1962)
P (ppm)	Available	< 3.0	3.0-4.0	5.7	> 8.0	Watanabe and Olsen (1965)
K (ppm)	Extractable	10-25	100	125-175	> 200	Temhane and Subbiah (1962)
Co (me l^{-1})	Soluble	< 0.01	0.1-1.0	1.0-10	10-20	Harding and Chapman (1950)
Mg (me l^{-1})	Soluble	< 0.2	0.2-3.0	3.0-5.0	10-20	Cottenie *et al.* (1979)
Zn (ppm)	DTPA-TEA	< 1.0	1.0-2.0	2.0- > 2.0	> 3.0	"
Cu (ppm)	"	< 1.0	1.0-2.0	2.0- > 2.0	> 3.0	"
Fe (ppm)	"	2.5	2.5-4.5	> 4.5	-	"
Mn (ppm)	"	Critical level	1.2			

Element (%)	Deficient	Low range	Satisfactory range	High range	Excess range	Author
Plants						
N	0.60-1.90	1.90-2.10	2.20-2.7	2.80-3.50	> 3.60	Chapman (1960)
P	< 0.09	0.09-0.19	0.19-0.29	0.29-0.39	> 0.30	"
K	0.15-0.30	0.40-0.90	1.00-170	1.80-1.90	> 2.00	"
Ca	< 2.0	2.00-2.90	3.00-6.0	6.10-6.90	> 7.00	"
Mg	0.05-0.15	0.16-0.20	0.30-0.6	0.70-1.0	> 1.00	"
Zn	4.0-15.0	15.00-24.0	25.00-100	110-200	> 200.00	"
Cu	< 4.0	4.10-5.0	5.10-15.0	15.0-20.0	> 20.00	"
Fe	< 40.0	40.00-60.0	60.00-150.0	> 150	> 240.00	"
Mn	5.0-20.0	21.00-24.0	25.00-100.0	100-200	300-1000	"

be converted to insoluble Zn by hydroxide, or formation of Ca-zincate, Fe may be converted from ferrous to ferric and Mn from divalent form to tetravalent form.

Correlation between soil organic matter and leaf nutrient contents: There was a highly significantly positive correlation between soil O.M and leaf N and P and nonsignificant positive correlation with Ca+Mg, Zn, Fe and nonsignificant negative correlation with K, Cu and Mn (Table 5). The reason for highly significant positive correlation with N and P might be that total N is 1/20th of organic matter in soil. So, there is a direct increase in soil N with increase in soil organic matter. Phosphorus is carried in organic combination in organic matter which is liberated upon mineralization. Leaf K has no direct relation with soil O.M perhaps clay amount and type controls it in soil and plant. McGrath *et al.* (1988) also found similar findings particularly regarding leaf macronutrients relations with soil O.M.

Correlation between clay contents and leaf nutrients: The data indicated that there was a highly significant positive correlation with leaf K, positive nonsignificant correlation with P, Ca+Mg, Zn. A negative correlation with the leaf N, Cu, Fe and Mn was observed (Table 5). The possible reason for the positive relationship between soil clay and leaf K and Ca+Mg contents might be the fact that clay has high structural and exchangeable K. The negative relationship between clay content and leaf N was due to the protein clay combinations in soil. Nitrogen in soil is stabilized through reaction between certain clays (beidellite) and protenaceous substances and other nitrogen compounds (Brady, 1966). The possible reasons for the negative relation between clay content and leaf Cu, Fe and Mn was perhaps the high pH due to the dominance of Ca+Mg.

Correlation between calcium carbonate and leaf nutrients: The results indicated that correlation between $CaCO_3$ was significantly positive with leaf Ca+Mg, P, K, Zn, Cu and Fe was non-significantly positive but negative correlation with N and Mn was observed (Table 5). There is no possible reason for negative correlation with N. It might be only due to the dilution of N in leaf because its concentration in soil is very low. The increased uptake of Ca with increasing $CaCO_3$ in soil might be due to increased amount of Ca on exchange complex as well as in soil solution. The decreased availability of Cu and Mn at high $CaCO_3$ content was probably due to high pH and precipitation of these elements.

Correlation between soil nutrients and leaf nutrients: The data indicated that there was a significant positive correlation between soil and associated leaf N and Ca+Mg whereas, a positive correlation was found between P and K content of soils and their respective composition associated with leaf samples (Table 6). The direct relationships might be due to the fact that these nutrient elements were present in soil in the form of ions on exchange sites and are also in equilbrium with the soil solution. The soil solution was in direct contact with the plant roots through which these nutrients are translocated to the leaves. These results are confirmed by the work of Dasberg *et al.* (1988).

The data also showed that there was a positive correlation between Zn, Fe and Mn contents of soil and Zn, Fe and Mn of citrus leaf respectively. The positive correlation was again due to the presence of these nutrients elements in soil on exchange sites and in soil solution and their subsequent uptake by the plants. Hellin *et al.* (1987) also reported similar results. A direct negative correlation is also apparent between soil Cu content and leaf Cu content respectively. These might be due to the possibility that many diverse factors were simultaneously acting upon the uptake mechanism of the plant and the net nutrient uptake was dominantly affected by one factor in one plant while a different factor dominated in the other case. Similar explanation was given by Fawzi *et al.* (1984).

All the soil samples were deficient in Zn, more than 80% low in N and K and more than 50% in P and 100% sufficient in Fe and Mn. In case of leaf samples no one was deficient in P, K, Fe, Cu and Mn while more than 60% were low in K and Zn and more than 30% sufficient in N. Nitrogen, phosphorus, potassium and zinc should be applied to the citrus orchards.

References

Anonymous, 1989-90. Economic survey. Ministry of Finance, Finance Div. Govt. Pakistan, Islamabad, Pakistan.

Birriel, A., F. Reyes and G. Laborem, 1984. Determination of nutritional status of the CENIAP citrus rootstock orchard. Agronomia Tropical, 34: 131-153. Venezuela.

Brady, N.C., 1966. The Nature and Properties of Soils. 8th ed. The McMillan Co., New York, pp: 147-148.

Chapman, H.D., 1960. Leaf and soil analysis in citrus orchards. Agricultural "Experimental Station-Extension Serv. Univ. California, USA.

Cottenie, A., M. Verloo, G. Velghe and L. Kiekens, 1979. Analytical Methods for Plants and Soils, pp: 27-28.

Dasberg, S., A. Bar-Akiva, S. Spazisky and A. Cohen, 1988. Fertigation versus broadcasting in an orange grove. Fertilizer Res. 15:147-154. Soil Phys. Agric. Res. Org., Israel.

Fawzi, A.F.A., A.H. Firgany, S.H. Sanad and F.F.K. El-Baz, 1984. Mineral nutrition of Naval orange at alternate bearing. 5^{th} Proc. Inter. Colloquium for the optimization of Plant Nutr., 1: 199-206. Natl. Res. Center, Cairo, Egypt.

Harding, R.B. and H.D. Chapman, 1950. Progress report on a study of soil characteristics in forty high performance orange orchards in California. Soil Sci. Soc. Am. Proc., 10: 243-248.

Hellin, E., R. Urena, F. Sevilla and C.F. Akcaraz, 1987. Comparative study on the effectiveness of several compounds in the iron chlorosis connection in citrus plants. J. Plant Nutr., 10: 411-412.

Hiroce, R., J.R. Gallo, J. Tesfilo, Sobrinho, A.A. Caetano, O. Rodriguez and J. Pompen Junior, 1984. Effect of 27 years of NPK fertilization on leaf macro and micronutrient contents of Baianinha orange. Empresa Catarinense de pesquisa Agropecuaria S.A. 2: 605-611. Brazil.

Jackson, M.L., 1962. Soil Chemical Analysis. Constable and Co. Ltd., London U.K.

Lal, H. and R.M. Sherma, 1985. Effect of nitrogen levels on growth, yield and quality of unshiumandarin. Progressive Horticulture, 17: 336-339.

Lindsay, W.L. Norvell, 1978. Development of a DTPA Soil test for Zn, Fe, Mn and Cu. Soil Sci. Soc. Am. J., 42: 421-428.

Lipas, E., 1986. Soil fertility levels in finnish citrus orchards. Finnish Forest Res. Inst. Dep. Soil Sci., 66: 19.

Liu, X.H., X.Q. Zhao, J.J. Zheng and H.C. Xie, 1984. A study of some mineral nutrients in the leaves of major cultivars for citrus. In Funjiam Pravince. Ujian Agric. College, 13: 31-38.

McGrath, S.P., J.R. Sanders and M.H. Shalaby, 1988. The effects of soil organic matter levels on soil solution concentrations and extractabilities of Mn, Zn and Cu. Geoderma, 42: 177-188.

Moodie, C.D., H.W. Smith and McCreery, 1959. Laboratory Manual for soil fertility. Washington State College, Mimeograph, 9: 31-39.

Munir, T.M., 1990. Physical, Chemical and nutritional status of the soils under citrus orchards in Sargodha district. M. Sc. Thesis, Dep. Soil Sci., Univ. Agric., Faisalabad, Pakistan.

Reddy, P.S. and G.S. Swamy, 1986. Studies on nutritional requirement of sweet orange (*Citrus sinensis* Linn) variety sathgudi. South Indian Hort., 34: 288-292.

Sharma, O.N., K.R. Gupta and R.K. Gupta, 1986. Soil status of healthy and chlorotic citrus orchards of Jammu (J and K). Research and Development Report, 3: 41-44.

Sharma, P.S. and P.V. Reddy, 1986. Nutrient status of leaves of acid lime (*Citrus aurantifolia*) (Christin) (Suringle) from fruiting and non-fruiting terminals. J. Res. APAU., 14: 83-84.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and pocedures of statistics. Second edition McGraw Hill Book Co. Inc, New York, USA.

Temhane, R.V. and B.V. Subbiah, 1960. Correlation between soil analyses and response to fertilizer with special reference to rice crop in India. IRC Newsletter, 9: 1-10.

Tuzcu, O., M. Kaplankiran, M. Ozsan, O. Gezerel and A.Y. Hizal, 1986. Nutritional status of citrus orchards in the mditerranean region of Turkey. Fruits, 4: 49-54.

U.S.Salinity Lab. Staff, 1954. Diagnosis and improvement of saline and alkali soils USDA hand Book 60, pp: 160.

Watanabe, F.S. and S.R. Olsen, 1965. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from Soil. Soil Sci. Soc. Am. Proc., 29: 677-678.

Zhuang, Y.M., L.R. Li, U.Y. Jing, R.J. Wang and M.H. Su, 1985. Preliminary studies on nutrient conditions in the high yielding ponkan (*Citrus reticulata* Banco) orchards in Fujian, China, J. Fujian Agric. College, 14: 23-29.