INDIAN JOURNAL OF
ARID HORTICULTURE
Vol.9 (1-2): 20-24

Influence of soil and leaf nutrients on quality of kinnow mandarin grown in aridisol of Punjab, India

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(Received: 10.11.2014; Accepted: 20.02.2015)

Abstract

The present study was conducted to determine the relationship between soil and foliar nutrient status with fruit quality of Kinnow orchards in aridisol of Punjab. All Kinnow orchards soils were found alkaline to saline in nature with pH value ranging from 8.4 to 9.5 and deficient of macronutrients while sufficient in most of micronutrients. Foliar analysis suggested that percent samples of different locations were nearly sufficient in Mn, Cu, Fe and Zn and deficient of K and N. Soil properties viz; pH, EC and $CaCO_3$ showed an adverse relationship with available major and micro-nutrients. Correlation studies suggested that soil properties showed a significant and negative relationships with soil and foliar N, P and K, while non-significant but negative with Mn, Cu, Fe and Zn. The results show pronounced effect of the soil and leaf nutrient conditions on physico-chemical quality characteristics of 'Kinnow' mandarin fruit besides other un-foreseen factors at different locations.

Key words: *Aridisol, Kinnow orchards, Macronutrients, Micronutrients, Punjab*

Introduction

Kinnow, is a hybrid between King Sweet orange and Willow Leaf mandarin, it is one of the most promising hybrid not only for the plains of northern India but also in the valleys and hilly tracts of medium altitude. Local over fertilization may decrease ground water quality, reduce profit margins, induce deficiency of other elements and interfere with metabolic processes. Soil and leaf analysis can be used to evaluate the nutritional status of the trees and nutrient availability in the soil to supply the trees with nutrients requirement (Embleton *et al.* 1996). Among them adequate supply of plant nutrients is a very important factor to produce the good quality fruits (Ioannis *et al.* 2004). The application of macro-nutrients particularly nitrogen (N), phosphorus (P) and potassium (K) plays important role in yield, as well as fruit quality (Liu *et al*. 2010), especially N is necessarily needed for optimum vegetative, as well as reproductive growth (Alva *et al*. 2006). The level of N fertility has more influence on the growth, yield and quality of citrus than any other single plant nutrient (Thompson *et al.* 2002) Hence, a balanced supply of N, P and K gives high yield with better citrus fruit quality (Albrigo 2002). In advanced countries, leaf tissue testing is a valuable tool to examine the tree nutritional status (Obreza *et al*. 1999), while soil analysis is common practice for evaluation of soil nutrients and planning for nutrient application to maintain high yield and good quality of citrus fruit (Lester *et al*. 2010), which is rarely practiced in aridisol. Although old information is available on leaf and soil analysis in citrus producing areas of aridisol, but it could not be adopted as a regular practice for designing a fertilizer application program. The present study was conducted to investigate the relationship of soil and foliage nutrient status with fruit quality of 'Kinnow' mandarin at different locations in the aridisol.

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Material and Methods

A survey from 2012-14 was carried out to investigate the causes of Kinnow orchards deterioration in aridisol and entisol of Punjab. Thirty six Kinnow orchards were selected and 108 soil samples were collected from them. Nine Kinnow orchards selected each for high yielding and low yielding orchards on the basis of yield. HYO = High yielding orchards (138-145kg/tree) and LYO = Low yielding orchards (75-104 kg/tree) on the basis of yield as per recommended. Four sites were selected in each Kinnow orchard; each site was a crossing point of four plants. Four samples were taken from each garden upto 15 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. One hundered and eight Kinnow leaf samples were collected from 5-7 months old spring flush immediately above the node, from the same orchards from where soil sampls were collected. Each plant sample was a composite of three sub-samples. Leaves were collected from 8-10 plants haphazadarly from an orchard and a total of 100 leaves were taken from each sample. All the leaves were sampled non-fruiting twigs 3-6 feet above the ground level. No Kinnow 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 varoius nutrients.

Analysis of soil, plants and fruit samples:

Soil and plant samples were analyzed using the following methodology. Soils were analyzed for their physico-chemical properties such as soil texture (Koehler *et al.* 1984), soil pH (1:2) (Mclean 1982) using 105 Ion Analyzer pH meter, Soil EC(1:2) and calcium carbonate content (Nelson and Sommers 1982). AB-DTPA extracts of soils (Soltanpour and Schwab, 1977) and plant digest (using HNO_3 and $HClO_4$ mixture for digestion) were prepared and analyzed for Cu, Fe, Mn and Zn using Atomic Absorption Spectrophotometer "Perkin Elmer" model No.2380 while K using' Perkin Elmer' Flame Photometer model No.2380 and P by Spectrophotometer "Spectronic Lmbda (ë) 35" using required standard solutions. Available nitrogen in soils and plants were determined using Kjeldahl distillation procedure as described by Subbiah and Asija (1956). The data were subjected to linear and multiple correlation analyses in order to diagnose the optimum leaf and available soil nutrients in relation to soil properties. Fruit quality parameters viz; SSC (soluble solids content), acidity and Vitamin-C were estimated as per recommended method.

Results and Discussions

The mean EC (Electrical conductivity) observed higher in low yielding orchards (0.39± 0.3dS m^{-1}) (Table 1). The results suggested that these soils were low (< 2-4 dS m^{-1} at 25°C) in electrolyte concentration due to leaching induced by heavy rainfall. Similar trend was found in $CaCO_3$ content. Soil texture of high and low yielding Kinnow orchards was loamy sand (Table 1). However, being well drained in nature, the chances of nutrient leaching are always more if the level of organic matter is not maintained. Thus, it is very important to add organic and chemical fertilizer to maintain adequate fertility status of these soils. Soil pH of high and low yielding orchards ranged from 8.4-9.2 and 8.5-9.5 (Table 1). Available N, P and K concentrations in Kinnow orchard grown in aridisol of Punjab was found sub-optimum in different Kinnow orchards (Table 2). P varied from1.21-5.47 and 1.21-1.46 kg/ha in two different productive orchards. Exchangeable K ranged from 103.2-121.4 and 51.0-103.2 kg/ha in high and low yielding Kinnow orchards in aridisol (Table 2). Similarly, Mn content varied from 1.78-3.80 and 1.89-2.94 in high and low yielding orchards. Values for Fe and Zn varied from 1.46-5.68 and 0.31-2.56 in high and low productive Kinnow orchards grown in aridisol (Table 2). The data showed that all samples contained low N, P and K (Table 4). The data showed that nearly all soil samples were deficient of Zn and Fe while for Cu and Mn sufficient. N concentration in the leaves ranged between 2.18-2.89 with the mean value of 2.32±0.1%**,** on dry matter basis, which tends to be low in high yielding Kinnow orchards (Table3). P-concentration in the mature leaves of high and low yielding orchards ranged between 0.09-0.13%, and 0.10-0.17 with respective means 0.09±0.01 and 0.15±0.20, which ranged between low and sufficient levels and with medium level mean. P & K concentration in the leaves ranged between low yielding and high yielding orchards (0.46-1.78%) and the mean is medium. Fe and Cu concentrations can be higher than, equal to, those in normal trees. The mean Fe-concentration was high and ranged from (249.5-492.0 ppm) in high yielding orchards (369.7±77.7) than mean value of (242.3±48.5) low yielding orchards. Mn ranged from 16.78-36.78 ppm and 191.3-362.4 ppm in high and low yielding orchards evaluated between low and medium. Zn concentration was low in most cases ranging between 13.61-41.0 and12.9-39.1 ppm in high and low yielding Kinnow orchards, respectively. Zn deficiency is widespread in citrus trees in India (Srivastava and Singh 2004) and in soils with very high pH, availability of Zn to plant roots is extremely low. In addition, Srivastava and Singh (2009) found that when severe Zn deficiency symptoms appear, early spring foliar sprays could increase the micronutrient concentration in the targeted organs.

Correlation between soil/foliar nutrients with soil physico-chemical properties and quality of fruits:

Data presented in Table 5 revealed that fruit yield was significantly and positively correlated with available N, P, K and Mn but, negatively and significantly with soil pH, EC and $CaCO_3$ content. Table 5 and 6 revealed that available/ foliar N showed a significant but negative relationship with soil pH (r = -0.469*/r = -0.532**). Similar, results were reported by Srivastava and Singh, (2004). A highly significant and negative relation was observed with EC (r = -0.522**/r =-0.573**) from this it may be concluded that increase of pH and EC resulted decrease in N availability. Data presented in Table 5 revealed that available P was significantly and negatively correlated with soil pH but non-significantly with EC and $CaCO_3$ content. From this it might be concluded that increase in the soil pH, EC and $CaCO_3$ would decrease the availability of foliar P. Exchangeable K like other macro-nutrients decreased with increase in soil pH and EC (Table 5) (r =

-0.633**, r = -0.589**). Similar, results were reported by Chinchmalatpure *et al.* (2000). However, foliar K significantly and positively correlated with EC (r = 0.416*). Available Mn showed non-significant but negative relationship with soil properties viz; pH and $CaCO_3$ but significant and negative relationship with EC (Table 5). Table 5 found that foliar Mn significantly and negatively related with soil pH (r = -0.477*). Foliar Cu showed negative and significant relationship with $CaCO_3$ content (Table 6). Available soil and foliar Fe showed negative and non-significant relationships with soil properties viz; soil pH, EC and $CaCO_3$ content (Table 5 & 6). Foliar zinc showed significant and negative relationship with soil pH (r = -0.456*) and EC (r = -0.451*) as shown in Table 6. Table 5 it has been shown that available N showed a significant and positive correlation with P (r = 0.533**), K(r = 0.622**) and Cu (r = 0.437*). Soluble solids content exhibited positive and significant correlation with vitamin C content (Table 7). Soluble solids content was positively correlated with soil (r = 0.591*)/ foliar N (r = 0.671*). Table 7 and 8 revealed that soluble solids content showed the significant and positive relation with soil K (r = 0.622**)/foliar (r = 0.742**). Fruit juice content exhibit the positive and significant correlation with available N (r = 0.577*) and exchangeable K (r = 0.685*) as shown in Table 7. Whereas, fruit juice related positively and significantly with foliar N (r = 0.566*) and foliar K (r = 0.561*) as shown in Table 8. Vitamin C content positively and significantly correlated with available P, Mn and Fe (Table 7). Foliar Mn correlated significantly with vitamin C content (Table 8).

Table1. Soil physico-chemical properties of Kinnow orchards growing aridisol.

	HYO		LYO	
	Range	Mean +SD	Range	Mean +SD
pH	8.4-9.2	8.8 ± 0.3	8.5-9.5	9.2 ± 0.3
EC(dS m^{-1})	0.06-0.32	0.14±0.1	0.13-0.84	0.39±0.3
$CaCO_3$ (%)	2.7-5.2	4.1±0.8	3.6-7.6	5.9±1.4
Sand (%)	46.8-72.4	57.7±2.9	47.2-55.1	62.4 ± 1.1
Silt (%)	20.4-39.2	31.0 ± 2.2	28.0-37.8	34.8 ± 1.0
Clay (%)	9.5-15.0	12.6 ± 0.5	11.6-17.7	14.4 ± 0.6

Table 2. Soil available N and AB-DTPA- P, K, Cu, Fe, Mn and Zn in Kinnow orchards growing aridisol.

	HYO		LYO		
	Range	Mean +SD	Range	Mean +SD	Evaluation
N (Kg/ha)	120-202	148.2±32.4	69-89	80.89±7.4	Low
P (Kg/ha)	1.21-5.47	2.69±1.5	1.21-1.46	1.26±0.1	Low
K (Kg/ha)	103.2-12	1.4114.5±8.3	51.0-103.2	73.52±26.7	Low
Mn (Kg/ha)	1.78-3.80	3.03±0.5 5	1.0-103.2	73.52±26.7	Medium
Cu (ppm)	0.52-2.36	1.75±0.7	1.07-1.56	1.20±0.1	High
Fe (ppm)	1.79-5.68	3.50±1.5	1.76-2.20	2.04±0.1	Low
Zn (ppm)	0.86-2.56	1.39±0.3	0.80-1.60	1.17±0.1	Low

Table 3. Foliar macro and micro-nutrients of Kinnow orchards grown in aridisol

	HYO		LYO		
	Range	Mean ± SD	Range	Mean ± SD	Evaluation
N(%)	2.18-2.89	2.32 ±0.1	2.11-2.53	2.28±0.20	Low
P(%)	0.06-0.13	0.09±0.01	0.10-0.17	0.15±0.20	Medium
K(%)	0.46-1.43	1.04±0.30	0.58-1.78	1.09±0.50	Medium
Mn(ppm)	16.78-36.78	23.34±7.6	17.14-32.42	24.94 ±5.30	Medium
Cu(ppm)	42.00-118.7	73.64±29.3	14.70-57.80	35.30 ±16.5	High
Fe(ppm)	249.5-492.0	369.7±77.7	191.3-362.4	242.3±48.5	High
Zn(ppm)	13.61-41.6	18.90± 3.7	12.9-39.1	16.12±2.1	Low

HYO = high yielding orchards
LYO = low yielding orchards

Table 4. Index values for available N and AB-DTPA- P, K, Cu, Fe, Mn and Zn in soils reported by various sources.

Soil Nutrient elements	Soil fertility class			References
	High	Medium	Low	
N (kg/acre)	> 543	271-543	< 271.0	Subbiah and Asiza (1956)
P(kg/acre)	> 9.0	5-9	< 5.0	Olsen *et al.* (1954)
K (kg/acre)	> 138.7	54.8-138.7	< 54.8	Jackson (1967)
Mn (ppm)	> 7.0	3.5-7.0	< 3.5	Foliet and Lindsey (1970)
Cu (ppm)	> 0.4	0.2-0.4	< 0.2	Jones (1972)
Fe (ppm)	> 9.0	4.5	< 4.5	Lindsey (1979)
Zn (ppm)	> 1.2	0.6-1.2	0.6	Peryea (2000)

Table 5. Relationship among macro and micronutrients of soils with soil properties of the tested soil samples of aridisol.

	Soil pH	EC	$CaCO_3$	N	P	K	Mn	Cu	Fe	Zn
Yield	0.548**	0.491**	0.448*	0.460*	0.830**	0.615**	0.549**	0.313	0.375	0.223
Soil pH		0.435*	0.212	-0.469*	-0.567**	-0.633**	-0.046	-0.138	-0.276	-0.151
EC			0.213	-0.522**	-0.241	-0.589**	-0.446*	-0.323	-0.156	-0.274
CaCO3				-0.273	0.036	-0.109	-0.320	0.318	-0.288	0.140
N					0.533**	0.622**	0.365	0.437*	0.088	0.253
P						0.457*	-0.110	0.184	0.221	0.165
K							0.205	0.265	0.101	0.365
Mn								0.171	0.187	-0.092
Cu									0.226	0.400*
Fe										0.507**
Zn										1

* = Significant at 5% level
** = Significant at 1% level

Table 6. Relationship among macro and micronutrients foliar with soil properties of the tested soil samples of aridisol.

	N	P	K	Mn	Cu	Fe	Zn
Yield	0.855**	0.581**	0.079	0.134	0.649**	0.627**	0.588**
Soil pH	-0.532**	-0.392*	0.202	-0.477*	-0.272	-0.265	-0.456*
EC	-0.573**	-0.583**	0.416*	-0.061	-0.334	-0.275	-0.451*
CaCo3	-0.471*	-0.394*	0.096	-0.038	-0.387*	-0.360	-0.214
N		0.605**	-0.057	-0.096	0.328	0.356	0.688**
P			0.004	0.196	0.574**	0.398*	0.453*
K				0.168	0.224	0.304	-0.055
Mn					-0.087	-0.011	0.042
Cu						0.432	0.481*
Fe							0.491**
Zn							1

* = Significant at 5% level
** = Significant at 1% level

Table 7. Relationship among soil macro and micro-nutrients with quality of fruits.

	Acidity	Juice	VitaminC	N	P	K	Mn	Cu	Fe	Zn
SSC	-0.335	0.205	0.516*	0.591*	-0.135	0.622**	0.160	-.389	0.160	0.404
Acidity		-0.401	0.406*	0.210	0.077	-0.211	-0.020	0.109	-0.097	0.003
Juice			0.380	0.577*	-0.219	0.685*	-0.331	-0.123	-0.364	-0.349
Vitamin C				0.272	0.668*	0.003	0.628*	-0.089	0.511*	0.142

* = Significant at 5% level
** = Significant at 1% level

Table 8. Relationship among foliar macro and micro-nutrients with quality parameters of the tested samples of aridisol.

	Acidity	Juice	Vitamin C	N	P	K	Mn	Cu	Fe	Zn
SSC	-0.335	0.205	0.516*	0.671*	-0.175	0.742**	0.260	-0.281	0.100	0.346
Acidity		-0.401	0.406*	0.314	0.171	-0.321	-0.120	0.209	-0.162	0.102
Juice			0.380	0.556*	-0.316	0.561*	-0.232	-0.423*	-0.234	-0.109
Vitamin C				0.128	0.162	0.012	0.527*	-0.091	0.233	0.091

* = Significant at 5% level
** = Significant at 1% level

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