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COMPARATIVE STUDIES OF SOIL NUTRIENT STATUS AND FRUIT CHARACTERISTICS OF LITCHI (*LITCHI CHINENSIS*. SONN) ORCHARD UNDER SUB-MOUTANE ZONE OF PUNJAB

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ABSTRACT
An experiment was conducted during 2013 and 2014 to study the soil nutrient status and fruit characteristics of Litchi (*Litchi chinensis* Sonn.) orchards under Sub-mountane zone of Punjab. Available soil pH (6.7 to 8.6), EC (0.15-0.44) dS/m, OC (0.22-0.39%), $CaCO_3$ (0.11-4.90%), N (302.4-436.8 kg/ha), P(11.9 to 24.3 kg/ha) and K (70.0 to 373.0 kg/ha) whereas soil micronutrients ranged from Zn(0.3-10.6 mg/ha), Fe(2.25-105.6 mg/ha), Mn(0.18-18.8 mg/ha) and Cu(-0.4-8-8.8) at 0-30 cm depth of soil in both litchi cultivars. Soil N, K and Zn content was positive and statistically significant with fruit yield whereas soil K was also positively significant correlate with fruit size, pulp and TSS and pulp stone ratio. From the present investigation it was conclude that subsurface of soil was deficient in soil N and k however the surface soil was adequate but few orchards were inadequate range.Soil micro-nutrients Zn,Cu,Mn and Fe content of soil were available in adequate ranges however fewer samples of Zn and Fe available in lower percentage as compare to other micro-nutrients.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.)recognized as "Queen of the fruits" is an important sub tropical evergreen fruit crop belongs to the family Sapindaceae. It is native of south china and reached India by the end of 17th century due to unique temperature and climatic requirements; it is widely distributed in the tropics and warm subtropics of the world (Pandey and Sharma, 1989). In India, Litchi is cultivated on an area 82,330 hectares of land with an annual fruit production of 0.57 mt and productivity of 7.02 MT/ha (FAO, 2013).

Although demand for litchi fruit is escalating in the world due to nutraceutical properties however, fruit productivity per unit area is quite low. The basic idea to conduct the nutritional surveys of litchi orchards is to be acquainted with the nutrient status of soil physico-chemical characteristics and their effect on fruit morphometric and fruit yield attributes.In Punjab, litchi growers are paying a very little attention on soil nutrition management and this could become one of the major contributing factor for lower fruit yield with poor quality characteristics. It is also well documented that poor soil nutriention management in litchi orchards substantially contributes towards fluctuation in fruit yield (Montanes *et al.*,1993). The augmentation in plant growth and fruit yield with the application of macro and micro nutrients as soil is also reported by Lal *et al.* (1999) and Sharma *et al.* (1995).Litchi nutrition management is based on monitoring soil nutrient status and adjustment of fertilizer practices should be done on the basis of tree canopy and fruit yield potential (Menzel *et al.*, 1992; Menzel, 2001). Likewise, vegetative growth and fruit yield was affected with the changes in soil mineral nutrients in litchi (Fan and Huang, 2004). Fruit growers must produce high-graded quality fruits in terms of taste, colour, flavour, and texture to satisfy consumer demands. Skin colour, soluble solid concentration (SSC), titratable acidity (TA) and SSC: TA ratio is generally considered important quality attributes to determine fruit quality at harvest (Oosthuyse and Westcott, 2005). Zhang *et al.* (2004) opined that nutrition plays significant role in litchi flowering, fruiting and productivity.

Diagnosis of nutrients through soil analysis represents the fundamental criteria and commonly used method to study the nutritional status of orchards. Hence, present investigations were conducted to study inherent physicochemical characteristics of soil and fruits, the intention of this work was to identify the adequate and inadequate level of orchards and their correlation with fruit yield and other quality parameters.

MATERIALS AND METHODS

A survey was carried out in litchi orchards to study soil nutritional status in Hoshiarpur, Gurdaspur and Pathankot districts of Punjab at the latitude and longitude of 32ºN and 75.27ºE, 31.32ºN and 75.57ºE and 32.17ºN and 75.45ºE, respectively. Soil samples were collected from 0-15 and 15-30 cm depths in between four plants from each area during the survey to study the general fertility of the soils of the litchi growing orchards. Each sample was formed from six random samples of an orchard and pooled together to form one representative sample for analysis (Jackson, 1973). The soil

samples were dried in shade at ambient temperature, passed through 2 mm sieve and stored for further analysis. The 2 mm sieved soil was ground using agate pestle and mortar to pass through 0.2 mm sieve for determination of organic carbon. The soil samples were analyzed for pH, EC, organic carbon, calcium carbonate ($CaCO_3$) available N, P, K, available Fe, Mn, Zn, Cu and hot water soluble B. The soil organic carbon was estimated by following Walkley and Black's method (1934). Available N was estimated by alkaline permanganate method. Available P was extracted using Olsen's reagent and estimated through spectrophotometer (Systronics PC based Double Beam Spectrophotometer, 2202) after developing blue colour by ascorbic acid method. Available K was extracted with neutral 1N ammonium acetate and estimated by flame photometer. The available Ca and Mg were estimated by using atomic absorption spectrophotometer after extraction with neutral normal ammonium acetate. The DTPA extractable Fe, Mn, Zn and Cu were estimated by using atomic absorption spectrophotometer. Calcium carbonate was computed with the Puri's Rapid Titration Method (Puri, 1930).

Fruit yield per plant was estimated at optimum maturity and was expressed in 'Kg/tree'.Fifty fruits were randomly harvested for the estimation of fruit size with the help of Vernier's Calliper and average was expressed in 'cm'.Fifty litchi fruits were weighed on digital weighing balance and average was expressed in 'g'.Aril percentage was estimated by extracting pulp from fruit and weight. Percentage was calculated on the basis of total fruit weight. Fruit density was calculated by dividing the fruit weight with fruit volume.

$$\text{Fruit density} = \frac{\text{Fruit weight}}{\text{Fruit volume}}$$

TSS was determined with Erma Hand Refractrometer at room temperature. One drop of extracted juice was placed on absolutely dry prism and readings were recorded in degree Brix (%). The values of total soluble solids were corrected at 20°C.Juice acid content was determined by titrating two ml of juice against 0.1 N NaOH solutions using phenolphthalein as an indicator. The end point was noted at the appearance of light pink colour and the results were expressed in terms of malic acid.

$$\text{Juice acidity (\%)} = 0.0067 \times \frac{0.1\text{N NaOH used}}{\text{Juice taken}} \times 100$$

(1 ml of 0.1 N NaOH = 0.0067 g malic acid)

RESULTS AND DISCUSSION

The present investigation entailed that soil physic-chemical characteristics were analysed of Litchi cultivars 'Dehradun' and 'Calcuttia' and result presented in Table 1. Menzel *et al.* (1990) reported that soil pH of commercial orchards established in China and Australia varied from 5.0 to 6.0; whereas orchards located in various states in India and Florida on calcareous soils ranged from 7.0 to 8.5. In litchi cv. Dehradun, soil pH ranged from 7.1 to 8.6, 7.3 to 8.6 and soil organic carbon content ranged from 0.25 to 0.37, 0.27 to 0.39 per cent at 0-15 cm depth with a mean value of 0.31 per cent whereas pH value ranged 6.7 to 7.9 and 6.4 to 7.6 Bali *et al.* (2010) reported that pH of soils piedmont and alluvial plain eco-sub region varied from 7.0 to 9.3. Organic carbon ranges varied from 0.12 to 0.26 and 0.17 to 0.24 per cent at 15-20 cm depth of soil.Similar findings are also reported by Brar *et al.* (1983) while analyzing the soils of Majha tract of Punjab and found that the soils were either low (<0.40 %) or medium (0.40 to 0.75 %) in OC whereas Chahal *et al.*, (2005) observed that organic carbon content, varied from 0.04 to 0.76%, 0.15 to 0.51% and 0.13 to 0.65% in the Entisols, Inceptisols, and Alfisols, respectively. In litchi cultivar 'Dehradun' available EC were ranged from 0.20 to 0.44 and 0.16 to 35 (dS/m) at 0-15 and 15-30 depths of soil however in cultivar 'Calcuttia' , The available EC was either low to high ranged 0.15 to 0.37 and 0.10 to 0.34 (dS/m) at different depths of soil. The available N was either low or moderate and ranged from 271.0 to 414.4 and 168.0 to 291.2 Kg/ha at 0-15 and15-30 cm depths of soil with mean 352.2 and 228.2 kg/ha whereas in other cultivar soil N ranged from 302.4 to 436.8 and 190.4 to 268.8 kg/ha. Similarly, these values were slightly higher than the values reported by Singh and Brar (2005) whereas Kumar (2014)The increase in available P, K and exchangeable Ca and Mg contents of soils under grass mulches may be due to increased microbial activity, fast decomposition, mineralization of mulches in the presence of nitrogen and improved soil structure.

The available P in cultivar 'Dehradun' the soil of different orchards varied widely from 11.9 to 22.8 and 4.4 to 19.8 kg/ha at surface and sub surface level of soil indicating that certain orchards were low/deficient and others were excess however in cv. Calcuttia it ranged from 13.3 to 23.3 and 5.4 to 19.3 kg/ha at different depths. Similarly, wide variation was noticed in available K in the present study that ranged from 101.9 to 258.7 and 94.1 to 232.6 kg/ha at 0-15 cm whereas in cv. Calcuttia varied from 88.9 to 386.8 and 88.3 to 256.1 kg/ha However, many orchards were found to be deficient/ low for K.Thus, the study revealed that the soils growing litchi are sufficiently rich in Ca and low in K status. Potassium status was not improved because an imbalance of K and Ca is likely to occur in these areas. The results of the present study indicated wide range in DTPA extractable Fe and Mn in soil.Similarly finding was reported by (Bakshi *et al.*, 2015) while analysis anola growing localities under Jammu regioni.e N (231.20 kg/ha), P (19.96 kg/ha), K (160.41 kg/ ha) and Mg (407.70 kg/ha).

In litchi cv. Dehradun soil DTPA extractable Fe ranged from 4.4 to 31.8, 2.2 to 24.8 kg/ha at 0-15 and 15-30 cm depths of soil whereas in litchi cv. Calcuttia ranged from 12.7 to 105.4, 3.7 to 61.9 kg/ha at different depths.

Available soil Mn ranged from 1.95 to 14.47, 0.18 to 6.61 kg/ha at 0-15 and 15-30 cm depths of different litchi orchards of both cultivars indicating that the soils of different orchards were almost at optimum/low level. Similarly, Cu was ranged from 3.2 to 8.8, 2.5 to 6.6 kg/ha whereas in cv. Calcuttia it varied from 0.1 to 2.6, -0.4 to 1.4 kg /ha. Soil Zn varied from 1.6 to 4.6, 1.1 to 2.9 kg/ha at 0-15 and 15-30 cm depth while in cv. Calcuttia ranged from 3.9 to 10.6, 0.3 to 8.3 at different depths.

These results evinced that Majority of surface samples of different districts of litchi growing area were under medium

Table 1: Soil physico-chemical characteristics of litchi orchards

Dehradun	pH		EC		Oc (%)		$Caco_3$ (%)	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Minimum	7.1	6.7	0.2	0.16	0.25	0.12	0.12	0.2
Maximum	8.6	7.9	0.44	0.35	0.37	0.26	3.8	4.95
S D	0.24	0.22	0.07	0.06	0.03	0.04	1.06	1.39
Mean	7.41 ± 0.07	7.15 ± 0.07	0.31 ± 0.02	0.26 ± 0.02	0.31 ± 0.01	0.20 ± 0.01	0.98 ± 0.32	1.39 ± 0.42
Calcuttia								
Minimum	7.3	6.4	0.15	0.1	0.27	0.17	0.21	0.26
Maximum	8.6	7.6	0.37	0.34	0.39	0.24	3.32	3.58
S D	0.28	0.31	0.06	0.08	0.04	0.03	1.11	1.32
Mean	7.9 ± 0.09	7.74 ± 0.08	0.28 ± 0.02	0.2 ± 0.02	0.31 ± 0.01	0.21 ± 0.01	1.61 ± 0.31	2.02 ± 0.37

Table 2: Soil macro nutrient status of litchi orchards

Dehradun	N		P		K	
Depth	0-15	15-30	0-15	15-30	0-15	15-30
Minimum	271	168	11.9	4.4	101.9	94.1
Maximum	414.4	291.2	22.8	19.8	258.7	232.6
S D	37.5	47.3	3.7	3.7	48.1	37.7
Mean	352.2 ± 11.3	228.1 ± 14.3	17.1 ± 1.1	9.3 ± 1.1	168.5 ± 14.5	143.4 ± 11.4
Calcuttia						
Minimum	302.4	190.4	13.3	5.4	88.9	88.3
Maximum	436.8	268.8	22.3	19.3	386.8	256.1
S D	42.6	33.6	2.3	4.5	93.1	51.2
Mean	357.52 ± 11.8	237.78 ± 9.3	19.1 ± 0.6	15.6 ± 1.2	201.5 ± 25.6	150.9 ± 14.2

Table 3: Critical limits for Soil nutrients

Determinant	Status			Reference
	Low	Medium	High	
OC (%)	< 0.40	0.40-0.75	> 0.75	Brar and Chhibba (1994)
N (kg/ha)	< 272	272-544	> 544	Singh and Brar (2005)
P (kg/ha)	< 12.5	12.5-22.5	> 22.5	Brar and Chhibba (1994)
K (kg/ha)	< 137.5	137.5-337.5	> 337.5	Singh and Brar (2005)
Zn (mg/kg)	< 0.58	0.58-8.80	> 8.80	Sidhu and Sharma (1995)
Cu (mg/kg)	< 1.12	1.12-3.02	> 3.02	Sidhu and Sharma (1995)
Mn (mg/kg)	< 14.20	14.20-111.60	>111.60	Sidhu and Sharma (1995)
Fe (mg/kg)	< 26.6	26.6-64.6	> 64.6	Sidhu and Sharma (1995)

Table 4: Soil macro nutrient status of litchi orchards

Dehradun	Zn		Fe		Cu		Mn	
Depth	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Minimum	1.67	1.12	4.41	2.25	3.27	2.57	1.95	0.18
Maximum	4.86	2.97	31.80	24.85	8.88	6.69	14.47	6.61
S D	1.1	0.5	7.6	5.9	1.6	1.1	4.0	2.2
Mean	2.59 ± 0.3	1.52 ± 0.2	10.52 ± 2.3	6.77 ±1.8	5.70 ± 0.5	4.46 ± 0.3	7.40 ±1.2	2.69 ± 0.7
Calcuttia								
Minimum	3.9	0.3	12.7	3.7	0.1	-0.4	3.5	3.6
Maximum	10.6	8.3	105.4	61.9	2.6	1.4	15.2	18.8
S D	2.1	2.1	28.4	18.0	0.9	0.6	3.6	3.8
Mean	7.4 ± 0.5	2.5 ± 0.5	48.6 ± 7.1	32.3 ± 4.5	0.8 ± 0.2	0.4 ± 0.1	8.1 ± 0.9	8.1± 0.9

ranges in available soil N. In Soil available P more than 50 per cent sample were observed in adequate amount at both depth of soil P whereas available soil K 15.6 and 32.1 per cent ranges were inadequate range in both the cultivars. Similar finding was reported by Sidhu and Sharma (1995) while surveying sub-mountane zone of Punjab DTPA-extractable Zn,Cu,Mn and Fe content of soil were available in adequate ranges however fewer samples of Zn and Fe available in lower percentage as compare to other micro-nutrients.

Correlation studies between soil nutrients and different fruit characteristics

The correlation matrix studies mentioned in table 6 showed that Soil K was positive and statistically significant with fruit yield, fruit length, fruit breadth, fruit weight, pulp, TSS and pulp stone ratio in both litchi cultivars.Likewise, soil N concentration had shown positive but statistically significant

Table 5: Soil nutrition status of litchi cv. 'Dehradun' and 'Calcuttia'

Cultivars	Determinant(kg/ha)	Soil Depth (cm) Per cent samples 0-15 Low	Medium	High	15-30 Low	Medium	High
Dehradun	N (kg/ha)	5.1	94.8	0.0	69.2	30.7	0.0
Calcuttia		15.0	85.0	0.0	75.0	25.0	0.0
Dehradun	P (kg/ha)	2.5	92.2	5.1	46.1	53.8	0.0
Calcuttia		0.0	82.1	17.8	57.1	42.8	0.0
Dehradun	K(kg/ha)	15.6	77.8	6.6	56.4	43.5	0.0
Calcuttia		32.1	57.1	10.7	53.5	46.4	0.0
Dehradun	Zn(mg/kg)	2.56	48.7	48.7	2.56	48.7	48.7
Calcuttia		3.6	39.3	57.1	3.6	39.3	57.1
Dehradun	Fe(mg/kg)	0.0	10.5	89.5	0.0	79.5	20.5
Calcuttia		78.6	21.4	0.0	78.6	21.4	0.0
Dehradun	Cu(mg/kg)	0.0	53.8	46.2	0.0	53.8	46.2
Calcuttia		0.0	39.3	60.7	0.0	39.3	60.7
Dehradun	Mn(mg/kg)	2.6	0.0	97.4	2.6	0.0	97.4
Calcuttia		0.0	2.3	97.7	0.0	2.3	97.7

Table 6: Correlation studies of soil and fruit physico-chemical characteristics of Litchi cv. 'Dehradun' and 'Calcuttia'

Cultivar	Nutrient element	Fruit yield(Kg)	Fruit length(cm)	FruitBreath (cm)	Fruit weight(g)	Fruit density	Pulp (%)	TSS(%)	Acidity (%)	Pulp stone Ratio(%)
Dehradun	N(Kg/ha)	0.81**	0.25	0.52*	0.20	0.33	0.32	0.24	0.28	0.38*
Calcuttia		0.75*	0.24	0.17	0.58*	-0.26	0.45*	-0.13	0.32*	0.51*
Dehradun	P(Kg/ha)	0.25	0.21	0.13	-0.18	0.24	0.18	0.18	-0.21	0.07
Calcuttia		0.30	0.27	0.11	-0.13	0.23	0.16	-0.28	0.21	0.18
Dehradun	K(Kg/ha)	0.37*	0.40*	0.43*	0.42*	0.46*	0.61*	0.46*	0.26	0.76*
Calcuttia		0.51*	0.36*	0.91**	0.93**	0.17	0.45*	0.35*	0.17	0.39*
Dehradun	Zn(mg/ha)	0.38*	0.12	0.19	0.23	0.33	0.39*	0.43*	0.06	0.31
Calcuttia		0.37*	0.25	0.28	0.34*	0.26	0.35*	0.04	0.13	0.33
Dehradun	Fe(mg/ha)	0.06	-0.08	0.14	0.15	-0.11	0.07	0.18	0.25	0.14
Calcuttia		0.28	0.01	0.04	0.51*	0.30	0.16	0.10	-0.10	0.20
Dehradun	Mn(mg/ha)	-0.04	-0.10	-0.21	-0.09	0.51*	0.16	0.03	-0.15	-0.18
Calcuttia		0.26	0.04	0.03	0.21	-0.06	0.15	0.02	0.03	0.10
Dehradun	Cu(mg/ha)	-0.07	-0.06	0.20	-0.12	0.26	0.10	0.45*	0.37*	0.25
Calcuttia		0.22	0.19	0.12	0.34*	0.38*	0.26	0.12	-0.18	0.33*

**Correlation is significant at 0.01level (2 tailed); *Correlation is significant at 0.05level (2 tailed)

correlation with fruit yield and pulp stone ratio however, soil N, P and Zn content showed positive but non-significant correlations with fruit.

Likewise, leaf N concentration had shown positive but statistically significant correlation with fruit yield (r = 0.81) and pulp stone ratio (r = 0.38) ; however, leaf N, P, Ca, and Zn content showed positive but non-significant correlations with fruit size except leaf N content with fruit breadth. On the contrary, leaf Mg and Mn showed negative non-significant with fruit length and breadth.

The results of present investigation emphasizes that the fruit yield and Quality are significantly correlated with Soil nutrients.

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