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Relationship between soil properties and leaf nutrient contents of pomegranate (*Punica granatum* L) orchards of Kullu district of Himachal Pradesh

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ABSTRACT

The relationship between available nutrients and leaf nutrient status provides a valuable tool for understanding the nutrient supplying capacity of soils. The study was conducted to determine the contribution of soils towards nutrient uptake by pomegranate trees. Soil and leaf samples were collected from thirty pomegranate orchards of Bhagwa cultivar in Kullu district of Himachal Pradesh. The samples were analyzed for the physico-chemical properties (texture, pH, EC and OC), macronutrients (N, P, K, Ca, Mg and S) and micronutrients (Cu, Fe, Mn, Zn, B and Mo). The relationships among soil characteristics and nutrient contents of soils and plants were established. The pH of surface depth showed significant and negative correlation with available Cu (r= -0.48) and Zn (r= -0.39) and highly positive and significant correlation with available Mo (r= 0.97). The OC was positively and significantly correlated with available N in both surface (r= 0.96) and sub-surface (r= 0.91) depths. Leaf Mg, B and Mo showed significant and positive correlation with available Mg, B and Mo respectively. Both soil and plant analyses are necessary for proper diagnostic and prognostic work for determination of nutritional needs of pomegranate trees.

Keywords: Correlation; physico-chemical properties; soil; nutrients; pomegranate

INTRODUCTION

Pomegranate (*Punica granatum* L) belongs to family Punicaceae. It is native to Iran, Afghanistan and Baluchistan. It is one of the premier fruit crops of India due to its demand for internal market and export potential. It is performing well in the mid-hill areas of district Kullu of Himachal Pradesh but the average productivity of this fruit crop in the state is far below the national average. Sub-optimal and imbalanced uses of fertilizer nutrients are claimed to be the prime causes of low productivity of pomegranate. Due to inadequate use of fertilizers, improper irrigation and various cultural practices the soil quality is depleting rapidly. Soil fertility plays a vital role in promoting plant vigour and productivity. The interactions between soil properties like soil texture, soil reaction and organic carbon with available nutrient concentration are used as a clue to indicate soil fertility status. Soil and plant analyses are complementary to each other because at a time one component may or may not provide the requisite information. The relationship between soil and plant nutrients provides such information which can be used as a tool in optimizing fertilizers use for better fruit yield and quality. Since the information on the availability of nutrients in relation to soil properties of the area was lacking therefore the present investigations were carried out with the objective to study the relationship between soil properties and leaf nutrient contents.

MATERIAL and METHODS

Based on uniformity in respect of tree age and vigour 30 orchards of Bhagwa cultivar were selected in Kullu district of Himachal Pradesh. Soil samples were drawn from two depths viz 0-15 and 15-30 cm in the month of June-July. The collected samples were air-dried, ground and passed through 2 mm sieve. These samples were stored in plastic containers for analysis. Organic carbon was determined by the method of

Walkley and Black (1934), available N by alkaline potassium permanganate method (Subbiah and Asija 1956), available P by using 0.5 M $NaHCO_3$ extractant (Olsen 1954) and available K on flame photometer by using the procedure given by Merwin and Peech (1951). Available Ca and Mg in the ammonium acetate extract were determined on flame photometer and atomic absorption spectrophotometer respectively (Sarma et al 1987), sulphate sulphur was extracted by Morgan's reagent and determined by turbidity method (Chesnin and Yien 1950). Available micronutrient cations (Cu, Fe, Mn and Zn) in DTPA extract were determined on atomic absorption spectrophotometer (Lindsay and Norvell 1978). Available B was extracted by the method given by Tandon (1993). The B in the extract was determined by using Azomethine-H-method (Gupta 1979). Available Mo in ammonium bicarbonate-DTPA extract was determined on ICPS (Soltanpour et al 1982).

Leaf samples (8^{th} leaf pair from the apex of non-fruiting secondary branches) were collected from the same trees from which soil samples were drawn as per the sampling time suggested by Bhargava and Chadha (1988). These leaf samples were washed in sequence with ordinary water, 0.1 N HCl and distilled water and air-dried in shade followed by oven drying at 60 ± 5°C for 72 hours (Kenworthy 1964), ground in stainless steel blender and stored in butter paper bags for chemical analysis. Micro-Kjeldhal method was followed for the estimation of total N. For the estimation of other nutrient elements except B and Mo the samples were digested in diacid mixture of HNO_3:$HClO_4$ (4:1). The P in the digest was determined by vando-molybdate yellow colour method (Jackson 1973), K and Ca by using flame photometer. The S was determined by turbidimetric method (Chesnin and Yien 1950). Leaf Mg and micronutrient cations (Cu, Fe, Mn and Zn) were estimated on atomic absorption spectrophotometer. Leaf samples were dry-ashed for estimation of B and B in the extract was determined by Azomethine-H method. For Mo leaf samples were digested with HNO_3 and $HCLO_4$ acid (Purvis and Peterson 1956) and Mo in the extract was estimated on ICPS. Simple correlation coefficients were computed to find out the extent of relationship between soil properties and leaf nutrient status. Correlation analysis was done by using SPSS v16.0.

RESULTS and DISCUSSION

The correlation coefficient values of physico-chemical properties viz soil pH, EC and organic carbon with available nutrient elements were worked out for both surface and sub-surface depths and are presented in Table 1. The relationship of available nutrient elements with their leaf nutrient contents is presented in Table 2.

Relationship of soil properties with available nutrient content in soils: The data in Table 1 reveal that soil pH of surface depth was significantly and negatively correlated with available Cu (r= -0.48) and Zn (r= -0.39). In sub-surface depth soil pH was found significantly and negatively correlated with Cu (r= -0.37), Mn (r= -0.37) and Zn (r= -0.37). However highly significant and positive correlation of soil pH with available Mo was observed in both surface (r= 0.97) and sub-surface (r= 0.96). The significant and negative correlation between soil pH and available micronutrient cations (Cu, Zn and Mn) indicated that their availability decreased with increase in pH. This might be due to the fact that solubility and availability of micronutrient cations are pH-dependent and their availability decreases 100-fold with each unit increase in pH (Tisdale et al 1995). Similar results were found by Verma and Tripathi (2007) and Kumar et al (2012). The highly significant and positive correlation of soil pH with available Mo shows that availability of Mo increases with increase in pH. This increase in availability of Mo may be due to ion exchange reaction between hydroxyl and molybdate ions. The significant and positive correlation between pH and available Mo was also reported by Medhe et al (2012) and Bhat et al (2017).

The EC in the surface depth exhibited a positive and significant correlation with Ca (r= 0.37) and DTPA extractable Cu (r= 0.48). A similar significant and positive correlation of EC with DTPA extractable Cu (r= 0.40) was also observed in sub-surface depth. However the relationship of soil EC with available Mo was found to be highly significant and negative in both surface (r= -0.98) and sub-surface (r= -0.98) depths. This showed decrease in Mo availability with an increase in EC. The significant and positive correlation of EC with available Cu was also observed by Ramana Murthy and Srivastava (1994).

The OC showed positive relationship with almost all the available nutrient elements at both the

Table 1. Relationship (r-values) of soil chemical properties with available nutrient elements in pomegranate orchards of Kullu district

Element	Chemical property at two soil depths					
	pH		EC		OC	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
N	-0.30	-0.31	0.34	0.29	0.96**	0.91**
P	-0.27	-0.26	0.33	0.33	0.35	0.29
K	-0.06	-0.07	0.11	0.12	0.15	0.13
Ca	0.16	0.19	0.37*	0.35	0.16	0.14
Mg	-0.19	-0.21	0.21	0.20	0.33	0.36*
S	-0.03	-0.11	0.13	0.19	0.19	0.18
Cu	-0.48**	-0.37*	0.48**	0.40*	0.04	0.04
Fe	-0.02	-0.35	-0.06	0.24	0.11	0.13
Mn	-0.30	-0.37*	0.27	0.35	0.10	0.02
Zn	-0.39*	-0.37*	0.34	0.31	0.11	0.27
B	-0.15	-0.08	0.09	0.06	0.15	0.09
Mo	0.97**	0.96**	-0.98**	-0.98**	-0.27	-0.31

*Correlation significant at 0.05 level (2-tailed), **Correlation significant at 0.01 level (2-tailed)

depths but this correlation was non-significant except N and Mg. The OC in surface depth recorded highly positive and significant correlation with available N (r= 0.96). For the sub-surface depth the OC was positively and significantly correlated with available N (r= 0.91) and Mg (r= 0.36). The significant and positive correlation of OC with available N of the soils is obvious since bulk of the total N is present in organic combinations and OC is one of the major sources of nutrient supply in the soil also being a reason of significant and positive correlation of available Mg with OC. Similar results have also been reported by Singh (1987), Raina (1988) and Kumari (2015) in orchard soils of district Kinnaur, Sirmour and Kangra respectively.

Relationship of available nutrient elements with their leaf nutrient contents: The perusal of data in Table 2 indicates that available nutrients in both surface and sub-surface depths depicted positive correlation with their respective leaf nutrient contents. Leaf N registered positive and significant correlation with available N in both surface (r= 0.43) and sub-surface (r= 0.42) depths. Available P in surface (r= -0.39) and subsurface (r= -0.36) depth showed negative and significant correlation with leaf Ca. Available K in both the depths (r= 0.38 and r= 0.36) showed positive and significant relationship with leaf Fe. This positive and significant correlation may be due to synergistic relationship between K and Fe. The negative and significant correlation was observed between leaf Mo and available Cu in surface (r= -0.52) and subsurface (r= -0.44) depths. This may be due to existence of mutual antagonism between Cu and Mo for most of the crops. Available Mo in surface (r= -0.37) and subsurface (r= -0.39) depth showed negative and significant correlation with leaf S. This indicates that uptake of S by the trees is reduced due to the application of Mo. This may be due to the direct competition between two divalent anions of the same size. Available Mg, B and Mo in surface depth were positively and significantly correlated with leaf Mg (r= 0.80), B (r= 0.38) and Mo (r= 0.96) respectively. Similar results were reported by Sharma and Bhandari (1992). In general correlation between other available nutrients with their respective leaf nutrients was positive but non-significant.

CONCLUSION

The positive and significant correlation between soil available nutrients (N, Mg, B and Mo) and leaf nutrients (N, Mg, B and Mo) suggest that soils were contributing towards the nutrient uptake by the roots of pomegranate trees. The fact that many correlations were significant statistically for both the depths suggest that the two measurements viz soil and foliar analyses are equally important in assessing the nutritional status and for making sound fertilizer recommendations. The poor correlations observed in some cases however may be due to the empirical nature of soil tests, the presence of large nutrient

Table 2. Relationship (r-value) of surface soil characteristics with leaf nutrient contents in pomegranate orchards of Kullu district

Soil characteristic	Leaf nutrient content											
	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn	B	Mo
0-15 cm surface soil depth												
pH	0.23	0.09	0.33	0.24	0.26	-0.39*	-0.28	0.15	-0.18	-0.02	-0.08	0.96**
EC	-0.24	-0.13	-0.34	0.06	0.34	-0.01	0.26	-0.22	0.26	0.05	0.15	-0.93**
OC	0.34	0.12	0.26	-0.10	0.19	0.02	0.19	0.20	0.02	-0.12	0.01	-0.31
N	0.43*	-0.13	0.30	-0.13	0.20	0.06	0.28	0.17	0.02	-0.06	0.04	-0.35
P	0.17	0.26	0.21	-0.39*	-0.12	0.16	0.01	-0.12	0.01	0.21	0.09	-0.22
K	0.19	-0.13	0.32	-0.30	-0.26	0.35	-0.25	0.38*	0.17	-0.25	-0.07	0.01
Ca	0.36*	0.04	-0.16	0.08	0.01	-0.20	-0.30	0.06	-0.04	0.31	-0.22	0.12
Mg	0.16	-0.22	0.36	-0.05	0.80**	-0.01	0.38*	-0.24	0.14	0.06	0.11	-0.26
S	0.32	0.08	0.02	-0.03	0.28	0.19	0.12	-0.04	0.20	0.41*	0.18	-0.07
Cu	0.30	-0.14	0.15	0.05	0.14	0.33	0.21	-0.03	0.46**	0.27	-0.14	-0.52**
Fe	0.06	-0.07	-0.03	0.07	-0.09	-0.09	-0.06	0.09	-0.27	-0.04	0.13	0.08
Mn	0.29	-0.25	0.06	0.03	0.16	0.25	-0.04	-0.01	0.12	0.22	-0.01	-0.22
Zn	0.14	0.03	-0.32	-0.34	0.17	0.15	0.04	-0.07	-0.14	0.26	0.05	-0.37*
B	-0.04	-0.14	-0.44*	-0.10	-0.12	-0.11	-0.21	-0.21	-0.39*	-0.27	0.38*	-0.06
Mo	0.22	0.14	0.35	0.23	-0.04	-0.37*	-0.27	0.21	-0.25	-0.02	-0.12	0.96**
15-30 cm sub-surface soil depth												
pH	0.22	0.10	0.32	0.21	0.23	-0.40*	-0.28	0.13	-0.19	-0.03	-0.09	0.95**
EC	-0.23	-0.12	-0.35	0.02	0.36*	-0.02	0.25	-0.18	0.22	0.05	0.11	-0.94**
OC	0.32	0.12	0.27	-0.08	0.21	0.03	0.18	0.19	0.01	-0.15	-0.01	-0.31
N	0.42*	-0.09	0.25	-0.16	0.27	0.07	0.36*	0.15	-0.09	-0.18	-0.04	-0.35
P	0.21	0.23	0.14	-0.36*	-0.18	0.14	-0.02	-0.13	0.07	0.25	0.10	-0.19
K	0.16	-0.02	0.29	-0.21	-0.25	0.44*	-0.25	0.36*	0.22	-0.22	0.12	-0.07
Ca	0.30	0.11	-0.20	0.07	0.07	-0.27	-0.19	0.05	-0.15	0.27	-0.25	0.13
Mg	0.09	-0.15	0.35	-0.10	0.77**	0.01	0.42*	-0.19	0.09	0.08	0.11	-0.30
S	0.35	-0.03	-0.04	0.04	0.27	0.18	0.13	-0.11	0.26	0.40*	0.19	-0.14
Cu	0.20	-0.14	0.15	-0.08	0.15	0.20	0.28	-0.12	0.34	0.24	-0.08	-0.44*
Fe	0.22	-0.07	-0.10	0.31	-0.10	0.19	-0.17	0.20	0.01	0.14	0.01	-0.19
Mn	0.23	-0.25	0.06	0.02	0.19	0.28	0.01	0.04	0.16	0.18	-0.02	-0.27
Zn	0.12	0.01	0.04	-0.33	0.40*	0.21	0.33	0.01	-0.03	0.27	-0.03	-0.35
B	-0.06	-0.13	-0.43*	-0.08	-0.12	-0.13	-0.24	-0.20	-0.40*	-0.27	0.37*	-0.02
Mo	0.22	0.15	0.34	0.22	-0.06	-0.39*	-0.28	0.19	-0.25	-0.02	-0.15	0.95**

reserves within the tree, ion antagonism and the effects of cultural and other environmental factors on nutrient uptake and translocation by trees. The statistical methods like correlation analysis can provide scientific basis for controlling and monitoring agriculture soil fertility management.

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