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Correlation of Physico-chemical Characteristic with Available Nutrients and Leaf Nutrient Content in Apple (Cv. Red Delicious) Orchard of Jammu and Kashmir (India)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To study the "Nutrient Status of Apple Orchard Soils of South Kashmir" a survey was carried in twenty apple orchards (cv. Red Delicious) of south Kashmir. The soil samples were analyzed for studying the Correlation between physico-chemical characteristic and available nutrients. The correlation coefficient studies revealed that pH indicated significant and positive correlation coefficient with exchangeable calcium and magnesium and exhibited significant and negative relationship with available nitrogen, phosphorus, potassium, sulphur, iron, manganese, zinc and copper. The organic carbon showed positive and significant correlation coefficient with available nitrogen, phosphorus, sulphur, iron, zinc and copper. The calcium carbonate showed significant and positive correlation with exchangeable calcium and magnesium but significant and negative correlation coefficient with available nitrogen, phosphorus, potassium, iron, manganese and zinc.

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The clay content revealed significant and positive relationship with available potassium only. The leaf analysis showed that apple orchards were adequate in all nutrients, whileas, nitrogen was marginal to high and phosphorus was marginal to adequate.

Keywords: Apple orchards; correlation; physico-chemical characteristic; nutrients.

1. INTRODUCTION

Apple is thought to have originated in the Caucasus region of southeastern Europe and possibly southwestern Siberia, from where, man widened its sphere of cultivation to almost every corner of the world. In India cultivation of apple is confined to the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and to the limited extent to the states of Arunachal Pradesh, Sikkim, Nagaland, Meghalaya and Manipur. The valley of the Kashmir, situated in the range of Himalayan mountains roughly between 33°,01′ and 35°,00′N and 73°,48′ and 75°,30″E has been suitable for apple cultivation. Nature has bestowed Kashmir valley with agro climatic conditions conducive for apple cultivation and a strong comparative advantage in its production and marketing. The fruit industry is the backbone of economy in Jammu and Kashmir and has a great potential to ameliorate the condition of rural people. Nutrition plays an important role in determining the quality and yield of fruit crops. Nitrogen, phosphorus and potassium are key elements required by apple tree for various important functions like growth of tissues, formation of carbohydrates, proteins, chlorophyll development, root growth, water uptake, transpiration, manufacture and translocation of sugars, starches and quality of fruit [1].

The deficiency or an excess of an essential element may cause disturbance in plant metabolism and its vital functioning may fail, leading to a sub-normal performance [2]. Nutrient management plays an important role in fruit production and fruit quality as nutrients are essential for plant life and a plant deprived of any one of the elements would cease to exist [1]. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants [3]. The requirement of micronutrients (boron, iron, copper, zinc, manganese, molybdenum and chlorine) is only in traces, which is partly met from the soil or through chemical fertilizer or organic sources.

The information on the nutritional status of apple orchard is important to serve as a guide for fertilizer recommendations for economic apple production and hence to assess the performance of apple orchards. Since the availability of nutrients in relation to the soil properties have not been studied in this area, so the present investigation was carried out with the objective, to study cccorrelation between physico-chemical characteristic and available nutrients in Apple (Cv. Red Delicious) orchard soils of Jammu and Kashmir (India).

2. MATERIALS AND METHODS

For studying the nutrient status of apple orchards of Kashmir soil samples from 20 orchards of uniform age and vigour were collected depth wise up to a depth of 75 cm with an increment of 25 cm. The leaf samples of Red Delicious cultivar of apple were collected by following the sampling procedure outlined by Chapman [4]. The leaf nutrients were determined by following methods. Nitrogen was estimated by Micro-kjeldahl's distillation method using potassium permanganate (0.32%) and sodiumhydroxide (2.5%) in distillation unit. The sample was heated by passing steam liberating ammonia which was absorbed in 20 ml of 2% boric acid containing mixedindicator solution turning pinkish colour to green. This was followed by titration with 0.02N sulphuric acid. The available N was then estimated by the formula given by Jackson [5]. Phosphorus was estimated by vandomolydate method given by Jackson [5] using 10 ml vanadomolybdate reagent. The transmittance/ absorbance was observed at 420 mμ (blue filter). Potassium was determined by flame photometer as described by Jackson [5] in acid mixture containing 750 ml conc. HNO_3 + 150 ml conc H_2SO_4 + 300 ml of $HClO_4$. Calcium and magnesium were estimated by versenate titration method given by Jackson [5]. Sulphur in the extract was determined by turbidity method given by Chesnin and Yien [6]. The micronutrient cations like zinc, copper, manganese and iron were determined on atomic absorption spectrophotometer. The micronutrient cations were determined taking 0.5 g of dried plant sample and was digested with 10 to 12 ml of di acid mixture (1 perchloric + 4 nitric acid) on hot

plate till the residue became colour less. The final volume of digestate was made to 50 ml and micronutrient content was recordedon AAS. coefficients of correlation (r-values) were worked out between physio-chemical properties and available nutrients as per the procedure outlined by Gomez and Gomez [7].

3. RESULTS AND DISCUSSION

3.1 Soil pH

The correlation coefficient values of physico-chemical properties viz. soil pH, organic carbon, calcium carbonate and clay with available nutrient elements were worked out for both surface and sub-surface soils. Data presented in Table-1 revealed that pH of surface soils exhibited significant and negative correlation coefficient with available nitrogen, phosphorus, potassium, sulphur, iron, manganese, zinc and copper. On the other hand, it had significant and positive relationship with exchangeable calcium and magnesium. The pH of subsurface soils indicated significant and negative correlation coefficient with available nitrogen, phosphorus, potassium, sulphur, iron, manganese and zinc while as, it showed significant and positive correlation coefficient with calcium and magnesium. The relationship of soil pH with available copper in sub-surface soil was observed to be negative but non-significant.

Singh and Mishra [8], Khokar et al. [9] and Patil et al. [10] have also found significant and negative correlation coefficient between soil pH and available nitrogen. The negative and significant relationship between soil pH and available phosphorus may be due to conversion of soluble phosphorus to insoluble calcium and magnesium phosphate with the rise in soil pH. Similar results were reported by Khokar et al. [9], Patil et al. [10] and Bhat et al. [11]. Potassium and sulphur showed a significant and negative relation with pH. These results are in accordance with the findings of Wani et al. [12]. A significant and negative relationship of pH with available zinc, copper, iron and manganese could be attributed to the precipitation of nutrients under alkaline pH. This is in agreement with the findings of Mir [13], Sharma et al. [14] and Singh and Rathore [15]. The increase in availability of calcium and magnesium with rise in soil pH is quite obvious because of basic nature of divalent cations. The results are in line with those of Wani [16], Medhe et al. [17] and Bhat et al. [11].

3.2 Organic Carbon

Soil organic carbon showed significant and positive correlation coefficient with available nitrogen, phosphorus, sulphur, iron, zinc and copper in surface soils, while as, it exhibited non-significant and negative relationship with calcium and magnesium. Sub-surface organic carbon content revealed significant and positive relationship with nitrogen, phosphorus, iron and manganese. However organic carbon in sub-surface soils revealed a significant and negative relationship with exchangeable calcium and magnesium.

The significant and positive correlation coefficient between organic carbon and available nitrogen could be due to release of mineralizable nitrogen from soil organic matter and adsorption of NH_4 – N by humus complexes in soil. These observations are in conformity with those of Meena et al. [18], Kumar et al. [19] and Patil et al. [10]. The significant and positive correlation coefficient between organic carbon and available phosphorus may be due to acidulating effect of organic carbon, formation of easily accessible organophosphate complexes, release of phosphorus from organic complexes and reduction in phosphorus fixation by humus due to formation of coatings on iron and aluminum oxides. These results are in agreement with the findings of Akther [20], Dar [21] and Ayele et al. [22]. The increase in availability of sulphur by organic carbon may be attributed to release of sulphur from organic complexes as well as acidulating action of soil organic matter thus enhancing the weathering of minerals containing sulphur. This was supported by the findings of Kher and Singh [23], Wani [16] and Pareek [24]. The significant and positive relationship between soil organic carbon and available iron content may be due to formation of iron chelates by organic matter, release of iron from organic complexes, acidulating action of soil organic matter and decrease in soil pH, thus increasing the solubility of iron. The results are in accordance with the observations of Nazif et al. [25], Sarwar et al. [26], Dar [21], Vijayakumar et al. [27]. The increase in availability of mangnese zinc, and copper may be attributed to the release of these elements from organic complexes as well as from the weathering of minerals containing these elements due to acidulating action of organic matter. Tripathi et al. [28], Najar [29] and Sharma et al. [14] also reported similar observations. The significant and negative relationship of organic carbon in sub-surface

soils with exchangeable calcium and magnesium in sub-surface soils could be attributed to the fact that organic matter on decomposition releases various acids due to which pH gets decreased and this may be cause for negative relationship of organic carbon with calcium and magnesium.

3.3 Calcium Carbonate

A significant and negative relationship of calcium carbonate was revealed with available nitrogen, phosphorus, potassium iron, manganese and zinc, whileas, significant and positive correlation coefficient was observed with exchangeable calcium and magnesium. Sub-surface calcium carbonate revealed a significant and negative correlation coefficient with available nitrogen, phosphorus, potassium, iron, manganese and zinc, whileas, it revealed a significant and positive relationship with exchangeable calcium and magnesium. The relationship between calcium carbonate with available nitrogen and potassium is in agreement with the findings of Mir [13] and Wani et al. [12]. The significant and negative correlation coefficients of calcium carbonate with available phosphorus may be due to formation of insoluble calcium phosphates thus reducing its availability. The results are supported by the findings of Mir [13], and Bhat et al. [11]. The negative and significant relationship between calcium carbonate and DTPA extractable zinc, copper and iron are in conformity with the results of Jalali et al. [30], Sharma et al. [14] and Najar [29].

3.4 Clay Content

The clay content showed significant and positive correlation coefficient with available potassium in both surface and sub-surface soils. The significant and positive relationship between available potassium and clay may be due to the illitic and micacious nature of clay minerals in these soils. These observations are supported by the findings of Mandal et al. [31], Gupta et al. [32] and Akhter (2005). The relationship between physico-chemical charecteristics and all other available nutrients was observed non-significant in both surface and sub-surface soils.

3.5 Leaf Nutrient Content of Apple Orchards

Leaf samples of apple (cv. Red Delicious) were analyzed for macro and micronutrient concentration and the results of chemical analysis of apple leaves are tabulated in Tables 2, 3 and 4.

3.6 Macronutrients

Nitrogen: The data in Table 2 indicated that nitrogen content of foliage of Red Delicious cultivar of apple ranged from 1.82 to 3.20 per cent with a mean value of 2.35 per cent. The maximum leaf nitrogen content (3.20 per cent) was observed in Keller, whereas, minimum (1.82 per cent) was found in Dalipora. The leaf nitrogen in orchards were marginal in 10 per cent samples, adequate in 60 percent samples and high in 30 per cent samples, hence it can be concluded that orchard soils are adequately supplied with nitrogen. This may be attributed to the application of manures and fertilizers and decomposition of natural and added organic matter together with biological nitrogen fixation. These results are supported by the findings of Ahlawat and Yamadagni [33] and Shaaban and El-Fouly [34].

Phosphorus: Phosphorus content of leaves varied from 0.14 to 0.28 per cent with a mean value of 0.21 per cent (Table 2). The highest (0.28 per cent) and lowest content (0.14 per cent) of phosphorous was recorded at Keller and Dalipora, respectively. The variation of leaf phosphorus among different orchards may be due to variation in available phosphorus, soil pH, climatic conditions, elevation and other associated factors. Leaf phosphorus content of similar magnitude has also been observed by Bhargava and Raghupathi [35], Kilby [36] and Muftuoglu et al. [37]. The phosphorus content of apple orchards were marginal in 15 per cent samples and adequate in 85 samples. The results may be due to sufficient available phosphorus content of these soils and favourable conditions for its uptake. Similar results were recorded by Ahlawat and Sindhu [38], Demirer et al. [39] and Yogeeshappa et al. [40].

Potassium: The foliar potassium content of different apple orchards ranged from 1.34 to 1.94 per cent with a mean value of 1.67 per cent (Table 2). The highest leaf potassium (1.94 per cent) was observed at Hurpora, whileas, lowest (1.34 per cent) was recorded at Dalipora. The variation of leaf potassium among different apple orchards may be due to variation in soil potassium, pH and other associated factors. The leaf potassium in similar magnitude was also reported by Ahlawat and Yamadagni [33] and Kunwar and Sinha [41]. Table 5 revealed that apple orchards under study were adequate to high in leaf potassium as 85 per cent samples were adequate and 15 per cent samples were

Table 1. Relationship between physico-chemical characteristics and available nutrients of apple orchards soils of south Kashmir

Soil properties	Available nutrients									
	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Iron	Manganese	Zinc	Copper
	Surface soils (0-30 cm)									
Ph	-0.722*	-0.857*	-0.772*	0.765*	0.837*	-0.642*	-0.860*	-0.834*	-0.869*	-0.825*
OC	0.465*	0.592*	0.444	-0.239	-0.391	0.562*	0.589*	0.424	0.879*	0.459*
$CaCO_3$	-0.792*	-0.834*	-0.779*	0.812*	0.742*	-0.402	-0.801*	-0.875*	-0.827*	-0.230
Clay	-0.353	-0.340	0.464*	-0.397	0.357	-0.179	-0.248	-0.366	-0.414	-0.446
	Sub-surface soils (30-90 cm)									
pH	-0.798*	-0.808*	-0.560*	0.737*	0.818*	-0.495*	-0.769*	-0.728*	-0.909*	-0.087
OC	0.861*	0.898*	0.418	-0.728*	-0.785*	0.441	0.808*	0.842*	0.292	0.027
$CaCO_3$	-0.702*	-0.824*	-0.577*	0.761*	0.691*	-0.340	-0.823*	-0.644*	-0.867*	-0.039
Clay	-0.444	-0.295	0.484*	0.085	0.217	-0.036	-0.201	-0.398	-0.416	-0.114

** Significant at 0.05 level*

high. This may be due to maximum amount of available potassium in soils and application of manures and fertilizers, which resulted in high uptake and in turn high potassium content in leaves. The findings are in accordance with those of Bhargava and Raghupathi [35], Demirer et al. [39] and Brent et al. [42].

Calcium: Perusal of data in Table 3 indicated that leaf calcium content of Red Delicious cultivar of apple was found in the range of 1.62 to 1.95 per cent with a mean value of 1.80 per cent. The maximum leaf calcium (1.95 per cent) was found at Dalipora and minimum (1.62 per cent) was observed at Hurpora. The difference in leaf calcium content may be attributed to difference in available calcium content, nutrient ion interactions and other associated factors. Leaf calcium content in similar range was supported by the findings of Singh [43], Arora et al. [44] and Yogeeshappa et al. [40]. The apple orchards were adequate in 35 per cent samples and high in 65 per cent samples. The results are in accordance with the findings of Singh [43], Bhargava and Raghupathi [35] and Muftuoglu et al. [37].

Magnesium: Data in Table 3 revealed that magnesium content in foliage of Red Delicious cultivar of apple ranged from 0.25 to 0.64 percent with a mean value of 0.47 per cent. Highest (0.64 per cent) and lowest (0.25 per cent) mean leaf magnesium content was recorded at Dalipora and Hurpora, respectively. The magnitude of these results are in agreement with those of Ahlawat and Sindhu [38], Bhargava and Raghupathi [35], and Yogeeshappa [40]. Further it was observed that 20 per cent orchards were adequate and 80 per cent were high in leaf magnesium content (Table 5), which could be due to optimum amount of soil magnesium and favourable conditions for its availability. These are supported by the findings of Upadhayay and Awasthi (1993) and Akhter (2005).

Sulphur: The sulphur content in foliage of apple (cv. Red Delicious) was found in the range of 0.27 to 0.47 per cent with a mean value of 0.40 per cent (Table-3). Highest leaf sulphur content (0.47 per cent) was recorded at Keller and lowest (0.27 per cent) at Dalipora. The magnitude of these values are in line with those of Gathala et al. [45], Yogeeshappa et al. [40] and Qayum and Misgar [46]. Data in Table 5 revealed that 95 per cent were adequate and 5 per cent of samples were marginal in leaf sulphur, which may be ascribed to adequate available sulphur and application of high quantity of fertilizers and sulphur containing fungicides. These observations are in line with the findings of Bhargava and Raghupathi [35] and Dar et al. [47].

3.7 Micronutrients

Iron: The data in Table-4 showed that leaf iron of Red Delicious cultivar of apple ranged from 116.00 to 146.00 mg kg^1 with a mean value of 132.15 mg kg^1. The highest iron content (146.00 mg kg^1) was recorded at Keller, whileas, lowest (116.0 mg kg^1) was observed at Tahab. The leaf iron in similar range was also reported by Bhargava and Raghupathi [35], Qayum and Misgar [46] and Dar et al. [47]. It was observed that 100 per cent apple orchards were high in leaf iron content (Table 5), which may be due to presence of high amount of organic matter content in these soils and favourable pH resulting in high uptake of iron content. These findings are in accordance with the observations of Demirer et al. [39], Khokhar et al. [48] and Shah et al. [49].

Manganese: Manganese content of apple leaves ranged from 58.00 to 85.00 mg kg^1 with a mean value of 72.25 mg kg^1 (Table 4). The maximum (85.00 mg kg^1) and minimum (58.00 mg kg^1) leaf manganese was observed at Keller and Dalipora, respectively. Similar range was observed by Singh [43] and Khokhar et al. [9]. All apple orchards under study were high in leaf manganese content (Table 5). This may be due to high available manganese and organic matter in soil and favourable pH for its uptake. The findings are supported by the observations of Muftuoglu et al. [37], Yogeeshappa et al. [40], and Qayum and Misgar [46].

Zinc: The foliar zinc content in Red Delicious cultivar of apple was found in the range of 14.00 to 51.00 mg kg^1 with a mean value of 37.30 mg kg^1. The highest leaf zinc content (51.00 mg kg^1) was recorded at Keller and lowest (14.00 mg kg^1) was observed at Dalipora. The leaf zinc in same range was reported by Bhargava and Raghupati [35], Fida et al. [50] and Qayum and Misgar [46]. The samples were adequate in zinc content as shown in Table-5, which may be due to adequate amount of organic matter and favourable pH for its uptake. This is supported by the findings of Najar [29] and Samiullah et al. [51].

Copper: Perusal of data in Table 4 indicated that leaf copper of Red Delicious cultivar of apple

Table 2. Leaf macronutrient status of apple (cv. Red Delicious) orchards of south Kashmir

Location	Per cent		
	Nitrogen	Phosphorus	Potassium
Keller	3.20	0.28	1.92
Hurpora	3.12	0.25	1.94
Killora	2.80	0.24	1.88
Loosdanan	2.72	0.25	1.89
Kachdoora	2.70	0.24	1.91
Harmain	2.58	0.23	1.88
Imamshab	2.46	0.23	1.71
Kapran	2.40	0.20	1.58
ReishNagri	2.27	0.20	1.62
Zainpora	2.20	0.22	1.60
Kamrizipora	2.25	0.22	1.65
Drabugam	2.15	0.22	1.62
Bandzoo	2.13	0.21	1.66
Rahmoo	2.08	0.21	1.60
Gossu	2.10	0.20	1.62
Rajpora	2.06	0.19	1.50
Arihal	2.01	0.19	1.48
Ashmander	1.97	0.15	1.53
Tahab	1.88	0.15	1.41
Dalipora	1.82	0.14	1.34
Range	**1.82-3.20**	**0.14-0.28**	**1.34-1.94**
Mean	**2.35**	**0.21**	**1.67**
C.D(P≤ 0.05)	**0.69**	**0.09**	**0.42**

Table 3. Leaf macronutrient status of apple (cv. Red Delicious) orchards of south Kashmir

Sampled location	Per cent		
	Calcium	Magnesium	Sulphur
Keller	1.63	0.29	0.47
Hurpora	1.62	0.25	0.47
Killora	1.72	0.37	0.42
Loosdanan	1.79	0.40	0.40
Kachdoora	1.66	0.36	0.43
Harmain	1.62	0.48	0.42
Imamshab	1.81	0.41	0.41
Kapran	1.72	0.45	0.37
ReishNagri	1.82	0.54	0.38
Zainpora	1.87	0.53	0.38
Kamrizipora	1.83	0.43	0.43
Drabugam	1.81	0.50	0.42
Bandzoo	1.86	0.59	0.43
Rahmoo	1.87	0.51	0.39
Gossu	1.89	0.53	0.40
Rajpora	1.91	0.51	0.41
Arihal	1.82	0.60	0.38
Ashmander	1.86	0.55	0.36
Tahab	1.92	0.54	0.36
Dalipora	1.95	0.64	0.27
Range	**1.62-1.95**	**0.25-0.64**	**0.27-0.47**
Mean	**1.80**	**0.47**	**0.40**
C.D(P≤ 0.05)	**0.31**	**0.27**	**0.13**

Table 4. Leaf micronutrient status of apple (cv. Red Delicious) orchards

Sampled location	mg kg^{-1}			
	Iron	Manganese	Zinc	Copper
Keller	146.00	85.00	51.00	24.00
Hurpora	143.00	80.00	48.00	22.00
Killora	144.00	80.00	43.00	20.00
Loosdanan	140.00	78.00	41.00	18.00
Kachdoora	142.00	77.00	45.0	18.00
Harmain	139.00	77.00	43.00	17.00
Imamshab	137.00	79.00	42.00	14.00
Kapran	140.00	78.00	40.00	14.00
ReishNagri	133.00	75.00	42.00	13.00
Zainpora	126.00	70.00	37.00	14.00
Kamrizipora	132.00	75.00	44.00	15.00
Drabugam	131.00	73.00	42.00	12.00
Bandzoo	131.00	72.00	39.00	11.00
Rahmoo	128.00	71.00	34.00	11.00
Gossu	123.00	66.00	36.00	11.00
Rajpora	121.00	64.00	33.00	11.00
Arihal	122.00	67.00	29.00	11.00
Ashmander	129.00	60.00	26.00	12.00
Tahab	116.00	60.00	17.00	13.00
Dalipora	120.00	58.00	14.00	11.00
Range	**116.00-146.00**	**58.00-85.00**	**14.00-51.00**	**11.00-24.00**
Mean	**132.15**	**72.25**	**37.30**	**14.60**
C.D (P≤ 0.05)	**17.23**	**21.09**	**3.51**	**2.73**

Table 5. Nutritional status apple orchards

Nutrient element	Nutritional level (%samples)			
	Deficient	Marginal	Adequate	High
N	-	10	60	30
P	-	15	85	-
K	-	-	85	15
Ca	-	-	35	65
Mg	-	-	20	80
S	-	5	95	-
Fe	-	-	-	100
Mn	-	-	-	100
Zn	5	5	85	5
Cu	-	-	85	15

varied from 11.00 to 24.00 mg kg^{1} with a mean value of 14.60 mg kg^{1}. The highest (24.00 mg kg^{1}) and lowest (11.00 mg kg^{1}) leaf copper was observed at Keller and Dalipora, respectively. These results are in line with those of Najar [29] and Yogeeshappa et al. [40]. Table 5 revealed that 85 per cent samples were adequate and 15 per cent were high in leaf copper content. This is in line with the findings of Sharma and Bhandari [52]. This may be ascribed to favourable pH, organic matter content and application of copper containing fungicides. These findings are in agreement with the observations of Patiram et al. [53] and Yogeeshappa et al. [40].

4. CONCLUSION

The effect of physico-chemical characteristics on the availability of nutrients is obvious as revealed from their relationship study. The leaf analysis revealed that apple orchards were marginal to high in all nutrient elements except zinc which is deficient in 5 per cent orchards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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