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Effect of Physico-Chemical Properties of Soil on Available Soil Nutrients in Apple Orchards of District Kulgam

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Abstract

Available nutrient status and their correlation with the physico-chemical properties is an important indicator of soil health and plant nutrition. To comprehend the nutrient status in relation to soil properties in apple orchards a study was conducted in temperate Kashmir Himalayas. We analyzed soil samples from major apple growing areas of South District Kulgam for various physio-chemical properties and available nutrient status of nitrogen, phosphorus, potassium, calcium and magnesium. The soils varied from silty clay loam to loam in texture with pH and organic carbon ranging from 4.97 to 6.24 and 1.52% to 2.78% respectively. The available N, P, K, Ca and Mg ranged from 152.32 to 428.62, 9.85 to 24.39, 206.86 to 464.92, 209.78 to 501.12, 509.43 to 621.23 Kg ha^{-1} respectively. Almost all samples were found to be in low to medium range in pH and electrical conductivity indicating soils are slightly alkaline and non-saline in nature.

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Keywords

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Introduction

Soil health and fertility are important factors of sustainable agriculture governing the soil tree growth environment[1]. The interdependence and interlink of soil health and soil fertility balance play an important role in the growth of plants. Soil fertility defined as the presence or absence of nutrients (macro and micro) is particularly sensitive to soil health environment affected by various physical, chemical and biological factors of soil[2,3].

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The soil health and soil quality concept has developed systematically with an enhancement in the discernment of soils and soil quality attributes[4,5]. Nutrient concentration in soil and availability to plants are appraised by the minerals present, soil forming factors and management practices[6,7].

Many authors have evaluated the available nutrient content of soils and their relationship with various physico-chemical properties of soils like pH[8], EC[9], OC[10], bulk density[11], soil texture[12] and porosity[11]. Management and cultural practices also play an important role in improving the nutrient use efficiency and sustaining the soil fertility by lowering nutrient losses, maintaining or increasing nutrient storage capacity, promoting recycling of plant-soil nutrients, applying fertilizers as additional nutrients in appropriate amounts[3]. So regular testing of soil nutrients and factors having a profound effect on their availability is of utmost importance in achieving the sustainable production levels and soil health.

The fruit productivity and quality of an apple tree, the most important horticultural crop in Jammu and Kashmir state of India, depends on various biotic and abiotic factors: such as soil and climatic conditions that affect processes of plant nutrition depending on the level of soil nutrient capacity and irrigation supply, rootstock vigor and variety combination cultivated, and cultural and management factors *viz.,* soil management (pre-planting, post-planting, fertilization, tillage, irrigation) and crop husbandry (training , pruning, thinning, nutrition, disease and pest management, etc.)[8].

In case of perennial crops like apple it is an essential practice to maintain higher levels of soil fertility for a longer time to sustain continuous cultivation of fruit crops both under irrigated and rainfed conditions while taking into account the existing horticultural facilities[13,14]. Keeping this in background a study was conducted in the apple orchards of South District of Kulgam, Jammu and Kashmir with the following objectives; (a) to evaluate the nutrient status and physico-chemical properties of soils and (b) to assess the correlation between the available nutrients and physico-chemical properties of soil of apple orchards.

Material and Methods

Study Area

The study was carried out in district Kulgam of the state of Jammu and Kashmir, India. District Kulgam is located at 33^0.65' North latitude & 75^0.02' East longitude and is situated on the southern side of Jammu & Kashmir State of India. It has an average elevation of 1739 meters. The region falls under the cold humid zone with soils ranging from clay loam to sandy loam in texture and alluvial in origin rich in illite[12].

Soil Sampling

Soil samples in three replicates from 10 apple growing villages (Mirhama, Ashthal, Chawalgam, Pombay, Kakran, Gopalpora, Nillow, Begam, Modergam and Lirow) of South District Kulgam were collected (Table 1). The soil samples were taken after harvesting the fruit in 2016 within the drip line of the canopy to a depth fertilization zone of 23 cm. These soils were air dried and sieved through 2 mm sieve prior to analysis. The samples were collected from the orchards of 15 years or above age.

Soil Physico-Chemical Properties

The pH and electrical conductivity (EC) were estimated in 1: 2.5 soil water suspension by standard procedures[15]. Particle size distribution was determined by international pipette method[15]. Oxidizable organic carbon was determined by Walkley and Black (1934) method[16]. Available nitrogen was determined by alkaline permanganate method of Subbiah and Asija (1956)[17], available phosphorus was determined by Bray P1[18] and available potassium by neutral normal ammonium acetate and determined on flame photometer as described by Jackson[15]. The exchangeable calcium and magnesium were determined by versenate titration method after extraction with ammonium acetate solution[15].

Statistical Analysis

The relationship between different soil parameters and available nutrient content of soils were determined using correlation analysis in SPSS 20.0.

Table 1: Physico-chemical properties of the apple orchard soils of district Kulgam (mean±SE)

S. No.	Village	Geographic Location		Texture	Sand (%)	Silt (%)	Clay (%)	OC (%)	pH(1:2.5)	EC (dSm^{-1})
		Latitude	Longitude							
1.	Mirhama	33°38'43.53"	74°57'40.96"	sicl	23.8	43.7	31.7	1.61±0.14	6.05±0.09	0.77±0.08
2.	Ashthal	33°37'45.70"	74°59'11.18"	l	42.3	33.0	23.7	2.08±0.23	5.65±0.30	0.65±0.12
3.	Chawalgam	33°38'43.52"	74°59'55.23"	sicl	22.4	47.8	31.0	2.19±0.21	5.40±0.10	0.61±0.04
4.	Pombay	33°38'50.06"	74°56'26.66"	l	34.2	39.1	25.2	2.02±0.04	5.80±0.46	0.44±0.17
5.	Kakran	33°39'0.97"	74°56'41.25"	cl	20.3	49.0	30.5	1.52±0.20	6.24±0.06	0.77±0.11
6.	Gopalpora	33°38'24.82"	74°55'40.48"	sicl	19.2	47.3	33.2	2.23±0.09	5.54±0.10	0.43±0.03
7.	Nillow	33°39'53.24"	74°57'16.91"	l	29.1	46.2	22.3	2.52±0.32	5.16±0.14	0.56±0.04
8.	Begam	33°39'19.92"	74°56'53.77"	sicl	18.3	48.2	33.9	2.41±0.14	5.38±0.19	0.52±0.02
9.	Modergam	33°38'41.21"	74°57'7.06"	sicl	17.8	51.3	30.4	2.78±0.28	4.97±0.03	0.52±0.05
10.	Lirow	33°38'46.93"	74°58'10.37"	l	36.8	33.6	28.9	2.20±0.13	5.54±0.23	0.47±0.04

Results and Discussion

Analytical Results

The analytical results of the soil for various physico-chemical properties and available nutrients are presented in table 1 and 2 respectively. The sand, silt and clay content ranged from 17.8 to 42.3, 33.0 to 51.3 and 22.3 to 33.9 % respectively thus soils in general belong to silty clay loam to loam in texture. The pH and OC ranged from 6.97 to 7.24 and 1.52 to 2.78 %, respectively. The lowest OC (1.52%) and highest pH (6.24) was observed in clay loam soils of Kakran while highest OC (2.78%) and lowest pH (4.97) was observed in silty clay loam soils of Modergam. The electrical conductivity ranged from 0.43 to 0.77 dSm^{-1} indicating soils of non-saline in nature and could be attributed to leaching of soluble salts and runoff transportation due to high precipitation. This is in accordance with the results of Balanagoudar and Satyanarayana[21] and Najar[22]. The available N, P, K, Ca and Mg ranged from 152.0 to 428.0, 9.0 to 24.0, 206.0 to 464.0, 209.0 to 501.0, 509.0 to 621.0 Kg ha^{-1} respectively. According to Methods Manual of Soil Testing in India[23] the critical limits of Nitrogen, Phosphorus and Potassium for normal growth of plant are 250 kg/ha, 10 kg/ha and 129 kg/ha respectively. With this consideration, the results indicate that almost all the available nutrients fall in low to medium range of availability. The lower values of available N are attributed to slow organic matter decomposition rate under temperate conditions of South Kashmir and removal of mineralized nitrogen by intensive cropping. Phosphorus low to medium availability range is attributed to poor P fertilization, low pH, organic matter content, and various soil management practices[24]. Similar results were presented by Yogeeshappa[25]. Higher content of available potassium is attributed to presence of illite (K rich clay minerals), higher K fertilizer application and manures The results are supported by the findings of Fida *et al.,*[26] and Patel *et al.,*[27].

Parent material strongly influence Ca and Mg concentration through mineral weathering and soil formation processes, which subsequently affect the cation exchange capacity and base saturation of exchangeable sites. This is in accordance with Bailey *et al.,*[28], Hintington *et al.,*[29], and Kabrick *et al.,*[30]. The medium and higher availability of Ca and Mg is therefore attributed to parent material as limestone with substantial quantity of dolomite and shale of Triassic age along with illite and chlorite minerals which typically supply base cations like Ca and Mg. Similar observations were recorded by the findings of Dar *et al.*,[31] and Yogeeshappa[25].

Relation Between Available Nutrients and Physico-Chemical Properties

Correlation analysis of physico-chemical properties of soil with available nutrients is presented in Table 3. The pH of soils showed significant negative correlation with N (r = -0.70) and P (r = -0.52) and non-significant correlation with available K while pH exhibited significant and positive correlation (r = 0.89 and r = 0.68) with available Ca and Mg respectively. The relation indicates that increase in pH decreases available N which is attributed to volatilization loss

of N with the rise in pH while in case of available P, conversion of soluble P to insoluble calcium and magnesium phosphate with rise in pH reduces its availability. Similar results were reported by Khokhar *et al.,*[32] and Patel *et al.,*[27]. The pH does not bear any significant correlation with available K. The increase in availability of Ca and Mg with rise in soil pH is attributed to basic nature of Ca and Mg cation as also reported by Medhe *et al.,*[33].

The OC showed positive and significant correlation with available N (r = 0.98), P (r = 0.80), but non-significant and negative correlation with Ca (r = -0.71) and Mg (r = -0.63). The significant and positive correlation of OC with available N is attributed to release of mineralizable N from soil organic matter in proportionate amounts and adsorption of NH4 –N by humus complexes in soil[34,35]. Acidulating effect of OC, 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 is responsible for significant correlation of available P with OC[36,37]. A significant and positive correlation of soil clay content was observed with available K (r = 0.62), Ca (r = 0.72) and Mg (r = 0.67), while with other nutrients its relationship was non-significant. A positive and significant correlation of clay with available calcium and magnesium content was also observed by Dar[12].

Table 2: Available nutrients present in apple orchard soils of district Kulgam (mean±SE)

S. No.	Village	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})	Mg (kg ha^{-1})
1.	Mirhama	355.24±07.93	20.74±2.24	340.05±11.14	209.78±8.57	521.63±10.02
2.	Ashthal	449.64±08.53	17.95±2.37	358.32±11.07	390.12±8.55	518.91±11.43
3.	Chawalgam	349.36±10.61	24.39±2.61	209.18±09.38	413.37±6.27	596.55±09.18
4.	Pombay	411.28±08.03	15.87±1.67	240.58±04.21	386.31±3.92	527.87±10.28
5.	Kakran	349.95±13.59	9.85±0.83	206.86±04.53	381.34±6.13	509.43±05.04
6.	Gopalpora	428.62±02.52	16.06±1.05	240.48±08.92	422.45±3.47	543.76±13.81
7.	Nillow	152.32±07.70	22.16±2.92	321.18±03.72	427.34±9.40	594.23±05.77
8.	Begam	427.97±07.23	39.31±5.08	464.92±07.86	436.12±7.47	558.10±09.27
9.	Modergam	409.33±11.30	16.72±0.84	306.09±03.76	501.12±4.47	621.23±09.66
10.	Lirow	450.64±12.65	22.09±2.51	308.92±07.82	420.30±8.05	437.42±13.97

Table 3: Correlation between physico-chemical properties and available nutrients of apple orchard soils of district Kulgam

	N	P	K	Ca	Mg
pH	-0.70**	-0.52**	0.12	0.89*	0.68**
EC	0.50	0.09	0.12	0.35	0.04
OC	0.98*	0.80*	0.41	-0.71*	-0.63**
Clay	0.50	0.37	0.62*	0.72**	0.67**

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

Conclusion

Soil health and fertility are key parameters for sustainable agriculture. Soil testing for available nutrient status and assessment of soil physico-chemical factors affecting their availability is an important tool for managing the nutrient balance and productivity levels in apple orchards. The studied soils have low to medium available nutrient levels

ranging from 152.0 to 428.0, 9.0 to 24.0, 206.0 to 464.0, 209.0 to 501.0, 509.0 to 621.0 Kg ha^{-1} for N, P, K, Ca and Mg respectively. Physico-chemical properties of pH, OC and clay have a profound effect on the availability of soil available nutrients. Proper management of these properties can help in restoring the fertility levels in the soil and their relation can prove beneficial for nutrient recommendation system of apple orchards of Kulgam.

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