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Research Paper

Nutrient status of chinese sand pear (Nakh) cultivar in district Budgam

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ABSTRACT

The present study was undertaken to assess the nutrient status of sand pear orchards in Budgam district of Jammu and Kashmir to support region-specific nutrient management strategies. Sand pear (*Pyrus pyrifolia*), locally known as Nakh Kashmiri, is an important temperate fruit crop valued for its high yield potential, crisp texture, extended shelf life, and market preference. Its resilience to climatic stress makes it a commercially viable crop in the Kashmir region. Twelve uniformly aged and vigorous orchards were surveyed using a simple random sampling method. Soil samples were collected from two depths-surface (0-25 cm) and subsurface (25-75 cm)-and analyzed alongside the corresponding leaf samples for macro-and micronutrient content. Surface soils were found to be medium in available nitrogen (321.50 kg/ha), medium to high in phosphorus (17.38 kg/ha), and medium in potassium (229.42 kg/ha), while sub-surface layers showed lower levels. Both soil layers exhibited high calcium and magnesium concentrations. Iron and manganese were abundant, whereas zinc and copper ranged from medium to high. Leaf analysis revealed medium to high nitrogen (1.98-2.64%), low to medium phosphorus (0.12-0.19%), and medium to high potassium (1.20–1.96%). Zinc and copper were found to be deficient to moderate, while iron and manganese were adequate. Correlation analysis indicated that soil pH and organic carbon significantly influenced nutrient availability, especially for micronutrient cations. Enhancing organic matter and adopting proper soil management practices can improve the micronutrient status of sand pear orchards.

Key words: Correlation analysis, macronutrients, micronutrients, sand pear, soil fertility

The pear (*Pyrus* spp.), a globally renowned temperate fruit, belongs to the subfamily Pomoideae of the family Rosaceae, with a basic chromosome number of $x = 17$. The Himalayan region, celebrated for its rich biodiversity, remains a haven for botanical exploration (Jan *et al.,* 2018). Pear is second only to apple in importance among temperate fruits, thriving in various climates and ranking third in terms of acreage and production (Raja *et al.,* 2019). It grows in areas ranging from foothills to high altitudes, requiring chilling hours between 500 and 1500 (Dar *et al.,* 2012). In India, pear varieties from *Pyrus pyrifolia* and *Pyrus communis* are commercially grown (Verma *et al.,* 2014). Among these, Chinese sand pear (*Pyrus pyrifolia*), locally known as Kashmiri Nakh, holds substantial economic value in the Kashmir valley due to its extended shelf life, crisp texture,

high productivity potential, and resilience to climatic stress. These attributes make it an ideal crop for the temperate regions of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand (Sharma *et al.,* 2019). In Budgam district, pear is cultivated across 1961.29 hectares, producing 18,139.45 Metric Tonnes annually. Charisharief leads with 13,940 Metric Tonnes from 557 hectares, followed by Loolipora at 3,788 Metric Tonnes from 326 hectares (Chief Horticulture Officer, 2020-21). However, yields remain low due to poor soil fertility and inadequate orchard management, which impair fruit quality and productivity (Maqbool *et al.,* 2018). Soil fertility, influenced by texture, moisture, and pH, is critical for pear growth and fruit quality (Wani *et al.,* 2017). Nutrient imbalances reduce yield, degrade fruit quality, and increase disease susceptibility, with phosphorus enhancing yield, potassium improving colour, calcium reducing disorders like bitter pit, and excessive nitrogen potentially lowering quality (Neilsen and Neilsen, 2009). Continuous nutrient removal without replenishment causes plant stress and yield loss (Foth and Ellis, 1997). Soil and foliar analyses are essential for assessing nutrient status, providing insights into availability, uptake, and utilization, particularly for deep-rooted crops like pears, where understanding nutrient distribution across soil depths can inform fertility management (Swamy *et al.,* 2016; Ganai *et al.,* 2018). This study aimed to evaluate the physico-chemical properties and nutrient status of soil and leaves in Chinese sand pear orchards in Budgam, Jammu and Kashmir, to identify factors contributing to low yield and develop site-specific nutrient management strategies to enhance productivity and fruit quality.

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MATERIALS AND METHODS

Budgam district, located between 32º.17′ to 37º.50′ N latitude and 72º.14′ to 80º.30′ E longitude at an altitude of 3700 meters, features an alluvial-filled basin with fertile Karewa formations from the Pleistocene and post-Pleistocene periods. These formations, with horizontally stratified lacustrine deposits, consist of sand, silt, clay, buff-coloured sandy clay, and compacted conglomerates. The region is renowned for cultivating temperate fruits like pear, apple, and walnut, showcasing nature's abundant richness. Soil samples from twelve uniform-age, vigorous pear orchards in Budgam district were collected at 25 cm intervals up to 75 cm using simple random sampling. After air-drying, the samples were crushed and sieved through a 2 mm mesh. Composite samples were analysed for physicochemical properties. Soil pH and electrical conductivity (EC) were measured using standard methods (Jackson, 1973). Organic carbon content was assessed via dichromate oxidation (Walkley and Black, 1947), while available nitrogen was determined by alkaline potassium permanganate distillation (Subbiah and Asija, 1956). Available phosphorus was extracted with 0.5 N sodium bicarbonate at pH 8.5 (Olsen *et al.,* 1954). Available potassium was extracted using 1N ammonium acetate (pH 7.0) and quantified by flame photometry (Jackson, 1973). Calcium, magnesium, and micronutrients (iron, zinc, copper, manganese) were measured via atomic absorption spectrophotometry after DTPA extraction (Lindsay and Norwell, 1978). Twelve healthy, well-spaced trees of pear cv. Chinese sand pear, uniform in age, vigour, and productivity, were selected for the study. Leaf samples were collected from the middle portion of the current season's growth between May 1 and October 1 at fortnightly intervals. The leaves were washed thoroughly with tap water, dipped in 0.1N HCl, distilled water, and then double-distilled water. After air drying, they were oven-dried at 58°C to a constant weight and ground using a steel Willey mill. Nitrogen content was determined by the micro Kjeldahl method, phosphorus by the Vanadomolybdo-phosphoric acid yellow colour method (Jackson, 1958), and potassium and calcium using a flame photometer. Magnesium and micronutrients were analysed via atomic absorption spectrophotometry (ECIL 4141). Correlation analysis was conducted using Opistat software.

RESULTS AND DISCUSSION

Physico-chemical properties: Soil pH ranged from 6.54 to 7.12 in surface layers and increased with depth, likely due to the leaching of basic cations from surface to subsurface horizons, influenced by high precipitation, organic matter variations, and temperature gradients (Table 1)

(Najar *et al.,* 2009; Wani *et al.,* 2016; Dar *et al.,* 2012). Similar pH trends have been reported in the soils of Himachal Pradesh and Kashmir (Bhandari and Randhawa, 1978; Wani, 2001). The electrical conductivity of all soils was within normal limits, showing an irregular pattern with increasing depth. Lower electrical conductivity in surface soils of high, mid, and low altitudes is attributed to the leaching of soluble salts and runoff caused by high precipitation, aligning with findings by Arjumend and Abbasi (2016), Najar (2002) and Dar *et al.* (2012).

Table 1. Physicochemical properties of Chinese sand pear in district Budgam

S.No.	Location	Depth (cm)	pH	E.C(dsm^{-1})	O.C (%)
01	Badipora	00.0-25.0	7.12	0.23	0.89
		25.0-50.0	7.46	0.37	0.70
		50.0-75.0	7.54	0.27	0.56
02	Chrari-sharief A	00.0-25.0	6.80	0.16	0.95
		25.0-50.0	7.36	0.19	0.68
		50.0-75.0	7..62	0.22	0.47
03	Chrari-sharief B	00.0-25.0	6.70	0.13	1.75
		25.0-50.0	7.24	0.21	1.28
		50.0-75.0	7.36	0.17	1.05
04	Chrawani	00.0-25.0	6.80	0.18	1.12
		25.0-50.0	7.16	0.25	0.94
		50.0-75.0	7.66	0.28	0.64
05	Nagam	00.0-25.0	7.04	0.18	0.98
		25.0-50.0	7.30	0.35	0.79
		50.0-75.0	7.48	0.32	0.51
06	Nowpora	00.0-25.0	7.40	0.16	1.58
		25.0-50.0	7.52	0.27	0.86
		50.0-75.0	7.60	0.20	0.62
07	Kaneer	00.0-25.0	6.58	0.14	1.95
		25.0-50.0	7.10	0.23	1.24
		50.0-75.0	7.38	0.30	0.79
08	Zoohama	00.0-25.0	6.94	0.24	0.84
		25.0-50.0	7.56	0.28	0.55
		50.0-75.0	7.76	0.20	0.36
09	Hanjoora	00.0-25.0	6.54	0.12	2.04
		25.0-50.0	6.70	0.17	1.46
		50.0-75.0	6.88	0.22	0.82
10	Tilsar	00.0-25.0	7.42	0.24	1.57
		25.0-50.0	7.56	0.17	0.95
		50.0-75.0	7.80	0.22	0.71
11	Dalwan	00.0-25.0	7.68	0.21	1.04
		25.0-50.0	7.86	0.28	0.56
		50.0-75.0	7.94	0.35	0.41
12	Footlipora	00.0-25.0	7.72	0.24	0.51
		25.0-50.0	7.96	0.30	0.34
		50.0-75.0	8.04	0.29	0.27
	Surface Range		**6.54-7.12**	**0.12-0.24**	**0.51-2.04**
	Mean		**7.06**	**0.19**	**1.27**
	Sub –Surface Range		**6.70-8.04**	**0.17-0.37**	**0.27-1.24**
	Mean		**7.49**	**0.26**	**0.73**

The organic carbon content in the analysed soils ranged from medium to high, with the highest levels found in surface layers, decreasing with depth. Surface soils contained organic carbon ranging from 0.51 to 2.04 percent, likely due to high rainfall and low temperatures promoting dense vegetation, alongside increased soil acidity that slows decomposition and mineralization, leading to organic matter accumulation (Najar *et al.,* 2009; Dar *et al.,* 2012). In contrast, lower organic carbon levels at lower altitudes may result from surface tillage, which reduces organic matter build-up,

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particularly under continuous cultivation, as reported by Wani *et al.* (2016), Verma *et al.* (1990) and Minhas *et al.* (1997).

Macronutrients status of soils (Primary nutrients)

Nitrogen: Available nitrogen in surface and sub-surface soils ranged from 174.00 to 502.00 kg/ha and 90.00 to 318.00 kg/ha, with mean values of 321.50 and 201.50 kg/ha, respectively (Table 2).

Table 2. Available nutrient status of Chinese sand pear in district Budgam

No	Location	Depth (cm)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (kg/ha)	Magnesium (kg/ha)
01	Badipora	00.0-25.0	280	16.00	229	4390.40	645.12
		25.0-50.0	246	11.00	186	4569.60	528.64
		50.0-75.0	180	07.20	197	4704.00	479.36
02	Chrari-shariefA	00.0-25.0	258	12.60	206	4748.80	618.24
		25.0-50.0	232	09.40	184	4816.00	591.36
		50.0-75.0	180	07.80	192	4860.80	667.52
03	Chrari shariefB	00.0-25.0	386	24.00	237	4659.20	551.04
		25.0-50.0	318	13.20	246	4793.60	501.76
		50.0-75.0	250	10.60	118	4883.20	600.32
04	Chrawani	00.0-25.0	288	15.40	214	4905.60	640.46
		25.0-50.0	200	11.80	161	5017.60	555.52
		50.0-75.0	166	08.60	167	5174.40	618.24
05	Nagam	00.0-25.0	266	13.40	216	5040.00	636.16
		25.0-50.0	218	10.80	198	5107.20	591.38
		50.0-75.0	134	09.40	186	5154.40	667.52
06	Nowpora	00.0-25.0	174	10.60	202	4816.00	707.84
		25.0-50.0	136	08.80	182	4860.80	680.94
		50.0-75.0	90	07.40	206	4950.40	663.04
07	Kaneer	00.0-25.0	502	27.20	334	4480.00	506.24
		25.0-50.0	278	18.60	212	4547.20	667.52
		50.0-75.0	220	11.40	169	4649.20	573.44
08	Zoohama	00.0-25.0	326	17.60	192	4524.80	627.20
		25.0-50.0	212	11.80	206	4659.40	658.56
		50.0-75.0	156	09.20	187	4726.40	564.48
09	Hanjoora	00.0-25.0	480	28.20	280	4816.60	542.08
		25.0-50.0	340	17.40	261	5017.60	582.40
		50.0-75.0	206	11.60	234	5174.40	631.68
10	Tilsar	00.0-25.0	334	13.80	207	5040.00	622.72
		25.0-50.0	208	09.60	119	5107.20	654.18
		50.0-75.0	156	11.80	108	5154.40	647.12
11	Dalwan	00.0-25.0	350	16.20	202	4905.60	542.08
		25.0-50.0	184	13.80	239	5017.80	663.04
		50.0-75.0	138	09.60	116	5106.20	582.40
12	Footlipora	00.0-25.0	214	11.80	234	4972.80	600.32
		25.0-50.0	166	9.40	168	5174.40	649.60
		50.0-75.0	122	08.00	144	5308.80	676.48
Surface Range			**174.00-502.00**	**10.60-28.20**	**192.00-334.00**	**4390.40-5040.00**	**506.24-645.12**
Mean			**321.50**	**17.38**	**229.42**	**4745.12**	**603.31**
Sub –Surface Range			**90.00-318.00**	**07.20-18.60**	**108.00-261.00**	**4547.20-5308.0**	**479.36-680.96**
Mean			**201.50**	**10.82**	**182.75**	**4917.38**	**612.36**

These findings align with Masrat (2015), Bhat *et al.* (2017), Wani *et al*. (2017) and Zargar (2005). The nitrogen variation is attributed to differences in climatic, physiographic, and organic matter conditions, as well as natural fertility and fertilizer usage. Surface soils had higher nitrogen content

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than sub-surface soils, with a decline in nitrogen as soil depth increased. This decrease is linked to higher organic matter, better mineralization conditions at the surface, and nitrogen depletion from crop uptake and fertilization. These results are consistent with Mushki (2013), Dar *et al*. (2012), Sireesha and Naidu (2013), Wani *et al.* (2017), Ranjha *et al.* (2002), Dar (2009) and Singh and Rathore (2013).

Phosphorus: The available phosphorus content in the studied soils ranged from medium to high (Table 2). Data showed surface soils contained 10.60 to 28.20 kg/ha, while sub-surface soils ranged from 7.20 to 18.60 kg/ha, with average values of 17.38 and 10.82 kg/ha, respectively. Phosphorus levels generally decreased with soil depth, likely due to favorable soil reactions and high organic matter, leading to the formation of organophosphate complexes and humus coating on iron and aluminum particles. This is consistent with Farida (2005) and Dar *et al.* (2012). The greater organic matter in surface soils likely accounts for higher available phosphorus in these layers, aligning with findings from Dar (2009), Fida *et al.* (2011), Devdas and Srivastava (2013), Kumar *et al.* (2014), Bhat *et al.* (2017) and Wani *et al.* (2017).

Potassium: Table 2 shows available potassium content ranging from 192.00 to 334.00 kg/ha in surface soils and 108.00 to 261.00 kg/ha in sub-surface soils, with mean values of 229.42 and 182.75 kg/ha, respectively. These results align with Dar *et al.* (2015), Bhat *et al.* (2017) and Nashik's *et al.* (2015). The higher potassium levels in surface and higher altitude soils may be due to intense weathering (Kirmani, 2004), release of labile potassium from organic residues, potassium fertilizer applications (Sireesha and Naidu, 2013), and upward translocation with capillary rise of groundwater (Sharma and Kumar, 2003). No specific trend with depth was observed, suggesting erratic potassium distribution influenced by weathering intensity, climate, and altitude, as noted by Dar (2009), Fida *et al.* (2011), Demirer *et al.* (2007), Ganai *et al*. (2018), Bhat (2010), Dar *et al.* (2012) and Wani *et al.* (2017).

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Secondary nutrients

Calcium: Table 2 reveals that pear orchard soils were well-supplied with available calcium, which was high across all soils. Surface soils contained available calcium ranging from 4390.40 to 5040.00 kg/ha (mean: 4745.12 kg/ha), while sub-surface soils ranged from 4547.20 to 5308.80 kg/ha (mean: 4745.12 and 4917.38 kg/ha). Variations in calcium content across locations can be attributed to differences in calcium-bearing minerals, soil pH, elevation, slope, and the presence of a thick limestone layer with dolomite and shale around the Kashmir valley (Wadia, 1981). The calcareous nature of the parent material, as noted by Handoo (1983), further contributes to the high calcium levels. These findings align with the work of Dar *et al.* (2015), Masrat (2015), Shaaban and El-Fouly (2012), Yogeeshappa *et al*. (2008), and Bhargava and Raghupathi (2001). Calcium content was generally higher in sub-surface layers than in surface layers, likely due to leaching from surface soils. This is consistent with the results of Wani (2001), Dar (2009), Bhat *et al.* (2017) and Wani *et al.* (2017).

Magnesium: Table 2 shows that the available magnesium content in surface and sub-surface soils ranged from 506.24 to 645.12 kg/ha and 479.36 to 680.96 kg/ha, with average values of 603.31 and 612.36 kg/ha, respectively, displaying an inconsistent trend with soil depth. The high magnesium levels may be attributed to the abundance of dolomite, favorable pH, and the presence of illite and chlorite minerals in Kashmir soils, as noted by Najar (2002) and Wani *et al.* (2016) in their studies on apple and pear orchards. The lack of a consistent trend in magnesium content with soil depth reflects the stratification of these soils, aligning with findings by Dar *et al*. (2015), Masrat (2015), Bhat *et al*. (2017) and Wani *et al.* (2017).

Micronutrient status of soils

Iron: The available iron content in surface and sub-surface soils ranged from 30.80 to 68.14 mg kg^{-1} and 19.74 to 54.66 mg kg^{-1}, with average values of 49.87 and 35.70 mg kg^{-1}, respectively (Table 3).

Table 3. DTPA extractable micronutrient status of Chinese sand pear orchard soils in District Budgam

S.No.	Location	Depth (cm)	Zinc (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)
01	Badipora	00.0-25.0	1.46	1.52	42.50	51.06
		25.0-50.0	1.18	1.36	37.84	42.48
		50.0-75.0	0.64	0.86	30.62	37.52
02	Chrari shariefA	00.0-25.0	1.22	1.48	46.80	44.60
		25.0-50.0	0.70	0.92	38.62	30.52
		50.0-75.0	0.44	0.74	30.40	27.56
03	Chrari shariefB	00.0-25.0	1.68	2.38	62.28	58.64
		25.0-50.0	1.48	1.96	54.66	43.72
		50.0-75.0	1.02	1.34	41.58	26.80
04	Chrawani	00.0-25.0	1.50	1.46	43.60	50.72
		25.0-50.0	1.14	1.24	35.28	38.60
		50.0-75.0	0.80	1.22	20.42	25.32
05	Nagam	00.0-25.0	1.32	1.65	58.40	46.30
		25.0-50.0	1.04	1.76	42.60	40.20
		50.0-75.0	0.86	1.86	34.60	32.80
06	Nowpora	00.0-25.0	0.58	0.52	30.80	27.00
		25.0-50.0	0.24	2.06	25.20	24.56
		50.0-75.0	Traces	2.26	19.74	18.90
07	Kaneer	00.0-25.0	1.42	1.38	66.40	60.40
		25.0-50.0	1.06	1.22	52.48	47.28
		50.0-75.0	0.74	1.44	37.90	35.60
08	Zoohama	00.0-25.0	1.22	1.60	41.76	45.38
		25.0-50.0	0.98	0.70	34.82	37.46
		50.0-75.0	0.74	1.22	29.34	24.32
09	Hanjoora	00.0-25.0	1.72	1.65	68.14	66.80
		25.0-50.0	1.38	1.76	49.08	52.24
		50.0-75.0	1.16	1.86	36.44	38.56
10	Tilsar	00.0-25.0	1.02	0.52	48.20	37.82
		25.0-50.0	0.76	2.06	39.00	24.36
		50.0-75.0	0.48	2.26	25.86	20.18
11	Dalwan	00.0-25.0	1.38	1.38	50.22	41.46
		25.0-50.0	0.90	1.22	43.18	33.72
		50.0-75.0	0.74	1.44	37.06	29.54
12	Footlipora	00.0-25.0	0.76	1.23	39.30	37.80
		25.0-50.0	0.54	0.82	35.26	29.00
		50.0-75.0	0.36	0.66	24.70	21.64
Surface Range			**0.58-1.72**	**0.86-2.38**	**30.80-68.14**	**27.00-66.80**
Mean			**1.27**	**1.64**	**49.87**	**47.33**
Sub –Surface Range			**0.00-1.48**	**0.52-1.96**	**19.74-54.66**	**18.90-52.24**
Mean			**0.81**	**1.13**	**35.70**	**32.62**

The distribution of iron showed an erratic pattern with depth, being higher in surface soils. This could be attributed to the higher organic matter content and the formation of iron chelates, as iron availability decreases with increasing soil pH, where it forms insoluble oxides. Organic matter also forms soluble complexes with iron, enhancing its plant availability. These findings align with those of Upadhyaya *et al.* (2000), Sharma *et al.* (2005), Nazif *et al.* (2006), Samiullah *et al.* (2013) and Wani *et al.* (2017), who noted that available iron is strongly influenced by organic carbon content.

Manganese: The available manganese content in surface soils ranged from 27.00 to 66.80 mg kg^{-1}, with an average of 47.33 mg kg^{-1}, while in sub-surface soils, it varied from 18.90 to 52.24 mg kg^{-1}, averaging 32.62 mg kg^{-1}. Surface soils had higher manganese levels, which decreased with depth, likely due to the lower pH and higher organic matter in the surface layers. The reduced manganese content in sub-surface soils may be linked to higher pH, which reduces its solubility, leading to

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precipitation and lower availability. These results align with Sharma *et al*. (2005) and Demirer *et al.* (2007). Pear orchards had adequate manganese, attributed to organic matter and favorable soil pH for manganese availability, as supported by Nazif *et al.* (2006).

Zinc: Zinc content in surface soils ranged from 0.58 to 1.72 mg kg^{-1}, with an average of 1.27 mg kg^{-1}, while in sub-surface soils, it ranged from 0.00 to 1.48 mg kg^{-1}, averaging 0.81 mg kg^{-1}. Surface soils exhibited higher zinc levels, which decreased with depth, likely due to the higher organic carbon in surface soils, as organic carbon is a key contributor to available zinc. These findings align with Shah *et al.* (2012). Organic matter can lower soil pH locally, enhancing zinc solubility, and its decay products may chelate zinc, making it more accessible to plants and less prone to fixation, as noted by Najar (2002), Dar (2009), Bhat (2010) and Samiullah *et al.* (2013).

Copper: The available copper content ranged from 0.86 to 2.38 mg kg^{-1} (mean: 1.64 mg kg^{-1}) in surface soils, while in sub-surface soils, it ranged from 0.52 to 1.96 mg kg^{-1} (mean: 1.13 mg kg^{-1}). Copper content decreased with depth, with surface soils exhibiting higher levels, likely due to increased organic matter and regular additions of plant residues, farmyard manure, and agricultural chemicals. These findings align with those of Najar (2002), Dar (2009), Ram *et al.* (2017) and Khokhar *et al.* (2012). All soils were classified as medium in available copper, which may be attributed to strong adsorption of copper to iron and aluminium oxides, leading to moderate extraction of available copper, as reported by Lindsay and Norwell (1978) and Shaaban and El-Fouly (2012).

Relationship between physico-chemical characteristics and available nutrients in surface and sub-surface soils.

Correlation coefficients between various physico-chemical properties, such as pH, calcium carbonate, organic carbon, and clay, with available nutrient elements were calculated for both surface and sub-surface soils of apple orchards in Budgam district, as shown in Table 4 and 5.

Table 4. Relationship between physico chemical properties and available nutrients in surface soils

Nutrient/ physico chemical properties	Soil reaction (pH)	EC (dSm^{-1})	OC (%)
Nitrogen	-0.605*	-0.460	0.688*
Phosphorus	-0.689*	-0.573	0.738*
Potassium	-0.526	-0.537	0.503
Calcium	0.476	0.076	-0.257
Magnesium	0.330	0.369	-0.421
Zinc	-0.695*	-0.439	0.343
Copper	-0.614*	-0.531	0.580*
Iron	-0.630*	-0.512	0.616*
Manganese	-0.811*	-0.556	0.484

Soil reaction: The correlation analysis presented in Table 4 shows that surface soil pH negatively correlated with nitrogen (r = -0.605*), phosphorus (r = -0.689*), zinc (r = -0.695*), copper (r = -0.614*), manganese (r = -0.811*), and iron (r = -0.630*), while showing no significant relationship with calcium, magnesium, or potassium. In sub-surface soils (Table 5), a similar negative correlation was observed with nitrogen (r = -0.726*), phosphorus (r = -0.587*), zinc (r = -0.627*), copper (r = -0.672*), and manganese (r = -0.733*), while no significant correlation was found with other elements. These findings confirm the negative relationship between pH and available nitrogen as reported by Wani (2001), Farida (2005) and Dar *et al.* (2015). The decreased availability of phosphorus with increasing pH is due to its conversion into insoluble tricalcium phosphates, with higher pH leading to fixation in apatite forms, as noted by Dar *et al.* (2015) and Maqbool *et al*. (2016).

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Table 5. Relationship between physio chemical properties and available nutrients in surface soils

Nutrient/ physico chemical properties	Soil reaction (pH)	EC (dSm^{-1})	OC (%)
Nitrogen	-0.726*	-0.369	0.756*
Phosphorus	-0.587*	-0.247	0.682*
Potassium	-0.667*	-0.037	0.291
Calcium	0.487	0.329	-0.282
Magnesium	0.328	0.086	-0.289
Zinc	-0.627*	-0.088	0.562
Copper	-0.672*	-0.230	0.789*
Iron	-0.483	-0.115	0.564
Manganese	-0.733*	-0.134	0.496

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Electrical conductivity (EC): Electrical conductivity in surface soils exhibited a negative, non-significant correlation with nitrogen, phosphorus, potassium, zinc, copper, manganese, and iron, while showing a positive, non-significant correlation with calcium and magnesium. In sub-surface soils, electrical conductivity showed a non-significant negative correlation with nitrogen, phosphorus, potassium, magnesium, zinc, copper, and iron, but a positive correlation with calcium and manganese. These results align with the findings of Ayele *et al*. (2013) and Maqbool *et al*. (2016).

Organic carbon: Soil organic carbon showed a significant positive correlation with nitrogen (r = 0.688*), phosphorus (r = 0.738*), copper (r = 0.580*), and iron (r = 0.616*), but a non-significant negative correlation with calcium (r = -0.257) and magnesium (r = -0.421). It showed no significant correlation with potassium, zinc, and manganese (Table 4). In sub-surface soils, organic carbon exhibited a significant positive correlation with nitrogen (r = 0.756*), phosphorus (r = 0.682*), and copper (r = 0.789*), but no significant relationship with potassium, calcium, magnesium, zinc, iron, and manganese (Table 5). The positive correlation between organic carbon and nitrogen suggests a close association of nitrogen with organic matter, where NH_4-N is adsorbed by humus complexes. Similar findings were noted by Singh and Rathore (2013), Adak *et al.* (2014), and Maqbool *et al.* (2017). The increased availability of nitrogen, phosphorus, copper, iron, and manganese may result from their release from organic complexes or mineral weathering influenced by the acidifying action of organic matter. The significant link between organic carbon and available phosphorus highlights the role of organic matter in limiting nutrients such as nitrogen, phosphorus, and potassium in soils, as reported by Panday *et al.* (2000) and Farida (2005), and Maqbool *et al*. (2016).

Leaf macro-nutrients

Nitrogen (N): The nitrogen content in pear leaves ranged from 1.98% to 2.64%, with an average of 2.28% (Table 6), which aligns with findings by Dar *et al.* (2012) and Wani *et al.* (2017). This adequate nitrogen level can be attributed to regular manure and fertilizer applications, along with the decomposition of both natural and added organic matter, as well as biological nitrogen fixation. These results support the work of Amiri and Fallahi (2009) and Wani *et al.* (2017). Significant variations in leaf nitrogen across different pear orchards may be linked to enhanced nitrogen availability and improved photosynthetic efficiency, which boosts nutrient uptake, as suggested by Faust (1989). Similar observations were made by Bist and Yadav (2000) and Gao *et al.* (2017) in apple and pear orchards.

Phosphorus (P): The leaf phosphorus content ranged from 0.124% to 0.192%, with a mean of 0.150% (Table 6), indicating sufficient phosphorus levels across various pear orchards. This can be attributed to regular nutrient application and high organic matter content, as supported by Najar (2002) and Dar *et al.* (2012) in apple orchards. Significant variations in leaf phosphorus among orchards may be due to differences in soil, climate, elevation, and other factors, consistent with the findings of Xu *et al.* (2015).

Potassium (K): Leaf potassium content in pear orchards ranged from 1.20% to 1.96%, with an average of 1.51% (Table 6). Similar levels of potassium have been reported by Dar (2009) and Dar *et al*. (2012). Significant variation in leaf potassium across orchards may be attributed to differences in soil potassium and other factors, as noted by Neilsen and Neilsen, (2008).

Table 6. Leaf Nutrient status of Chinese sand pear orchard soils in District Budgam

S.No.	Location	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)
1	Badipora	2.30	0.148	1.52	1.40	0.44
2	Chrari shariefA	2.14	0.136	1.34	1.54	0.42
3	Chrari shariefB	2.52	0.182	1.96	1.46	0.50
4	Chrawani	2.24	0.132	1.46	1.52	0.46
5	Nagam	2.11	0.130	1.22	1.66	0.42
6	Nowpora	1.98	0.126	1.20	1.58	0.40
7	Kaneer	2.64	0.192	1.84	1.48	0.36
8	Zoohama	2.20	0.154	1.32	1.42	0.44
9	Hanjoora	2.56	0.178	1.76	1.50	0.48
10	Tilsar	2.32	0.146	1.48	1.54	0.42
11	Dalwan	2.34	0.150	1.58	1.56	0.46
12	Footlipora	2.00	0.124	1.59	1.60	0.40
	Range	**1.98-2.64**	**0.12-0.19**	**1.20-1.96**	**1.40-1.66**	**0.36-0.50**
	Mean	**2.28**	**0.150**	**1.51**	**1.52**	**0.43**

Calcium (Ca): Leaf calcium content ranged from 1.40% to 1.66%, with a mean of 1.52%, indicating sufficient levels across all samples (Table 6). These findings align with Najar (2002). Significant variation in leaf calcium among orchards could be due to factors like soil calcium, pH, moisture, nutrient interactions, calcium carbonate content, and rootstock effects, influencing uptake. Similar observations were made by Milosevic and Milosevic (2015) and Wani *et al.* (2017) in apple and pear orchards in Kashmir.

Magnesium (Mg): Leaf magnesium content in pear orchards ranged from 0.36% to 0.50%, with a mean of 0.43%, as shown in Table 6. These values are consistent with Mushki (2013). All orchards exhibited sufficient magnesium levels, likely due to optimal pH, which enhances magnesium availability. These findings are supported by Farida (2005), Dar (2009), and Mushki (2013).

Leaf micronutrients

Zinc (Zn): The zinc content in pear leaves ranged from 14.60 to 44.00 mg g^{-1}, with an average of 31.10 mg g^{-1} (Table 7), aligning with Chaplin and Westwood (1980), Shear and Faust (1980), Shen (1989), and Dar (2009). The adequate zinc levels observed can be attributed to sufficient organic matter, available zinc in the soil, and favourable pH for uptake, as supported by Najar (2002), Dar (2009), and Samiullah *et al.* (2013) in studies on apple, pear, and peach in Kashmir.

Copper (Cu): The copper content in pear leaves ranged from 5.60 to 20.40 mg g^{-1}, with an average of 13.33 mg g^{-1} (Table 7), consistent with Chaplin and Westwood (1980), Rathore (1991), Arora *et al.* (1992), Seth (1997), and Dar (2009). Most samples showed low to adequate copper levels, likely due to high organic matter, available copper in soils, and favourable soil pH, as supported by Mamgain *et al*. (1998), Najar (2002), Dar (2009), and Xu *et al*. (2015).

Iron (Fe): Iron content in pear leaves ranged from 64.30 to 178.30 mg g^{-1}, with an average of 126.43 mg g^{-1} (Table 7), aligning with Najar (2002), Singh *et al*. (2005), and Dar (2009). The leaves exhibited adequate iron levels, likely due to favourable soil pH, sufficient organic matter forming soluble complexes, and other uptake factors, as supported by Najar (2002), Dar (2009), and Wani *et al.* (2017).

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Table 7. Leaf micronutrient status of Chinese sand pear orchard soils in District Budgam

S.No.	Location	Zinc (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)
1	Badipora	34.30	12.60	114.60	65.30
2	Chrari shariefA	26.00	11.20	108.30	60.60
3	Chrari shariefB	42.60	19.40	166.00	90.30
4	Chrawani	35.00	11.80	122.30	74.00
5	Nagam	28.30	13.20	96.60	72.30
6	Nowpora	14.60	05.60	64.30	42.00
7	Kaneer	38.60	17.00	174.00	114.30
8	Zoohama	32.30	11.20	115.60	57.60
9	Hanjoora	44.00	20.40	178.30	71.30
10	Tilsar	26.60	13.80	135.30	58.00
11	Dalwan	35.50	14.20	142.60	60.60
12	Footlipora	15.60	09.60	99.30	58.30
	Range	**14.60-44.00**	**05.60-20.40**	**64.30-178.30**	**42.00-114.30**
	Mean	**31.10**	**13.33**	**126.43**	**68.72**

Manganese (Mn): Leaf manganese content ranged from 42.00 to 114.30 mg g^{-1}, with a mean of 68.72 mg g^{-1} (Table 7), consistent with findings by Najar (2002) and Dar (2009), who also reported adequate manganese in Kashmir orchards. Significant variation in manganese levels across orchards was likely due to available manganese, high organic matter, and favorable soil conditions, as supported by Dar (2009), and Xu *et al.* (2015).

Table 8. Correlation coefficient between available nutrients and leaf nutrient content in pear cultivar Chinese sand pear in district Budgam

S.No.	Nutrient	Surface soils	Sub Surface Soils
1	Nitrogen	0.958*	0.904*
2	Phosphorus	0.941*	-0.044
3	Potassium	0.726*	0.125
4	Calcium	0909*	0.807*
5	Magnesium	0.188	-0.522
6	Zinc	0.962*	0.933*
7	Copper	0.986*	0.973*
8	Iron	0.843*	0.831*
9	Manganese	0.765*	0.663*

Correlation coefficient between available nutrients and leaf nutrient contents in pear cultivar Chinese sand pear in district Budgam: Soil and leaf analysis are crucial for assessing the nutritional status and diagnosing deficiencies, as they complement each other. Understanding the nutrient levels in both fruit trees and soil is vital for making informed fertilizer recommendations to optimize fruit production and evaluate tree performance. The relationship between soil nutrients and leaf content in pear orchards of district Budgam (Table 8) is summarized below. Nitrogen content in pear leaves showed a strong positive correlation with available nitrogen in both surface (r=0.958*) and sub-surface soils (r=0.904*), aligning with Jivan and Sala (2014) and Najar (2002). Phosphorus in pear leaves had a significant positive correlation with surface soil phosphorus (r=0.941*), but a non-significant negative correlation with sub-surface soils (r=-0.044), as reported by Farida (2005) and Dar (2009). Leaf potassium showed a significant positive correlation with

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available potassium in surface soils (r=0.726*), while the correlation with sub-surface soils was non-significant but positive (r=0.125), consistent with findings by Wani (2001), Najar (2002), Dar *et al*. (2013), and Wani *et al*. (2016). Foliar calcium content was positively correlated with available calcium in both surface (r=0.909*) and sub-surface soils (r=0.807*), supporting Singh (1987), Najar (2002), and Dar (2009). Our study found no significant relationship between leaf magnesium and available magnesium, likely due to the complex interactions in magnesium uptake, translocation, and utilization, influenced by factors such as soil pH, potassium levels, and nutrient interactions. This obscures a direct link between leaf and soil magnesium, as similarly noted by Najar (2002) and Dar (2009). On the other hand, leaf zinc, copper, iron, and manganese exhibited positive and significant correlations with their respective available soil contents in both surface and subsurface layers, in line with Mushki (1994). The variation in correlation strength across soil depths could be attributed to differences in root structure, competition with cover crops, nutrient ion interactions (Beattie and Ellenwood, 1950), and the influence of weather, crop size, and orchard management practices (Reuther, 1961). These findings suggest that nutrient absorption occurs predominantly from both surface (0-25 cm) and subsurface soils (25-75 cm), explaining the variable correlations between soil nutrient supply and plant content. For accurate nutritional assessments, both soil and leaf analysis must be considered together, as the significant correlations highlight their combined potential for providing reliable data. This underscores the importance of using both analyses for diagnosing and forecasting nutrient needs in pear orchards, thus enhancing fertilizer recommendations for optimized fruit production.

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CONCLUSION

The soils were neutral with normal electrical conductivity, and organic carbon levels ranged from medium to high, gradually decreasing with soil depth. The soil pH, electrical conductivity, and organic carbon showed significant variations with altitude. Available nitrogen was low to medium, while phosphorus and potassium were medium to high. Calcium and magnesium were high, and DTPA-extractable micronutrients were medium to high, except for zinc, which ranged from low to high. Overall, available phosphorus and potassium were medium to high in pear orchards, while nitrogen was low in low-altitude soils. The study indicates that altitude influences soil nutrient availability and physico-chemical properties, likely due to climatic factors and soil mineral composition. A significant negative correlation was found between pH and nitrogen, phosphorus, and micronutrient cations, while organic carbon positively correlated with nitrogen, phosphorus, copper, and iron. Leaf nutrient levels were generally marginal to adequate. Soil analysis showed that most nutrients were medium to high, except nitrogen and zinc, which were low in 33% and 8% of orchards, respectively. Leaf analysis revealed that nitrogen, phosphorus, calcium, zinc, copper, and manganese were marginal in 50%, 33%, 17%, 17%, 8%, and 25% of orchards in Budgam district. While the soils possess good nutrient reserves, they exhibit a low release rate, emphasizing the need for regular soil nutrient assessments to prevent degradation and depletion. Further insights could be gained by examining the mineralogical characteristics of the soils.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest. All research activities complied with relevant legal, institutional, and ethical standards

AUTHOR CONTRIBUTION

All the authors contributed equally in this research article.

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