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Status of macro- and micro-nutrients in soils of Chamoli district of Uttarakhand

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ABSTRACT

A GPS based soil survey was conducted in nine blocks of Chamoli district of Uttarakhand (n=300) to evaluate the status of extractable macro- and micro-nutrients and to relate them with general soil properties. Soil texture ranged from sandy loam to clay loam, pH from 4.8 to 8.29, electrical conductivity from 0.170 to 5.431 dSm^{-1} and organic carbon content from 3.14 to 30.72 g kg^{-1} soil. Among the macro-nutrients, Olsen's and Bray's extractable P varied from 1.41 to 47.20 mg kg^{-1} soil, neutral normal ammonium acetate extractable K content from 24.82 to 269.1 mg kg^{-1} soil. Exchangeable Ca and Mg content varied from 20 to 1620 mg kg^{-1} and 12 to 288 mg kg^{-1} soil, respectively. The content of 0.15% $CaCl_2$ extractable S content varied from 1.23 to 26.64 mg kg^{-1} soil. The DTPA extractable Zn, Cu, Fe, Mn content varied from 0.09 to 15.41, 0.08 to 9.03, 3.13 to 84.22 and 1.93 to 54.96 mg kg^{-1} soil, respectively. Hot water-soluble B content varied from 0.23 to 2.61 mg kg^{-1} soil while ammonium oxalate (pH 3.3) extractable Mo content varied from 0.18 to 1.36 mg kg^{-1} soil. Simple correlation showed that soil pH had a significant and positive correlation with soil extractable P, Ca, S, B and Mo but a negative one with extractable Cu, Fe and Mn. Soil EC had a significant and positive correlation with extractable P, K, Mg, S, Fe, B and Mo. Soil organic carbon had a significant and positive correlation with extractable K. On the basis of calculated nutrient indices (N.I.), the soils of Chamoli district were low in soil extractable S, medium in extractable K and Zn, high in organic carbon content, extractable P, Ca, Mg, Cu, Fe, Mn, B and Mo with sporadic cases of Zn, Cu and B deficiency.

Keywords: General soil properties, macro-nutrients, micro-nutrients and nutrient index

INTRODUCTION

Soil fertility refers to the inherent capacity of a soil to supply essential nutrients to plants in adequate and right proportion for the optimum growth and it is one of the key components to determine soil productivity. Management of the fertility of Indian soil is a priority for sustainable production to feed its burgeoning population. Proper management of soil fertility demands a careful identification of current nutrient deficiencies and regular monitoring of changes in soil fertility to predict the emerging deficiencies in a region. Macronutrients (N, P, K, Ca, Mg, S) and micronutrients (Zn, Fe, Cu, Mn, B, Mo) control soil fertility. Owing to imbalanced and inadequate use of fertilizers with low efficiency of other inputs, the response of chemical fertilizers (nutrients) has also declined under intensive cultivation in recent years. The inherent variation in nutrients supply is a natural phenomenon and some of these nutrients may be sufficient while others may turn deficient. These deficiencies need to be alleviated through sound and proven practices to sustain food production at a reasonable level. Thus, management of soil health vis-à-vis nutrient management is one of the key factors in achieving high and sustainable productivity. In Uttarakhand the major soil zones are Hill soil, *Bhabar* soils and *Tarai* and agriculture land is very limited. In northern part of the state the soils are susceptible to erosion. The major crops grown in the hills are wheat, paddy, mandua, ramdana and potato. Therefore, the survey of Chamoli district was undertaken to assess the soil fertility in relation to status of available nutrients.

MATERIALS AND METHODS

The study area belongs to Chamoli district of Uttarakhand state between 30.42^0 N and 79.33^0 S latitude and longitude respectively. As the elevation of the district ranges from 800 m to 8,000 m above sea level the climate of the district vary largely depending on the altitude. The winter season is from about mid November to March. As most of the region is situated on the southern slopes of the outer Himalayas, monsoon currents can enter through the valley, the rainfall being heaviest in the

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monsoon from June to September. The district experienced a maximum temperature of 34^0 celcius and a minimum temperature of 0^0 celcius. For the Administrative convenience, the district has been divided into 9 developmental blocks viz.Dasoli, Garsain, Deval, Ghat, Joshimath, Karnaprayag, Naryanbagar, Pokhari and Tharali. Global Positioning System (GPS) based soil samples were collected from nine developmental blocks of Chamoli district of Uttarakhand at 0-15 cm depth. Soil pH was determined in soil-water suspension (1:2) using a combined glass electrode equipped pH meter (Jackson, 1973). Soil electrical conductivity was determined in the supernatants of soil water suspensions (1:2) with the help of a conductivity meter and the values were expressed as dSm^{-1} at 25º C. Soil organic carbon content in the soil samples was determined by modified Walkley and Black method (Jackson, 1973). Soil $CaCO_3$ was determined by acid neutralization method. In neutral to alkaline soils, P was extracted by 0.5 M $NaHCO_3$(pH 8.5) as described by Olsen *et al.* (1954) while in acidic soils (pH 4.5-5.5), P was extracted by 0.03 N NH_4F + 0.025 N HCl as described by Bray and Kurtz (1945). Soil exchangeable K, Ca and Mg were extracted using 1N ammonium acetate (pH 7.0) and determined by flame photometry and versene titration method, respectively. Soil S was extracted with 0.15% $CaCl_2$ and determined turbidimetrically (Chesnin and Yien, 1951). Soil Zn, Cu, Fe and Mn were extracted by DTPA (pH 7.3) as described by Lindsay and Norwell (1978) and determined on atomic absorption spectrophotometer. Hot water-soluble B in the soil samples was extracted by following the method of Berger and Troug (1939) and determined by Azomethane H method. Molybdenum in the soil samples was extracted in 1M ammonium oxalate (pH 3.3) and determined using a colorimetric method (Grigg, 1953). Soil samples were categorized into low, medium and high categories for different nutrients following the criteria adopted by Bungla *et al.* (2019). Based on the number of samples in each category for a given nutrient the nutrient index (NI) value was calculated as:

$$\text{Nutrient index (NI)} = [(N_L \times 1) + (N_M \times 2) + (N_H \times 3)]/ (100)$$

Where, N_L, N_M and N_H are indicating the number of soil samples in low, medium and high categories, respectively. Accordingly, the areas with nutrient index value > 2.33 were considered high, those with NI between 1.67 to 2.33 were considered medium and those with values < 1.67 were regarded as low in the native supply of that nutrient (Ramamoorthy and Bajaj, 1969).For statistical analysis, simple correlation analysis was done as per the statistical procedure outlined by Snedecor and Cochran (1967). The test of significance was performed both at $p \leq 0.05$ and ≤ 0.01. The statistical analysis of the data was done with the help of a computer.

RESULTS AND DISCUSSION

General soil properties

The soils of Chamoli districts varied from loamy sand to sandy clay loam in texture. These soils were acidic to slightly alkaline (4.81-8.29) in reaction (Table 1). The highest mean value of pH (6.88) was observed in Karnaprayag block. Acidic soil pH in many blocks could be related to high organic C content releasing some organic acids upon decomposition resulting low pH in soils of lower buffering capacities (Aziz *et al.* 2012). The electrical conductivity of the Chamoli district ranged from 0.17 to 5.43 dSm^{-1} and the highest average value was observed in Pokhari block (1.21dSm^{-1}). The organic carbon content of Chamoli district ranged from 3.14 to 30.72 g kg^{-1} and the highest value was noticed in Dasoli block (20.20 g kg^{-1}). The organic carbon accumulation in soil may also be attributed to better root biomass in legume crop (Shah *et al.* 2018).

Table 1: General properties of Chamoli district soils

Blocks	Texture	pH (1: 2)	EC (dSm^{-1})	OC (g kg^{-1})	Free lime (%)
Deval	Loamy sand- clay loam	5.32-7.16 (5.93)*	0.22to 1.62 (0.60)	3.49-24.31 (14.38)	Traces
Tharali	Loamy sand- Sandy clay loam	5.25-7.25 (6.06)	0.24to1.21 (0.60)	6.64-29.90 (16.18)	Traces
Naryanbagar	Sandy loam- Clay loam	4.85-8.09 (6.58)	0.30 to 1.69 (0.88)	7.52-26.75 (16.58)	Tr. to 6.08
Karnaprayag	Loamy sand- Clay loam	5.84-8.29 (6.88)	0.30-2.41 (1.03)	5.77-26.23 (14.87)	Tr. to 6.2
Pokhari	Loamy sand- Sandy clay loam	5.25-7.33 (6.35)	0.38-5.43 (1.21)	5.77-24.65 (15.36)	Traces
Ghat	Sandy clay loam- silty clay loam	5.55-7.27 (6.23)	0.17 to 1.42 (0.71)	6.82-27.45 (18.42)	Traces
Garsain	Loamy sand-clay loam	5.12-7.24 (6.31)	0.33 to 1.23 (0.74)	11.54-27.45 (18.94)	Traces
Dasoli	Sandy loam- Sandy clay loam	5.65-7.17 (6.30)	0.29 to 1.23 (0.67)	3.14-30.25 (20.20)	Traces
Joshi math	Loamy sand-Sandy clay loam	4.18-8.15 (6.18)	0.34to 1.61 (0.89)	4.54-27.63 (16.60)	Tr. to 5.02
Entire Chamoli district	Loamy sand-sandy clay loam	4.81-8.29 (6.29)	0.17-5.43 (0.80)	3.14-30.72 (16.72)	Tr. to 6.2

Status of macro-nutrients

The extractable P concentration varied from 1.41 to 47.20 mg kg^{-1} with a mean value of 10.82 mg kg^{-1} in soils of Chamoli district and the highest mean value was noticed in Naryanbagar block (19.74 mg kg^{-1}). The extent of P deficiency were 5, 20, 13.3, 23.3 and 10.0 percent in Deval, Tharali, Pokhari and Garsain blocks, respectively with an overall deficiency of 9.3% for the entire district. The extractable K content ranged from 24.82 to 269.11 mg kg^{-1} with a mean value of 117.47 mg kg^{-1}. The highest average extractable K content was observed in Joshimath block (172.50 mg kg^{-1}). Percent soil samples deficient in extractable K were 20.0, 30.0, 3.3 and 6.7 % in Tharali, Naryanbagar, Pokhari and Dasoli blocks, respectively with an overall deficiency of 7.0 % for the whole district. The exchangeable Ca content ranged from 20 to 1620 mg kg^{-1} with a mean value of 617.26 mg kg^{-1} while the exchangeable Mg content in the soils of Chamoli district of Uttarakhand ranged from 12 to 288 mg kg^{-1} with a mean value of 59.88 mg kg^{-1}. The highest average extractable Ca content was found in Karnaprayag block (880.6 mg kg^{-1}) and highest average extractable Mg content was reported in the Pokhari block (110.4 mg kg^{-1}). In the entire Chaomoli district, only 5.6 and 2.0 % soil samples were low in exchangeable Ca and Mg, respectively. The extractable S in the soils of Chamoli district of Uttarakhand ranged from 1.23 to 26.64 mg kg^{-1} with a mean value of 7.92 mg kg^{-1}. Percent soil samples deficient in soil extractable S were 40.0, 77.5, 90.0, 86.7, 60.0, 63.3, 93.3 and 100.0 % in Deval, Tharali, Naryanbagar, Karnaprayag, Pokhari, Ghat, Garsain and Joshimath blocks, respectively with an overall deficiency of 77.6 percent for the entire Chamoli district. Low S status in these soils could be ascribed to their very high altitude and low temperature with a probable low S mineralization and mineralized S was likely to be washed away from coarse textured soil due to snow melting in summers followed by rainy season.

Status of micro-nutrients

The DTPA extractable Zn content ranged from 0.09 to 15.41 mg kg^{-1} and the highest average Zn content was observed in Naryan bagar block (3.96 mg kg^{-1}).The extent of Zn deficiency in different blocks were 5.0, 15.0, 10.0, 13.3, 6.6 and 10.0 % in Deval, Tharali, Naryanbagar, Karnaprayag, Pokhari and Garsain blocks, respectively with an overall deficiency of 8.0 % for the district. Athokpam *et al.* (2013) also observed similar results where the DTPA extractable Zn content in the surface soils of Senapati district of Manipur varied from 1.30 to 4.9 mg kg^{-1}. The DTPA extractable Cu content ranged from 0.08 to 9.03 mg kg^{-1} and percent

Table 2: Extractable macronutrient status (mg kg^{-1}) in soils of Chamoli district

Blocks	Extractable P	Extractable K	Extractable Ca	Extractable Mg	Extractable S
Deval	1.41-15.51 (6.19)*	54.1-232.3 (115.6)	220-920 (570.5)	12-120 (40.2)	5.57-26.64 (12.06)
Tharali	1.59-26.47 (5.58)	42.7-259.1 (92.9)	160-1440 (726.5)	12-132 (47.7)	5.57-21.07 (8.80)
Naryanbagar	3.97-47.20 (19.74)	24.8-250.2 (83.2)	60-1460 (617.3)	12-204 (57.6)	3.09-22.31 (7.16)
Karnaprayag	3.36-35.00 (19.72)	54.1-269.1 (88.5)	60-1620 (880.6)	12-204 (56.8)	1.23-17.97 (6.65)
Pokhari	1.62-26.37 (10.43)	45.1-197.6 (115.7)	20-1400 (603.3)	24-288 (110.4)	2.47-20.45 (9.72)
Ghat	1.59-23.26 (8.43)	54.1-264.1 (119.9)	140-1440 (608.0)	12-168 (56.8)	3.71-24.16 (10.30)
Garsain	1.95-29.31 (9.84)	31.2-255.2 (125.5)	80-1040 (614.0)	12-192 (54.4)	1.85-12.39 (5.57)
Dasoli	3.14-26.52 (11.21)	26.3-238.8 (133.5)	200-1020 (470.6)	12-240 (54.4)	3.09-13.01 (6.50)
Joshi math	1.62-26.26 (9.86)	57.5-252.2 (172.5)	80-1240 (487.0)	12-144 (59.7)	1.23-9.91 (4.16)
Entire Chamoli district	1.41-47.20 (10.82)	24.8-269.1 (117.4)	20-1620 (617.2)	12-288 (59.8)	1.23-26.64 (7.92)

soil samples deficient in extractable Cu were 7.5 and 6.67 % for Deval and Narya bagar blocks, respectively with an overall deficiency of only 2.3 % for the district. The highest average Cu content was recorded in the Pokhari block (2.02 mg kg^{-1}).Similar range was also reported by Kamble *et al.* (2013) for the Ahmednagar district of Maharashtra. The DTPA extractable Fe and Mn content in the soils of Chamoli district varied from 3.13 to 84.22 and 1.93 to 54.96 mg kg^{-1} soil, respectively and only 3.3 % soil samples were low in extractable Fe and Mn in Karanprayag block with an overall deficiency of 0.33 % soils for both nutrients in the district. The highest average Fe content (44.97 mg kg^{-1}) in Joshimath block and the highest average Mn content was observed in Pokhari block (23.26 mg kg^{-1}). A similar range of soil extractable Mn had been reported by Thakor *et al.* (2014). Hot water-soluble B ranged from 0.23 to 2.61 mg kg^{-1} with a mean value of 0.96 mg kg^{-1}. The highest average soil extractable B content was recorded in Joshimath block (1.31 mg kg^{-1}). Among different blocks, only 2.5 % soil samples of Deval block were low in B with an overall deficiency of 0.33 %for the entire district. Soil extractable Mo content varied from 0.18 to 1.36 mg kg^{-1} with a mean value of 0.62 mg kg^{-1} and no soil sample in the entire district was low in extractable Mo. The highest average value of extractable Mo content was observed in Karnaprayag block (0.80 mg kg^{-1}). Shukla *et al.* (2015) also reported a range of 0.12 to 1.84 mg extractable Mo kg^{-1} soil for U.S. Nagar district of Uttarakhand.In general, high availability of micronutrients in these soils could be ascribed to high organic matter content which helped to maintain high supply of micronutrients due to chelating action of humic substances which also could prevent their fixation, precipitation, oxidation and leaching in soils (Bungla *et al.* 2019). Besides this, the soils of medium and fine texture also maintained higher contents of extractable macro- and micro-nutrients as compared to coarse textured soils having low content of soil colloids.

Correlation among soil properties and extractable macro- and micro-nutrients

Soil pH showed a significant and positive correlation with extractable P ($r = 0.652$), exchangeable Ca ($r = 0.211$) at $p < 0.01$ and S ($r = 0.120$) at $p < 0.05$ but a negative correlation with Cu ($r = -0.511$) at $p < 0.01$, Fe ($r = -0.143$), Mn (-0.117) at $p < 0.05$. This relationship might be due to the presence of more than 50% of phosphorus in organic forms and after the decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P fixation with Al and Fe thus reduce phosphorus adsorption/ phosphate fixation (Tisdale *et al.*, 1997).

Table 3: Extractable micronutrient status (mg kg^{-1}) in soils of Chamoli district

Blocks	Extractable Zn	Extractable Cu	Extractable Fe	Extractable Mn	Extractable B	Extractable Mo
Deval	0.55-15.41 (2.64) *	0.13-8.73 (1.36)	9.87-64.78 (38.80)	4.47-52.69 (15.42)	0.23-2.04 (0.76)	0.18-1.00 (0.55)
Tharali	0.35-8.14 (1.77)	0.24-6.72 (1.24)	12.12-71.42 (39.02)	2.05-48.66 (12.14)	0.50 to 0.70 (0.91)	0.27-1.09 (0.58)
Naryanbagar	0.09-13.10 (3.96)	0.08-6.82 (1.96)	7.96-74.88 (33.98)	4.49-46.86 (14.76)	0.34-2.11 (0.94)	0.18-1.27 (0.66)
Karnaprayag	0.35-6.23 (2.05)	0.12-7.14 (1.78)	3.13-60.47 (27.53)	1.93-52.64 (19.14)	0.42-2.61 (0.95)	0.27-1.36 (0.80)
Pokhari	0.45-13.07 (2.83)	1.04-4.92 (2.02)	10.23-70.69 (39.65)	6.85-54.96 (23.26)	0.38-2.27 (0.96)	0.27-1.09 (0.65)
Ghat	0.43-14.53 (3.18)	0.25-3.27 (1.32)	7.46-84.22 (42.75)	6.10-53.08 (18.24)	0.26^{-1}.84 (0.72)	0.36-1.00 (0.55)
Garsain	0.39-8.16 (1.51)	0.59-3.62 (1.75)	9.83-74.36 (30.88)	6.59-37.08 (14.25)	0.30^{-1}.88 (0.97)	0.36-1.09 (0.61)
Dasoli	0.56-6.10 (1.95)	0.51-9.03 (1.78)	10.36-71.28 (36.71)	3.35-14.65 (7.86)	0.46-2.46 (1.04)	0.36-1.00 (0.61)
Joshi math	0.76-15.33 (3.87)	0.37-1.92 (0.96)	15.41-81.44 (44.97)	4.69-24.52 (11.55)	0.53-2.61 (1.31)	0.18-1.36 (0.63)
Entire Chamoli district	0.09-15.41 (2.65)	0.08-9.03 (1.54)	3.13-84.22 (37.52)	1.93-54.96 (14.96)	0.23-2.61 (0.96)	0.18-1.36 (0.62)

This showed that acidic soil pH become more conducive for leaching of Ca and S. The negative correlation of soil pH with Fe indicates as soil pH increases there is a reduction in the availabilty of Fe. Similar results were reports by Chander *et al.* (2014) in vegetable growing soils of sub-humid and wet- temperate zones of Himachal Pradesh. Extractable Mn showed a significant and negative correlation with soil pH indicating that its availability is largely influenced by acidic nature of the soil. Similar results were reports by Chander *et al.* (2014) in vegetable growing soils of sub-humid and wet- temperate zones of Himachal Pradesh Soil EC showed a significant and positive correlation with extractable P (r = 0.266), K (r = 0.227), Mg (r = 0.261), S (r = 0.274), Fe (r = 0.153), B (r = 0.159), Mo (r = 0.365) at p <0.01 indicating thereby higher solubility of these nutrients in soil solution. Soil organic carbon showed a significant and positive correlation with extractable K (r = 0.168) at p <0.01 and this behavior could be attributed to higher retention of K on exchange sites contributed by soil organic matter (Kakkar et *al.* 2020). Soil organic C, however, showed a significant negative correlation with Mn (r =- 0.133) at p <0.05 indicating formation of stable complexes of Mn with soil organic matter in these soils (Andrade *et al.* (2002).

Table 4: Correlation between soil properties and available nutrients in the soils of Chamoli district

Nutrients	pH (1:2)	EC (dSm^{-1})	Organic carbon ($g\ kg^{-1}$)
P	0.652^{**}	0.266^{**}	-0.017
K	0.082	0.227^{**}	0.168^{**}
Ca	0.211^{**}	0.099	0.014
Mg	0.033	0.261^{**}	-0.007
S	0.120^{*}	0.274^{**}	-0.023
Zn	0.012	0.085	0.057
Cu	-0.511^{**}	-0.087	0.036
Fe	-0.143^{*}	0.153^{**}	-0.042
Mn	-0.117^{*}	0.010	-0.133^{*}
B	0.132^{*}	0.159^{**}	0.074
Mo	0.898^{**}	0.365^{**}	-0.003

***Significant at p≤0.01 and * Significant at p≤0.05*

From this study, it can be concluded that soil texture of Chamoli district ranged from coarse to fine and had acidic to slightly alkaline soil reaction with high content of organic carbon. Soil CaCO3 was found only in traces in some blocks like Naryan bagar, Karna prayag and Joshimath blocks where the soil pH was above 7.5. On the basis of calculated nutrient index, the entire district was very low in S particulary, in Joshimath block. The district was medium in K but high in P, Ca and Mg. Among micro-nutrients, supply of Zn was medium while rest micro-nutrients such as Fe, Zn, Mn, B and Mo were sufficient.

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