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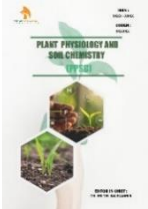

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RESEARCH ARTICLE

ANALYTICAL STUDY ON SOIL FERTILITY STATUS ALONG WITH ELEVATION GRADIENT AND DEPTH OF CHITWAN–MUSTANG TRACK, NEPAL

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ABSTRACT

The distribution of soil properties under different elevations and soil depths was evaluated by taking soil samples from peripheral agricultural land of Chitwan to the Mustang roadway track with the integrated use of the Geographical Information System (GIS). Soil organic matter (SOM), total nitrogen (N), available phosphorous (P_2O_5), available potassium (K_2O), and soil ph. were determined on 10 samples each from 0-15 cm and 15-30 cm soil depths of each categorical elevation (194-604 masl, 604-1399 masl, 1300-2846 masl) were analyzed (Total 60 samples). The highest SOM (4.21%) was recorded at surface soil (0-15 cm) of elevation 1300-2846 masl. The highest total nitrogen (0.245%) was also found at the surface layer of elevation 1300-2846 masl. Phosphorous and Potassium were highest at the surface layer of elevation 1300-2846 masl. The available nutrients Nitrogen, Phosphorous, and Potassium were medium in range and decrease with the increase in depth, which might be due to in-situ in a corporation of leaf litters, residue, etc. as well as applied manure on the surface. In general, the study result revealed altitude did not impose any significant effect in aggravating soil reaction and phosphorous. Whereas soil depth affected significantly not only ph. but also SOM and available potassium. Thus, the study concludes the increasing trend of primary nutrients with increasing elevation and decreases with increasing depth.

KEYWORDS

Soil, Geographical Information System, Soil elevation, Soil depths, Soil Parameters

1. INTRODUCTION

Nepal has been a major agricultural country and 66% of the population depends on agriculture and affiliated livelihoods (MOAD, 2015). In order to remain safe and improve the production and production of food and vegetable crops, the Government of Nepal has created Pockets, Blocks, Zone, and Super Zone for certain plants depending on the suitability of the plants according to the agro-ecological and soil conditions. Green mountains cover major land areas (41.68%) in the country allowing higher population density and more pressure on the vulnerable mountain land resources. Tropical flat land of terai and Siwalik occupy 23.12% of the land area and serve as the breadbasket of the country (MOAC, 2010). 27% of the total land of Nepal is agricultural land, 39.6% is forest land, 12% is grassland, 2.6% is water, and 17.2% is snow land and rock (DOA, 2069).

Mustang is particularly declared as the pocket area for Apple production. People of mustang as a livelihood, involve in farming buckwheat, necked barley (Uwa), Finger millet, rapeseed. Myagdi is known among the top citrus producers while Parbat, Kaski Tanahun, and Chitwan are famous for their vegetable production. Soil is important for sustainable agriculture with significant effects on food security and quality of life and increased agricultural production in this area will require extensive knowledge of the soil, its quality and fertility status (Dumanski and Pieri, 2000; Mulumba and Lal, 2008). Soil fertility is the backbone on which all high-level agricultural production systems can be built (Al-Zubaidi et al., 2008; Robert, 2013).

Topography as the main feature of the area is one of the most suitable for building the soil. Therefore, geomorphometric variations have been used successfully in many studies to predict soil characteristics, soil classes and soil composition (Behrens et al., 2014; Huggett, 1975; Pennock et al., 1987). With regard to soil chemical properties had a negative impact on the slope angle in the soil of organic carbon (SOC), nitrogen (N) and the pH of the topsoil of Chalk soils in Berkshire and Wiltshire Downs in the south of England (Anderson and Furley, 1975; Gao et al., 2015; Wu et al., 2013). It was discovered in the Gutianshan National Nature Reserve that the height of the study areas, SOC, soil moisture and the total phosphorus content of the topsoil were important factors that formed the mold community and soil pH were strongly associated with microbial biomass, he height and pH of the soil are important factors influencing this positive relationship on both the northern and southern islands (Wu et al., 2012). Despite the fact that soil nutrients are very important for plant biomass, their impact on surface biomass and plant richness will be weak and meaningless (Bhandari et al., 2019). Terrain markers make important predictions of soil fertility and tree growth in environmental research. The variability of soil fertility is explained by local characteristics and that tree growth is positively influenced by soil fertility, as well as by local characteristics (Scholten et al., 2017).

Assessing soil fertility status necessitates soil testing for specific areas. Soil testing is an important diagnostic tool for quick determination of the nutrient status of soil to make fertilizer recommendations in the soil for apple production as in other crops and to make a recommendation of soil amendments in problematic soils in most cases. It has an advantage over the other methods of estimating the soil fertility status because of its rapidity to measure the number of nutrient elements that are extractable from the soil. Fertility analysis of soil was done to assess pH, organic matter, available phosphorus, total nitrogen, and available potassium along different elevation gradients also, to analyze the influence of elevation and depth aspects on soil fertility.

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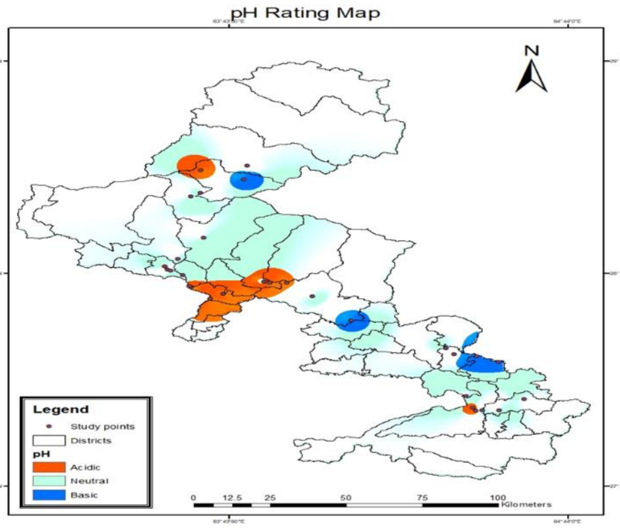

Plate 3: pH Rating Map

Table 10: Effect of elevation and soil depth in selected parameters		
Treatments	**K20**	**P2O5**
Elevation (m)	**kg/ha**	
Up to 604	90 [a]	32.5
604 – 1300	101 [b]	29
1300-2846	195 [b]	44.8
GM	129	35.4
SEM	21.2	5.87
LSD	60**	16.61 [ns]
CV%	73.50%	74.20%
Depth (cm)		
0 – 15	163	40.5
15 -30	95	30.2
GM	129	35.2
SEM	18.2	4.82
LSD	51.5*	13.62*
CV%	77.20%	74.60%

Note: Means followed by the common letter (s) within a column are not significantly different at 5% level of significance was determined by DMRT, *, **indicates significant at $p<0.05$ and $p<0.1$, ns= non-significant

3.3 Available Potassium

3.3.1 Elevation effect on available potassium

The available potassium content of 194-604m soil ranged from 20.173 to 212.194 kg/ha. The available potassium content of second category soil, 604-1300m ranged from 20.174 to 376.782 kg/ha. Also, the available potassium content of 1300-2846m soil ranged from 64.526 to 578.124 kg/ha. The potassium contents of soil at lower elevation were found to be lower.

The trend of higher potassium content at a higher elevation was supported (Luitel et al., 2020). It might be due to the higher addition of manures as K predominately occurs as soluble inorganic K from inorganic wastes and in animal wastes, potassium content was found to be around 0.22% of dry matter (Havlin et al., 2016).

Table 11: Frequency of potassium content at different elevation					
	Potassium/Nutrient category*				
Elevation (masl)	Very Low	Low	Medium	High	Very High
194-604	6(30)	7(35)	7(35)	0(0)	0(0)
604-1300	6(30)	10(50)	3((15)	1(5)	0(0)
1300-2846	1(5)	6(30)	8(40)	4((20)	1(5)

*Figures in parenthesis indicates percentage value

3.3.2 Available potassium under different depths

Available potassium was medium in surface soil and showed a regular decrease with the depth. D1 (0-15cm) soil depth ranged from 40.25 to 578.12 kg/ha with a median value of 163 kg/ha in available potassium. Also, Available potassium of D2 (15-30cm) depth soil ranged from 20.17 to 239.62 kg/ha with a mean value of 95 kg/ha. The highest available K was observed in the surface soil and showed a more or less decreasing trend with soil depth (Figure 5). A similar result was revealed by where he observed decreasing trend of available potassium with depth (ud din Khanday et al., 2018). This might be attributed to more intense weathering, the release of liable K from organic residues, application of K fertilizers, and upward translocation of K from lower depths along with the capillary rise of groundwater (Joshi et al., 2017).

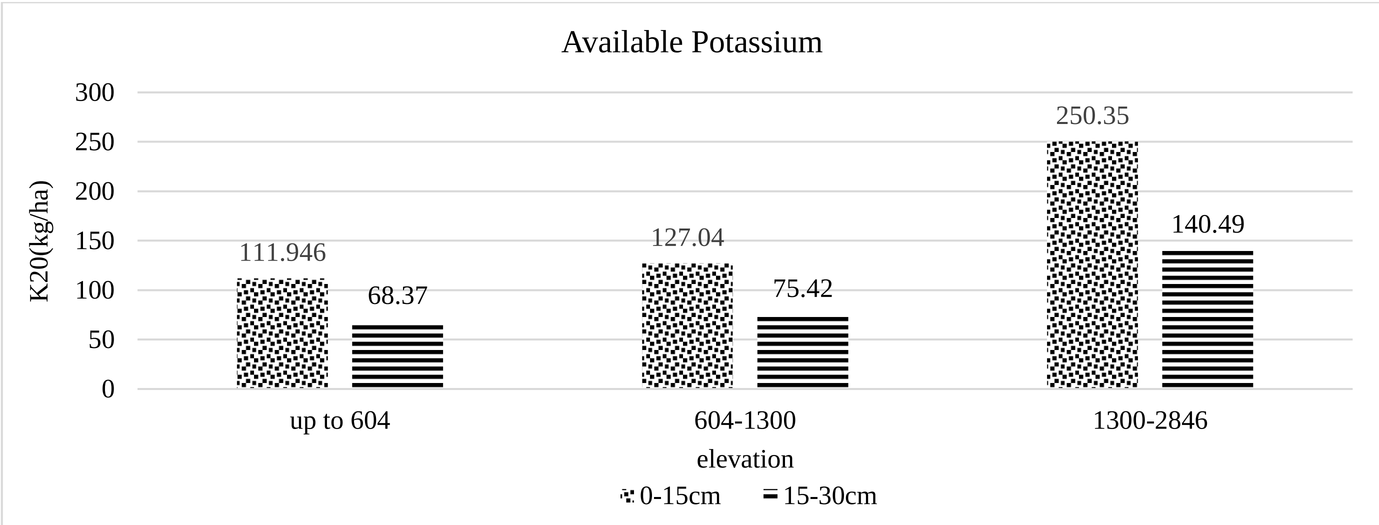

Figure 5: Different land elevation and available potassium at different depths

3.4 Available Phosphorus

3.4.1 Available phosphorus under different elevation

There was no significant difference in available phosphorus between the three categorical elevations. Although more or less variation among the treatment was seen. An increasing trend with altitudes like that of nitrogen, organic matter, and potassium was not seen in phosphorus. Available phosphorus was higher at a higher elevation and considerably lower phosphorus content at a lower elevation. The available phosphorus content of T1 (194-604m) soil ranged from 2.02 to 90.06 kg/ha with an average value of 32.5kg/ha. The available phosphorus content of second category soil, T2 (604-1300m) ranged from 2.025 to 92.675 kg/ha with an average value of 29kg/ha. Also, the available phosphorus content of T3 (1300-2846m) soil ranged from 5.287 to 108.67 kg/ha with an average value of 44.8kg/ha. The result was consistent with the findings of who reported the higher available phosphorus in higher altitudes compared to a lower altitude (Luitel et al., 2020). The higher available soil phosphorus content at higher elevations might be due to the inherent higher phosphorus level of soil at higher altitudes (Kidanemariam et al., 2012).

Table 12: Frequency of potassium content at different elevation					
Phosphorus/Nutrient category*					
Elevation(masl)	Very Low	Low	Medium	High	Very High
194-604	1((5)	9((45)	8(40)	2(10)	0(0)
604-1300	3((15)	10((50)	4((20)	3(15)	0(0)
1300-2846	2(10)	6(30)	5(25)	7(35)	0(0)

*Figures in parenthesis indicates percentage value

3.4.2 Available phosphorus under different depths

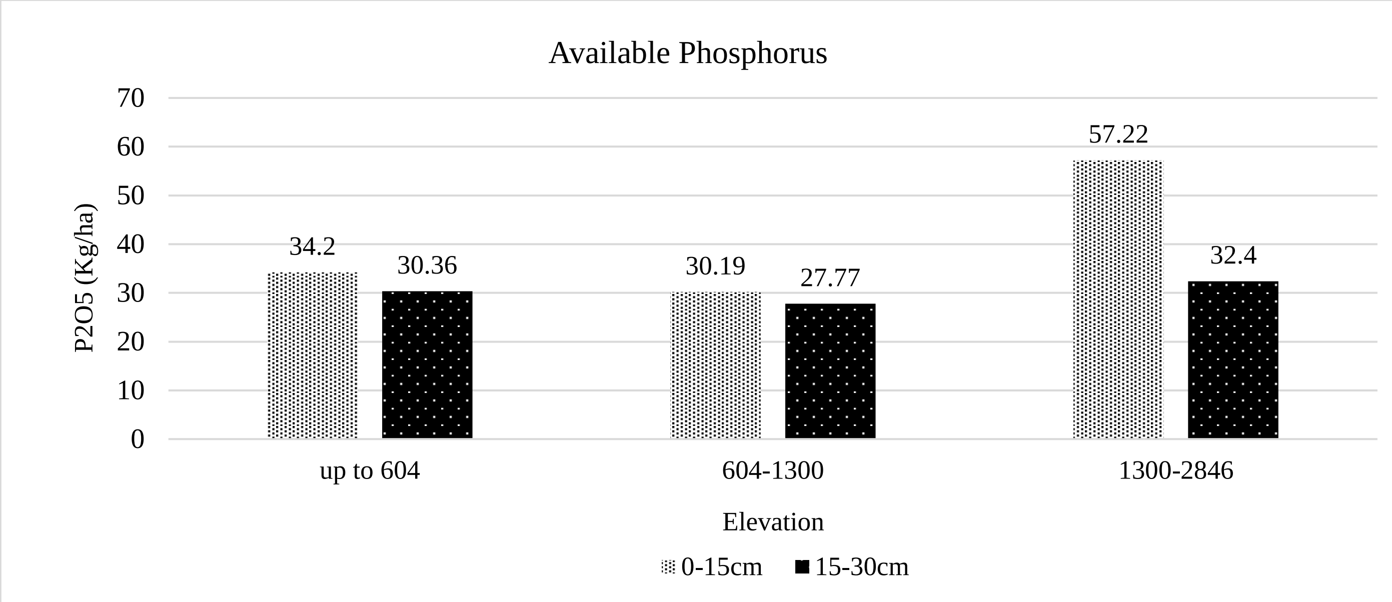

Figure 6: Different land elevation and available phosphorous content at different depth

The significantly higher available phosphorus was found from 0-15cm soil compared to 15-30cm depth soil (Table 8ss). The evaluation of phosphorus from two major soil depths showed D1 (0-15cm) ranged from 2.025 to 108.67kg/ha with the mean value of 40.5kg/ha and D2 (15-30cm) ranged from 2.02 to 75.06kg/ha with the mean value of 30.2kg/ha. The highest available P was observed in the surface soil and showed a decreasing trend with soil depth (Figure 6). The highest available P was observed in the surface horizons and decreased with depth. It might be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external sources i.e., fertilizers and presence of free iron oxide and exchangeable Al3+ in smaller amounts (Singh and Mishra, 1996). The lower phosphorus content in sub-surface horizons in these profiles could be attributed to the fixation of P by clay minerals and oxides of iron and aluminum (Luitel et al., 2020).

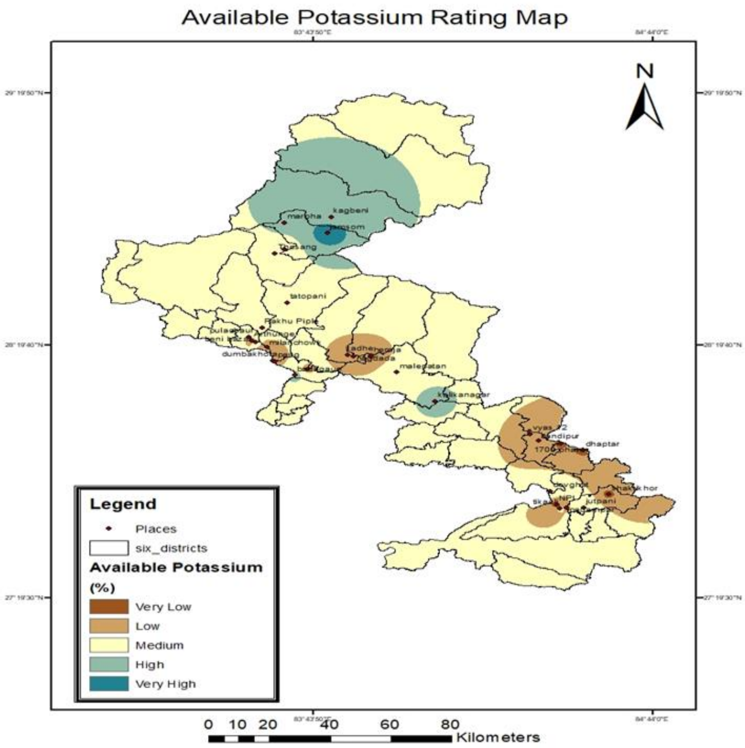

Plate 2: Available Potassium Rating Map

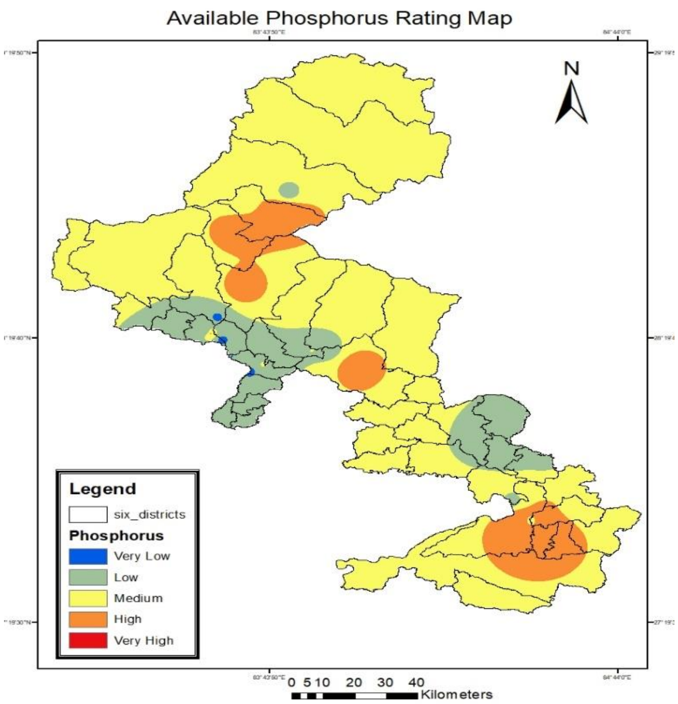

Plate 5: Available Phosphorus Rating Map

3.5 Interaction Effect of Elevation and Soil Depth on Soil Parameters

Soil organic matter/SOM content was significantly ($p<0.5$) affected by the interaction of elevation with soil depth (Table 12). The interaction effect of elevation by soil depth on the variability of SOM was significantly higher (4.21%) at the surface layer of T3 (1300-2846masl) and lower (1.63%) at the subsurface layer of T2 (604-1300masl) soil. This result is in agreement with (ud din Khanday et al., 2018). Although more or less variation is seen among the treatments, all other parameters were non-significantly affected by interaction. Total nitrogen was higher (0.245%) at the surface layer of T3 (1300-2846masl) and lower (0.079%) at the subsurface layer of T1 (194-604masl). Available phosphorus was higher (57.2kg/ha) at the surface layer of T3 (1300-2846masl) and lower (27.8kg/ha) at the subsurface layer of T2 (604-1300masl). PH was higher (7.47) at the subsurface layer of T1 (194-604m) and lower (6.72) at the surface layer of T2 (604-1300m). Available potassium was higher (250.3kg/ha) at the surface layer of T3 (1300-2846m) and lower (68.4kg/ha) at the subsurface layer of T1 (194-604masl).

Table 13: Interaction effect of elevation and depth on soil parameters

Parameters	Elevation						Trt SED	Dep SED	T×D SED	CV (%)
	194-604 masl		604-1300 masl		1300-2846 masl					
OM (%)	2.29^{b}	1.64^{b}	2.66^{b}	1.63^{b}	4.21^{a}	2.41^{b}	0.471*	0.385**	0.667*	60.3
pH	7.19^{a}	7.47^{a}	6.72^{a}	7.03^{a}	6.75^{a}	7.42	0.246^{ns}	0.201*	0.348^{ns}	11.0
TN (%)	0.112^{b}	0.079^{b}	0.13^{b}	0.99^{b}	0.245^{a}	0.146^{b}	0.033*	0.027*	0.047^{ns}	77.2
P (kg/ha)	34.2^{b}	30.4^{b}	30.2^{b}	27.8^{b}	57.2^{a}	32.4^{b}	8.17^{ns}	6.67^{ns}	11.55^{ns}	73.1
K (kg/ha)	112^{b}	68.4^{b}	127^{b}	76^{b}	250.3^{a}	140.5^{b}	28.2***	23.0**	39.9^{ns}	69.1

Note: Means followed by the common letter (s) within a column are not significantly different at 5% level of significance was determined by DMRT, *, **, ***indicates significance at $p<0.05$, $p<0.1$ and $p<0.01$, ns= non-significant

4 Conclusion

The fertility status of the soil was higher at a higher elevation. On moving up with the elevation, soil parameters like Nitrogen, SOM, and Available potassium were in the increasing trend. But Available phosphorus and pH did not show such a trend. Also, primary nutrients were in decreasing trend along with the depth of soil. Thus, it can be concluded that soil fertility of the research locale can be improved by better use of agricultural inputs and better management of soil types.

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