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Fertility Assessment in Different Depth of Soil in Rice - Wheat Cropping System of Western Terai of Nepal

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Abstract: ***Soil fertility assessment plays a vital role in improving fertilizer efficiency by indicating the nutrients available in the soil. A research was conducted in 4 districts (Banke, Dang, Kapilvastu, and Rupandehi) at the western Terai of Nepal to study the fertility status at different soil depths (0-20, 20-40, and 40-60cm) in the paddy harvested fields. 10 samples each were collected from each district to study the nutrients available in different soil depths so that the necessary amendments could be made for the sustainable and scientific production of rice wheat. Four districts were taken as blocks and 3 different depths as the main plot. Composite soil samples were collected in each study site at 0-20,20-40 and 40-60cm soil depth. Soil physical and chemical properties like soil texture, pH, total nitrogen, available potassium, and available phosphorus were tested in the Soil laboratory at HICAST. GenSTAT, MS-Excel, and SPSS were used for data analysis. All the soil fertility parameters analyzed were significantly affected (P<0.05) by the variation in soil depth. The soil organic matter and nitrogen level were significantly higher in Kapilvastu district (1.2767% & 0.075%) and in the upper surface of the soil (1.45% & 0.86%) while lowest soil organic matter and nitrogen levels were recorded from Rupandehi district (0.669%) and in Dang district (0.052%) respectively. In contrast, the available Phosphorus was highest in Banke district (80.02 kg/ha) and in the top depth of 0-20cm (55.32kg/ha), lowest in Kapilbastu district (35.97 kg/ha) and in the depth of 40-60cm (37.26kg/ha). The available K content followed the order: Kapilbastu (177.0kg/ha) > Dang (120.8kg/ha) > Banke &Rupendehi (81.4kg/ha) and 0-20cm depth (168.3kg/ha) > 20-40cm depth (157.7 kg/ha) >40-60cm depth (151.7kg/ha). There was no significant difference in available K levels in different depths of soil. The lowest pH was recorded in Kapilbastu district at the depth of 20-40cm (5.5). The pH of 0-20cm depth (7.147), 20-40cm depth (7.52) and 40-60 cm depth (7.449) were not significantly different as determined by DMRT. The results obtained from the study indicated that the land under rice-wheat cropping system in the western terai of Nepal has poor soil health, therefore future research strategy should be built based on the soil fertility status of the research to judge the nutrient requirement and application of nutrients for the sustainable management of crop and soil health.***

I. INTRODUCTION

Soil fertility studies and mapping is an effective way to diagnose soil status and recommend as per the need of the nutrient to particular crop in the area. Mapping can help decision makers and farmers to effectively manage soil acidity, fertilizer management, organic matter management and also physical and biological maintenance of the soil. Soil related limitations affecting the crop productivity including nutritional disorders can be determined by evaluating the fertility status of the soils. Soil testing provides the information about the nutrient availability of the soil upon which the fertilizer recommendation for maximizing crop yield is made. Land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc (Celik, 2005; Liu et al., 2010). As a result, it can modify the processes of transport and re-distribution of nutrients.

Productivity of paddy per hectare in the country is to increase to 3.5 tons in 2017-18 against 3.37 tons per hectare productivity recorded in the previous fiscal. However, paddy productivity in Nepal is comparatively low. Different crops requires different types of soil properties and nutrients for their optimum yield. Therefore, it is very much important to know the exact situation of soils and map them for further use. Synergism and antagonistic effect of each nutrient could also be forecasted depending upon the inherent soil nutrient status. It is estimated that during rice harvest, about 110 kg N, 34 kg P and 156 kg per hectare per year is removed from the soil (De Dutta, 1989). It is estimated that 60% soils of Nepal have low OM, 23% have low P and 18% have low potash and 67% of the soils are acidic (Mandal, 2007). Also, the farmers of western terai are not much acquainted with the use of Chemical fertilizers. They use 115 kg/ha Urea, 95 kg/ha DAP and 17 kg/ha Potash which is equivalent to 70 kg/ha N. 43 kg/ha P, 10 kg/ha K (Bhandari, Bhattarai, & Bista, 2017) which is totally irrational to the recommended dose of fertilizer. This irrational use of fertilizer is continuously degrading the soils of Nepal.

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II. MATERIALS AND METHODS

A. Study Area and Soil Sampling

The survey was conducted at four districts of western Terai of Nepal, i.e. Banke, Dang, kapilvastu and Rupendehi, and soil routine test of soil samples was carried out at soil laboratory in HICAST and in Soil Science Division (SSD) of Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur. From each district, 10 samples each were taken from. These districts stand at an average elevation of approximately 339 masl and cover a total area of 8390 sq. km. 29.75 percentage of total paddy and 30.03 percentage of total wheat in the country is produced in these districts.

The random sampling method was used to collect samples during mid-October and November from the fallow land after paddy harvest. A composite soil sample was taken from three different depths of 0-20cm, 20-40 cm, and 40-60cm. Collected samples were cleaned by removing roots, stones, and plant debris. The soil sample collected from the 40 points at different depths was reduced in size, air-dried, and sieved through a 2mm sieve. Then the prepared soil samples were carefully placed in leveling bags and were transported to the soil analysis laboratory of HICAST and subjected to routine analysis.

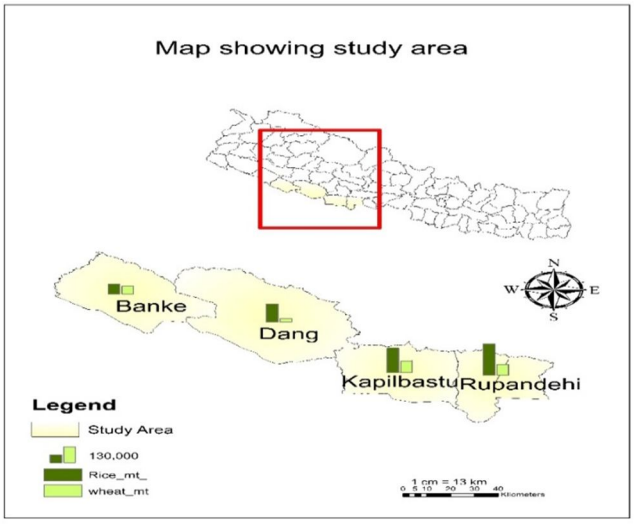


Figure 1: Map of study area

B. Soil anaLysis

Soil properties of the collected soil sample like pH, available nitrogen, available potassium, available phosphorus, soil organic matter, and the texture in various depths were analyzed at Soil Testing Laboratory, HICAST.

C. Statistical Analysis and Data Presentation

Data pertaining to soil organic matter and nitrogen were rated according to the standard rating of Soil Science Division, Khumaltar, Lalitpur and data related to phosphorus and potassium were recorded based on Wardlab laboratories rating. pH obtained from laboratory analysis were rated according to Khatri-Chhetri,1991 and analyzed using Gen STAT and Microsoft Excel. The data were subjected to analysis of variance (ANOVA) appropriate to the split-plot design technique. When significant differences existed between treatment means, a comparison of the means was done using Duncan's Multiple Range Test (DMRT) at 5% probability levels. Correlation analysis was done between organic matter and nitrogen level to know the effect of organic matter on the nitrogen content of soils.

Rating chart for classification of fertility status of the studied soils according to Soil Science Division, Khumaltar, Lalitpur (2002) and Wardlab laboratories

Nutrient status	SOM (%)	Total N (%)	Available P_2O_5 (mg/kg)	Available K_2O (mg/kg)
Very low	<1	<0.05	0-3	0-40
Low	1-2.5	0.05-0.1	4-9	41-80
Medium	2.5-5	0.1-0.2	10-16	81-120
High	5-10	0.2-0.4	17-30	121-200
Very high	>10	>0.4	>30	>200

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Rating chart for soil reaction rating of the studied soils according to Khatri- Chhetri (1991)

Soil pH value	Soil reaction rating
<6	Acidic
6.0-7.5	Neutral
>7.5	Alkaline

III. RESULT AND DISCUSSION

A. Soil PH

Almost all the soils were found to have neutral to slightly alkaline. The soil pH of Banke, Dang, and Rupandehi were found to be almost the same whereas the pH of the Rupandehi district was found to be significantly different from the other three districts. The variation of depth was found to be insignificant to the soil pH.

Table 1: pH status in a different district and their variability with response to different depths within the research area.

District	pH	Remarks	Depth	pH	Remarks
Banke	7.565[b]	S.Alkaline	0-20cm	7.147[a]	Neutral
Dang	7.626[b]	S.Alkaline	20-40cm	7.52[a]	S.Alkaline
Kapilbastu	6.714[a]	S.Alkaline	40-60cm	7.449[a]	Neutral
Rupandehi	7.583[b]	S.Alkaline			
District*depth LSD(0.05)		0.7362**			
District*depth SEM(±)		0.3714			
Grand mean		7.372			
% CV		11.3 %			

Means followed by the same letter in a column are not significantly different at a 5% level of significance in DMRT test (Significant at 0.05% P level)

The highest pH was recorded in Banke district with pH 10.07 at the depth of 40-60 cm. The lowest pH value was recorded in the Kapilbastu district with pH 5.5 in the depth (20-40cm). This experiment supports the general finding that application of chemical fertilizer increases soil acidity. (Mashely et al., 1994) found lower pH value in chemical farming soil.

As the pH of soil affects the availability of different nutrients, the result obtained from the research clearly states the variation of pH value affects the nutrient availability in different depths. The pH of the soil may be different at depth depending upon the physical properties of the soil, irrigation availability and the cultivation practice adopted irrespective of the depth.

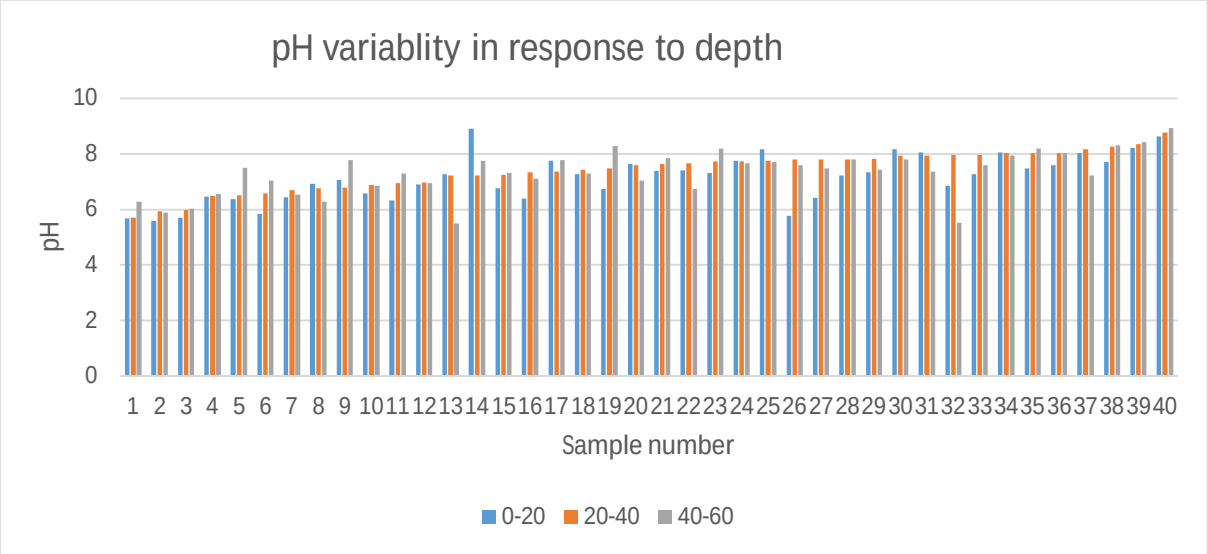


Figure 2. Graph showing the pH variability in different depths of soil.

Since both paddy and wheat are shallow-rooted crops with a maximum depth of about 20 cm, the upper depth of the soil plays a major role in the rice-wheat cropping system. Among the 40 samples, the pH of every sample in the top horizon of 0-20 cm was observed to be above 5, 17 samples was found to have the pH range of 5-7 ,15 samples were found in the pH range of 7-8 and 8 samples were found to have the pH value more than 8.

B. Texture

The majority (33%) of soil was found to be loam, followed by silty clay loam (21%), silt loam (22%), clay loam (17%, silt clay (5%), and sandy loam (2%) respectively.

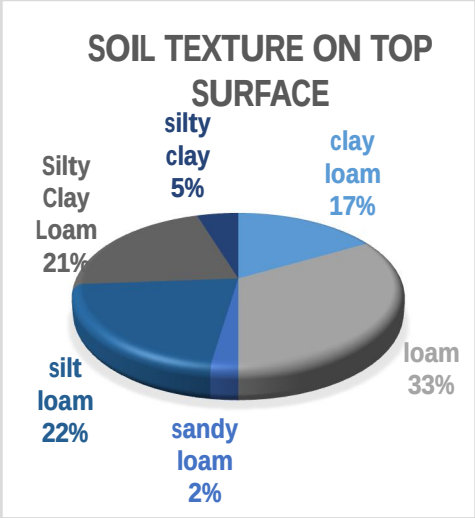


Figure 3. Texture distribution in different sample points.

C. Organic Matter Content in the Soil

The results of the study indicated that in all samples, SOM in the upper surface was significantly more in comparison to the lower depth. It was found that 97.62 percent of the samples from the upper surface had a low organic matter content, containing the SOM less than 2.5 %, and only 2.38 % of the sample was found to have medium SOM containing organic matter and none of soil sample had high organic matter content.

Table 2. SOM status in different districts and their variability with different depths in the research area.

District	SOM (%)	Depth	SOM (%)
Banke	0.866^{a}	0-20cm	1.4515^{c}
Dang	0.815^{a}	20-40cm	0.7328^{b}
Kapilbastu	1.2767^{b}	40-60cm	0.5358^{a}
Rupandehi	0.669^{a}		
District*depth LSD(0.05)	0.0344^{**}		
District*depth SEM(±)	0.1228		
Grand mean	0.907		
% CV	42.8 %		

*Means followed by same letter in a column are not significantly different at 5% level of significance in DMRT test (* Significant at 0.05% P level)

The results of the study indicated that the status of SOM at different depths was significant (P<0.05) in all four districts. The highest (1.2767%) amount of SOM was recorded in Kapilbastu district whereas the lowest (0.669%) was recorded in the Rupandehi district on the topsoil surface. Banke, Dang, and Rupandehi were found to be significant (P<0.05) to each other whereas Kapilbastu with a higher SOM % was found to be insignificant.

The top surface of the soil was found to have higher (1.4515%) SOM content whereas the middle depth (0.7328%) and the lower depth (0.5358%) were found to have lower SOM percentage .The result also showed that the SOM was nonsignificant in each depth.

Variable	Rating	Range (%)	Observed frequency(%)
Organic matter	Low	<2.5	97.62
	Medium	2.5-5	2.38
	High	>5	-

D. Total Nitrogen

The status of nitrogen varies from one soil sample to another soil sample. Through this study, it was found that the nitrogen amount goes on decreasing with the increase of soil depth. The following graph clearly indicates that the total nitrogen content has decreased in different depth in each of the samples collected .The nitrogen content was seen to be gradually decreasing in different depth of soil.

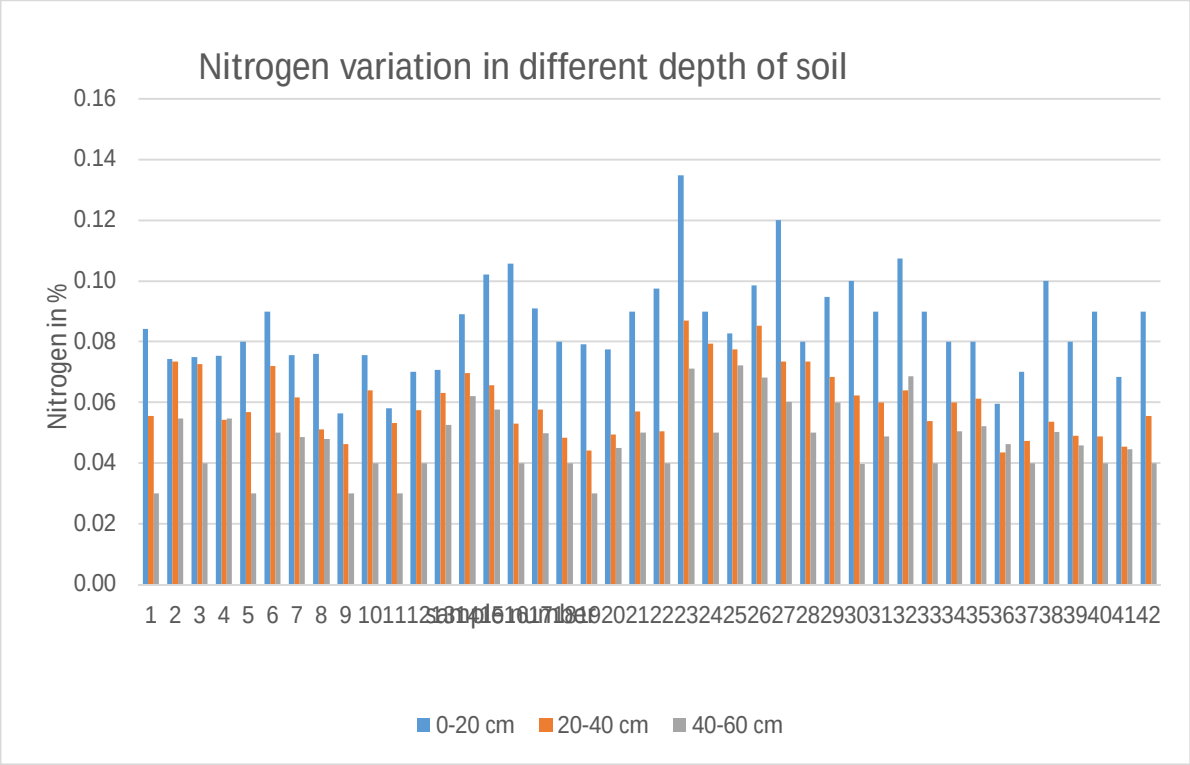


Figure 4: A graph showing the nutrient status in different depth of soil in different sample points.

Table 3: Nitrogen status in different district and their variability with response to different depth within the research area.

District	Nitrogen (%)	Depth	Nitrogen (%)
Banke	0.066[b]	0-20cm	0.086[c]
Dang	0.061[a]	20-40cm	0.06[b]
Kapilbastu	0.075[b]	40-60cm	0.052[a]
Rupandehi	0.062[a]		
District*depth LSD(0.05)	0.01[**]		
District*depth SEM(±)	0.005		
Grand mean	0.0661		
% CV	17.1 %		

Means followed by same letter in a column are not significantly different at 5% level of significance in DMRT test (Significant at 0.05 P level)

The nitrogen content on the top surface was found to be relatively low in comparison to the standard rate recommended by government of Nepal. Among the 40 samples collected it was found that all 40 samples has lower nitrogen percentage.

Variable	Rating	Range (%)	Observed frequency(%)
Nitrogen	Low	<0.15	100
	Medium	0.075-0.15	-
	High	>0.15	-

E. Available phosphorus

Phosphorus plays an important role in energy transformations and metabolic processes in plants (Rai et al., 2012). The Available phosphorus status of the research area shows that majority i.e. 92.7 %of the soil samples were found to have gradual decrease in phosphorus content in the lower depth of the soil whereas 7.1 % of samples were found to have lower phosphorus content on the upper surface of the soil.

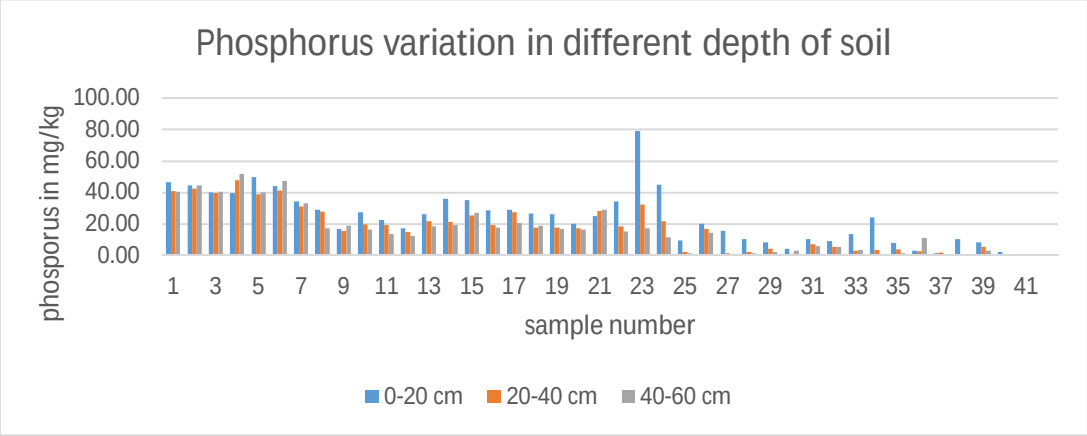


Figure 5: Graph showing the status of phosphorus in different depth of soil.

Table 4: Available phosphorus status in different district and their variability with response to different depth within the research area.

District	Phosphorus(kg/ha)	Depth	Phosphorus(kg/ha)
Banke	80.02[d]	0-20cm	55.32[b]
Dang	48.85[c]	20-40cm	40.09[a]
Kapilbastu	35.97[b]	40-60cm	37.26[a]
Rupandehi	12.05[a]		
District*depth LSD(0.05)	20.43**		
District*depth SEM(±)	10.31		
Grand mean	44.2		
% CV	52.1%		

*Means followed by same letter in a column are not significantly different at 5% level of significance in DMRT test.(* Significant at 0.05% P level)

The effect of land use systems on available phosphorus is shown in table 5. The highest (80.82kg/ha) phosphorus was found in Banke district (80.02) and that of lowest (12.05) in Rupandehi district. The difference in district and depth had a significant (P<0.001) effect on available phosphorus. The P content in the depth of 0-20cm was found to be 55.32kg/ha where as in 20-40cm and 40-60cm was 40.09kg/ha and 37.26kg/ha respectively .The second and third depth were found to be significant at 0.05 p level.
The Phosphorus content on the top surface in 21.43% of sample was found to be low, 28.57% of sample was found to be medium and remaining 50% of sample was found to have higher potassium content in comparison to the standard rate recommended by government of Nepal.

Variable	Rating	Range kg/ha	Observed frequency (%)
Phosphorus	Low	<31	21.43
	Medium	31-55	28.57
	High	>55	50

F. Available Potassium

Potassium help to reduce the chances of disease attack to plant to some extent. The Available potassium status of the research area shows that majority i.e. 54.8% of the soil samples were found to have gradual increase in potassium content in the lower depth of the soil whereas 45.6 % of samples were found to have higher potassium content on the upper surface of the soil.

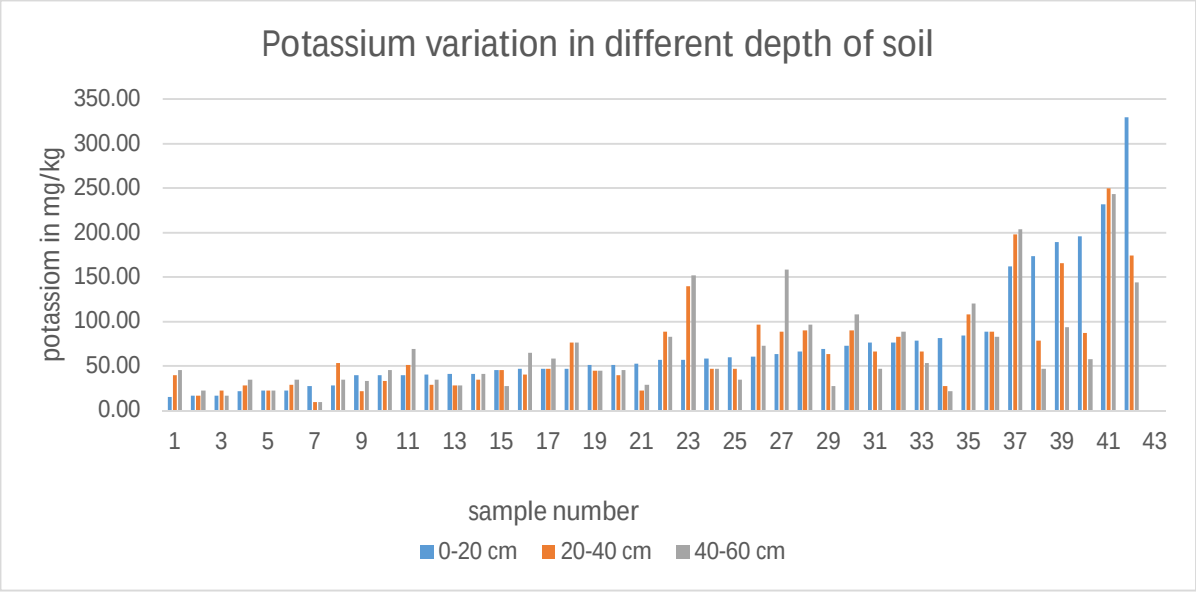


Figure 6: Graph showing the potassium variability in different depth of soil.

Table 5: Available potassium status in different district and their variability with response to different depth within the research area.

District	Potassium(kg/ha)	Depth	Potassium (kg/ha)
Banke	81.4[a]	0-20cm	168.3[a]
Dang	120.8[ab]	20-40cm	157.7[a]
Kapilbastu	177.0[b]	40-60cm	151.7[a]
Rupandehi	81.4[a]		
District*depth LSD(0.05)	99.9[**]		
District*depth SEM(±)	50.3		
Grand mean	159		
% CV	70.6%		

Means followed by same letter in a column are not significantly different at 5% level of significance in DMRT test. (Significant at 0.05 P level)

The available potassium (K) was significantly affected (P<0.001) in different district but the depth had no significant effect on potassium availability. The available K level in Kapilbastu district (177 kg/ha was found to be significantly higher than all other districts. Dang was observed to have significant amount of available potassium to the highest kapilbastu district and to the lowest Banke and Rupendehi (81.4kg/ha each). The top surface (168.3kg/ha) had higher available K levels than both of the lower depths, but there was not any significant difference in availability of potassium in any of the three depths .The top depth, middle depth and the lower depth were found to have 168.3kg /ha, 157.7 kg/ha and 151.7kg/ha of available potassium respectively .

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The Potassium content on the top surface in 42.8% of sample was found to be low, 42.8% of sample was found to be medium and remaining 14.4 % of sample was found to have higher potassium content in comparison to the standard rate recommended by government of Nepal.

Variable	Rating	Range kg/ha	Observed frequency (%)
Potassium	Low	**<110**	42.8
	Medium	110-280	42.8
	High	**>280**	14.4

G. Correlation Among total SOM and total Nitrogen

In table 6, the data analysis revealed that there was a highly significant positive correlation between SOM and total soil N (r=0.930**). (Brady, 2004) reported that the distribution of soil organic N paralleled that of soil organic matter due to the fact that nitrogen along with other nutrients are present in organic combination and are slowly released by the process of mineralization. This is also supported by (Pal, 2000) who said that 95-98 percent of total nitrogen is found in organic form.

Table 6. Simple correlation coefficient of OM level and N level

Correlations

		SOM	Nitrogen%
SOM	Pearson Correlation	1	.930**
	Sig. (2-tailed)		.000
	N	120	120
Nitrogen%	Pearson Correlation	.930**	1
	Sig. (2-tailed)	.000	
	N	120	120

**. Correlation is significant at the 0.05 level (2-tailed).

IV. CONCLUSION

Nitrogen, phosphorus and potassium, SOM, and pH in the soil in the maximum field were ranged low in different depths of soil which may be due to haphazard use of fertilizer and farmers being unaware of the recommended dose and the sustainable management of nutrient. The determined nutrient index data also supported the soil fertility status of the research field. The pH and texture of most of the samples was slightly acidic and loamy respectively. The high variation on the particular nutrients might be due to the adoption of heterogeneous management practices in the field. Therefore, before starting any experiment keeping the land for one season can be a suitable option for reduction of error due to soil fertility heterogeneity. The fertilizer for each crop should be applied based on the determined status in the farm. The proper nutrient management practice should be adopted especially for those nutrients having very low and very high in status, because crop may suffer from their stress. Therefore, it is anticipated that the findings of the present study would help to guide required practices for sustainable soil fertility management as well as developing future research strategy in the farm.

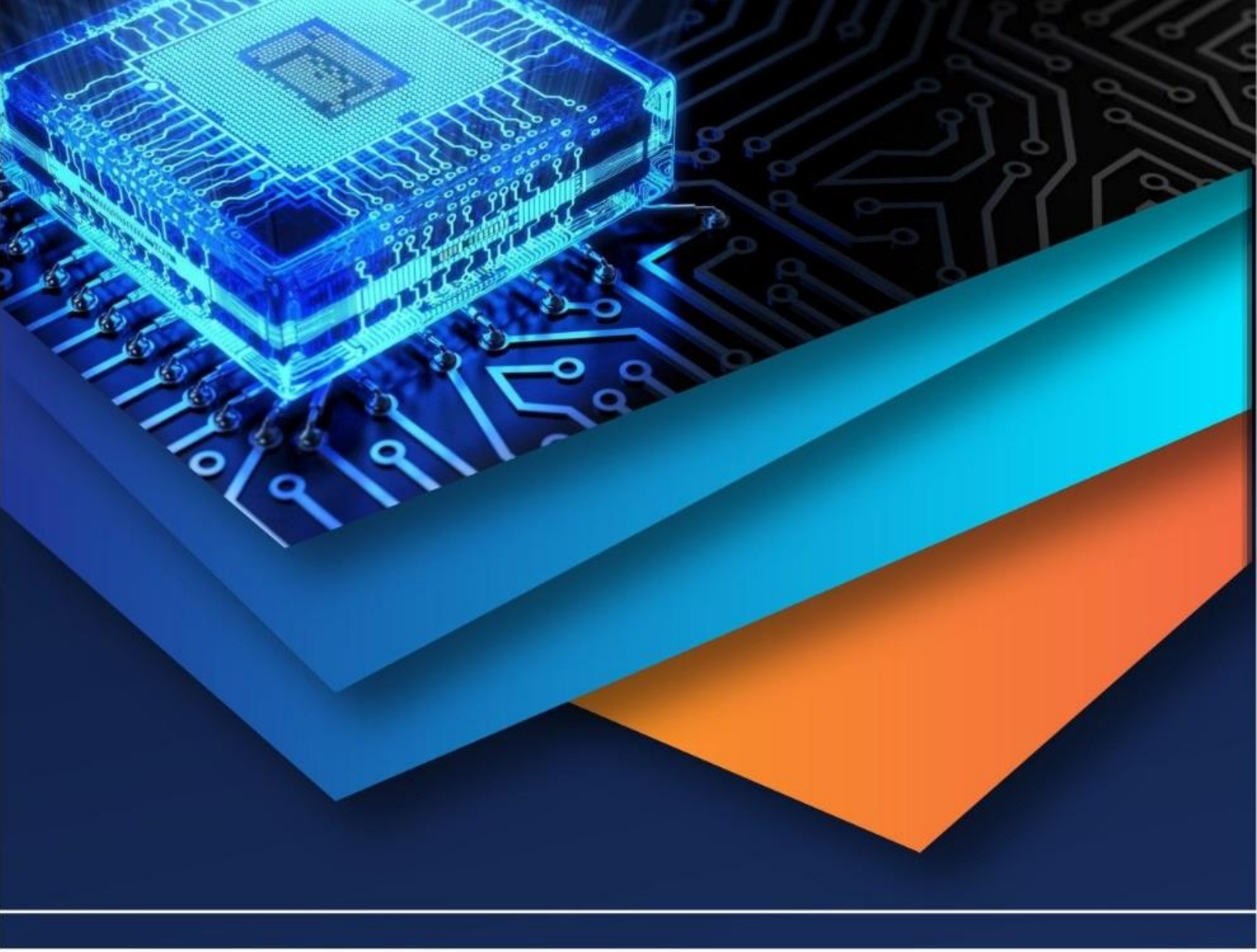
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