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Research Article

Depth-wise variations of soil physicochemical properties in the apple growing area of Mustang district, Nepal

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ABSTRACT
Understanding the soil fertility is an important management tool in assessing the nutrient requirement of the crops. Considering this, a study was done to determine depth-wise soil parameters distribution in the apple growing areas of Gharpajhog Rural Municipality, Mustang during October 2019. The total 68 sampling points were selected randomly in the different sites, and collection was done from three depths viz. 0-20cm, 20-40cm and 40-60cm by using soil sampling auger. The soil separates, pH, organic matter, total N, available P_2O_5 and K_2O were determined following standard methods in National Soil Science Research Centre, Khumaltar. The results of the study revealed that the effect of depth was significant in the sand and silt proportion, while non-significant in clay proportion. The highest (40.17±1.57%) sand content was in 40-60cm depth, meanwhile highest (45.64±1.07%) silt content was in surface (0-20cm) depth. In addition to this, soil pH, OM, total N, available P_2O_5 and K_2O were also affected by the depth. The highest (8.27) pH was determined in the lower (40-60cm) depth. On the other hand, highest OM (4.93±0.2%), total N (0.24±0.01%), available P_2O_5 (43.47±4.35 mg/kg) and available K_2O (95.91±5.8 mg/kg) in surface (0.20 cm) depth. The surface depth possessed strong content of studied soil parameters might be due to in-situ incorporation of leaf litter, residue etc. as well as applied manure in the surface. Finally, we can also conclude that the adopted current nutrient management practice should be continued for apple production in the study area.
Keywords: Apple growing area; Nutrient management**;** Primary nutrients, soil analysis, soil depth

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INTRODUCTION
Apple is one of the most important fruit crops among the deciduous fruits in terms of area, production and household economy in mountain districts of Nepal (Atreya &Kafle, 2016). Accordingly, it is being prioritized as high value cash crop in the high hills of Nepal since long ago (APP, 1995). Currently the area under apple cultivation in the country is 4133 ha with the total volume of production of 28895 mt (FAOSTAT, 2020). Among the several apple growing districts of the country, Mustang is the second largest one regarding the area of production. Most of the households are involved in the production of different varieties of apples in many parts of the district. The apple produced in the Mustang district is considered the best for their texture, juiciness and crunchiness. These several attributes makes the district

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popular for apple production. The district alone produced about 5300 mt of apples in 2017 (my Republica, 2017).

Several factors such as climate, soil, irrigation, varieties, human labor, disease and insect management factors etc. are important for the maintaining apple production among which inherent soil fertility status is the one. It influences greatly to the fruit production as well as tree health (Kopytko et al., 2017). For assessing the soil fertility status, it necessitates the testing of soils of the particular areas. Soil testing is an important diagnostic tool for quick determination of the nutrient status of a soil to make fertilizer recommendations in the soil for apple production as in other crops and to make recommendation of soil amendments in problematic soils in most of the cases. It has an advantage over the other methods of estimating the soil fertility status because of its rapidity to measure the quantity of nutrient elements that is extractable from the soil (Sallato et al., 2019).

Slightly acidic to neutral soil (pH 5.8 to 7.0) is required for apple production. Extreme soil pH value results unavailability of nutrient to the plant and poor tree and fruit development (Yara 2020). Thus, understanding the acidic and basic natures of soils and their physical and chemical parameters is very vital for the apple production. Soil texture is an important soil physical parameter and soil pH, organic matter, macro and micro nutrients etc. are important soil chemical parameters. The physical and chemical tests provide the information about capacity of soil to supply mineral nutrients (Ganorkar & Chinchmalatpure, 2013). Furthermore, knowing the information about the distribution of nutrients status in different depth is equally important for sustainable management of orchard. But, the information on those parameters in the apple growing areas of Mustang is very limited. Therefore, the study was carried in the Mustang district in order to assess the depth wise nutrient distribution pattern of apple growing areas.

MATERIALS AND METHODS

Description of study area

The study area belongs to the various sites of Gharpajhog Rural Municipality, Mustang district, Nepal. The various sites were Chairo, Bhote-camp, Tibettian-camp, Marpha, Dhawang and Syang. Apple is a main temperate fruit grown in the study area. In addition to this, organic source of nutrients like compost is an imperative medium for the nutrient management. The study sites are located in 83.678 – 83.711 north longitude and 28.729 - 28.773 east latitude. The altitude ranged from 2600-3068 masl.

Sampling of soil

Soil samples were collected from Mustang district of Nepal during October 2019. Sixty eight soil samples were collected randomly from different depth of 0-20cm, 20-40cm and 40-60cm by using sampling auger.

Laboratory analysis

The collected soil samples were analyzed at Soil Science Division laboratory, Khumaltar, Lalitpur. The different tested soil parameters as well as adopted methods to analyze are shown on the Table 1.

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Statistically analysis

Recorded value of soil parameters was first complied and tabulated in Microsoft Excel Professional Plus 2010. These data were subjected to one-way Analysis of Variance (ANOVA), and Significant means were separated using Least Significant Difference (LSD) Test at 1% or 5% level of significance as described by Gomez and Gomez (1984) and Shrestha (2019). Moreover, Violin and boxplot were also performed for data visualization. All the statistical work was done in R programming. Rating of soil parameters (very low, low, medium, high, and very high) were based on rating chart of Soil Science Division (2019).

Table 1. Parameters and methods adopted for the laboratory analysis

S.N.	Parameters	Methods
1.	Physical	
	Soil Texture	Hydrometer (Bouyoucos, 1927)
2.	Chemical	
2.1	Soil pH	Potentiometric 1:2 (Jackson, 1973)
2.2	Soil organic matter	Walkley and Black (1934)
2.3	Macro-nutrients	
2.3.1	Total nitrogen	Kjeldahl (Bremner and Mulvaney, 1982)
2.3.2	Available P_2O_5	Modified Olsen's (Olsen et al., 1954)
2.3.3	Available K_2O	Ammonium acetate (Jackson, 1967)

RESULTS AND DISCUSSION

Soil fertility status with respect to soil texture, soil pH, organic matter and primary macro nutrients of different depth of study area were assessed and the result obtained were presented and discussed under following headings.

Soil texture

Soil texture is defined as the composition of soil separates i. e. sand, silt and clay particles (Havlin et al., 2010). The distribution of sand, silt and clay in different depth was shown in the figure 1-3. The result of this study indicated that the sand and silt percent of soil samples was significantly differed with soil depth (Table 3). The sand percent was increased with soil depth, but the silt percent of soil was decreased with soil depth. Similarly, the percent clay of soil was not significant with soil depth. However, decreased with soil depth. The higher content of sand in lower depth might be due to geological structure of hilly area, where proportion of rock is higher inside the surface soils. Due to higher content of sand percent in lower depth, this study suggested to the apple grower to apply nutrient only surface to subsurface zone during pit preparation to minimize the nutrient losses.

Table 3. Depth-wise variation of soil texture in Apple growing area

Soil depth (cm)	Sand	Silt	Clay
		%	
0-20	32.81^{b}	45.64^{a}	21.56
20-40	35.14^{b}	43.39^{a}	21.47
40-60	40.17^{a}	39.51^{b}	20.31
LSD(0.05)	4.40**	3.01**	2.12^{ns}
Grand mean	36.04	42.85	21.11
SEM	1.57	1.07	0.74
CV%	35.96	20.69	28.80

** Significant at 1% level of probability; ns =non-significant; Means having same letter (s) do not differ significantly at 5 % level of probability

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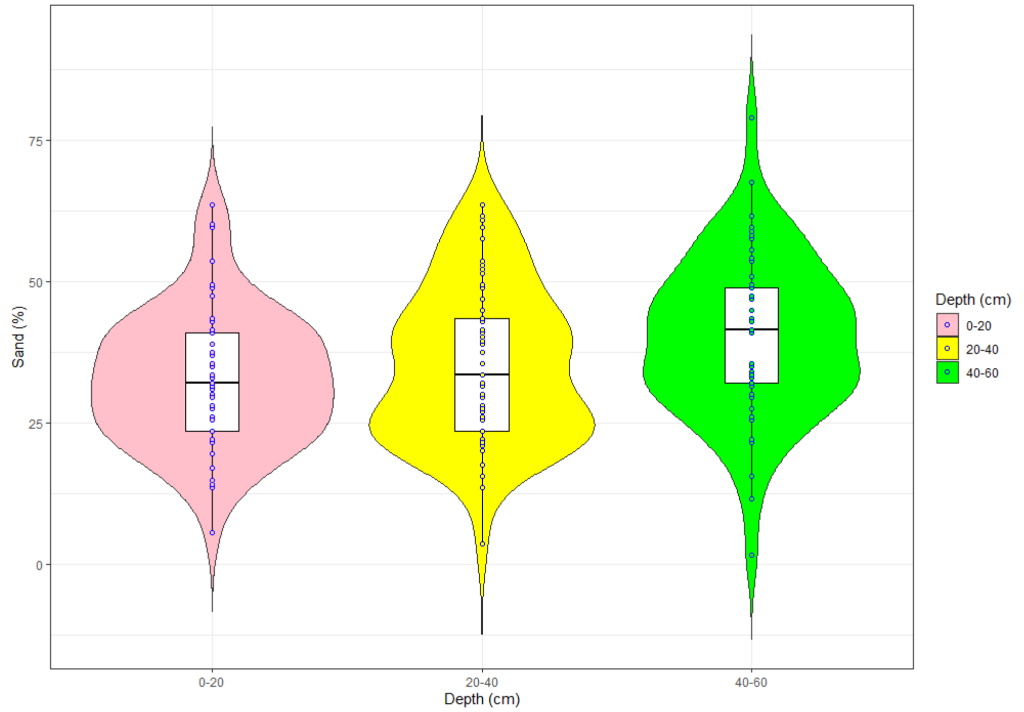

Figure 1. Distribution of sand proportion in the soil depth

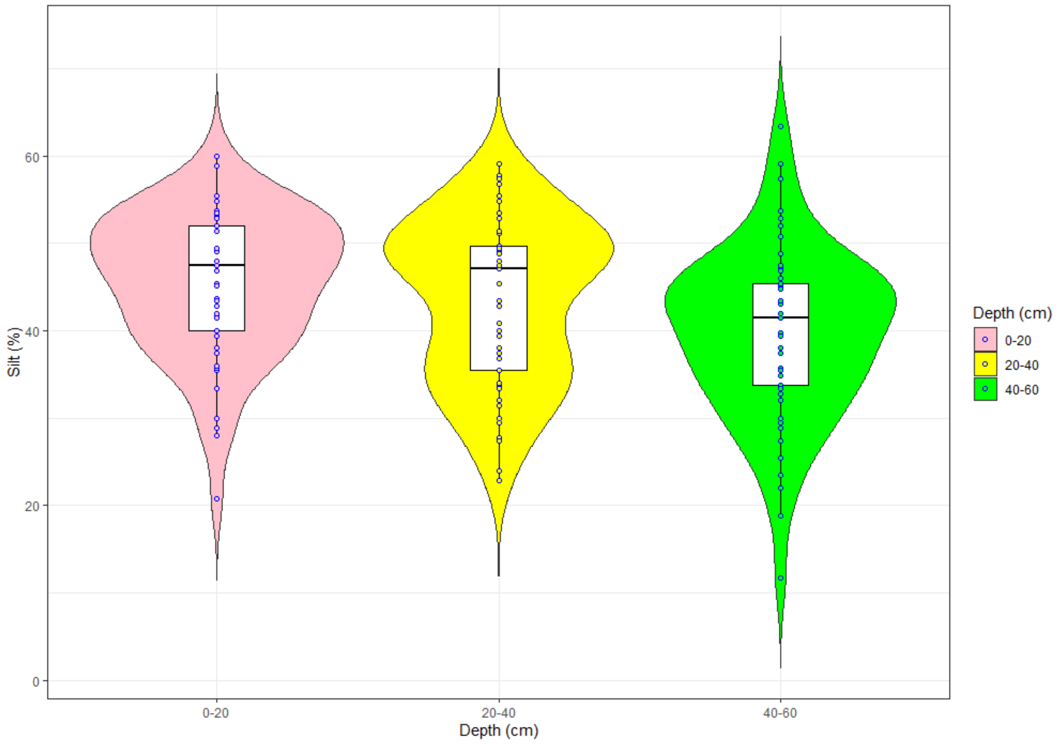

Figure 2. Distribution of silt proportion in the soil depth

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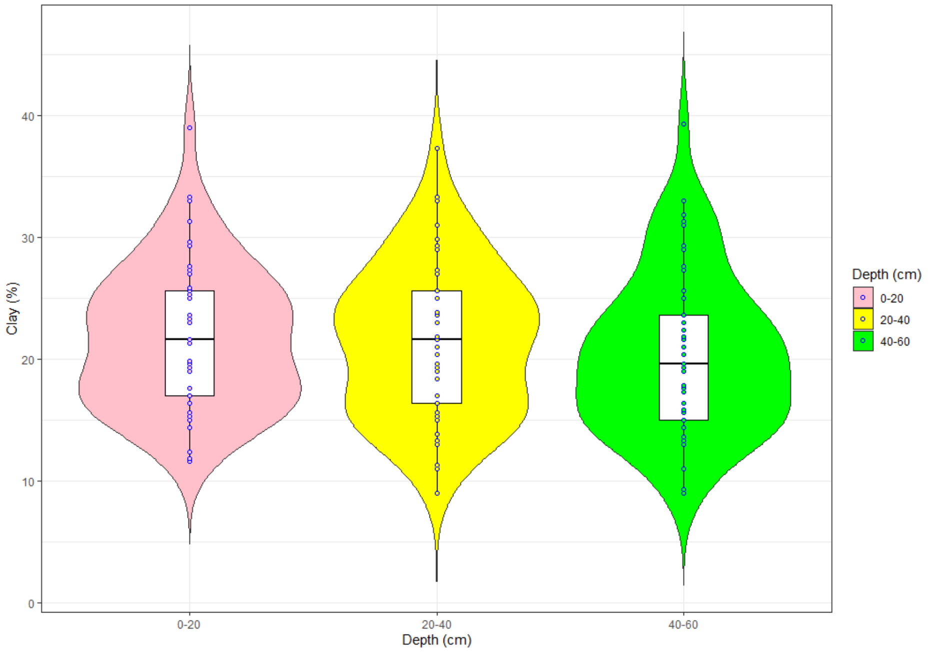

Figure 3. Distribution of clay proportion in the soil depth

Soil pH

Soil reaction (whether it is acidic, alkaline or neutral) is the most important characteristic of soil solution as it significantly affects the availability of most of the chemical elements of importance to the plants (Brady, 2000). The distribution of pH in different depth was shown in Figure 4. The pH in soil varied significantly with depth. The range was varied from 7.08 to 8.72 with a mean value of 8.13 in 0-20cm depth. Soil pH in 20 to 40cm depth was varied from 7.31 to 8.91 with the mean value of 8.25. Similarly, the pH in soil depth of 40-60cm depth was varied from 7.74 to 8.91 with the mean pH value of 8.27 (Table 4). This result indicated that Soil pH was moderately alkaline status. As apple fruit required slightly acidic to neutral pH, lowering the pH in study area is essential. This study indicated that higher the organic matter percent lower the soil pH. This may be due to the organic matter improve the buffering capacity of soil. Thus, continuous application of organic matter should be the better option for the sustainable apple production.

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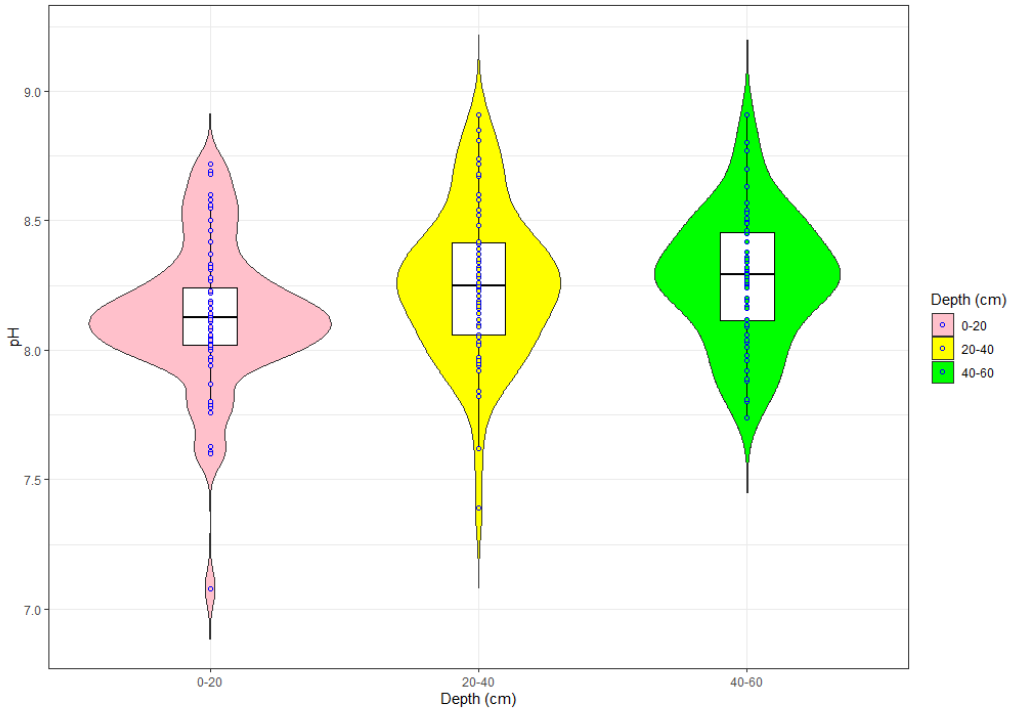

Figure 4. Distribution of pH in the soil depth

Table 4. Depth-wise variation of soil fertility status in Apple growing area

Soil depth(cm)	pH	OM	TN
		%	
0-20	8.13[b]	4.93[a]	0.24[a]
20-40	8.25[b]	2.99[b]	0.14[b]
40-60	8.27[a]	1.88[c]	0.09[c]
LSD(0.05)	0.09**	0.55**	0.029**
Grand mean	8.22	3.21	0.16
SEM	0.03	0.2	0.01
CV%	3.30	54.33	54.03

** Significant at 1% level of probability; Means having same letter (s) do not differ significantly at 5% level of probability

Organic matter

Soil organic matter is the foundation of healthy and productive soils as it improves soil structure, water holding capacity, soil aeration and infiltration, nutrient supplying power of soil and feeds soil micro flora and fauna. Distribution of soil organic matter in different depth was demonstrated in figure 5. Effect of soil depth on soil organic matter was found highly significant. The organic matter content in soil was varied from 0.70 to 9.63% in 0-20cm depth with a mean value 4.93%. The result revealed that the mean organic matter was medium in organic matter status however the range showed the high variation in organic matter distribution. Similarly, in 20-40 cm depth the range of organic matter was varied from 0.16 to 5.41% with a mean value of 2.99 %. In 40-60cm depth, the organic matter content in soil varied from 0.16 to 5.41% with a mean value of 1.88% which indicated the low organic matter status (Table 4). This study indicated that the organic matter % was found higher in upper surface and decreases with increasing the soil depth. This may be due to the application of manure and in-situ incorporation of plant residues on surface layer.

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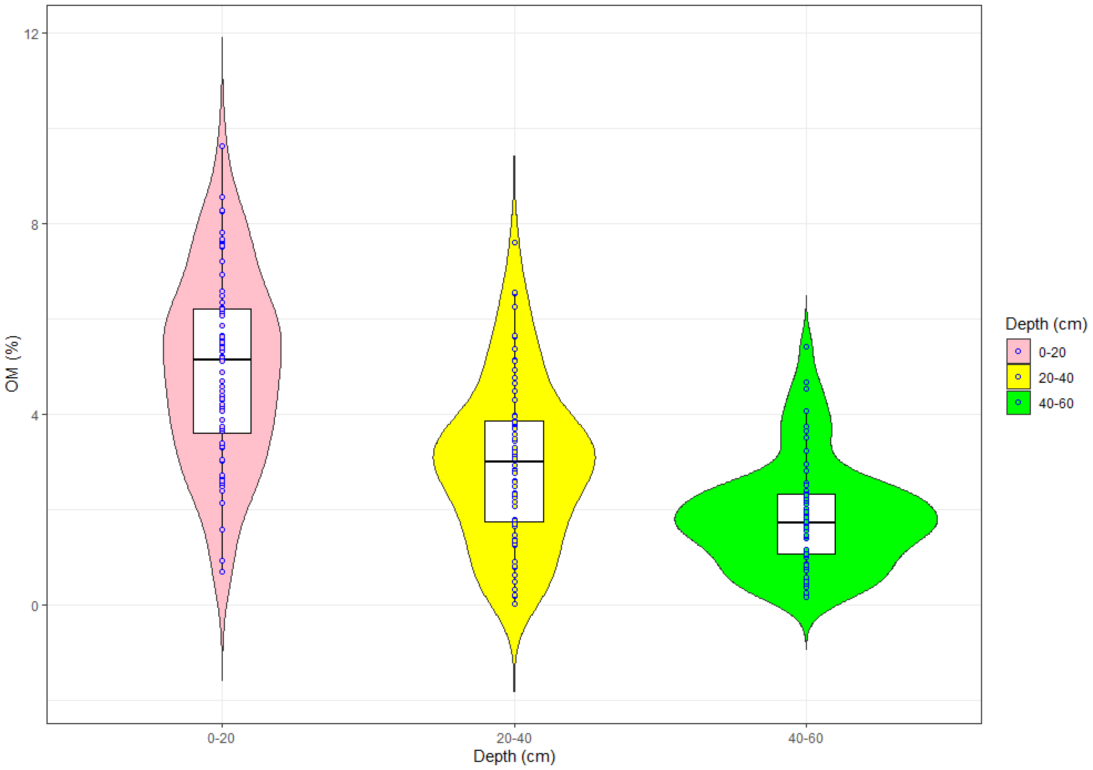

Figure 5. Distribution of organic matter in the soil depth

Total nitrogen

Total nitrogen content in soil with in different depth was found significantly differed. The result showed that the total nitrogen content was in decreasing order with increasing the soil depth (Table 4). The mean total nitrogen status was found high in 0-20cm soil depth with a mean value of 0.24% however the range of total nitrogen was found 0.035% to 0.481% which showed highly variation. With increasing the soil depth (20-40cm) soil total nitrogen varied from 0.001to 0.381 % with mean value of 0.14%. The result showed that the mean value of total nitrogen was medium in status. Similarly 40-60 cm depth the total nitrogen was varied from 0.008% to 0.27% with a mean value of 0.09%. This result indicated that the mean nitrogen was low in status. The distribution of soil total nitrogen in different depth was shown in figure 6. In general, the total nitrogen was found maximum in surface soils and decreasing regularly with increasing the soil depth. This may be due to the decreasing trend of organic matter with increasing the depth and more mineralization of organic matter in surface soil and also cultivation of crops are mainly confined to surface horizon and depleted nitrogen content was supplemented by the external addition of fertilizer. This result was similar with Khanday *et al*. (2018), Bhat *et al.* (2017) and Ganai *et al*. (2018).

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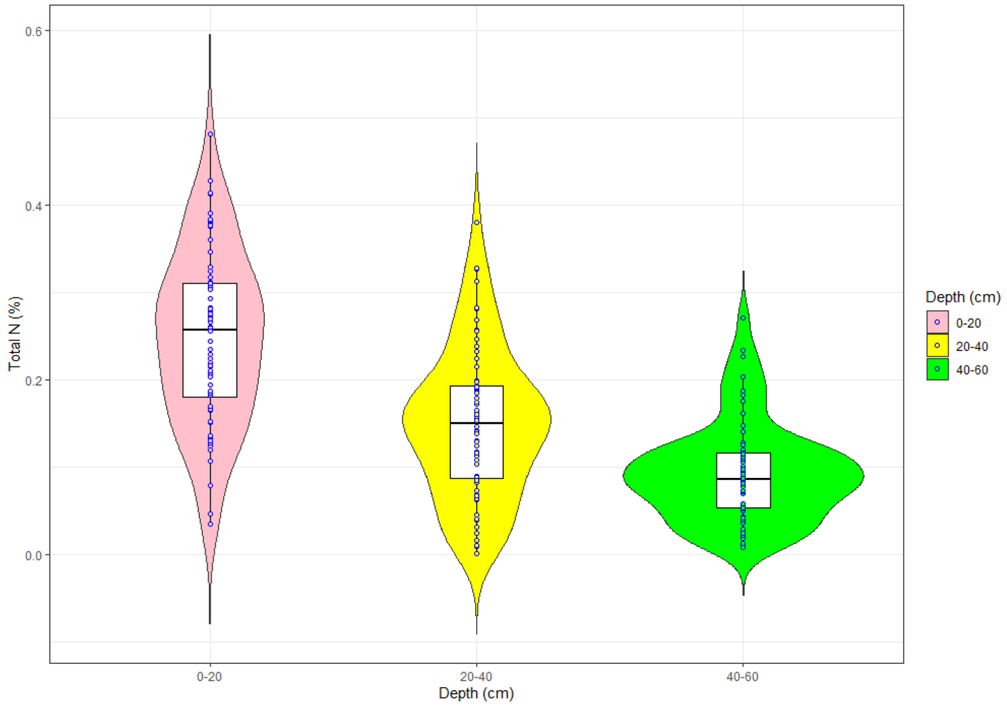

Figure 6. Distribution of total nitrogen in the soil depth

Available phosphorus

The study indicated that available phosphorus was significantly affected by soil depth. The mean available phosphorus was found maximum in surface soils and decreasing with increasing the soil depth. The mean available P_2O_5 status was high in 0-20cm and 20-40cm soil depths (43.47 mg kg^{-1}, 25.24 mg kg^{-1}, respectively (Table 5). However, the range of available phosphorus varied from 5.83 to 217.70 mg kg^{-1} in 0-20cm depth and 7.96 to 112.18 mg kg^{-1} in 20-40cm depth which showed high variation. Similarly, mean available phosphorus status was medium in 40-60cm depth (21.17 mg kg^{-1}) although the range varied from 6.79 to 115.84 mg kg^{-1}. The distribution of available phosphorus in different depth was shown in figure 7. Decreasing order of available phosphorus with depth was also found by Sartaj *et al*. (2017) and Khanday *et al*. (2018). It might be due to the confinement of cultivation to the surface and supplementing the depleted phosphorus by external fertilizers. Similar result was also reported by Bhat *et al.* (2017) and Ganai *et al*. (2018). The higher amount of available phosphorus found in upper surface may be due to the higher amount of organic matter in upper surface.

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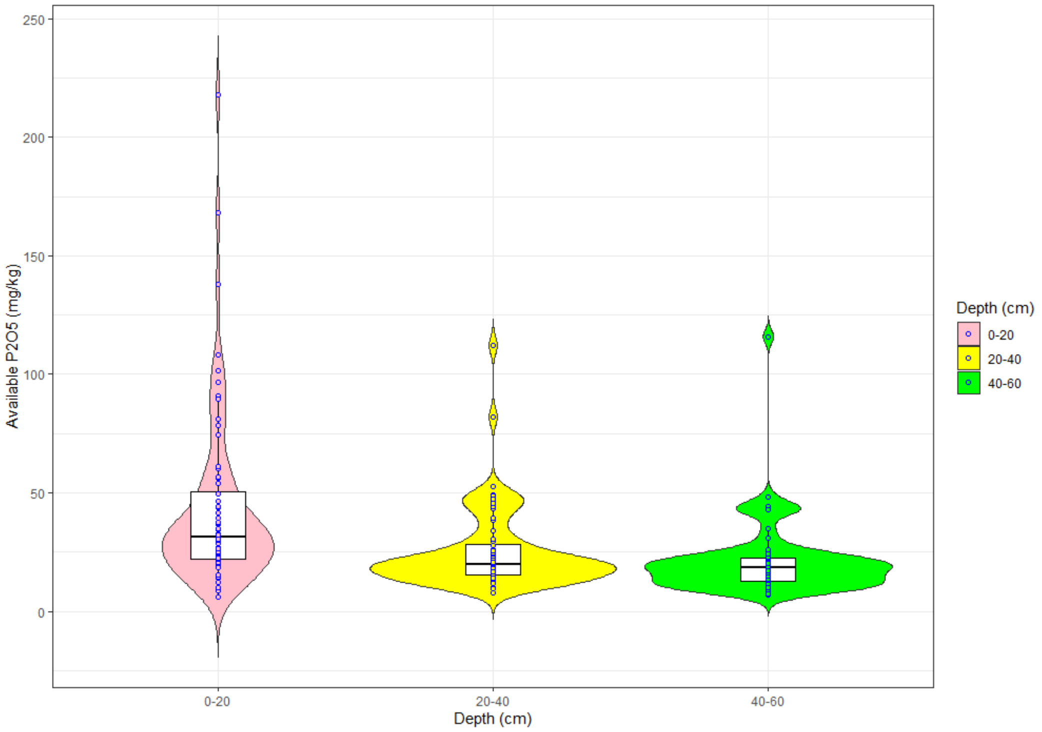

Figure 7. Distribution of available phosphorus in the soil depth

Available potassium

The extractable potassium content in soil was differed significantly by soil depth. Distribution of available potassium in different depth was shown in figure 8. Result revealed that extractable potassium content was varied from 17.34 to 300.24 mg kg^{-1} in 0-20cm soil depth with a mean of 95.91 ±5.8 mg kg^{-1}. This suggests the medium status of extractable potassium in case of mean value but the range showed high variation. The extractable potassium in 20-40cm the was varied from 0.05 to 296 mg kg^{-1} with a mean value of 45.83 ±5.8 mg kg^{-1}which indicate the overall mean value of potassium was lower in status although the range was highly varied. Similarly in 40-60cm depths the extractable potassium was ranged from 0.05 to 118.51 mg kg^{-1} with a mean value 29.63±5.8 mg kg^{-1} (Table 5). In general, the mean extractable potassium was found maximum in upper surface and decreasing with depth. This might be due to release of liable K from organic residues, application of external fertilizers. Similar findings were also observed by Sartaj *et al*. (2017), Khanday *et al*. (2018), Bhat *et al.* (2017) and Ganai *et al*. (2018).

Table 5. Depth-wise variation of soil fertility status in Apple growing area

Soil depth(cm)	Available P_2O_5	Available K_2O
	mg kg^{-1}	
0-20	43.47^{a}	95.91^{a}
20-40	25.24^{b}	45.83^{b}
40-60	21.17^{b}	29.63^{c}
LSD(0.05)	8.57**	16.17**
Grand mean	29.96	57.12
SEM	4.35	5.8
CV%	84.65	83.72

** Significant at 1% level of probability; Means having same letter (s) do not differ significantly at 5 % level of probability

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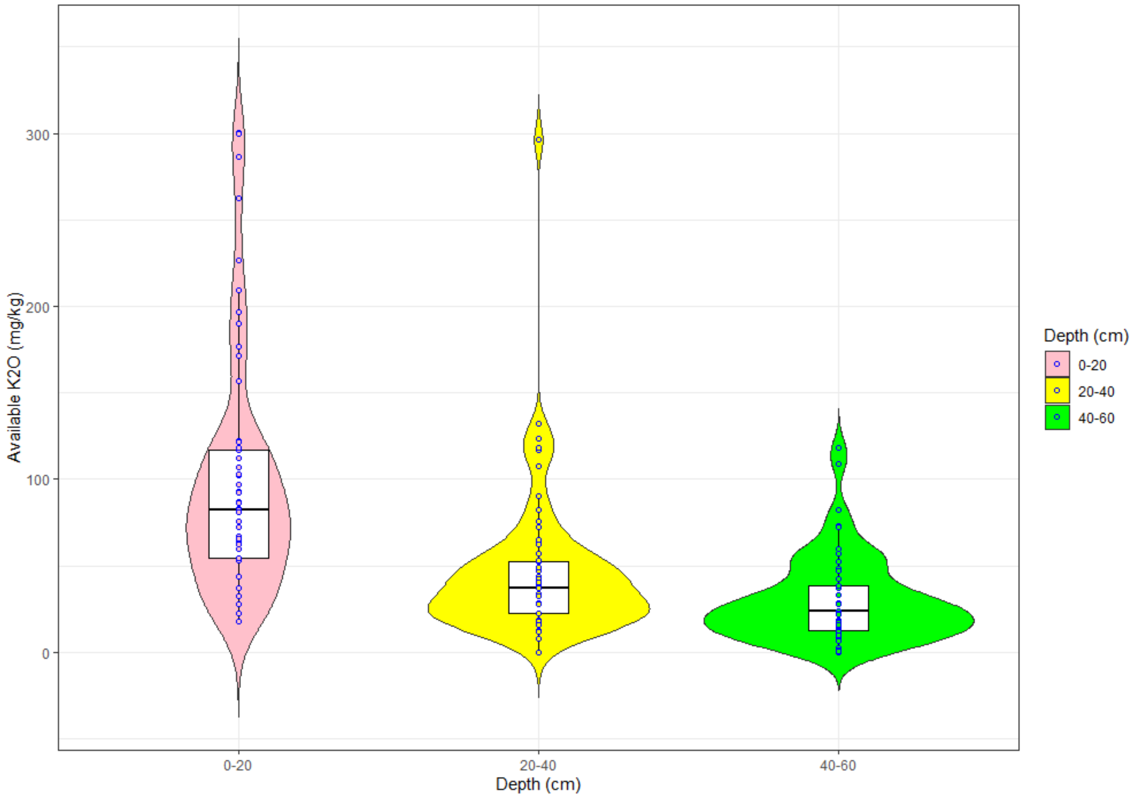

Figure 8. Distribution of available potassium in the soil depth

CONCLUSION

In general, soil texture, pH, organic matter and all primary macronutrients observed significant variation with soil depth. The surface layer possessed highest content of majority soil parameters. The higher content of majority soil parameters indicates current nutrient management practice is satisfactory in the study area. Therefore, for maintaining long-term sustainable nutrient management, current practice should be maintained. In addition, because of having higher proportion of sand in the lower depth, it is suggested to apply nutrient only within the surface to sub-surface layer in the sapling plantation pit during new orchard establishment. Moreover, stakeholder should suggest strategy to apple grower for reducing alkaline effect, because apple prefer slightly acidic to neutral soil pH.

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Author contributions

This manuscript was prepared by R. Amgain. Similarly, D. Khadka and R. Malla contributed for collection of soil sample from the study area. Moreover, R. Amgain, D. Khadka and S. Joshi played important role during laboratory work and final manuscript preparation.

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Conflict of author

The authors declare that there is no conflict of interest.

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