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RESEARCH ARTICLE

EVALUATION OF SOIL NUTRIENT STATUS IN APPLE ORCHARDS LOCATED IN DIFFERENT ALTITUDES IN KALIKOT DISTRICT, NEPAL

Dhruba Baral *, Anup Paudel, Himal Acharya, Madhav Prasad Neupane

Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal
****Corresponding Author Email: baralafu2015@gmail.com***

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ABSTRACT

This study was conducted to assess the fertility status of different altitude of apple orchard and their effect upon soil nutrients and to study the relationship between different altitude and their availability. Seven different orchards located in 2800, 2700 2600, 2500, 2400, 2300 and 2200 at Apple Zone, Raskot, Kalikot were selected as treatments. They were replicated three times in Randomized Complete Block Design. Composite soil samples were collected in each study site from 0-3 ft soil depth in 'W' pattern from each plot. Analyses of soil samples were done in regional soil testing laboratory, Surkhet for chemical properties. There was a significant effect ($p<0.05$) of altitude on soil macronutrients except available potassium level. Maximum amounts of soil organic matter, acidic and soil rich in nitrogen and phosphorus were found in 2800 masl whereas more basic soil , poor soil organic matter and soil poor in nitrogen and phosphorus were found in 2200 masl. Result showed that in altitude of 2200 masl has poor soil nutrients compared to apple orchards in higher altitude. Kalikot is the top producer of apple in Nepal. This assessment will helps apple growers for adopting better nutrient management plan in their orchards according to the altitude in the district. Further, it is recommended to conduct soil nutrient assessments for all other apple growing regions in the country.

KEYWORDS

Assess, fertility, macronutrients, Malus, pumila.

1. INTRODUCTION

Agriculture is the main economic activity of Nepal, employing about 65% of the population and providing 27.10% of GDP with annual growth rate of 2.72% (AITC, 2019). Fruits are consumed for rituals and cultural purposes since ancient time in Nepal (Karki et al., 2017). There is a need to explore the potentiality of fruit cultivation in Nepal for export promotion as well as import substitution (MoAD, 2017). Apple contributes about 4.2 percent of the total fruit production and occupies 5.08 percent of the total fruit area in Nepal (MoALD, 2017). Apple (*Malus pumila*) is an important fruit crop of world and it is also called as the king of temperate fruits (USAID, 2008). Apple accounts for more than 50% of the deciduous tree fruit production in the world. Nepal's total and productive area under apple was 12,025 ha and 3,707 ha respectively with 19,850 mt and 5.36 mt ha^{-1} production and productivity respectively (MoALD, 2017). The average production, area and productivity of the apple in Kalikot district was 836 mt, 805 ha and 8.09 mt ha^{-1} in the fiscal year.

Topographically, Kalikot district has 53.01% forest land, 2.31% bushes land, 29.35% bare area, 5.83% snow cover area and only 9.46% agriculture land (GoN, 2011). The district has 136,948 of total population involving 94.82% in the agriculture (GoN, 2011). Healthy soils which help to increase production and address food security of nation. Soil health can be evaluated by soil characteristics like pH, soil organic matter (SOM), total nitrogen (N), available phosphorus (P) and available Potassium (K). People plant the apple in unfertile and ignore land than fertile. No any excess of transportation facilities in the upper part and farmers have less knowledge about the soil nutrients. According to local farmer, soil test was done only through kit-box which was not accurate and authentic. The national recommended dose for apple is 300 kg ha^{-1} of Farm Yard Manure, 8.7 kg ha^{-1} of diammonium phosphate, 14 kg ha^{-1} of urea, 2.7 kg ha^{-1} of muriate of potash respectively in a year (AITC, 2019). Arguably, Kalikot district is emerging as the apple grower from last decade.

This is one of the major temperate fruit. It has been cultivated in the sandy loam soil having pH range 6.5 to 8 and ignored lands in its few first of cultivation (DoSM, 2015). This study focusses on the comparison of the different altitude soil nutrient. This will give an idea about the soil nutrients and health status of soil under different altitude apple cultivation. This information will help the farmers and the policy makers to make plans according to the profitability. This will make the block to think about how to accommodate the other growers by raising the awareness about these effects of cultivation on soil. This will make the adoption of the new cultivation technology more effectively. The objective is to study about different altitude soil chemical properties on apple orchard.

2. MATERIALS AND METHODOLOGY

2.1 Treatment Details

The sampling activities were conducted in different altitude of apple orchards in Apple Zone, Raskot, Kalikot. The statistical method adopted in this study was Randomized Complete Block Design (RCBD) by selecting apple orchards from different altitudes (i.e. 2200, 2300, 2400, 2500, 2600,

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2700 and 2800 masl) as seven treatments area of each treatment was 500 m^2 and contain 20 apple trees. Each altitude was replicated three times comprising a total of twenty-one soil sampling plots. To maintain homogeneity within a replication, the samples from each block were collected within the same vicinity. Each block was located in south facing slope. The density of apple trees was almost similar in all the treatments.

Table 1: Basic information of the study

Design	**:**	**RCBD**
Treatment combinations	:	7
Replications	:	3
Total number of plots	:	7 × 3 = 21
Crop	:	Apple
Season	:	Spring
Location	:	Raskot (Septi and Bisali), Kalikot
Sampling time	:	Last week of March, 2019
Climatic region	:	Temperate region
Slope of Area	:	South facing slope

Evaluations of soil nutrients (N, P, K, pH & Organic matter) according to altitude with 7 treatment and 3 replications of each.

T1= 2800masl (soil nutrient test; N, P, K, pH & OM)
T2=2700masl (soil nutrient test; N, P, K, pH & OM)
T3= 2600masl (soil nutrient test; N, P, K, pH & OM)
T4= 2500masl (soil nutrient test; N, P, K, pH & OM)
T5= 2400masl (soil nutrient test; N, P, K, pH & OM)
T6=2300masl (soil nutrient test; N, P, K, pH & OM)
T7=2200masl (soil nutrient test; N, P, K, pH & OM)

2.2 Soil sample collection and preparation

Soil samples were collected from each treatment. Three sub samples were collected randomly from each plot within a replication (i.e., 1ft, 2ft, and 3ft). These subsamples were then collected and standard procedure was followed for obtaining 0.5 kg of composite sample. A total of twenty-one composite soil samples were collected. The collected soil samples were labeled, brought to Directorate of Soil testing laboratory, Birendranagar, Surkhet, Karnali Province. These samples were air dried and then ground and sieved through 2mm sieve for chemical analysis and through 0.2mm sieve for SOM analysis.

2.3 Laboratory analysis

Soil samples collected from each location and orchards were analyzed for soil pH, soil organic matter, total nitrogen, available phosphorus and potassium content of the soil. Laboratory methods used for analysis of different soil fertility parameters are depicted in Table 02.

Table 2: Laboratory analytical techniques for different soil physical and chemical properties

Parameters	**Study method**
Soil texture	Mechanical analysis method (Day,1965)
Organic matter	Walkley – Black method (Houba et al., 1989)
Soil pH	Glass-calomel electrode pH meter using 1:2 soil water ratio (Cottenie et al., 1982)
Total nitrogen	Kjeldhal distillation unit (Bremner and Hauck, 1982)
Available phosphorus	Modified Olsen bicarbonate method
Available potassium	Ammonium acetate extraction method

2.4 Statistical analysis and data presentation

Data pertaining to soil organic matter and nitrogen were rated according to standard rating of Soil Science Division, Khumaltar, Lalitpur and data related to phosphorus and potassium were recorded based on Ward lab laboratories rating Table 03. The pH obtained from laboratory analysis were rated according to Khatri- Chhetri, 1991 Table 04 and analyzed using Gen STAT software 15th Edition and Microsoft Excel. The data were subjected to analysis of variance (ANOVA) appropriate to randomized complete block design technique. When significant difference existed between treatment means, 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 nitrogen content of soils. SPSS software was used for Correlations analysis.

Table 3: Rating chart for classification of fertility status according to Soil Science Division, Khumaltar, Lalitpur (2002) and Ward lab laboratories

Nutrient status	**SOM (%)**	**Total N (%)**	**Available P (mg/kg)**	**Available K (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

Table 4: Rating chart for soil reaction according to Khatri-Chhetri

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

3. Results and Discussion

3.1 Soil pH

The pH level in different altitude of apple orchard is shown in Table 05. The result of the study indicated that the effect of altitude on pH was highly significant (P<0.001).

Table 5: pH variation in different altitude apple orchards in Apple Zone, Kalikot

Altitude of apple orchard (masl)	**pH**
2800	5.50^{c}
2700	5.88^{bc}
2600	6.31^{b}
2500	6.28^{b}
2400	6.31^{b}
2300	6.38^{b}
2200	7.19^{a}
SEm(±)	0.177
LSD (0.05)	0.54***
CV,%	4.9
Grand mean	6.264

Means followed by same letter (s) in a column are not significantly different at 5% level of significance in DMRT test. NS: Non-significant SEm: Standard Error of Mean,Coefficient of Variance (CV), *** is significant at P<0.001

The altitude had significant impact upon the pH level (P<0.001). The maximum pH was observed in 2200m (7.1) and lowest pH was observed in 2800m (5.5) which is acidic in nature. The pH of 2300m (6.38) to 2600m (6.31) were not significantly different and remained closer neutral range. According to the rating chart adopted from (Khatri-Chhetri,1991). Soil reaction was acidic in the elevations of 2700 (5.88) and 2800m (5.50). The lower soil pH in higher height might be due to its higher slope, and less evaporation (Yeshaneh, 2015). Yeshaneh reported lower soil pH in the soils at higher slopes as soils of sloppy areas with good drainage are often acidic in nature due to loss of soluble basic cations (Pal, 2016). Decomposition of leaf litter from trees releases organic acids lowering the soil pH (Gustafson, 1937). The results indicated that the pH is increasing with decreasing height. These findings are similar with the findings of in Ladakh India (Charan et al., 2013).

3.2 Soil organic matter (SOM)

The SOM level in different altitude is shown in Table 6. Soil organic matter content was more in higher altitude compared to lower altitude.

Table 6: Soil organic matter variation in different altitude apple orchards in Apple Zone, Kalikot

Altitude of apple orchard (masl)	**SOM (%)**
2800	2.15^{a}
2700	1.94^{a}
2600	0.86^{b}
2500	0.68^{b}
2400	0.60^{b}
2300	0.43^{b}
2200	0.41^{b}
SEm(±)	0.183
LSD (0.05)	0.56***
CV, %	31.3
Grand mean	1.01

Means followed by same letter (s) in a column are not significantly different at 5% level of significance in DMRT test. NS: Non-significant SEm: Standard Error of Mean, Coefficient of Variance (CV), *** is significant at P<0.001

The results of the study indicated that the effect of altitude on SOM was highly significant (P<0.001). The highest amount (2.15%) of SOM was found in 2800m whereas the lowest (0.41%) found in 2200m. This result was consistent with the research outcomes of Charan, et al.(2013), they found that SOM was increases with increase in altitude from 10000ft to >12000ft. The SOM % of other altitude are similar because of similar practices of inter cropping pattern and supply of OM (Bot and Benites, 2005). The SOM level is high in higher altitude because of not leaching of organic matter in uncultivable land where soil wasn't disturbed (Brady and Weil, 2005). In inter cropping system due to the more tillage practices soil erosion and leaching occurs which wash out the surface organic matter (Funderburg, 2016).

3.3 Soil nitrogen

The total nitrogen was lowest (0.02 %) in 2200m altitude level where as the highest N percentage (0.15%) was reported in the orchard located in 2800 m. Nitrogen percentages in 2600m (0.070) and 2500m (0.066) were similar whereas no significant difference was reported in 2400m (0.033), 2300m (0.021) and 2200m (0.021) altitude levels (Table 7).

Table 7: Nitrogen variation in different altitude apple orchards in Apple Zone, Kalikot

Altitude of apple orchard (masl)	Nitrogen
2800	0.157[a]
2700	0.136[a]
2600	0.070[b]
2500	0.066[b]
2400	0.033[c]
2300	0.021[c]
2200	0.021[c]
SEm(±)	0.00892
LSD (0.05)	0.02749***
CV,%	21.5
Grand mean	1.01

Means followed by same letter (s) in a column are not significantly different at 5% level of significance in DMRT test. NS: Non-significant SEm: Standard Error of Mean, Coefficient of Variance (CV), *** is significant at P<0.001

There was a positive correlation (r=.917**) between SOM and N level indicating that the highest nitrogen level was in 2800 m. Similar findings were put forward by they found that amount of nitrogen increases with increases in SOM because soil required nitrogen to decompose the organisms into organic matter (Charan et al., 2013). The availability of nitrogen to plants is substantially affected by quantity and type of soil (Chen and Avnimelech, 1986). The total nitrogen was found more in high altitude which are uncultivated land and had no leaching and soil problem then lower altitude which were intercropping land having leaching and erosion problem. In high hilly area there is problem of washing up surface nutrient due to sloppy land (Brady and Weil, 2005). The nitrogen level in Raskot area is low below the 2600masl so recommendation of Organic matter and cultivation of legumes crops can be given.

3.4 Available phosphorus

Comparison of available phosphorus was done on the basis of Ward lab ratings, the P in soils of 2800m found to be high following 2500m (Table 8). The lowest available phosphorus was reported in 2200m, 2600m and 2400m and no significant difference was observed.

Table 8: Phosphorus variation in different altitude apple orchards in Apple Zone, Kalikot

Altitude of apple orchard (masl)	Phosphorus (mg/kg)
2800	23.50[a]
2700	19.09[ab]
2600	17.21[bc]
2500	17.76[b]
2400	16.47[bc]
2300	12.85[cd]
2200	11.21[d]
SEm(±)	2.058
LSD (0.05)	4.484**
CV,%	14.9
Grand mean	16.87

Means followed by same letter (s) in a column are not significantly different at 5% level of significance in DMRT test. NS: Non-significant SEm: Standard Error of Mean, Coefficient of Variance (CV), *** is significant at P=0.001

As shown in Table 08 the altitude had a significant (P<0.001) effect on available phosphorus. Maximum P was observed in 2800m (23.50) and 2500m (19.09). It indicated that the soil of Raskot area contains medium level of phosphorus. On the basis of Ward lab ratings available P ranges from 10 mg kg^{-1} to 16 mg kg^{-1} is medium range. A positive correlation was observed (r =.629**) between SOM and available phosphorus. Sharma reported 21.99% less annual phosphorus input via tree litter fall than other macronutrients (Sharma, 2004). This might be the possible cause of lower available phosphorus in this study. The acidic condition of soils might have caused transition of phosphate into less soluble compounds with the reaction of Fe and Al.

3.5 Available potassium

The effect of stand age on available potassium levels is given in. There was no significant effect of stand age on the soil potassium level shown in Table 9

Table 9: Potassium variation in different altitude apple orchards in Apple Zone, Kalikot

Altitude of apple orchard (masl)	Potassium
2800	70.53[a]
2700	72.69[a]
2600	77.90[a]
2500	71.62[a]
2400	76.44[a]
2300	78.33[a]
2200	67.11[a]
SEm(±)	4.59
LSD (0.05)	NS
CV,%	7.70%
Grand mean	73.5

Means followed by same letter (s) in a column are not significantly different at 5% level of significance in DMRT test. NS: Non-significant SEm: Standard Error of Mean, Coefficient of Variance (CV)

The highest available Potassium (mg/kg) was reported as 2300m (78.33) followed by 2600m (77.90), 2400m (76.44), 2700m (72.69), 2500m (71.62). The lowest available potassium was found in 2200m (67.11) but all of these results were statistically non-significant. The soil potassium was high in all soil samples according to the Ward lab chart. Carson also reported that Nepalese soils are rich in potassium (Carson, 1992). The soil potassium is affected by the parental material of the soil in bed rock. Potassium from deep subsoil horizons is taken up by deep rooted perennials and recycled to soil surface through translocation into leaves and following leaf fall and decomposition (Lehmann and Schroth, 2002). The low level of available soil K in 2200masl might be due to higher leaching loss and more K harvest from the soil. Under irrigated condition, available K is subjected to considerable leaching loss (Brady and Weil, 2005).

3.6 Simple correlation coefficient (r) among different soil nutrient parameters

The correlation analysis was done in soil pH with soil nitrogen content, phosphorus availability and potassium availability. The correlation of SOM with soil pH, soil nitrogen content, plant available phosphorus and available potassium are shown in Table 10.

Table 10: Soil pH and SOM with different soil nutrient parameters in different altitude of apple orchards

Parameters	pH	SOM (%)	Phosphorus (ppm)	Potassium (ppm)
Nitrogen (%)	-.707**	.917**	.778**	-.133
pH		-.716**	-.796**	-.096
SOM (%)			.693**	-.186

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

3.6.1 Relationship of soil pH with different soil nutrient parameters

Relationship between soil pH and Soil organic matter - The correlation between soil pH and SOM was significant (r= -0.716**) negatively. The

coefficient of determination (R^2) value was 0.512 that the SOM contributes 51.2% to the change in soil pH level while the rest effects was due to other factors which is shown in Figure 1.SOM content had significant effect on change in soil pH.

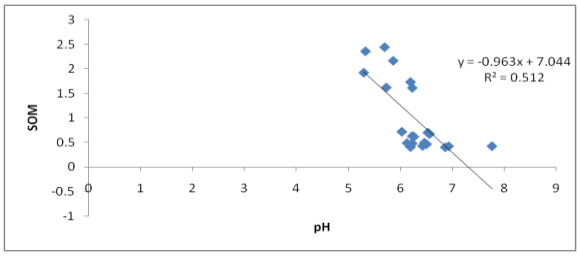

Figure 1: The relationship between SOM content and the soil pH

Relationship between soil pH and soil nitrogen content: - The correlation between soil pH and N was significant (r =-0.707**) but negatively. The coefficient of determination (R^2) value was 0.500 that the in-soil pH level 50% to the change in soil nitrogen level while the rest effects was due to other factors as shown in Figure 2. Soil pH had significant effect on change in soil nitrogen level.

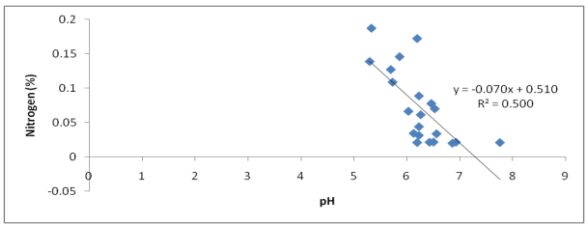

Figure 2: The relationship between nitrogen content and the soil pH

Relationship between soil pH and available phosphorus: - The soil pH and plant available phosphorus content had negative correlation (r= -0.796**) with each other. The coefficient of determination (R^2=0.633) indicated that the contribution of SOM content to the available phosphorus was 63.3% and rest of the effects was due to other factors which is shown Figure 3. Soil organic matter had significant effect on phosphorus availability.

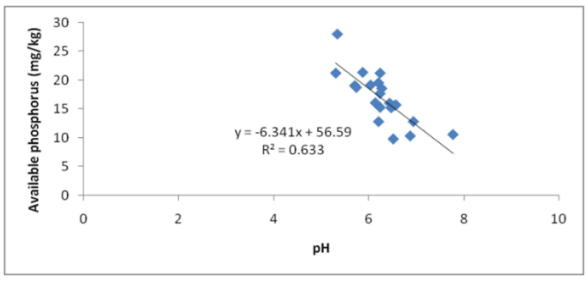

Figure 3: The relationship between available phosphorus and the soil pH

3.6.2 Relationship of Soil organic matter with different soil nutrient parameters

Relationship between soil organic matter content and soil nitrogen: - The soil organic matter and soil nitrogen content had a highly significant positive correlation (r= 0.917**) with each other. The coefficient of determination (R^2=0.841) indicated that the contribution of SOM content to the soil nitrogen content was 84.1% and rest of the effects was due to other factors as shown in Figure 4. Soil organic matter had highly significant effect on soil nitrogen level changes.

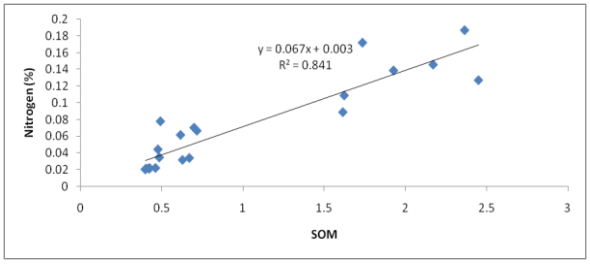

Figure 4: The relationship between SOM content and nitrogen content

Relationship between soil organic matter content and available phosphorus: - The correlation between SOM content and available phosphorus was highly significant (r = 0.693**) positively. The coefficient of determination (R^2) value was 0.479 that the contribution of the SOM content to the amount of available phosphorus content was 47.9% and rest of the effect was due to other factors as shown in Figure 5. Soil organic matter had significant effect on plant phosphorus availability.

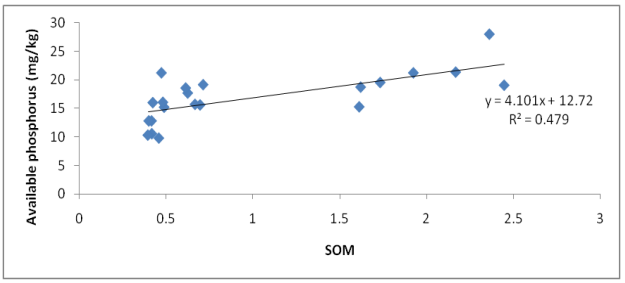

Figure 5: The relationship between SOM content and available phosphorus

4. Conclusion

The result of present findings concluded that the altitudinal variation of apple orchard had a considerable effect on soil nutrient pool except for potassium availability. Soil nutrient contents increased significantly from the lower altitude to higher altitude. The highest amount of SOM was found in 2800 masl which was significantly higher with 2200 masl. The SOM level is high in higher altitude because of not leaching of organic matter in uncultivable land where soil wasn't disturbing and also due to temperature effects. The soil of Raskot, Kalikot consists of low SOM and nitrogen whereas medium to high in the case of phosphorus and potassium. Soil pH was acidic in higher altitude and neutral in lower altitude. The pH is inversely related with the SOM, nitrogen and phosphorus. Highest soil chemical nutrients (SOM, N, P) was found in 2800 masl and lowest was found in 2200 masl but pH was maximum in 2200 masl and minimum in 2800 masl. SOM, N and P showed decreasing trend with decreasing altitude and pH was increasing with altitude. This research was conducted in south facing slope and further investigations are needed to cover all directions to come up with more precise findings.

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