Research article

Study of the Relationship between different Soil Properties in Agricultural Fields, Kyee Inn Village, Myanmar

SWE SWE MAR*
Department of Soil and Water Science, Yezin Agricultural University, Myanmar
Email: swesmooth@gmail.com

NAING NAING MOE
Department of Soil and Water Science, Yezin Agricultural University, Myanmar

KYAW NGWE
Department of Soil and Water Science, Yezin Agricultural University, Myanmar

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Abstract An understanding of the physical and chemical properties of soils is necessary due their relationship with productivity in agricultural fields. A study was conducted in 480 hectares of agricultural fields at Kyee Inn, Pyinmana Township, Naypyitaw, Myanmar to determine the relationship between different soil properties (bulk density, soil moisture, soil pH, cation exchange capacity, organic matter, total nitrogen, total phosphorus, and total potassium) using Geographic Information Systems (GIS). Soil samples were collected on a grid method (300 m × 300 m) from three places in each grid at a depth of 0-15 cm. Global Positioning System (GPS) was used to determine the coordinates of sampling points. The collected samples were composited to 80 soil samples and analyzed. To compute the relationship between soil properties, simple linear correlation was performed using statistix 8th version. Finally, the relationship among the soil properties was shown by overlay mapping in Arc Map 10.5 with the spatial analytical function of ArcGIS software. The results revealed soil pH was significantly and negatively correlated with total nitrogen ($r = -0.412$), and significantly and positively correlated with total phosphorus ($r = 0.248$). Total potassium content was highly significant and positively correlated with soil moisture ($r = 0.782$). The relationships that are commonly found among soil properties are evident in this study with a positive correlation of soil organic matter and total nitrogen ($r = 0.058$), a negative correlation of bulk density with soil organic matter($r = -0.191$) and soil moisture ($r = -0.066$), a positive correlation of cation exchange capacity with total potassium ($r = 0.204$), and a negative correlation of cation exchange capacity with bulk density ($r = 0.018$), but these were not statistically significant. The observed information from this study can provide a clear understanding of the relationship among soil properties, which positively or negatively affect nutrient availability.

Keywords GIS, GPS, relationship among soil properties

INTRODUCTION

The overall productivity and sustainability of a given agricultural sector are functions of fertile soils and productive lands (Buol et al., 2003). Food productivity and environmental quality is dependent on the physical and chemical properties of soil, so it is very important to have a detailed knowledge of properties of soil (Tale and Ingole, 2015).

The productive capacity of Myanmar soils is an increasing concern. Many years of poor agriculture and land management practices has led to serious land degradation. As elsewhere, the agricultural sector's performance in Myanmar is highly dependent upon soil quality (IFDC, 2018). Soil quality is controlled by the physical, chemical and biological properties of soil and their interaction (Papendick and Parr, 1992). Therefore, it is important to maintain soil health for food security and to allow for increasing agricultural production. An understanding of physical and chemical conditions of any soil is essential for the proper implementation of other management practices (Tale and Ingole, 2015). Most physical and some chemical characteristics of soils allow a ranking, indicating whether an area has a high potential for agricultural production (Lelago and Buraka, 2019).Therefore a physico-chemical study of soil is very important because both these properties affect soil productivity (Tale and Ingole, 2015).

OBJECTIVE

The main objective of this research is to determine the relationship between different soil properties in the agricultural fields of the study area.

METHODOLOGY

Site Description and Soil Sampling

The study was conducted in agricultural fields of Kyee Inn Village, Pyinmana Township, situated in mid-Myanmar. The study covers a total area of 480 hectares, situated between 19°42'30"-19°43'40" N and 96°13'30"-19°15'30" E (Fig. 1). This area receives a mean annual rainfall of about 1420 mm and an average temperature of 26.8°C and monsoon rice and pulses are the main crops. Soil sampling was on a grid method (300 m × 300 m). There was a total 80 grid plots, and soil samples were collected from three places for each grid at 0-15cm depth using GPS to determine the coordinates of the sampling points. All samples were taken after the harvest of the previous crops and before the land preparation for the next season to ensure base line conditions for the analysis.

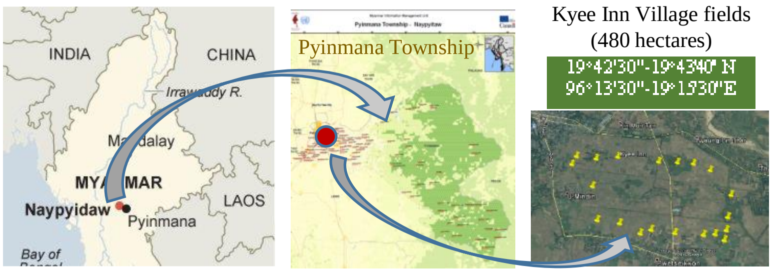

Fig. 1 Location of the study site

Laboratory Analysis

Table 1 Soil parameters and analytical methods adopted for laboratory analysis

	Soil Parameters	Unit	Analytical Methods
Physical	Bulk Density	g cm^{-3}	Core sampler method (Black, 1965)
	Soil Moisture	%	Gravimetric method (Black, 1965)
Chemical	Soil pH	-log $[H^+]$	1:5 (soil: water) pH meter (Hesse, 1971)
	Cation Exchange Capacity	meq100 g^{-1} soil	Bascomb's method (Bascomb, 1964)
	Organic Matter	%	Walkley and Black method (Walkley and Black, 1934)
	Total Nitrogen	%	Modified Kjeldahl Digestion method(Ohyma et al., 1991)
	Total Phosphorus	%	Molybdivanado phosphoric acid method (Spectrophotometer)
	Total Potassium	mg kg^{-1}	Atomic Absorption Spectrophotometer (AAS) (Flame)

The collected soil samples were composited for each grid. The samples were air-dried, ground, and sieved. The soils' pH levels, organic matter content, cation exchange capacity, bulk density, soil moisture, total content of nitrogen, phosphorus, and potassium were measured. Analysis was done at the laboratory of the Department of Soil and Water Science, Yezin Agricultural University. The analytical methods used for conducting this analysis are described in Table 1.

Statistical Analysis and Overlay Mapping

The laboratory results of all soil properties were subjected to correlation analyses to detect functional relationship among soil parameters using statistix (8^{th} version). Firstly, the interpolation maps were generated using an inverse distance weighting (IDW) method in ArcGIS software version 10.5 and then some of the more significant relationships among soil properties were able to be shown by overlay mapping.

RESULTS AND DISCUSSION

Correlation Matrix of Soil Properties

The correlation coefficient values of soil parameters viz; soil pH, cation exchange capacity, bulk density, soil moisture, soil organic matter, total content of nitrogen, phosphorus and potassium were determined for the surface soils (0-15 cm) and are presented in Table 2.

Table 2 Correlation between the different soil parameters under study

	pH	CEC	OM	TN	TP	TK	BD	SM
pH	1							
CEC	0.014	1						
OM	-0.025	0.035	1					
TN	-0.416**	0.145	0.058	1				
TP	0.242*	-0.036	-0.107	0.216	1			
TK	0.047	0.204	0.238*	0.045	-0.217	1		
BD	0.052	-0.018	-0.191	0.092	0.096	-0.161	1	
SM	-0.047	0.352**	0.162	0.182	-0.117	0.782**	-0.066	1

**Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level*
CEC: cation exchange capacity, OM: organic matter, TN: total nitrogen, TP: total phosphorus, TK: total potassium, BD: bulk density, SM: soil moisture

Relationships between Soil Parameters

In Fig. 2 (a), the correlation coefficient reveals soil pH shows a highly significant but negative correlation with total nitrogen content (r = -0.416). This suggests that pH accounts for about 16.96% of the total variability in total nitrogen. Similarly, with an increase in pH, total nitrogen decreases progressively and vice-versa. In addition to this, with an increase on soil pH by one unit, total nitrogen decreases by 0.098 unit and vice-versa. According to major crops growing in this area, pulses may take much cations and thus may cause lowering soil pH, but growing of pulses on every year may also lead to encourage total nitrogen content by fixing nitrogen of pulses.

Similar results were obtained by Singh and Mishra (2012). Similarly, Khadka et al. (2016) stated that total nitrogen content was significantly and negatively correlated with soil pH. Xue et al. (2013) also reported that the correlation between the soil nitrogen forms and soil pH was negative. However, a significant and positive correlation between soil pH and total nitrogen was obtained by Athokpam et al. (2013), and a non-significant relationship was obtained by Dhamak et al. (2014).

Figure 2 (b) illustrated that soil pH is significantly and positively correlated with total phosphorus (r = 0.242). For these parameters, the results are in harmony with the findings of Athokpam et al. (2013). But non-significant correlation between them was observed by Ogaard (1994).

According to the literature, soils with inherent pH values between 6 and 7.5 provide ideal conditions for phosphorus availability, while pH values below 5.5 and between 7.5 and 8.5 may limit phosphorus availability to plants due to fixation by aluminum, iron, or calcium. The observed pH values of this study ranged from 5.48 to 7.58, and therefore, the soil test phosphorus content would be expected to be significantly and positively correlated with this observed pH range.

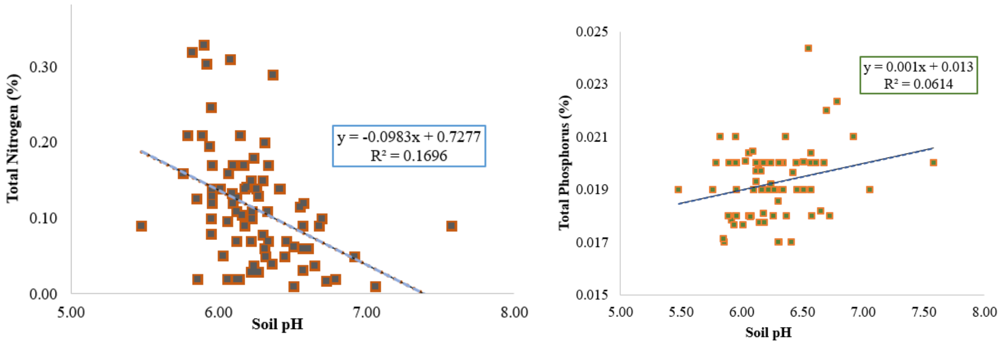

Fig. 2 Relationship between soil pH with (a) total nitrogen and (b) total phosphorus

The total potassium content is positively correlated with soil moisture, to a highly significant level, expressed in the correlation matrix of r = 0.782 (Fig. 3 (a)). The results were in conformity with those of Singh and Singh (2004), and Zeng and Brown (2000) who found a positive correlation between moisture content and potassium content in soils. Total potassium also shows a significant positive correlation with soil organic matter and a significant negative correlation with total phosphorus. In addition, it shows a non-significant positive correlation with soil pH, total nitrogen, cation exchange capacity, and a negative correlation with soil bulk density. This means that the total potassium content may increase with increases in pH, cation exchange capacity, soil organic matter, total nitrogen, and may decrease with increases in bulk density and total phosphorus and vice versa.

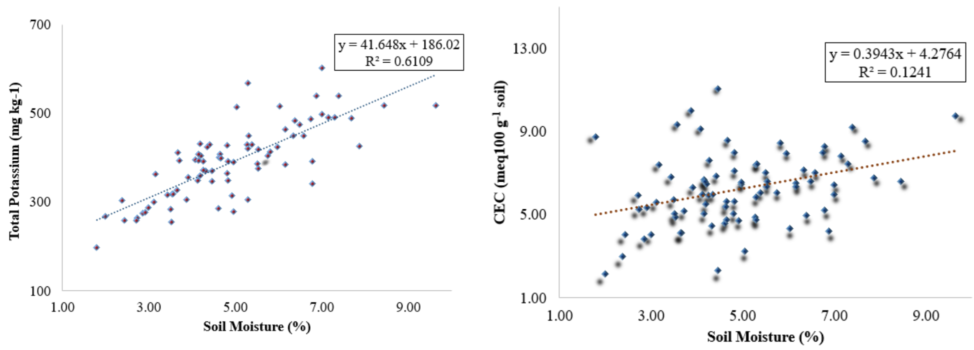

Fig. 3 Relationship between soil moisture with (a) total K and (b) CEC

The commonly found relationships between soil properties is also observed in non-significant correlations, such as the positive correlation of soil organic matter and total nitrogen (r = 0.058), the negative correlation of soil bulk density with soil organic matter(r = -0.191) and soil moisture (r = -0.066), and the positive correlation of the soil's cation exchange capacity with total potassium (r = 0.204) and the negative correlation of cation exchange capacity with bulk density (r = -0.018). A significant and positive correlation between cation exchange capacity and soil moisture content (r = 0.352) is also observed (Table 2 and Fig. 3 (b)). According to topographic position of this area, relatively higher soil moisture content was found on slightly lower elevation of southwest and also northeast portion as located nearby a small stream on this side. The cation exchange capacity and total potassium were obviously increased with high moisture content portions of this area.

The negative correlation between bulk density and soil moisture content suggests two possibilities that soil moisture content declines as bulk density increases due to less storage space or that soil moisture content is sufficient for the soil to resist compaction (Carter and Shaw, 2002). This is consistent with studies that have examined bulk density and soil moisture content (Hill and Sumner, 1967). Many researchers (Askin and Ozdemir, 2003; Morisada et al., 2004) obtained the relationship between organic matter and bulk density of soils all indicating a strong correlation between them. Bulk density tends to decrease as a soil's organic matter concentration increases (Curtis and Post, 1964).

Overlay Mapping of Significant Relationships of Soil Parameters

Figure 4 (a) and (b) display an overlay map showing significant relationships of soil pH with the total contents of nitrogen and phosphorus in the study area. It can be seen clearly that the areas with higher total nitrogen content correspond to areas largely occupied 'Moderately acidic' soil pHs in the study area and vice versa. The total phosphorus content, however, is positively distributed in all classes of soil pH of the study area. The overlay map of the significant positive relationships of soil moisture content with CEC and total potassium are shown in Fig. 5 (a) and (b). It is obvious that the variation of CEC and total potassium is positively coincidental with areas with a higher amount of soil moisture content.

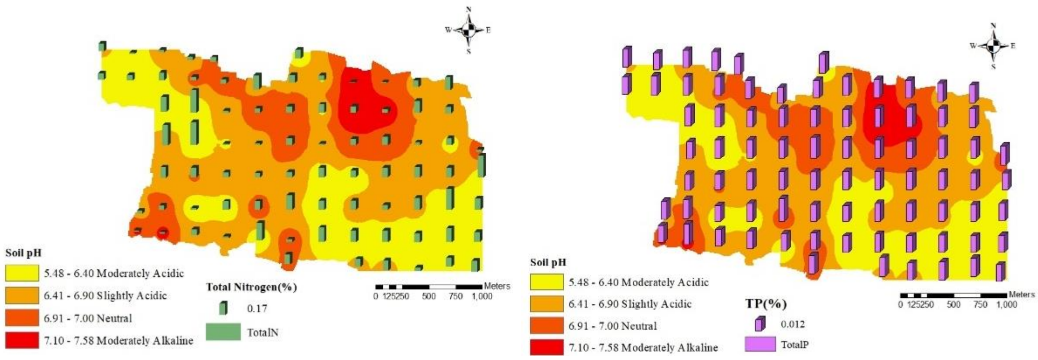

Fig. 4 Overlay maps of soil pH with (a) total N and (b) total P

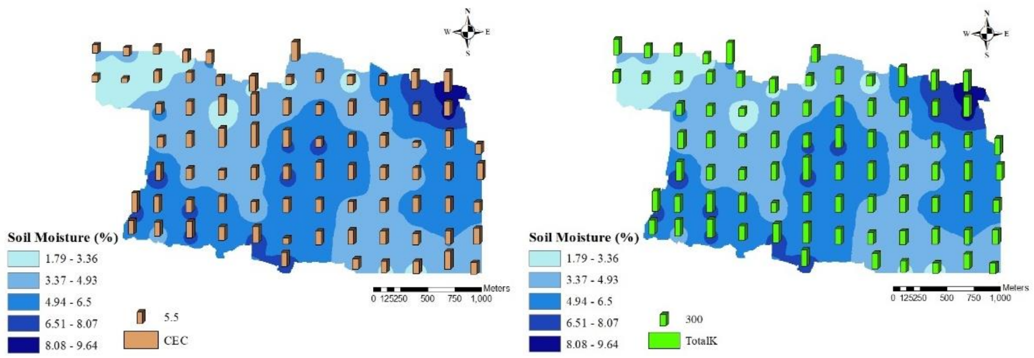

Fig. 5 Overlay maps of soil moisture with (a) CEC and (b) total K

CONCLUSION

Results from correlation analysis show that many of the soil parameters are interrelated with each other but often these relationships are non-significant. Since this study area occupies agricultural fields and thus some soil properties can be reflected by many practices of crops growing such as tillage systems, application of inputs, cropping patterns and so on. The results of this study have discussed and suggested with farmers as field day for proper implementation of their soil management practices. Finally, this study clearly illustrates that an understanding of soil properties and their inter-relationship, would prove to be useful for the development of an effective soil management plan allowing for efficient utilization of limited agricultural land resources.

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REFERENCES

Aşkin, T. and Özdemir, N. 2003. Soil bulk density as related to soil particle size distribution and organic matter content. Poljoprivreda / Agriculture, 9, 52-55.

Athokpam, H., Wani, S. H., Kamei, D., Athokpam, H. S., Nongmaithem, J., Kumar, D. and Devi, L. 2013. Soil macro-and micro-nutrient status of Senapati district, Manipur (India). African Journal of Agricultural Research, 8 (39), 4932-4936.

Bascomb, C.L. 1964. Rapid method for the determination of cation exchange capacity of calcareous and non calcareous soils. Journal of Science of Food and Agriculture, 15 (12), 821-823.

Boul, S.W., Southard, R. J., Graham, R.C. and McDaniel, P.A. 2003. Soil genesis and classification. 5th ed. Iowa State University Press. Ames, USA.

Buraka, T. and Lelago, A., 2016. Physico-chemical properties and agricultural potentials of soils of Tembaro Woreda, Kembata Tembaro Zone, Southern Ethiopia.

Carter, E.A. and Shaw, J.N. 2002. Correlations and spatial variability of soil physical properties in harvested Piedmont Forests. Paper presented at the Proceedings of the Sixth International Conference on Precision Agriculture, USA. ASA-CSSA-SSSA, 677, South Segoe Road: Madison, WI.

Curtis R.O. and Post, B.W. 1964. Estimating bulk density from organic matter content in some Vermont Forest soils. Soil Sci. Soc. Am. Proc., 28, 285-286.

Dhamak, A.L., Meshram, N.A. and Waikar, S.L. 2014. Identification of major soil nutritional constraints in Vertisol, Inceptisol and Entisol from Ambajogai Tahsil of Beed District. Journal of Research in Agriculture and Animal Science, 2 (10), 35-39.

Hesse, P.R. 1971. A textbook of soil chemical analysis. John Murray, London.

Hill, J.N.S. and Sumner, M.E. 1967. Effect of bulk density on moisture characteristics of soils. Soil Sci., 103, 234-238.

International Fertilizer Development Center. 2018. Soil fertility and fertilizer management strategy for Myanmar. Muscle Shoals, AL 35662, USA.

Khadka, D., Lamichhane, S. and Thapa, B. 2016. Assessment of relationship between soil pH and macronutrients, Western Nepal. Journal of Chemical, Biological and Physical Sciences, 6 (2), 303-311.

Lelago, A. and Buraka, T., 2019. Determination of physico-chemical properties and agricultural potentials of soils in Tembaro District, KembataTembaro Zone, Southern Ethiopia. Eurasian Journal of Soil Science, 8(2), 118-130.

Morisada, K., Ono, K. and Kanomata, H. 2004. Organic carbon stock in forest soils in Japan. Geoderma, 119, 21-32.

Ogaard, A.F. 1994. Relationships between the ratio of plant-available phosphorus (p-al) to total phosphorus and soil properties. Acta Agric. Scandinavica, Sect. B, Soil and Plant Science, 44, 136-141.

Ohyma, T., Ito, M., Kobayashi, K., Araki, S., Yasuyoshi, S., Sasaki, O. and Ikarashi, T. 1991. Analytical procedures of N, P, K contents in plant and manure materials using H_2SO_4-H_2O_2 Kjeldahl digestion method. Bull. Fac. Agric. Niigata Univ., 43, 111-120.

Papendick S.B. and Parr, J.F. 1992. Soil quality: Attributes and relationship to alternative and sustainable agriculture. American J. Alter. Agri, 7 (1-2), 2-3.

Sing, G. and Sing, B. 2004. Influence of soil water regime on nutrient mobility and uptake by Dalbergia sissoo seedlings. Tropical Ecology, 45 (2), 337-340.

Singh, R.P. and Mishra, S.K. 2012. Available macronutrients in the soils of Chiragaon block of district Vanarasi in relations to soil characteristics. Indian J. Sci., 3 (1), 97-100.

Tale, K.S. and Ingole, S. 2015. A review on role of physico-chemical properties in soil quality. Chem Sci. Rev. Lett. 2015, 4 (13), 57-66.

Walkley, A. and Black, I.A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci., 37 (1), 29-38.

Xue, Z., Cheng, M. and An, S. 2013. Soil nitrogen distributions for different land uses and landscape positions in a small watershed on Loess Plateau, China. Ecological Engineering, 60, 204-213.

Zeng, Q. and Brown, P.H. 2000. Soil potassium mobility and uptake by corn under differential soil moisture regimes. Plant and Soil, 221 (2), 121-134.