Research article

Assessment of Soil Properties using GIS Technologies in a Selected Area in Myanmar

HLA MOE KHAING*
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar
Email: hlamoekhaing45@gmail.com

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

SWE SWE MAR
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar

HTAY HTAY OO
Dept. of Agronomy, Yezin Agricultural University, Myanmar

Received 24 December 2020 Accepted 12 May 2021 (*Corresponding Author)

Abstract This study evaluates selected soil properties and maps these under different cropping patterns of Sipintharyar village, Zeyarthiri Township, Myanmar. A total of 130 soil samples were collected at a depth of 0-20 cm, with sample points selected using a Global Positioning System. Soil fertility maps were created using Kriging interpolation in ArcGIS software 10.5. Soil textures in the study area were loam, loamy sand, clay loam and sandy loam. The soils were strongly acidic to moderately alkaline and contained a very low status of soil organic matter (84%), available potassium (89%) while total nitrogen was at a medium (56.92%) level. The coefficient of variation (CV) showed that soil pH was the least variable (9.91%) parameter examined, with mean values ranging from 4.95 to 8.47, while available potassium was highly variable (86.95%) with content values ranging from 1 to 578 ppm. Other selected properties such as bulk density, total nitrogen, CN ratio, electrical conductivity and soil organic matter were found, respectively, to have the following variabilities; 11.68%, 33.84%, 34.86%, 72.23% and 52.07%. Levels of soil organic matter were highly significant, and positively correlated with total nitrogen and available potassium. These variations in soil properties are probably related to the different cropping patterns and fertility management practices employed in the study area.

Keywords soil properties, global positioning system, Arc GIS

INTRODUCTION

The agriculture sector in Myanmar accounted for 30% of gross domestic product, 60% of employment, 29% of value addition, and 23% of exports in 2016 (Agriculture Guide, Myanmar, 2018). Therefore, an evaluation of the fertility status of soils of an area is an important aspect in promoting sustainable agricultural production (Singh and Mishra, 2012). In Myanmar, the major soil fertility issues are understood only at the higher level with limited information at local levels. Soil fertility and productivity have a direct relationship in ensuring food security for the increasing world population. The optimum plant growth and crop yield might be influenced by not only the total amount of nutrients present in the soil at a particular time, but also on the availability of these, a process controlled by physicochemical properties (Bell and Dell, 2008). In addition, nutrient properties vary over time and space. Wakene and Heluf (2003) stated that the periodic evaluation of important soil properties and their responses to changes in land management is required to apply proper soil fertility management techniques, and to improve and conserve the fertility and productivity of soils. Additionally, the spatial variability of soil fertility and its classification can be mapped by applying GIS, to clearly show the specific locations where attention is required with respect to management of plant nutrients (Jatav et al., 2013). Currently, there is little information on the spatial variability of these soil fertility parameters and very few efforts in generating soil fertility maps for the agricultural soils in Myanmar. Furthermore, without detailed soil related information at a specific local level, sustainable crop production cannot be achieved. From this, understanding the spatial variability of soil fertility in specific agricultural fields is essential in optimizing the application of agricultural inputs and ensuring maximum crop yields in Myanmar.

OBJECTIVES

The main objective of this research is to evaluate the spatial variability of selected soil properties and to map soil fertility status under different cropping patterns in the study area.

METHODOLOGY

Study Area, Soil Sampling and Data Collection

Total study area is 0.6 km^2 and it is located at Sipintharyar village (19˚44'43" N - 19˚45'22" N and 96˚17'42" E - 96˚18'02" E), Kyidaung village Tract, Zeyarthiri Township, in central Myanmar (Fig. 1). It receives a mean annual rainfall of about 1265 mm and has an average temperature of 26.8°C.

The grid map preparation was created using ArcGIS (Ver.10.5) software for the collection of soil samples, in March 2020. The soil samples were collected after harvesting of crops and during the cultivation of horticultural crops, with samples from 300 m × 300 m grid points for determining soil texture, and 75 m × 75 m for the other soil parameters, and at 0-20 cm depth by using auger and hand-hoe from the selected points (Fig. 2). Ten soil samples were taken from each grid to form a composite a representative sample, with a 130 soil samples in total. After labelling and packing, samples were tested at the laboratory of the department of Soil and Water Sciences, Yezin Agricultural University, Myanmar. After air drying, the samples were gently crushed, sieved (2 mm) and properly stored for analysis. Furthermore, interviews were conducted with farmers using structured questionnaires to identify variations in management practices. Sixty farmers were selected as sample respondents and interviewed. The data collected related to method of land preparation, fertilizer management and the cropping patterns practiced by the respondents in the study area.

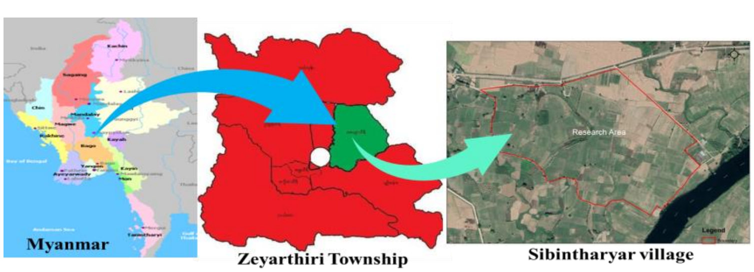

Fig. 1 Loation of study area

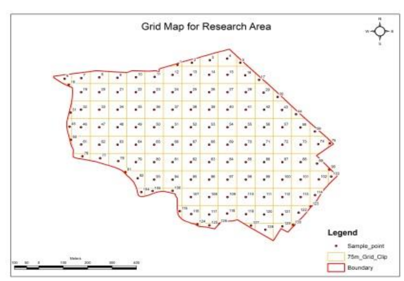

Fig. 2 Soil sampling grid points

Laboratory Analysis

The composited soil samples were analyzed to determine soil texture, adopting a pipetted method (Ryan et al., 2001), with bulk density determined by gravimetric method. Soil pH and electrical conductivity were measured in an extract, with a soil: water (1:5) suspension, using a digital pH-meter and EC meter (Hesse, 1971). Total nitrogen was determined by the Modified Kjeldahl Digestion method (Ohyma et al., 1991). Heanes (Rayment and Lyons, 2011) wet digestion method was used to determine soil organic matter and available potassium was determined by Atomic Absorption Spectrophotometer.

Statistical Analysis and Soil Fertility Mapping

The soil results were analyzed by using statistix (8^{th} version). The coefficient of variation (CV) was also determined to measure nutrient variability according to Ogunkunle (1993), where, soil properties having a CV between 0 and 15% are considered least variable, those with 15 and 35%, moderately variable, and larger than 35%, highly variable. These results were used to create soil fertility maps. The soils were classified into different categories of fertility i.e., very low, low, medium, high, and very high on the basis of the measured soil parameters. Nutrient index was also calculated by Ramamoorthy and Bajaj (1969).

RESULTS AND DISCUSSION

Spatial Distribution in Soil Properties

The results of the descriptive statistics of soil samples are presented in Table 1. There is a large variation in soil properties in the study area. Electrical conductivity shows the highest variability with 72.23% CV, followed by soil organic matter, with a CV value of 52.07%. However, least variability across sample areas was found for bulk density and soil pH, with CV values of 11.68%and 9.91%respectively. Moderate variability occurred for the CN ratio and total nitrogen, which have CV values of 34.86% and 33.84%, respectively.

Table 1 Descriptive statistics of soil physicochemical parameters

Variables	Unit*	Minimum	Maximum	Mean	SD	CV%
Sand	%	24.44	78.80	56.38	18.04	31.99
Silt	%	7.72	33.36	17.04	8.23	48.29
Clay	%	13.06	42.20	26.58	11.04	41.53
Bulk Density	g cm^{-3}	0.80	1.51	1.21	0.14	11.68
pH	-	4.95	8.47	6.94	0.69	9.91
Electrical Conductivity	dS m^{-1}	0.03	0.72	0.17	0.12	72.23
Organic Matter	%	0.31	3.55	1.41	0.73	52.07
Total Nitrogen	%	0.11	0.39	0.23	0.08	33.84
Available Potassium	ppm	1.00	578.00	87.08	75.72	86.95
Carbon : Nitrogen (CN ratio)	-	1.19	7.85	3.43	1.20	34.86

SD: Standard Deviation, CV: Coefficient of Variation;
** Units represent for the columns of minimum, maximum and mean in the table*

Soil Texture and Bulk Density (BD)

Sandy loam was the dominant soil textural class throughout the study area (Fig. 3), indicating a similarity in soil forming processes and parent materials. According to USDA soil texture classification system, six points in a 12 point of soils describes a sandy loam (58.33%) textural class; whereas two points describe clay loam (16.67%) and loam (16.67%) and one point represents loamy sand (8.33%), respectively. The spread of BD values ranged from 0.8 to 1.51 g cm^{-3}, with a mean value of 1.21 g cm^{-3}. From the survey, all farmers use machine, animal and manpower from the land preparation to the harvesting process, for crop production and grow the different cropping patterns in every year.

Soil pH and Electrical Conductivity (EC)

The pH values of the soil samples ranged from strongly acidic to moderately alkaline, (4.95 to 8.47) with a mean value of 6.94. The spatial distribution map of soil pH is presented in Fig. 5 and the pH can be seen as mostly neutral (47.69%), strongly alkaline (1.54%), moderately alkaline (26.92%), slightly acidic (13.85%), moderately acidic (9.23%) with only 0.77 % strongly acidic. Gazey and Davies (2009) indicated that the pH values between 5.5 and 8.0 are considered as ideal for plant growth.

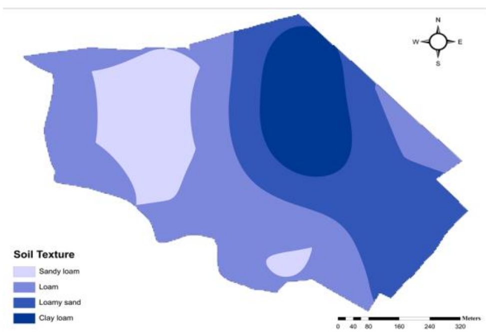

Fig. 3 Spatial variability of soil texture

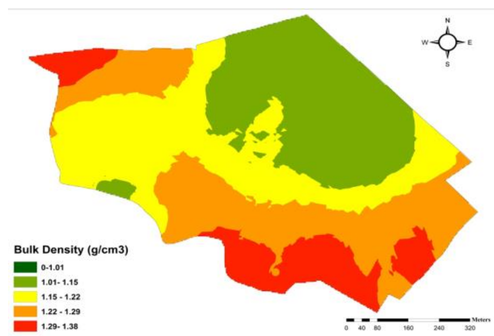

Fig. 4 Spatial variability of soil bulk density

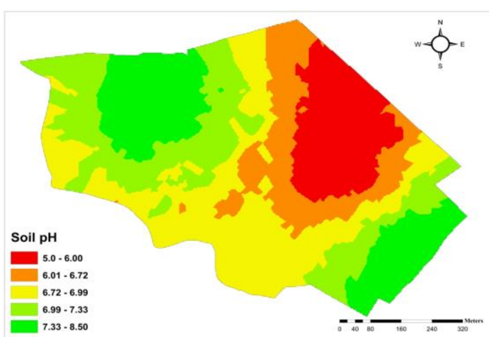

Fig. 5 Spatial variability of Soil pH

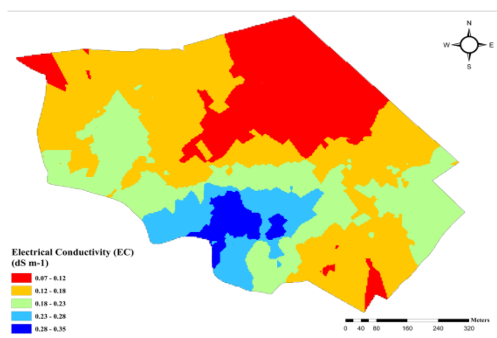

Fig. 6 Spatial variability of EC

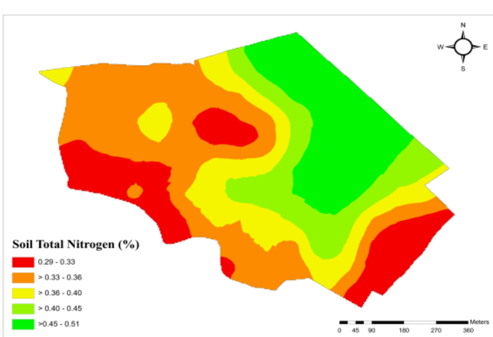

Fig. 7 Spatial variability of total N

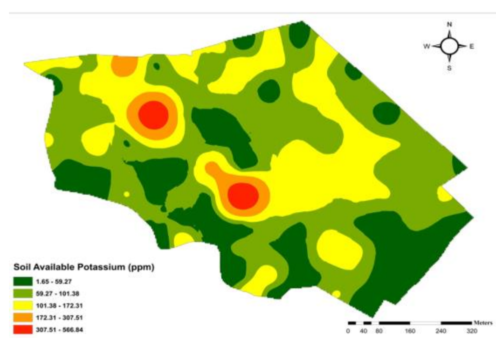

Fig. 8 Spatial variability of available K

Therefore, the observed pH values are suitable for different crops and the availability of most of plant nutrients should not be subject to restrictions within the observed pH range. The values of EC range from 0.03 to 0.72 dS m^{-1} with an average of 0.011 dS m^{-1} (Fig. 6). According to the Soil Guide (Moore, 2001), these EC values are situated between a low EC value (0.03 – 0.47 dS m^{-1}; 96.92%) and a medium level (0.52 – 0.72 dS m^{-1}; 3.77%), which would have no effect on plant growth.

Total Nitrogen (TN) and Available Potassium (AK)

Variation in the TN content of the soil samples ranged from 0.11% to 0.39%, with a mean value of 0.23%. The study confirms that about 20.77% of the sampled area has low levels of TN, while 56.92% has medium levels and 22.31% of the sampled area has high levels (Fig. 7). The areas of medium to high (79.23%) levels of TN would probably be as a result of the addition of nitrogen fertilizer and the intercropping with legumes. The AK levels appears to be low, with 89% of the sampled area being in the lower range, whereas 9% and 2% of the samples showed medium and high levels (Fig. 8), respectively. The low levels of AK may be due to infrequent application of potassium fertilizers in their cultivation, and this only through the use of compound fertilizers.

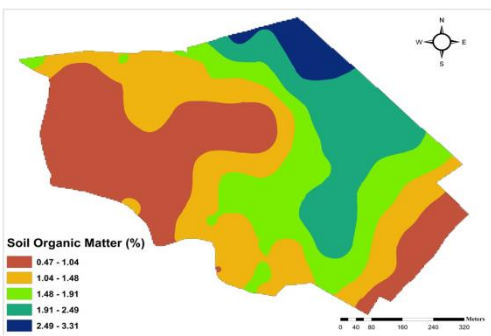

Fig. 9 Spatial variability of SOM

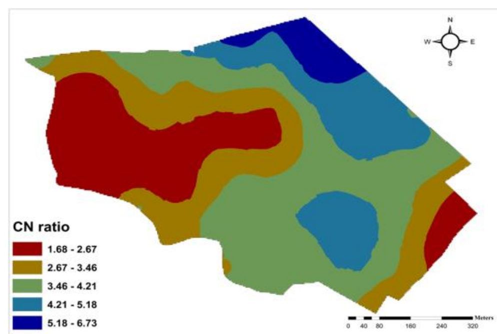

Fig. 10 Spatial variability of CN ratio

Soil Organic Matter (SOM) and Carbon : Nitrogen (CN Ratio)

The spatial distribution of SOM is displayed in Fig. 9. The SOM content of soil ranges from 0.31% to 3.55% with a mean value of 1.41%. Most (84%) of the study area has very low levels of SOM. Based on the survey data, this may be as a result of the complete removal of crop residues, the failure to add organic manures and the burning of crop residues after harvesting. This finding is in line with Alemayehu, K. and Sheleme, B. (2013) who report that SOM recorded in cultivated fields as being lower than for other land uses because of the effect of continuous cultivation and SOM oxidation. There is a very low spatial variation of CN ratio throughout the study area, with ratios ranging from 1.19 to 7.85, and with a mean value of 3.43 (Fig. 10).

Nutrient Index Value (NIV) and the Relationship among Soil Parameters

NIV of the SOM, CN ratio and AK content for the studied area clearly reveals these parameters are at low levels, while soil TN was at a medium level. The ranking of nutrients according to NIV is total N > available K > Soil organic matter > CN ratio. According to the results, TN content was highly significant and positively correlated with SOM and AK at a 1% confidence interval level, and CN ratio at a 5% level, and SOM also shows a highly significant positive correlation with AK and the CN ratio (Table 2).

Table 2 Correlation among the different soil parameters

	BD	*pH*	*EC*	*TN*	*SOM*	*C:N*
pH	0.255 **					
EC	0.225**	-0.029 ns				
TN	-0.437**	-0.490**	0.018 ns			
SOM	-0.333**	-0.399**	-0.081 ns	0.791**		
C:N	-0.034 ns	-0.095 ns	-0.093 ns	0.212*	0.730**	
K	-0.119 ns	0.003 ns	0.053 ns	0.431**	0.302**	0.059 ns

**Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level*
(EC: electrical conductivity, BD: bulk density, SOM: soil organic matter, TN: total nitrogen, C:N: carbon nitrogen ratio, K: Available potassium)

Crop Patterns and Soil Fertility Management Practices

The most common cropping patterns in the study area are rice-black gram, rice-fallow, maize-tomato, maize- tomato and lablab bean intercropping, okra-tomato and okra-Japanese mustard-onion. Moreover, some farmers grow mango, guava, banana and ambarella. Almost all farmers, except rice growers, practice mixed cropping, crop rotation and intercropping systems for fertility management. According to the survey data, 78% of farmers have no knowledge about the soil fertility testing or analysis, whereas the remaining 22% know about this but cannot afford the cost of analysis. The most common types of inorganic fertilizers used by the respondents were urea, foliar and NPK compound fertilizers.

CONCLUSION

The ranges of soil pH and EC measured should not be detrimental to crop cultivation. However, the distribution of soil TN percentage are 50% of the study area at medium, 25% low and 25% at high levels, whereas most of the levels for SOM, CN ratio and AK are at low levels. The study also shows that NIV of TN and SOM are only at medium levels, while that of CN ratio and AK are at low levels. Based on the survey results, farmers in the study area, in their crop management practice, use nitrogen (urea) fertilizer regularly, but without applying potassium fertilizer, apart from manure and NPK compound. The spatial variability in soil properties appear to be largely due to the differences in crop management practices, diverse cropping patterns and the variety of chemical fertilizers available. Therefore, these soil fertility maps may greatly assist farmers in identifying nutrient levels for the specific areas they crop and so help them to improve their crop fertility management programs, leading to an increase in productivity and higher incomes.

ACKNOWLEDGEMENTS

I would like to gratefully acknowledge the JICA-TCP, Japan International Cooperation Agency, through its Capacity Development program at Yezin Agricultural University, for providing the research grant. My thanks also go to the supervisory committee, Staff at DOA, and to the farmers in the study area who have provided technical and manual support through their participation in the study.

REFERENCES

Alemayehu, K. and Sheleme, B. 2013. Effect of different land use systems on selected soil properties in south Ethiopia. Journal of Soil Science and Environmental Management, 4 (5), 100-107.

Bell, R.W. and Dell, B. 2008. Micronutrients for sustainable food, feed, fibre and bioenergy groduction (1st ed.). IFA, Paris, France. Retrieved from https://www.fertilizer.org/

Gazey, C. and Davies, S. 2009. Soil acidity: A guide for WA farmers and consultants. Department of Agriculture and Food, Perth, Western Australia.

Hesse, P. 1971. A text book of soil chemical analysis. John Murray, London.

Jatav, M.K., Dua, V.K., Kumar, M., Trehan, S.P. and Kumar, S. 2013. Spatial distribution of soil available nutrients in the potato growing pockets of Hoshiarpur district of Punjab. Potato Journal, 40 (2), 128-134.

Moore, G.A. 2001. Soil guide: A handbook for understanding and managing agricultural soils. Department of Primary Industries and Regional Development, Bulletin 4343, Western Australia, Perth.

Ogunkunle, A.O. 1993. Variation of some soil properties along two top sequences on quartile schist and banded gnesis in southern Nigeria. Geoderma, 30 (4), 397-402.

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.

Ramamoorthy, B. and Bajaj, J.C. 1969. Available nitrogen, phosphorus and potassium status of Indian soils. Fertilizer News, 14, 25-36.

Rayment, G.E. and Lyons, D.J. 2011. Soil chemical methods - Australasia. CSIRO publishing, Collingwood, VIC, Australia.

Ryan, J., Estefan, G. and Rashid, A. 2001. Soil and plant analysis laboratory manual (2nd ed.). International Center for Agricultural Research in the Dry Areas (ICARDA), Syria and National Agricultural Research Center, Pakistan.

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.

The European Chamber of Commerce in Myanmar. 2018. Agriculture guide 2018. Myanmar.

Wakene, N. and Heluf, G. 2003. Forms of phosphorus and status of available nutrients under different land use systems of Alfisols in Bako area, Ethiopia. Ethiopian Journal of Natural Resources, 5 (1), 17-37.