Original Research Article

Assessment of Soil Chemical Properties Under Different Land Use Systems in Department of Agricultural Research

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Abstract

Assessment of soil chemical properties is valuable for agricultural production. A study of soil chemical properties under different land use systems was carried out to assess the chemical properties of soil under different land use systems in Department of Agricultural Research (DAR) for better soil management decisions and the improvement of yield production. The study area was carried out in the field of DAR, which is located at Zayar Thiri Township, Nay Pyi Taw in Myanmar. A total of 235 soil samples were collected by using Global Positioning System (GPS) at the grid point of 50 m × 50 m with a depth of 0-20 cm. The area of the research field size was about 52 ha. The land use systems selected for study area of Hybrid Rice Research Section (Rice), Other Cereal Crops Research Section (Maize and rice), Food Legume Research Section (Pulses and rice) and Plant Pathology Research Section (Rice) were about 10.4 ha, 24.3 ha, 12.1 ha and 4.7 ha respectively. Soil pH varied from 5.37 to 6.15, electrical conductivity varied from 0.05 to 0.07 dS m^{-1} and CEC varied from 4.81 to 5.88 cmol kg^{-1}. Soil organic matter (SOM) content ranged from 1.44 to 1.86%. Soil total nitrogen content varied from 0.10 to 0.16%, available soil phosphorus from 9.52 to 16.79 mg kg^{-1} and available soil potassium from 65.06 to 85.16 mg kg^{-1}. From this investigation it is concluded that soil total nitrogen, SOM, CEC and soil available potassium were low conditions in different land use systems in DAR soils. Because of lowering the soil chemical properties, adopting incorporated soil fertility management, and applying organic fertilizer may preserve the existing conditions and enhance soil properties.

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Keywords: soil chemical properties, land use systems, DAR

1. INTRODUCTION

Soil chemical properties play a crucial role in determining the fertility, productivity, and overall health of an ecosystem. Understanding these properties is essential for effective soil management, particularly in agricultural landscapes where soil quality directly influences crop yields. Fertility and quality of soil also depend upon the cropping system and farming practices, which affect the soil fertility, crop quality and yield production (Jin et al., 2011) Constant tillage in soil and the use of diverse agro-chemicals has severe effects on soil biodiversity and its habitats (Begum et al., 2013).

Soil property is affected by biotic, climatic and topographic factors and these factors often cause heterogeneity in soil properties at the spatial and temporal scales (Yavitt et al., 2009). The spatial distribution of soil fertility varies from the field to larger regional scales and is influenced by both land-use types and soil management practices (Liu, Wu & Cao 2022). It is crucial for improving sustainable land-use strategies to reveal the spatial variability of soil fertility and its influencing factors. In different land use systems, the main variables affecting soil fertility, crop quality are variations in fertilizer application, cropping systems, and farming techniques.

Department of Agricultural Research (DAR) is Zayar Thiri Township, Nay Pyi Taw in Myanma. The total area of DAR is approximately 283 ha, about 202 ha is used for agriculture. The study area of the research field is about 47 ha. Rice, maize and pulses are cultivated as the main crops in the study area of DAR. The main factors affecting soil fertility are farming techniques, cropping systems and cultivation patterns (Wezel, Steinmüller & Friederichsen 2002). In addition, continuous cropping are doing in DAR. Soil management requires particularly integrated practices that can increase soil fertility and nutrients. DAR has facing difficulties, like a lack of organic manure application, intensive cultivation, and declining soil fertility, which has resulted in low yield production. Therefore, this study aimed to assess the chemical properties of soil under different land use systems in DAR for better soil management decisions and the improvement of yield production.

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2. MATERIAL AND METHODS

2.1 Study area and soil sampling

The study area was carried out in the field of Department of Agricultural Research (DAR), which is located at Zayar Thiri Township, Nay Pyi Taw in Myanmar, and is situated between 19°49'50'' - 19°50'5''N (Latitude), 96°15'40'' - 19°15'55''E (Longitude) (Figure 1). It has an elevation ranging from 121.55m to 125.21m above sea level. The study area had an average temperature of 26.8°C and a mean annual rainfall of about 1420mm. The area of the research field size was about 52ha. The soils sampling area of Hybrid Rice Research Section, Other Cereal Crops Research Section, Food Legume Research Section and Plant Pathology Research Section were about 10.4ha, 24.3ha, 12.1ha and 4.7ha respectively. The description of the selected land use systems and their land use management was given in

Table 1. A composite soil sample was randomly collected using auger from the topsoil (0-20 cm) in each selected area of DAR before tillage operations for the cultivation of next crops. The sampling procedure was done on a grid basis (50m x 50m), using GPS to determine the coordinate of the sampling points. In total, 235 soil samples were collected from the sampling plots.

Figure 1 Location of studied area

Table 1 Characteristics of each land use type in the selected area of DAR

Research section	Land use systems	No. of Sample	Historical land use management	Soil Texture
Hybrid Rice Research Section	Rice	40	Intensive tillage, fertilizer application and irrigation	Sandy loam, sandy clay loam and loamy sand
Food Legume Research Section	Pulses, rice	71	Intensive tillage, fertilizer application and irrigation	Sandy loam, sandy clay loam and loamy sand
Other Cereal Crops Research Section	Maize, rice	103	Intensive tillage, fertilizer application and irrigation	Sandy loam, sandy clay loam and loamy sand
Plant Pathology Research Section	Rice	21	Intensive tillage, fertilizer application and irrigation	Sandy loam, sandy clay loam and loamy sand

2.2 Analysis of the Soils

Soil pH and the electrical conductivity (EC) of soils were determined using a soil: water ratio of 1:5 with the aid of SP 2000 Analyzer, Skalar. The Walkley and Black (1934) wet digestion method was used to determine soil carbon (OC) content and percent soil organic matter (SOM) was obtained by multiplying percent soil OC by a factor of 1.724. Total nitrogen was analyzed using the Kjeldahl distillation method. Olsen method was used for the available phosphorus extraction and read using a spectrophotometer (PD-303 UV) at 860 nm. Available potassium was determined by 1N ammonium acetate solution method by using atomic absorption spectrophotometer (AA-7000, Shimadzu). Cation exchange capacity

(CEC) was determined by 1N ammonium acetate extraction method using flame atomic absorption spectrophotometer.

2.3 Data Analysis

The soils chemical properties were subjected to descriptive statistics analysis by using Statistix (8th version). The coefficients of variation (CV) were grouped into three categories; these being, least variation (<15%), moderately variation (15-35%) and extremely variation (>35%) (Wilding, 1985).

3. RESULTS AND DISCUSSION

3.1 Soil pH

Results show that the lowest pH was found in Other Cereal Crops Research Section (5.37) and the highest in Plant Pathology Research Section (6.15) (Table 2). However, soil pH had the lowest coefficient of variation (CV) compared to other soil fertility parameters in different land uses, which represents the lowest degree of heterogeneity from collected soil samples. Soil pH values are rated by Horneck, Sullivan, Owen & Hart, 2011. Soil pH of Hybrid Rice Research Section (6.12), Food Legume Research Section (6.08), Other Cereal Crops Research Section (5.37) and Plant Pathology Research Section (6.15) were moderately acid to slightly acid conditions. The lower soil pH might be associated with the uptake of basic cation by the tree roots that enhances the accumulation of Al^{3+} and H^+ (Molla Getnet & Mekonnen 2022). In addition, the low value of soil pH in the agricultural soils was due to poor managed cultivation. The pH value of the Other Cereal Crops Research Section was lower than that of other Sections. The inappropriate use of inorganic fertilizers in the fields and ongoing cultivation techniques may be to blame for the pH variations. The findings demonstrated that these Sections had higher exchangeable acidity contents due to intensive farming and the use of inorganic fertilizers.

Table 2 Selected soil parameters of different land use system in DAR

Land use system		pH	EC dS m^{-1}	Total N %	OM %	Available P mg kg^{-1}	Available K mg kg^{-1}	CEC $cmol_c$ kg^{-1}
Hybrid rice research section (Rice)	Mean	6.12	0.05	0.11	1.55	15.84	66.54	5.88
	Minium	4.82	0.02	0.05	0.84	4.00	14.60	2.55
	Maximum	7.53	0.15	0.20	2.65	27.91	248.00	12.82
	SD	0.60	0.03	0.04	0.43	4.25	45.78	1.92
	CV%	9.86	51.81	33.13	22.93	26.85	68.79	32.63

Food legume research section (Pulses, Rice)	Mean	6.08	0.07	0.16	1.86	14.70	81.69	5.59
	Minium	4.91	0.03	0.05	0.62	2.21	14.60	1.77
	Maximum	7.22	0.18	0.22	3.07	20.27	259.08	12.91
	SD	0.50	0.03	0.04	0.45	3.71	57.80	2.19
	CV%	8.25	43.30	32.27	29.08	25.27	70.76	39.11
Other cereal crops research section (Maize, Rice)	Mean	5.37	0.06	0.10	1.51	9.52	85.16	4.81
	Minium	4.82	0.02	0.05	0.33	1.95	11.39	2.09
	Maximum	7.33	0.15	0.18	2.85	27.61	316.87	10.39
	SD	0.50	0.02	0.03	0.59	4.66	54.02	1.94
	CV%	8.43	27.70	27.10	39.19	37.18	63.43	40.44
Plant pathology research section (Rice)	Mean	6.15	0.07	0.12	1.44	16.79	65.06	5.06
	Minium	5.29	0.04	0.08	0.85	10.61	9.95	2.19
	Maximum	7.12	0.09	0.19	2.02	23.18	212.15	9.11
	SD	0.45	0.02	0.04	0.31	3.23	54.98	2.08
	CV%	7.37	27.61	28.95	21.52	19.23	84.51	41.10
Average	Mean	6.08	0.06	0.11	1.59	14.96	74.61	5.34
	Minium	4.96	0.03	0.06	0.66	4.69	12.64	2.15
	Maximum	7.30	0.14	0.20	2.65	27.14	259.03	11.31
	SD	0.51	0.03	0.04	0.45	3.96	53.15	2.03
	CV%	8.48	37.61	30.36	28.18	27.13	71.87	38.32

3.2 Electrical Conductivity (EC)

Electrical conductivity of soil significantly differed under different land use systems. It ranged from 0.05 to 0.07 dS m^{-1} (Table 2). However, EC had extreme coefficient of variations (CV) in Hybrid Rice Research Section (51.81%), Food Legume Research Section (43.30%) and moderately CV% in Other Cereal Crops Research Section (27.70%), Plant Pathology Research Section (27.61%). The coefficient of variation (CV) in soil electrical conductivity (EC) can vary due to several factors. Differences in soil texture (e.g., sandy vs. clayey soils) affect EC. Clay-rich soils tend to have better electrical conductivity due to their larger surface area and water retention capacity. Soils with varying organic matter content exhibit different EC values. Organic matter influences soil structure and water retention, impacting EC variability (Agbenin, 2003).

3.3 Soil Total Nitrogen

The mean soil total nitrogen ranged from low (0.10%) in Other Cereal Crops Research Section to medium (0.16%) in Food Legume Research Section (Table 2). Soil total nitrogen rated by Ethiosis, 2014. The high soil total nitrogen in Food Legume Research Section may associate with the legumes enhance soil nitrogen by fixing atmospheric nitrogen, facilitating residue decomposition, and promoting symbiosis with nitrogen-fixing bacteria. The results showed that the Food Legume Research Section had a higher level of soil total nitrogen than that of other Sections. As legume plants grow, their above-ground residues, roots, and nodules gradually decompose. Soil microorganisms break down the nitrogen-rich organic material, releasing nitrogen into the soil. This decomposition contributes to soil-building organic matter and increases soil nitrogen content (Wang, Fu, Qiu & Chen, 2001).

3.4 Soil Organic Matter (SOM)

Soil organic matter content significantly differed under different land use systems and varied from 1.44% to 1.86% (Table 2). Rating of SOM referred to Ethiosis, 2014. SOM variability was higher in Food Legume Research Section (1.86 %), which may be due to legumes contribute to high soil organic matter content through their unique ability to fix atmospheric nitrogen. In addition, the high productivity and leguminous properties of pulses plantations may link to the recovery of soil nutrients and the speeding up of nutrient cycling in soils. However, the lower OM from rice and maize soils could be the removal of crop residues for energy and animal feed and soil disturbances during plowing and harvesting that expose the soils. In long-term rice and maize cultivation, SOM degradation may occur due to a tighter relationship between organic matter and clay particles. Additionally, lower air content (reduced aeration) can lead to lower mineralization intensity, affecting SOM levels. Another reason was that the low SOM could be due to the tillage mixes oxygen into the soil and raises its average temperature, thereby contributing to an increased rate of organic matter decay.

3.5 Available Phosphorus

The available phosphorus content in soil varied significantly under different land use systems and varied from 9.52 mg kg^{-1} to 16.79 mg kg^{-1} (Table 2). Rating of soil available phosphorus by Olsen method referred to the soil test interpretation guide of Oregon State University. The highest value of available soil phosphorus was recorded in Plant Pathology Research Section (16.79 mg kg^{-1}) followed by Hybrid Rice Research Section (15.84 mg kg^{-1}). The lowest value of available soil phosphorus was found in Other Cereal Crops Research Section (9.52 mg kg^{-1}). Availability of phosphorus in cultivated soil strongly depends on soil pH. Hence, very low P in Other Cereal Crops Research Section might be due to low pH. The soil pH in Other Cereal Crops Research Section (5.37) was lower than 5.5, a favorable condition in which phosphorus is fixed in the soil as aluminum phosphate ($AlPO_4$) and becomes unavailable (Thomason 2002). The medium values of phosphorus in the other sections may be due to greater pH and the residual effect of external chemical fertilizers, since only 20% to 50% of the phosphorus applied is absorbed by crops during the growing season and unused phosphorus is retained in the soils, ultimately increasing the soil available phosphorus concentration (Richardson et al., 2009).

3.6 Available Potassium

The effect of land use systems on available potassium is shown in Table 2. Available potassium had the highest coefficient of variation (CV) compared to other soil fertility parameters in different land use which represents the highest degree of heterogeneity from collected soil samples. Rating of soil available potassium referred to Hazelton & Murphy, 2007. The highest (85.16 mg kg^{-1}) amount of potassium was found in the Other Cereal Crops Research Section and the lowest (65.06 mg kg^{-1}) in Plant Pathology Research Section. Under different land use systems soil can be classified with a low rating for available potassium content. The low level of potassium in the lowland farm might be due to higher leaching loss and more K harvest from soils. Under irrigated conditions, potassium is subjected to considerable leaching loss. In the lowland farm, cereal crops are harvested along with the whole plant and little residue is left on the soil surface (Harter 2007).

3.7 Cation Exchange Capacity (CEC)

The CEC values of the soil samples did not differ under different land use systems (Table 2). CEC values were in the range of 4.81 $cmol_c$ kg^{-1} in Other Cereal Crops Research Section to 5.88 cmol kg^{-1} in Hybrid Rice Research Section. CEC values are rated by Hazelton & Murphy, 2007. The observed CEC values were relatively low in whole study areas possibly due to some factors such as low pH level (acidic soil), low soil organic matter level, and high sandy soil content. The lower the CEC of soil, the faster the soil pH will decrease with time. Soils with low CEC are more likely to be deficient in potassium (K^+), magnesium (Mg^{2+}), and other cations while high CEC soils are less likely to be leached out from these cations. There are two practical ways to increase soil CEC. If the soil is highly acidic, use lime to raise the pH as far as the range pH required for crops. One of the benefits of liming or lime application in acidic soils is to increase the CEC of the soil. Otherwise, adding organic matter is the most effective way to improve soil CEC (Magdoff & Van Es, 2000).

4. CONCLUSION

The results concluded that different land use systems of DAR soils were moderately acid and slightly acid. The study area was non-saline conditions. Soil total nitrogen was

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REFERENCES

Agbenin, J. O. (2003). Soil saturation extract composition and sulfate solubility in a tropical semiarid soil. *Soil Science Society of America Journal, 67*(4), 1133- 1139.

Begum, F., Bajracharya, R. M., Sitaula, B. K., & Sharma, S. (2013). Seasonal dynamics, slope aspect and land use effects on soil mesofauna density in the mid-hills of Nepal. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *9*(4), 290-297.

Ethiosis (2014). Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia. *Ethio SIS, Addis Ababa*.

Harter, R. D. (2007). Acid soils of the tropics. *ECHO Technical Note, ECHO*, *11*.

Hazelton, P. A. & Murphy, B.W. (2007). *Interpreting soil test results: What do all the numbers mean?* Melbourne: CSIRO Publishing.

Horneck, D. A., Sullivan, D. M., Owen, J. S., & Hart, J. M. (2011). Soil test interpretation guide.

Jin, J. W., Xu, Y. F., Ye, H. C., Shen, C. Y., & Huang, Y. F. (2011). Effect of land use and soil management practices on soil fertility quality in North China cities' urban fringe. *African Journal of Agricultural Research*, *6*(9), 2059-2065.

Li, Y., Liu, W., Feng, Q., Zhu, M., Yang, L., & Zhang, J. (2022). Effects of land use and land cover change on soil organic carbon storage in the Hexi regions, Northwest China. *Journal of Environmental Management*, *312*, 114911.

Liu, Y., Wu, K., & Cao, H. (2022). Land-use change and its driving factors in Henan province from 1995 to 2015. *Arabian Journal of Geosciences*, *15*(3), 247.

Magdoff, F., & Van Es, H. (2000). *Building soils for better crops* (Vol. 4). Beltsville: Sustainable Agriculture Network.

Molla, E., Getnet, K., & Mekonnen, M. (2022). Land use change and its effect on selected soil properties in the northwest highlands of Ethiopia. *Heliyon*, *8*(8).

Richardson, A. E., Barea, J. M., McNeill, A. M., & Prigent-Combaret, C. (2009). Acquisition of phosphorus and nitrogen in the rhizosphere and plant growth promotion by microorganisms.

Thomason, W. (2002). Understanding Phosphorus Behavior in Soils. *The Samuel Roberts Noble Foundation*.

Wang, J., Fu, B., Qiu, Y., & Chen, L. (2001). Soil nutrients in relation to land use and landscape position in the semi-arid small catchment on the loess plateau in China. *Journal of arid environments, 48*(4), 537-550.

Wezel, A., Steinmüller, N., & Friederichsen, J. R. (2002). Slope position effects on soil fertility and crop productivity and implications for soil conservation in upland northwest Vietnam. *Agriculture, Ecosystems & Environment*, *91*(1-3), 113-126.

Wilding, L. P. (1985). Spatial variability: its documentation, accommodation and implication to soil surveys.