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ASSESSMENT OF SOIL CHEMICAL PROPERTIES UNDER CULTIVATED SOILS IN SELECTED AREA OF DEPARTMENT OF AGRICULTURAL RESEARCH

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Abstract

Spatial variability of soil chemical properties is critical for improving crops productivity and sustainable farming techniques. This study was conducted to determine chemical properties of soils in selected area of Department of Agricultural Research (DAR). The study area was located at the field of Department of Agricultural Research, which is located at Zayar Thiri Township, Nay Pyi Taw in Myanmar. A total of 235 soil samples were collected in a systematic grid design using geographical positioning system (GPS). Each grid was specified with the distance of 50 m × 50 m. Variables measured were soil pH, Electrical conductivity (EC), organic matter, total nitrogen, available phosphorus, available potassium, exchangeable calcium, exchangeable magnesium, exchangeable sodium and cation exchange capacity (CEC). Among the statistical results, exchangeable Mg showed the highest variability and soil pH showed the least variability with a coefficient of variation (CV) 69.37% and 8.40% and the values ranged from 0.24 $cmol_c$ kg^{-1} to 6.83 $cmol_c$ kg^{-1} and 4.82 to 7.53, respectively. The electrical conductivity with an average of 0.059 dS m^{-1} was obtained. The spatial distribution of cation exchange capacity ranged from 1.86 $cmol_c$ kg^{-1} to 12.82 $cmol_c$ kg^{-1}. Low to high range of available phosphorus was observed between 1.95 mg kg^{-1} and 27.91 mg kg^{-1}. The available potassium content in the selected area of DAR soils ranged between 10 mg kg^{-1} to 317 mg kg^{-1}. Exchangeable calcium varied from 1.13 to 8.35 $cmol_c$ kg^{-1}. The soil exchangeable sodium values of the selected area of DAR soil samples varied from 0.05 $cmol_c$ kg^{-1} to 0.69 $cmol_c$ kg^{-1}. The pH of the soils was strongly acid to moderately alkaline and EC was non saline condition. The organic matter content found in the selected area varied from 0.33% to 20.85% and the variability of soil chemical properties existed largely due to the differences in management practices by the researchers, and therefore, the researchers should be encouraged to adopt organic matter improvement practices for improving the long-term storage of soil fertility

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level in crop production. The observed various spatial variability of soil properties that affected soil fertility would provide the information of effective management and decisions making for crop cultivation in Department of Agricultural Research.

Keywords: soil chemical properties, cultivated soils, DAR

1. Introduction

Intensive cultivation is generally characterized by application of large quantities of fertilizer, frequent irrigation, repeated tillage operations and limited crop rotation with short lived crops (Alliaume et al., 2013; Norris and Congreves, 2018). Owing to the characteristic of shallow root system, these crops obtain nutrients from a small volume of soil but remove higher amount of plant nutrients from the cropping field through biomass yield within a short period of time (Wijewardhana, 2000). These restless management practices and different unbalance inputs have created vulnerability to soil degradation in these systems. Hence, soil properties in cropping systems have been seriously changed in many parts of the world.

Some of the elements such as nitrogen (N), phosphorus (P) and potassium (K) are given more attention in Department of Agricultural Research (DAR) in evaluating soil fertility because of plants' urgent need for them and the common deficiency of these elements in most DAR soils. Similarly, soil organic matter, a key indicator of soil quality, is also considered an important and effective factor in soil productivity (Yadav et al., 2000). Soil organic matter influences the supply of nutrients like N and P for growing plants, their availability or otherwise could increase or decrease the crop yields (Singh and Sherma, 2000).

Soil fertility improvement in the agricultural sector plays an important role in the context of sustainable agricultural production. Several researches on soil chemical parameters have been conducted in DAR but information on the chemical properties of soils of DAR is limited. Therefore, knowing the variability in soil properties becomes imperative in Agricultural development. Hence this study is designed to determine chemical properties of soils in selected area of DAR.

2. Materials 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 2.1). It has an elevation ranging from 121.55 m to 125.21 m above sea level. The study area has an average temperature of 26.8°C and a mean annual rainfall of about 1420 mm. The area of the research field size is about 47 ha. The soils sampling area of Hybrid Rice Research Section, Other Cereal Crops Research Section and Food Legume Research Section were about 10.4 ha, 24.3 ha, and 12.1 ha respectively (Table 2.1). A composite soil sample was collected using auger from the topsoil (0-20 cm) in each randomly selected area of DAR before tillage operations for the cultivation of next crops. Sampling was done on a grid basis (50 m x 50 m), using GPS to determine the coordinate of the sampling points. In total, 235 soil samples were collected from the sampling plots.

Table 2.1 Area and soil samples distribution of selected land use site in DAR

Land Use Site	Area (ha)	No. of soil samples
Rice based rice	10.4	66
Rice based maize	24.3	90
Rice based legumes	12.1	79

Figure 2.1. Location of the studied area

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 content and percent soil OM was obtained by multiplying percent soil OC by a factor of 1.724. Total N was analyzed using the Kjeldahl distillation method. Olsen method was used for available P extraction and read using a spectrophotometer (PD-303 UV) at 860 nm. Available K was estimated by Neutral normal ammonium acetate extraction by using atomic absorption spectrophotometer (AA-7000, Shimadzu). Cation exchange capacity (CEC) was determined by 1N ammonium acetate extraction method and measured with flame atomic absorption spectrophotometer.

2.3 Data Analysis

The soils chemical properties were subjected to descriptive analysis by using Statistix (8th version).

3. Results and Discussion

3.1 Spatial Variation in Soil Chemical Properties

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). That is, the higher the CV the more variable the soil property measured. The results for each soil chemical parameters overall soil samples are presented in Table 3.1. In the selected area of DAR soils, there is a large variation in soil chemical properties. Exchangeable Mg showed the highest variability with 69.37% in its CV, followed by available K, exchangeable Ca, exchangeable Na and cation exchange capacity with CV values of 68.55%, 44.21%, 47.65% and 38.24% respectively. Least variability among soil samples was found in soil pH with CV value of 8.40%. Moderate variability occurred in soil electrical conductivity (EC), soil organic matter, available P and total nitrogen, which have CV values of 34.88%, 34.83%, 30.88% and 28.88% respectively.

Table 3.1 Distribution of soil chemical parameters

Variables	Unit	Minium	Maximum	Mean	SD	CV%
pH		4.82	7.53	6.02	0.51	8.40
EC	dS m^{-1}	0.021	0.150	0.059	0.02	34.88
Organic matter	%	0.33	2.85	1.62	0.56	34.83
Total nitrogen	%	0.05	0.20	0.11	0.03	28.88
Available phosphorus	mg kg^{-1}	1.95	27.91	14.14	4.37	30.88
Available potassium	mg kg^{-1}	10.00	317.00	79.15	54.26	68.55
Exchangeable calcium	$cmol_c$ kg^{-1}	1.13	8.35	3.46	1.53	44.21
Exchangeable magnesium	$cmol_c$ kg^{-1}	0.24	6.83	1.29	0.89	69.37
Exchangeable sodium	$cmol_c$ kg^{-1}	0.05	0.69	0.28	0.13	47.65
Cation exchange capacity	$cmol_c$ kg^{-1}	1.86	12.82	5.23	1.99	38.24

3.2 Soil pH

The pH values of the selected area of soil samples ranged from strongly acid to moderately alkaline with minimum pH value of 4.82 to maximum value of 7.53 and mean value of 6.02 (Table 3.1). Gazey & Davies (2009) stated that the pH value between 5.5 and 8.0 were considered as ideal for plant growth. Therefore, this study area was suitable for the cultivation of crops with the pH of the soil samples within the optimum value.

The spatial distribution of soil pH values were observed as mostly moderately acid (42.55%), slightly acid (40.00%), neutral (11.49%), strongly acid (5.53%) and only 0.43% moderately alkaline (Table 3.2). Some grid plots showed slightly acidic to moderately acidic in reaction probably due to some factors such as mineralogy of soil (i.e high iron content) and farmer's practice such as using acid-forming nitrogenous fertilizers for crop production every year. It was stated that most of the acidic soils were probably due to natural systems like mineralogy (soil containing high Fe, Al, etc.), climate (high annual average rainfall) and weathering, use of acid-forming nitrogen fertilizers, or removal of bases such as potassium, calcium, and magnesium (Rawal et al., 2018).

Table 3.2 Number of samples and percentage of total soil samples of measured pH values of soil samples in the selected area

pH	Category	No. of samples (% of total soil samples)
< 5.1	Strongly acid	13 (5.53)
5.2-6.0	Moderately acid	100 (42.55)
6.1-6.5	Slightly acid	94 (40)
6.6-7.3	Neutral	27 (11.49)
7.4-8.4	Moderately alkaline	1 (0.43)

3.3 Soil electrical conductivity (EC)

The values of EC of the selected area of soil samples ranged from 0.021 to 0.150 dS m^{-1} with an average of 0.059 dS m^{-1} (Table 3.1). All EC values of soil samples were noticeably lower than 0.15 dS m^{-1}. According to the soil guide (Moore, 2001); low EC levels (0.051 and 0.5 dS m^{-1}) can only have a minimal impact on plant growth. Therefore, the observed mean value of the selected area was not have a salinity problem for growing crops and it was suitable for agriculture.

Table 3.3 Number of samples and percentage of total soil samples of measured EC values of soil samples in the selected area

EC (dS/m)	Category	No. of samples (% of total soil samples)
< 0.15	Non-saline	235 (100)

3.4 Soil total nitrogen

The soil total nitrogen content of the selected area of soil samples ranged from 0.05% to 0.20% with a mean value of 0.11% (Table 3.1). The critical value of total nitrogen in soil is 0.12% (Shah et al., 2008). Overall results of the selected area of soil samples showed that the soil total nitrogen content was very low to medium range. The results indicated that about 42.98% of the soil samples were very low and 46.38% were low levels, while 10.64% of the soil samples were medium (Table 3.4). The low levels of total soil nitrogen in the selected area of DAR may be likely the low levels of soil organic matter, high nitrogen removal by crops and due to high temperature, which encourages faster decomposition and removable of organic matter leading to the shortage of soil nitrogen reserve.

Table 3.4 Number of samples and percentage of total soil samples of measured total nitrogen values of soil samples in the selected area

Total N %	Category	No. of samples (% of total soil samples)
< 0.1	Very low	101 (42.98)
0.1-0.15	Low	109 (46.38)
0.15-0.3	Medium	25 (10.64)

3.5 Soil organic matter (SOM)

The organic matter content found in the selected area varied from 0.33% (very low) to 2.85% (medium). About 2.55% of soils in the selected area had very low, 76.60% of soils had low and 20.85% of soils had medium (Table 3.5). The depletion of organic matter in the cultivated fields can be associated with intensive tillage and the removal of plant residue. Kiflu and Beyene (2013) who reported that soil organic matter recorded in cultivated fields as being lower than for other land uses because of the effect of continuous cultivation and soil organic matter oxidation. 20.85% of the selected area of soils had medium level of soil organic matter due to the incorporation of green manures and farmyard manures.

Table 3.5 Number of samples and percentage of total soil samples of measured soil organic matter values of soil samples in the selected area

Organic matter %	Category	No. of samples (% of total soil samples)
< 0.68	Very low	6 (2.55)
0.68-2.0	Low	180 (76.60)
2.0-3.0	Medium	49 (20.85)

3.6 Available phosphorus

The variations of available phosphorus were from 1.95 mg kg^{-1} to 27.91 mg kg^{-1}, a mean value of 14.14 mg kg^{-1} (Table 3.1). The spatial distribution of soil available phosphorus content of the sampling area was observed at a low level of 17.87% whereas 77.45% of medium level and 4.68% of high level (Table 3.6). Low to high status of soil available phosphorus in the selected area of DAR soils might be due to the variation of soil pH in the selected area and different vegetation. In addition to these factors, human activities such as fertilizer application can also affect the availability of phosphorus in soil.

Table 3.6 Number of samples and percentage of total soil samples of measured available phosphorus values of soil samples in the selected area

Available P mg kg^{-1}	Category	No. of samples (% of total soil samples)
< 10	Low	42 (17.87)
10-20	Medium	182 (77.45)
20-40	High	11 (4.68)

3.7 Available potassium

The available potassium content in the selected area of DAR soils ranged between 10 mg kg^{-1} to 317 mg kg^{-1} and with a mean value of 79.15 mg kg^{-1} (Table 3.1). About 88.94% of the soil samples were low in available potassium content and about 9.79% and 1.28% of the soil samples were medium and high category range, respectively (Table 3.7). The lowest available potassium in this study area might be due to the lowest soil organic matter and the continuous removal of potassium by cereal crops, as the field has been intensively cultivated for a long period (Table 2.1). The value of K was highly concentrated in some areas, whereas the higher organic carbon was observed in some areas of the study site.

Table 3.7 Number of samples and percentage of total soil samples of measured available potassium values of soil samples in the selected area

Available K mg kg^{-1}	Category	No. of samples (% of total soil samples)
< 150	Low	209 (88.94)
150-250	Medium	23 (9.79)
250-800	High	3 (1.28)

3.8 Exchangeable calcium

In the selected area of DAR soils, exchangeable calcium varied from 1.13 to 8.35 $cmol_c$ kg^{-1}, with a mean value of 3.46 $cmol_c$ kg^{-1} (Table 3.1). The spatial distribution of exchangeable Ca content of the selected area was observed at low level of 84.68% whereas 15.32% of medium was also observed (Table 3.8). Soil exchangeable calcium levels can vary due to a variety of factors, including soil type, pH and organic matter content. Low levels of soil exchangeable calcium can be caused by soil acidification, low soil organic matter, low soil pH and high cation exchange capacity (CEC). Medium levels of some areas were found in the selected area of DAR soils because optimum used of calcium rich fertilizers and high soil pH.

Table 3.8 Number of samples and percentage of total soil samples of measured exchangeable calcium values of soil samples in the selected area

Exchangeable Ca $cmol_c$ kg^{-1}	Category	No. of samples (% of total soil samples)
< 5	Low	199 (84.68)
5-10	Medium	36 (15.32)

3.9 Exchangeable magnesium

The spatial distribution of exchangeable magnesium in the selected area of DAR soils were ranged from 0.24 $cmol_c$ $kg^{-1}$to 6.83 $cmol_c$ kg^{-1}, with a mean value of 1.29 $cmol_c$ kg^{-1} (Table 3.1). The results of the selected area of DAR soils indicated that the exchangeable magnesium content was low to high. About 13.19% of the soil samples had low levels and 55.74% had medium levels, while 31.06% had high levels (Table 3.9). The amount of exchangeable magnesium in soil can vary due to the several factors. Soil pH is one of the most important factors that affect exchangeable magnesium levels. In acid soils, exchangeable magnesium levels are low, which can lead to magnesium deficiency in crops. Organic matter content and cation exchange capacity (CEC) also play a role in determining exchangeable magnesium levels. Organic matter content and CEC affect the ability of soil to retain magnesium, with higher organic matter content and CEC leading to higher exchangeable magnesium levels.

Table 3.9 Number of samples and percentage of total soil samples of measured exchangeable magnesium values of soil samples in the selected area

Exchangeable Mg $cmol_c\ kg^{-1}$	Category	No. of samples (% total soil samples)
< 0.5	Low	31 (13.19)
0.5-1.5	Medium	131 (55.74)
>1.5	High	73 (31.06)

3.10 Exchangeable sodium

The soil exchangeable sodium values of the selected area of DAR soil samples varied from 0.05 $cmol_c\ kg^{-1}$ to 0.69 $cmol_c\ kg^{-1}$ and a mean value of 0.28 $cmol_c\ kg^{-1}$ (Table 3.1). The spatial distribution of soil exchangeable sodium values of the selected area of soil samples were very low levels to medium levels. The spatial distribution of exchangeable sodium content of the sampling area was observed at very low level of 8.94% whereas 52.77% of low level and 38.30% of medium levels were observed (Table 3.10). Soil exchangeable sodium levels can vary due to organic matter content and CEC. Organic matter content and CEC affect the ability of soil to retain sodium, with higher organic matter content and CEC leading to lower exchangeable sodium levels.

Table 3.10 Number of samples and percentage of total soil samples of measured exchangeable sodium values of soil samples in the selected area

Exchangeable Na $cmol_c\ kg^{-1}$	Category	No. of samples (% total soil samples)
< 0.1	Very low	21 (8.94)
0.1-0.3	Low	124 (52.77)
0.3-0.7	Medium	90 (38.30)

3.11 Cation exchange capacity (CEC)

The spatial distribution of CEC in the selected area of DAR soils were ranged from 1.86 $cmol_c\ kg^{-1}$ to 12.82 $cmol_c\ kg^{-1}$, with a mean value of 5.23 $cmol_c\ kg^{-1}$ (Table 3.1). In the selected area of DAR soils, 68.09%, 31.49% and 0.43% of sampling grid plots were characterized as a very low, low and medium (Table 3.11). CEC of a soil is influenced by several factors, including the soil type, soil pH and soil organic matter. Soil texture is one of the most important factors that affects CEC. Soils with more clay and organic matter have a higher CEC, while soils with more sand have a lower CEC. Soil pH also plays a crucial role in determining the CEC of a soil. As the pH of the soil increases, the number of negative charges on the soil colloids increases, which increases the CEC. Soil organic matter content is another important factor that influences CEC. The negative charges on the surfaces of soil organic matter particles attract positively charged ions, such as calcium, magnesium and potassium, which are important plant nutrients. The more soil organic matter a soil has, the more negatively charged sites it has, and the more positively charged ions it can be hold.

Table 3.11 Number of samples and percentage of total soil samples of measured cation exchange capacity (CEC) values of soil samples in the selected area of DAR

CEC $cmol_c\ kg^{-1}$	Category	No. of samples (% total soil samples)
< 6	Very low	160 (68.09)
6-12	Low	74 (31.49)
12-25	Medium	1 (0.43)

4. Conclusion

The present study concluded that there was wide variation in soil chemical properties in the study area. The CV values of soil chemical properties of the study area observed a wide range of variation from 8.40% to 69.37%. In the whole study area, very low levels of percentage of total soil samples were observed 42.98% in soil total nitrogen, 2.55% in soil organic matter, 8.94% in exchangeable Na and 68.09% in CEC, whereas low levels of percentage of total soil samples were 46.38% in soil total N, 76.60% in SOM, 17.87% in soil available P, 88.94% in soil available K, 84.68% in exchangeable Ca, 13.19% in exchangeable Mg, 52.77% in exchangeable Na and 31.49% in soil CEC. However, the medium levels of percentage of total soil samples were observed 10.64% in soil total N, 20.85% in SOM, 77.45% in soil available P, 9.79% in available K, 15.32% in exchangeable Ca, 55.74% in exchangeable Mg, 38.30% in exchangeable Na and 0.43% in CEC, and high levels of percentage of total soil samples were 4.68% in soil available P, 1.28% in available K and 31.06% in exchangeable Mg of the studied area.

The pH value varies among the collected soil samples. But this is not restricted for plant growth and availability of plant nutrients. All soil samples from study area were revealed in 'non-saline' condition and the study area does not have a salinity problem. There were no problems in pH and EC in the study area. The soil OM content and CEC were low condition in most soils, therefore using of crop management practices such as organic manure and crop residue incorporation, reduced tillage, crop rotation, mulching, cover cropping etc. are prerequisite for the studied area.

Total N and available K were low and available P was medium condition, adequate supply of nitrogen and potassium is required for crops in the farm and the appropriate amount of phosphorus should be applied for the medium status of soil. Therefore, it is necessary to follow effective application of nutrients management for crops in the study area.

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