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MANAGEMENT AND SPATIAL DISTRIBUTION OF SOIL PROPERTIES OF AL-SWEIRA MODEL FARM IN WASIT GOVERNORATE

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ABSTRACT

This study was carried out on a model farm in Al-Sweira. The spatial distribution of physical and chemical soil characteristics and mapped using geostatistical method to ease the map exportation procedure in the geographic information system researches. Physical and chemical soil properties were measured. Distribution of soil particle sizes and some chemical characteristics (soil salinity, organic matter content, cation exchange capacity, carbonate mineral content, total nitrogen, above ground biomass), Clay content and Soil salinity showed high soil variation in comparison to other soil properties in the spatial distribution maps prepared using IDW method in ArcMap protocol, also, above ground biomass showed a relationship to land use where the more land used in agriculture, the highest biomass found in the upper horizon. Soil Organic Carbon and soil organic matter showed lower spatial variation due to the low component of them in soil. CEC has correlated to clay content distribution in the upper horizon of soil pedons, where it also showed high spatial variation in soil. Total nitrogen was measured and showed low and medium ranges of where spatial distribution explains the variability in this property. Using geotechniques is feasible to explain soil variability and spatial distribution of soil properties to explain soil forming factors and processes, hence, it is a suitable method to map soil properties and understand soil variability. Land suitability for grain crops was mapped for this farm, the most extensive suitability class was Class S3, moderate suitability.

Keywords: soil variability, geotechniques, soil properties, spatial distribution.

ادارة والتوزيع المكاني لخصائص التربة في مزرعة الصويرة النموذجية في محافظة واسط

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الخلاصة

أجريت هذه الدراسة في مزرعة نموذجية في منطقة الصويرة. التوزيع المكاني لخصائص التربة الفيزيائية والكيميائية ورسم خرائطها باستخدام الطريقة الجيوإحصائية لتسهيل إجراء تصدير الخرائط في أبحاث نظم المعلومات الجغرافية. تم قياس الخواص الفيزيائية والكيميائية للتربة. أظهر توزيع أحجام جزيئات التربة وبعض الخصائص الكيميائية

[*] **This article is taken from the first researcher's master's thesis.**

(ملوحة التربة، محتوى المادة العضوية، قدرة تبادل الكاتيونات، محتوى معادن الكربونات، النيتروجين الكلي، الكتلة الحيوية فوق سطح الأرض)، محتوى الطين وملوحة التربة تبايناً كبيراً في التربة مقارنة بخصائص التربة الأخرى في تم إعداد خرائط التوزيع المكاني باستخدام طريقة IDW في بروتوكول ArcMap، كما أظهرت الكتلة الحيوية فوق الأرض علاقة باستخدام الأراضي حيث كلما زادت مساحة الأراضي المستخدمة في الزراعة، وجدت أعلى كتلة حيوية في الأفق العلوي. أظهر الكربون العضوي في التربة والمواد العضوية في التربة تباينًا مكانيًا أقل بسبب انخفاض مكوناتهما في التربة. ارتبط CEC بتوزيع محتوى الطين في الأفق العلوي لبيدونات التربة، حيث أظهر أيضًا تباينًا مكانيًا كبيرًا في التربة. تم قياس النيتروجين الكلي وأظهر مستويات منخفضة ومتوسطة حيث يفسر التوزيع المكاني التباين في هذه الخاصية. يعد استخدام التقنيات الجيوتقنية ممكنًا لشرح تغايرات التربة والتوزيع المكاني لها لشرح عوامل وعمليات تكوين التربة، وبالتالي، فهي طريقة مناسبة لرسم خريطة لخصائص التربة وفهم تقلبات التربة. تم رسم خريطة لملاءمة الأرض لمحاصيل الحبوب لهذه المزرعة، وكانت فئة الملاءمة الأكثر شمولاً هي الفئة S3، الملاءمة المعتدلة.

الكلمات المفتاحية: التغايرات المكانية، التقانات الجيومكانية، صفات التربة، التوزيع المكاني.

INTRODUCTION

Soil is a dynamic natural body affected by environmental factors over time and space that affect the physical and chemical properties of the soil. To study the spatial variation of the physical and chemical properties of the soil in order to manage soil nutrients, the spatial variation of the soil properties was studied, including studying some physical properties such as the distribution of soil particle sizes (clay, silt, and sand) and some chemical characteristics such as soil salinity, organic matter, measurement of the exchange capacity of positive ions and other soil characteristics. The spatial variation in soil characteristics is formed due to some factors called soil formation factors besides some external factors represented by human activities (**Delbari *et al*., 2019**). The reason of these variation in the distribution of soil characteristics is also caused by the natural and human factors such as (fertilization, microbial activities, rainwater, and other factors), therefore, spatial variation in soil characteristics appears in response to climatic variations that affect the parent material, as it affects the characteristics and qualities of the soil, the depth of the horizons, its thickness, and its content of organic matter, and often the spatial variation of soil properties occurs in a series of soils resulting from the difference in terrain (**Alessandrino *et al*., 2022**). Studying the spatial distribution of soil characteristics and their influence on natural and human factors is of great importance. The description of the spatial diversification of soil characteristics based on site characteristics and their influence on climate, terrain, parent material, biological factors on soil formation, and spatial variation in soil characteristics (**Berti *et al*., 2017**) as well as physical, chemical, and biological processes affect the spatial distribution of soil characteristics (**Lmhof *et al*., 2000; &Wang *et al*., 2007**). Previous studies investigated the spatial distribution of soil characteristics and their relationship with environmental factors (**Liu *et al*., 2010**). The topographic factor is one of the important factors that affects the spatial distribution of soil characteristics. Therefore, the spatial distribution of soil characteristics and the relationship between soil components and environmental factors are complex concepts (**Yavitt *et al*., 2009; &Wijesinghe *et al*., 2005**). The main source of spatial variation in soil characteristics is soil forming factors, especially topography, and management practices (**Jankowski *et al*., 2011**).

Therefore, evaluating and studying the spatial distribution of physical and chemical soil characteristics is essential for good farm management practices and obtaining high productivity (**Gajda *et al*., 2016**; **Abdullatiff &Wheib, 2019)** assessed the soil organic carbon variability along toposequence in Erbil governorate northern Iraq, and they confirmed that organic carbon had a positive relationship with altitude and soil aspect while it was negative relationship with slope property of the toposequence. **Suliman,(2014)** has studied the spatial variability of physicochemical properties in Mesopotamian plain of the area extended between Tigris and Euphrates using time series, and found that autocorrelation of soil properties has ranges between 0.188-0.488 where the lowest values of autocorrelation was related to the distance of 250 m of sand, ECe, Carbonate minerals, and ESP, while the highest values of autocorrelation was at 10000 , of bulk density in a reference that the least property is the least variable property in soil while those at the first shoed highest variability.

The spatial variation in soil characteristics is one of the basic sources for evaluating and managing agricultural land. Many studies, survey projects, and mapping projects have been implemented to clarify the variation in the distribution of soil characteristics and the factors affecting them. The distribution of soil particle sizes and some chemical characteristics are among the basic soil characteristics that control soil management. The human factor or activity is one of the main influences on the variation or difference in these characteristics. The soil is affected by a group of different processes and factors over time and place that work to determine the characteristics of the soil and the variation in its distribution. Drawing maps and surveying them by applying geographic information systems is an important role that plays a major role in evaluating and studying the distribution of soil properties, and quality in terms of soil management and agricultural use. Soil characteristics vary in space and time, and the spatial distribution of soil characteristics is linked to soil formation factors (climate, natural vegetation, topography, migratory development, time, and parent material). In addition to the sixth human factor (**Jenny, 1941**; **Abdul-Ameer *et al*., (2019**) studied the spatial distribution of nutrients in Mussayab project area, and the found that organic matter showed the least spatial variability while nitrogen content showed higher variability especially in depression topographic unit. Alshujairy and Ali has used the geotechniques methods in predicting and mapping soil properties, where the focused on using GIS applications as a proximal soil sensing in soil fertility. Soil mapping combines field and laboratory data on soil characteristics to accurately predict values, study the spatial distribution of soil physical and chemical characteristics, and study influencing factors such as topography (**Safaee, 2023**). The spatial distribution of physical and chemical soil characteristics is a major input for planning sustainable agriculture, saving effort and cost, and providing accurate data and information. Geostatistical methods are used to assess soil qualities and characteristics to improve soil management and land use (**Robinson *et al*., 2006)**, as the spatial distribution of soil characteristics is extremely important. To manage this soil and crop and to map the spatial distribution of physical or chemical soil characteristics (**Abdel-Rahman *et al*., 2022). Wheib &Abbas, (2021**) have studied the spatial distribution of soil properties in a hydrosequence in grain cropping farms southern Iraq, and they found that soil salinity was the most variable property in soil, also, particle size distribution showed a wide variability in comparison of other soil properties.

Study area

Al-Sweira Farm is located within the lands of Wasit Governorate, on the eastern bank of the Tigris River, about 50 km southeast of Baghdad. It is bordered to the north by the Nahrawan Canal, to the south by the Tigris River, to the east by the Hafriya Project, and to the west by the Salman Pak Project. The soil of the Al-Sweira Model Farm (Al-Sweira Research Station) was surveyed by the Directorate of Soil and Public Land Reclamation (abolished), with an area of five thousand dunums. Figure 1 represents the study area.

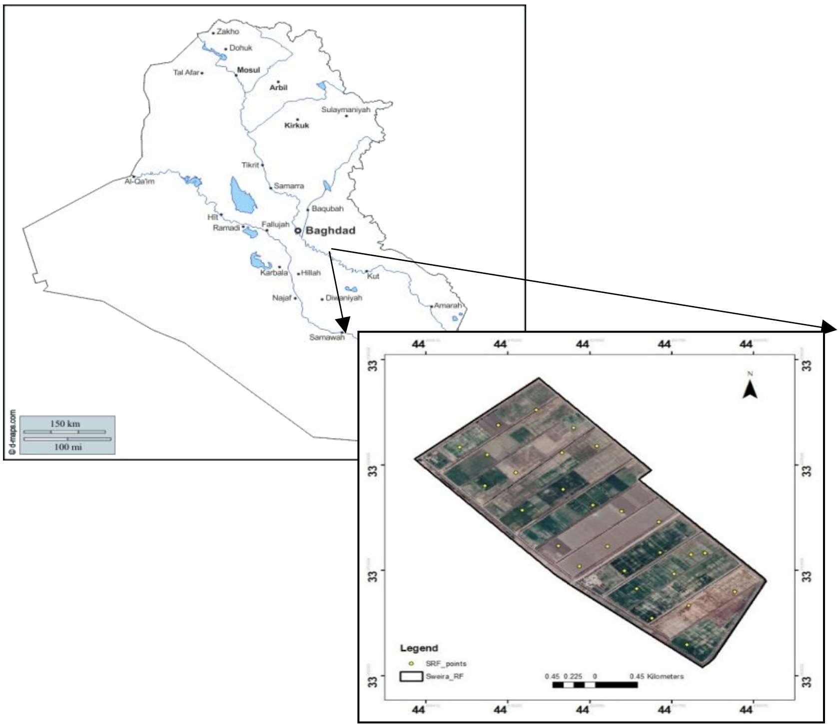

Figure (1): Location of the study area.

Laboratory measurements

After obtaining the study samples (surface samples and pedons), soil samples were taken from the pedons after describing them morphologically according to the Soil Survey Manual (**Soil Survey Staff, 1993**). The samples were collected in plastic bags. The samples were transported to the laboratory, air-dried, ground, and sieved through 2 mm diameter opening. They were kept in plastic boxes for the purpose of conducting laboratory analyses on them.

Physical characteristics: particle sizes distribution of soil samples was estimated according to Day's method mentioned in **Black (1965).**

Chemical properties: Some chemical properties of the soil were estimated as follows:

- Electrical conductivity of the saturated extract (ECe): The electrical conductivity was measured in a 1:1 extract and transferred to the saturated soil paste extract using an Electrical Conductivity Bridge device according to the method mentioned in **Richards (1954).**
- Soil reaction (pH): was carried out with a pH meter according to the method mentioned in **Jackson, (1958).**
- Cation exchange capacity (CEC): Ammonium acetate 1N NH_4OAc was used at (pH = 7.0) according to the method in **Black, (1965).**
- Carbonate minerals equivalent: was estimated using the calcimeter method using HCL according to **Hesse, (1972).**
- Soil Organic Carbon (SOC) and organic matter (OM): estimated by the wet digestion method according to the Walkley and Black method mentioned in Jackson, 1958. The value of organic carbon was calculated first, and the value of organic matter was calculated using the following equations: Organic matter (%) = Total organic carbon (%) x 1.72
- Available Nitrogen: It was determined in the soil by extraction method with a 2 Molar KCl potassium chloride solution according to the method of Keeney and Nelson, described in **Page *et al.*, (1982)**.
- Above Ground Biomass: Above ground biomass was estimated according to the method described in EPA Publication 1994 and according to the equation:

Standing Biomass = Dry Weight (of above ground tissues) / Plot Area

Biomass was calculated for the sampling season, which occurred at the beginning of the winter season (**January, 2023**).

RESULTS AND DISCUSSION

Soil properties: Some physical, chemical, and fertility characteristics of the soil were measured to study their spatial distribution, on the one hand, and the relationship between those characteristics and some evidence that was studied and deduced from images taken by drones. Table 1 displays the values of some physical and chemical characteristics of the surface soil samples of the study area, including the upper horizons of the study pedons.

Particle size distribution: The lowest content of sand particles reached 65 g kg-1 in the fifth surface sample, which belongs to the DM97 series, while its highest content reached 496 g kg-

1 in the seventh surface sample, which belongs to the DF126 series. We noted that although the DF126 series is characterized by an upper classification layer with a clay texture, soil phase light textures. The reason for the difference in sand content in the soil of the study area is due to the nature of sedimentation in that region, which is affected by the physiographic nature and sedimentation processes that occurred at early times during the formation and development of these soils. As for the content of the silt separate, the lowest content was 270 g kg-1 in the second surface sample, which belongs to the DF86 soil series, while the highest content of the silt reached 654 g kg-1 in the eighth sample, which belongs to the DM97 soil series. It is also noted that the lowest content of clay separate reached 65 g kg-1 in the twenty-third surface layer, which belongs to the DM47 soil series, while the highest content of clay reached 547 g kg-1 in the tenth sample, which belongs to the soil series DF126. It is worth noting that the DF126 series was the highest in frequency, followed by the DM97 series because they are the most widespread in the study area, and they in turn belong to the unit of river basins and physiographic irrigation channels.

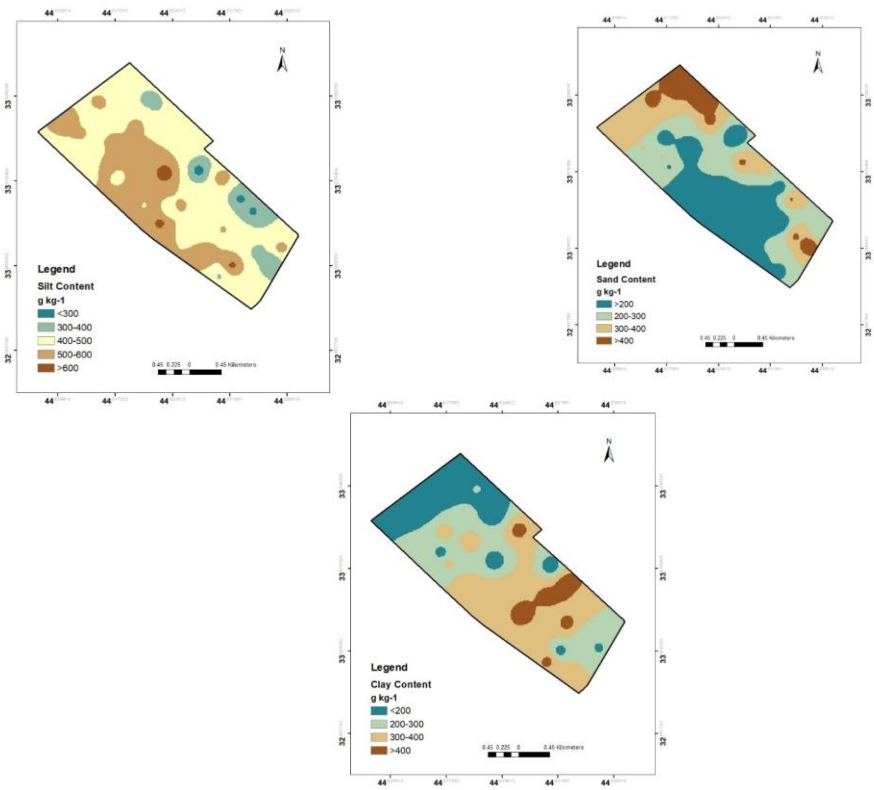

Figure (2): Spatial distribution of soil particles.

(Figure, 2) shows the spatial distribution map of soil particles (sand, silt, and clay). It is observed from this figure how the content of soil particles varies spatially, as it is noted that the sand content had the highest variation, followed by the clay content and then the silt with coefficients of variation amounting to 53%, 46% and 20%, respectively. It is also noted that the sand content was significantly inversely related to the content of Clay with a correlation coefficient of 0.6, while the content of separated silt was not significantly related to the contents of sand and clay. This indicates that the increase in sand content was at the expense of the decrease in clay content, and this is what results from sedimentation processes in sedimentary soils, as coarse particles are deposited at the beginning of placement and formation. The soil is followed by finer particles, then finer particles, and this was confirmed by the study of (**Kalala *et al*., 2017; &Reza *et al*., 2016, Saleh &Muhaimeed, 2013).**

Soil salinity: The lowest value of soil salinity was 2.20 dS m-1 in the fourteenth surface sample belonging to the DM97 series, and the highest value was 40.0 dS m-1 in the second surface sample belonging to the DF86 soil series (Table 1). Figure 3 shows the spatial distribution of the soil salinity characteristic. In the surface soil samples of the study area, it is noted that soil salinity was affected first by land use, followed by the physiographic location (**Bhardwaj *et al*., 2019; Shahrayini &Noroozi, 2022; Wu *et al*., 2018**), as soils affected by salts spread in the soils left unused, which are located southwest of the study area in general. Which led to its deterioration. It is noted that the value of the coefficient of variation in soil salinity was high, reaching 97%. The soil salinity unit, which ranges between 4-8 Jessie Siemens m-1, prevailed in the Al-Sweira farm area, which is a soil that is lightly affected by salts. The reason for this may be due to the nature of the use of those lands exploited for the cultivation of grain crops on the one hand and fodder crops on the one hand, followed by the saline unit with a range of salinity. 8-16 dS m-1, then the salinity unit is highly salinized (more than 16 dS m-1). It is worth noting that the highly salinized unit represented some degraded lands left without cultivation, in addition to its proximity to ineffective sewers that needed to be maintained.

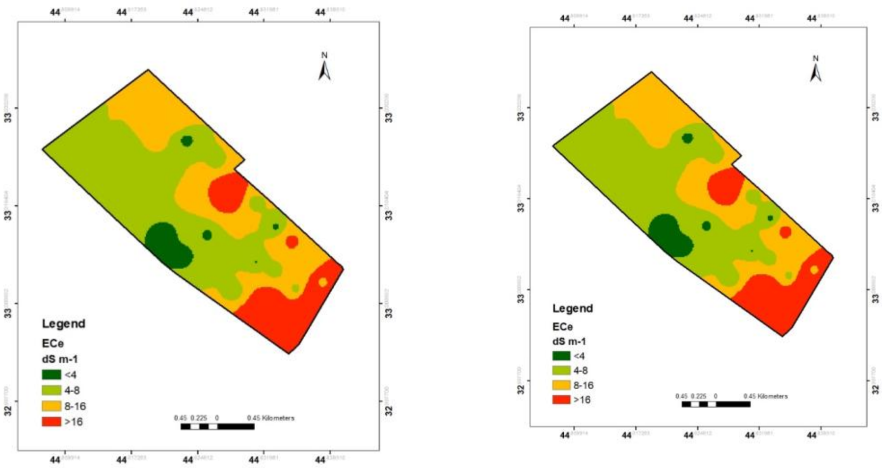

Figure (3): Spatial distribution of soil salinity.

Carbonate mineral content: The content of carbonate minerals in surface samples of soil from the study area ranged between 205.0 - 445.0 g kg-1 throughout the study area. The lowest value was found in the DF126 soil series, while its highest value appeared in the DF46 soil series (Table 1). Spatially, it is noted from Figure 4 that the soil unit with the most widespread calcium carbonate mineral content was in the range less than 300 g kg-1. Which happened to be proportional to the spread of soil salinity, as the unit appeared with a carbonate mineral content of more than 300 g kg-1 in the salinity unit of saline and highly saline soil.

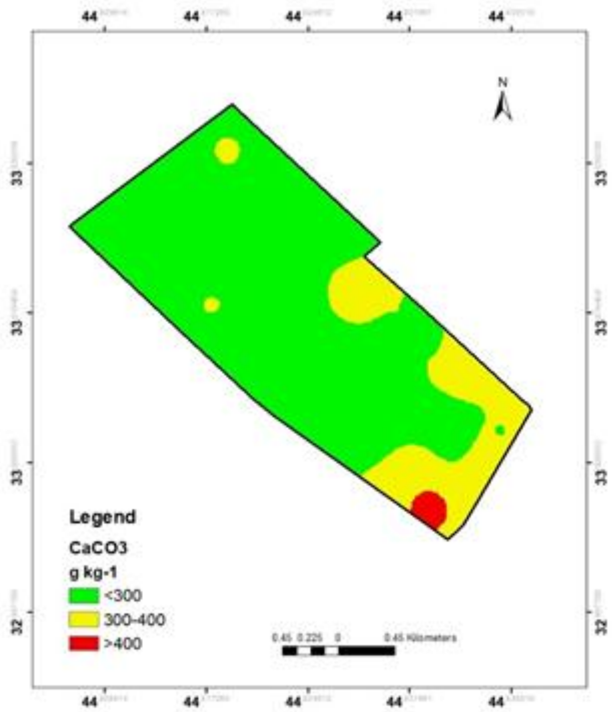

Figure (4): Spatial distribution of carbonate mineral content

The coefficient of variation for this property reached 19%, which is relatively low compared to the rest of the soil properties. The reason is due to the convergence of the values of carbonate mineral content in the soils of dry and semi-arid areas, as the high content of carbonate minerals in the soils of the study area is due to the fact that the original materials from which the soil originated are calcareous, in addition to Secondary deposition of these minerals is common in soils of arid and semi-arid climates with high climatic extremes, and this has been confirmed by numerous studies (**Wahba *et al.*, 2019;Hameed *et al.*, 2018;Zamanian *et al.*, 2016**).

Cation Exchange capacity: The values of the cation exchange capacity in the soil of the study area ranged between 8.07-38.67 $Cmol_c$ kg-1. The lowest value for this characteristic appeared in the DM47 soil series, while its highest value appeared in the DF126 soil series (Table 1). This is due to the effect of the fine particle size content in the soil samples of these series, as higher values are observed in the fine and medium-fine textures compared to the coarse and medium-coarse textures. The soil units were distributed based on the cation exchange capacity spatially, with an average coefficient of variation of 36%. The most widespread unit appeared with a range between 20-30 $Cmol_c$ kg-1, followed by the unit with a range of 10-20 $Cmol_c$ kg-1 (Figure 5). Likewise, many studies have confirmed the association of the cation exchange capacity with soil particles (**Khaladian *et al.*, 2017; Shiri *et al.*, 2017**).

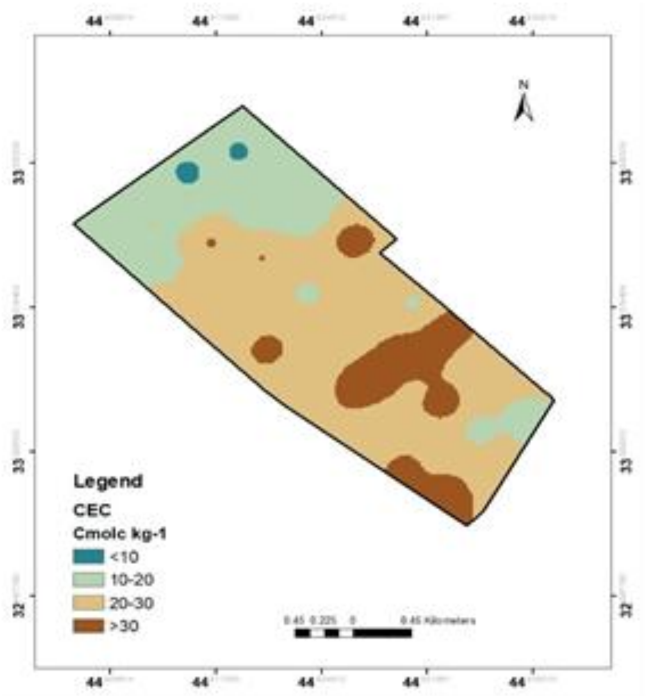

Figure (5): Spatial distribution of cation exchange capacity

Organic carbon: Organic carbon was measured in soil samples from the surface study, with its lowest content reaching 3.2 g kg-1 and its highest content reaching 13.6 g kg-1 for the same series DF126 (Table 1). The reason is due to the dominance of this series in area, which has led to the diversification of land use this soil series. Part of it is exploited for cultivating cereal crops and rice, especially in the dry farming method, which may lead to the accumulation of organic materials on the surface of the soil compared to other parts of the soil of this series that was barren. The coefficient of variation in this characteristic was characterized by being an average of 36%, which is somewhat high when compared to other areas in the alluvial plain.

The reason is due to the diversity of land uses in the study area, as it is primarily designated for conducting agricultural research such as breeding, improvement, testing varieties, and applying some administrative procedures for the soil as well as production. This Many studies have confirmed that the diversity of land use leads to a clear difference in the organic carbon content of the soil (**Shrestha *et al.*, 2013; Caravaca *et al.*, 2002**). (Figure 6) shows the map of the spatial distribution of organic carbon content in the soil, and it is noted that two units for the distribution of organic carbon in the soil appeared, as the unit with low organic carbon content dominated, which ranged between 7.5-15 g kg-1 (equivalent to 1.25-2.5%). . This is also found by **Abbas &Wheib (2019) &Hamad *et al.*, (2021)**.

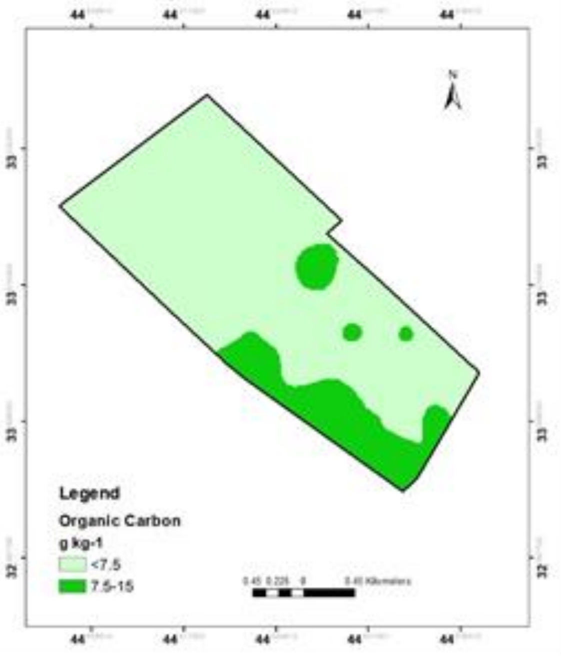

Figure (6): Spatial distribution of organic carbon content

Total nitrogen: Table 1 shows that the highest value of total nitrogen in the soil of the surface samples was 0.16% in the first surface sample belonging to the DM95 soil series, while its lowest value was 0.03% in the twenty-sixth surface sample belonging to the TM1175 series. The reason for the high total nitrogen value in the DM95 series of soils is due to the heavy use of the soils of this series compared to the rest of the series, especially in agricultural experiments that require fertilization and intensive cultivation. The relatively high coefficient of variation for this characteristic reached 41% due to the nature of land use in the soil of the study area, as the nature of land use is an important indicator of the increase or decrease in the amount of total nitrogen in the soil (**Wang *et al.*, 2009, Zhang *et al.*, 2019, Liu *et al*., 2020**).

(Figure 7) indicates the spatial distribution of the total nitrogen content in the soil, as it is noted that two varieties are dominant, namely the variety with poor content (less than 0.1%) and the variety with moderate content (0.1-0.15%) in the soil of the study area, while there was a non-significant appearance of the variety with low content. Good total nitrogen (more than 0.15%). It is also noted from the figure that the soils with a moderate content of total nitrogen were also related to the spatial distribution of the soil series and their land uses. It is observed spatially that this type prevails in the soils of the DM95 and DW55 series.

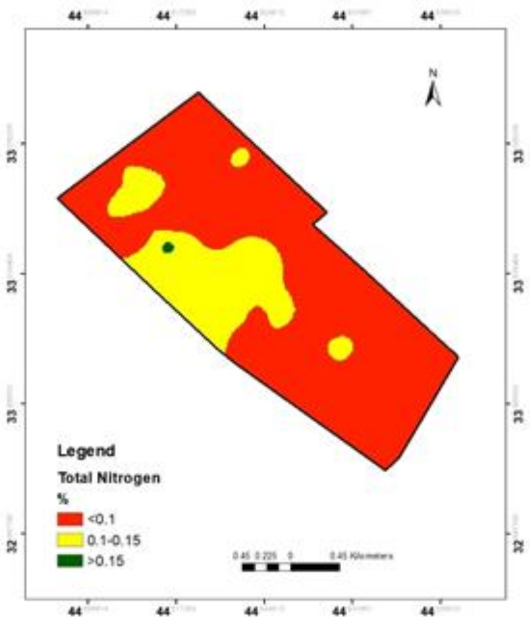

Figure (7): Spatial distribution of total nitrogen content

Above ground biomass: It is noted from Table 1 that the highest content of biomass above the soil surface reached 169.5 gm m-2 in the surface sample of the sixth beadon, which belongs to the soil series DW55, while its lowest content reached 7.31 gm m-2 in the third surface sample, which belongs to the soil series DF126. Here, it can be said that the intensity of land use affects the biomass content of the soil, but the matter is linked to the period of taking the sample. Lands prepared for agriculture may have a high content of organic carbon or total nitrogen, but it shows a decrease in the biomass content because the land is prepared for agriculture and may be devoid of plants. Sleeping in it at the time. Also, soils affected by salts may be dominated by salt-tolerant plants with dense growth, as was observed during field visits and taking soil and plant samples compared to fields whose soil was prepared for cultivation(**Castillo *et al.*, 2017;Hermhuk *et al.*, 2020**). The coefficient of variation in biomass above the ground reached 73%, which is relatively high compared to the rest of the traits. The reason here is due to the difference in the density of plants spread in the study area, whether natural or cultured. It was noted that the fields cultivated with fodder crops were high in their biomass content as well. In fact, it was observed that some abandoned lands with some natural plants growing had an increase in this characteristic compared to lands prepared for agriculture after the previously cultivated crop had been harvested, plowed, and smoothed, and thus almost devoid of plants. Figure 8 also shows the values of above-ground biomass distributed over the soil series in the study area. Figure 17 also shows the spatial distribution of above-ground biomass distributed into four classes, in which the class 50-100 g m-2 dominated, followed by the class less than 50. g m-2, with a significant increase in soils with a biomass content of 100-150 g m-2. It is worth noting that the increase in biomass values above the ground was spatially linked to land use, especially land cultivated with fodder crops, as in the DW55 and DM95 soil series. Figure 9, shows the spatial distribution of above ground biomass in the studied area. It is noted that Soils with higher biomass is correlated to the most used soil series.

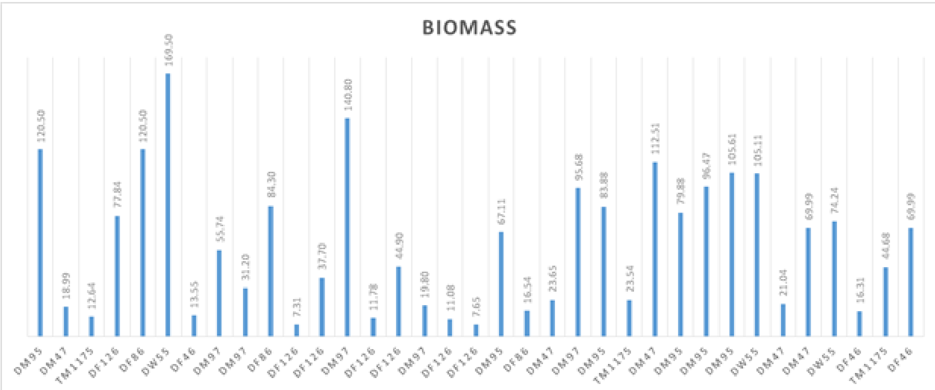

Figure (8): Biomass values with soil series of the study area

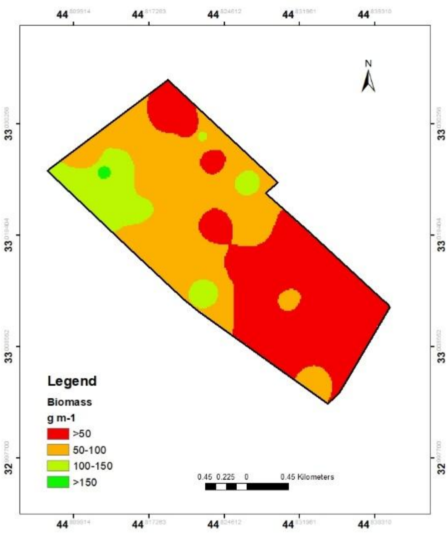

Figure (9): Spatial distribution of above ground biomass.

Soil Management and Land suitability for grain crops production:

After disclosing the spatial distribution of soil properties and their variation, land capability for crops evaluation of the soil series was conducted according to Sys et al., 1980, as follow:

Cs=A*B*C*D*E*F*G*H*I

Where: Cs = land capability for crops, A: Texture index, B: Index of carbonate minerals, C: Gypsum content index, D: salinity index ECe, E: Exchangeable Sodium percentage index (ESP), F: Internal Drainage index, G: Soil Depth index, H: horizon thickness index, I: weathering index.

Figure 10 shows the stability classes for grain crops in the study area, where the most extensive land suitability class for grain crops was class S3 which refers to moderate suitability, followed by Class 4 and Class N which they both refer to low and no suitability for grain crops production. Some areas showed Classes S1 and S2 which they refer to suitable and very suitable classes.

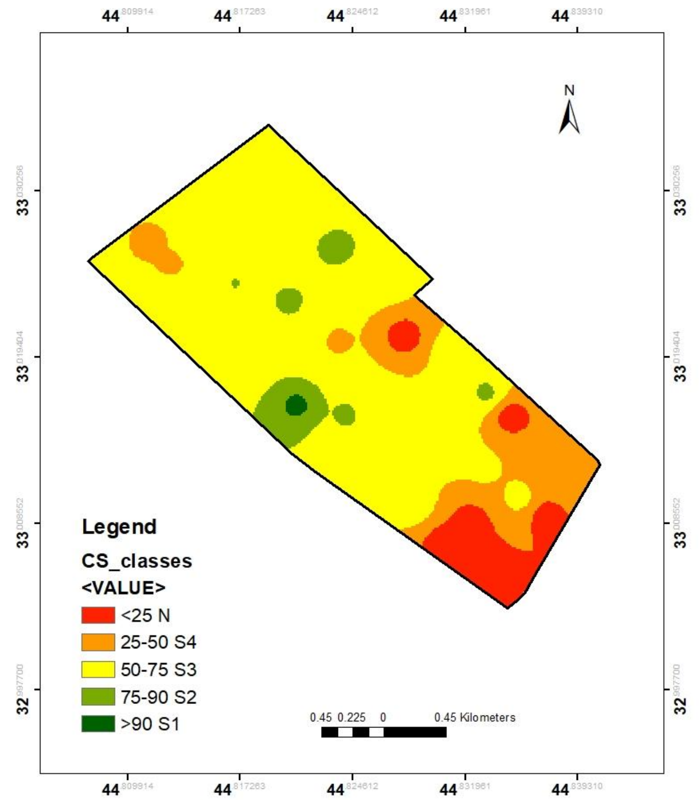

Figure (10): Suitability classes for grain crops production

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