Assessing Spatial Variability of Soil Characteristics in Cereal-Cultivated Areas under Pivot Irrigation in Arid Regions: A Case Study in El Outaya, Biskra, Algeria

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Abstract

The evaluation of agricultural production system sustainability in irrigated regions demands vigilant scrutiny of soil quality. In this investigation, we delve into the nuanced spatial variations of soil characteristics within cereal-cultivated areas employing a pivot irrigation system situated in El Outaya, Biskra, Algeria, located in the southeast Algeria. Two farmed sites and a control site (non-disturbed soil). were extensively investigated by systematic sampling, each comprising four years of wheat cultivation. pH, electrical conductivity (EC), organic matter (OM), and equivalent calcium carbonate (total limestone) were rigorously measured. Our results show that pH in farmed soils ranged from moderately alkaline to slightly alkaline in the reference soil. Total limestone measurements suggested a strongly calcareous character across all sites with poor organic matter content, whereas electrical conductivity data indicated high salinity levels in cultivated soils and moderate salinity in the reference soil.The coefficient of variation for the examined parameters displayed minimal spatial variation in organic matter, with values of 40.99 %, 36.44 %, and 52.33 % for both cultivated sites and the reference soil, respectively. Regarding electrical conductivity, pivot 1 exhibited a coefficient of variation of 27.35 %, pivot 02 had 25.80%, and the reference soil displayed 17.08 %. Total limestone values were 17.46 %, 12.82 %, and 12.12 %, respectively, for the same locations. Conversely, pH values appeared to be relatively consistent, with values of 9.33 %, 6.75 %, and 2.13 % for pivot 01, pivot 02, and the reference soil, respectively.These findings underscore the profound impact of agricultural practices on soil characteristics, emphasizing the necessity for improved management strategies for agricultural water and soils to ensure the long-term sustainability of farming systems.

Keywords: Algeria ,Cereal lands , Geostatistics, Physico-chemical , Pivot irrigation system.

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Introduction

Arid regions, which make up a significant portion of Earth's landmass, are known for their harsh environmental conditions, including limited and unpredictable rainfall, high winds, intense sunlight, and high potential evapotranspiration (Modarres & da Silva, 2007; Rathore et al., 2019). These areas are home to over a third of the world's population and face increasing risks and vulnerabilities due to climate change (Mortimore et al., 2009).In Algeria , it presents almost 95% of the national territory, including 80% in the hyper-arid area (Halitim,1988).Soil degradation, particularly in arid and semi-arid regions, poses a significant threat to crop production (Mohamed et al., 2019).Historically, there has been limited interest in the soil of arid regions because of its simple mineral composition, minimal development, and low organic matter content (Aubert, 1960 ; Khouri, 2003). The agricultural sector in arid regions faces various challenges, including declining productivity and the depletion of natural resources (Rathore, 2019). Scarce and irregular precipitation often results in reduced crop yields and, in severe cases, complete crop failures (Li et al., 2000). Soil degradation, especially in arid areas, remains a significant concern (Mohamed et al., 2019).Nonetheless, arid regions, exemplified by the Algerian Sahara, present formidable challenges due to their limited water resources and suboptimal soil quality. The increasing demands of a growing population, combined with water scarcity and decreasing agricultural yields in northern arid regions of Algeria, have necessitated the establishment of new irrigated areas (Benbrahim, 2018). The use of pivot irrigation systems in the Algerian Sahara has become essential for cultivating these soils (Talaat & Ahmed, 2007), even though irrigation significantly alters soil properties, leading to notable changes caused by the introduction of soluble salts (Benbrahim, 2001; Daoud & Halitim, 1994). These changes can result in soil degradation through processes like alkalinization, salinization, and sodification (Cheverry & Robert, 1998). Therefore, monitoring soil quality in irrigated areas is crucial to assess the long-term sustainability of agricultural production systems (Hamel et al., 2022).The underperformance in these areas can be attributed to adverse soil and climate conditions and a lack of understanding of cultivation techniques, particularly under pivot irrigation systems (Hakima et al., 2019). The spatial variation in soil properties is influenced by several factors, including soil characteristics, water quality, topography, climate variables, and human mismanagement of irrigation and drainage systems (Daoud & Halitim, 1994;Yang et al., 2019) Economically, wheat production plays a vital role in Algeria's agricultural sector and food security. While the country's domestic wheat production might not meet the entire demand, it remains crucial for reducing reliance on imports and ensuring a stable food supply (FAO, 2022).Efforts to enhance crop productivity and sustainability in regions like El Outaya persist, despite challenging arid climatic conditions such as water scarcity and soil salinity issues (Boudibi et al., 2021). This study aims to uncover the changes in soil properties under pivot irrigation systems in cereal fields and the impacts of intensive agricultural practices in arid zones. Our ultimate goal is to reveal the relationships between the parameters we are investigating, thereby contributing to a deeper understanding of the spatial variability of selected physicochemical properties in irrigated soil within El Outaya, Biskra (Lhissoui et al., 2014). We will employ geostatistical techniques, including ordinary kriging, semivariograms, and statistical analysis. These findings hold great promise for advancing our understanding of the complex dynamics involved in managing soil and water resources in arid regions, ultimately leading to improved crop yields and sustainability in these challenging environments

Material And Methods

Presentation of El Outaya Study Area:

The study was conducted during august 2022 at CAZDA COSIDER company in Biskra. The experimental plots are located at "Dris Amor farm" south of the commune of El Outaya (about 5 km). The geographical coordinates of thesite are: •X=34°58057 ' N , Y=005°36 939'E, the data projection is GCS-WGS 1984.The site is divided into 27 pivots with the surface of 20.5 Ha for each. These were planted with wheat since 2018,Three pivots were chosen for the work.

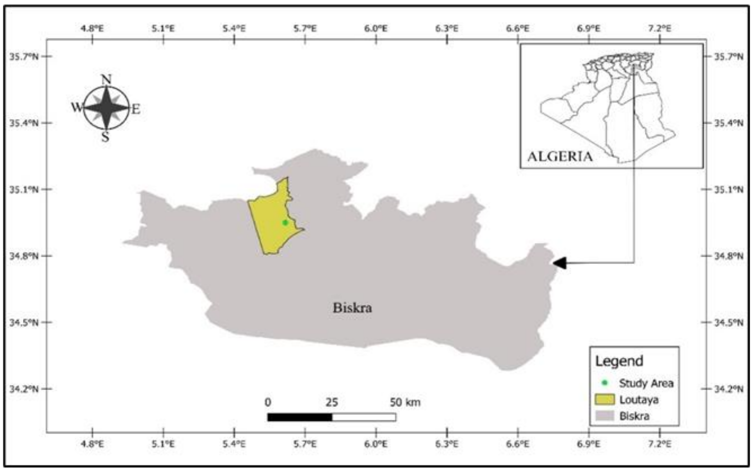


Figure 1. Presentation of the study region and sampling method (El Outaya).

El Outaya is located in the northern Sahara Desert. According to the Köppen-Geiger climate classification system. The weather is very hot and dry, characterized by two seasons: a hot and dry season (from April to September) and a moderate season (from October to March) (Hamel et al., 2022) with extreme heat during the summer months of July and August. Summer daytime temperatures can reach or exceed 45 °C. During the winter, temperatures can drop to around 5-10 °C at night, with daytime temperatures ranging from 18-22 °C.

The humidity in El Outaya is very low, typically ranging between 10 % and 20%.Throughout the year, rainfall is scarce, with an annual precipitation average of less than 100 mm (Climate-Data.org). it is also characterized by hot and dry winds, with sandstorms and dust storms on occasion(Gaouaoui et al., 2017). Because of the extreme temperatures, low humidity, and lack of rainfall, the climate in El Outaya is difficult for agriculture (Naorem et al., 2023). The region is known for its hot and arid desert conditions, as well as its scarcity of vegetation and natural resources (Boudibi et al., 2021) .

Soil samples

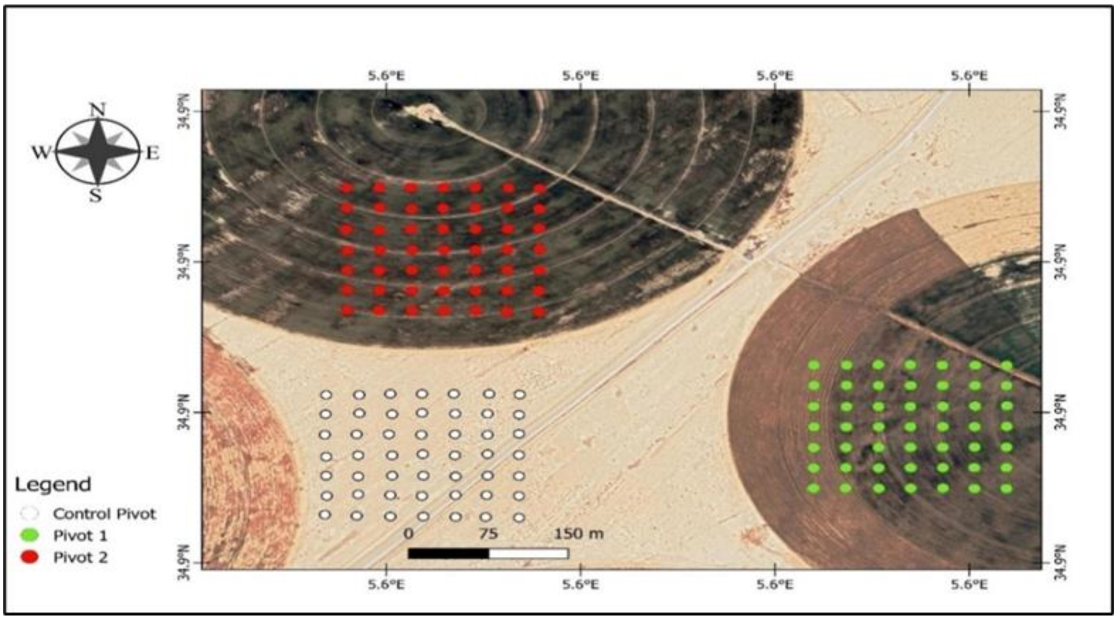


Figure 02. Sampling method map.

In order to execute the study, three specific experimental plots were meticulously chosen from within P1 and P2. These plots have been consistently utilized for wheat cultivation over a continuous span of four years. In contrast, the control plot, denoted as (T) remained devoid of any soil exploitation and can be categorized as undisturbed soil.

Sampling activities were conducted at a soil depth ranging from 0 to 30 centimeters, targeting the topsoil layer due to the sandy nature of the soil, which promotes deeper root growth. The spatial separation between each sample was fixed at 30 meters. The collected samples were preserved within labeled plastic bags, marked with the corresponding date of collection. A total of 49 soil samples were procured for each of the experimental pivots, P1 and P2. This position of points is statistically perfect. The results can be presented by all type of cartography and the geostatic exploitation is possible (Belkassem & Lemiere, 2006).

Soil samples were air-dried at room temperature and sieved using a 2 mm mesh size. then transferred to the laboratory for the determination of organic matter content, according to the method of WALKLEY and BLACK (Walkley & Black, 1934).The electrical conductivity and the pH were measured at a temperature of 25 °C on a soil to water ratio of 1/5 for the pH and 1 /2.5 for the electric conductivity following the procedure described by the United States Salinity Laboratory (USDA) (Richards,1954). The determination of Total limestone is carried out according to the method Acid digestion method using the Calcimetre (Gee & Bauder, 1986),For the Granulometry ASTM D6913/D6913M-17, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis was preformed.

Statistical Analysis

The data were subjected to a standard analysis to obtain descriptive statistics, specifically the

mean, minimum and maximum, median, variance, standard deviation (SD), coefficient of variation(CV).All data processing and analysis was carried out using ArcGis 10.8 © software and statistical processing with Microsoft Excel ©.

Predictive Mapping

In this study, Ordinary kriging is used for mapping the spatial distribution of soil physicho-chemical parameters (EC,pH,TL,OM) based only on the field measurements. The data were verified by a normality test (QQ Plot) to evaluate the distribution of the data. These data were normalized using the logarithmic decimal method.

Results And Disscusion

Table 1. Granulometric analysis for soil texture of the 3 sites.

Sites	clay%	Fine silt%	Fine Sand %	Coarse Sand %	Coarse silt %	Granulometry
Pivot 01	29	34	15	13	10	Clay loam
Pivot 02	35	43	9	1	13	Silty clay loam
Control soil	19	54	10	1	16	Clay loam

Soil texture in both working sites and testimony belongs to clay loam soil. according to soil texture Diagram courtesy of the USDA-NRCS.

The index was mathematically expressed by the following formula (Hossain et al., 2018):

Soil textural index (Txw)=ln (% Sand*5+% Silt) / (% Silt+% Clay*10).

Clay loam soils have good water-holding capacity due to the presence of clay particles, which makes them beneficial for plant growth in areas with limited rainfall. In addition, clay loam soils are able to retain nutrients such as nitrogen, phosphorus, and potassium (Tahir & Marschner, 2016), However, in arid regions, clay loam soils can be vulnerable to soil salinization due to the accumulation of salts in the soil (Munns & Tester, 2008).The soil may also be affected by wind erosion and lack of water (Lal, 2017), which can lead to soil degradation and desertification.

It should be noted that the water used for irrigation in the station is characterized by a high salinity with an average of 8.65 ds/m at 25 °C . According to laboratory analyses preceded.

Table 2.Descriptive statistics of pH, EC, TL, AL, OM dataset used for pivot 01, pivot 02 and Control soil .

Output	Date set	Number	Mean	Max	Min	CV%	Var	Sd .dev
pH	pivot 01	49	6.98	8.15	3.73	9.33	0.425	0.65
pH	pivot 02	49	7.06	8.15	6.17	6.75	0.22	0.47
pH	Control	49	7.71	7.95	7.09	2.13	0.02	0.16
	Total	147	7.25	8.15	3.73	2.74	0.03	0.19
EC	pivot 01	49	3.70	5.6	0.38	27.35	1.02	1.01
EC	pivot 02	49	3.89	7.3	2.17	34.80	1.84	1.35
EC	Control	49	2.05	3.1	1.4	17.08	0.12	0.35
	Total	147	3.14	5.8	0.38	15.59	0.24	0.49
TL	pivot 01	49	42.78	73.04	33	17.46	55.84	7.47
TL	pivot 02	49	41.76	51.42	30.06	12.82	28.68	5.35
TL	Control	49	33.69	47.82	25.77	12.12	16.67	4.08
OM	pivot 01	49	2.26	3.3	0.05	40.99	0.86	0.92
OM	pivot 02	49	2.17	3.5	0.04	36.44	0.63	0.79
OM	Control	49	1.18	2.66	0.06	52.33	0.38	0.61
	Total	147	1.87	3.5	0.04	12.79	0.05	0.23

Max: maximum, Min: minimum, St. dev: standard deviation, Cv: coefficient of variation, Var: variation.

The summary of descriptive statistics for soil salinity, based on 149 samples from two pivots (49 samples for each pivot) and an additional 49 samples from the control site, is presented in (Table 02). In Pivot 01 and Pivot 02, the soil exhibits organic matter content ranging from 3.3 to 0.05 and 3.5 to 0.04, with average values of 2.264 ± 0.92 and 2.178 ± 0.79, respectively. This indicates a low organic matter (OM) content in the soil of these two pivots. In contrast, the control site shows organic matter content ranging from 2.66 to 0.06, with an average of 1.181 ± 0.61.

The pH values are relatively high, with a mean of 6.98 ± 0.65 for Pivot 01, 7.06 ± 0.47 for Pivot 02, and 7.71 ± 0.16 for the control site. These values suggest a slightly alkaline nature of the soil under study.

Regarding electrical conductivity (EC), Pivot 01 exhibits a maximum of 3.7 dS/m, Pivot 02 has 3.6 dS/m, and the control site records 2.05 dS/m. These EC values classify the studied soil as very saline (Aubert, 1978).

The average total limestone (TL) content for Pivot 01 and Pivot 02 is 42.78 ± 7.47 and 41.76 ± 5.35, respectively, while the control site has an average of 33.69 ± 4.08. These values indicate that the chosen sites have very high calcareous soil (Hopkins & Ellsworth, 2005; Keshavarzi et al., 2018).

The Coefficient of Variation (CV) serves as an indicator of the dispersion level of random variables. Typically, a CV of less than 10% signifies weak variability, while a CV falling between 10% and 100% indicates moderate variability. In contrast, a CV exceeding 100 % suggests strong variability (Gardner et al., 2002 ; Madden & Hughes., 1995).

For the parameters under examination, the coefficient of variation reveals limited spatial variation in organic matter, with values of 40.99 %, 36.44 %, and 52.33 %.

for both cultivation sites and the control site, respectively. This spatial variation in soil organic matter may be attributed to factors such as land use, irrigation systems, and schedules.

In terms of electrical conductivity, Pivot 1 exhibits a coefficient of variation of 27.35 %, Pivot 02 has 25.80 %, and the control site shows 17.08 %. Meanwhile, the values for total limestone content are 17.46 %, 12.82 %, and 12.12 %, respectively.

However, pH values appear relatively uniform, with measurements of 9.33 %, 6.75 %, and 2.13 % for Pivot 01, Pivot 02, and the control site, respectively.

Distribution of Soil physic-chemical parameters Using OK Interpolation

Ordinary kriging is used in this study to map the spatial distribution of soil physicochemical parameters (EC,Ph,TL,OM) based solely on field measurements. A normality test (QQ Plot) was used to evaluate the distribution of the data, (the results do not follow a normal distribution). The logarithmic decimal method was used to normalize these data.

Table 3.Descriptive statistics after logarithmic transformation for total limestone, pH, Electric conductivity, Organic matter.

Output	Date set	Number	Mean	Max	Min	St.dev	Cv	Var
pH	pivot 01	49	42.91	49.44	37.4	2.72	6.34	7.39
pH	pivot 02	49	41.79	48.92	36.53	2.62	6.28	6.86

pH	Control	49	33.79	38.28	28.74	2.57	7.62	6.6
EC	pivot 01	49	6.97	7.97	5.6	0.49	7.04	0.24
EC	pivot 02	49	7.06	7.56	6.63	0.21	3.05	0.04
EC	Control	49	7.71	7.84	7.52	0.08	1.08	0.006
TL	pivot 01	49	3.68	4.37	2.65	0.36	9.98	0.12
TL	pivot 02	49	3.65	4.53	2.67	0.38	10.65	0.14
TL	Control	49	2.06	2.78	1.57	0.23	11.48	0.05
OM	pivot 01	49	2.61	2.9	1.17	0.44	19.54	0.19
OM	pivot 02	49	2.17	2.776	1.12	0.37	17.39	0.13
OM	Control	49	1.17	1.767	0.41	0.26	22.53	0.06

Subsequently Variograms of the KRIGING method were calculated from the normalized data.

In Pivot 01, we delve into the geospatial attributes of four crucial soil parameters. Electrical conductivity (EC) is characterized by a low spatial dependency, demonstrated by an exponential best-fit model with a range of 56.2 meters. Total limestone (TL) exhibits moderate spatial dependence with an exponential model and a range of 108.4 meters. Organic matter (OM) similarly displays a moderate spatial dependency with an exponential model and a range of 135.7 meters. Conversely, the pH level is depicted with a Gaussian best-fit model, featuring a high nugget-to-sill ratio, suggesting reduced spatial dependency, and a range of 56.2 meters.

Table 4. Best-fit variogram models for OM, TL, pH, EC parameters for the three sites.

Parameters	**Best-Fit**	**Nugget**	**Sill**	**Range**	**Ratio Level of value**
	Model	**(C0)**	**(C0+C)**	**(m)**	**%**
EC pivot 01	Exponential	0.48	0.49	56.2	98.4 > 75 % (Low)
EC pivot 02	Gaussian	0.76	1.12	56.2	67.87 25-75 % (Moderate)
EC Control	Gaussian	0.01	0.13	58.94	7.46 < 25 % (High)
TL pivot 1	Exponential	22.65	33.94	56.2	66.74 25-75 % (Moderate)

TL pivot 02	Gaussian	10.48	24.74	58.94	42.37 25-75 % (Moderate)
TL Control	Gaussian	3.52	14.96	61.82	23.52 25-75 % (Moderate)
pH pivot 1	Gaussian	0.01	0.44	56.2	2.24 < 25 % (High)
pH pivot 2	Exponential	0.01	0.21	56.2	4.66 < 25 % (High)
pH Control	Spherical	0.002	0.02	58.94	7.68 < 25 % (High)
OM pivot 1	Exponential	0.25	0.88	124.99	28.78 25-75 % (Moderate)
OM pivot 02	Exponential	0.05	0.59	56.2	8.35 < 25 % (High)
OM Control	Spherical	0.01	0.43	207.37	0.02 < 25 % (High)

In Pivot 01, we delve into the geospatial attributes of four crucial soil parameters. Electrical conductivity (EC) is characterized by a low spatial dependency, demonstrated by an exponential best-fit model with a range of 56.2 meters. Total limestone (TL) exhibits moderate spatial dependence with an exponential model and a range of 108.4 meters. Organic matter (OM) similarly displays a moderate spatial dependency with an exponential model and a range of 135.7 meters. Conversely, the pH level is depicted with a Gaussian best-fit model, featuring a high nugget-to-sill ratio, suggesting reduced spatial dependency, and a range of 56.2 meters.

Pivot 02 also undergoes a comprehensive assessment of soil attributes. EC maintains a moderate spatial dependency, following an exponential best-fit model with a range of 56.2 meters. TL presents similar characteristics with a moderate spatial dependence, adhering to an exponential model and a range of 108.4 meters. OM follows a comparable pattern, displaying moderate spatial dependency with a range of 135.7 meters. However, in this pivot, the pH level is depicted using an exponential best-fit model with a high nugget-to-sill ratio, indicative of reduced spatial dependency, and a range of 56.2 meters.

The control section reveals distinct findings. EC, TL, and OM all demonstrate high spatial dependence, evident from the low nugget-to-sill ratio. EC exhibits a range of 58.94 meters, TL extends to 117.87 meters, and OM spans 143.62 meters. The pH level is characterized by a spherical best-fit model and a high nugget-to-sill ratio, aligning with the spatial dependence observed in the other parameters, with a range of 58.94 meters. These findings provide valuable insights into the spatial characteristics of these soil parameters, contributing to a better understanding of soil behavior and management.

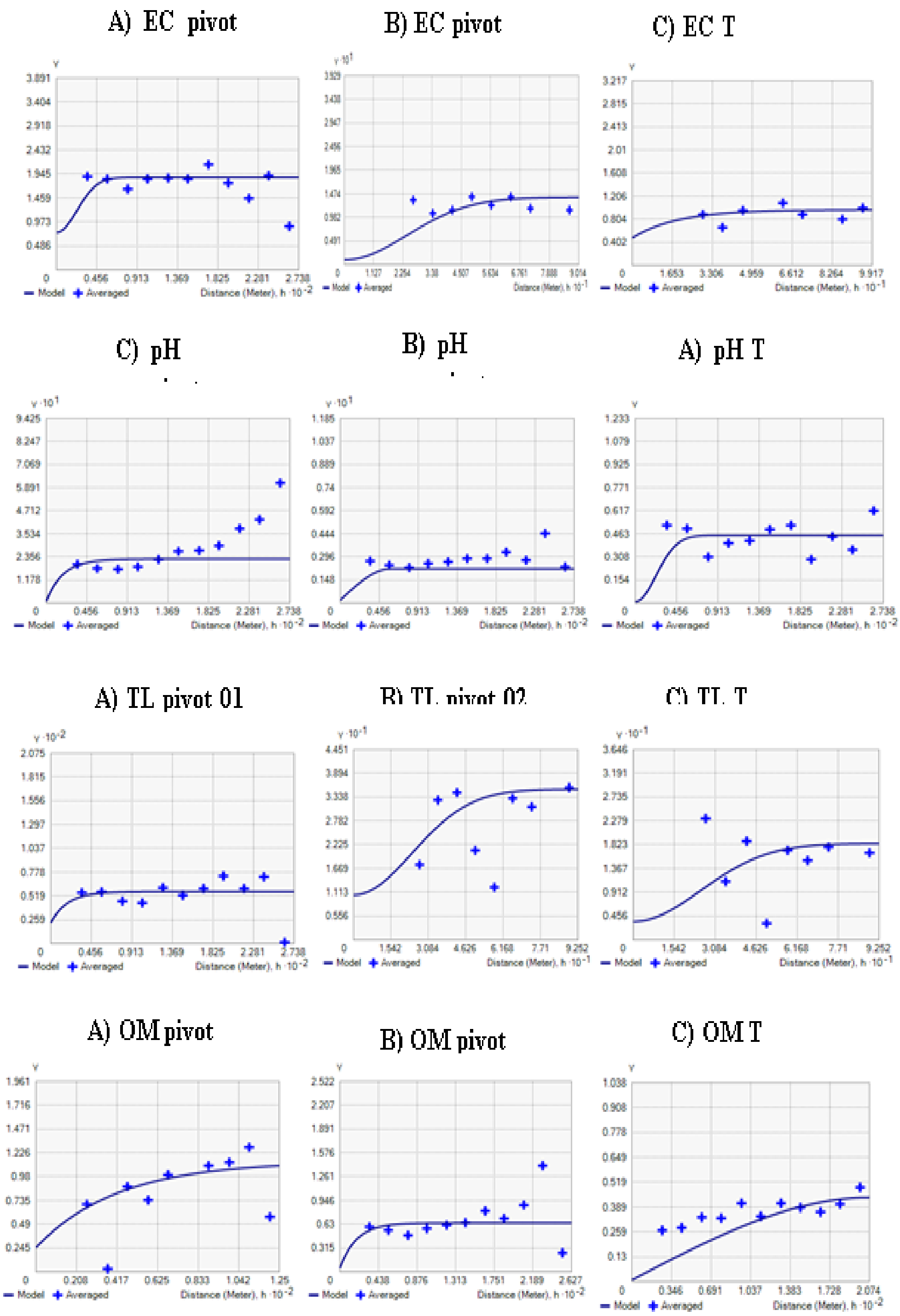
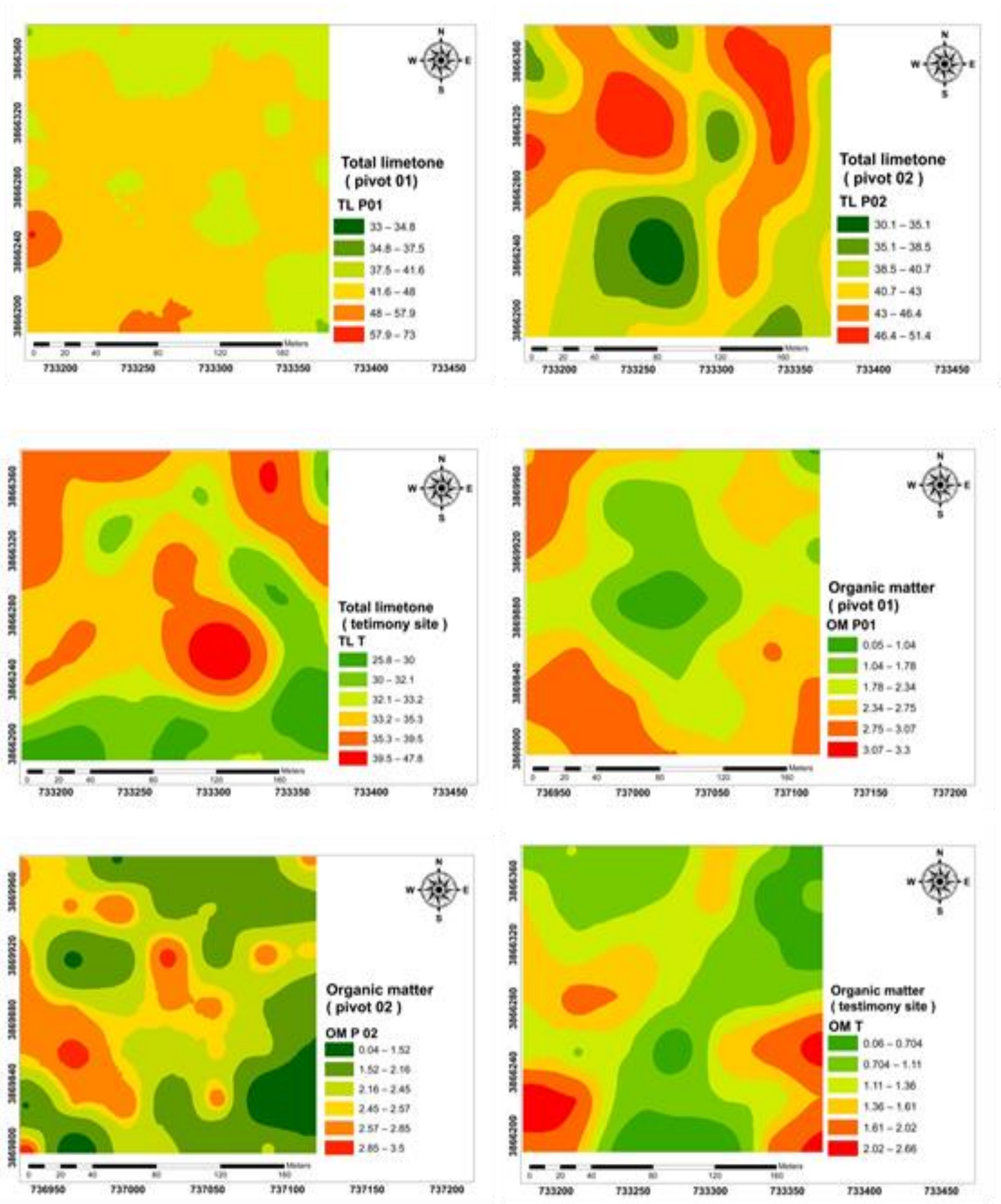


Figure 3.Directional semivariograms model calculated for soil total limestone, organic matter,Ph and Electric conductivity with log transformed data.


Total limetone
(pivot 01)
TL P01
33 – 34.8
34.8 – 37.5
37.5 – 41.6
41.6 – 48
48 – 57.9
57.9 – 73
Total limetone
(pivot 02)
TL P02
30.1 – 35.1
35.1 – 38.5
38.5 – 40.7
40.7 – 43
43 – 46.4
46.4 – 51.4
Total limetone
(tetimony site)
TL T
25.8 – 30
30 – 32.1
32.1 – 33.2
33.2 – 35.3
35.3 – 39.5
39.5 – 47.8
Organic matter
(pivot 01)
OM P01
0.05 – 1.04
1.04 – 1.78
1.78 – 2.34
2.34 – 2.75
2.75 – 3.07
3.07 – 3.3
Organic matter
(pivot 02)
OM P 02
0.04 – 1.52
1.52 – 2.16
2.16 – 2.45
2.45 – 2.57
2.57 – 2.85
2.85 – 3.5
Organic matter
(testimony site)
OM T
0.06 – 0.704
0.704 – 1.11
1.11 – 1.36
1.36 – 1.61
1.61 – 2.02
2.02 – 2.66

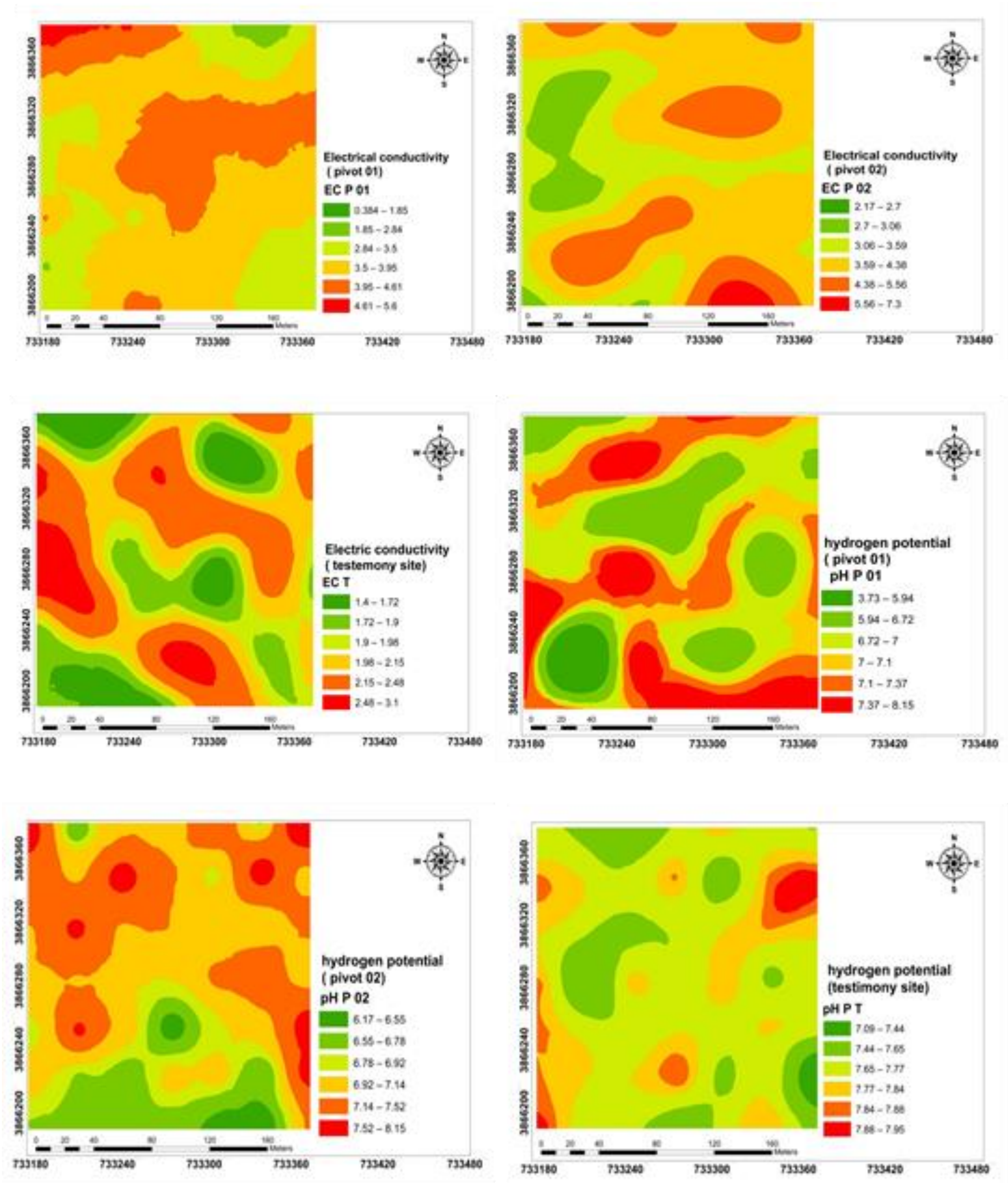


Figure 4.Spatial Distribution maps of soil total limestone(TL), organic matter(OM) , electric conductivity (EC) and pH for the three sites using Ordinary Kriging Interpolation method.

Based on the spatial distribution maps of pH levels, we observe fluctuations in pH classes within these pivot areas, ranging from slightly alkaline to slightly acidic. Notably, elevated pH values are primarily concentrated in the southern sectors of Pivot 02 and along the periphery of Pivot 01. It's important to note that the spatial analysis indicates relatively low pH variation across the study area, with coefficient values of variation amounting to 9.33% for Pivot 01, 6.75% for Pivot 02, and 2.13% for the Control soil.

Similarly, when examining the spatial distribution maps of total limestone content in the soil, the values classify total limestone content into categories ranging from highly calcareous to very strongly calcareous, based on the Scale of Salinity (Triki Fourati et al., 2017). The preponderance of high values is chiefly evident in the northern regions of Pivot 02 and the central region of Pivot 01. Furthermore, the analysis reveals a relatively low variation in total limestone content across the study area, characterized by a moderate coefficient of variation.

When examining the spatial distribution maps of organic matter content, the data classify organic matter content in the soil as very low and deficient in organic matter (Koull & Halilat, 2016). The most notable accumulations of organic matter are identified in the southern regions of Pivot 01 and the western sector of Pivot 02. In contrast to pH and total limestone, organic matter demonstrates a significant degree of spatial variability, with coefficient values of variation reaching 40.99 % for Pivot 01, 36.44 % for Pivot 02, and 52.33 % for the reference soil.

Furthermore, when examining the spatial distribution maps of electric conductivity (EC), these values categorize EC into classes ranging from very saline soil to extremely saline soil. Predominantly elevated EC values are concentrated in the central regions of both working pivots. The spatial analysis reveals a moderate degree of EC variation across the study area.The distribution of soil properties is elucidated through an analytical examination of the pivot irrigation system, which is intricately regulated by climatic factors, particularly during the summer season marked by elevated temperatures and evaporation rates, in conjunction with the velocity and orientation of prevailing winds.This phenomenon is further compounded by the agricultural practice known as "intensification agriculture". Furthermore, anthropogenic activities have engendered suboptimal natural resource management and perturbations to the soil structure. The employment of groundwater-based irrigation can exert a substantial influence on soil salinity, especially within regions characterized by elevated concentrations of dissolved salts in the groundwater (Triki et al., 2016). Upon irrigation, water undergoes a partitioning process, with a fraction undergoing evaporation, while the remainder percolates through the soil profile, transporting dissolved salts along (Jones, 2016). The deleterious consequences of heightened soil salinity encompass water stress, perturbations in nutrient equilibrium, and toxicity, thereby negatively affecting plant growth and crop yields.

Elevated levels of soil salinity can detrimentally affect the capacity of cereal crops to assimilate water and vital nutrients, culminating in stunted growth, diminished harvests, and potentially plant mortality (Akbarimoghaddam et al., 2011). Moreover, excessive salt concentrations can induce ion imbalances within plants, subsequently precipitating nutrient deficiencies and a reduction in photosynthetic efficiency (Yadav et al., 2011.).

The relationships among these variables are in line with the recognized significance of electrical conductivity (EC) and total limestone in affecting soil salinity. The increase in electrical conductivity, due to the introduction of organic matter, is attributed to the mineralization of organic compounds, subsequently raising soil salinity. Additionally, a correlation exists between pH and total limestone, as limestone has the ability to neutralize acidity by reacting with hydrogen ions (H+) in acidic solutions. The specific amount of limestone required to achieve a particular pH level depends on the initial pH and the amount of acid present. This reaction is commonly referred to as acid neutralization or the acid-base reaction (Haby & Leonard, 2002 ; Brady & Weil, 1990). Furthermore, negative correlations are observed between pH and electrical conductivity, indicating that as the calcium concentration in the solution decreases, pH tends to increase (Brady & Weil, 1990). This decline in pH is associated with the presence of limestone in the soil, as noted in Benbrahim's 2018 study, consistently demonstrating a negative correlation between pH and electrical conductivity.

Conclusion

agriculture in arid regions, exemplified by the Algerian Sahara, confronts notable impediments due to the scarcity of water resources and suboptimal soil conditions. The utilization of the pivot irrigation system has proven to be an efficacious means of conserving water resources for Algerian Sahara farmers, albeit with potential adverse ramifications on soil properties. The cultivation of wheat in locales such as El Outaya in Biskra region is further compounded by specific challenges associated with soil quality fluctuations, encompassing variations in organic matter content and overall limestone composition.It is imperative to acknowledge that soils across the entirety of the Algerian Sahara exhibit limited correlations between organic matter content and total limestone content at distinct sites. Our research substantiates that the soil examined in the El Outaya region is predominantly calcareous while being deficient in organic matter. Augmenting our comprehension of soil characteristics and their heterogeneity assumes pivotal importance in formulating efficacious strategies for the judicious management of soil and water resources in arid regions.The analysis of the repercussions of agricultural practices holds the potential to enhance our comprehension of the alterations brought about by the implementation of pivot irrigation systems. Ultimately, these endeavors may culminate in improved crop yields and the promotion of sustainable agricultural practices in the challenging milieu of the Algerian Sahara.

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