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Submitted by:

Zerrouki Nour El imen

Kerfah Abdelaala oussama

Cartography and modeling of major NPK elements in cereal soil

In the Tiaret region

Board of Examiners:

President: BOUCHENAFI NADIA

Promoter: DELLAL ABEDELKADER

Examiner: OULBACHIR KARIMA

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Dedication

I dedicate this modest work:

*To my dear parents **Ali** and **Bakhta** for all their sacrifices, their love, their tenderness, and their prayers throughout my studies.*

*To my adorable sister, **Ikram**, my second mother.*

*My Angel, **Rayane**.*

*And my dear brothers, **Youcef, Abd El basset** and **Yassine**.*

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Imen

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List of Abbreviations and Acronyms

CEC: electrical conductivity.

DSA: Agricultural Services Directorate

GIS: Geographic Information System

MO: Organic matter.

N: Nitrogen.

NPK: major elements in the soil (Nitrogen, phosphorus, potassium).

PNDA: National Agricultural Development Program.

P: phosphorus.

PH: Hydrogen potential

K: potassium.

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General Introduction

General Introduction

The total area of Algeria amounts to 238 million hectares of which 191 million are unproductive. The agricultural area is 8.2 million hectares, almost half of which is usually set aside. Herbaceous crops cover 3.8 million hectares.

The agricultural sector is important for the Algerian economy, both in terms of its contribution to its primary function of covering the country's food needs (which it provides up to 70% on average), and that of protecting resources. Natural resources, and a provider of employment and income.

For four years, the National Agricultural Development Program (PNDA) has been promoting agricultural intensification. It provides for the establishment of cropping systems based on the country's agro-ecological zones and encourages a reduction in fallow land. However, an extension effort should be made to promote more appropriate and balanced fertilization. Especially in cereal-growing areas, phosphorus and potassium are essential to increase drought tolerance and promote nitrogen assimilation.

The TIARET region is located in the central-western part of the country, with an area of 2 million square kilometres (BOUACHA 2019) and is considered a regional economic centre as well as one of the agricultural areas par excellence, since it has a vast area of agricultural land, which is estimated at one million 589 thousand and 530 hectares, of which 688725 hectares are suitable for agriculture and occupy the largest share of durum wheat cultivation with an area of 120,260 hectares, and the rest of the area is divided between wheat and barley or in registers an abundant production despite the low rainfall, due to its fertile soil and its diversified climate, and our choice of the Tiaret region is explained by the fact that the region has suffered for several years from the problem of fertilization which has a negative impact on crop yields.

Also, due in particular to the lack of monitoring of water stress and the areas that suffers from it. Do not use modern methods to detect areas, such as the use of remote sensing.

Soil quality is an essential element in ensuring sustainable agricultural production. However, soil degradation is a phenomenon that quickly spreads in regions with intensive crop cultivation. Mapping and modelling of major NPK elements in the soil of cereal-growing regions is a crucial step in understanding the distribution and accuracy of these elements in the soil, as well as in developing effective land management strategies for agriculture.

Numerous studies have been conducted on soil mapping and modeling around the world. For example, a study conducted by Bourenane et al. (2009) in France concluded that soil mapping is essential for decision-making in agriculture as it identifies areas with specific physicochemical properties.

Furthermore, major NPK elements are key components for the growth of cereal crops. The amount of these elements available in the soil can affect the quality, quantity, and growth of crops. Therefore, multiple research studies have been conducted to assess the presence and distribution of these elements in soils. For instance, Djebbar et al. (2014) evaluated the spatial distribution of major NPK elements in the agricultural soils of Northwestern Algeria.

In this work, we used precision Agricultural for mapping and modelling of major NPK elements in the soil of cereal-growing regions in the Tiaret region of Algeria will be examined. The objective of this study is to understand the distribution of these elements in soils in order to develop effective land management strategies to improve soil quality and agricultural production.

It is also worth noting that several other factors influence soil quality, such as texture, pH, and organic matter content. Thus, mapping and modeling of these elements may be conducted in conjunction with mapping and modeling of major NPK elements to provide a complete understanding of soil properties in the Tiaret region.

In conclusion, mapping and modeling of major NPK elements in the soil of cereal-growing regions are crucial for improving soil quality and increasing agricultural production. This study is an important contribution to research on the management and preservation of agricultural soils in the Tiaret region, Algeria.

Chapter I

Exploration Tool

I.1 Digital Soil Available N-P-K

Tester (Do not use it for measuring dry hard soil and liquid)

I.1.1 Working principle:

The electro-chemical method and the method of ionization redaction were adopted.

I.1.2 Application:

The tester is for field use to quickly test instant Nitrogen Instant Phosphorus and Instant Potassium. Content in soil.

I.1.3 Specification:

Measuring range:	0-1999 mg/Kg (mg/l)	Resolution:	1mg/Kg (mg/l)
Accuracy:	2% F.S.	Working temp:	5-45°C (41-113°F) /ATC
Feature:	Auto-switch-off in about 8 minutes	Display:	LCD with back light;
Calibration:	Factory standard calibrated	Probe length:	140 mm
Dimension:	Ø50.5 x 250 mm	Weight:	100g
Power supply:	DC 9V < (9V280/6F22 NMH rechargeable battery)		
Model:	ZD-1804N. P. K Combined ZD-180IN CI ZD-1802P ZD-1803K		

I.1.4 Usage:

1. Take off the protective cap from metal probe.
2. Press OFF/ON button Tester displays 0.
3. **Quick testing:** Water the soil with distilled water before testing. Make sure the water can go 10 cm deep the least. Best humidity is 70% 80% Insert the metal probe into soil vertically and clock wisely, to about 6-8 cm deep. Make sure the soil has thorough contact with metal probe. After about 6 seconds, the tester will display the measured value Tightness of soil will affect measuring result. Multiple tests at the same and different points should be performed and take the average as final result.

accurate testing: Use a 200ml beaker container, mix dried soil with distilled water at the stir and make it into a mud form Put the metal probe into the mud about 6-8CM deep. About 6 seconds, the tester will display the measured value.

4. Wipe the metal probe with towel or tissue paper after each test. Make it clean and dry, till the display shows 0.

I.1.5 Warring:

1. Do not use the tester to measure liquid. Do not measure dry and hard soil. Do not leave the metal sensor in the wet soil long (take out immediately after each test). Or it will damage the metal sensor and shorten the lifespan. Wipe the metal sensor clean and dry after each test.

2. The tester is factory calibrated. No need for calibration for users.

3. If the display fades, jumps, power supply may be not enough. Replace the battery.

4. When store the tester, put the protective cap onto the metal probe. Avoid touching metal probe with hands, avoid scratch with hard objects. Keep the tester in clean and dry environment. Keep it away from magnetic.

5. Measuring units: $1\text{mg/Kg}=1\text{mg/l}=1\text{ug/ml}=1\text{ppm}$.



Figure 01 : Digital Soil Instant N.P.K Nutrient Tester

Part

Experimental

Chapter II

Practical side

II. Presentation of the wilaya of Tiaret:**II.1 Geographic location:**

The wilaya of Tiaret is located in the northwestern part of the country and covers an area of 20,050.05 km² with a population of 988,129 as of 2020. It extends over a part of the Atlas Mountains in the north and over the high plateaus in the center and south. Its geographic coordinates are 1° 34' 59" E longitude and 34° 55' 0" N latitude (DSA, 2023).

Due to its geographical location, the wilaya of Tiaret is considered as a zone of contact between the north and south, and it is made up of three main areas which are as follows:

Mountainous area in the north,

High plains in the center,

And steppes in the south.

Tiaret is bordered by the provinces of:

- Chlef, Tissemsilt, and Relizane to the north
- Laghouat and El Bayadh to the south
- Mascara and Saida to the west
- Djelfa to the east.

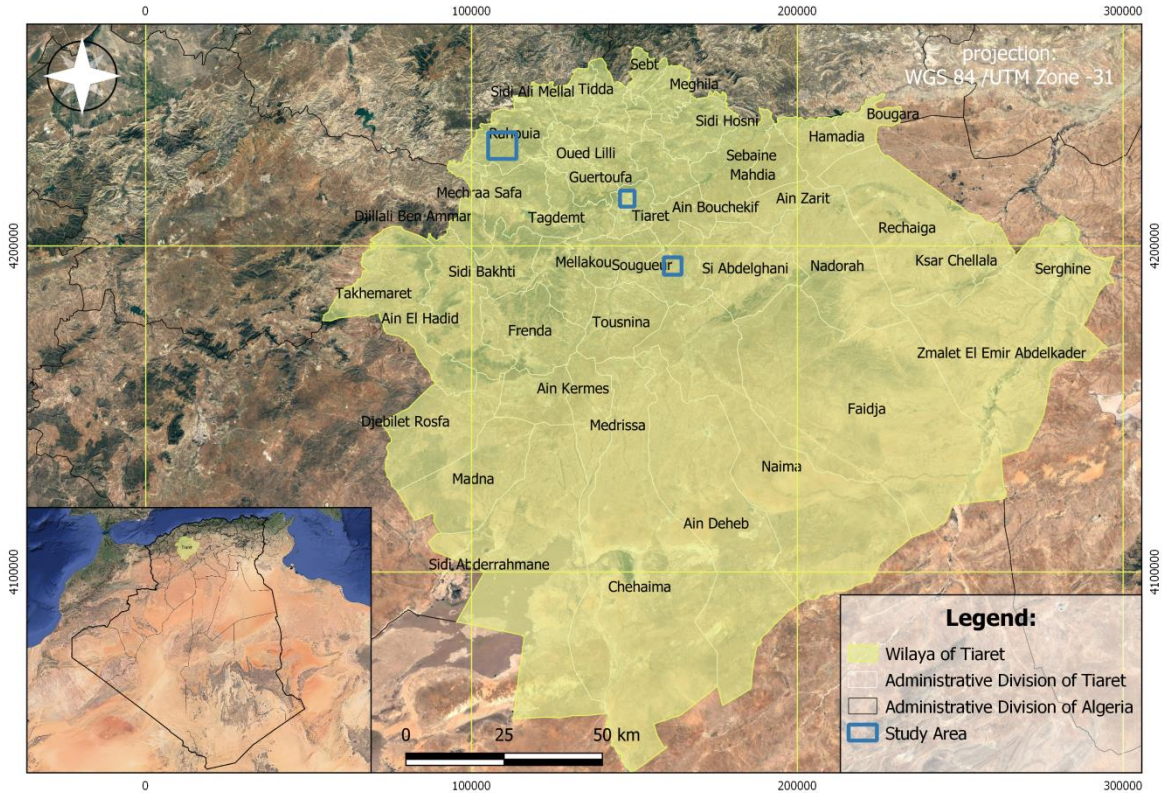


Figure 02: Geographies Situation carte for Wilaya of Tiaret

II.2 Relief:

The relief of the region is diverse and consists of a:

- mountainous zone in the North
- high plateaus in the center
- semi-arid areas in the South

Accounting for a significant percentage of the land (68.44%). This wilaya holds a wealth of natural potential, such as 1,609,900 hectares of agricultural land, 142,966 hectares of steppe areas, and a forest zone covering 142,422 hectares. The agricultural land is apportioned with 704,596 hectares of useful agricultural land, of which 14,561 hectares are irrigated, and one million hectares in steppe, Pasture, Alfa, and Forests. This region is primarily based on the "cereals-livestock" system, which is integrated to form the backbone of agricultural production and economic growth (Achir, Hellal 2016).

II.3 Climate:

The location of this area is situated at an altitude of 1150 meters and experiences two distinct seasons: an intense winter and a hot, arid summer with an average temperature of 37.2°C. An average temperature of 24°C is usually observed in a typical summer. The region of Tiaret province typically experiences an annual rainfall of 300 to 400 mm, with seasonal fluctuations ranging from 157 mm in winter to 31 mm in summer. This area is classified as belonging to the lower semi-arid Bio-climate zone, with a Mediterranean climate style and cool winters. (Achir, Hellal 2016).

II.4 Temperature:

According to DuPont and Altenbach (2003), the ideal temperature range for achieving optimal growth and maximum yield in plants is between 15°C and 20°C. However, temperatures exceeding 32°C can result in irreversible damage, potentially causing complete organ or plant destruction.

II.5 Mean Temperature:

The average Mean temperatures for the observation period of the agricultural year (2023) are shown in figure 03.

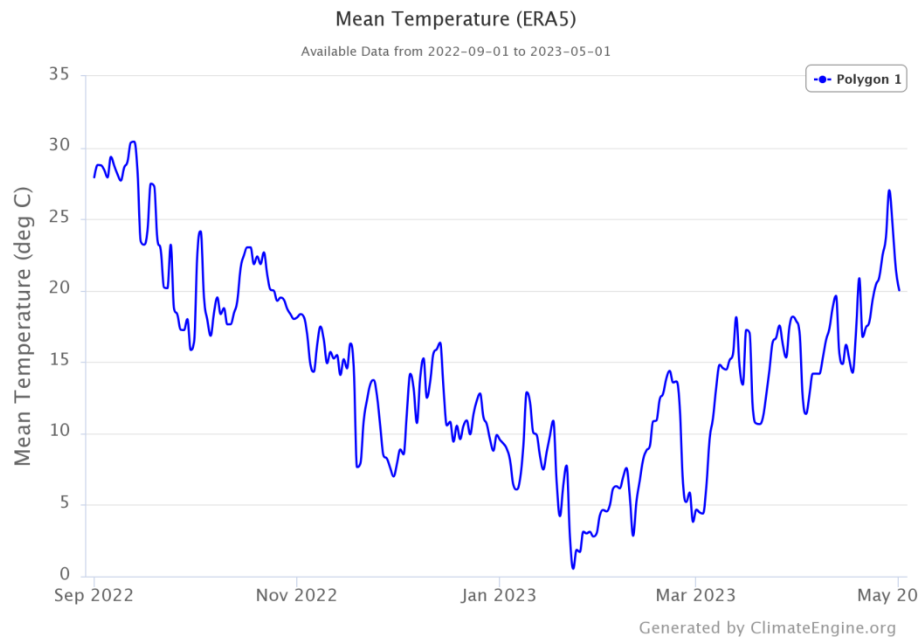


Figure 03: Mean Temperature of the Wilaya of Tiaret (2023)

Let's note that the annual average temperatures of the wilaya of Tiaret province are variable. Indeed, they range between 1°C and 30.5°C. The hottest month was recorded in September and May with 30.5°C and 28°C respectively, while the least hot period was marked in January and March with only 1°C and 4°C respectively.

II.6 Precipitation:

The wilaya of Tiaret province has an average annual rainfall of 300 to 400 mm. It falls into the lower semi-arid bioclimatic level and experiences cool winters with a Mediterranean type climate. Analysing the climate requires taking into account the essential element of rainfall. As highlighted by Estienne and Godard in 1970.

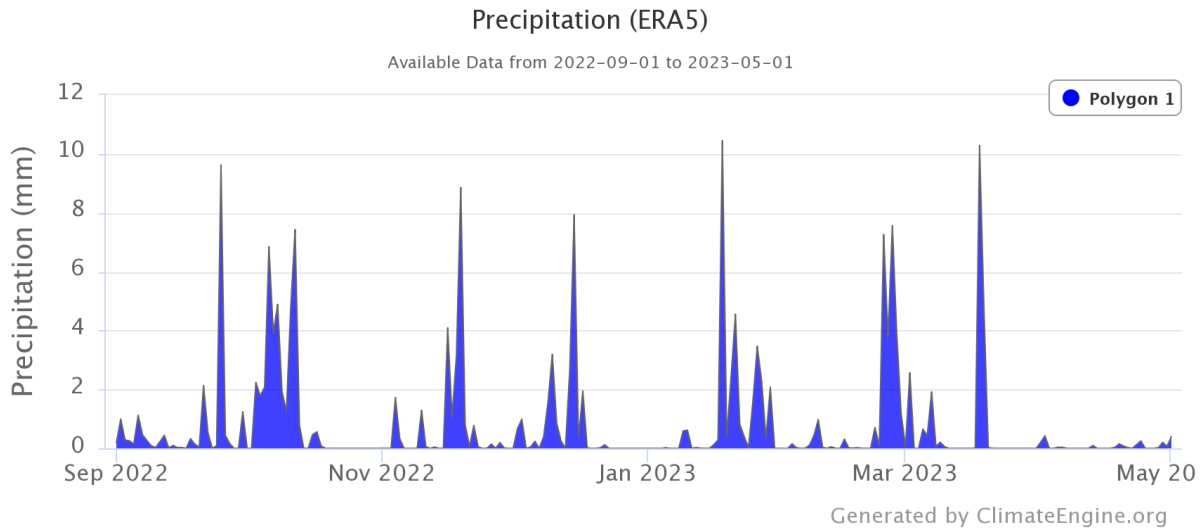


Figure 04: Distribution of rainfall in the wilaya of tiaret (2023)

Precipitation varies, over a period of 2023 (Sep-May), between a minimum 0.1 mm and a maximum of 10.5mm. The rainiest months were October, December and February and March with respective amounts of 9.5mm, 9mm and 10.5mm, 7.5mm. The months January, April and May were the driest with respective amounts of 1mm, 0.5mm and 0.3mm. We observe a variation of precipitation from 0mm to 10.5mm, indicating a very irregular internal regime.

II.7 Presentation of the study area:

II.7.1 Geographical location of Souger:

The study took place at the pilot farm "Sherif El-Din Soukra", The Sougueur District is located less than 30km south of the Tiaret Province, in the high plateaus at the southwest limit of the Sersou plateau. It is bordered by:

- To the North by the municipalities of Ain Dzarit, Bouchekife and Mellakou
- Southeast by the province of Laghouat.
- To the East by the municipalities of Zmalet Emir AEK and Nadhoura.
- To the West by the municipalities of Medroussa and Frenda.
- To the Southwest by the municipality of Medrissa.
- To the South by the municipalities of Chehaima and Naima.
- Its total area is 3263.02km².

II.7.2 Geographical location of Rahouia:

The study took place at the pilot farm "Boukhetache Bouziane" belonging to the Evaluation and Valorization of Farms and Agricultural Perimeters Society (SEVFPA), Ministry of Agriculture and Rural Development (MADR), located in the municipality of Rahouia at an altitude of 620 meters, between 35°31' northern latitude and 1°1' eastern longitude. It is a cereal zone located 38 km northwest of the capital of the Tiaret province. It has a cereal vocation in addition to sheep/cattle farming.

Climate is one of the essential factors that influence the development and spatial and temporal distribution of vegetation. Thus, Rahouia has a continental climate with a very harsh winter and a hot and dry summer according to the Köppen-Geiger classification. Throughout the year, the average temperature in Rahouia is 14.9°C and the rainfall is on average 300 to 400 mm.

Chapter II

Experimental protocol

III. Experimental protocol:

The objective of our study to Create maps of the distribution of the major NPK elements (nitrogen, phosphorus, and potassium) in cereal soils the region of Tiaret:

Develop a model to predict the levels of NPK elements in cereal soils based on various factors such as soil type, climate, and agricultural practices.

Use the maps and model to identify areas where the levels of NPK elements are low or high and suggest ways to optimize fertilizer application and other management practices to improve soil health and crop yields.

Overall, the objective of this work is to improve our understanding of the distribution, factors affecting, and management of NPK elements in cereal soils, which can help to enhance sustainable agriculture practices and food security.

III.1 Site selection:**III.1.1 Agricultural significance:**

Rahouiya and Souger are known for their agricultural significance, particularly in cereal production. These regions are among the primary cereal producing locations in Algeria, which makes them suitable for a study focusing on cereal soil.

III.1.2 Variability in soil properties:

The soil properties in Rahouiya and Souger vary significantly, making them ideal for studying NPK elements in cereal soil. Soil variability poses a challenge to farmers, and understanding the distribution of NPK elements in the soil may help farmers make informed decisions when applying fertilizers.

III.1.3 Availability of data:

These regions have been the focus of various soil investigations, and data related to soil properties and nutrient content are available. This availability of data can save time, money, and resources in collecting necessary background information for the study.

III.1.4 Ease of access:

The regions are easily accessible, making it convenient to collect soil samples in a relatively short time. This access can reduce the cost associated with conducting fieldwork.

III.1.5 Room for comparability:

Rahouiya and Souger share similar environmental and climatic conditions, which may allow for comparability of study outcomes. Comparability of outcomes is essential in scientific research, and this makes these regions ideal for our study.

Chapter IV

Materials and methods

IV. Collection of soil samples:

Prior to initiating the sampling process, it is crucial to assess the consistency of the terrain, taking into account factors such as its level uniformity, vegetation and soil type, and any modifications that have been made. In line with the guidelines provided by Dari (2013), samples must be collected under equivalent physical conditions, including identical temperature and humidity levels, and always on the same day.

In the sampling process, we included the entire selected agricultural plot in each district (Souger, Rahouiya). This is not an easy task, but it is necessary to achieve the goal of the study and to ensure accurate results. Systematic sampling sites must be identified and movement across the entire plot is required. Samples were taken from depths of 20-30 cm to a distance of 100-150 meters (depending on the area of studied plot) using a special auger to take soil samples, and put them in individual bags. At each point we save the geographic coordinates with an Android application (UTM geo map).

The total number of samples is 46 Each sample was clearly identified by a label attached to the bag indicating a reference number then were sent to the pedology laboratory of the Faculty of natural and life sciences for the purposes of physicochemical analyses.

IV.1.1 The first outing (Souger):

The 21/03/2023

- Durum wheat plot (*Triticum durum* desf)
- Area of approximately (80ha)
- Semeto (G3) variety
- Previous fallow crop
- Seeding density (1.8 Qx/ha)
- AXIAL weedkiller (1L/ha)
- AZOSUL+ coverage (1Q/ha)
- Soil samples: 30

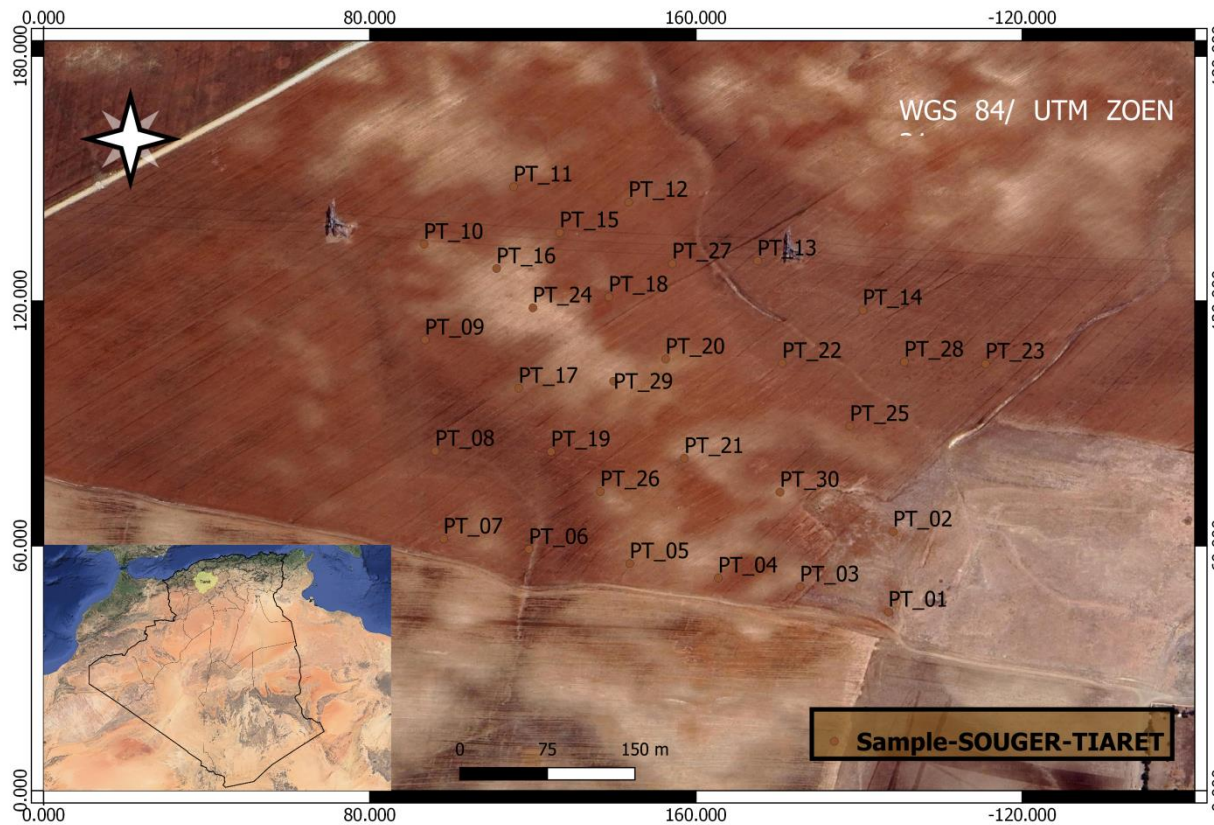


Figure 05: Soil sampling points of Souger Region

IV.1.2 The second outing (Rahouiya):

The 11/04/2023

- Barley Plot (*Hordeum Vulgare*)
- Area of approximately (70ha)
- Saida (G4) variety
- Previous fallow crop
- Seeding density (1.4 Qx/ha)
- Soil samples: 16

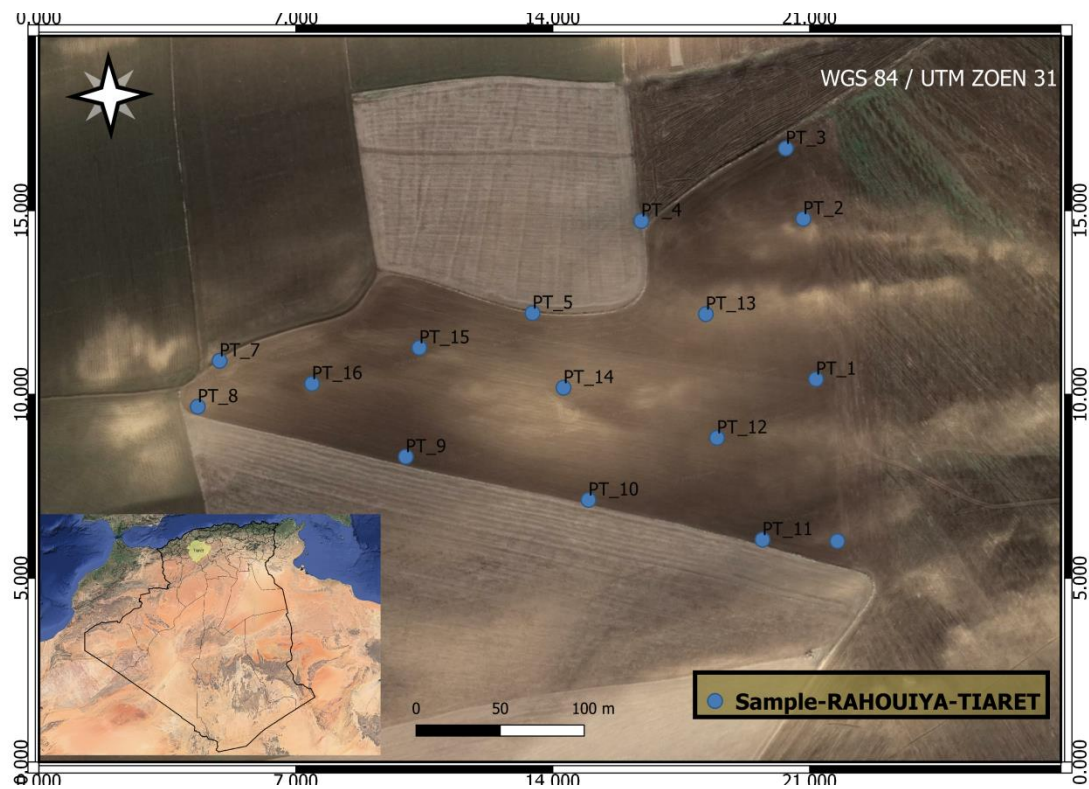


Figure 06: Soil sampling points of Rahouiya Region

The samples taken were air-dried for 7 days, then crushed and sifted through a 2mm sieve (Figure). After obtaining fine soils, we performed the following analyses (Figure 08): water pH and KCl pH, organic matter, electrical conductivity,

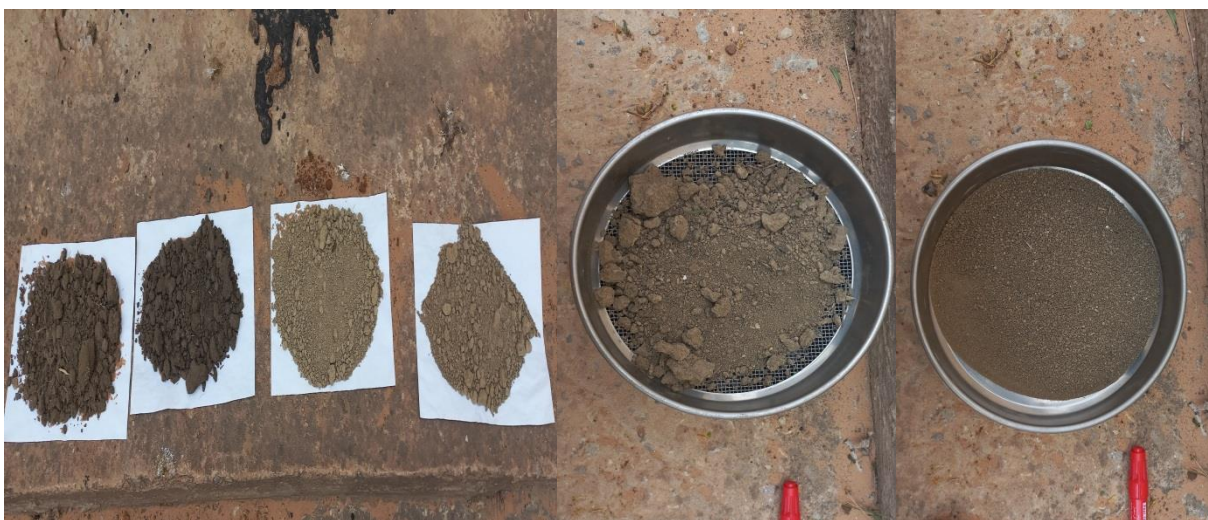


Figure 07: Drying, grinding, and sieving of soil samples

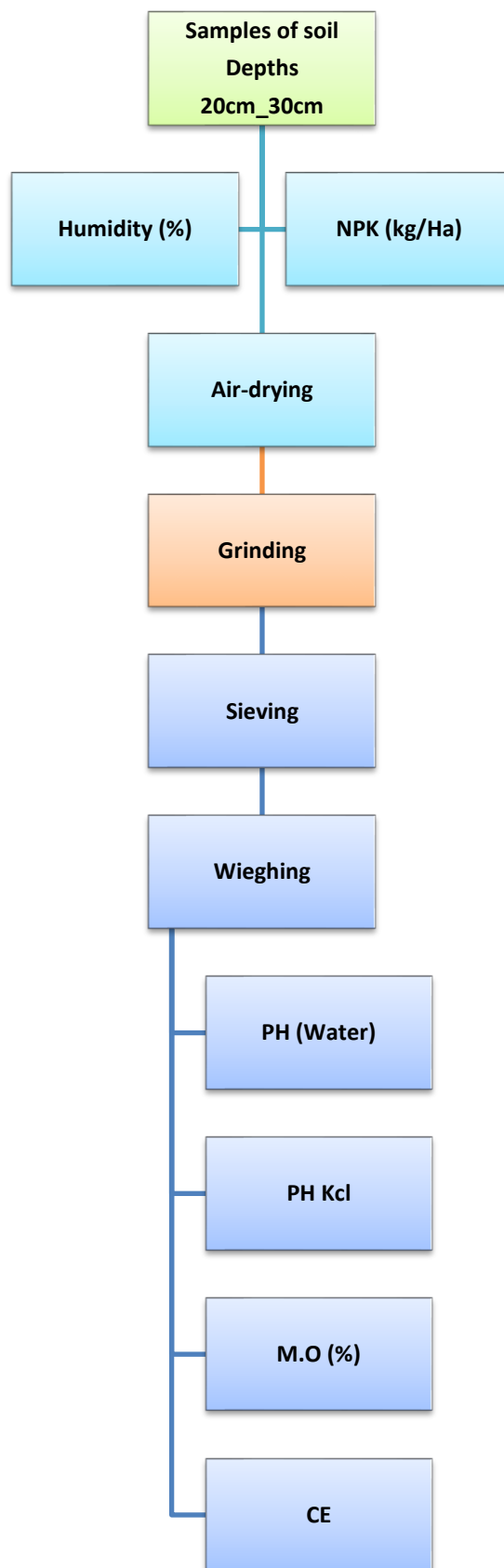


Figure 08: Organizational chart of soil sample preparation and analysis

IV.2 Physico-chemical analysis:

The analysis carried out on the soil samples are:

The pH is determined using a pH meter.

NPK is determined using the Digital Soil Available N-P-K.

The organic matter is identified through the following formula: $MO (\%) = CO \times 1.72$.

Electrical conductivity is determined using a multispectral suitcase.

Other equipment used:

sieve, magnetic stirrer, graduated cylinder, volumetric flask, capsules, timer, oven, precision balance, conductivity meter, ROBENSON pipette".

IV.2.1 Humidity:

The level of moisture contained in the soil, known as humidity, is measured by taking a percentage of the water content in relation to the amount of dry soil. The determination of this measurement involves drying a 10 g soil sample in an oven set at 105°C (as demonstrated in figure 20), and the variance in weight pre- and post-drying indicates the quantity of water present (ITA, 1975).

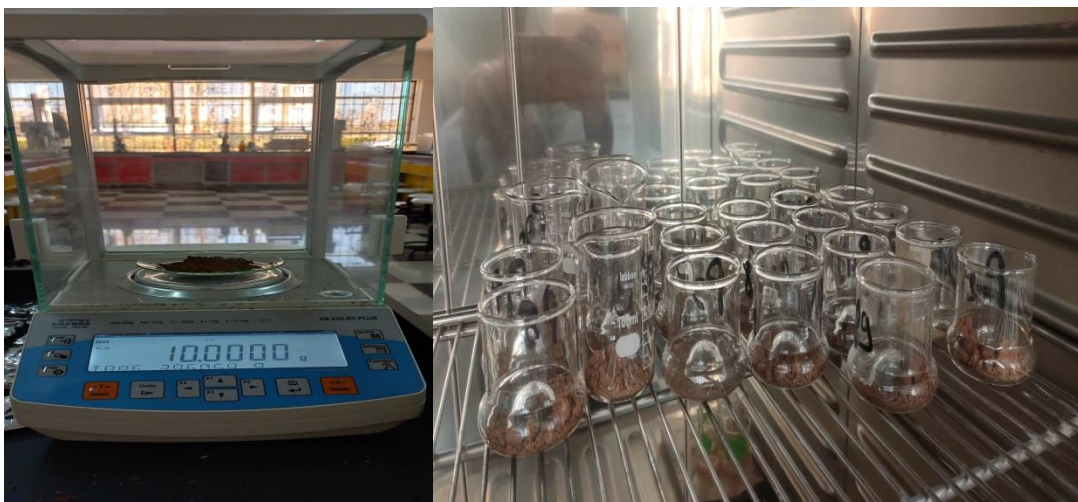


Figure 09: Moisture of the samples

IV.2.2 Water pH measurement:

Using a laboratory pH meter (Mathieu and Pielain, 2009), the electrochemical method was utilized to measure the pH of a 1/5 extract.

2.2.1 Operating mode:

Take 10 g of fine soil plus 50 ml of distilled water.

Shake for 5 minutes, and then let it rest for 30 minutes.

Insert the electrode into the supernatant (figure 21).

Read the number as soon as it becomes stable.

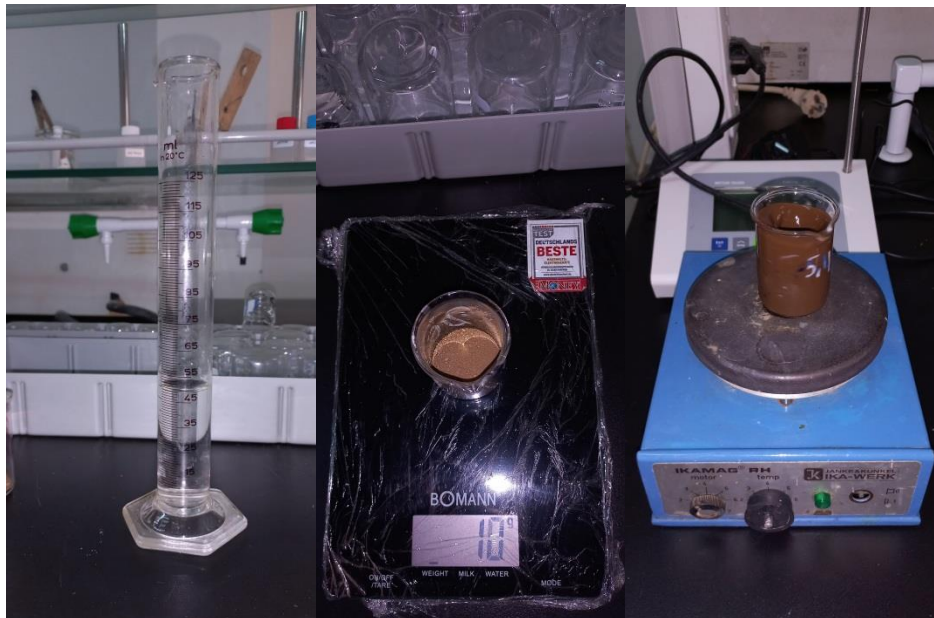




Figure 10: Preparation and Measurement of the pH of a soil sample using a pH meter

IV.2.3 Electrical conductivity:

The total soil salinity is determined by the electrical conductivity, which is influenced by the type and quantity of soluble salts found in the soil (Guessoum, 2001).

2.3.1 Operating mode:

Weigh 10 g of soil and add 50 ml of distilled water;

- Shake for 5 minutes and then let it rest for 30 minutes;
- Heat up to 25 °C;
- Immerse the Conduct-meter electrode and read the conductivity value once the needle is stationary.

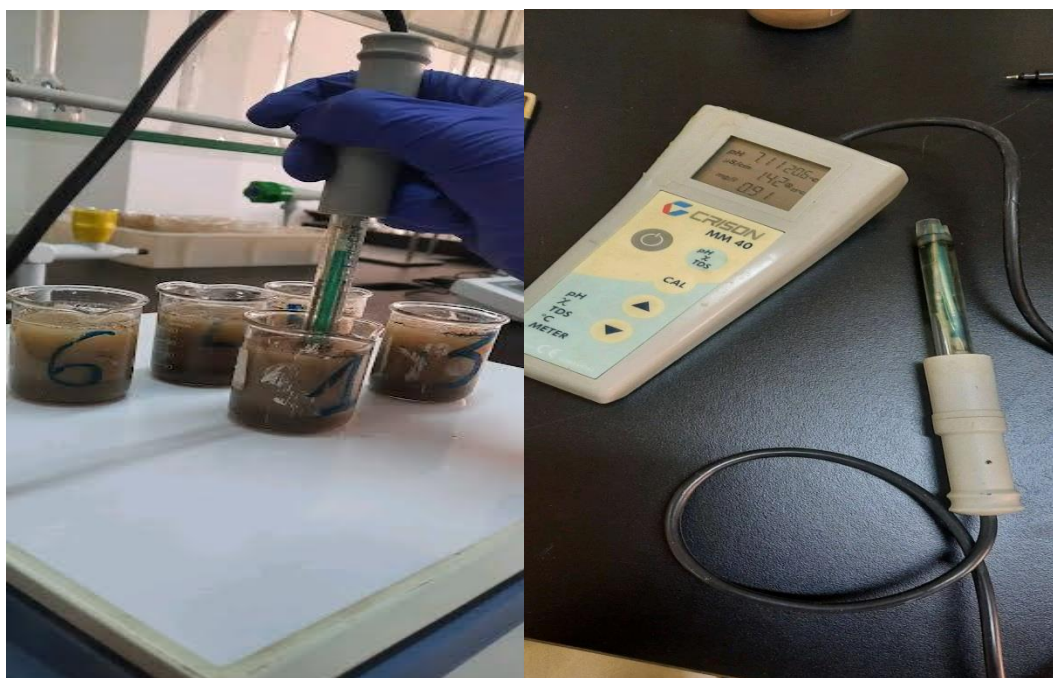


Figure 11: Measurement of soil electrical conductivity using a conduct-meter

IV.2.4 Organic material:

The organic matter content was assessed by measuring carbon levels using potassium dichromate ($K_2Cr_2O_7$) oxidation in acidic media. The excess $K_2Cr_2O_7$ was then titrated using MOHR's salt ($(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$), with diphenylamine and sodium fluoride present, resulting in a color change from purple to green. As noted by Aubert (1978), the amount of reduced dichromate is directly proportional to organic carbon content.

2.4.1 Operating mode:

Weigh 1g of soil; add 10ml of potassium Dichromate and 15ml of sulfuric acid connect the flask to the condenser (figure 25).

Heat using a hot plate until the first drop appears, wait 5 minutes after the sample boils, remove the flask and let it cool;

Transfer the contents to a 250ml volumetric flask; fill with distilled water up to 250ml;

Shake well (10 times) and let it rest for half an hour;

Take 50ml of the solution and add 1.5ml of concentrated phosphoric acid (H_3PO_4) and 3 drops of the colored indicator (diphenylamine);

Titrate with Mohr's salt.

The percentage of organic matter is then calculated according to the following relationships:

$$C\% = (V' - V) * 0,3$$

$$MO\% = C\% * 1,72$$

- V' : the amount of Mohr's salt used in the blank (without soil).
- V : the amount of Mohr's salt used in the soil sample.



Figure 12: Preparation and Measurement of Organic carbon dosage

IV.2.5 NPK major elements:

The Major Elements There is six essential minerals for plant development, called major elements, which include: nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg). Among the six mentioned elements, the first three, N, P, and K, are crucial elements that the plant needs in larger quantities. These are elements that are found in the composition of the majority of chemical fertilizers. (Coïc and Coppenet, 1989)

2.5.1 Operating mode:

- We start by weighing (50g) of soil.
- Add (100ml) of distilled water in a 50ml beaker.
- Mix in the shaker for one hour.



Figure 13: Preparation of soil solutions for measuring NPK

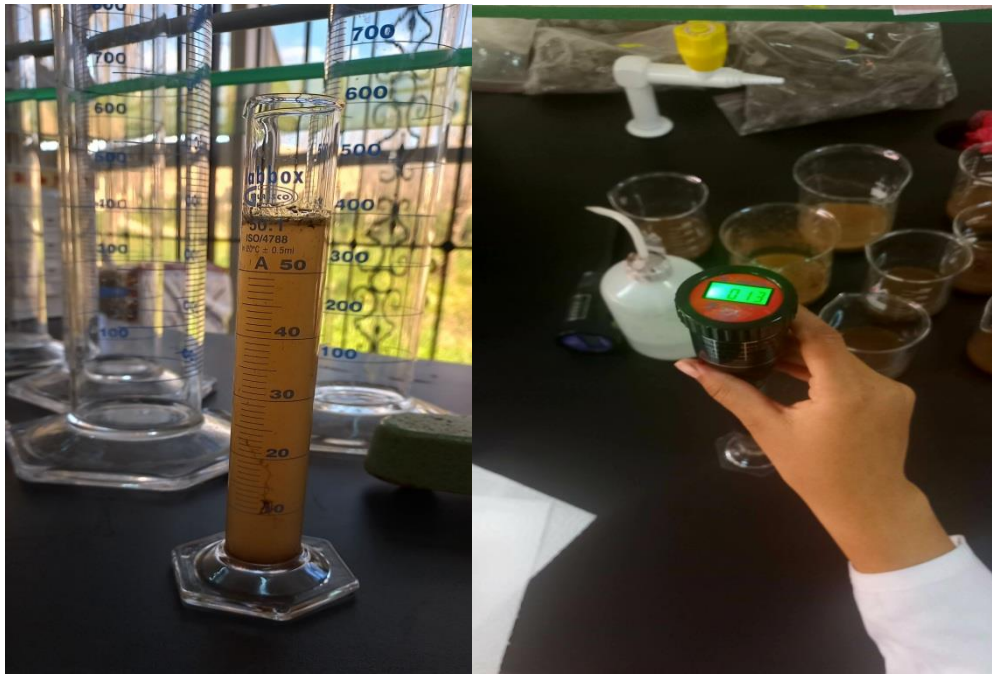


Figure 14: NPK measurement with sensors

IV.3 Remote sensing part:

IV.3.1 QGIS:

QGIS (formerly Quantum GIS) is a free and open-source Geographic Information System (GIS) software that can be used for cartography and modeling in various fields such as geography, environmental science, urban planning, and more. Here are some ways you can use QGIS for cartography and modeling:

3.1.1 Map Design:

QGIS provides a powerful set of tools for creating visually appealing maps. You can add various layers such as vector data (shapefiles, geodatabases), raster data (satellite imagery, digital elevation models), and even web mapping services. QGIS allows you to customize symbology, labels, legends, and layouts to create professional-quality maps.

3.1.2 Spatial Analysis:

QGIS has a wide range of spatial analysis tools that can be used for modeling and simulation. You can perform operations like buffer analysis, overlay analysis, proximity analysis, and more to understand spatial relationships and patterns in your data. These tools are valuable for tasks such as site selection, suitability analysis, and impact assessment.

3.1.3 3D Visualization:

QGIS has a built-in 3D visualization tool called QGIS2Threejs, which allows you to create interactive 3D maps and models. You can display elevation data, extrude buildings or terrain features, and even integrate photographs or textures to create realistic 3D representations of landscapes or urban environments.

3.1.4 Network Analysis:

QGIS includes various network analysis plugins that can be used for modeling transportation networks, routing, and accessibility. For example, you can calculate shortest paths, find optimal routes based on different criteria (e.g., distance, time, cost), and analyze connectivity or service coverage in a network.

3.1.5 Time-series Analysis:

QGIS has tools and plugins for handling time-series data, allowing you to analyze temporal patterns and trends. You can animate data over time, perform temporal queries, and create dynamic maps or visualizations that show changes in your spatial data over different time periods.

3.1.6 Geospatial Statistics:

QGIS provides tools for geospatial statistics, enabling you to analyze and model spatial patterns and relationships in your data. You can perform statistical tests for spatial autocorrelation, clustering, hotspots, spatial interpolation, and more. These tools are useful for understanding spatial distributions and making predictions or estimations in your study area.

Overall, QGIS is a versatile software for cartography and modeling, offering a broad range of tools and functionalities to support various spatial analysis and visualization tasks.

IV.3.2 Google Earth Engine:

Is a cloud-based platform that allows users to analyze and visualize geospatial data sets. It combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers.

With Google Earth Engine, users can perform a variety of geospatial analyses, including land cover classification, change detection, vegetation indices calculation, time series analysis, and

more. The platform supports coding in JavaScript and Python and provides access to a wide range of satellite imagery, such as Landsat, Sentinel-2, and MODIS, as well as climate and environmental datasets.

Google Earth Engine also provides tools for data visualization, allowing users to create maps, charts, and animations from their analysis results. Additionally, it offers collaboration features, so multiple users can collaborate on projects and share their analyses and visualizations with others.

Overall, Google Earth Engine is a powerful platform that enables users to explore and leverage large-scale geospatial data for various applications, including environmental monitoring, agriculture, urban planning, and disaster management.

IV.3.3 UTM Geo Map:

Is a simple android application to help your work related to Coordinates, Maps, and GIS & Spatial Analysis. Created by Geodesy Engineers with a dozen years of experience in the world of digital mapping, UTM Geo Map can meet the professional needs of mapping applications as well as being easy to use for ordinary users.

Today UTM Geo Map is used by more than 1 million users around the world and translated into 14 different languages.

Chapter V:

Results and Discussion

V. Results and Discussion:

Pedagogical analyses are important in understanding the components and physical and chemical characteristics of soils, as noted by Bonneau and Souchier in 1979. The following section presents findings from multiple analyses, including NPK, pH levels of water and KCL, moisture, conductivity, and organic matter.

V.1 Physicochemical analysis:**V.1.1 Humidity:**

The concept of moisture content pertains to comprehending the chemical and hydrological characteristics of soils, along with their impact on the growth of plants (Michel et al, 2011).

The table displays the results obtained for all soil samples (barley, durum wheat):

Table 01: Descriptive humidity statistics

Statistics	Plot	Durum wheat	Barley
MIN		1.223	1.158
MEAN		5.570	2.226
MAX		11.61	3.211

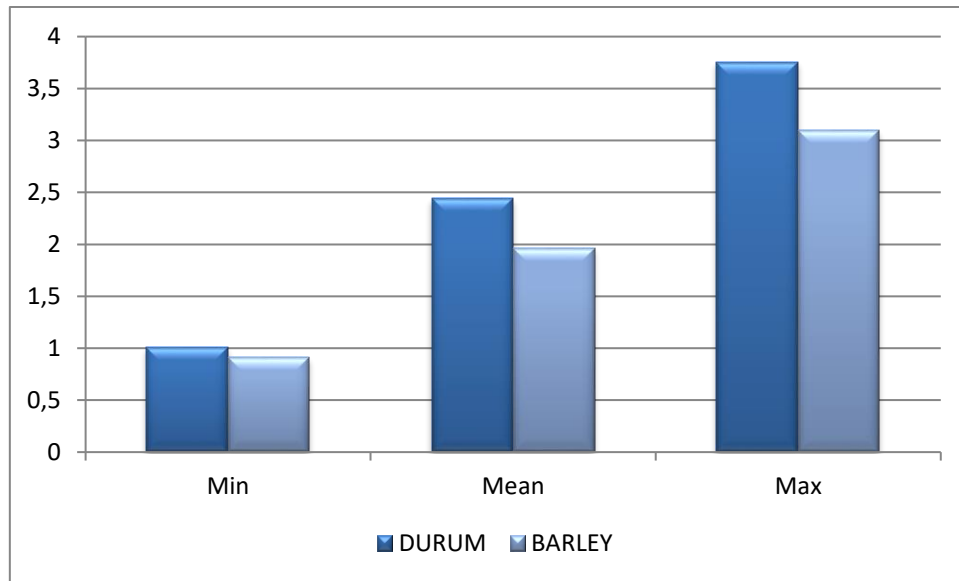


Figure 15: Graphical presentation of humidity levels of Durum and Barley

According to the (figure15), we find that Barley has a relative frequency in all classes the Humidity is low; on the other hand Durum has a high frequency in three classes of humidity Can be explained by the meticulous tillage of the soil which promotes the improvement of Porosity as well as permeability in addition, it is the effect of irrigation.

V.1.2 Water pH measurement:

The measurement of acidity in a solution is expressed as pH, which is the negative logarithm of the H^+ concentration. Plant growth is influenced by pH levels, as it impacts the assimilation of nutrients. The ideal pH range for this process is between 5.5 and 7.5 (unknown, 1977).

The table presents the statistical characteristics of pH in the soils of the two plots:

Table 02: Descriptive Water pH statistics

Plot	Durum wheat	Barley
MIN	7.04	7.49
MEAN	7.92	8.205
MAX	8.37	8.45

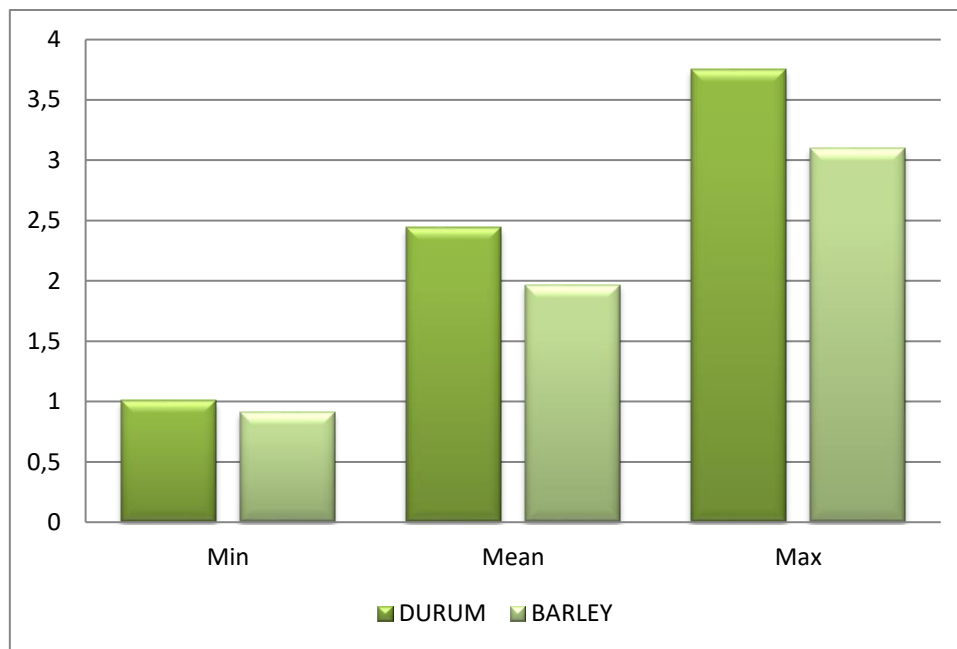


Figure 16: Graphical presentation of pH levels of Durum and Barley

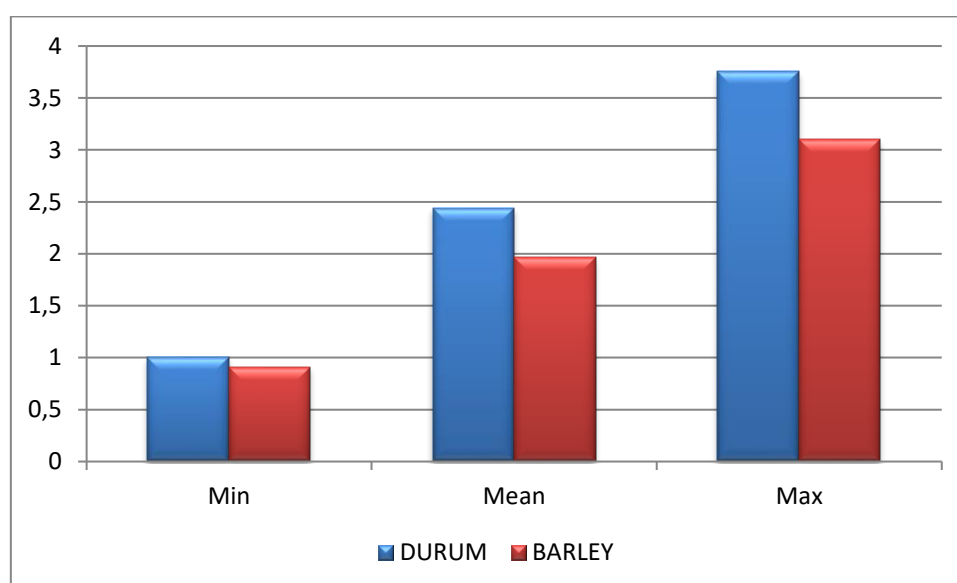
When comparing the graphical presentation of pH levels between durum and barley, there is a clear distinction between the two. Durum, generally exhibits higher pH levels compared to barley. The graph representing durum's pH levels showcases a consistently higher range, indicating an alkaline nature. On the other hand, the pH levels for barley are visibly lower, appearing more acidic in nature. This contrast in pH levels underscores the fundamental difference in the chemical composition and characteristics of these grains. It highlights why durum is well-suited for making pasta while barley is primarily used for brewing and animal feed.

V.1.3 Electrical conductivity:

According to the figure 17, there is no variation between the electrical conductivity of the different soil samples. The values of the electrical conductivity, of the soil samples, recorded are between 32 and 351 $\mu\text{S}/\text{cm}$. strong ionic force these high values indicate a presence of soluble salts and a mineral character in the soil.

Table 03: Descriptive Electrical conductivity statistics

Plot	Durum wheat	Barley
MIN	89.5	32.4
MEAN	126.93	182.99
MAX	282	351

**Figure 17:** Graphical presentation of CE levels of Durum and Barley

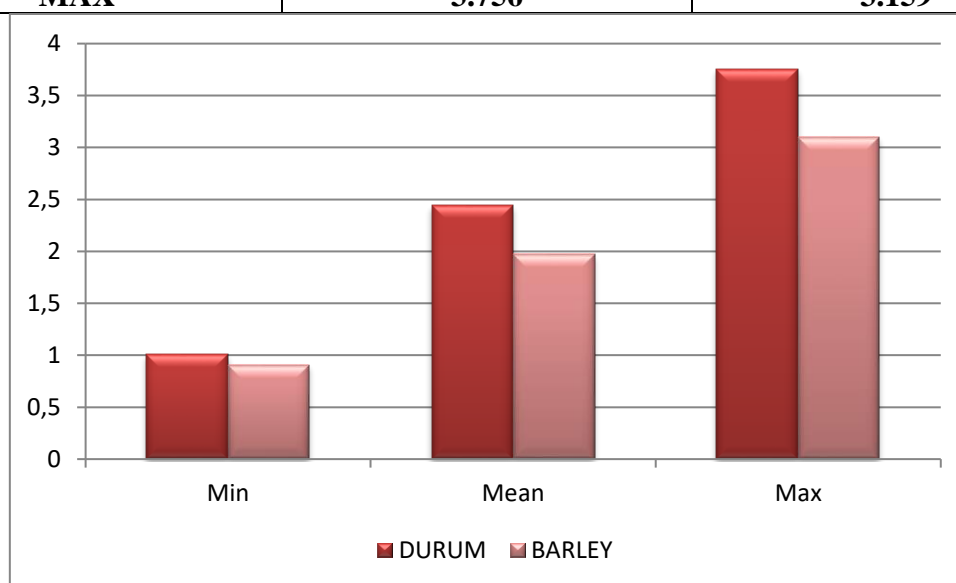
Through the figure 17 we notice that Barley and Durum are distributed on unsalted and slightly saline soils. This refreezing of the EC in both types of cereal is certainly due to the water used for irrigation there is a Decrease in EC for healthy standing, which may be due to solubilization of salts and their deep entrainment by the leaching processor.

V.1.4 Organic material:

The amount of organic matter in the soil makes it possible to assess its impact on certain soil evolution processes.

Table 04: Descriptive Organic material statistics

Plot	Durum wheat	Barley
MIN	1.0062	0.908
MEAN	2.442	1.966
MAX	3.756	3.159

**Figure 18:** Graphical presentation of Organic material levels of Durum and Barley

The distribution of durum and barley is shown in the three strata of organic matter (Figure18).

The fertility of the soil is certainly due to the added inputs of organic matter and/or Agricultural crops that we observed during our exit (appendix).

V.1.5 Discussion of NPK Results:

The values in Table 05 represent the nutrient application ranges for durum wheat and Barley, expressed in kilograms/hectare (kg/ha). For durum wheat:

The nitrogen (N) range is 28,3 kg/ha to 64,8kg/ha.

The phosphorus (P) range is 23,1kg/ha to 54 kg/ha.

The potassium (K) range is 75,6kg/ha to 176,4kg/ha.

For Barley:

The nitrogen (N) range is 39,6kg/ha to 61,2 kg/ha

The phosphorus (P) range is 36kg/ha to 65,2 kg/ha.

The potassium (K) range is 90kg/ha to 165,6kg/ha.

Table 05: Results of soil NPK analysis study

Statistics	Plot	Durum wheat			Barley		
		N	P	K	N	P	K
NPK (Kg/ha)							
MIN		28,3	23,1	75,6	39,6	36	90
MEAN		38,03	36,59	103,92	47,47	47,57	127,35
MAX		64,8	54	176,4	61,2	65,2	165,6

These values represent the recommended quantities of nitrogen, phosphorus, and potassium for optimal growth and yield of durum wheat and soft wheat crops. It is important to note that nutrient requirements can vary depending on factors such as soil type, climate, wheat variety, and farming practices. Therefore, it is recommended to consult specific standards and recommendations for your region and consider local conditions to determine the precise amounts of fertilizer to use.

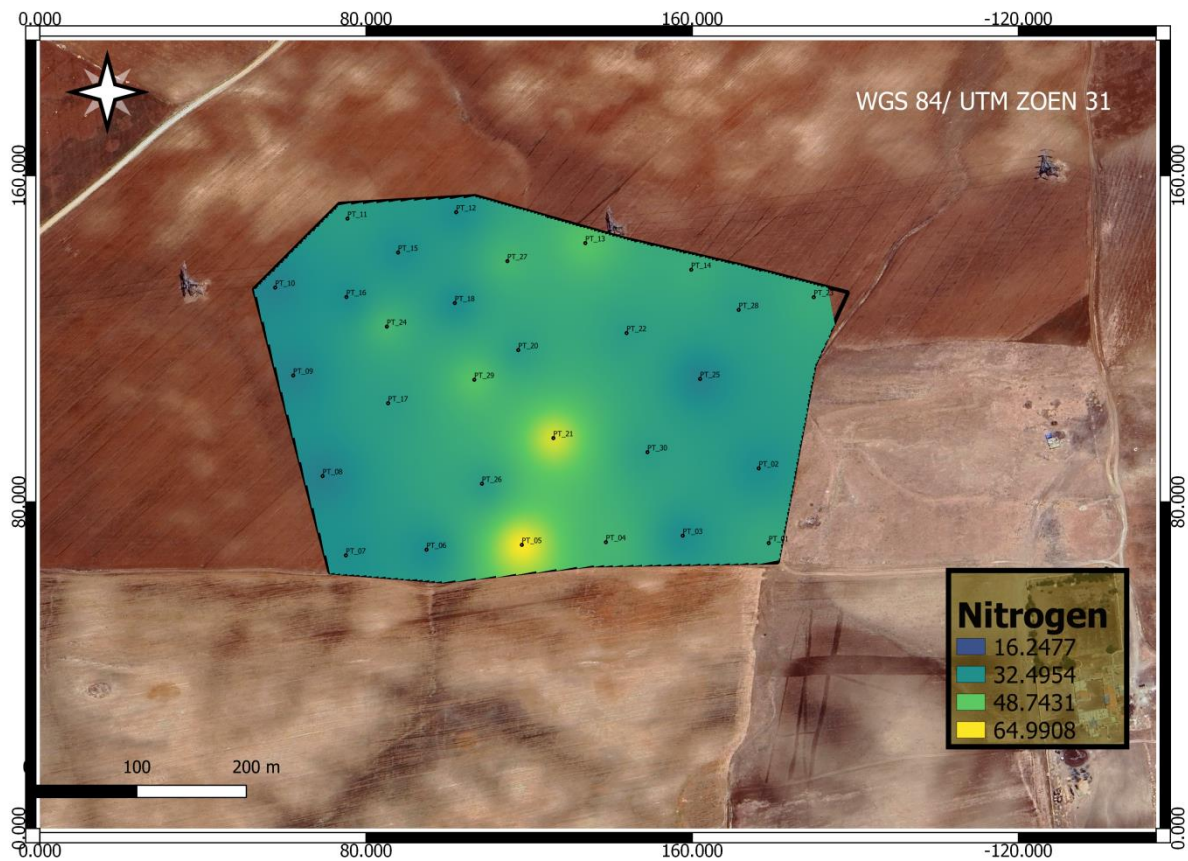


Figure 19: interpolation carte for N for Durum wheat

The map represents nitrogen values in durum wheat at the Sherif El-Din Soukra experimental farm in Tiaret. The N values range from 16,24 to 64,99. These values represent nitrogen concentrations. By using the map legend, we notice that purple color correspond to the lowest concentrations, while Yellow corresponds to the highest concentrations. There are also shades of light Blue and green for average values.



Figure 20: interpolation carte for N for Barley

The map represents nitrogen values in Baley at the Boukhttache experimental farm in Tiaret. The N values range from 15, 24 to 60, 99. These values represent nitrogen concentrations. By using the map legend, we notice that purple color correspond to the lowest concentrations, while Yellow corresponds to the highest concentrations. There are also shades of light Blue and green for average values.

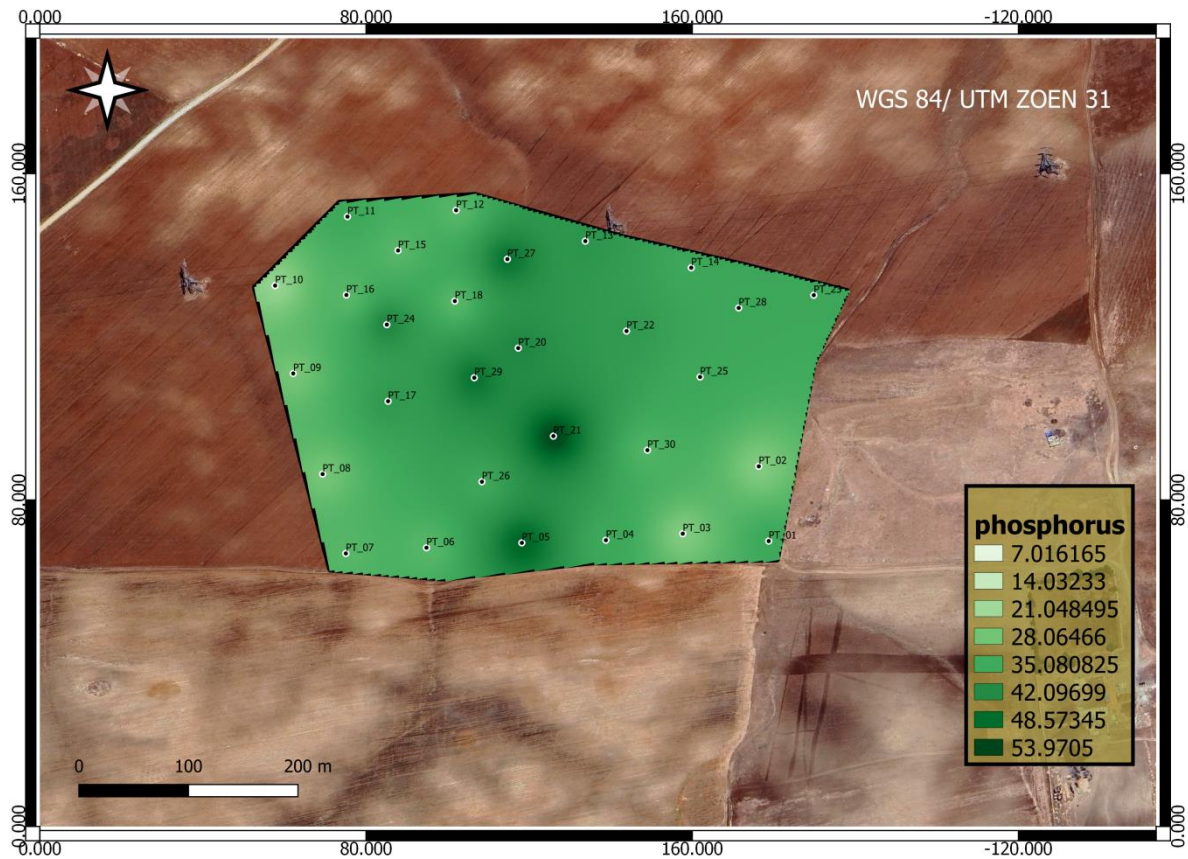


Figure 21: interpolation carte for P for Durum wheat

The map represents phosphorus values in durum wheat at the Sherif El-Din Soukra experimental farm in Tiaret. The P values range from 7,01 to 53,97. These values represent phosphorus concentrations. By using the map legend, we notice that white color correspond to the lowest concentrations This explains the phosphorus deficiency and requires specific management to improve the availability of phosphorus.

while Dark green corresponds to the highest concentrations, and this is explained by the map as areas with higher levels of phosphorus, which are more conducive to plant growth. The variation in phosphorus values is attributed to soil fertility, represented in green on the map. also shades of light green for average values.



Figure 22: interpolation carte for P for Barley

The map represents phosphorus values in Baley at the Boukhttache experimental farm in Tiaret. The P values range from 7,62 to 60,99. These values represent phosphorus concentrations. By using the map legend, we notice that white color correspond to the lowest concentrations this explains the phosphorus deficiency and requires specific management to improve the availability of phosphorus.

While Dark green corresponds to the highest concentrations, and this is explained by the map as areas with higher levels of phosphorus, which are more conducive to plant growth. The variation in phosphorus values is attributed to soil fertility, represented in green on the map. Also shades of light green for average values.

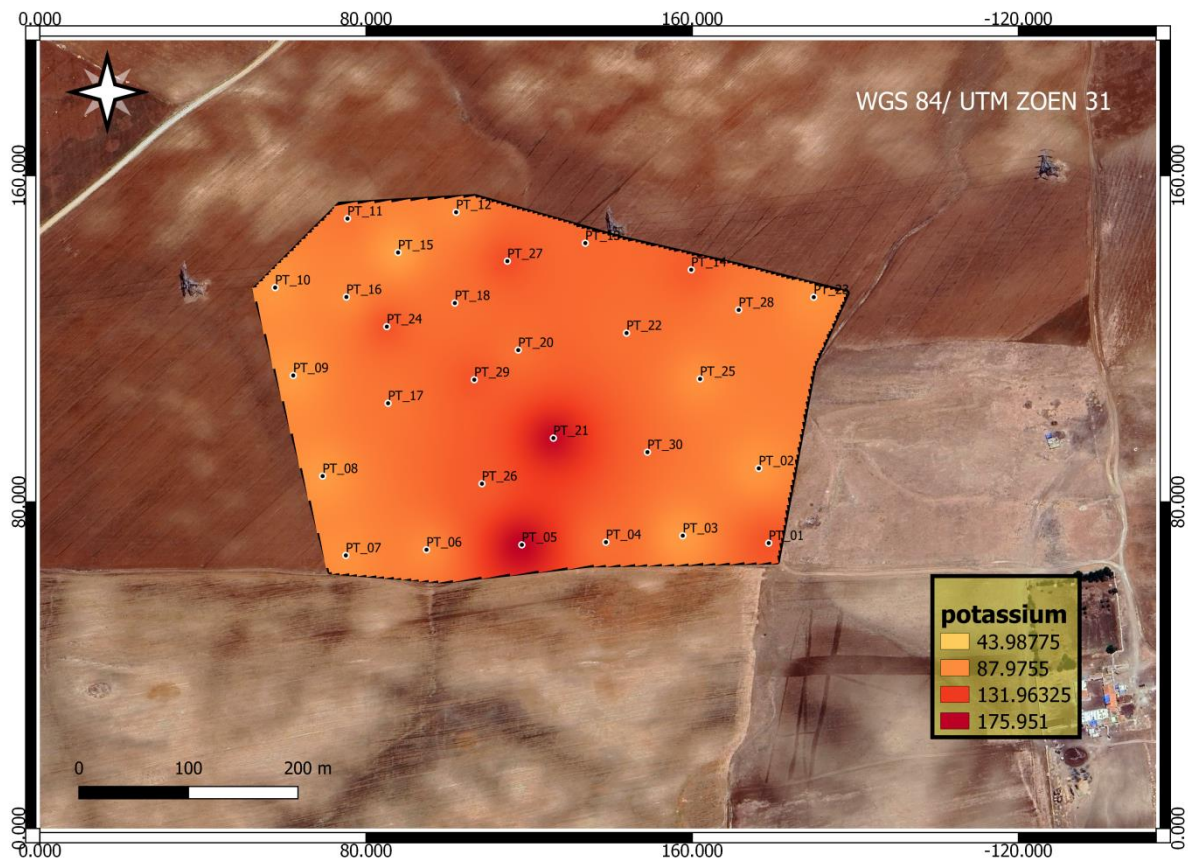


Figure 23: interpolation carte for K for Durum wheat

The map represents potassium values in durum wheat at the Sherif El-Din Soukra experimental farm in Tiaret. The K values range from 43,98 to 175,95. These values represent potassium concentrations. By using the map legend, we notice that light orange corresponds to the lowest concentrations, while red corresponds to the highest concentrations. There are also shades of light orange and red for average values.



Figure 24: interpolation carte for K for Barley

The map represents potassium values in in Baley at the Boukhtache experimental farm in Tiaret. The K values range from 41,49 to 165,99. These values represent potassium concentrations. By using the map legend, we notice that light orange correspond to the lowest concentrations, while red corresponds to the highest concentrations. There are also shades of light orange and red for average values.

Conclusion

Conclusion

The study of cartography and modeling of major NPK elements in the cereal soil region of Tiaret has provided significant insights into the current state of soil fertility and nutrient management practices in the region. The results obtained from this study have shed new light on the spatial distribution patterns of nitrogen, phosphorus and potassium in the soil, and have also highlighted the importance of proper soil nutrient management practices for the sustainable development of the agricultural sector in Tiaret.

Through the use of sophisticated analytical techniques, such as Geographic Information Systems (GIS), multivariate statistics and spatial interpolation, this study has been able to produce highly detailed and accurate maps of NPK distribution in the area, which can serve as important decision-making tools for farmers, policymakers and other stakeholders involved in the agricultural sector.

The findings of this study confirm that proper management of soil nutrients is crucial for ensuring high crop yields and maintaining soil fertility in the long term. The application of appropriate fertilizers at appropriate rates and times can help significantly reduce nutrient imbalances in the soil, which in turn can lead to improved crop productivity and reduced environmental degradation.

Furthermore, this study has demonstrated the importance of adopting a holistic approach to sustainable soil management, which takes into account the various environmental and socio-economic factors that impact soil fertility. Policies aimed at promoting sustainable agricultural practices, including precision fertilization and nutrient recycling, can help ensure the long-term viability of the agricultural sector in Tiaret and contribute towards achieving global food security.

In conclusion, the results of this study have important implications for the management of soil nutrients in the cereal soil region of Tiaret and for the wider agricultural sector. It is hoped that these findings will contribute towards the development of more effective policies and strategies for promoting sustainable soil management practices, which can help ensure the long-term viability of the agricultural sector in the region and beyond.

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List of references

List of references

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Appendices

appendices

Appendices 01: Soil pH scale (feller and demarsily, 2016).

Gamme de pH	Appréciations
Inférieur à 4,5	Extrêmement acide
4,6 – 5,2	Très acide
5,3 – 5,5	Acide
5,6 – 6,0	Modérément acide
6,1 – 6,6	Légèrement acide
6,7 – 7,2	Neutre
7,3 – 7,9	Légèrement alcalin
8,0 – 8,5	Alcalin
Supérieur à 8,6	Très alcalin

Appendices 02: Classification of the degree of salinity (feller and demarsily, 2016)

Conductivité Électrique ($\mu\text{S}/\text{cm}$)	Degré de salinité
2,50	Non salé
2,50-5,00	Légèrement salin
5,00-10,00	Salé
10,00-20,00	Très salé
>20,00	Extrêmement salin

appendices

Appendices 03: The MO% scale (Morand, 2001).

MO%	Nom de classe
0.5 à 1 %	Très faible en MO
1 à 2 %	Faible en MO
2 à 3 %	Moyenne (ou modérée) en MO
3 à 5 %	Elevée en MO
> à 5 %	Très élevée en MO

Résumé:

L'étude consiste en l'utilisation de techniques de cartographie et de modélisation pour étudier les éléments majeurs NPK (azote, phosphore et potassium) dans le sol de la région céréalière de Tiaret, en Algérie. L'objectif est de produire une cartographie complète des niveaux de NPK dans la région, en utilisant des données de terrain et des analyses de laboratoire. Ces données seront ensuite utilisées pour créer des modèles de prédiction pour les niveaux de NPK dans le sol, en se basant sur des facteurs environnementaux tels que la topographie, le climat et la géologie. Les résultats de ce projet peuvent aider les agriculteurs de la région à améliorer la santé des sols et à augmenter la production de céréales

Mots clés: Cartographie, Modélisation, Éléments majeurs.

Summary:

The study consists of using mapping and modeling techniques to study the major elements NPK (nitrogen, phosphorus, and potassium) in the soil of the cereal region of Tiaret, Algeria. The objective is to produce a comprehensive mapping of NPK levels in the region, using field data and laboratory analysis. These data will then be used to create prediction models for NPK levels in the soil, based on environmental factors such as topography, climate, and geology. The results of this project can help farmers in the region improve soil health and increase cereal production.

Keywords: Mapping, Modeling, Major elements.