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Study of some fertility characteristics of soils with different agricultural uses in the Aqra Region/Duhok

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Abstract

A study was conducted in the Aqra region to investigate the fertility characteristics of soils with different agricultural uses. The study included (40) sites, representing surface soils (0-30 cm). Soil samples were transported to the laboratory for physical and chemical analyses. The results showed that the majority of the studied soils were heavy soils with clayey texture (C) to clay loam texture (CL) and sandy clay loam texture (SCL). The pH values were mostly neutral in specific sites and slightly alkaline in most of the studied sites, Nitrogen values ranged between (6.27 – 43.90) ppm. Phosphorus values ranged between (1.05– 30.56) ppm, and it is natural for phosphorus dissolution to decrease due to plant absorption, adsorption, and fixation over time. This indicates a significant consumption of phosphorus in the soil, possibly attributed to elevated temperatures at the end of the season and reduced irrigation operations before harvest, leading to decreased phosphorus dissolution and increased fixation. The ratios of N in Kriging ranged between (27.44 - 32.61) represented the majority of the studied area, while he P for the first five categories ranged through the program between (1.05-9.70). and K for rest of study sites had low and variable values, as they appeared in red and light yellow, and their values ranged between (190 - 374).

Keywords: NPK; Kriging; Fertility; Land use; Maps; Aqra

1. Introduction

Soil is considered a fundamental element in agricultural production. Therefore, soil surveys and assessments of its potential for specific uses are essential for any land evaluation. Ineffective use of this natural resource leads to land degradation as Oldman [1]. The basic principle in the process of deterioration is to clarify the difference between land use requirements and the characteristics of available natural resources as noted by Dregne [2].

Despite studies related to the application of nitrogen, phosphorus, and potassium fertilizers through foliar spray, major nutrients are generally expected to be supplied from the soil. The remaining plant requirements can be provided through supplementary foliar fertilization. It has been proven that excessive use of chemical fertilizers, often driven by agricultural policies to support inputs in many countries without considering the actual needs of soil fertilization, leads to various negative effects on the environment, human health, and animal health alike. Most soils in Iraq tend to be alkaline and lack organic matter and biological activity, which are essential components of the triple fertility system (physical, chemical, and biological) as Fares [3].

A sound agricultural and economic policy must consider preserving the environment's integrity and community health. Therefore, encouraging agricultural producers to follow proper fertilization methods is essential to ensure the production of healthy, high-quality food

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Fertility assessment, as well as predictive equations based on remote sensing techniques and spatial data to diagnose different land uses in large areas in the shortest possible time, protect against the risk of unjustified fertilizer additions, and maintain soil and environmental balance as mentioned by Al-Waeli, [4]. Integrating remote sensing data with laboratory examination values enabled the prediction of some soil fertility properties for consecutive previous years and the creation of digital maps within predictive models using linear and non-linear regression formulas with spatial accuracy that surpassed traditional maps previously used as noted by Taha et al., [5]. Therefore, this study aims to use Kriging technology as a geostatistical method to predict or extrapolate values for other unsampled locations based on known soil property values, reducing effort, cost, and speed in completing the work. There is a spatial dependence measure based on the distance between one point and another with measured data, making this technique predict or anticipate values for unknown locations based on their proximity or distance from the source and reported by Burrough and McDonnel [6].

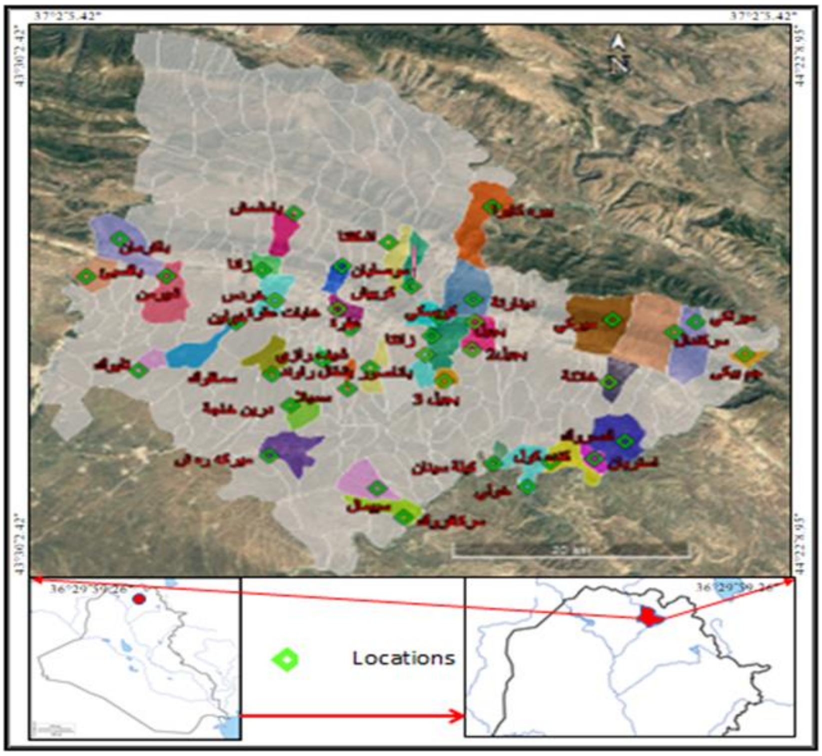
1.1. Study Objectives

Study some of the availability nutrient elements in the soil. And using the Kriging model for each property to obtain the distribution of some elements, create a map specific to each, and predict unsampled values based on that.

2. Material and methods

2.1. Study Area

The research was conducted in the Aqra region, geographically located in the northeastern part of Iraq, about (80) km from Nineveh Province, within the administrative boundaries of Duhok Province. It is bordered to the east by Soran District within the boundaries of Erbil Province, to the north by Shiladze Subdistrict, to the west by Amadiya, and to the south by Bardarash Subdistrict. It extends between latitudes (37°2¯5.42˭ - 36°29¯59.26˭) North and longitudes (43°35¯56.84˭ -44°18¯31.56˭) East, as shown in Figure (1), along with the sampling locations.



Figurer 1 Map of the Study Area

2.2. Geology of the Study Area

The study area is part of the Zagros Fold and Thrust Belt in northern Iraq. It represents the current northeastern edge of the Arabian Plate. Tectonically, it falls within the domain of high folds. The southern and southwestern flanks of the convex Aqrah Fold form the southern and southwestern boundaries of the High Folded Zone in this region, adjacent to the Foothill Zone. Aqrah Fold is an asymmetric, overturned, and locally doubly plunging fold that extends from the Bajil area in the east to the Bakrman region in the west, with a roughly 34 km axial length. The fold is bordered to the north by the convex Piris Fold, to the east by the convex Pirat Fold, and to the northwest by the convex Atrosh Fold. The city of Aqrah is situated to the south of the fold (see Figure 2).

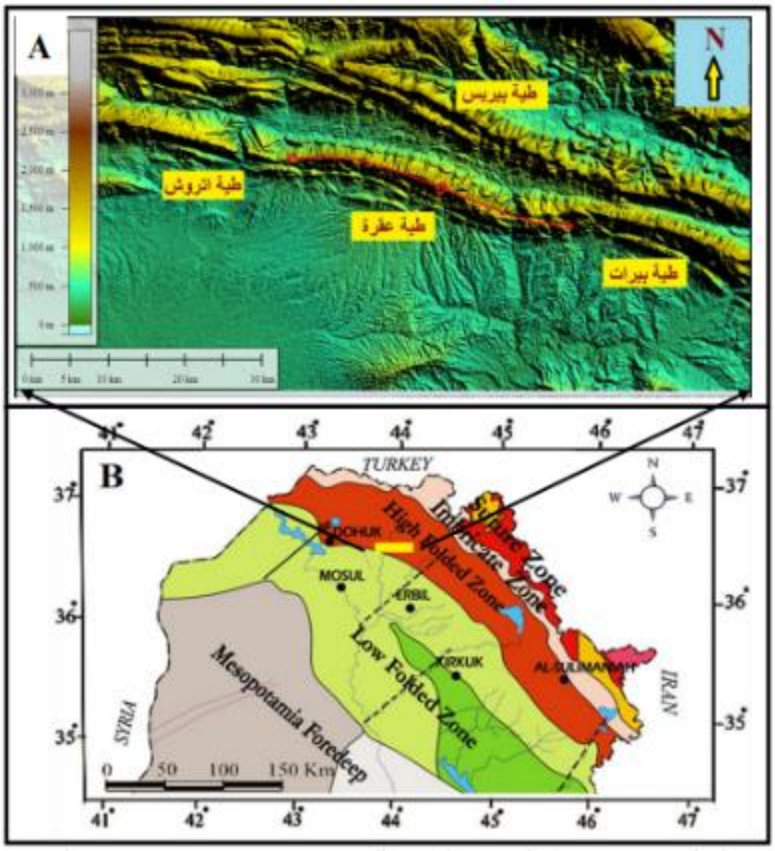


Figure 2 Tectonic Division Map of Iraq Showing the Surrounding Regions of the Study Adapted from Fouad [7]

2.3. Laboratory Analyses

2.3.1. Physical Characteristics Estimation

Particle Size Analysis

Soil samples were analyzed using the hydrometer method to separate the three soil aggregates (sand, silt, and clay) by adding sodium hexametaphosphate as a dispersing agent, following the method described by Gee and Bauder [8].

Bulk Density

Determined using the paraffin wax method according to Black's procedure (1965) as mentioned in Page et al. [9].

Moisture Content

Soil moisture was quantified based on the weight of completely dry soil using an oven at 105 degrees Celsius for 24 hours, following Hesse [10].

2.3.2. Chemical Characteristics Estimation

Electrical Conductivity (EC)

EC was measured in the saturated soil paste extract according to the method outlined by Page et al. [9].

pH

Soil pH was measured in a soil-water extract ratio of 1:1 using a pH-meter (HI9811 HANNA), following the standard method described by Page et al. [9].

Organic Matter

Organic matter content in soil samples was determined using the wet oxidation method (Walkley and Black) as mentioned by Jackson [11].

Calcium Carbonate (CaCO3)

Calcium carbonate content was estimated by titration using hydrochloric acid (HCl) with a concentration of 1N and titration with sodium hydroxide (NaOH) with a concentration of 1N, following Ryan et al.[12].

Gypsum Content

Gypsum was quantified using the acetone precipitation method. Electrical conductivity was measured after dissolving the precipitate in distilled water to calculate the gypsum percentage, following Richard [13].

Cation Exchange Capacity (CEC)

Determined using ammonium acetate (NH4OAc 1N) at pH 7.0, following the method described by Black [14].

Available Nitrogen (N)

Estimated in the soil using potassium chloride solution (2N KCl) and magnesium oxide (MgO). Nitrate ions were reduced to ammonium (NH4) using Devarda alloy, distilled, and titrated with diluted sulfuric acid (N 0.005), following Keeney and Nelson's method by Page et al. [9].

Available Phosphorus (P)

Extracted using sodium bicarbonate (NaHCO3 0.5N) at pH 8.5. The color was developed using molybdate-ammonium and ascorbic acid, and phosphorus content was measured using a spectrophotometer at a wavelength of 882 nm, following Olsen's method by Page et al. [9].

Available Potassium (K)

Extracted with ammonium acetate (NH4OAC 1N) at pH 7 and measured using a flame photometer, according to the method outlined by Page et al. [9].

2.4. Kriging Interpolation Analysis

Kriging is based on the assumption that the unknown value at a specific location should be the average of known values at neighboring locations, weighted by the distance between known and unknown locations. The main goal of kriging is to find statistical weights for observations to provide unbiased estimates with minimal variance.

3. Results and Discussion

3.1. Soil Particle Size Distribution

Table (1) illustrates the particle size distribution of the soil. The majority of the sampled sites exhibited heavy clay (C) to clayey loam (CL) and sandy clay loam (SCL) textures, with some fields and orchards having a loamy (L) texture. This variation can be attributed to the topography and parent material, aligning with the findings of Rasheed [15].

3.2. Bulk Density

The bulk density was observed to be relatively consistent across all soil types, with slight variations among sample locations. Bulk density values are influenced by factors such as texture, structure, organic matter content, and soil compaction conditions pointed by Luqi et al. [16]. The values are indicative of the interstitial void size, which is affected by several factors, emphasizing the importance of soil composition and environmental conditions.

3.3. Soil Moisture

The relative soil moisture content in the study area varied between 2.0% and 11.8%, indicating fluctuations in different locations. Soil moisture levels depend on both the water content in the soil and the soil texture. Soils with finer textures tend to retain more moisture, while coarser-textured soils have lower moisture retention. Additionally, environmental conditions such as temperature and precipitation play a crucial role in determining soil moisture levels, as highlighted by Siltecho and Behboudia [17].

Table 1 Physical Properties of the Soil in the Study Area

No	Location	PSD %			Class	Bulk density	Moisture
		Sand	Silt	Clay		Mg.m-3	%
1	Banasor	15.3	30.0	54.7	C	1.22	3.5
2	Bejel	17.3	36.8	45.9	C	1.53	3.2
3	Bejel 2	40.3	30.0	29.7	CL	1.60	2.0
4	Bejel 3	40.3	25.0	34.7	CL	1.60	2.4
5	Aqre Fori.	40.3	30.0	29.7	CL	1.58	2.7
6	berkhwlen	17.3	26.8	55.9	C	1.40	5.2
7	Telbok	22.3	32.5	45.2	C	1.42	4.8
8	Smaqok	29.8	22.5	47.7	C	1.33	6.7
9	Znta	47.8	22.5	29.7	SCL	1.61	5.6
10	Gelasenan	42.8	32.5	24.7	L	1.62	5.1
11	khooly	12.9	34.3	52.7	C	1.59	5.4
12	kendaqul	49.9	28.3	21.8	L	1.58	2.4
13	Esteryan	19.8	35.0	45.2	C	1.58	5.3
14	qasrook	29.8	21.3	48.9	C	1.50	6.1
15	Sebimal	10.0	35.1	54.9	C	1.60	5.3
16	khelana	14.4	24.2	61.4	C	1.59	5.0
17	sherman	21.0	24.2	54.8	C	1.58	10.0
18	jembeke	10.3	26.8	62.9	C	1.47	6.8
19	merge	56.5	22.6	20.9	SCL	1.46	8.3
20	Sergendal	52.3	20.0	27.7	SCL	1.52	5.5
21	Merge	21.8	28.2	49.9	C	1.49	8.3
22	Bakerman	26.8	25.7	47.5	C	1.47	5.2
23	Meslyain	26.1	22.5	51.4	C	1.47	4.2
24	Mergarush	42.8	32.5	24.7	L	1.38	10.3
25	Zana	50.3	30.0	19.7	L	1.38	7.3
26	Semela	16.9	35.7	47.4	C	1.48	5.8
27	Shefrazi	56.0	17.6	26.4	SCL	1.42	4.5
28	Kherdes	21.0	35.1	43.9	C	1.58	4.1
29	Eshkefta	36.0	32.6	31.4	CL	1.42	4.4
30	Kerbesh	52.3	17.5	30.2	SCL	1.10	4.3

31	Denartah	51.6	14.5	33.9	SCL	1.60	4.5
32	Kuske	31.0	30.1	38.9	CL	1.60	4.0
33	Bemeshmesh	39.3	24.3	36.4	CL	1.57	3.2
34	Derenkhaja	43.5	17.6	38.9	CL	1.56	6.8
35	Erkafrok	27.3	32.5	40.2	C	1.46	3.5
36	Beqasbe	26.0	47.6	26.4	L	1.48	4.2
37	Kholeen	26.8	13.2	59.9	C	1.57	4.6
38	Bash.Rawand	30.5	18.1	51.4	C	1.40	6.6
39	Berakabra	38.5	20.1	41.4	C	1.52	4.1
40	Akri	28.2	30.4	41.4	C	1.20	11.8

3.4. Chemical Properties

3.4.1. Soil pH

The results in Table (2) indicate that the pH values were neutral in certain locations, such as in the Bashqal Rawand site, and slightly alkaline in most of the studied sites. The soil pH ranged between (7.4-8.1) under the study area conditions due to low rainfall and long dry periods, and the abundance of calcium carbonate, which resists changes in soil pH. These results are consistent with Soriano et al.[18].

Table 2 Chemical Properties of the Study Area Soil

No	Location	pH	EC	OM	CaCO3	CEC
			dSm^{-1}	gkg^{-1}		$Cmolkg^{-1}$
1	Banasor	7.8	0.90	14.0	130	17.39
2	Bejel	7.9	0.54	16.5	220	16.03
3	Bejel 2	8.1	1.24	24.0	420	19.39
4	Bejel 3	8.1	0.73	17.2	290	18.82
5	Aqre Fori.	7.8	0.13	22.3	250	29.74
6	Berkhwlen	7.7	0.33	27.8	340	34.73
7	Telbok	7.9	0.55	3.4	355	28.40
8	Smaqok	8.1	0.47	24.0	150	27.13
9	Znta	7.7	0.96	23.3	195	30.67
10	Gelasenan	7.7	0.73	20.6	110	34.15
11	Khooly	8.0	0.75	27.5	190	37.81
12	Kendaqul	8.0	0.12	16.1	215	16.54
13	Esteryan	7.9	0.55	28.5	150	35.42
14	Qasrook	7.9	0.70	20.2	125	35.39
15	Sebimal	7.8	0.62	20.6	150	34.27
16	Khelana	7.8	0.93	14.7	425	30.36
17	Sherman	7.9	0.81	29.2	205	24.64
18	Jembeke	7.9	0.33	15.4	195	34.18

19	Merge	7.8	0.61	32.6	160	29.36
20	Sergendal	7.7	0.13	17.1	245	34.01
21	Merge	7.8	0.71	34.3	175	29.33
22	Bakerman	7.6	0.16	25.1	180	24.96
23	Meslyain	7.8	0.77	19.6	265	34.66
24	Mergarush	7.8	0.19	18.9	210	25.11
25	Zana	7.8	0.80	29.9	435	19.95
26	Semela	8.1	0.91	10.3	300	19.60
27	Shefrazi	7.9	0.67	7.5	115	34.45
28	Kherdes	7.8	0.80	29.2	460	26.89
29	Eshkefta	7.8	0.47	4.4	240	29.18
30	Kerbesh	8.0	0.82	15.8	450	18.63
31	Denartah	8.1	0.98	5.1	275	27.55
32	Kuske	7.9	0.72	29.9	335	27.09
33	Bemeshmesh	7.9	0.68	6.8	190	19.36
34	Derenkhaja	7.6	0.19	6.8	190	35.00
35	Erkafrok	7.6	0.99	18.5	295	26.09
36	Beqasbe	7.8	0.61	24.0	310	30.87
37	Kholeen	7.8	0.55	10.3	120	29.07
38	Bash.Rawand	7.4	0.31	24.0	125	37.62
39	Berakabra	8.0	0.12	5.5	140	28.99
40	Akri	8.0	0.89	27.5	420	33.28

Electrical Conductivity (EC)

Table (2) shows that the electrical conductivity values for soil samples in the study area ranged between (0.12-1.24) dS m-1. The highest salt content was observed in the Bajil 2 site, and the elevated salinity in this area may be attributed to the accumulation of organic matter and the decomposition of root exudates, with a noticeable increase in gypsum content at the same depth. However, most of these samples had very low electrical conductivity values.

Organic Matter (OM)

The result indicates that the organic matter content in the studied soils ranged between (3.4-34.3) gkg-1. There was variability in the values of organic matter in all soils due to the nature of the dry climatic conditions, low rainfall, high temperatures, and reduced inputs of organic matter and nutrients from external sources. This aligns with Rahimabady et al. [19].

Calcium Carbonate ($CaCO_3$)

Table (2) shows that the calcium carbonate content ranged between (110-460) gkg-1, with the highest value recorded in the Khurdas village site. The high values of calcium carbonate in most sites can be attributed to the nature of the original soil material being rich in calcium carbonate. Additionally, the geological formations in this area are rich in carbonate minerals. The low rainfall also contributes to the accumulation of calcium carbonate in subsurface horizons, in agreement with Mohammed et. al [20].

Cation Exchange Capacity (CEC)

It is a process of fixing and exchanging positive ions due to the electrostatic capacity of clay minerals in the soil (Duffy, 2011). This function is provided by soil colloids, which are predominantly negatively charged and capable of attracting cations present in the soil as mentioned by McCauley and Hayes [21].

3.5. N, P, K in Soil

The results in Table (3) showed variations in nitrogen (N) values, with values ranging between (6.27 – 43.90) ppm. An increase in nitrogen in the soil contributes to improving the soil structure and changing its physical properties due to the decomposition of organic matter, which enhances aeration and encourages the nitrification process in the soil. This aligns with the findings of Al-Lami and Al-Rubaie [22].

As for phosphorus (P), the values ranged between (1.05 – 30.56) ppm, and it is natural for phosphorus to decrease in availability for plants due to its absorption and assimilation over time. Consequently, a significant amount of phosphorus is consumed in the soil. The decrease in phosphorus solubility may be attributed to higher temperatures towards the end of the season and reduced irrigation operations before harvesting, leading to decreased phosphorus solubility and increased fixation, as mentioned by Singh et al.[23]

Additionally, potassium (K) values ranged between (190 – 570) ppm. There was a noticeable decrease in potassium content in the rhizosphere soil in the study area. This may be attributed to potassium absorption by plant roots from the area near the roots in larger quantities than the area farther from the roots. Alternatively, it could be due to increased microbial activity in general. These observations are consistent with the findings of Singh et al.[23]

Table 3 Results of Elements in Soil

No	Location	N	P	K
		Ppm in Soil		
1	Banasor	18.81	3.68	456
2	Bejel	23.52	3.42	190
3	Bejel 2	23.52	14.75	323
4	Bejel 3	31.36	2.37	247
5	Aqre Fori.	32.92	22.39	456
6	berkhwlen	23.52	1.05	247
7	Telbok	17.24	6.58	361
8	Smaqok	21.95	1.05	361
9	Znta	21.95	9.22	228
10	Gelasenan	42.33	12.9	570
11	Khooly	37.63	4.47	513
12	kendaqul	36.06	27.93	380
13	Esteryan	36.06	2.89	437
14	Qasrook	42.33	8.16	456
15	Sebimal	43.90	5.00	380
16	Khelana	28.22	1.84	380
17	sherman	34.49	17.02	418
18	jembeke	40.76	1.84	247
19	Merge	36.06	2.37	513
20	Sergendal	31.36	6.58	285

21	Merge	31.36	5.00	437
22	Bakerman	6.27	30.56	570
23	Meslyain	28.22	13.70	456
24	Mergarush	31.36	28.45	570
25	Zana	39.20	25.03	532
26	Semela	14.11	13.17	437
27	Shefrazi	31.36	8.69	380
28	Kherdes	39.20	1.31	304
29	Eshkefta	28.22	10.01	247
30	Kerbesh	14.11	22.92	342
31	Denartah	39.20	4.74	551
32	Kuske	39.20	3.16	247
33	Bemeshmesh	32.92	5.27	247
34	Derenkhaja	29.79	11.06	418
35	Erkafrok	31.36	1.317	247
36	Beqasbe	34.49	2.63	266
37	Kholeen	26.65	11.33	304
38	Bash.Rawand	18.81	13.43	342
39	Berakabra	31.36	1.31	209
40	Akri	39.20	25.29	418

Figure (3) shows the distribution of nitrogen values in the soil, which were within the moderate range in all locations, with little variation in values in the study soils. The high values were concentrated in the study area (43.90), represented by the green color in the southeastern part, while the lowest value was (6.72). It was represented in dark red and was limited to small sites within the study area, but it is clear from the figure that the ratios that ranged between (27.44 - 32.61) represented the majority of the studied area, which indicates that most of the study areas may fall within this range.

Likewise, for phosphorus, the highest values were in the Bakerman area in the northwestern part of Akre, which was represented by the green color, as shown in Figure (4). In general, the Kriken program classified the phosphorus ranges into ten categories, as the first five categories represented, which ranged through the program between (1.05-9.70) The majority of the study areas were concentrated towards the center of the study area towards the southern and eastern parts, exploiting an area of 60% of the total area, while the other five types were represented in the northwestern sites, whose values ranged between (9.71-30.6). It is clear from Figure (5) that the high values of potassium, represented by the green color, were concentrated in the areas representing the lands (the forests of Akre and the vineyards in Bakkerman, the koja trees in Merke Resh, and the peach trees in Kilet Sinan). In other words, the highest values appeared in Lands planted with trees. The high values were mostly concentrated in the central regions and a few western regions, which appeared in green and did not take up large areas, while the rest of the study sites had low and variable values, as they appeared in red and light yellow, and their values ranged between (190 - 374).

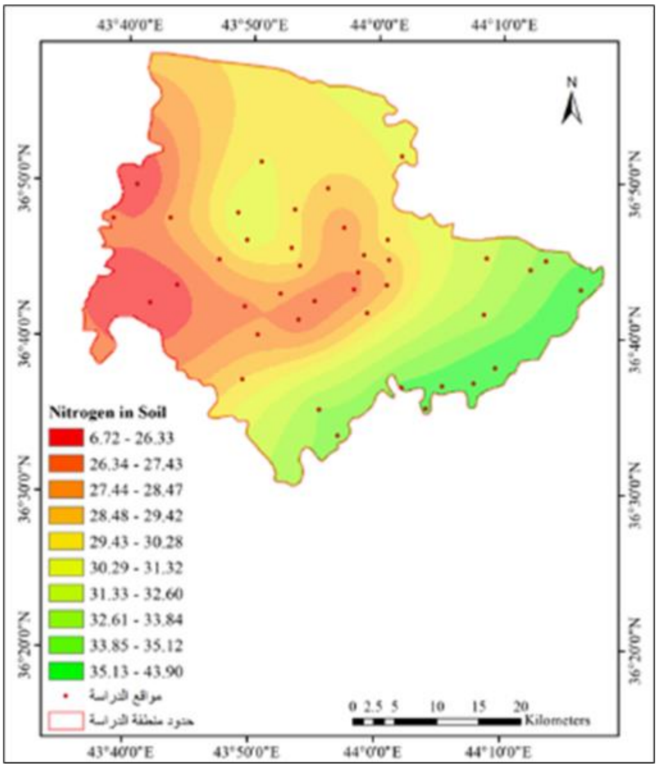


Figure 3 N distribution in soil using Kriging

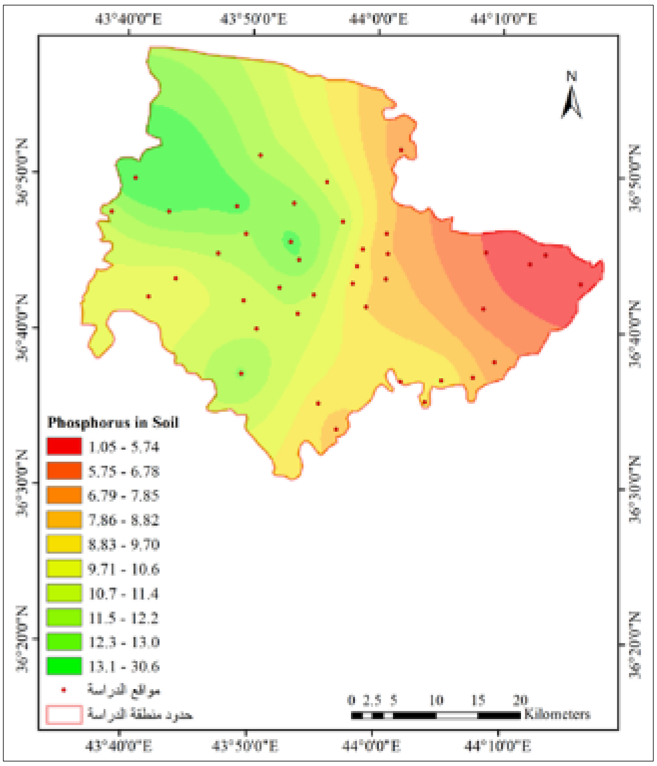


Figure 4 P distribution in soil using Kriging

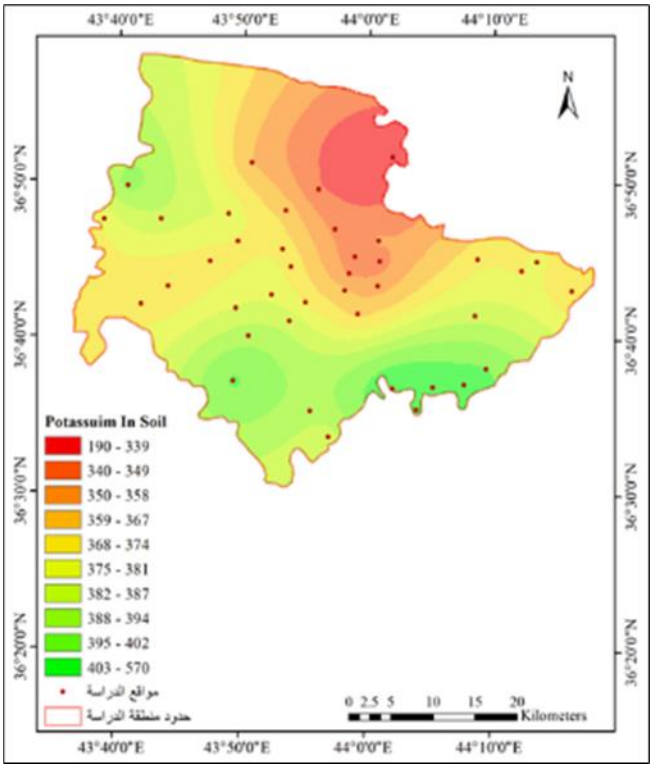


Figure 5 K distribution in soil using Kriging

4. Conclusion

- The importance and effectiveness of the kriging program in interpreting the results of ready-made nitrogen, phosphorus and potassium in the soil.
- The possibility of benefiting from remote sensing data in preparing maps of various soil properties as well as plants, with the possibility of monitoring temporal and spatial change in a more practical way than field surveying and in a way that suits the speed of change in ready-made NPK images in the soil

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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