Eco. Env. & Cons. 27 (February Suppl. Issue) : 2021; pp. (S365-S370)
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ISSN 0971–765X

Evaluating the availability of nutrient elements (N, P, K) for the soils of Al Kifl district in Babil governorate using geographic information systems (GIS)

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(Received 15 July, 2020; accepted 3 September, 2020)

ABSTRACT

The study area was chosen in the Kifl district of Babel governorate, which is about 30 km south of the city of Hilla, the governorate center in Iraq, and its area is 49,553.04 hectares. Samples were obtained from 50 sites from the surface depth 0-30 cm. The samples were preserved and prepared from drying, milling and sifting and laboratory measurements were conducted on them. Necessary and important for the purpose of fertility evaluation, including organic matter and the percentage of N, P, K, CEC, CE, pH, $CaCO_3$ and ESP. The fertility assessment maps and the spatial distribution map of organic matter and CEC and N, P, K have been drawn. The results showed that the soil of the study area has good fertility status and that the variety F1 occupied the largest area of the study area, the percentage of organic matter was good, the salinity was low, and the ratios of nutrients, N, P, and K were high.

Key words *: Nutrients N, P, K, Fertility evaluation, GIS*

Introduction

The fertility assessment is the process of estimating the soil's ability to prepare the plant nutrients required for ideal growth, and the need to know the correct way to assess the state of fertile soil and to know the deficiency in nutrients, as nitrogen, phosphorus and potassium are among the main and determinants in crop growth and increasing the yield (Parry *et al*, 2005).

Havlin *et al.*, (2005) indicated that the analysis of the readiness of the main nutrients needed by the plant in high quantities of soil is adequate if combined with the estimation of the soil content of organic matter, as it is a reservoir and a natural supplier of most of the nutrients necessary for the plant, especially those required in low quantities, not to complete its life cycle. Soil fertility assessment on the basis of analysis of ready-made nutrients and the content of organic matter in it is necessary and important to visualize the state of chemical reactions within the concepts of soil fertility and provide a full understanding of the physical environment through which the nutrient moves from the soil colloidal to the area of root absorption (Griffiths *et al.*, 2010). The use of geographic information systems software has a very effective and beneficial effect in modifying soil survey and classification maps prepared by the relevant authorities, and preparing maps of suitable lands for cultivation is important in agricultural planning and distribution of crops according to their suitability for the soil, as well as monitoring the plant's nutritional status and treating any defect and addressing the deficiency. In soil fertility (Thomas *et al.*, 2013).

Xu *et al.*, 2018 clarified the necessity to estimate the nitrogen available in the soil at the start of the planting season and at the end because failure to maintain an adequate amount of it available in the soil would cause a serious imbalance not in the fertile equilibrium, but rather leads to the weakening of the vital beneficial activity in the soil, as well as (Morshedizad *et al.*, 2018) confirmed that the accuracy of the recommendation for phosphate fertilizer for any crop depends mainly on the evaluation of its release under soil conditions in order to avoid its loss and loss by stabilization) . Pimstein *et al.*, 2011) clarified that it is indispensable to estimate the ready-made potassium in the soil and for the different plant growth stages, and in a complementary way to estimate its absorption in the plant.

Bischoffi *et al.*, (2018) concluded that conducting any assessment of soil fertility in isolation from estimating the soil content of organic matter may not explain the dynamics of transitions to nutrient ions in the soil, and that their estimation often gives strong support to the chemical interpretation of soil fertility and spares the researcher and the author of the fertilizer recommendation on Both are a lot of errors, as Rakkar *et al.*, (2015) emphasized that the adoption of spatial analysis to assess soil organic matter content is important in the quantitative assessment of soil fertility. Because of the importance of fertility evaluation, the research was directed to assess the readiness of nitrogen, phosphorus and potassium nutrients through geographic information systems.

Materials and Methods

The study area was chosen in Al-Kifl district in Babil governorate - Iraq, and the area of the study area reached 49,553.04 hectares, 50 sites were identified and representative samples were taken from a depth (0-30) cm, and their coordinates were determined using the global positioning system GPS with a UTM coordinate system and spatially fallen in ArcGIS 10.7 software for the purpose of meeting spatial analysis requirements (Figure 1).

The samples were dried and milled, and passed through a sieve with a diameter of 2 mm holes, and the following laboratory analyses were conducted:

- The pH reaction and electrical conductivity of the soil extract was estimated at 1: 1, according to Richards, 1954
- The percentage of the exchange sodium ESP was calculated by dividing the exchanged sodium by the exchange capacity of cationic ions multiplied by 100 as reported in Richards, 1954.
- The percentage of calcium carbonate minerals was estimated according to Jackson, 1958
- CEC was estimated by a method through sodium as reported in Bashour and Al-Sayegh, 2007
- The organic matter was estimated by the wet digestion method according to the method given in Jackson, 1958
- The nitrogen available in the soil was estimated by an extraction method, using a micro-correction device, according to the Nelson and

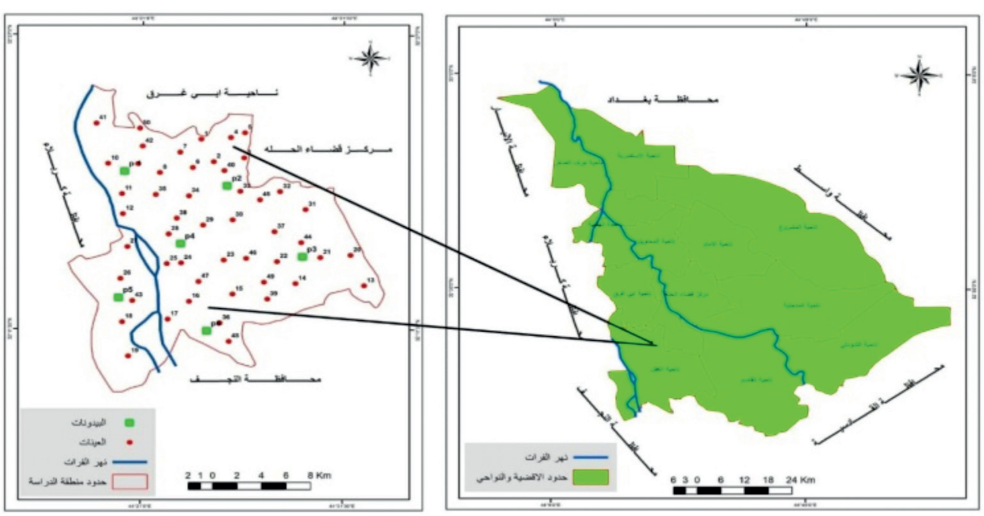

Fig. 1. Amap of soil locations for the study area

keeney method described in *et al.*, (1982) Page

- Available soil phosphorous was extracted according to the Olsen method mentioned in Page *et al.*, 1982.
- Extract the potassium available with ammonium acetate according to the method mentioned in Page *et al.*, 1982.

Soil characteristics that affect the fertility of the soil for growing crops were determined by the standard multiplication method for evaluating lands that modified from the method of (Sys *et al.*, 1980) for evaluating lands by entering the available K, P, N, pH and OM to become the fertility evaluation equation according to the equation

F = T * OM * CEC * $CaCO_3$ * N * P * K * pH * EC * ESP

That:-

F = Evidence for soil fertility assessment

T = Texture, OM Organic matter, cation exchangeable capacity CEC

Calcium carbonate = $CaCO_3$, N = Nitrogen, P = Phosphorous, K = Potassium pH. = PH. , EC = Electric conductivity, Exchngeable sodium percentage = ESP

Sys *et al.*, 1980. The evidence values are calculated from special pre-prepared tables as shown in the tables below

A fertility map was prepared using ArcGIS 10.7 software, depending on the data for the characteristics of the soil characteristics of the study area, as a special database was created for the study area, as the data obtained from the laboratory measurements of the samples, which are the metadata, were linked to the spatial data in the study area and depending on the technology kriging in mapping and spatial distribution of traits important in assessing soil fertility.

Table 1. Soil fertility classes with standard index

Degree class	class	symbol	Index value
First class	Very fertile	F1	<80
Second class	Fertility	F2	80-60
Third class	Fertile medium	F3	60-40
Fourth class	Fertile low	F4	40-20
Fifth class	Non fertility	N	20>

Results and Discussion

Characteristics of the soil of the study area included in fertility evaluation

Organic matter

The results of Table 2 and Fig 2 indicated that the percentage of organic matter in the study area ranged from low, medium, high and very high, as this percentage is considered normal under conditions of dry climate and lack of natural vegetation. Organic matter is a determining factor for growing crops, because it is one of the fertility factors that are important in Determining the suitability for growing crops, improving soil properties, and maintaining fertile and nutritional balance in the soil.

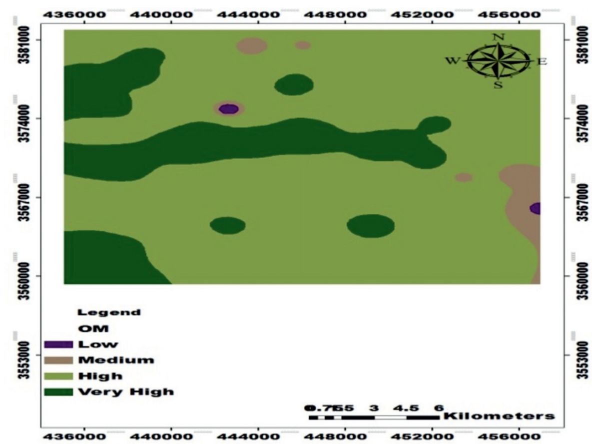

Fig. 2. Spatial distribution of the classes of organic matter in soil for the study area

Table 2 showed that the higher variety occupied the largest area of 28421.68 hectares, and the ratio of 57.36% between the total area of the study area, while the low variety occupied the smallest area of 2001.21 hectares with a rate of 4.04%. The reason is that the sampling sites are from the surface depth that has a content Good from organic matter and agricultural processes occur.

CEC

The results of Table 2 and Fig. 3 indicated that the values of the exchange capacitance of the positive ions were proportional to the values of organic matter in the soil, as the higher variety occupied the largest area amounted to 27 110.05 hectares of the total area of the study area and by 54.71% of the total area of the study area, and the lower variety occupied the smallest area. 1420.11 hectares, or 2.87%. As the CEC gives a good idea about the ability of the soil to hold the ions added in the form of fertilizers, and it is an important factor for soil fertility, and the soil tissue was medium soft and soft con-

Table 2. Spatial distribution of areas and percentages of soil properties for the fertility and nutrient assessment N, P ,K

Class of organic matter	Area hectare	%	Class of CEC	Area hectare	Class of available nitrogen	%	Area hectare	%
Low	2001.21	4.04	low	1420.11	2.87	Medium	6786.98	13.70
Medium	4621.22	9.33	Medium	5982.61	12.07	High	12422.31	25.07
High	28421.68	57.36	high	27110.05	54.71	Very high	30343.75	61.23
Very high	14508.93	29.28	Very high	15040.27	30.35			
Sum	49553.04	100	sum	49553.04	100	Sum	49553.04	100
Class of available Potassium	Area hectare	%	Area hectare of available Phosphorous	class	%	Class of soil fertility	Area hectare	%
Medium	3211.21	6.48	medium	11369.45	22.94	F1	28676.92	**57.87**
High	20645.67	41.66	high	38183.59	77.06	F2	12841.72	**25.92**
Very high	25696.16	51.86				F3	3421.09	6.90
						F4	4613.31	9.31
Sum	49553.04	100	sum	49553.04	100	sum	49553.04	100

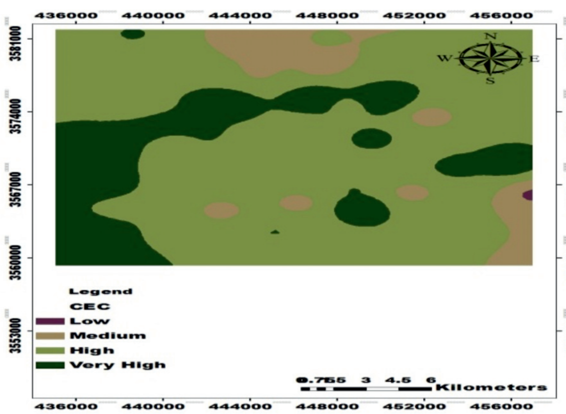

Fig. 3. Spatial distribution of the classes of CEC in soil for the study area

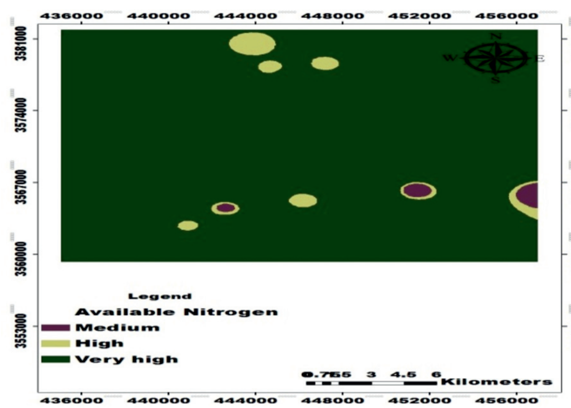

Fig. 4. Spatial distribution of the classes of available Nitrogen in soil for the study area

taining quantities of clay.

Available nitrogen

The results of Figure 4 showed that the study area was the percentage of available nitrogen is good, as the values were distributed between medium, high and very high varieties, as nitrogen is a determining factor for soil fertility and crop cultivation due to its direct effect on the growth and activities of various vital plants.

The results of Table 2 show that the very high category of nitrogen occupied the largest area which amounted to 30343.75 hectares, with a percentage of 61.23% of the total area of the study area, followed by the medium type as it occupied an area of 12,422.31 hectares and by 25.07%. As for the medium type, it occupied the smallest area amounting to 6786.98 hectares and by 13.70% of the total area of the study area. The reason may be attributed to the addition of fertilizers in some locations of the study area.

Available phosphorus

The results of Figure 5 showed that the percentage of phosphorus available in the soils of the study area may be divided into two classes only, namely the medium variety and the high variety, as the higher variety occupied an area of 38,183.59 hectares and 77.06% of the total area of the study area, while the medium variety occupied an area of 11,369.45 hectares. By 22.94% of the total area of the study area (Table 10), the reason may be attributed to the addition of phosphate fertilizers and the presence of organic matter that reduces its adsorption

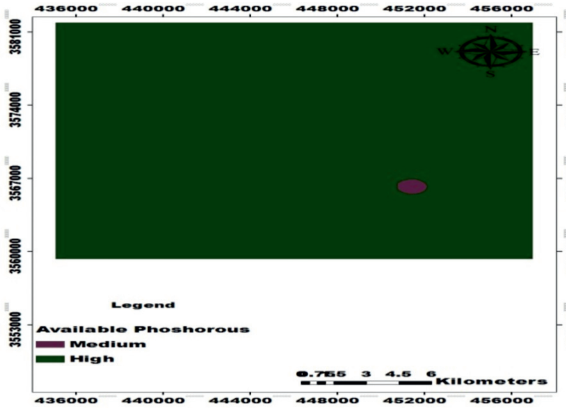

Fig. 5. Spatial distribution of the classes of available Phosphorous in soil for the study area

capacity and thus works to increase its readiness for the plant by increasing its concentration in the soil solution, as phosphorus is considered one of the determinants of soil fertility and cultivation. Crops, because it is important for plant growth.

Available potassium

The results of Figure 6 show that the percentage of available potassium was high and it was divided into three varieties: medium, high and very high, as the largest area for the very high variety reached 25696.16 hectares, with a rate of 51.86%, followed by the high variety with an area of 20645.67 hectares and 41.66%, while the medium type had a smaller occupancy An area of 3211.21 hectares, or 6.48% of the total area of the study area. As potassium is a determining factor for soil fertility and crop cultivation, although it was not added to the soil by farmers, the level of potassium was OK in the study area because the potassium content of the soil is good because the soil tissue is mostly SiCL, CL which contains A high percentage of potassium-stabilizing clay that is ready to plant over time.

Fig. 6. Spatial distribution of the classes of available Potassium in soil for the study areaAssessment of soil fertility in the study area for growing crops and readiness of nutrients

The results of Table 10 and Fig. 7 indicated that there are four classes of fertility evaluation according to the standard multiplication method in the study area, as follows:

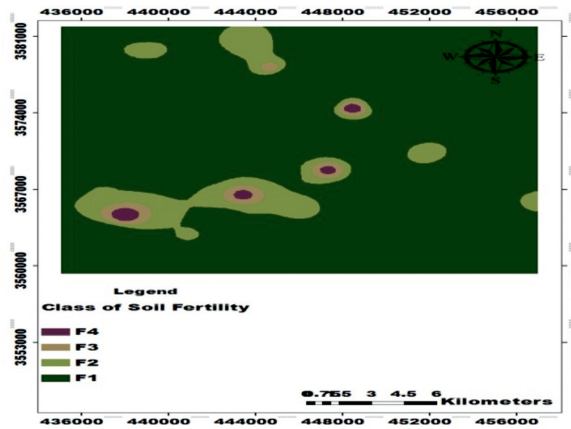

Fig. 7. Spatial distribution of the classes of soil fertility in soil for the study area

Very fertile F1

The presence of this variety in a very large area, because the soils of the study area had a good percentage of organic matter, CEC with a high percentage, medium texture and neutral pH. This variety covered most of the area because its content of N,P,K was high and of low salinity, as it occupied an area of 28,676.92 hectares and the proportion of 57.87 %

Fertile F2

This variety was found with a large area of 12,841.72 hectares and 25.92% of the total area of the study area, because the area's soils have high NPK, good organic matter, neutral pH, high CEC and low salinity.

Medium fertility F3

This type is found with an area of 3421.09 hectares, at a rate of 6.90% of the total area, and the reason may be due to the presence of some sites with a high percentage of lime, low organic matter and medium salinity, but their N, P, K content is good.

Low fertility F4

This variety occupies an area of 4613.31 hectares, with a rate of 9.31% of the total area of the study area, as these soils are characterized by low organic matter, neutral pH, high lime percentage, medium CEC, and good N, P, K content with moderate salinity.

Conclusion

The soil of the study area has good N, P, K nutrients and good fertility content. The very fertile F1 variety occupied the largest area of the study area. However, there are few sites that were of low fertility due to the fact that there is little organic matter and high lime content in them.

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