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Fertility Evaluation of Some Regions of Dhi Qar and Wasit Governorates for Wheat Yield Indicators Using GIS Technique

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Abstract

The study was carried out in the district of Al-Hay and Al-Muwaffaqia Sub-district of Wasit Governorate and Qalat Sukkar and Al-Fajr Districts from Dhi Qar Governorate, where the soils of the study areas differed in some of their physical and chemical properties. Al-Hay field is located between longitudes (46° 1'55.36" - 46° 2'3.66") E and latitudes (32° 19'57.57" - 32° 19'59.70") N. Al-Muwaffaqia field is located between longitudes (45°53'8.51" - 45°53'33.90") E and latitudes (32°24'30.46" - 32°24'33.16") N, as for Qalat Sukkar district, it lies between longitudes (46° 9'32.82" - 46° 8'49.30") E and latitudes (31° 51'24.65" - 31° 51'32.30") N. Al-Fajr field is located between longitudes (45°58'42.42" - 45°58'20.76") E and latitudes (31°58'22.88" - 31°58'19.28") N.

The studied fields in this study were planted with wheat (Edna class) for the year of 2022, and only nitrogen and phosphate fertilizers were added to all fields. Plant samples were taken from the fields in the flowering stage to perform some required analyzes. Geographical information systems (GIS) technology was used to predict some soil fertility criteria and to produce a fertility map for each region by adopting the fertility assessment. As well as linking the final fertility map with the wheat yield for each region. A database was built for the characteristics of the soil and the yield with the least effort and costs. The results of the study indicated the following:

- *There are three types of soil in terms of fertility assessment (fertile, medium and low fertile soils) in the study areas, and the two types of very fertile and non-fertile soils did not appear in the study areas.*
- *The fertile soil class of Al-Hay area outperformed in growth indicators, yield and its components, the plant height was (111.70) cm, leaf area was (53.9) cm^2 and weight of a thousand grains was (36.9) gm compared to non-fertile soils class.*
- *The fertile soil class of Al-Muwaffaqia area outperformed in growth indicators, yield and its components, the plant height was (110.40) cm, leaf area was (53.3) cm^2 and weight of one thousand grains was (36.7) gm compared to non-fertile soils class.*
- *The fertile soil class of Qalat Sukkar area was superior in growth indicators, yield and its components, plant height was (110.10) cm, leaf area was (52.6) cm^2 and weight of one thousand grains was (36.2) gm compared to non-fertile soils class.*
- *The characteristics included in this assessment (fertile soils class) are not ideally available in the study area in Al-Fajr district, which contributed to their non-appearance in this category.*

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Introduction

The increase in population in the world is one of the most important challenges facing peoples in providing food, which led researchers to resort to searching for modern technologies in order to increase production, improve quality and reduce economic costs by knowing the ability of soil to provide plants with nutrients through fertility assessments.

This assessment includes a number of processes in which laboratory and field diagnostics are used. Soil management and knowledge of its fertility can be inferred from the traditional examination of it. While, the plant growth index reflects the extent of the plant's response to soil properties, but the currently used methods are weak in predicting production, temporal and spatial change, and its limited ability to reflect constantly changing soil parameters.

In view of the danger of dwindling various food resources and the increase in demand for agricultural production in contributing to filling the global food shortage as a result of dangerous climatic changes facing humanity, Therefore, some modern ways must be used to inventory and identify natural resources, which include soil and water, and these methods are:

Remote Sensing (RS) Technology and Geographic Information Systems (GIS) Applications,

The use of these systems has a very effective effect in modifying the classification and the soil surveying maps prepared by the competent authorities. The preparation of appropriate maps of agricultural lands is of importance in the agricultural future and the distribution of plants according to their suitability to the soil, as well as follow-up of the nutritional status of the crop in the stages of growth and the possibility of treating any defect. It is also possible to know the dates of maturity, harvest and marketing (Al-Badiri, 2018).

Wheat (*Triticum aestivum L*) plant is one of the most important cereal crops in terms of food and economy in the world, hundreds of millions of people depend on foods made from wheat, and it is the main source of human and animal nutrition. Also, wheat is a source of processing for minerals, vitamins, amino acids and fiber. Therefore, its cultivation occupies a strategic importance in view of the extent of its exchanges in the global markets.

Wheat plant covers the largest area of the Earth's surface than any other food crop, despite this importance; Iraq still suffers from the lack of self-sufficiency in wheat.

Despite the increase in production per unit area almost to double at the end of the last century, there is still a shortage in the productivity of this crop for several reasons, including the failure to follow scientific methods in soil and water management, low soil fertility, high salt content and lack of water resources, so researchers resorted to using modern technologies, through which it is possible to reduce the gap between the decrease in production and the increase in demand in securing food needs (Mazal, 2021).

Materials and methods

Four sites were selected, two of them in the south of Wasit Governorate, which are Al-Hay District and Al-Muwaffaqia sub-District, and two in the north of Dhi Qar Governorate, namely, Qalat Sukkar District and Al-Fajr District. The approximate areas of the study areas were as follows: Qalat Sukkar (105 acres), Al-Fajr (100 acres), Al-Hay (100 acres) and Al-Muwaffaqia (98 acres).

The soil was prepared in terms of plowing, smoothing and leveling, then it was divided into slabs and the main and subsidiary streams were made. The soils of the studied areas are densely planted with cereal crops, especially wheat and barley, as well as yellow corn.

The location of each field was located and samples were taken from the fields in the flowering stage to perform some required analyzes. The coordinates of the sample locations in the study area were taken using the GPS (Carmen type) with a UTM coordinate system, them these locations spatially dropped using ArcGIS 10.8.1 software for the purpose of meeting the requirements of spatial analysis.

The soil was planted with seeds of bread wheat (Edna class) by the farmers in the districts of Al-Hay, Al-Muwaffaqia, Qalat Sukkar and Al-Fajr in the form of stripes in slabs, the area of the slab was 2500 m^2. The seeds were sown on 1/11/2021, 3/11/2021, 1/11/2021 and 7/11/2021 for Al-Hay, Al-Muwaffaqia, Qalat Sukkar and Al-Fajr fields respectively.

The distance between one line and the other was 15 cm. The soil was fertilized with nitrogen and phosphate fertilizers, the crop service was carried out when it needed. On 04/30/2022, at full maturity of the grains (yellowing spike and foliage), the plants were manually harvested from an area of 1 m^2 , It was taken from 10 locations for each field and according to the coordinates taken by the (GPS) device and the following characteristics were measured:

Plant height(cm):

Plant height was measured from the base of the plant from its contact with the soil surface to the base of the spike on the main stem at harvest and as an average of ten plants per square meter harvested (Khan and Spilde, 1992).

Leaf area (cm^2):

F.L.A=(L)(MW)0.75

F.L.A: The area of the flag leaf (cm^2), which was estimated at the flowering stage

L: length of the flag leaf (cm); MW: width of the flag leaf at the middle (cm).

Weight of 1000 grains (g):

A random sample of grains was taken from the harvested square meter area and 1000 grains were counted and weighed.

Standard multiplication method for land valuation:

Soil characteristics that affect soil fertility for growing crops were determined through this method, which was modified from (Sys et al., 1980) to assess land by entering ready N, P, K, pH and OM to become a fertility assessment equation, where the assessment estimates for different soil characteristics are multiplied by each other for the purpose of obtaining the final estimate of fertility assessment, through which the soil suitability class is determined according to the following equation:

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

F= Soil fertility assessment indicator

T= Texture, OM= Organic Matter, CEC= Cation Exchangeable Capacity, $CaCO_3$= Calcium Carbonate, N= Nitrogen, P= Phosphor

K= Potassium, EC= Electric Conductivity, ESP= Exchangeable Sodium Percentage

Results and discussion

Plant height (cm):

The results showed there were relative differences in the average height of the crop for each of the study areas. As can be seen in figure

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(1), where the highest average height of the wheat crop in Al-Hay was (111.70 cm), compared with the lowest average height, which was (99.90 cm). Thus, this height corresponds to the fertility assessment of the soil in Al-Hay area, as the fertile soil class had the highest average and the lowest average was for the low fertile soil class.

Figure (2) also indicated there are differences in Al-Muwaffaqia area for the average height of the wheat plant. The highest average height was (110.40 cm) compared to the lowest average height, which was (93.20 cm). Thus, it fits with the fertility assessment of the soil in Al-Muwaffaqia field, as the fertile soil class had the highest average and the lowest average was for the low fertile soil class.

Figure (3) indicated there were differences in the area of Qalat Sukkar in the average height of the wheat plant, so that the highest average was (110.10 cm) compared to the lowest average height (92.40 cm), and this fits with the fertility assessment over there, The fertile soil class had the highest average and vice versa.

Also, the previous relationship was appeared in Al-Fajr area, the highest rate of plant height was (99.80 cm) compared to the lowest rate (92.20 cm). Thus, it fits with the soil fertility assessment in Al-Fajr area, as the highest average plant height was for the medium fertile soils class, and the lowest average was for the low fertile soils, see figure 4.

Comparing the figures (1, 2, 3 and 4), one can note there were differences in the average height of wheat plant among the study areas, where the highest average was in Al- Hay area with fertile soils class, reaching (111.70 cm) compared to the lowest average (92.20 cm), which was in Al- Fajr area with low-fertility soils.

The addition of nitrogen fertilizer to the field of Al-Hay area in a higher amount than the rest of the study areas has affected the increase in plant height, and this is evident from the positive effect of nitrogen fertilizer on the activity of meristematic tissues and their role in cell division, In addition to its entry into the synthesis of chlorophyll and in the formation of many important compounds such as nucleic acids, proteins, enzymes, cell membranes and energy compounds that affect the increase in plant growth, Thus, it leads to an increase in dry weight, leaf area and plant height (Ali et al., 2014). Increasing the availability and absorption of phosphorus in the soil increases the growth and branching of the roots, and thus helps in the absorption of nutrients and water as well as its participation in the formation of energy, nutritional balance and acceleration of plant growth. There is also a role for potassium in the elongation and increase in the number and thickness of knots and the accumulation of carbohydrates in the stem, which contributes to increasing the height of the plant (Abu Dahi and Younis, 1988).

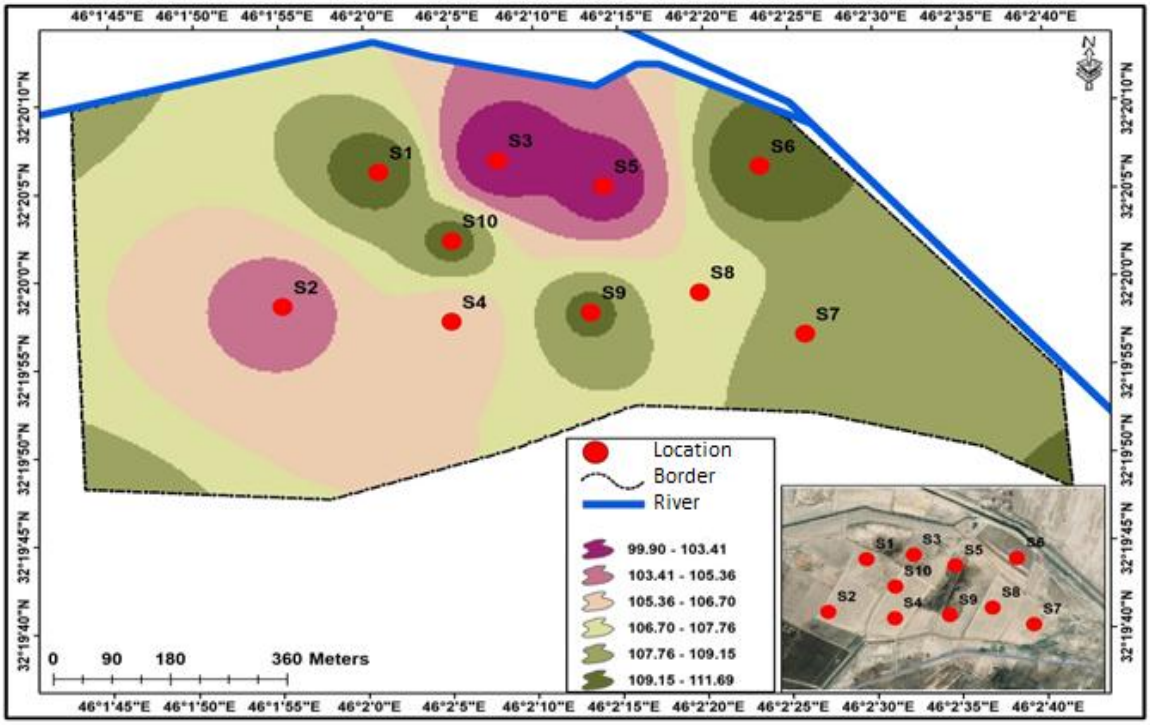

Figure (1) Relationship of the fertility assessment with the average height of the wheat plant (cm) by Cokriging method for Al-Hay area

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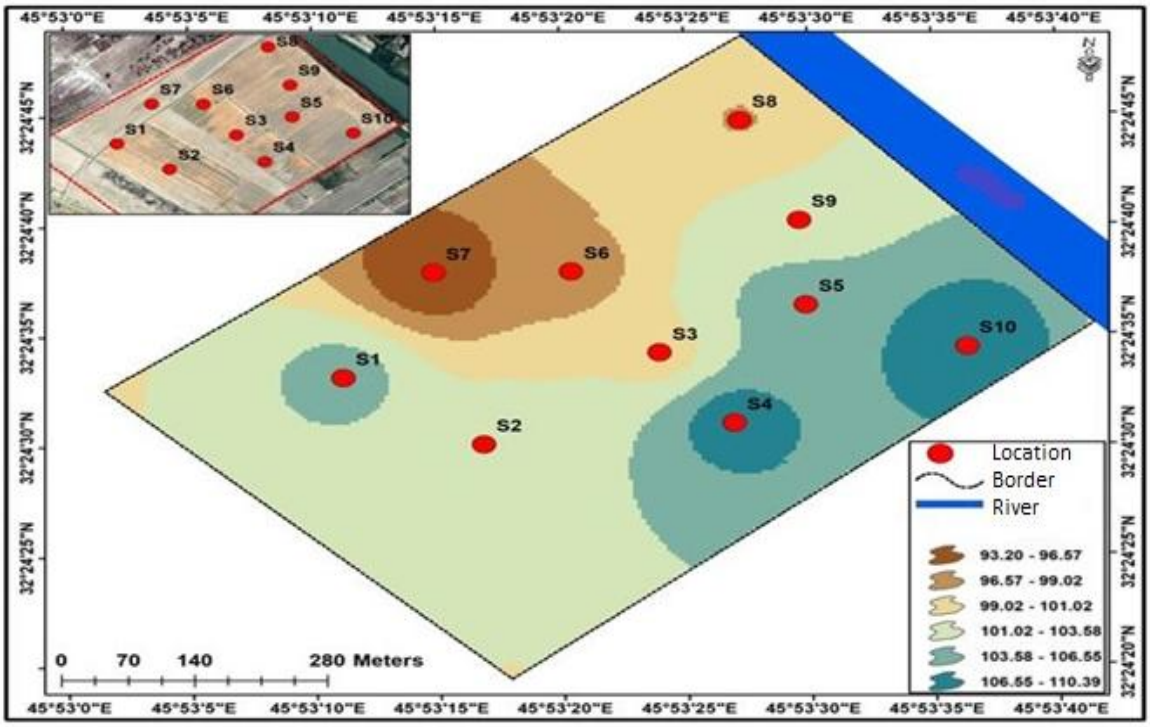

Figure (2) Relationship of the fertility assessment with the average height of the wheat plant (cm) by Cokriging method for the Al-Muwaffaqia area

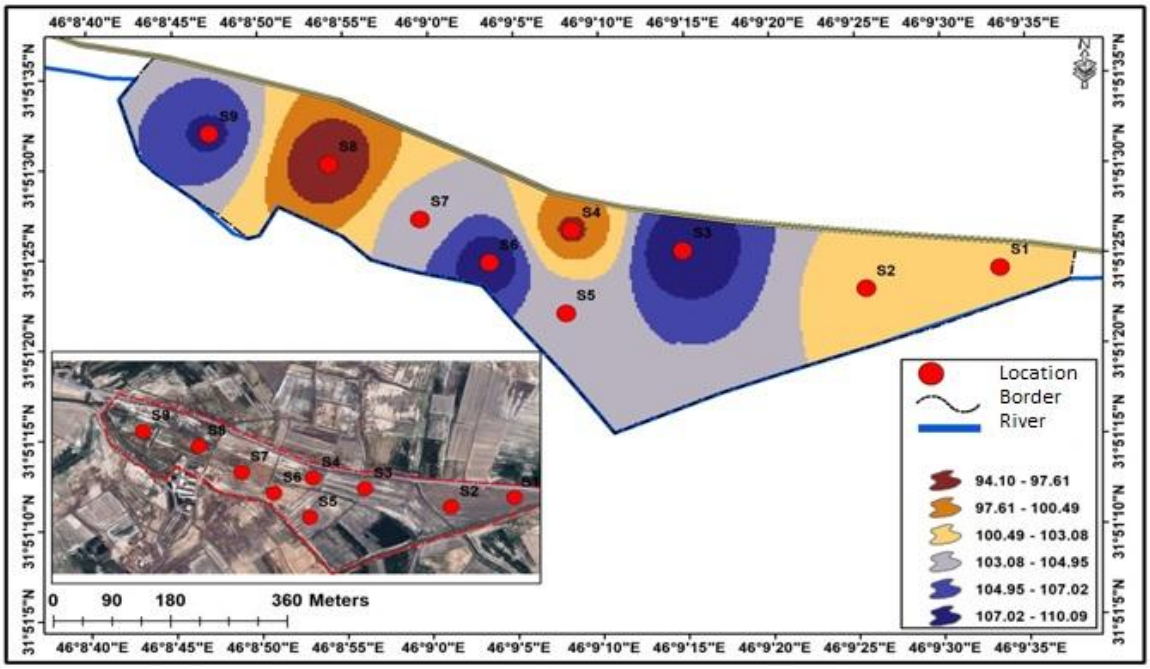

Figure (3) Relationship of fertility assessment with mean plant height (cm) by Cokriging method for Qalat Sukkar area

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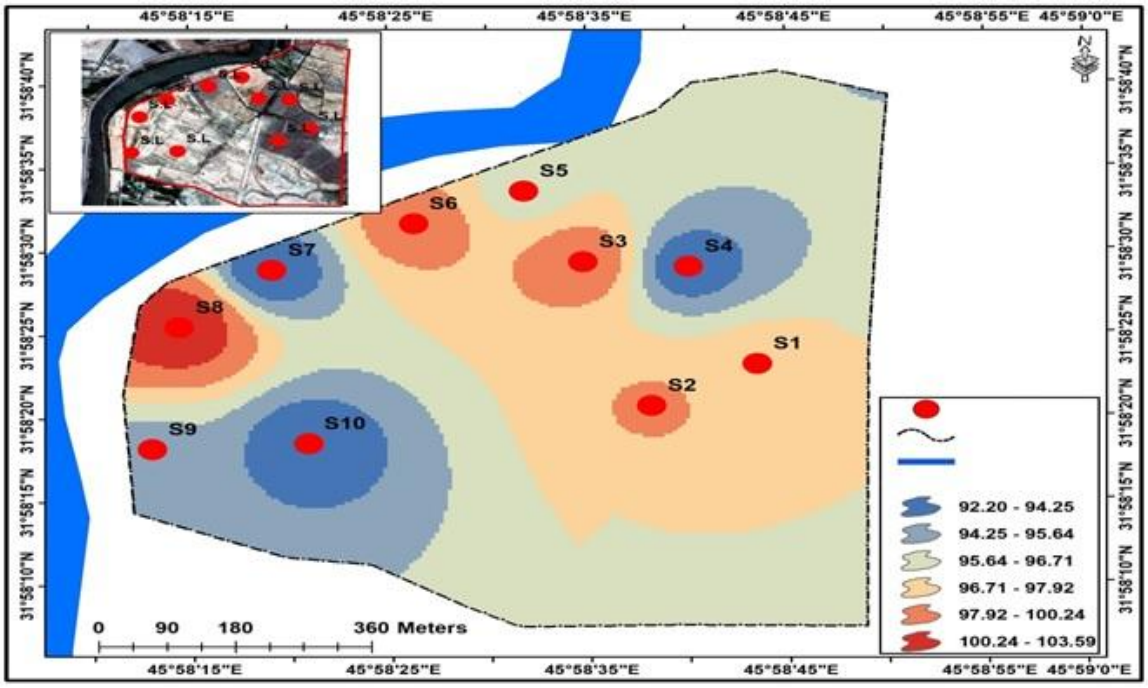

Figure 4: The Relationship of fertility assessment with mean plant height (cm) by Cokriging method for Al-Fajr area

Leaf's area (cm^2)

The results showed there were differences in the average of leaf area of wheat plant in each of the study areas, figure (5) showed that the highest average of leaf area in Al-Hay was (53.9 cm^2) compared to the lowest average of (47.9 cm^2). This is consistent with the fertility assessment of the soil in Al-Hay area, as the highest average was for the fertile soils class, and the lowest average was for the poorly fertile soils class.

Figure (6) also showed there were differences in Al-Muwaffaqia area for the average of the leaf area of the plant, where the highest average reached (53.3 cm^2) compared to the lowest average which was (47.5 cm^2). This is consistent with the fertility assessment of the soil in Al-Muwaffaqia area, as the highest average was for the fertile soils class, and the lowest average was for the poorly fertile soils.

Figure (7) also showed that the highest average of leaf's area in Qalaat Sukkar study area was (52.6 cm^2) compared to the lowest average of the leaf's area, which amounted to (47.2 cm^2); this is consistent with the fertility assessment of the soil in the region, as the highest average was for the fertile soils class, and the lowest was for the poorly fertile soils class.

In Al-Fajr area, the highest average leaf 's area was (51.5 cm^2) compared to the lowest average area, which was (47.1 cm^2), this is consistent with the fertility assessment of soil in Al-Fajr area, as the highest average was for the medium-fertility soils class and the lowest average was for the low-fertility soils class, see figure (8).

Figures (5, 6, 7 and 8) indicated there was a difference in the average of the leaf's area of a plant between the study areas. The highest one was in Al-Hay area with fertile soils class, which reached (53.9 cm^2) compared to the lowest one (47.1 cm^2) which was at Al-Fajr field with low fertile soils.

It was observed that there was an effect in increasing the average area of the flag leaf resulting from the increase in the addition of nitrogen fertilizers, as Al-Hay area outperformed the rest of the study areas. The increase in the leaf's area has been attributed to the role of nitrogen in increasing cell size, division and elongation as a result of the efficiency of carbon metabolism and the encouragement of meristematic activity and food making, and then increasing the leaf's area (Abu Dahi and Younis, 1988; Havlin et al., 2005).

The increase in the availability of nitrogen and phosphorous in the soil contributed to the production of the necessary nutrients in the growth of the crop and the increase in the leaf's area, which led to an increase in the growth of the roots and the vegetative total of the plant as well as the essential role of potassium in the physiological functions of plants, the composition of the protoplasm, the metabolic processes of carbohydrates, the encouragement of the growth of meristematic tissues and its contribution to the regulation of the activities of various nutrients, and then the formation of good root and vegetative growth to increase the efficiency of the absorption of ready nutrients and water in the soil.

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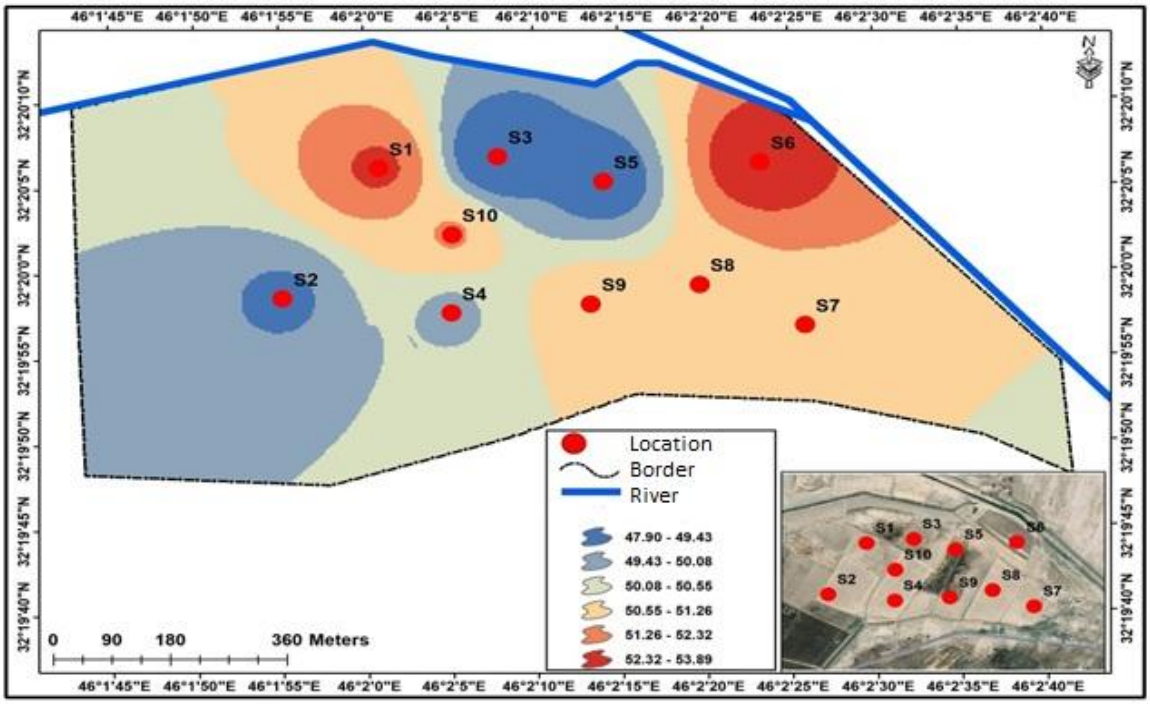

Figure (5) The relationship of fertility evaluation with the average leaf area of wheat plant (cm^2) by Cokriging method for Al-Hay area

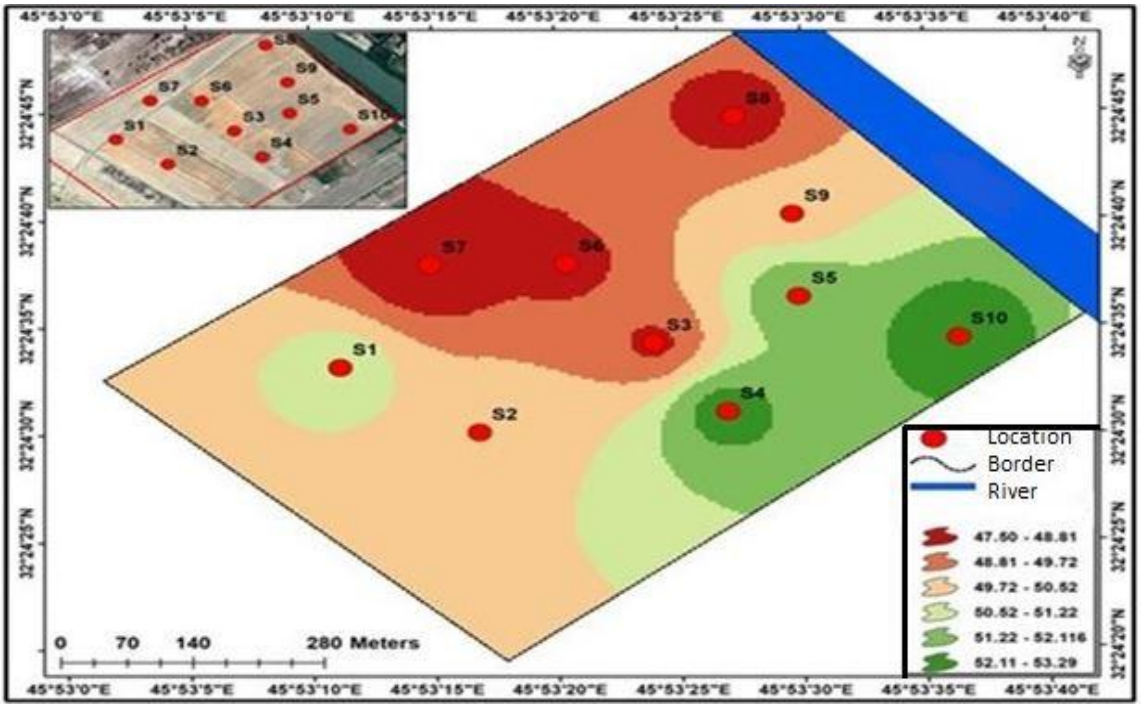

Figure (6) The relationship of fertility evaluation with the average leaf area of wheat plant (cm^2) by Cokriging method for Al-Muwaffaqia area.

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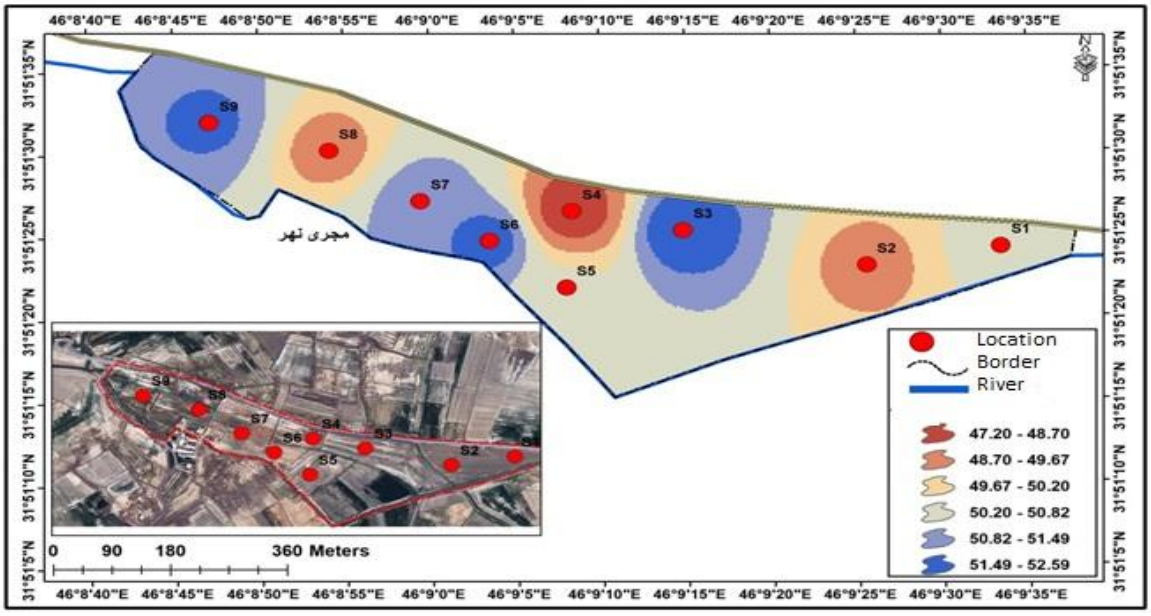

Figure (7) The relationship of fertility evaluation with the average leaf area of wheat plant (cm^2) by Cokriging method for Qalat Sukkar area

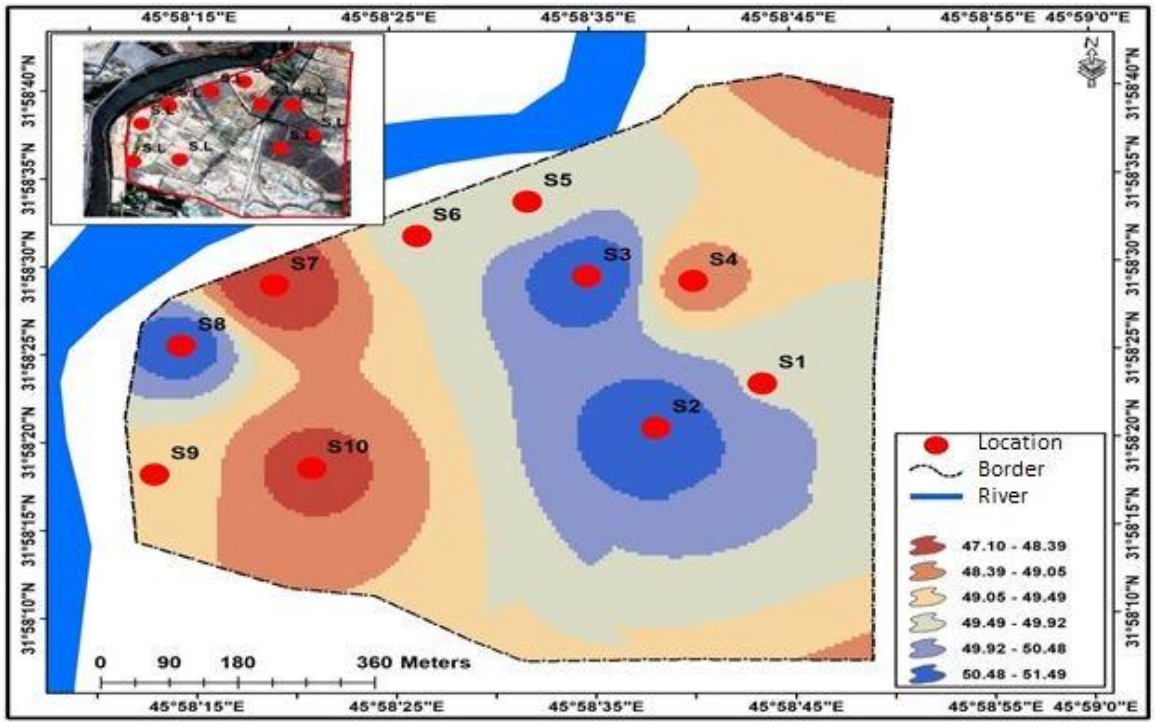

Figure (8) The relationship of fertility evaluation with the average leaf area of wheat plant (cm^2) by Cokriging method for Al-Fajr area

Weight of a thousand grains (g):

The results showed there were differences in the average weight of a thousand grains of wheat in each of the study areas.

Figure (9) shows that the highest average weight of a thousand grains in Al-Hay area was (36.9 g) compared with the lowest average weight, which amounted to (33.5 g), this is consistent with the fertility assessment of the soil in Al-Hay area, as the highest average was for the fertile soils class and the lowest was for the low fertile soils.

Figure (10) shows that the highest average weight of a thousand grains was in Al-Muwaffaqia, which amounted to (36.6 g) compared to the lowest average weight, which amounted to (32.8 g), this is commensurate with the fertility assessment of the soil in Al-Muwaffaqia area, the highest rate was for the fertile soils class and vice versa.

Figure (11) shows that the highest average weight of a thousand grains in Qalat Sukkar was (36.2 g), compared to the lowest average weight, which was (32.4 g). This is consistent with the fertility assessment of soil in Qalat Sukkar area, as the highest average weight was found in the fertile soils class and the lowest was found in the poorly fertile soils.

Finally, figure (12) shows that the highest average weight of one thousand grains in Al-Fajr area was (35.7 g) compared to the lowest average weight (32.1 g) in the same area and this is consistent with

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the fertility assessment of Al-Fajr soil, as the highest average was for the medium-fertility soils and the lowest average weight was for the low-fertility soils.

The results in Figures (9-12) showed there were differences in the average weight of one thousand grains of wheat between the study areas, where the highest average weight (36.9 g) was in Al-Hay area with fertile soils class compared to the lowest average weight(32.1 g) which it was in Al-Fajr area with the little fertility soil class. The reason for the increase in the weight of the wheat plant may be due to the increased addition of nitrogen in the vegetative growth stage, and also may be due to the direct effect of the leaf's area, which leads to an increase in the plant's ability to carry out the photosynthesis process and thus increase the efficiency of the transfer process from leaves to grains, nitrogen has a clear role in increasing the volume of food tissue, as it helps in increasing the efficiency of the saffron in the production of starch, which turns into sugars, in addition to the dissolved nutrients as a result of aging of the stem and leaves, this means there is a clear relationship between the weight and fullness of the grains, the increase in the surface area of the leaf and the decrease in the percentage of atrophic grains (Al-Badiri, 2018).

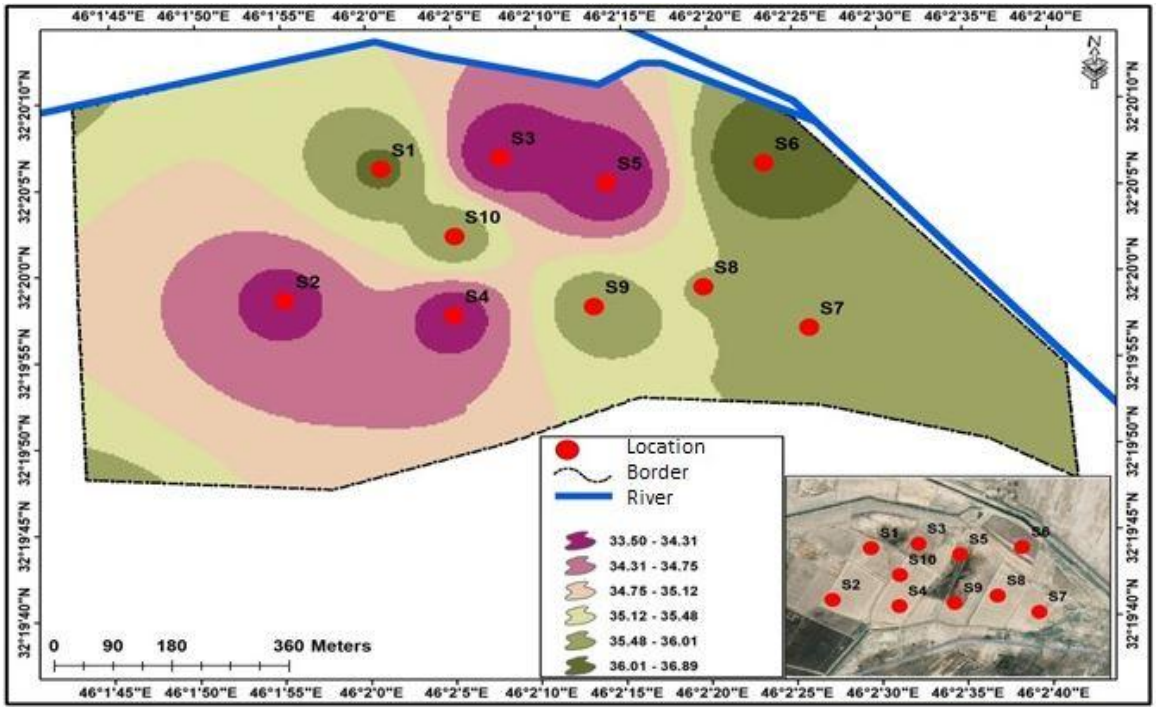

Figure (9) The relationship between the fertility evaluation with the average weight of one thousand grains of wheat (g) by Cokriging method for Al-Hay area

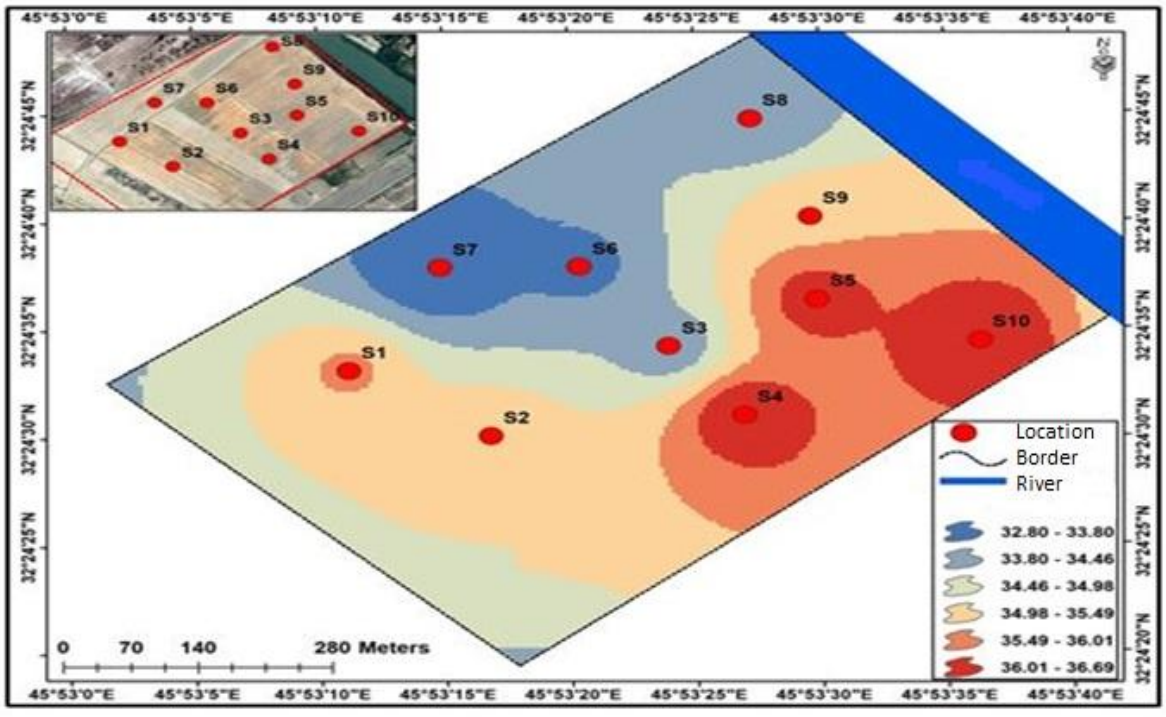

Figure (10) The relationship between the fertility assessment with the average weight of one thousand grains of wheat (g) by Cokriging method for the Al-Muwaffaqia area

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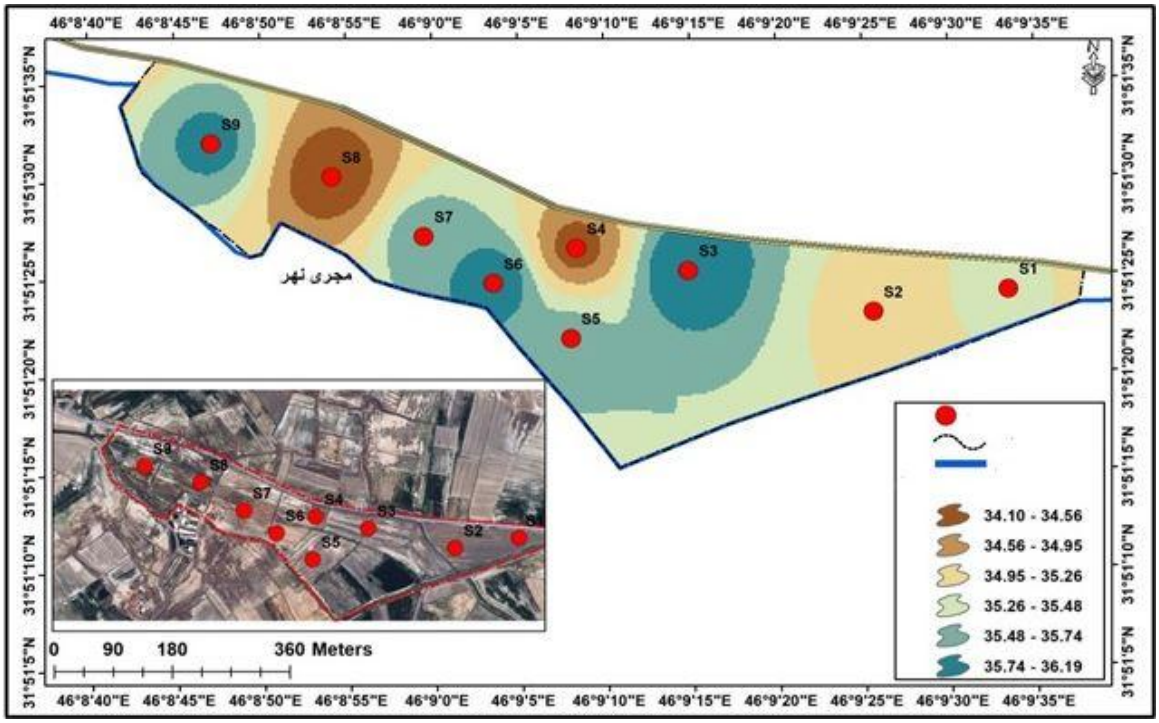

Figure (11) The relationship between the fertility assessment with the average weight of one thousand grains of wheat (g) by Cokriging method for Qalat Sukkar area

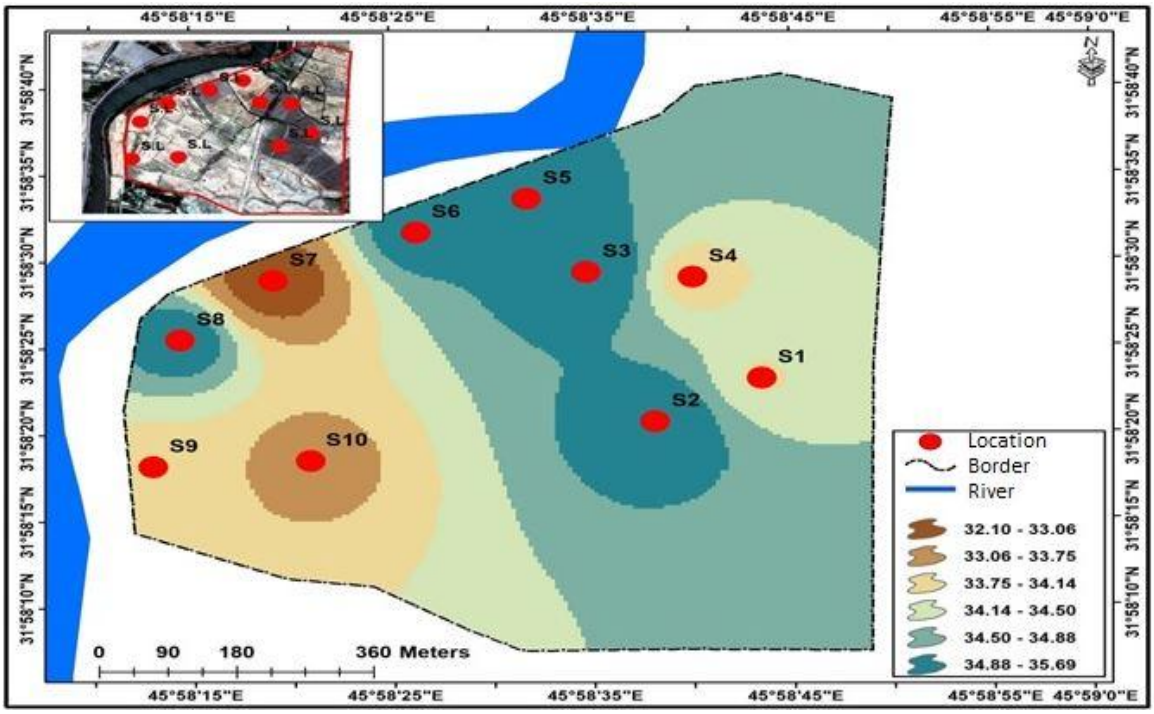

Figure (12) The relationship between the fertility assessment with the average weight of one thousand grains of wheat (g) by Cokriging method for Al-Fajr area

Conclusions

1- The addition of nitrogen fertilizer had a positive effect in activating meristematic tissues and its positive role in cell division and in the formation of many important compounds that affect the increase in plant growth and thus lead to an increase in dry weight, leaf's area and plant length.

2- Adding potassium fertilizer has very important role in elongating and increasing the number and thickness of knots and the accumulation of carbohydrates in the plant stem, which increases the height of the plant.

3- Al-Hay study area outperformed the rest of the study areas as a result of adding nitrogen fertilizer to its field in a higher quantity than the rest of the study areas, which gave positive results.

Recommendations

1- We recommend the use of the study areas in the cultivation of strategic crops such as wheat, barley and

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corn due to their suitability for the cultivation of these crops according to the results of the study.

2- Attention to the management and reclamation of low-fertility and non-fertile soils.
3- Using modern methods such as the use of geographic information systems to reduce effort and costs.

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