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SPATIAL VARIABILITY OF SOME FERTILITY PROPERTIES IN RICE CULTIVATED SOILS USING GIS

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Abstract

The study area was selected in the Abbasid district of Najaf Governorate, which is confined between two longitude 32° 06 42.8 ° to 32 ° 07 57.2 ° North and two latitude 44 ° 25 ° 16.4 ° to 44 ° 24 30.5° east. Coordinates of pedons study locations were determined by GPS. Eight pedons were detected for soils cultivated with rice, the pedons were described morphologically. Samples were obtained from each horizon interfaces samples was obtained randomly of four equal depths of 25-0 cm, 50-25 cm, 75-50 cm, 100-75 cm, for the study of spatial variability for the properties of those soils, then the necessary laboratory analyzes, statistical and geological analysis were conducted, and the samples number for each property was calculated. When using geological statistics to describe the variability of fertility properties, the availability zinc was the most variability in the horizons C1 and C2, followed by the availability iron in the horizons Ap and C1 and the total zinc at horizon C3. The effective distance values ranged for these properties in those horizons between 208-653 m, and the appropriate statistical models to describe the variability of soil properties when the geological statistics uses, it was the spherical model and the Circular model by 50% for each. It found that the appropriate technology for obtaining soil samples be represented more efficiently, Depending on the effective range value with a strong spatial dependence of all the properties studied. As the number of samples that were calculated by the randomization law for fertility properties between 1-1586 samples, but when using geological statistics, the number of samples varied 4-12 sample. The soil of the study was classified within order of modern soil composition (Entisol), suborder of river deposits (fluvents), the great group (Torrifluvents) and sub group (Typic Torrifluvents).

Key words : Rice soils, fertility properties, spatial variability, semivariance.

Introduction

The source of the spatial variability of the soil arises from various factors, the most important of which are soil composition factors and soil management practices, which effect on the production (Mulla and Bratney, 2000). The importance of studying the variations of soil traits for the success of agriculture or quality management, that the description of the variability of soil properties is a good documentation of these properties, Determining the extent of variability in soil gives us more accurate estimates for use in soil management and in planning land management projects. These variations may be systemic variability or random variability (Sigua and Jabro *et al*., 2006; Chang, 1976) showed that the northern of Vietnam and northern of Thailand were characterized by rice cultivation. The soil is medium smooth, the availability of some multi-equivalent elements is increased in it such as iron and the pH of soil is low but salts content is washed down and salinity is low. Most of the Iraqi soils, especially lime, suffer from a clear lack of availability iron content for most plants, especially economic ones. The content of availability iron is limited in relation to its total content due to its impact on many factors, including soil interaction and the content of carbonate minerals, clay minerals and organic substance (Sharma *et al*., 2004), so there is variability of availability iron in those soils. Boisse *et al*. (2006), explained that although the soil content of total iron is high, the amount of availability from it does not meet the need of the plant. The extent of the presence of iron in the soil is determined by its texture and content from organic substance, in addition to environmental conditions, iron (III) oxides represent the most abundant form in the surface layer, The most common forms of iron are Fe^{+2}, which are easily oxidized

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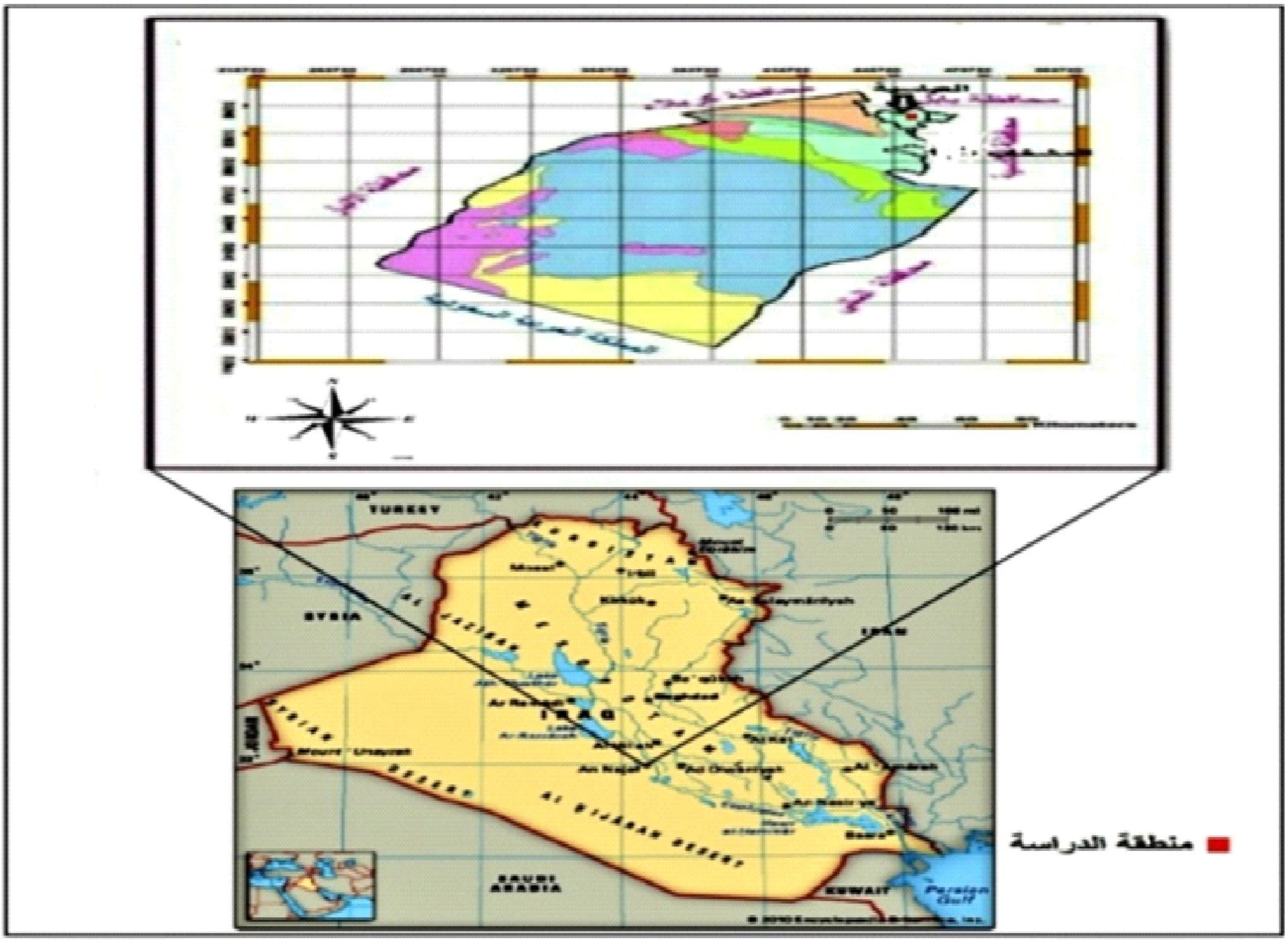

Fig. 1 : Map for the location of the study area.

to the most stable form Fe_2O_3 (Ibrahim, 2008).

The availability of both iron and zinc in the soil varies according to the factors affecting their availability as well as variability depending on the soil type and its physical, chemical, mineral and fertility traits, the more thing leads to the variability of soil properties and the availability of elements is the soil water, which is the appropriate media to dissolve the nutrient elements and move it to the plant, influence in many soil interactions, especially the reactions of oxidation and reduction, In well-ventilated soils, moisture content is (low - moderate), so the soil is poorly equipped with iron and zinc, with increased soil ventilation accompanied by an increase in ferric concentrations at the expense of iron (Lindsay, 1979). Geological statistics are used to predict the values of these traits in locations where samples were not taken with a minimum of error using (Kriging); the variance is used to estimate values between the samples taken roughly (Diggle and Ribeirro, 2007). Geological statistics can be used to describe and model spatial variability between the values of different soil traits by calculating the Semi-variance function of these traits (Bachmaier and Backes, 2008).

Materials and Methods

Information was collected about the study area. The Najaf Governorate Department of Agriculture was used to determine the study area that is characterized by the cultivation of the rice crop for a long period of more than 50 years. The locations of the pedons were then determined and their coordinates were obtained by means of a GPS device and random sampling of four equal depths (0-25, 25-50, 50-75, 75-100 cm) was obtained to follow the spatial variations of the soil traits. The samples were then collected from each horizon and their coordinates were determined and kept in bags for the purpose of carrying out the necessary laboratory tests. The study area placed in the Abbasid district of Najaf Province as shown in fig. 1, which is confined between two longitude 32° 06 42.8° to 32° 07 57.2° North and two latitude 44° 25° 16.4° to 44° 24 30.5° east.

The availability iron and availability zinc was estimated using the extraction method by DTPA solution. The mixture is then filtered and measured in a Flame Atomic

Absorption Spectrophotometer Shimadzu 7000A (Japan), as described in Lindsay (1978). Total iron and total zinc are estimated by using the royal water digestion method, 3 units of HCL and one unit of HNO_3. The mixture is then filtered and measured in a Flame Atomic Absorption Spectrophotometer Shimadzu 7000A (Japan), as described in (Ming Chen, 2001). The geological statistic was used to calculate the half-variance function using the Arc 9.3 program. The coordinates of the locations of the pedons taken by the GPS device were demarcated so that it could take the distance readings from the program and a geographical correction of the locations of the studied pedons for use in the program mentioned and then following calculations were done :

1. Semi-variance function as in equation (1)
2. Variogram: The relationship between the Semi-variance function and the distance h is used to determine the effective distance (Range) and spatial variability
3. Effective distance (Range)

The calculation of the number of samples required for soil properties by the following methods:

Spatial Dependence Method

The longest axis of the study area is divided, as it was the longest axis reached of 2587.628 m (2.59 km) on the effective distance (Range) using one of the randomization laws according to Al-Nasser and Al-Merzouk (1989) as under :

$$N = t2\alpha\ \sigma2/(\alpha\bar{x})2 \quad (1)$$

Where, N = number of samples required, tα = t value based on degrees of freedom, σ2 = varianceα = significant levels (0.05), x = average

The calculation of the spatial variability was done as follows :

Spatial Dependence = nugget / (nugget + sill) × 100 (2)

In terms of the qualitative description of spatial dependence, we relied on equation (2) adopted by Iqbal *et al*. (2005), Strong spatial dependence is described as strong because the ratio is less than 25%, dependence is described as moderate if the ratio is between 25-75, if the ratio is more than 75%, it is described as weak.

The randomization ratio was calculated using the following equation :

Randomization ratio = SD/Sill × 100 (3)

The basic assumption of spatial analysis is that the proximal points of unknown points are more influential than others when determining the values of unknown points. Therefore, the estimation of their values should be based on the proximal points. The kriging method is

Table 1 : Statistical analysis of total and availability for both iron and zinc and using geological statistics.

Traits	Horizon	Range (m)	Nugget	Partial Sill	Sill	Model	Spatiality Dependent	Spatial dependence cultivar
Total iron	Ap	602	0.02	321.58	321.6	Circular	0.006	Strong
	Cl	542	3.515	600.2	603.715	Spherical	0.58	Strong
	C2	610	2.7	4000	4002.7	Circular	0.07	Strong
	C3	535	0.26	443.66	443.92	spherical	0.06	Strong
Availability iron	Ap	299	0.02	2.06	2.08	Circular	0.951	Strong
	Cl	464	0	9.539	9.539	Spherical	0	Strong
	C2	223	0.065	6	6.065	Spherical	1.06	Strong
	C3	453	0.41	18.06	18.47	Spherical	2.17	Strong
Total zinc	Ap	502	0.024	10.667	10.691	Circular	0.22	Strong
	Cl	602	0	9.045	9.045	Circular	0	Strong
	C2	653	1.516	20.762	22.278	Spherical	6.37	Strong
	C3	319	0	20	20	Spherical	0	Strong
Availability zinc	Ap	304	0	0.14	0.14	Circular	0	Strong
	Cl	297	0	0.13	0.13	Spherical	0	Strong
	C2	208	0	0.718	0.718	Circular	0	Strong
	C3	435	0.02	0.47	0.49	Spherical	3.92	Strong

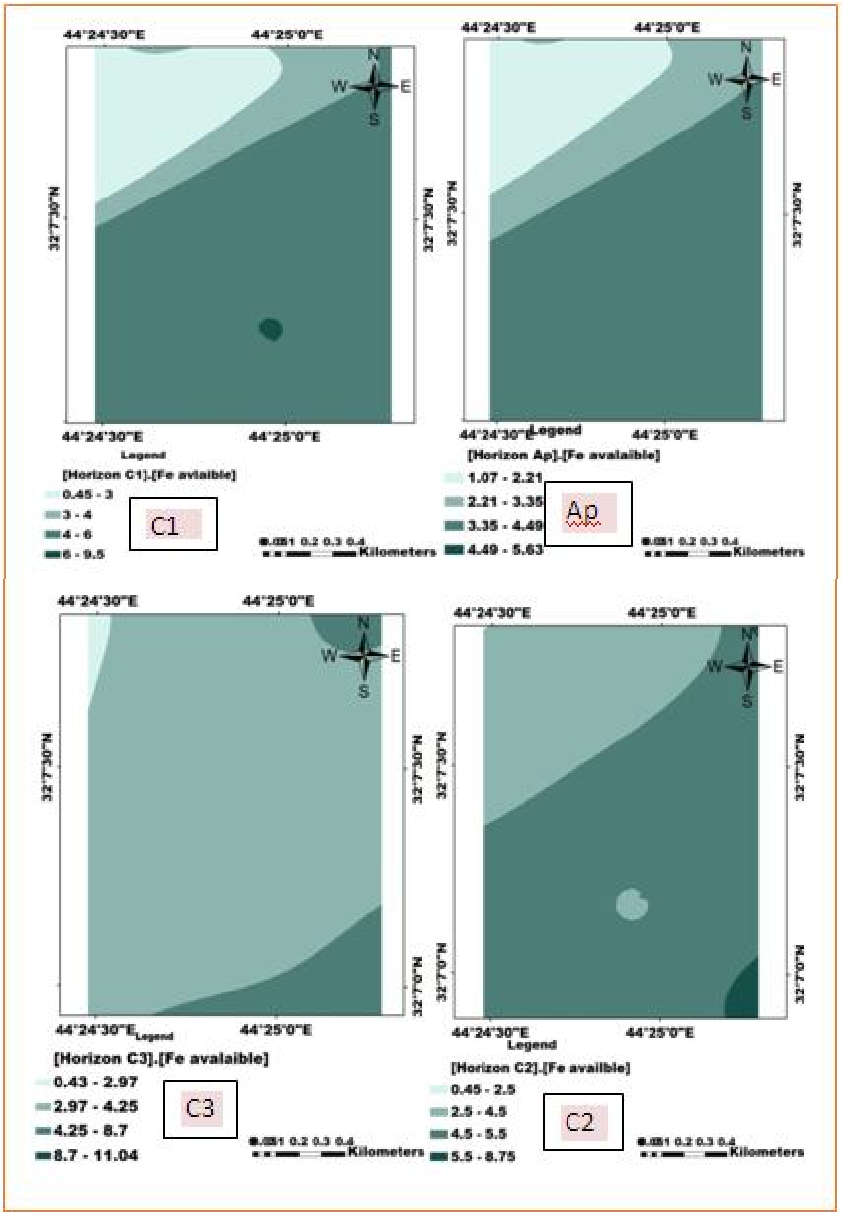

Fig. 2 : Spatial distribution of availability iron for the studied soil.

more complex, advanced mathematics is used to measure distances between all possible pairs of sampling points, This information is used to form an automatic spatial correlation of the specific surface to be formed (Demers, 1989). The characteristics of this curve are as under:-

Sill : Represents the maximum value of half-variance.

Range : The value of the effective distance (Lag distance) that corresponds to the highest sill value.

Nugget : represents the amount of error in measuring the values of sample point pairs.

Results and Discussion

Table 1 shows the results of the statistical analysis, the availability iron was highly variability in horizons Ap and C2 and there was little variance in the horizons C1 and C3, the effective distance (range) values of the iron component in these horizons reached 299, 464, 223 and 453 m for the Ap, C1, C2 and C3, respectively. The effective distance that describes the total iron variability, The results showed that the total iron variability was slightly in all horizons, the effective distance is reached 602, 542, 610, and 535 m for Ap, C1, C2 and C3, respectively. This may be due to the fact that the availability iron in the soil, even though it was a tuber, was seasoned. But the quantities are low in the soil has been consistent with the content of organic substance, calcium carbonate and clay content. This makes the availability iron variability high

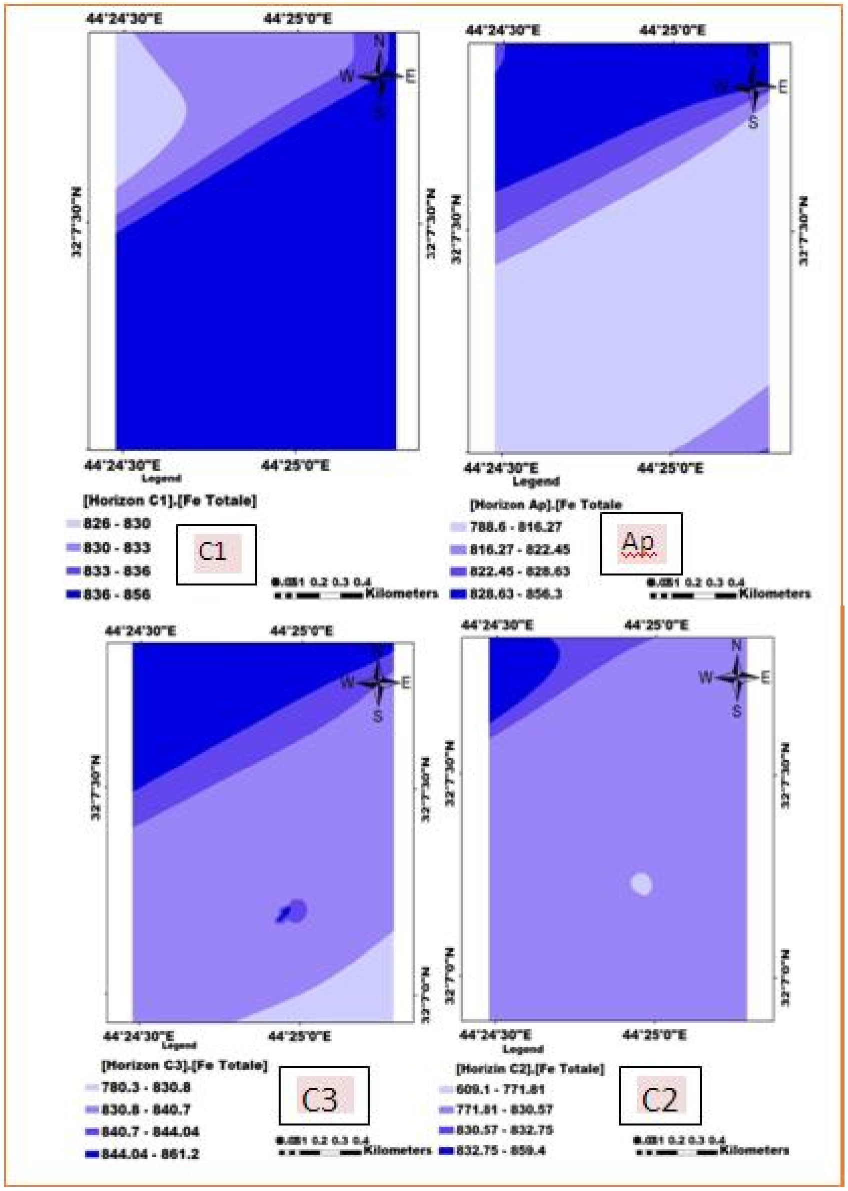

Fig. 3 : Spatial distribution maps of the total iron of the studied soil.

for the effect of these factors on its availability. Total iron in the soil is relatively high; the effect of these factors on it is less.

Therefore, the iron variability at the Ap horizon to variability the content of organic substance and horizon C2 was observed to variability the content of clay and calcium carbonate. Kartike *et al*. (2014), found that when studying spatial variability of small elements in Indian soil; found that availability iron variability was high. The appropriate model for describing availability iron variability, the spherical model was in the horizon Ap, whereas the circular model is the appropriate model to describe its variance in horizons C1, C2 and C3. This is in line with what Hussain *et al*. (2009), when studying the variability of microelements of the soil in Pakistan. The appropriate model for describing the total iron variability, the circular model was in the horizons Ap and C2, while the spherical model was the appropriate model for describing the variance in horizons C1 and C3. The results of (table 2) and spatial distribution maps for availability iron in Fig. 2 indicate that the percentage of the area occupied by the medium cultivar of availability iron was the highest with 71.57%, 75.07% and 66.52% for Ap, C1 and C2, respectively. While the low cultivar occupied the highest percentage of 70.48% in the horizon C3. The very high cultivar of availability iron has occupied the lowest area in the horizons Ap, C1 and C3, 0.25 and 1.38 and 0.06% respectively (Sood *et al*., 2004) in their

Table 2 : Spatial distribution of areas and percentages of iron and zinc total and availability for the study area.

Horizon / Traits	Ap			C1			C2			C3		
	Area	**%**	**class**	**Area**	**%**	**class**	**Area**	**%**	**class**	**Area**	**%**	**class**
Total iron	1456206	49.18	Very low	307542.1	10.39	Very low	22850.75	0.77	Very low	598563.3	20.21	Very low
	460607.5	15.55	Low	520494	17.58	Low	2500174	84.43	Low	1422888	48.05	Low
	436569.8	14.74	Medium	259056.3	8.748	Medium	302584.5	10.23	Medium	220265.9	7.44	Medium
	607832.9	20.53	High	1874124	63.29	High	135606.8	4.58	High	719499.2	24.30	High
Sum	2961216	100		2961216	100		2961216	100		2961216	100	
Availability iron	387593.9	13.09	Very low	362002.4	12.22	Very low	12313.09	0.42	Very low	38133.7	1.29	Very low
	446851.5	15.09	Low	335439.7	11.33	Low	890021.2	30.06	Low	2086935	70.48	Low
	2119356	71.57	Medium	2222999	75.07	Medium	1969732	66.52	Medium	834240.9	28.17	Medium
	7414.89	0.25	High	40775.28	1.38	High	89149.74	3.01	High	1906.398	0.06	High
Sum	2961216	100		2961216	100		2961216	100		2961216	100	
Total zinc	135846.7	4.59	Very low	9152.369	0.31	Very low	452606.4	15.28	Very low	261030.3	8.81	Very low
	533849.3	18.03	Low	623199.7	21.05	Low	329737.7	11.14	Low	2223798	75.10	Low
	276877.1	9.35	Medium	1268929	42.85	Medium	1557466	52.60	Medium	414037.3	13.98	Medium
	2014643	68.03	High	1059935	35.79	High	621406.2	20.98	High	62350.26	2.11	High
Sum	2961216	100		2961216	100		2961216	100		2961216	100	
Availability zinc	1478416	49.93	Very low	1561601	52.74	Very low	1605482	54.22	Very low	444745.1	15.02	Very low
	66252.49	2.24	Low	81261.73	2.74	Low	711590.9	24.03	Low	1764760	59.60	Low
	503220.9	16.99	Medium	924567.6	31.22	Medium	599039.7	20.23	Medium	459074.8	15.50	Medium
	913326.9	30.84	High	393785.2	13.30	High	46003.46	1.55	High	292635.7	9.88	High
Sum	2961216	100		2961216	100		2961216	100		2961216	100	

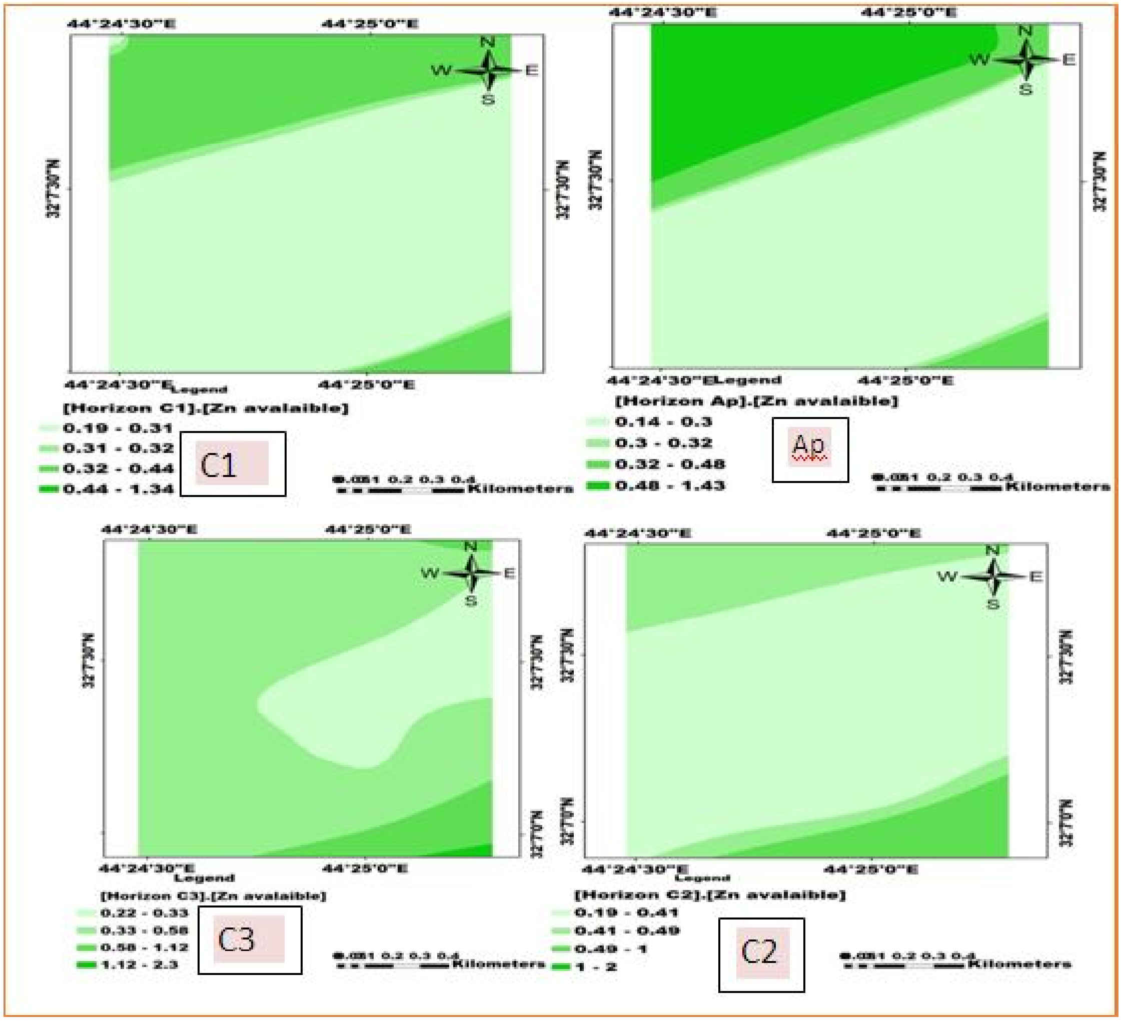

Fig. 4 : Distribution maps of availability zinc values for the studied soil.

study of the spatial distribution of micro-elements in the soil of India, explained that it is due to the content of the soil horizons of the quantities of the availability or total element. In addition to the effect of soil conditions in the internal availability of the element and the total amount of organic substance, the content of the clay and calcium carbonate, which leads to variability in the soil. Fig 3 indicates the spatial distribution of total iron in the soil horizons. As indicated in table 2, the percentage of the highest area occupied by the very low cultivar of total iron in the horizon Ap, where it amounted to 49.18%, the highest cultivar occupies second in terms of the proportion of high area in the horizon Ap amounted to 20.53%. Then came the low and then the medium in that horizon. This may be due to the variation and effect of clay content and organic substance in that horizon. On the horizon C1 was the highest cultivar is the highest percentage area of 63.28% followed by low, then medium and then very low in the total iron distribution in that horizon. The cultivars with the high proportion of the area in the horizons C2 and C3 occupied the low cultivar, Reaching 84.43% and 48.05%, respectively. The very low cultivar occupies the lowest area in the C2 horizon of 0.77%. The medium cultivar had the lowest area in the horizon C3 of 7.43%, This may be due to its content in those horizons and its quantitative compatibility with clay content and organic substance. This was confirmed by Attar *et al*. (2012) that found when studying spatial variability of iron and zinc in soil fields cultivated with wheat.

Table 1 indicates to the variance of the availability zinc. The values of the effective distance (Range) that describe its variance indicate that it had a high variability in horizons C1 and C2, higher than the Ap and C3 horizons, reaching 304, 297, 208 and 435 m for Ap, C1 and C2 and C3, respectively. The reason for its high variability is the factors affecting its availability, such as organic substance, soil interaction, clay content and iron effect .The appropriate model that describes its variation was the circular model in the horizons Ap and C2, while the spherical model was the appropriate model to describe

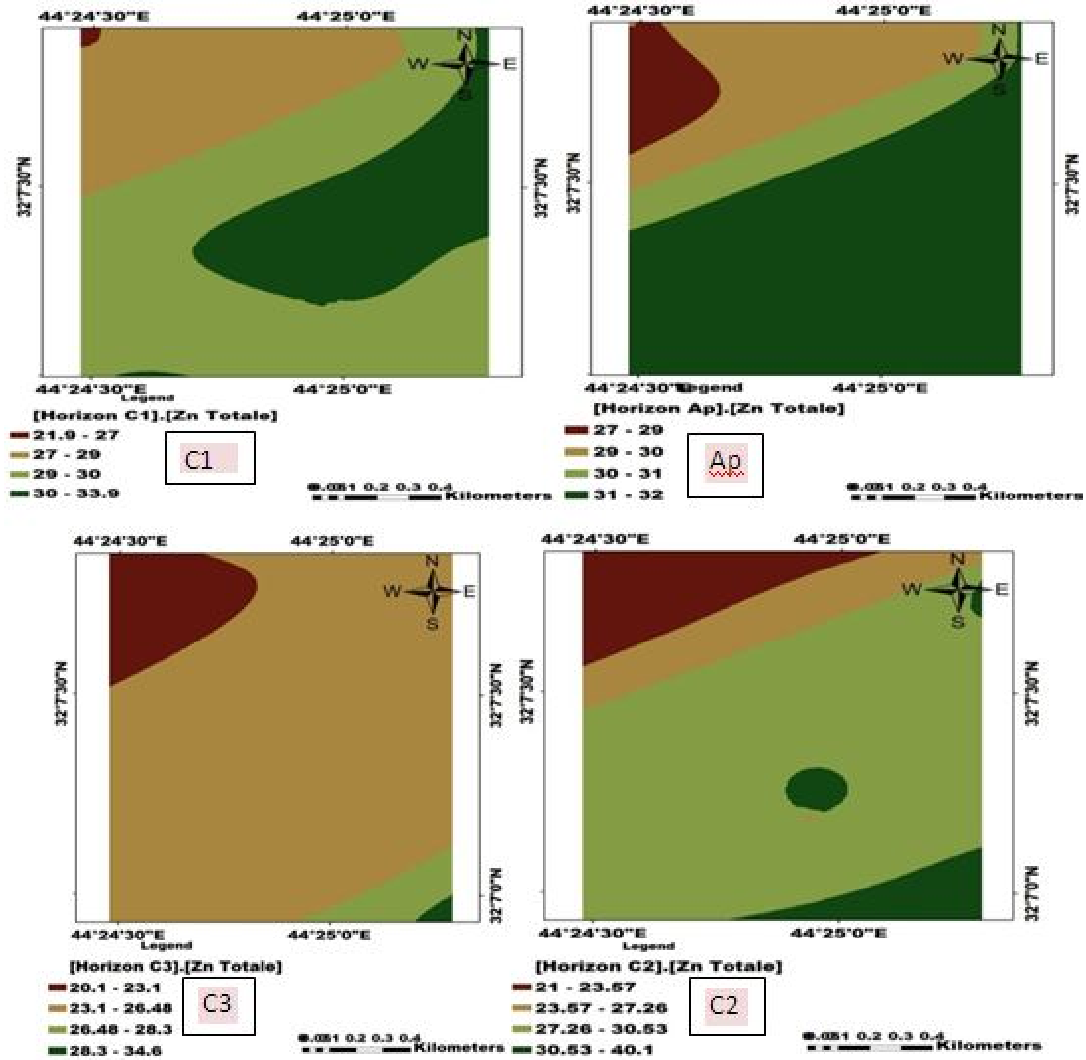

Fig. 5 : Distribution maps of total zinc values for the studied area.

the variance in the horizons C1 and C3. The reason is that these models gave the best representation of the function of the half-variance and also gave less variation error. The results of (table 2) showed that total zinc was slightly variability. As the effective distance values that describe its variation reached 502, 602, 653, and 319 m, to Ap, C1, C2 and C3, respectively. The reason for the lack of its variability to the stability of its quantity in those soils and the lack of conditions suitable for variability. In addition, what is present in the dry and semi-dry areas of the total zinc is considered a good quantity and because the availability of it is low due to high temperatures, lack of rain and the lack of organic substance in the soil. The appropriate model for describing total zinc variability was the circular model in the Ap and C1 horizons and the spherical model was the appropriate model for describing the variance in horizons C2 and C3, for the same reasons mentioned above.

Fig. 4 shows the availability zinc distribution in the horizons of the studied soil, that the very low class has occupied a percentage area of the horizon in Ap, C1 and C2, Reaching 49.93, 52.74 and 54.22%, respectively, While the lowest class had the highest area of horizon C3, Reaching 59.60% as for the smallest area, the lowest class has the lowest area of Ap and C1, amounted to 2.24% and 2.74% respectively, the C1 and C3 horizons were the lowest percentage area in the high class was 1.55% and 9.88%, respectively.

Fig. 5 shows that the total zinc distribution in the study soil horizons, as class variability in the proportion of area, as the highest class occupied the highest proportion of the area in the horizon Ap was 68.03%. The lowest percentage area for very low class amounted to 4.59%. This indicates the total zinc correlation with organic substance and clay. The medium class had the highest area in the horizons C1 and C2 with 42.85% and 52.60%

Table 3 : Number of samples by random method and geological statistics of fertility traits.

Traits	Horizon	Randomity percentage	Number of samples by the random method	Number of samples by the geological statistics
Total iron	Ap	5.98	1	4
	C1	2.8	1	5
	C2	1.72	13	4
	C3	5.31	1	5
Availability iron	Ap	171.78	24	9
	C1	33.22	22	6
	C2	88.97	65	12
	C3	22.58	47	6
Total zinc	Ap	13.72	331	5
	C1	31.16	648	4
	C2	11.43	529	4
	C3	14.71	820	8
Availability zinc	Ap	250.71	1091	9
	C1	599.62	1020	9
	C2	73.4	1586	12
	C3	140.2	1422	6

respectively, while the highest area in horizon C3 was occupied by the low class of 75.10%, The lowest area was occupied by the very low class C1 of 0.31%, and in C2 in the low class was 11.14%, while the higher class had the lowest area of horizon C3 of 2.11%.

The varariogram was drew after calculating the half-variance function according to Equation 1 through the GIS program and by using Geostatistics and Kriging technique, and plot the relationship with the Lag distance to see the spatial dependence or the effective distance (Range). As for the sampling and depending on the technique that takes into consideration the spatial correlation, the focus was on the effective distance in the calculation of the number of samples representing the study path. The longest distance was divided on the effective distance. The number of samples for fertility traits ranged between 4-12 samples during the use of geological statistics. The lowest number for the trait of total iron and total zinc in most horizons and the highest number of availability iron and zinc. The number of samples using the randomization law ranged between 1-1586, the lowest total iron count was at Ap, C1 and C3 and the highest number of Zn at C2.

Conclusion

1. Availability iron and availability zinc are more variability than total iron and total zinc.

2. Most attributes with spatial dependence required fewer samples depending on the half-variance scheme, while a large number of samples were required in case of reliance on the randomization law.

3. There was a positive relationship between the availability iron with the availability zinc and a negative relationship of total iron with total zinc and iron was associated with a negative relationship with negative clay and calcium carbonate and organic substance and soil interaction as well as availability.

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