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STATUS AND DISTRIBUTION OF AVAILABLE NUTRIENTS IN SOUTH EL-AMIRIA SOILS, ALEXANDRIA GOVERNORATE, EGYPT USING GIS TECHNIQUE.

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ABSTRACT: The current work aims to study the status and distribution of available nutrients in south El-Amiria soils, Alexandria Governorate, Egypt, using Geographic Information System (GIS) technique. The capability of GIS technique was used to create the classified fertility maps of available macro and micro nutrients status of the studied area. Available nitrogen varies widely from low to medium limits and has significantly positive correlation with organic matter, clay, gypsum and silt. Available phosphorus appears, generally, low limit and has positive and significant correlation with soil salinity, clay, silt and lime contents. Available potassium changes widely between low and high limits and has positive and significant correlation with silt, clay, soil salinity and lime contents. Available iron is in a low limit and has significant and positive correlation with organic matter content only. Available manganese shows, generally, low limits too and has positive and significant correlation with silt, clay, lime and organic matter. Available zinc differs between medium and low limits, and appears positive and significant correlation with organic matter, clay, silt, lime and gypsum. Available copper tends to be in low limits and has positive and significant correlation with clay, organic matter, lime, silt and gypsum. Effects of total sand contents on availability of most different studied elements show significant negative correlation except available iron contents which appear insignificant correlation. Evaluation of the nutrition requirements for annual and perennial crops of both groups reveal the deficiency levels of P, Fe, Mn, Zn and Cu.

Key word : Available nutrients , Marine-Lacustrine plains, Windblown sand, GIS Technique.

INTRODUCTION

Soil fertility plays an important role in increasing productivity per area unit. Recently, Gaafar *et al.* (2021) noticed a deterioration of the soil as a result of intensive cultivation methods and increase the absorption of elements by plants without adequate compensation. Sandy and calcareous soils represent large areas in arid and semi-arid regions, especially in the Arab world. These soils are generally characterized by low fertility levels, easy volatilization of ammonia, low water retention capacity and alkaline effect (El-Tapey *et al.*, 2019 and Habib, 2021).

Above 90% of the bulk mass of living matter is composed mainly of organic compounds and water. Mineral and organic-mineral compounds form a relatively small portion of living matter. The chemical elements of carbon, hydrogen, oxygen, and nitrogen formed the biggest part of living matter. Meanwhile, the Potassium, phosphorous, calcium, magnesium, sulfur, sodium and chloride are present in living organisms in smaller and variable amounts. All these elements are readily mobile in the biosphere and are known to form either volatile or easily soluble compounds that are involved in major environmental cycles (Kabata- Pendias and Pendias, 1992).

Jenny (1962) and El-Toukhy (1995) mentioned that available nitrogen in Egypt ranged between 125 and 174 mg/Kg soils. On the other hand, Abd El-Razik (2002) reported a range from 14 to 115.42 mg/Kg soils. El-Fahham (2003) found that available nitrogen fraction ranged from 1.0 to 10.0 mg/Kg soil in west Mersa Matrouh.

Phosphorus element comes as the second after the nitrogen element in terms of its importance for plant growth through the vital role and its importance in promoting the spread

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of roots and propagation (Della *et al.,* 2018 and Mian *et al.,* 2021). It is an insufficient nutrient, due to its complex chemical reactions in soil, and the speed of its transformation to insoluble form, makes it highly deficient nutrient in most soils especially calcareous soils (Hellal *et al.,* 2019 and Farrag and Bakr, 2023).

Mengel and Kirkby (1979) indicated that, the total content of soil phosphorus was in the range of 0.02 to 0.15% P. Ibia and Udo (1993) recorded that, the amount of P in available forms is between 0.10 and 0.25% of total P. According to El-Fahham (2003), available P in soils in west Mersa Matrouh differs from 0.45 to 7.50 mg/Kg soil. Hamed (1983) and El-Toukhy (1987) observed an increase in soil available P associated with increasing soil salinity. El-Damaty *et al.,* (1971) showed that calcium carbonate is the main compound limiting the soil phosphate availability to growing plants.

Potassium is a crucial nutrient, which can enhance higher plant dry matter and crop productivity (Tolba *et al.,* 2021). Potassium fulvate is a necessary natural substance that can be used to improve the physio- biochemical attributes of soils and their performance, which reflect on the productivity of plants as mentioned by Taha *et al.,* (2023).

Total K in soils commonly ranges between 0.25 and 2.5% (Chapman and Pratt, 1978). According to El-Fahham (2003), available K in soils of west Mersa Matrouh ranges from 1.3 to 17.83 mg. Kg^{-1} soil. Available K in Sinai ranges from 387.1 to 1941.3 ppm, 46.5 to 193.6 ppm and 46.9 to 152.5 ppm in soils of El-Tina plain, northern coastal plain and Wadis, respectively (Abu El-Hag, 2004).

Lithosphere, contains about 5% of iron (Fe), thus it is considered a major constituent (Kabata-Pendias and Pendias, 1992). In soils, Fe occurs mainly in forms of oxides and hydroxides, as small nanoparticles or in amorphous forms, associated with other soil particles and minerals. Iron minerals also are formed pedogenically and biologically. Free Fe minerals and compounds are used as a key characterization for soils and soil horizons (Kabata-Pendias and Szteke, 2015). El-Gundy *et al.,* (1990) found that, the available Fe ranged from 1 to 13 ppm in some areas in Sinai. El-Fahham (2003) stated that available Fe changed between 0.36 and 1.90 ppm in soils of western Mersa-Matrouh. Abu El-Hag (2004) indicated that available Fe is ranging from 37.0 to 200 ppm, 20 to 200 ppm and 18.0 to 45 ppm in soils of El-Tina plain, northern coastal plain and Wadis, respectively. El-Sayed (2004) found that, available Fe was between 0.12 and 3.86 mg.Kg^{-1} in East Owynat.

The abundance of soluble Mn in the soil solution is reported to range from 25 to 2200 μgL^{-1}. The most important Mn function in plant is related to the oxidation-reduction process (Kabata- Pendias and Pendias, 1992). Manganese contents in worldwide soils are highly diverse, and range approximately from 10 to 9000 mg/kg. Its highest levels occur in loamy and calcareous soils. Its elevated contents are also in soils derived from mafic rocks, and rocks rich in Fe compounds and soluble organic matter. However, it is usually accumulated in topsoil, as the result of its fixation by organic matter (Kabata-Pendias and Szteke, 2015). According to Krauskopf (1972), total Mn in soils varies widely from trace to 10,000 ppm, but most soils contain an average from 500 to 1000 ppm. El-Gundy *et al.,* (1990), found that, available Mn ranged from 0.0 to 15.8 ppm in some Sinai soils. El-Fahham (2003) found that, available Mn changed between 0.60 and 1.21 ppm in soils western Mersa Matrouh. Abu El-Hag (2004) indicated that, available Mn was ranged from 10.0 to 132.5 ppm, 5.0 to 40.0 ppm and 8.5 to 12.5 ppm in soils of El-Tina plain, northern coastal plain and Wadis, respectively. El-Sayed (2004) found that, the available Mn was ranged between 0.04 and 1.98 mg.Kg^{-1} in East Owynat soils.

Zinc microelement plays an important role in many vital plant processes such as: cellular communication and participates in DNA transcription, intracellular and extracellular signaling (Caldelas and Weiss, 2017 and Abd El-Zaher *et al.,* 2022). Zn deficiency has been addressed as a public health problem in the developing world, giving rise to severe health complications and socio-economic problems (Stein *et al.,* 2007 and, Mandal and Ghosh, 2021).

Total zinc in 27 samples represent different modes of soil formations ranged from 18 to 165 ppm. The highest values are recorded in heavy alluvial soils, while the lowest values are observed in sandy soils. On the other hand, El-Kady, (1970) reported that, the available Zn ranged between 0.07 and 2.46 ppm. El-Fahham (2003) stated that available Zn varied from 0.60 to 1.10 ppm in soils western Mersa Matrouh. El-Sayed (2004) found that, available Zn differs between 0.12 and 1.32 $mg.Kg^{-1}$ in soils of East Owynat.

In some Sinai soils, total Cu ranged from 20 to 120 ppm, while its available ranged between 0.4 and 10.6 ppm (El-Gundy *et al.,* 1990). El-Fahham (2003) recorded that, the values of available Cu varied between 0.09 and 0.81 ppm in soils western Mersa Matrouh. Abu El-Hag (2004) showed that the available Cu ranged from 3.3 to 10.0 ppm, 3.3 to 7.5 ppm and 4.0 to 7.5 ppm in soils of El-Tina plain, northern coastal plain and Wadis, respectively. El-Sayed (2004) found that, soils of East Owynat had available Cu contents between 0.01 and 0.41 $mg.Kg^{-1}$.

The area belongs to Mamura formation is formed from limestone and calcareous shale sequence which is the marine equivalent of the Moghra with uniform lithology. It rests above the Dabaa formation and is conformably over line by the middle Miocene Marmarica formation (Said, 1990).

Ganzour *et al.,* (2020) concluded that, the incorporation of the geographic information systems (GIS) methodology could be very helpful to produce accurate digital maps for the different soil characteristics, total and available nutrients status, land capability, land suitability for crops and the adequate fertilizer recommendation requirements for them. Ayad *et al.,* (2022) concluded that, GIS program provides the optimal handling, processing, management, analysis and updating of information and large data, especially as it relies mainly on remote sensing data, to simplify the process of studying, analysing and comparing it and making appropriate decisions for planning and development in the study area. Thus, the maps represent the quantity, quality, and high accuracy, and analytical ease for the receiving reader, especially when using graphic symbols in them. Pal *et al.,* (2021) concluded that GPS and GIS based secondary and micronutrient thematic soil fertility map for intensive cultivation for these districts helps the farmers, planner and scientists for site specific nutrient management and monitoring of soil health for present and future agriculture. Akhter *et al.,* (2010) prepared detailed maps using GIS for the soil fertility of the region and to link the status of fertility with agricultural practices. The soil samples were taken from 80 spatially distributed locations from a depth of 0-60 cm. And the interpolated maps for the status of micro and macro nutrients show a clear deficiency of nutrients across the district. Nitrogen is deficient in 96 %, potassium and phosphorus are below the critical levels in 95 and 76 % of the soils of the irrigated area, respectively. Pandu *et al.,* (2022) used Arc-GIS. The data generated was processed and mapped. Kriging and inverse distance weighting interpolation method was followed. A raster map was developed using the grid points merged with analysed data and then vector spatial soil fertility maps were generated using Arc-GIS. Fertilizer recommendations based on soil tests help to improve soil fertility and crop output with less fertilizer use.

The current study aims to identify the soil potentiality or fertility levels of different essential elements and prediction of fertilizer needs for the South El-Amiria soils by using GIS technique.

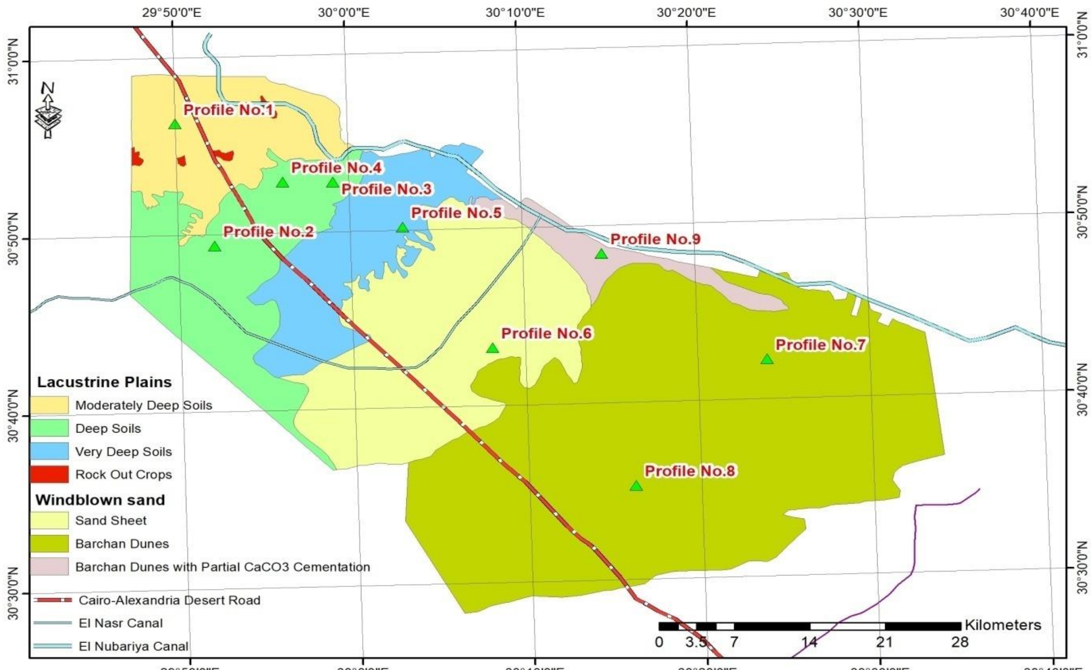
MATERIALS AND METHODS

The study was carried out on the south El-Amiria soils, Alexandria governorate, Egypt. Two main physiographic units, i.e., marine-lacustrine plains and windblown sand were distinguished (Map, 1). The study area is located between longitudes 29^{o} 47` 36.92``and 30$^{o}$ 34` 8.63`` East and latitudes 30^{o} 28` 19.78`` and 30$^{o}$ 59` 3.6`` North which comprise an area of about 571168 feddans. Physiographic map was carried out using digital image processing of Landsat images, digital elevation model and geological classes of the studied area. The mini pits (more than 70 pits) were dug to check the validity and accuracy of the different purified physiographic unit boundaries. Nine representative soil profiles were dug down to 150 cm. or bedrock contact. Twenty-two soil samples were collected according to different morphological features of each representative soil profile. Soil texture differed from sand to silty clay loam. Total carbonate contents changed widely from 2.53 to 45.26 %. Gypsum contents concentrated in soil profile 5 whereas its contents were between 12.90 and 38.18%, while in the other soil profiles contents varied from 0.69 to 6.71%. Also, the other physical and chemical properties were illustrated by Zayed *et al.*, (2020) for the previous investigated two physiographic units.

Available nitrogen was extracted using 5 g soil with 50 mL 2 M KCl (Page *et al.*, 1982), and determined using Kjeldahl methods (Jackson, 1985). Available phosphorus in soil was extracted using sodium bicarbonate solution, 0.5 M at pH 8.5 according to Olsen *et al.*, (1954), and determined using ascorbic acid (Van Reeuwijk, 1993). Absorbance was detected using Spectro-Photometer at 882 nm. Available potassium in soil was extracted using 1N ammonium acetate solution "NH_4OAC" at pH 7 according to Page *et al.*, (1982). The extract was determined using flame spectrophotometer. Available forms of Fe, Mn, Zn and Cu were extracted using DTPA method (diethylene triaminepenta acetic acid) according to Follet and Lindsay (1971) and Lindsay and Norvell (1978), and determined using the Optical Emission Spectrometer, Ultima Expert Lt, 1159, HORIBI, France.

Data of available macro and micronutrients were averaged to cover the circulation root zone, which classified into two clusters: the first was for annual crops (AC) which its root zone includes epipedon and subsurface from 0 to 50 cm. While the second was for perennial crops (PC) which includes epipedon and control section from 0 to 100 cm according to Afify *et al.*, (2005).

The soil fertility status was studied according to the critical levels after Page *et al.*, (1982) and Lindsay and Norvell (1978) in mg. kg $^{-1}$ soil as shown in Table (1).



Map 1. Physiographic units, sub-units and representative soil profiles of South El-Amiria soils (after Zayed *et al.*, 2020).

Table 1. Critical levels of macro and micro nutrients mg. kg $^{-1}$

Limits	Page *et al.* (1982)			Lindsay and Norvell (1978)			
	Macronutrients			Micronutrients			
	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	>10.0	>170.0	> 6.0	> 5.0	> 2.0	> 1.0

Distributions of soil fertility status in surface layer are illustrated on maps of physiographic units of the studied area and calculation their areas using GIS techniques according to ESRI. (2014) and ILWIS 3.3. (2007).

Statistical analysis of nutrients results was carried out according to Piskunon (1969).

Results

Macronutrients status

Nitrogen

Data in Table 2 reveal that, available nitrogen content differs from 7.56 to 57.72 mg.Kg^{-1} soil. Generally, the higher content levels were observed in soil profiles number 2, 3, and 5. Surface soil layers of profiles 2, 3, 5, and 6 considered having a medium limit as compared with the critical levels of Page *et al.* (1982) in Table (1). While, the rest layers were located at the low limit. The low and medium limits represent about 63.49 and 36.27 % of the total area, respectively, which have 571167.6 feddans as shown in Table (4) and Map (2). With regard to the relationship between crop type and nitrogen content, data in Table (3) show that, soil of profiles 2 and 5 of marine-lacustrine unit recorded N values in the medium limit for both annual and perennial crops which depend on the root depth. Annual crops of profiles 3 and 6 show a medium limit, while perennial crops have low limit. The rest profiles belong to the low limit for two previous crop types. Correlation coefficient between available nitrogen and different variables are shown in Table (5).

Phosphorus

Available phosphorus (Table, 2) ranged from 2.06 to 9.61 mg.Kg^{-1} soil. The highest values were found in the surface layers of studied soil profiles, which decreased with depth in the two physiographic units. Medium level is observed in different layers of profile 3, surface layer of profile 5 and subsurface layer of profile 1, which belongs to soils of marine-lacustrine plains, while in windblown sand, the medium level (Table, 1) was found in surface layer of profile 6. The rest layers contained the low limit. Data in Table (4) and Map (2) show that, the calculated low limit by GIS technique was 60.4 % of total area, while medium one was 39.36 %. Correlation coefficient between available phosphorus and different variables are shown in Table (5). Concerning to the two investigated crops data in Table (3) show that, the available Phosphorus contents were found in medium limit for both annual and perennial crops as observed in profiles 3 and 6, while profiles 1 and 5 were for annual crops only. The rest profiles showed the low limits for both crop types.

Potassium

Data in Table (2) show that, available potassium differs between 28.3 and 256.1 mg.Kg^{-1} soil. Soils of marine-lacustrine plains have a higher content of available potassium than soils of windblown sand. Distribution of available potassium through different representative profiles tends to decrease with depth, while soils of profile 3 show an opposite trend. Surface layers have a higher content of available potassium except soils of profile 3. Soil profiles 1, 2 and 3 of marine-lacustrine plains show high limit (Table 1), while the rest profiles belong to medium limit except the deepest layers of profile 4. Soils of windblown sand show low limit except surface layer of profile 6 which has medium limit. According to the GIS technique and data in Table (4) and Map (2), the low, medium and high limits of available potassium were, 48.68, 17.55 and 33.53 % of total area. Data in Table (3) show that the high limits of available potassium in soils of marine-lacustrine plains were recorded in profiles 1, 2 and 3 for annual and perennial crops, while the medium limits were observed in profiles 4 and 5. Soils of windblown sand showed a low limits in profiles 7, 8 and 9, while profile 6 recorded the medium limit for annual and perennial crops. Correlation coefficient between available potassium and different variables are shown in Table (5).

Micronutrients status

Iron

Data in Table (2) reveal that, the available iron contents in the studied area differ from 1.36 to 3.47 mg/Kg soil. In general, the distribution pattern of available iron content is high in the soil surface and has gradually decreasing with depth. Contents of available iron are below the low limit (4 mg/Kg) in all representative profiles which may be due to effect of high contents of lime. Average values of available iron in Table (3), show that, both annual and perennial crops have low limits in both physiographic units, marine – lacustrine plains and windblown sand. Data in Table (5) show the correlation coefficient between available iron and different variables. Distribution of available iron in the surface layers is distinct in Map (3) and its area of each status is registered in Table (6). The low limits present represent 88.19 % of the total area, while medium limits represent 11.57 %.

Table 2. Available macro and micronutrients contents (mg. kg $^{-1}$soil) of representative soil Profiles.

Physiographic Unit	Profile No.	Depth cm.	Macro Nutrients mg kg $^{-1}$			Micro Nutrients Mg kg $^{-1}$			
			N	P	K	Fe	Mn	Zn	Cu
Marine-Lacustrine plains									
Moderately deep	1	0 - 20	25.62	4.65	241.6	2.72	1.82	1.00	0.32
		20 - 60	16.28	6.38	235.0	2.21	1.60	1.04	0.30
		60 – 90	7.74	3.21	240.3	1.52	2.08	0.65	0.29
Deep	2	0 - 50	56.95	4.21	245.2	2.63	2.11	2.00	0.65
		50 – 110	36.61	4.17	230.9	2.25	1.76	1.09	0.55
	3	0 - 45	45.43	9.61	241.3	3.16	1.85	0.96	0.51
		45 – 110	35.25	6.12	256.1	3.05	1.42	0.58	0.33
	4	0 - 30	24.15	3.79	117.2	2.42	1.23	1.11	0.49
		30 - 70	18.13	3.42	105.4	3.47	1.06	0.70	0.35
		70 – 130	15.51	3.46	74.5	2.18	0.58	0.46	0.30
	5	0 - 30	57.72	5.30	89.7	3.20	1.63	1.80	0.62
Very deep		30 - 80	42.00	4.91	86.4	2.56	1.47	0.96	0.41
		80 - 160	37.24	3.28	85.1	2.44	1.12	0.67	0.31
Windblown sand									
Sand Sheet	6	0 - 50	45.57	6.22	86.5	3.39	1.51	0.26	0.28
		50 – 100	21.35	3.81	42.4	2.25	1.17	0.15	0.16
Barchan dunes	7	0 - 20	18.41	2.37	33.6	2.18	0.88	0.12	0.05
		20 – 100	8.37	2.06	28.3	2.11	0.71	0.10	0.04
	8	0 - 20	16.73	2.44	34.6	1.79	0.56	0.12	0.06
		20 – 100	7.56	2.31	31.0	1.36	0.33	0.09	0.03
Barchan dunes with partial $CaCO_3$ cementations	9	0 - 40	37.94	4.07	67.2	3.22	1.18	0.41	0.28
		40 - 80	22.51	2.61	38.4	2.19	0.49	0.29	0.06
		80 - 120	14.63	3.17	40.2	3.13	0.57	0.30	0.19

Table 3. Evaluation of status soil macro and micro nutrients (mg.Kg^{-1}soil) versus requirements of annual and perennial crops.

Physiographic unit	Profile No.	Crop	N		P		K		Fe		Mn		Zn		Cu	
			Average values	limit	Average values	limit	Average Values	limit	Average values	limit	Average Values	limit	Average values	limit	Average values	limit
Marine-Lacustrine plains																
Moderately deep	1	AC* PC**	20.02 15.51	L† L	5.9 4.9	M L	237.6 238.2	H$^{\#}$ H	2.4 2.1	L L	1.7 1.8	L L	1.0 0.8	M L	0.31 0.30	L L
Deep	2	AC PC	56.94 67.76	M‡ M	4.2 4.2	L L	245.2 238.1	H H	2.6 2.4	L L	2.1 1.9	M L	2.0 1.5	M M	0.65 0.60	M M
	3	AC PC	44.42 39.9	M L	9.3 7.7	M M	242.8 249.4	H H	3.1 3.1	L L	1.8 1.6	L L	0.9 0.8	L L	0.49 0.41	L L
	4	AC PC	21.74 19.43	L L	3.6 3.5	L L	112.5 102.8	M M	2.8 2.9	L L	1.2 1.0	L L	0.9 0.8	L L	0.43 0.38	L L
Very deep	5	AC PC	51.42 45.29	M M	5.1 4.5	M L	88.4 87.0	M M	2.9 2.7	L L	1.6 1.4	L L	1.5 1.1	M M	0.54 0.44	M L
Windblown sand																
Sand Sheet	6	AC PC	45.57 33.46	M L	6.2 5.0	M M	86.5 64.5	M L	3.4 2.8	L L	1.5 1.3	L L	0.3 0.2	L L	0.28 0.22	L L
Barchan dunes	7	AC PC	12.39 10.36	L† L	2.2 2.1	L L	30.4 29.4	L L	2.1 2.1	L L	0.8 0.7	L L	0.1 0.1	L L	0.04 0.04	L L
	8	AC PC	11.24 9.38	L L	2.4 2.3	L L	32.4 31.7	L L	1.5 1.4	L L	0.4 0.4	L L	0.1 0.1	L L	0.04 0.04	L L
Barchan dunes with partial $CaCO_3$ cementations	9	AC PC	34.86 27.09	L L	3.8 3.3	L L	61.4 50.3	L L	3.0 2.8	L L	1.0 0.7	L L	0.4 0.3	L L	0.24 0.17	L L

AC* = Annual crops L† = Low limit M‡ = Medium limit H$^{\#}$= High limit PC **= Perennial crops

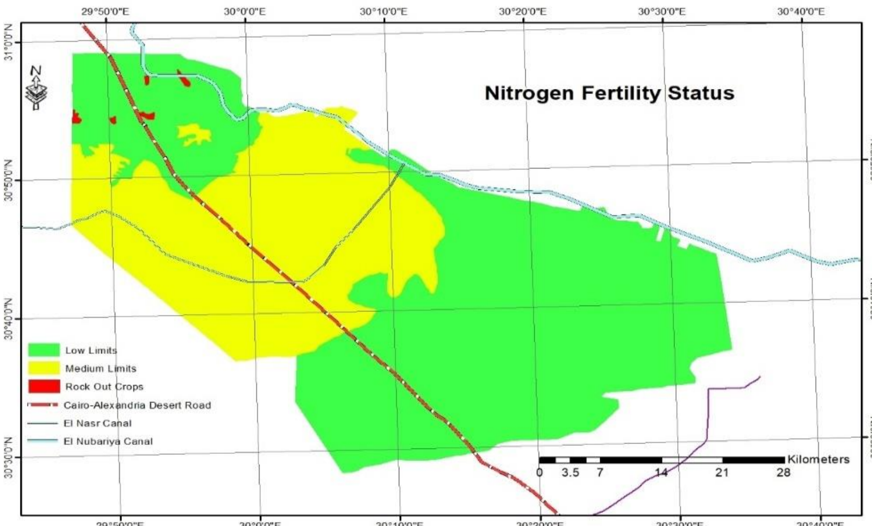
Table 4. Macro nutrients status and their areas of South El-Amiria.

Nutrient status		Area	
		Feddan	%
Nitrogen	Low Limits	362615.97	63.49
	Medium Limits	207157.28	36.27
	Rock Out Crops	1394.35	00.24
	Total Area	571167.60	100.00
Phosphorus	Low Limits	344981.2	60.40
	Medium Limits	224792.0	39.36
	Rock Out Crops	1394.4	0.24
	Total Area	571167.6	100.00
Potassium	Low Limits	278049.3	48.68
	Medium Limits	100260.9	17.55
	High Limits	191463.1	33.53
	Rock Out Crops	1394.3	0.24
	Total Area	571167.6	100.00

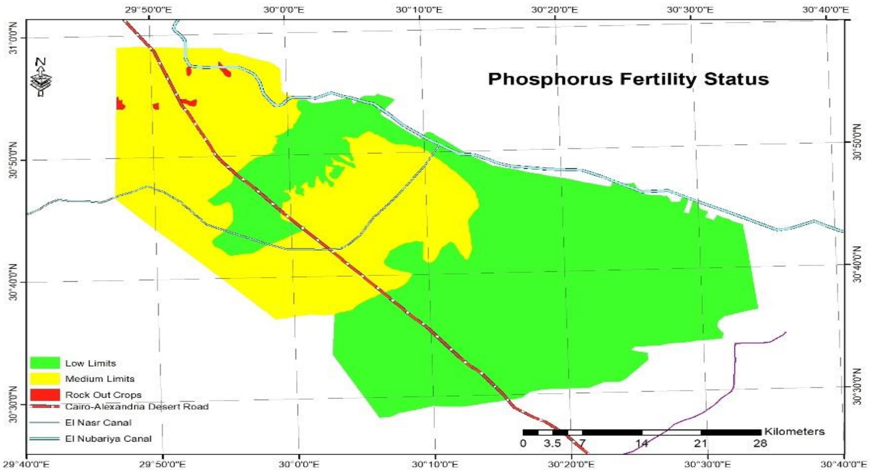
Table 5. Correlation coefficients (r) between available contents of nutrients with some soil properties.

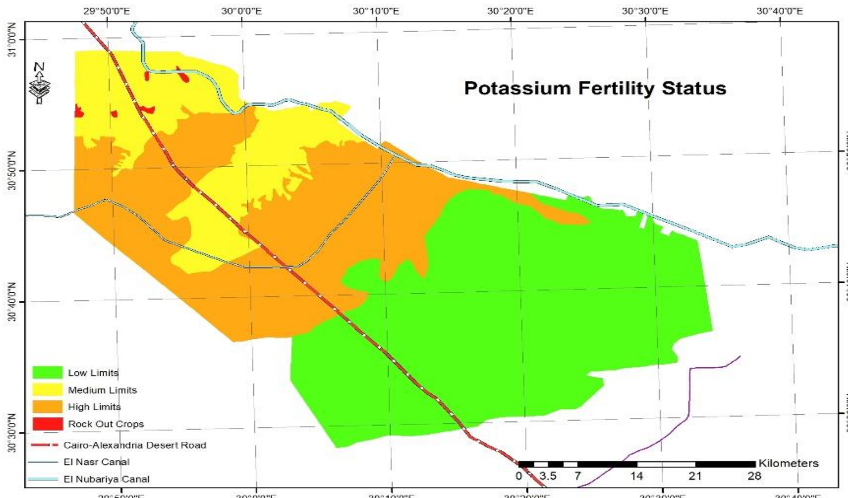
Variable	N	P	K	Fe	Mn	Zn	Cu
Total sand	-0.5271**	-0.6074**	-0.8695**	-0.1918	-0.8100**	-0.7636**	-0.7711**
Silt	0.4280*	0.5813**	0.9059**	0.1161	0.8269**	0.7314**	0.6945**
Clay	0.6504**	0.6004**	0.7342**	0.3041	0.7127**	0.7693**	0.8357**
EC	0.2321	0.7933**	0.4344*	0.2292	0.3156	0.1690	0.2615
Lime	0.3049	0.3952*	0.7400**	0.1025	0.6918**	0.7387**	0.7821**
Gypsum	0.5958**	0.2764	0.0321	0.2456	0.3108	0.6044**	0.5127**
Organic matter	0.8519**	0.3288	0.2550	0.4788*	0.5319**	0.7968**	0.8155**

*****Significant. ****** Highly significant.

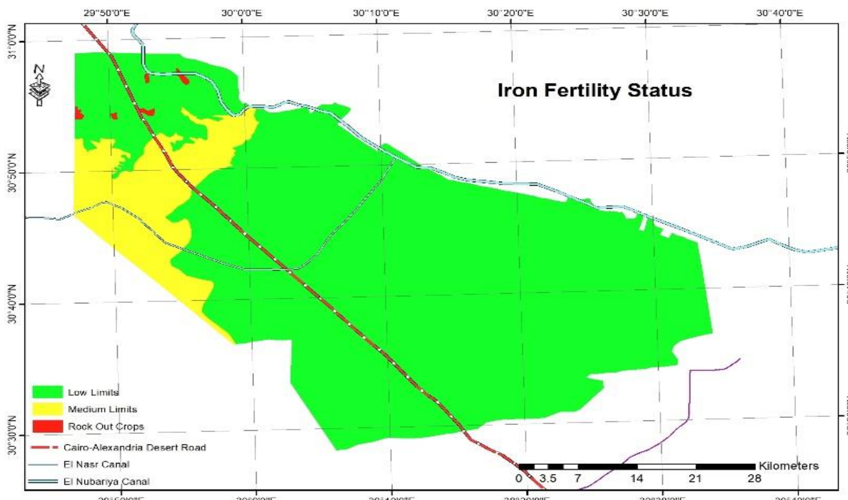


Map 2. Distribution of macronutrients status of South El-Amiria

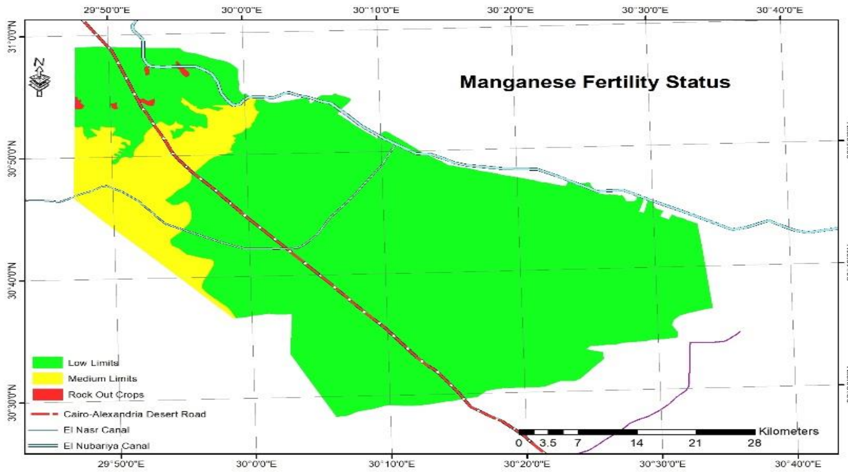


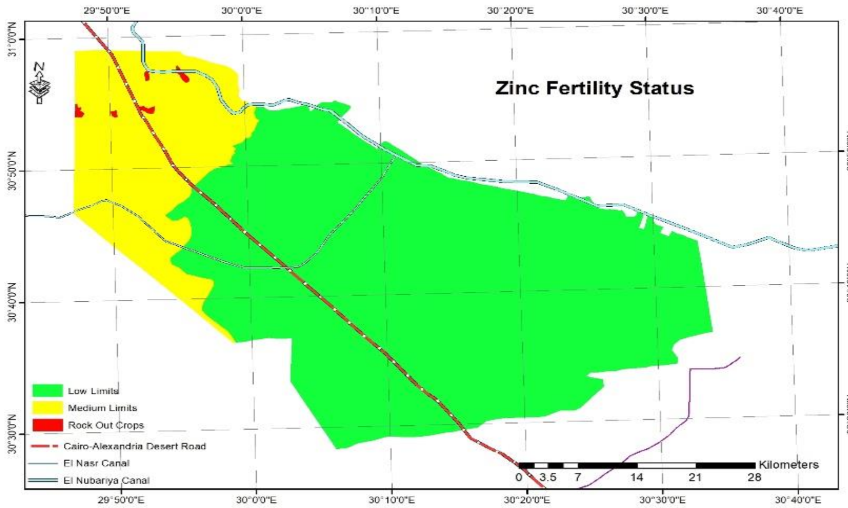


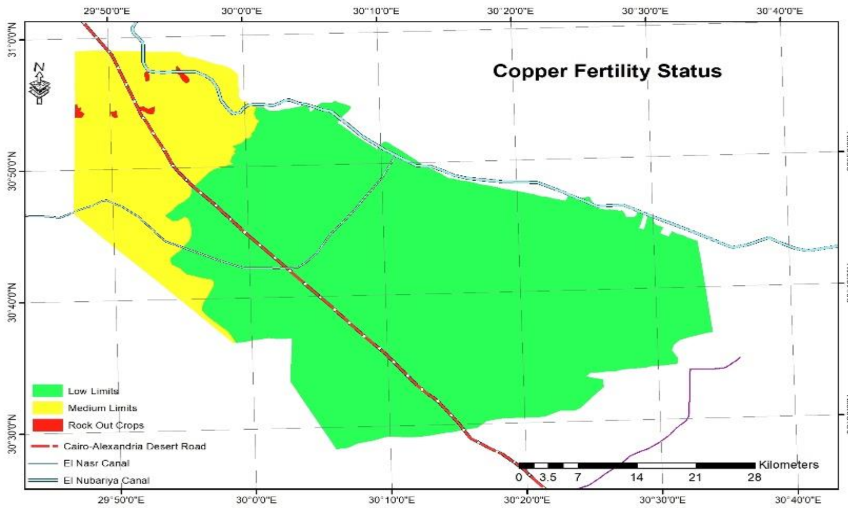
Map 2. Cont.



Map 3. Micronutrients fertility status of South El-Amiria


Manganese Fertility Status
Low Limits
Medium Limits
Rock Out Crops
Cairo-Alexandria Desert Road
El Nasr Canal
El Nubariya Canal
Kilometers
0 3.5 7 14 21 28


Zinc Fertility Status
Low Limits
Medium Limits
Rock Out Crops
Cairo-Alexandria Desert Road
El Nasr Canal
El Nubariya Canal
Kilometers
0 3.5 7 14 21 28


Copper Fertility Status
Low Limits
Medium Limits
Rock Out Crops
Cairo-Alexandria Desert Road
El Nasr Canal
El Nubariya Canal
Kilometers
0 3.5 7 14 21 28

Map 3. Cont.

Table 6. Micro nutrients status of South El-Amiria Area

Nutrient status		**Area**	
		Feddan	**%**
Iron	Low Limits	503696.5	88.19
	Medium Limits	66076.7	11.57
	Rock Out Crops	1394.4	0.24
	Total Area	571167.6	100.00
Manganese	Low Limits	503696.5	88.19
	Medium Limits	66076.7	11.57
	Rock Out Crops	1394.4	0.24
	Total Area	571167.6	100.00
Zinc	Low Limits	451621.9	79.08
	Medium Limits	118151.4	20.68
	Rock Out Crops	1394.4	0.24
	Total Area	571167.6	100.00
Copper	Low Limits	451621.9	79.08
	Medium Limits	118151.4	20.68
	Rock Out Crops	1394.4	0.24
	Total Area	571167.6	100.00

Manganese

Data in Table (2) show that, the available manganese varies between 0.33 and 2.11 mg/Kg soil. In general, soils of surface soil layers have a higher content of available manganese which tend to decrease with depth. Contents of available manganese are in low levels (< 2 $mg.Kg^{-1}$ soil) except deepest and surface layers of profiles 1 and 2, respectively, which have medium levels (2.0 -5.0 $mg.Kg^{-1}$soil) as compared with the critical levels of Lindsay and Norvell (1978) in Table (1). High contents of available manganese are related to the high contents of organic matter in surface layer of profile 2. Data in Table (5) show the correlation coefficient between available manganese and different variables. Data in Table (3) reveal that, the average values of available manganese show low limits for both annual and perennial crops in both physiographic units except annual crops in profile 2 which belong to deep marine – lacustrine soils which show medium limit. Distribution of available manganese in the surface layers is distinct in Map (3) and its area of each status is registered in Table (6). The low limit represents 88.19 % of the total area, while the medium limit shows 11.57 %.

Zinc

Data in Table (2) show that, the available zinc differs from 0.09 to 2.00 $mg.Kg^{-1}$ soil. Distribution of available zinc through representative profiles tends in general to decrease with depth. High content of available zinc is related to the high content of organic matter in the surface layer of profile 2. Contents of available zinc are situated within low limits (Table, 1) except soils of profile 2. Upper two layers of profile 1 and surface layer of profiles 4 and 5 appear medium levels. Data in Table (3) show that, the average values of available zinc for annual and perennial crops recorded medium limit in profiles 2 and 5 of marine – lacustrine plains.

Also, the medium limit was observed in profile 1. The low limit of the both crop types was recorded in the rest soil profiles of marine – lacustrine plains and windblown sand. Distribution of available zinc in surface layers is distinct in Map (3) and its area of each status is registered in Table (6). The low limit represents 79.08 %, while the medium limit shows 20.68 % of the total area. Correlation coefficient between available zinc and different variables are shown in Table (5).

Copper

Data in Table (2) show that the available copper differs widely between 0.03 and 0.65 mg.Kg^{-1}soil. Surface layers recorded the high contents. It decreases with depth as general trend. Medium contents were observed in soil profile 2 and surface layer of profiles 3 and 5, while the rest profiles and layers have low limit. Data in Table (3) clear that, both annuals and perennial crops are suffering from low limits of available copper except the deep marine lacustrine soils (profile 2). Also, annual crops of very deep soils (profile 5) of marine – lacustrine plains have medium limits. Data of correlation coefficients (r) between available contents of copper with some soil properties are illustrated in Table 5. Distribution of available copper in surface layers is distinct in Map (3) and its area of each status is registered in Table (6). The low and medium limits were, 79.08 and 20.68 % of the total area, respectively.

Discussion

Macronutrients status

The available content of nitrogen, phosphorus and potassium in the studied soils showed a close relationship with the type of physiographic unit, which affected by soil texture and organic matter content. Soils of marine-lacustrine plains contained higher values of NPK, while the soils of windblown sand contained the lowest one. The correlation coefficient (r) values confirmed this fact. Soil minerals and organic matter exert significant direct and indirect influences on the supply and availability of most nutrient elements (Jones, 2012 and Sparks, 2018). The available nutrient supply in soils is considered to be the sum of both soluble and exchangeable forms (Kome *et al.,* 2019). The organic matter contents in soils of the two investigated physiographic units play an important role in the availability of the macronutrients to the plant, this is because, soil organic matter content provides plants with nutrients and improves soil fertility. Thus, the soil organic matter is responsible for a large part of soil surface CEC (Thabit *et al.,* 2023).

Nitrogen

Available nitrogen has a positive and highly significant correlation with contents of organic matter, clay and gypsum and significant and positive correlation with silt content. While, the total sand appears negative and highly significant one. The previous relationships could be summarized in the following multi-regression equation:

Available nitrogen =
210.05 + 0.648 organic matter – 0.26 clay + 0.125 gypsum – 1.0 silt – 1.4 total sand.

Organic carbon and nitrogen contents have a significant relationship with fine particles content, characteristics, and mineralogy (Thabit *et al.,* 2023). One of the nitrogen sources is the mineralization of soil organic matter which contributes to increase nitrogen in the studied soil especially soils of marine-lacustrine plains. The quantitative relationship between the amounts of extracted organic N and N mineralization might vary depending on the land use and soil type (Sano *et al.,* 2004).

Phosphorus

Available phosphorus had highly significant and positive correlation with soil salinity, clay contents and silt contents and significant and positive correlation with total carbonate ($CaCO_3$), while total sand appears highly significant and negative trend. The multi-regression equation of these relationships could be cleared as follows:

Available phosphorus = 9.422+0.647EC - 0.23 clay - 0.59 silt - 0.03 $CaCO_3$- 1.2 total sand.

The deep soils of marine-lacustrine unit were characterized by the highest content of phosphorus. While the soils of barchan dunes of windblown sand recorded the lowest values, because they contains the lowest concentrations of organic matter contents and fine fractions.

Phosphorus availability is strongly affected by the adsorption of P onto the positively charged sites of Fe and Al oxides and clay minerals and the formation of P-containing minerals (Xiong *et al.*, 2022). Also, Jindo *et al.*, (2023) stated that the soil organic matter has a critical role in regulating soil phosphorus (P) dynamics and producing phyto available P. However, soil P dynamics are often explained mainly by the effects of soil pH, clay contents, and elemental compositions, such as calcium, iron, and aluminium.

Potassium

Clay minerals are the main source of plant nutrients in soil, as their specific surface characteristics determine the release pattern of some important nutrients, such as potassium (Raheb and Heidari, 2011). Available potassium shows highly significant and positive correlation with silt, clay and $CaCO_3$ contents, significant and positive correlation with soil salinity (EC) and highly significant and negative correlation with total sand. Effects of the previous factors are summarized in the following multi regression equation:

Available potassium = -330.72 + 1.85 silt +0.21 clay + 0.114 $CaCO_3$+ 0.156 EC+ 1.3 total sand.

The highest values of available potassium were found in the soils of marine-lacustrine plains, particularly in the deep soils which were characterized by high contents of organic matter and clay minerals. Then the release of K from clay minerals is influenced by particle size and chemical composition (Huang, 2005). Meanwhile, the lowest values of available potassium contents were recorded in soils of barchan dunes of windblown sand unit which may be due to the previous reasons. These results are in agreement with those obtained by Khadka (2016) who mentioned that, the soil organic matter was significantly and positively correlated with extractable K_2O (r=.35**). In addition, Bader *et al.*, (2022) showed that, the availability of potassium in the soil can be increased with various amendments. Application of organic manure increased potassium release and decreased potassium fixation which is recorded in the cultivated area of the studied soils.

Micronutrients status

Iron

Available iron contents have a significant and positive correlation with organic matter contents only. The other studied soil factors did not have a significant correlation, especially with clay and silt component. This is due to the fact that the component of lime and gypsum is mostly located within the diameters of clay and silt. These results are in agreement with Naeem, (1996) and Abd El-Hadi, (2004), who said that DTPA extractable iron was significant and positive correlation with organic matter and cation exchange capacity. In addition, increasing $CaCO_3$ level in soils decreased all forms of iron (Singh and Dahiya, 1975). Moreover, El-Gundy *et al.*, (1990) found that DTPA extractable iron has insignificant correlation with different soil variables. The regression equation which represents this relationship is as follows:

Available iron = 2.027 +0.479 organic matter.

Manganese

Available manganese contents showed a highly significant and positive correlation with silt, clay, total carbonate and organic matter contents, similar results were obtained by Hafez *et al.* (1992) for clay, silt and lime content, Naeem, (1996) for clay, silt and organic matter as well as Abd El-Hadi, (2004) for clay and organic matter. While, the highly significant and negative correlation was obtained with total sand as agreed with Abd El-Hadi, (2004).

These relationships may be summarized in multi-regression equation as follows:

Available manganese =
4.49 – 0.44 silt -1.4 clay -0.03 $CaCO_3$+ 0.444 organic matter – 2.4 total sand.

Zinc

Available zinc contents show a highly significant and positive correlation with organic matter, clay, silt, $CaCO_3$ and gypsum contents, while highly significant and negative correlation was with total sand. The variation in zinc content is attributed to the variation of soil texture and / or organic matter (Kameh, 1977). On the other hand, Naeem, (1996) stated that, the available zinc had a positive significant correlation with clay, silt and organic matter, while it had significant negative correlation with sand content. The contribution of each previous factors affecting these relationships could be shown in the following multi-regression equation:

Available zinc = 3.218 + 0.612 organic matter – 1.2 clay – 0.83 silt + 0.265 $CaCO_3$ + 0.171gypsum – 2.1 total sand.

Copper

Available copper contents had a highly significant positive correlation with clay, organic matter, $CaCO_3$, silt and gypsum contents. It showed a highly significant negative correlation with sand content. Similar results were obtained by Abd El-Kariem (1995), Naeem, (1996) and Abd El-Hadi, (2004) who mentioned that, DTPA- extractable copper appeared positive and significant correlation with clay, silt and organic matter contents. While, it showed a negative and significant correlation with sand content. Also, they mentioned that, the available copper contents increased with increasing each of clay and organic matter content. The correlations of available copper with the previous factors could be showed from the following multi-regression equation:

Available copper = 0.261 + 0.039 clay + 0.520 organic matter + 0.381 $CaCO_3$–0.35 silt – 0.01 gypsum – 0.52 total sand.

Generally, the study area suffers from a deficiency of micronutrients in both the physiographic units. The marine-lacustrine unit was affected by the high content of lime, which impedes the availability of micronutrients. According to FAO, (1992), the relatively high values of soil pH and soluble calcium, derived from carbonation process of $CaCO_3$, led to restrict nutrients availability especially micronutrients. The presence of coarse texture in the soils of windblown sand unit, gave the same result. From these results, it is clear that the presence of organic matter, clay and silt, is important for the availability of these elements.

Conclusion

South El-Amiria region, Egypt is one of the most promising agricultural areas whose soils need more studies to identify their fertility status in order to increase their production by setting appropriate fertilization programs. The soils of the studied area include two physiographic units, i. e., marine-lacustrine plains and windblown sand, with an area of 571168 faddans. The fertility status of the marine-lacustrine unit was better than that of windblown sand due to the improvement of its physicochemical properties.

The laboratory results and the use of Geographic Information System technique (GIS) showed that, the low limits of available nitrogen and phosphorus covered 63.49 and 60.4 % from the total area, respectively, while the medium limits of each included the remainder of the total area. Potassium recorded 48.68, 17.55 and 33.53 % for the low, medium and high limits, respectively. The low limits of the micronutrients covered the highest percentage (88.19) % of the total area. The concentrations of macro and microelements did not affect the type of crops, whether annual or permanent due to homogeneity of the soil profiles.

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حالة وتوزيع العناصر الغذائية الميسرة فى أراضى جنوب العامرية– محافظة الإسكندرية – مصر باستخدام تقنية نظم المعلومات الجغرافية

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الملخص العربي

يهدف هذا العمل الى دراسة حالة وتوزيع بعض العناصر الغذائية الميسرة فى أراضى جنوب العامرية حيث كان المحتوى من النيتروجين الميسر ذو مدى بين المستوى المنخفض والمتوسط كما أظهر إرتباطا معنويا إيجابيا مع كل من المادة العضوية والمحتوى من الطين والجبس والسلت. أظهر المحتوى من الفوسفور الميسر مستوى منخفضاً على وجه العموم وارتباطاً معنوياً موجباً مع المحتوى الملحى والطينى والسلتى والجيرى. دلت بيانات المحتوى من البوتاسيوم الميسر على أنه ذو مدى واسع من المحتوى المنخفض إلى العالى و ذو إرتباط معنوى موجب مع كل من السلت و الطين و ملوحة التربة والمحتوى الجيرى. أشار المحتوى من الحديد الميسر إلى أنه ذو مستوى منخفض وإرتباط معنوى موجب مع المحتوى من المادة العضوية فقط كما دل المحتوى من المنجنيز الميسر على مستوى منخفض أيضا كما أظهر اتجاها معنويا موجبا مع كل من المحتوى من السلت والطين والجير والمادة العضوية. تراوح المحتوى من الزنك الميسر بين المتوسط والمنخفض كما أظهر ارتباطا معنويا موجبا مع المحتوى من المادة العضوية والطين والسلت والجير والجبس، وقد أنتمى المحتوى من النحاس الميسر إلى المستوى المنخفض وأظهر ارتباطا معنويا موجبا مع المحتوى من الطين والمادة العضوية والجير والسلت والجبس، وقد أظهر المحتوى الكلى من الرمل تأثيراً ذو أرتباط معنوى سالب على تيسر مختلف العناصر المدروسة فيما عدا المحتوى من الحديد الميسر والذى أظهر ارتباطا غير معنوى سالبا.

أشار تقييم الاحتياجات الغذائيه لكل من المحاصيل الحولية والدائمة، على وجه العموم إلى وجود مستويات نقص فى كل من الفوسفور والحديد والمنجنيز والزنك والنحاس ومن ناحيه أخرى فإن مستويات كلاً من النيتروجين والبوتاسيوم الميسران كانتا بين العالية والمتوسطة فى أراضى السهول البحرية - البحيرية. كما أظهرت أراضى الرمال الريحية مستويات من النيتروجين الميسرتتراوح من المنخفض إلى المتوسط لكل من المحاصيل الحولية والدائمة . بينما اتجه البوتاسيوم الميسر بها إلى المستويات المنخفضة لكلا النوعين من المحاصيل. كما أن درجة مساهمة كل عامل من العوامل المؤثره على تيسير العناصر الكبرى والصغرى قد درست من خلال اشتقاق معادلات الانحدار المتعدد كما تم توقيع توزيع مستويات المحتوى من العناصر المدروسة في الطبقات السطحية على الخرائط الفيزيوجرافية وتحديد مساحاتها باستخدام تقنية نظم المعلومات الجغرافية GIS ، وعموما فإن منطقة الدراسة تحتاج الى مزيد من الدراسات حول برامج التسميد.