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STATUS OF THE MAJOR NUTRIENTS IN SOME SOILS WEST OF THE NILE DELTA, EGYPT USING GIS TECHNIQUE

Zayed, A. A.; El-Tapey, H. M. and Al-Toukhy, A.A.

Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt.

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ABSTRACT: The current study aimed to investigate and evaluate the status of the major macro and micronutrients in soils of the area adjacent to west of the Nile Delta. This area have two main physiographic units namely, river terraces and Wadi El-Natrun complex.

The results showed that, available nitrogsen contents vary from low to medium limits and correlated mainly with organic matter contents. Available phosphorus contents generally, tend to be in low levels having positive and significant correlation with soil salinity, lime clay and silt. Available potassium contents appear limits from low to high, having significant positive correlation with lime, soil salinity, clay and silt contents. Available iron differs from low to high limits and have positive and significant correlation with clay and silt. Available manganese contents record low level along side moderate and have positive and significant correlation with clay, silt, salinity and gypsum. Available zinc contents are similar to available manganese. Available zinc have a positive and significant correlation with organic matter, clay, soil salinity and lime contents while gypsum contents show an opposite relationship. Available copper contents, generally, appear low levels, which have positive and significant correlation with organic matter, clay , salinity and lime contents.

Requirement of both annual and perennial crops show that available nitrogen show low levels, while available potassium differ widely between low and high levels. Available iron ,manganese and zinc change from low to medium, while available phosphorus and copper are in low levels.

Distributions of different levels of the studied nutrient elements and their areas in the surface layers of the studied soil are presented on physiographic maps using GIS technique.

Key word : Nutrients Status , River Terraces, Wadi EL-Natrun, GIS technique.

INTRODUCTION

Sandy and calcareous soils represent large areas in the 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 Gaafar *et al.*, 2021).

Nutrient availability to plants is determined by both factors which affect the ability of the soil to supply the nutrients and factors which affect the plants ability to utilize the nutrients which are supplied. The Nutrients dissolved in the soil solution may be derived from a number of sources such as weathering of primary minerals, decomposition of organic matter, deposition from the atmosphere, application of fertilizer materials, seepage from other areas etc. (Dinauer, 1973 and Zayed *et al.*, 2023).

For agronomic purpose, the mineral macronutrients required from soil are separated arbitrarily into two groups namely: (i) Nitrogen, phosphorus and potassium are taken up by plants in moderate or large amounts, deficiencies are common, and they are the major constituents of commercial fertilizers and (ii) Calcium, magnesium and Sulphur are taken up by plants in moderate amounts, and although deficiencies are generally less common. The micronutrients iron, manganese, copper, zinc, boron, molybdenum and chlorine, also known as trace elements, are believed to be required by all higher plants (Mengel and Kirkby, 1982).

Fuohring (1973) reported that calcareous soils are usually some what low in organic matter so their nitrogen is often the most limiting nutrient. He added that the calcareous soils are buffered to a pH range of 8.0 to 8.4 resulting in low availability of native soil phosphorus. El-

*Corresponding author: hanyeltapey@gmail.com

Toukhy (1995) found that the available nitrogen ranged from 125 to 174 mg/kg soil, while Abd El-Razik (2002) mentioned that the available nitrogen differed between 14 and 115.42 mg/kg soil. Mengel and Kirkby (1982) indicated that content of soil phosphorus was in the range of 0.02 to 0.15% . On the other hand, Dahnk *et al.* (1985) & Ibia and Udo (1993) reported that the amount of P in available form is low representing 0.1 to 0.25% of total P. Dinauer (1973) mentioned that soils contain large amount of K, but only a small part, usually less than 1% of the total K, is in exchangeable form, and much smaller amounts are in soil solution.

Abd El-Hamid *et al.* (1991), EL-Shazly *et al.* (1991) and Mohamed (1992) in their studies have been conducted on micronutrients status in many soils of Egypt as follows: available Fe from 0.05 to 26.0, available Mn from trace to 33, available Zn from trace to 20 and available Cu from 0.05 to 4.0 mg/kg. Chapman and Pratt (1978) stated that the contents of available boron usually vary from less than one to several parts per million.

Laila *et al.* (2001) found that soil surface layers (0-30 cm) of Nile alluvial, calcareous and sand which were collected from Damietta, North Tahreer and El-Khatatba respectively had available iron: 17.5, 10.1 and 4.7 ppm. Available zinc: 2.5, 1.8 and 1.2 ppm, available manganese: 5.0, 6.2 and 3.3 ppm, and available copper 2.5, 1.5 amd 2.4 ppmrespectively. Abo Zied and Nashida (2004) studied available macro and micronutrients in area cover about 2000 fedans located 7 km west of Armant city. Available macro and micronutrients in root zone of the studied soils differ from 9.94 to 49.86, 3.63 to 8.59, 47.93 to 167.84, 2.43 to 6.08, 0.52 to 1.11,0.38 to 1.18and 0.32 to 0.89 (mg/kg soil) for available N, P, K, Fe, Mn, Zn and Cu respectively. Abd El-All (2004) studied the available macro and micronutrients at some scattered areas in El-Fayoum Governorate that have different lithological parent materials and developed on various physiographic units which illustrated in Table (1).

Abd El-Khalek (2016) found the available N, P, K, Fe, Mn, Zn and Cu in soils of Wadi E L-Natrun, Behaira Governorate were, ranged from 3.1 to 17.51, 5.33 to 11.29, 101.4 to 990.0, 1.55 to 6.89, 1.24 to 3.80, 0.16 to 0.99 and 0.71 to 0.80 $mg.kg^{-1}$, respectively. Also, EL-Shawadfi (2017) recorded the values of available of N, P, K, Fe, Mn, Zn and Cu which were ranged from 4.6 to 86.0, 0.008 to 0.800, 0.0 to 15.5, 0.0 to 7.7, 0.0 to 0.50, 0.0 to 7.70 and 0.0 to 2.70 $mg.kg^{-1}$ in the northest of Baharia Oasis, respectively. The previous respctive corresponding values for South El-Amiria soils, Alexandria Governorate were ranged from 7.56 to 57.72, 2.06 to 9.61, 28.3 to 256.1, 1.36 to 3.47, 0.33 to 2.11, 0.09 to 2.00 and 0.03 to 0.62 $mg.kg^{-1}$ (Zayed *et al.*, 2023).

Zinck (1998) createed the purified soil map using the geopedological method (fig.1) as follows :

Table 1: Physiographic units and available nutrients in root zone of some scattered areas in El-Fayoum after Abd El-All (2004) .

Physiographic unit	Depth (cm)	N	P	K	Fe	Mn	Zn	Cu
Lacustrine depressed plain	0-20	71.82	9.54	695.13	5.37	3.15	1.76	1.43
	20-50	45.4	5.97	182.75	4.86	1.03	0.95	0.86
Lacustrine terraced	0-25	78.06	6.82	756.75	7.86	1.79	0.75	0.76
	25-55	64.22	5.36	617.93	10.37	1.15	0.54	0.43
Alluvial terraces	0-15	49.86	7.18	402.78	5.92	2.09	1.06	0.89
	15-80	47.57	4.69	377.65	4.74	0.92	0.82	0.73
Nile Alluvial soils	0-25	58.50	3.38	632.24	5.02	1.25	0.75	.067
	25-70	49.63	2.74	467.67	7.78	0.83	0.87	0.54
treated by amendments	0-30	83.72	7.96	730.31	8.85	0.95	0.85	0.79
	30-80	53.34	5.77	548.67	13.46	0.78	0.74	0.62
Aeolian soils	0-35	12.93	3.67	46.37	3.65	0.67	0.54	0.34
	35-90	26.75	5.59	67.69	4.96	0.84	0.79	0.56

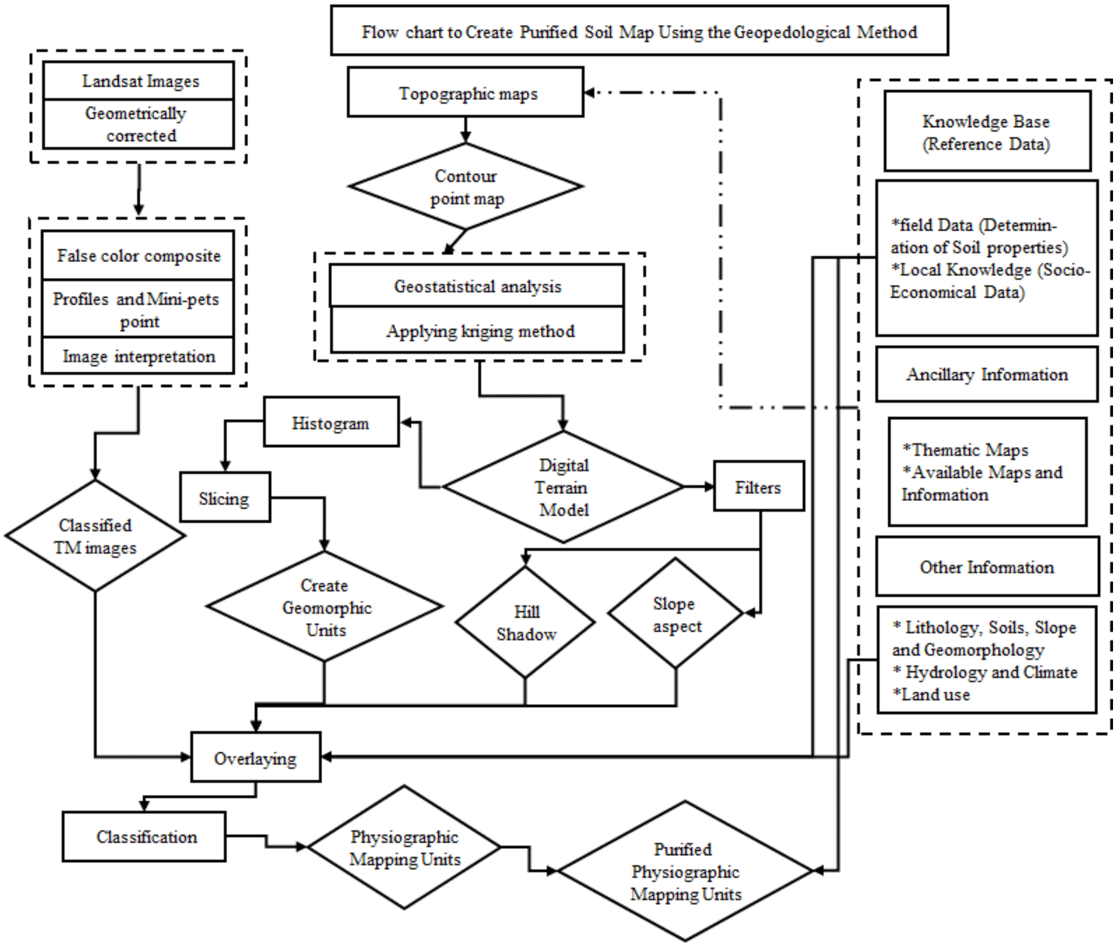


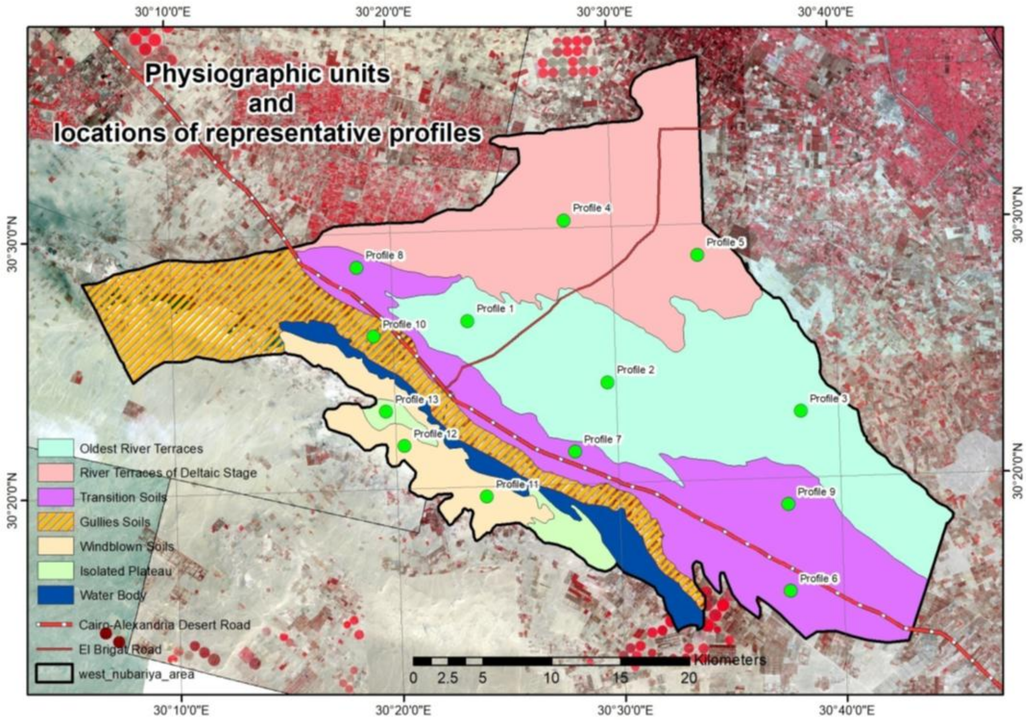
Figure (1): Flow chart to create purified soil map using the geopedological method (Zinck, 1998).

The current study aimed to investigate and evaluate the status of the major macro and micronutrients in soils of the area adjacent to west of the Nile Delta.

MATERIALS AND METHODS

The current study was conducted in the desert area adjacent to the alluvial soils of West of the Nile Delta. It is situated between latitudes 30^{O} 10` 00`` and 30$^{O}$ 37` 30`` North and longitudes 30^{O} 05` 00 `` and 30$^{O}$ 47` 30`` East, which include two physiographic units i.e., river terraces and Wadi El-Natrun complex according to Zayed *et al.* (2021) as shown in Map (1). The studied area comprises about 274540.9 feddans, which is represented by thirteen soil profiles and thirty-four soil samples. Soil texture changed from sand to sandy clay loam. Soil salinity (dS/m), gypsum (%), $CaCO_3$ (%) and organic matter (%) values were 1.50 to 136.28, 0.52 to 12.90, 1.69 to 48.64 and 0.04 to 0.37, respectively. Both physical and chemical properties were analyzed as described by Burt (2004).

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 "NH4OAC" at pH 7 according to Page *et al.*, (1982). The extract was determined using flame spectrophotometer.



Map 1: Physiographic units and locations of the representative soil profiles of the studied area west of Nile Delta, Egypt (after Zayed *et al.*, 2021).

Available iron, manganese, zinc and copper were extracted using ammonium bicarbonate DTPA extract according to Lindsay and Norvell (1978), and their contents measured using atomic absorption spectrophotometer.

The obtained data of available macro and micronutrients were averaged to match two soil profiles slices according to root zones of different crops. The first is annual crops (AC), which have root zones including epipedon and sub – epipedon from surface soil to 50 cm depth. The second is perennial crops (PC) which have root zones including epipedon and soil control section from surface soil to 100 cm depth.

The critical limits of nutrients in mg/kg soil after Lindsay and Norvell (1978) and Page *et al.* (1982) as follows:

Limits	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	>10.0	>170.0	>6.0	>5.0	>2.0	>1.0

Distribution of soil fertility status in surface layers and calculation their areas are illustrated on maps of physiographic units of the study region using capability of GIS techniques according to ESRI. (2014) and ILWIS 3.3 (2007).

RESULTS AND DISCUSSION

Nutrient availability to plants is determined by both factors which affect the ability of the soil to supply the nutrients and factors which affect the plant ability to utilize the supplied nutrients. The nutrients dissolved in the soil solution may be derived from a number of sources such as weathering of primary minerals, decomposition of organic matter, deposition from the atmosphere, application of fertilizer materials, seepage from other area, etc. (Dinauer, 1973). There is a requirement to replenish the soils solution because the concentrations of many of the nutrients in the solution are low. Replenishment occurs by desorption from the surfaces of the minerals and organic components of soil and by mineralization of soil organic matter (Breeze and Hopper, 1987).

Macronutrients statues

Available nitrogen

Crops all over the world are probably more often deficient in N than in any other element and yet there doesn't seem to be any well accepted method for testing soils for available N. This is a reflection in part, on the fact that 97 to 99% of the N in soils is present in very complex organic compounds that are not available to plants. This N slowly becomes available to plants through microbial decomposition of the organic matter and conversion to available inorganic forms of N. The problem of developing for available soil N is further complicated by the fact that (i) the rate at which microorganisms decompose soil organic matter is dependent on temperature, moisture, aeration, type of organic matter, pH and other factors, and (ii) the main form of available N, nitrate-nitrogen, is subjected to leaching, denitrification and immobilization by microorganisms (Dinauer, 1973).

Data of available nitrogen are given in Table (2). The result of available nitrogen fraction ranges from 5.70 to 47.8 mg/kg soil. The windblown soils, which are represented by profile 11, have the lowest contents, while soils of isolated plateau have the highest one.

Surface layers of all representative profiles show higher contents. Generally, distribution of available nitrogen tends to decrease with depth. Higher content of available nitrogen associates the higher content of organic matter in surface layer of profile 13. Available nitrogen in surface soil layers of profiles 3, 7 and 13 have medium levels while rest profiles and layers show the low levels.

Soils of profile 3 and 13 appear medium levels of available nitrogen for annual crops while, the rest of annual and all perennial crops appear low levels (Table, 3).

Distribution of available nitrogen through surface layers is illustrated in Map (2) and area of each status is recorded in Table (4).

Available nitrogen appears positive and highly significant correlation with organic matter contents (Table, 5). This is in agreement with EL-Sayed (2015) and Zayed *et al.,* (2023).

This relationship may be clear through the following regression equation:

Available nitrogen= 25.816 +0.551 organic matter.

Available phosphorus

The solubility of the Fe, Al and Ca phosphates are all markedly pH-dependent as solubility of sorbed molybdate (MoO_4^{-2}) and SO_4^{-2} anions. Sorbed MoO_4^{-2}, SO_4^{-2} and P bonded to Fe and Al, all increase in solubility with increasing pH; while P bonded to Ca decreases in solubility with increasing pH. Another factor is the redox potential. Reduction of ferric oxides will frequently result in the release of phosphate "fixed" by the oxide, which can make a contribution to nutrition of crops such as rice which can grow under submerged conditions (Dinauer, 1973).

Data in Table (2) show that available phosphorus differs from 2.06 to 8.55 mg/kg soils. Soils of profile 3 in soils of river terraces have higher contents. Also, soils of profile 13 of Wadi El-Natrun have higher contents. The vertical distribution of available phosphorus shows an increase with depth in soils of profiles 3 and 13, while the rest profiles have an opposite trend. High content of available phosphorus is recorded in deepest layer (55-100 cm) of profile 13 that has high contents of silt, clay and salinity. With regard to soil salinity, soils that have high salinity content appear high contents of available phosphorus in different layers of profile 13 except surface one and soils of profile 3 as well as surface layer of profile 4. Soils of river terraces appear low limits of available phosphorus except soils of profile 3 and surface layer of profile 4 which have medium limits. Soils of Wadi El-Natrun show a low limit of available phosphorus too, except surface layer of profile 9 and the two deepest layers of profile 13 which have medium limits. The study area recorded low levels of available phosphorus for both annual and perennial crops except soils of profile 3 of oldest river terraces which have medium levels (Table, 3).

Distribution of available phosphorus through surface layers are illustrated in Map (2) and it's of each status area is recorded in Table (4).

Table (2): Available macro and micronutrients (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
River Terraces									
Oldest river terraces	1	0 - 25	33.4	4.18	68.5	5.38	3.15	0.49	0.31
		25 - 60	23.7	3.37	50.7	4.11	3.01	0.32	0.24
		60 - 100	21.9	3.92	33.2	3.07	3.00	0.24	0.18
	2	0 - 50	28.5	4.03	56.1	1.98	3.25	0.50	0.26
		50 - 110	12.8	2.16	27.3	1.13	2.81	0.11	0.06
	3	0 - 50	39.7	5.56	166.5	2.30	4.84	0.17	0.15
		50 - 100	10.1	5.72	57.9	1.06	2.25	0.12	0.04
River terraces of deltaic stage	4	0 - 20	35.9	5.98	132.1	3.18	2.12	0.49	0.36
		20 - 40	16.8	4.56	53.6	2.60	1.36	0.21	0.20
		40 - 60	8.2	2.73	64.7	2.88	1.49	0.28	0.26
		60 - 100	6.5	2.43	41.4	2.07	1.20	0.11	0.11
	5	0 - 20	26.0	2.56	36.9	1.77	2.14	0.32	0.18
		20 - 55	10.4	2.33	32.5	1.42	1.61	0.21	0.13
		55 - 120	5.7	2.13	27.4	1.10	1.11	0.09	0.05
Wadi EL-Natrun									
Transition soils	6	0 - 45	27.9	4.16	125.1	3.37	1.86	1.01	0.31
		45 - 100	14.3	2.82	57.4	2.06	1.33	0.62	0.22
	7	0 - 20	35.2	4.34	279.1	7.58	3.12	1.18	0.40
		20 - 70	21.5	3.71	160.4	4.61	2.00	0.96	0.26
		70 - 120	22.6	3.82	161.3	4.83	1.75	1.08	0.28
	8	0 - 20	19.4	3.11	52.2	4.17	1.74	0.41	0.36
		20 - 100	9.6	2.06	40.2	2.25	1.13	0.07	0.16
	9	0 - 12	35.2	5.28	156.2	7.17	2.64	0.85	0.28
		12 - 35	27.4	4.33	161.3	7.00	2.11	0.80	0.16
		35 - 95	7.6	2.19	46.3	3.66	1.65	0.37	0.07
		95 - 150	19.8	4.11	100.2	4.12	1.97	0.53	0.29
Gullies soils	10	0 - 30	16.9	4.22	57.4	4.60	2.18	0.87	0.43
		30 - 100	12.9	3.51	31.2	2.57	1.54	0.40	0.19
Windblown Soils	11	0 - 40	14.7	4.09	36.2	3.69	1.69	0.52	0.26
		40 - 120	11.0	2.26	32.1	3.14	1.24	0.30	0.15
	12	0 - 50	18.5	2.57	34.2	2.68	1.88	0.71	0.09
		50 - 120	11.7	2.31	21.6	2.25	1.19	0.22	0.04
Isolated plateau	13	0 - 40	47.8	3.67	45.3	5.10	3.76	1.21	0.57
		40 - 55	30.6	6.12	226.1	3.40	2.40	1.04	0.38
		55 - 100	23.0	8.55	251.4	4.22	3.18	1.00	0.39

Table (3): Evaluation of status soil macro and micro nutrients ($mg.kg^{-1}$) 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
River Terraces																
Oldest river terraces	1	AC*	28.6	H^{Ø}	3.8	L$^{\#}$	59.6	L	4.7	M	3.1	M	0.4	L	0.28	L
		PC**	25.4	M$^{\pm}$	3.8	L	48.2	L	4.0	M	3.0	M	0.3	L	0.23	L
	2	AC	28.5	H	4.0	L	56.1	L	2.0	L	3.3	M	0.5	L	0.26	L
		PC	20.7	M	3.1	L	41.7	L	1.6	L	3.0	M	0.3	L	0.16	L
	3	AC	41.7	H	5.6	M	166.5	M	2.3	L	4.8	M	0.2	L	0.15	L
		PC	25.9	M	5.6	M	112.2	M	1.7	L	3.5	M	0.1	L	0.10	L
River terraces of deltaic stage	4	AC	22.7	M	4.8	L	87.2	M	2.9	L	1.7	L	0.3	L	0.28	L
		PC	14.8	M	3.6	L	66.6	L	2.6	L	1.5	L	0.2	L	0.21	L
	5	AC	16.7	M	2.4	L	34.3	L	1.6	L	1.8	L	0.3	L	0.15	L
		PC	11.4	L	2.3	L	31.1	L	1.3	L	1.5	L	0.2	L	0.10	L
Wadi EL-Natrun																
Transition soils	6	AC	26.5	M	4.0	L	118.3	M	3.2	L	1.8	L	1.0	M	0.30	L
		PC	20.4	M	3.4	L	87.9	M	2.6	L	1.6	L	0.8	L	0.26	L
	7	AC	31.0	H	4.0	L	207.9	H	5.8	M	2.4	M	1.0	M	0.32	L
		PC	26.6	M	3.9	L	184.4	H	5.3	M	2.1	M	1.0	M	0.29	L
	8	AC	13.5	L	2.5	L	45.0	L	3.0	L	1.4	L	0.2	L	0.24	L
		PC	11.6	L	2.3	L	42.6	L	2.6	L	1.3	L	0.1	L	0.20	L
	9	AC	23.3	M	3.9	L	125.6	M	6.0	M	2.1	M	0.7	L	0.16	L
		PC	16.1	M	3.1	L	88.6	M	4.9	M	1.9	L	0.5	L	0.13	L
Gullies soils	10	AC	15.3	M	3.9	L	46.9	L	3.8	L	1.9	L	0.7	L	0.33	L
		PC	14.1	M	3.7	L	39.1	L	3.2	L	1.7	L	0.5	L	0.26	L
	11	AC	14.0	M	3.7	L	35.4	L	3.6	L	1.6	L	0.5	L	0.24	L
		PC	12.5	L	3.0	L	33.7	L	3.4	L	1.4	L	0.4	L	0.19	L
Windblown Soils	12	AC	18.5	M	2.6	L	34.2	L	2.7	L	1.9	L	0.7	L	0.09	L
		PC	15.1	M	2.4	L	27.9	L	2.5	L	1.5	L	0.5	L	0.07	L
Isolated plateau	13	AC	44.4	H	4.2	L	81.5	L	4.8	M	3.5	M	1.2	M	0.53	M
		PC	34.1	H.	6.2	M	165.2	M	4.4	M	3.3	M	1.1	M	0.46	L

AC* = Annual crops PC** = Perennial crops L$^{\#}$ = low limit M$^{\pm}$ = Medium limit H^{Ø} = High limit

Table (4): Macro nutrients status and their areas in the studied area.

Nutrient status		Area	
		Feddan	%
Nitrogen	Low Limits	258611.14	94.20
	Medium Limits	5229.79	1.90
	Water Body	10699.97	3.90
	Total Area	274540.9	100.00
Phosphorus	Low Limits	234301.7	85.34
	Medium Limits	29539.2	10.76
	Water Body	10700	3.90
	Total Area	274540.9	100.00
Potassium	Low Limits	136807.0	49.83
	Medium Limits	116786.0	42.54
	High Limits	10247.9	3.73
	Water Body	10700	3.90
	Total Area	274540.9	100.00

Table (5): Correlation coefficients (r) between available contents of nutrients and Some soil properties.

Variable	N	P	K	Fe	Mn	Zn	Cu
Total sand	-0.2397	-0.5696**	-0.4616**	-0.4658**	-0.3371*	-0.3128*	-0.2783
Silt	0.1985	0.5330**	0.4086**	0.4155**	0.3279*	0.2570	0.2477
Clay	0.2764	0.5836**	0.5011**	0.5017**	0.3305*	0.3633*	0.3004*
EC	0.1513	0.7896**	0.5348**	0.0715	0.3034*	0.3140*	0.3111*
Lime	0.2580	0.6011**	0.5718**	0.1223	0.2738	0.4207**	0.3979*
Gypsum	0.1760	0.2212	-0.0244	-0.2254	0.4768**	-0.3073*	-0.2842
Organic matter	0.5511**	0.2164	0.2419	0.2635	0.2527	0.6282**	0.6520**

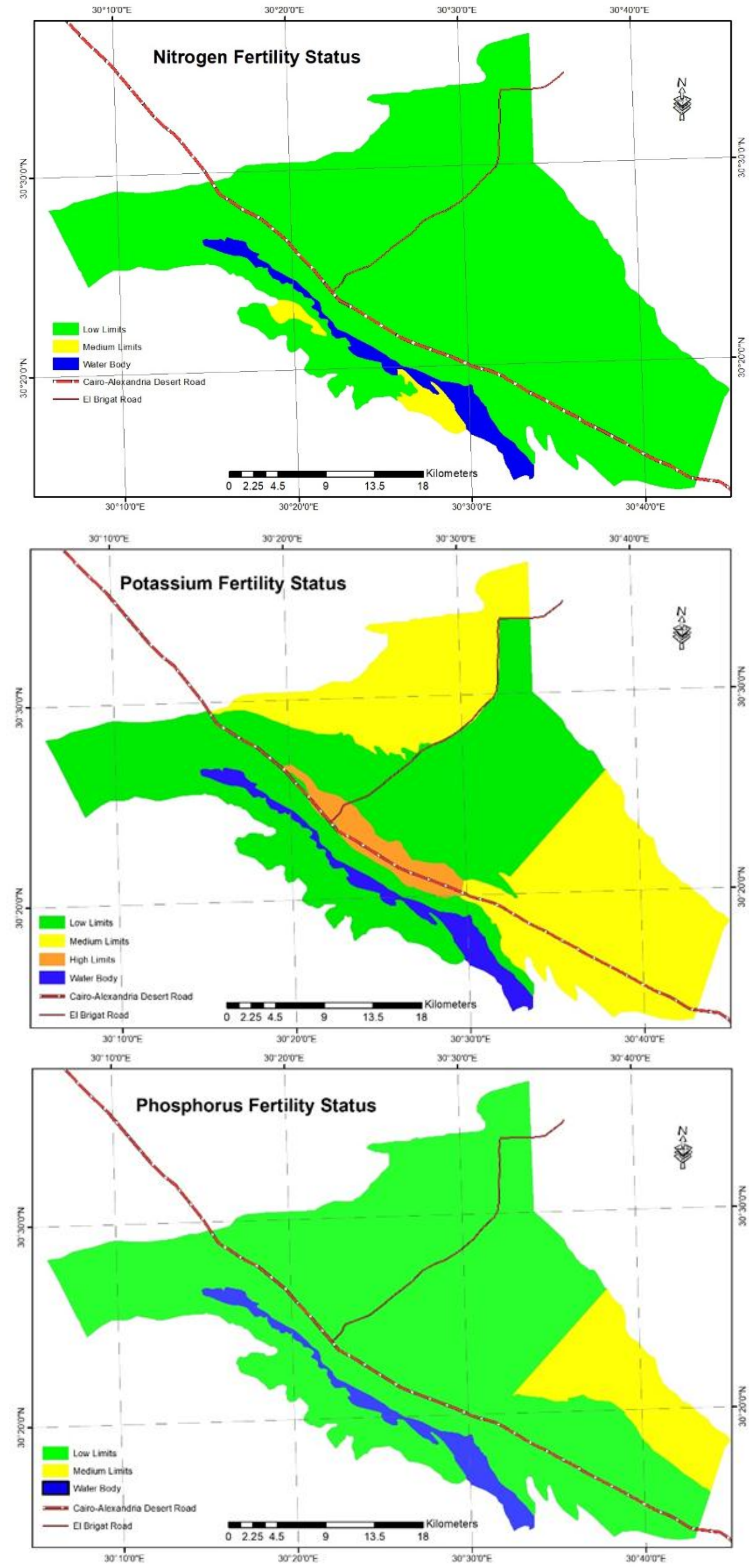
****** Highly significant. * Significant.

Available phosphorus contents appear positive and highly significant correlation with soil salinity, lime, clay and silt contents, and negative and highly significant with total sand (Table, 5). The interaction between different factors which effect on phosphorus clear through the following multi-regression equation:

Available phosphorus = 14.351 + 0.605EC + 0.17 lime -0.2 clay- 0.41 silt – 0.84 total sand.

Available potassium

Soils contain large amounts of K, but only a small part, usually less than 1% of total K, is in exchangeable form and much smaller amounts are in soil solution. Much of this non-exchangeable K is a component of some primary minerals or in some secondary clay minerals. Some workers have divided the non-exchangeable K into unavailable, slowly available and readily available forms. The last two forms of K may comprise a substantial portion of available K for plant uptake (Dinauer, 1973).



Map (2): Distribution of macronutrients status in the studied area.

Available potassium recorded in Table (2), differs between 21.6 and 279.1 mg/kg soil. Contents of available potassium tend to decrease with depth except soils of profile 13 which have an opposite trend. Contents of available potassium in profile 13 associate with contents of clay, silt, total sand and salinity. Soils of surface layer of different representative profiles have high contents of available potassium except soils of profiles 9 and 13. The windblown soils (profiles 11 and 12) in Wadi El-Natrun and some soils of river terraces of deltaic stage (profile 5) record lower contents, while soils of isolated plateau (profile 13) and some soils of transition soils (profiles 7 and 9) record higher contents. Soils of river terraces show low limits of available potassium except surface layer of profiles 3 and 4 show medium limits. Soils of Wadi El-Natrun record low limits too. The medium limits were observed in surface layer of profile 6, profile 7 except surface layer and profile 9 except layer 35-95 cm and the high limits were recorded in surface layers of profile 7 and profile 13 except the surface layer.

Generally, available potassium is in low levels for annual and perennial crops except profile 7 of transition soils which appears high levels while soils of profile 3 of oldest river terraces and profiles 6 &9 of transition soils show medium one (Table, 3). Distribution of available potassium through surface layers is illustrated in Map (2) and area of each status is recorded in Table (4).

Data in Table (5) show that available potassium has high significant positive correlation with contents of lime, soil salinity, clay and silt, whereas, have high significant negative correlation with total sand. Degree of contribution of each effective factor on potassium availability by using regression equation was as follows:

Available potassium = 318.776 + 0.331 EC + 0.217 lime + 0.297 clay - 0.5 silt - 0.41 total sand.

Previous findings for nitrogen, phosphorus, and potassium were consistent with both EL-Sayed *et al.,* (2015) and Zayed *et al.,* (2023).

Previous findings for nitrogen, phosphorus, and potassium were consistent with both EL-Sayed *et al.,* (2015) and Zayed *et al.,* (2023).

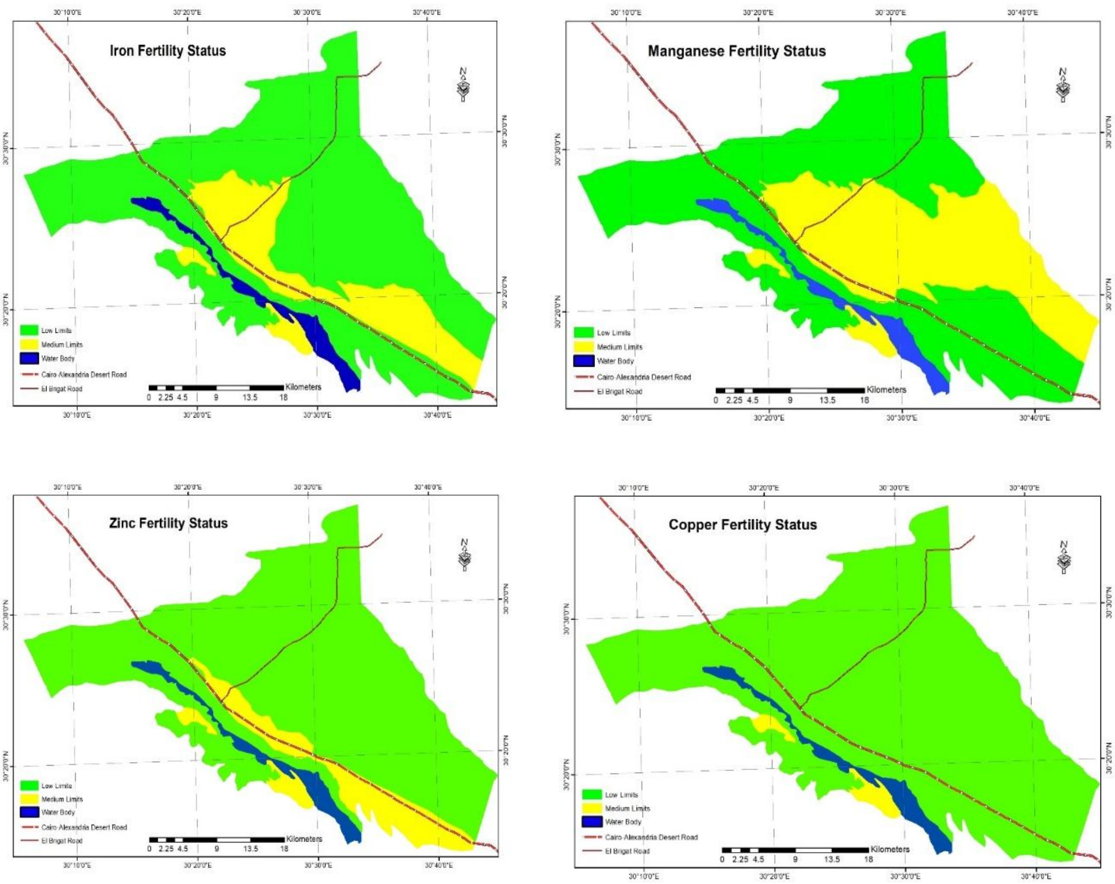
Micronutrients status

Available iron

The concentration of Fe in soil solution within common soil pH levels ranges from 50 to 550 µgL^{-1}, whereas in alkaline pH range reaches a minimum. When soils are waterlogged, the reduction of Fe^{3+} to Fe^{2+} takes place and is reflected in an increase in Fe solubility. Soil Fe exhibits a great affinity to form mobile organic complexes and chelates. These compounds are largely responsible for the Fe migration between soil horizons and for Fe leaching from soil profiles and are important in the supply of Fe to plant roots (Kabata-Pendias and Pendias 1992).

Contents of available iron are between 1.06 and 7.58 mg/kg soil (Table, 2). The surface layers of the studied soils of have higher contents. The distribution of available iron through the representative profiles tends to decrease with depth. The transition soils of Wadi El-Natrun have higher contents of available iron. The surface layer of profile 7 and upper two layers of profile 9 show adequate or high level of available iron. On the other hand, medium levels are recorded in the upper two layers of profile 1, subsurface layers of profile 7, surface layer of profiles 10 & 13 and deepest layer of profile 9, while the rest have low limits. Both annual and perennial crops in Table (3) show medium levels of available iron for profile 1 of oldest river terraces, profiles 7 & 9 of transition soils and profile 13 of isolated plateau, while the rest appear low levels. Distribution of available iron through the surface layers is illustrated in Map (3) and area of each status is recorded in Table (6).

Data in Table (5) show that available iron shows positive high significant correlation with clay and silt contents. While it appears a negative high significant correlation with total sand. The same trend was obtained by El-Gundy *et al.,* (1990), Abd El-Hadi, (2004) and Abou Kota (2012).



Map (3): Micro fertility status of Western Delta.

Degrees of contribution of each factor affecting on iron availability express by the following multi - regression equation:

Available iron = 10.429 + 0.472 clay -0.49 silt - 0.48 total sand.

Available manganese

The solubility of manganese in soils is highly dependent on the pH and redox potential. The reported abundance of soluble species of Mn in the soil solution ranges from 25 to 2200 μgL^{-1}. Soluble Mn in soil solutions is mainly involved in organic complex, (Kabata-Pendias and Pendias 1992).

Data in Table (2) show that available manganese changes from 1.11 to 4.84 mg/kg soil. The surface layers of the studied soils have higher contents of available manganese, which tend to decrease with depth. Contents of available manganese show medium level in soils of profiles 1, 2, 3, 13 and upper two surface layers of profiles 7 and 9 in addition to surface layers of profiles 4, 5 and 10, while the rest profiles and layers have low levels.

Requirements of both annual and perennial crops for available manganese in Table (3), appear medium levels for all soils of oldest river terraces, isolated plateau and soils of profile 7 of transition soils and so soils of profile 9 for annual crops. The rest of soils show low levels. Distribution of available manganese through surface layers is illustrated in Map (3) and area of each status is recorded in Table (6).

Table (6): Micro nutrients status in the studied area.

Nutrient status		Area	
		Feddan	%
Iron	Low Limits	209892.4	76.45
	Medium Limits	53948.5	19.65
	Water Body	10700	3.90
	Total Area	274540.9	100.00
Manganese	Low Limits	169239.3	61.64
	Medium Limits	94601.6	34.46
	Water Body	10700	3.90
	Total Area	274540.9	100.00
Zinc	Low Limits	229929.6	83.75
	Medium Limits	33911.2	12.35
	Water Body	10700	3.90
	Total Area	274540.9	100.00
Copper	Low Limits	258611.4	94.20
	Medium Limits	5229.5	1.90
	Water Body	10700	3.90
	Total Area	274540.9	100.00

Data in Table (5) show that, the available manganese has a positive significant correlation with silt, clay, salinity and gypsum contents, these results tend to be agreed with EL-Sayed (2015) and Zayed *et al.,* (2023) for silt and clay, and Vijayakumar *et al.,* (2011). On the other hand, a negative significant correlation with sand was found as reported by EL-Sayed (2015). However, the multi- regression equation, which has the relationship between factors affecting of availability of manganese is as follows:

Available manganese = -0.319 + 0.496 gypsum + 0.227 clay + 0.279 silt + 0.163 EC + 0.193 total sand.

Available zinc

The solubilization of Zn minerals during weathering produces mobile Zn^{+2}. Zn is easily adsorbed by minerals and organic components and thus in most soil types, its accumulation in the surface horizons is observed (Kabata-Pendias and Pendias, 1992).

Contents of available zinc in Table (2), fluctuate between 0.07 and 1.21 mg/kg soil. Soils of Wadi EL-Natrun have contents of available zinc higher than soils of river terraces. Distribution of available zinc contents show a decrease with depth and surface layer of all representative profiles contains higher quantities. Available zinc tends to be in a low limit except in soils of profile 13, profile 7 except subsurface layer and surface layer of profile 6, which appear medium limits. Generally, available zinc is in low levels for annual and perennial crops, except soils of isolated plateau and soils of profile 7 of transition soils, which show medium levels (Table, 3). Distribution of available zinc in surface layers is distinct in Map (3) and area of each status is registered in Table (6).

Data in Table (5) show that available zinc has a high positive significant correlation with organic matter and lime and a positive significant correlation with clay contents and soil salinity. While it has a negative significant correlation with total sand and gypsum. Ibrahim (2001) found in some soils of EL-Bahaira Governorate a positive significant correlation between zinc and both organic matter and clay contents. El-Sayed (2015) added silt content to what was mentioned above in some soils of Fayoum Governorate, also he found a negative significant correlation between zinc and both sand content and pH. In this regard, Zayed *et al.*, (2023) recorded a positive significant correlation between zinc and organic matter, silt, $CaCO_3$ and gypsum. While they found a negative significant correlation with total sand in south El-Amiria soils, Alexandria Governorate. Degree of contribution of each factor on availability of zinc is illustrated through multi-regression equation as follows:

Available zinc = -1.52 + 0.685 organic matter + 0.121 lime + 0.888 clay - 0.09 EC + 0.432 total sand - 0.14 gypsum.

Available copper

Copper is a very versatile trace cation and in soils or depositional material exhibits a great ability to chemically interact with mineral and organic components of soil. The Cu ions can also readily precipitate with various anions such as sulfide, carbonate and hydroxide. All soil minerals are capable of adsorbing Cu ions from solution and these properties depend on the surface charge carried by adsorbents. The surface charge is strongly controlled by pH. Many kinds of organic substances form both soluble and insoluble complexes with Cu, thus Cu solubility is highly dependent on the kind amount of organic matter in soils (Kabata-Pendias and Pendias, 1992).

Contents of available copper in the studied soils differ from 0.04 to 0.57 mg/kg soil (Table, 2). Soils of profile 13 have higher contents followed by soils of profile 17, while soils of profile 12 appear lower one. Distribution of available copper through different layers of each representative profile shows a trend of deceasing with depth. Contents of available copper appear low limits except surface layer of profile 13 that has medium limit. Data of available copper record low levels for both annual and perennial crops except in soils of isolated plateau which show medium level for annual crops (Table, 3). Distribution of available copper in surface layers is distinct in Map (3) and its area of each status is registered in Table (6).

Data in Table (4) show that available copper contents have a high significant positive correlation with organic matter and significant positive correlation with lime, soil salinity and clay contents. These finding is closely agreement with EL- Khososy (2007) in calcareous soils. Multi-regression equation clears this relationship as follows:

Available copper = -0.012 + 0.731 organic matter + 0.12 lime + 0.888 clay -0.08 EC + 0.427 clay.

CONCLUSION

The soils adjacent to west of the Nile Delta in Egypt are from the important areas for agricultural expansion, especially with the increase in population. These soils are characterized by their low content of nutrients for plant growth and production. The current study was conducted in the desert area adjacent to the alluvial soils of Western Nile Delta. This area includes two physiographic units namely river terraces and Wadi El-Natrun complex, with area comprises about 274540.9 feddans. Mostly available nutrients show a positive significant correlation with organic matter and clay, and a negative significant correlation with sand. The results of Geographic Information System technique (GIS) showed that, the low limits of available nitrogen, phosphorus and potassium were, 94.20, 85.34 and 49.83 % from the total area, respectively. Also, the low limits of the micronutrients covered the highest percentage 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. However, Generally, the soils under consideration are suffering from infertilely levels. The indemnity of these shortage are necessary to maintain good growth and yeild of most crops.

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حالة العناصر المغذية الأساسية في بعض أراضي غرب دلتا النيل بمصر باستخدام نظم المعلومات الجغرافية

عادل محمد عبد الرحمن زايد، هانئ محمد أحمد التابعي، عبد المنعم عبد المجيد الطوخي

معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – جيزة- مصر.

الملخص العربى

تقييم حالة الخصوبة بمنطقة الدراسة يعد خطوة هامة فى مجال الاستثمار الزراعى، ويهدف هذا البحث إلى دراسة وتقييم حالة العناصر الأساسية الكبرى والصغرى فى الأراضى المتاخمةلغرب دلتا النيل بمصر، وقد تباين المحتوى من النيتروجين الميسر بين المستوى المنخفض والمتوسط مع ارتباطه بالمحتوى من المادة العضوية. وينتمى المحتوى من الفوسفور الميسرعلى وجه العموم إلى الحدود المنخفضة، كما ارتبط ارتباطا إيجابيا ومعنويا مع ملوحة التربة ومحتوى الجير والطين والسلت. وقد تباين المحتوى من البوتاسيوم الميسر بين الحدود المنخفضة والمرتفعة وارتبط ارتباطا إيجابيا ومعنويا مع المحتوى الجيرى وملوحة التربة والمحتوى من الطين والسلت. وتبين أن المحتوى من الحديد الميسر بين المستوى المنخفض والعالى كما أظهر ارتباطا معنويا موجبا مع المحتوى من الطين والسلت. تردد المحتوى من المنجنيز الميسر بين المستو المنخفض والمتوسط وأظهر ارتباطا معنويا موجبا مع المحتوى من الطين والسلت وملوحة التربة والمحتوى الجبسى. كان االمحتوى من الزنك الميسر مشابها للمحتوى من المنجنيز الميسر وقد أظهرا ارتباطا معنويا موجبا مع المحتوى من المادة العضوية والطين وملوحة التربة بينما أظهر المحتوى الجبسى اتجاها عكسيا. كان المحتوى من النحاس الميسرعلى وجه العموم منخفضا وقد أظهر النحاس الميسر ارتباطا معنويا موجبا مع المحتوى من المادة العضوية والطين وملوحة التربة والمحتوى من الجير. والعلاقة بين المحتوى من الرمل ومختلف العناصر الغذائية الميسرة تحت الدراسة كانت سالبة ومرتبطة معنويا مع كل من الفسفور والبوتاسيوم والحديد والمنجنيز والزنك. وأظهرت الاحتياجات الغذائية لكل من المحاصيل الحولية والدائمة أن المحتوى من النتروجين والبوتاسيوم الميسران كانا ذا مدى واسع من المستويات المنخفضة إلى العالية. أما مستويات الحديد والمنجنيز والزنك الميسرة فكانت بين المنخفضة والمتوسطة. بينما كان المستوى من الفوسفور والنحاس الميسران منخفضا. وقد تم توقيع توزيع مختلف المستويات من العناصر المدروسة فى الطبقة السطحية على الخرائط الفيزيوجرافية و تحديد مساحاتها باستخدام تقنية GIS.

تم حساب معادلة الانحدار المركب (المتعدد) Multi-regression equation لكل عنصر لإظهار درجة مساهمة كل عامل من العوامل المؤثرة على تيسره. وعموما فإن أراضى المنطقة تحت الدراسة بحاجة إلى زيادة الإهتمام ببرامج التسميد. وعموما فإن الأراضى تحت الدراسة تعاني من انخفاض الخصوبة وتعويض هذا النقص يعد ضروريا للحفاظ على جودة النمو وإنتاج معظم المحاصيل.