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EVALUATION OF SOIL FERTILITY STATUS AT WEST DELTA AREA USING GIS TECHNIQUE

Ali, A. M.[1], K. G. Soliman[2], Atiat, E. Nasr-Alla[2], and R. N. Kamh[1]

1. Soil Fertility and Microbiology Dept., Desert Research Center, Egypt.
2. Soil Science Dept., Faculty of Agric., Zagazig Univ., Egypt.

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ABSTRACT: The recent approach in precision agriculture researches has focused on use of management zones as a method for variable application of inputs like fertilizers. Since productivity is influenced by soil characteristics, the spatial patterns of productivity could be caused by a corresponding variation in certain soil properties. Determine the source of variation in productivity can help achieve more effective site-specific management. This study was designed to optimize the use of fertilizers especially nitrogen, phosphorus, and potassium fertilizers based on local specific conditions of the soil of west delta area especially at Nubaria. Soil properties spatial data were presented as individual maps by GIS (EC, pH, $CaCO_3$, available N, available P, available K, active Na, texture). A barley pot experiment has been conducted to identify the relation between soil properties and plant yield then quantify layers weighing codes in GIS. The correlation data between barley and soil properties show that the most effective properties were texture, salinity, calcium carbonate, and pH. A decision map (management zones map) were created based on weighed overlay in GIS between the texture, salinity, calcium carbonate, and pH and its codes were 41.5, 21.83, 21.16, and 15.51 %, respectively. Distinguish 4 management zones in the study area are created, each zones has its potentiality on the yield then should have a specific management conditions. The average wheat yield in the fields took the same direction of the zones regularly and confirmed the management zones delineation technique. The concentration of plant nitrogen took the same direction ranges regularly of the zones and that is indicating that nitrogen the most nutrient limited plant yield in the

study area. There are a little variation between zones in plant phosphorus and potassium, but in general, all nutrients far from the optimal concentrations. CND model (compositional nutrient diagnosis) has been used to inventory the nutrient balance in plant. Nitrogen was found negatively and its arrangement upward with the zones. Phosphorus was found positively, and potassium negatively, but in general there are a little variations in the concentration of phosphorus and potassium between the zones unlike nitrogen.

Key words: Soil fertility, GIS, management zones, precision farming.

INTRODUCTION

Agricultural managers have generally made decisions regarding fields based on average conditions, but the management of agricultural production is undergoing a change, both in philosophy and technology (National Research Council, 1997).

Robert(1999) expressed that precision agriculture (PA) is the start of a revolution in nature resource management based on information technology, bringing agriculture into the digital and information age. In fact PA is based on the use of revolutionary technology such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS). The use of GPS indicates correct position of each soil or plant sample taken in the field and GIS eases the handling of the data, allowing both graphical representation of variability of measured parameters and analysis. Furthermore, PA has lead to development of several technologies, *e.g.*, sensor to measure several soil properties, automatic yield recording systems and variable rate, basic for the collection of data and the application of decisions.

Precision farming or site-specific crop management can be defined as the management of spatial and temporal variability at a sub-field level to improve economic returns and reduce environmental impact (Blackmore *et al*., 2003).

Doerge (2005) defined management zones as sub regions of a field with homogeneous yield-limiting factors. Using a management zone approach, a field can be separated into areas of similar productivity potential, and fertilizer can be applied variably in accordance with the nutrient needs of each zone.

Several studies have documented that soil properties vary across farm fields, causing spatial variability in crop yields (Rockstrom *et al*., 1999; Gaston *et al*., 2001). Precision farming or site-specific management is aimed at managing soil spatial variability by applying inputs in accordance with the site-specific requirements of a specific soil and crop (Fraisse *et al*., 1999).

Farmers didn't put the different physical and chemical properties of the soils in consideration. They always added the same amount of fertilizers, which may be too low or too high for a given soils. Consequently, wheat yield varies in most soils of west Nile Delta. So, the overall objective of the study is to optimize the use of fertilizers especially nitrogen, phosphorus, and potassium fertilizers based on local specific conditions of the soil (what the farmers do and are supposed to do). Specifically, (1)Identify and quantify spatial variability within fields using GIS. (2)Delineation soil fertility management zones using GIS. (3) Determine which of analyzed soil parameters influenced positively or negatively on the yield of wheat. (4) Identification of wheat yield-limiting nutrients and inventory the nutrient balance.

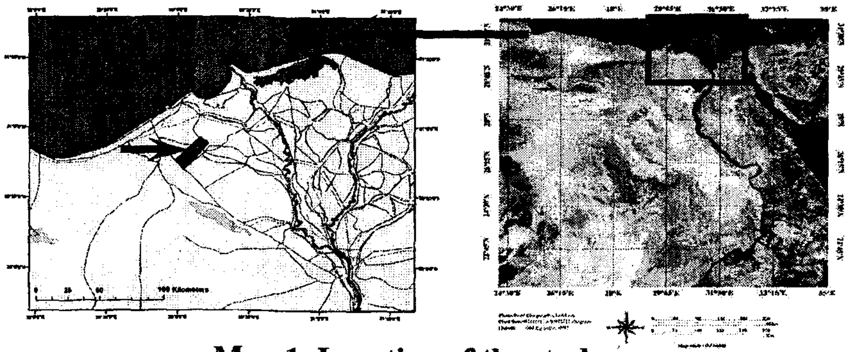
MATERIALS AND METHODS

Site Description

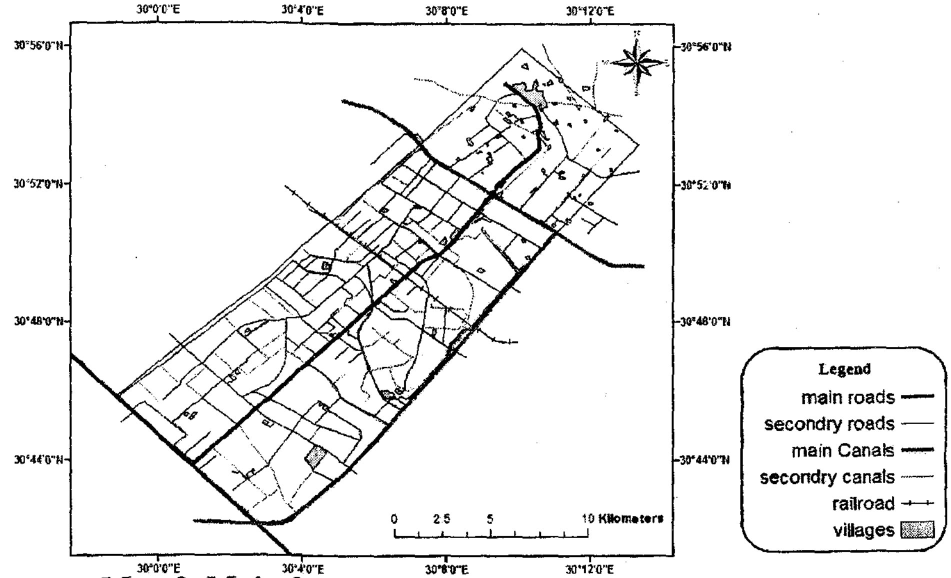
The study area is located in west delta area at Nubaria region (Map 1). The study area covers an area of 50,000 fed. (1 feddan = 4200 m^2). Cairo-Alexandria desert road limiting the area from the West, on the south El-Nasr canal, and Nubaria canal penetrates the area from the eastern part. Abo El-Matamer road is divided the area into two parts north and south. Many of the villages, secondary roads and canals spreading in the study area as illustrated in Map 2.

There are two main sources of irrigation water in the study area the first is El-Nubaria canal which contribute El-Nasr canal, the second source. The main irrigation systems in the study area are surface systems (for all wheat-rice fields), dripping system (for maize fields), and sprinkler center pivot system (for potato fields). Put surface system is the dominant one.

The dominant crops cultivated in the study area are wheat, clover, corn, gourds, and a separate orchard fields.



Map 1. Location of the study area



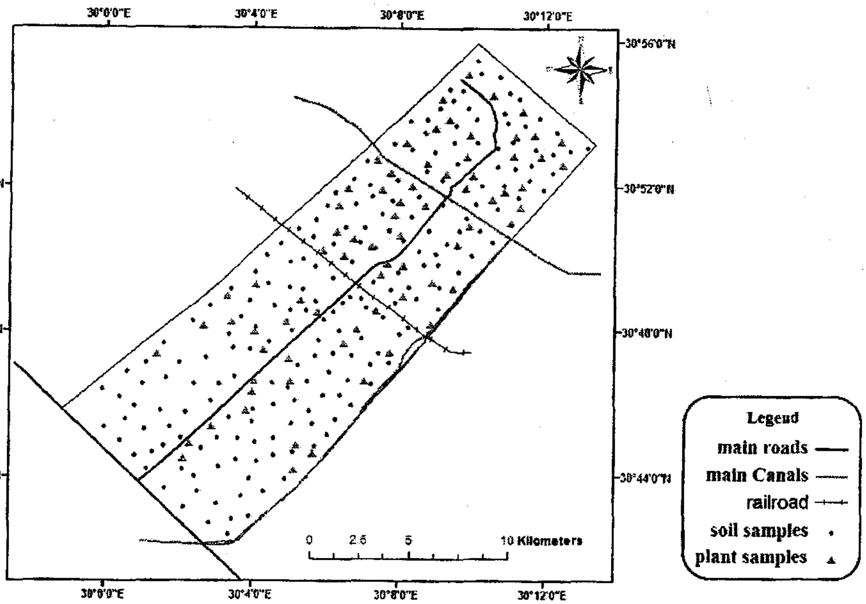
Map 2. Main features of the study area

Field Work

The fieldwork carried out at April 2006 and 2007. Soil and wheat plant samples were collected for analysis. 200 soil samples at a depth of 0-30 cm, and 75 wheat plant samples (two seasons) were collected from the study area (Map 3). Each soil and plant samples was recorded its location by GPS (global position system).

Laboratory Work

The following works were carried out in the laboratories of Desert Research Center, Egypt (DRC).



Map 3. Soil and plant samples locations

Soil analysis

The collected soil samples were air dried and gently grounded, then sieved through a 2 mm sieve. Selected soil physical and chemical properties that have been related to productivity potential were measured as follows:

Physical analysis

Soil texture were determined using the hydrometer method (Gee and Bauder, 1986) The method were done without remove $CaCO_3$.

Saturation percentage (SP) was determined using water saturated soils (Wilcox 1951).

Chemical analysis

pH value was measured in (1:2.5) soil: water suspension using pH meter as described by Jackson (1973).

Electrical conductivity value was measured as dSm^{-1} at 25^{o} C in soil paste as described by Jackson (1973).

Soil organic matter content was determined using the procedure of Walkely and Black outlined by Jackson (1973).

Total Calcium Carbonate content was measured using Collin's calcimeter according to Piper (1950).

Available nitrogen was extracted by 2 *M* potassium chloride (KCl) solution, according to Dahnke and Johnson (1990) and then determined by micro-Kjeldahl method according to (Chapman and Pratt, 1961).

Phosphorus was extracted by 0.5 *N* $NaHCO_3$ solution at pH 8.3 (Olsen *et al.*, 1954) and determined using ascorbic acid and ammonium molybdate according to (Page *et al.* 1982).

Sodium and potassium are extracted by 1 *M* ammonium acetate pH 7.0 (Black, 1965) and determined using flame photometer, Jackson (1973).

Cation exchange capacity (CEC) was determined by ammonium acetate as mentioned by Jackson (1973).

Plant analysis

Plant samples were dried in an oven at 70^{o} C, then grounded .

Plant samples were wet digested using H_2SO_4- $HCLO_4$ mixture according to (Cresser and parsons, 1979). The acid digest was analyzed for N, P and K.

The total N was determined using micro-Kjeldahl apparatus (Chapman and Pratt, 1961).

Phosphorus was determined according to (Page *et al.* 1982).

Potassium evaluated by flame photometer, Jackson (1973).

Statistical Analysis

Excel software (as a component in Microsoft office software 2003) and SPSS 16.0 software, were used for the purposes of the computations and statistical analysis of data.

GIS Work

Four topographic maps with scale of 1:50000 covering the study area were prepared and scanned, then rectification, subset, and mosaic processes were done using ERDAS imagine software 8.7. The main feature in the study area were digitized as line (canals, roads, and railroads), polygon (villages). The feature types were created in ArcCataloge software as shape file then edited in ArcMap software.

Soil samples ID, longitude, latitude, and soil properties values were exported from Microsoft excel and linked to ArcMap software. The samples locations were added to the map in ArcMap as X,Y then exported its data. The data interpolated to create individual attribute maps in raster format. Reclassification was performed for some attributes layers to its standard categories, and others as a local category under the conditions of the study area. Overlay process was carried by weighed values in order to create management zones map by selected its weighed values based on the correlation between every soil parameters and yield of barley plants as an indicator plant under a controllable conditions. The software ArcGIS 9.2 used for the GIS purposes of this investigation.

RESULTS AND DISCUSSION

Soil Test Variability

Summery descriptive statistics [minimum, maximum, range, mean, variance, standard deviation (SD), and coefficient of variation (CV)] were calculated for whole field sampling to determine variability in soil test values for each sample (Table 1).

The results showed that medium to high soil test variability for CV (Figure 1) and take this arrangement, EC > active Na > pH > available P > CEC > available nitrogen > available K > clay >organic matter > $CaCO_3$ > saturation percentage by the values 118.85, 91.56, 87.14, 80.58, 59.09, 55.93, 54.55, 50.10, 47.83, 29.32, 23.35 %, respectively.

Statistical analysis were performed to calculate the correlation coefficient between soil properties (Table 2).

Soil Spatial Variability Maps

Spatial variability of soil has been studied for many years. For the most part, this variability has been measured using samples collected in the field and analyzed in a laboratory. Understanding the spatial variability in the samples has increased with the availability of global positioning system (GPS) measurements of the sample locations, and geographic information systems (GIS) for the spatial mapping and analysis of these data. Inman *et al.* (2005) reported that fields that have a high degree of spatial variability in soil properties could be better managed using site-specific management zones.

In order to map the spatial distribution of the physical and chemical properties of soil and thus evaluate its fertility level, it is necessary to know the spatial variability of its properties.

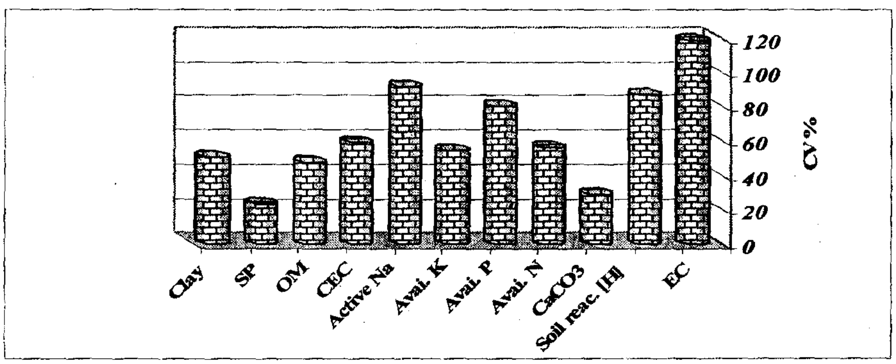


Fig. 1. Coefficient of variation for the selected soil properties

Table 1. Statistical descriptive analysis for soil properties in the studied area

Soil properties	Minimum	Maximum	Range	Mean	Variance	St. Dev.	C.V %
EC (soil paste), ds/m	0.66	32.22	31.56	3.11	13.59	3.69	118.65
Soil reaction (1:2.5) as $[H^+]$, *M*	5.89E-10	5.88E-10	3.236E-5	2.179E-7	6.457E-12	2.54E-6	87.14
Calcium carbonate, %	3.01	27.07	24.08	10.80	10.03	3.17	29.32
Available nitrogen, ppm	5	160	155	46.45	675.06	25.98	55.93
Available phosphorus, ppm	0.64	184	183.36	35.3	909.06	28.44	80.58
Available potassium, ppm	19.78	520.79	501.01	178.36	9462.38	97.27	54.55
Active sodium*, ppm	26.94	1259.9	1266.88	212.32	37793.39	194.41	91.56
CEC, cmol(+)kg^{-1}	2.85	23.02	20.17	7.48	19.54	4.42	59.09
Organic matter, %	0.45	2.10	1.65	1.15	0.31	0.55	47.83
Saturation percentage, %	18	52.32	34.32	27.49	41.21	6.42	23.35
Clay, %	5	25	20	8.80	20.08	4.48	50.10

*Active sodium = soluble + exchangeable sodium which extracted by ammonium acetate

Table 2. Pearson correlation coefficient matrix for soil properties in the studied area

	EC	pH	$CaCO_3$	N	P	K	Na	CEC	OM	SP	Clay
EC	1	0.173*	0.068	0.104	0.084	0.502**	0.813**	0.112	0.135	0.039	0.083
pH		1	-0.236**	-0.186*	-0.226**	-0.076	0.127	-0.321**	-0.190*	-0.290*	-0.353**
$CaCO_3$			1	0.215**	0.064	0.275**	0.249**	0.499**	0.521**	0.632**	0.687**
N				1	0.143	0.347**	0.296**	0.551**	0.562**	0.231*	0.421**
P					1	0.416**	0.153*	0.161*	0.166*	0.077	0.171*
K						1	0.691**	0.597**	0.566**	0.227*	0.515**
Na							1	0.411**	0.431**	0.164*	0.424**
CEC								1	0.623**	0.76**	0.782**
OM									1	0.556**	0.632**
SP										1	0.80**
Clay											1

* Correlation is significant at the 0.05 level - ** Correlation is significant at the 0.01 level

Soil salinity spatial variability map

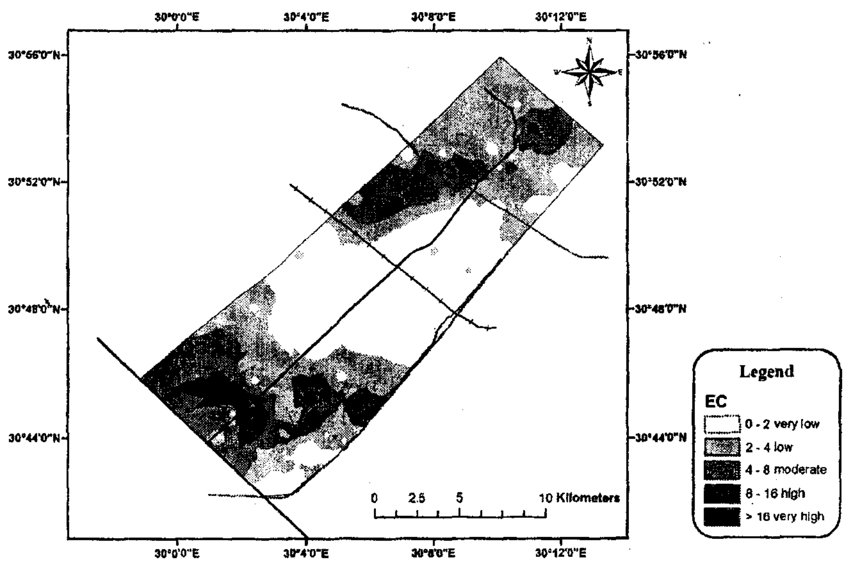
The studied area has strong variations in soil salinity. soluble salts content varied between 0.66 to 32.22 dsm^{-1}. Map 4 show the spatial distribution of salinity in the study area. The map was classified into 5 zones as very low (< 2 dsm^{-1}), low (2-4 dsm^{-1}), moderate (4-8 dsm^{-1}), high (8-16 dsm^{-1}), and very high (16 dsm^{-1}). These zones have an areas about 30111.7, 14903.9, 4469.2, 426.4,and 88.8 fed., Respectively.

pH spatial variability map

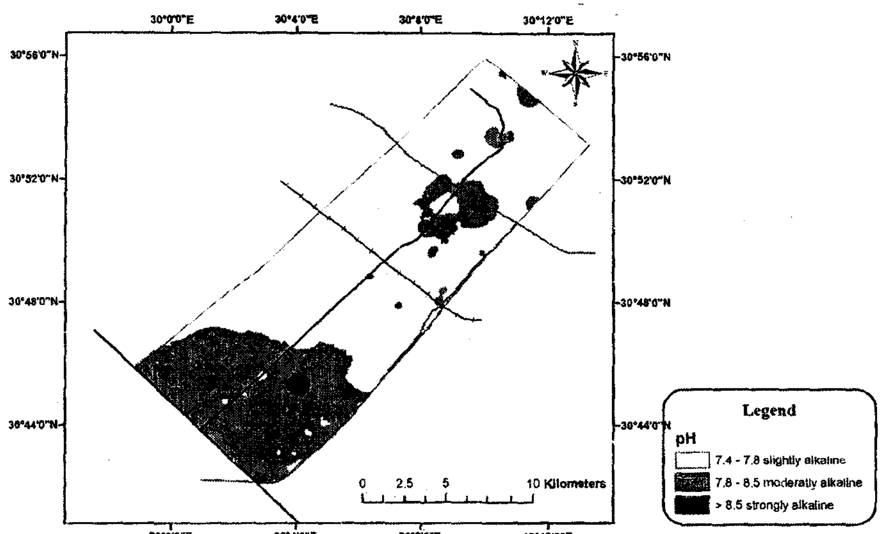
The pH values were varied between 7.4-9.23 with coefficient of variation 87.14 % and that is show that there are a high variation in soil pH. Map 5 show the spatial distribution of pH in the study area. The map was classified into 3 zones as slightly alkaline (7.4 – 7.8), moderately alkaline (7.8 – 8.5), and strongly alkaline (>8.5). These zones have an areas about 32654.4, 17039.7, and 305.9 fed., Respectively.

Calcium carbonate spatial variability map

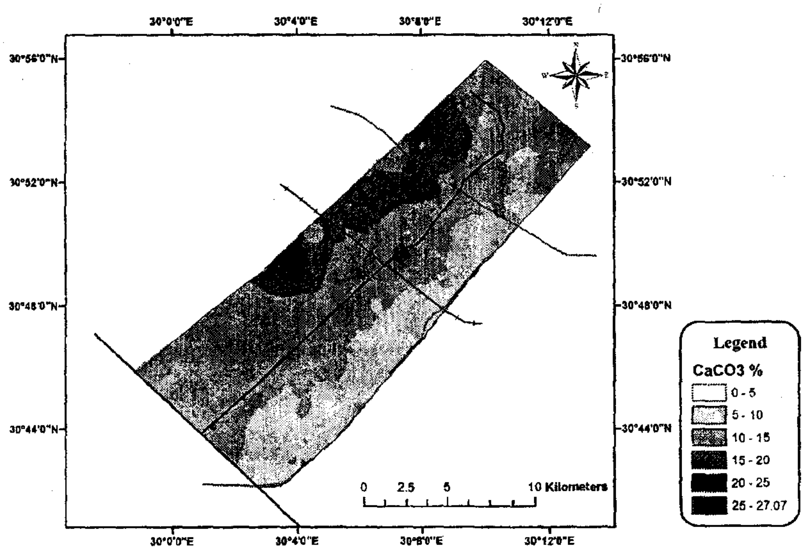
The $CaCO_3$ values were varied between 3.01-27.07 % with coefficient of variation 29.32 % and that is show that there are a moderate variation in $CaCO_3$. Map 6 show the spatial distribution of calcium carbonate in the study area. The map was classified into 6 zones as 0-5 , 5-10 , 10-15, 15-20 , 20-25 , 25-27.07. These zones have an areas about 13.8, 12675.6, 29411.9, 7493.3, 288.7, 116.7 fed., Respectively.



Map 4. Spatial variability of salinity



Map 5. Spatial variability of pH



Map 6. Spatial variability of calcium carbonate

Nitrogen spatial variability map

The available nitrogen values were varied between 5-160 ppm with coefficient of variation 55.93 % and that is show that there are a specific high variation in available nitrogen. Map 7 show the spatial distribution of nitrogen in the study area. The map was classified into 5 zones as very low (< 28 ppm), low (28-46 ppm), medium (46-64 ppm), high (64-82 ppm), and very high (> 82 ppm). These zones have an areas about 2441.8, 25162.9, 13221.9, 6948.6, and 2224.8 fed., Respectively.

Phosphorus spatial variability map

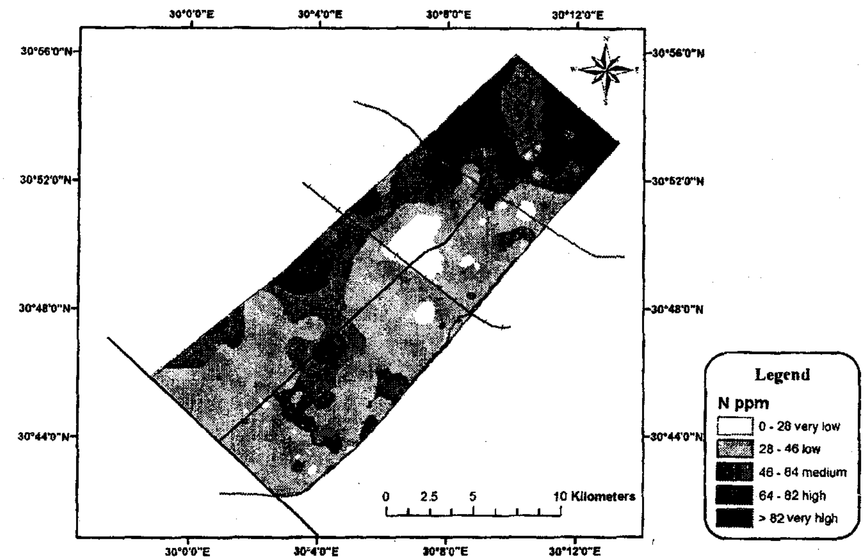
The available phosphorus values were varied between 0.64-184 ppm with coefficient of variation 80.58 % and that is show that there are a high variation in available phosphorus. Map 8 show the spatial distribution of phosphorus in the study area. The map was classified into 4 zones as low (<10 ppm), medium (10-20 ppm), high (20-40 ppm), and very high (> 40 ppm) as indicated by Marx et al. (1999). These zones have an areas about 371.1, 3859.2, 30022.9, and 15746.8 fed., Respectively. There a heavy application of phosphorus fertilizers yearly, add to this issue the phosphorus immobile nutrient and didn't lost from the soil, this reasons which conducted a high level of phosphorus in soil.

Potassium spatial variability map

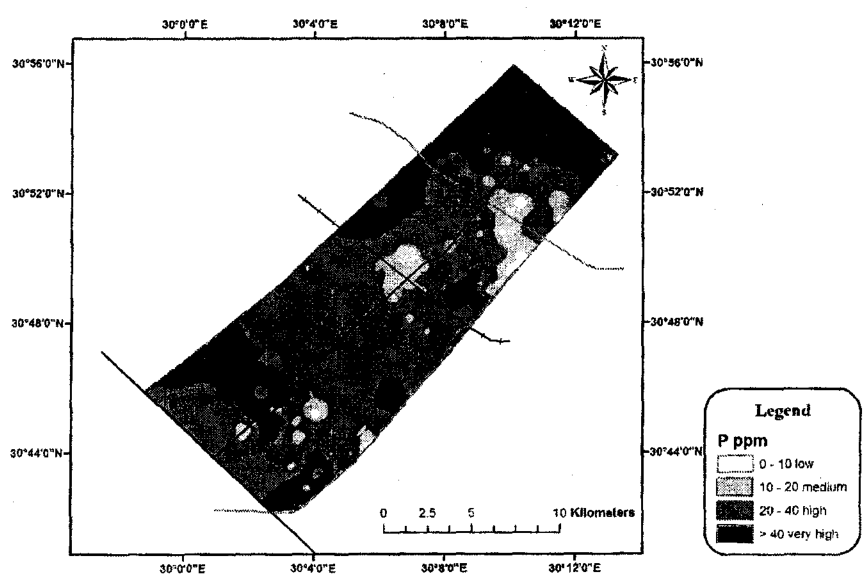
The available potassium values were varied between 19.78-520.79 ppm with coefficient of variation 54.55 % and that is show that there are a specific high variation in available potassium. Map 9 show the spatial distribution of potassium in the study area. The map was classified into 3 zones as low (<150 ppm), medium (150-250 ppm), and high (250-800 ppm) as indicated by Marx et al. (1999). These zones have an areas about 18368.3, 22975.6, and 8656.1 fed., Respectively.

Active sodium spatial variability map

The active sodium values were varied between 26.94-1259.9 ppm with coefficient of variation 91.5 % and that is show that there are a high variation in active sodium. Map 10 show the spatial distribution of sodium in the study area. The map was classified into 6 zones as 0-100 , 100-200 , 200-300, 300-400 , 400-500 , 500-1259.9. These zones have an areas about 11814.5, 14092.5, 9674.7, 8417.3, 4315.2, 1685.8 fed., Respectively.



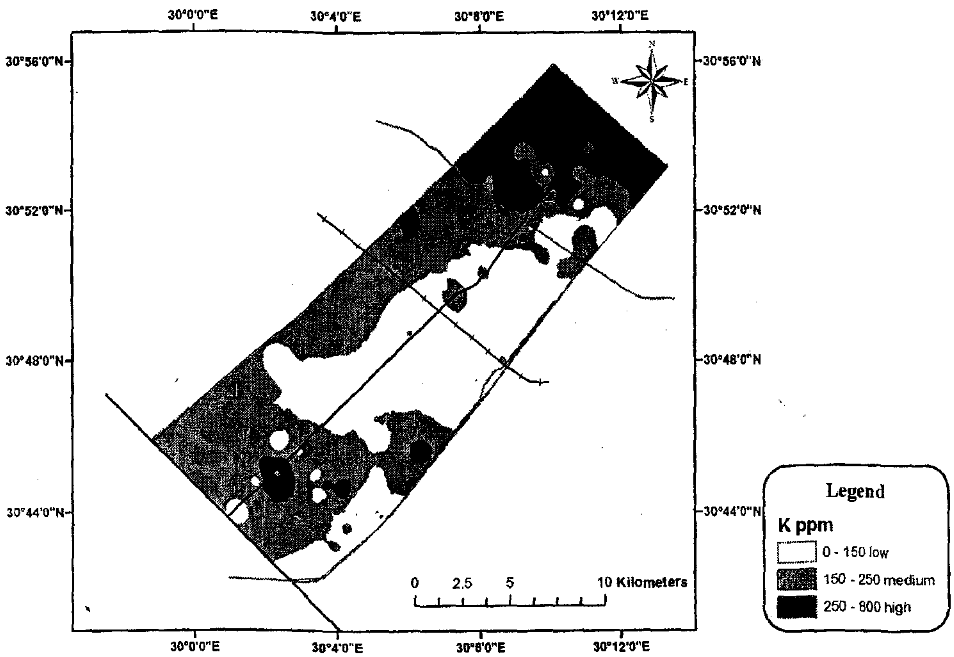
Map 7. Spatial variability of nitrogen



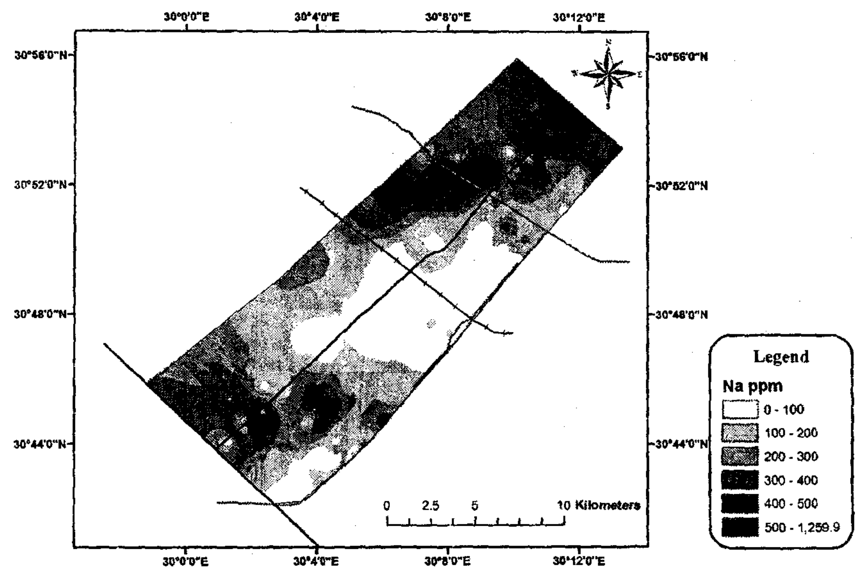
Map 8. Spatial variability of phosphorus

Texture spatial variability map

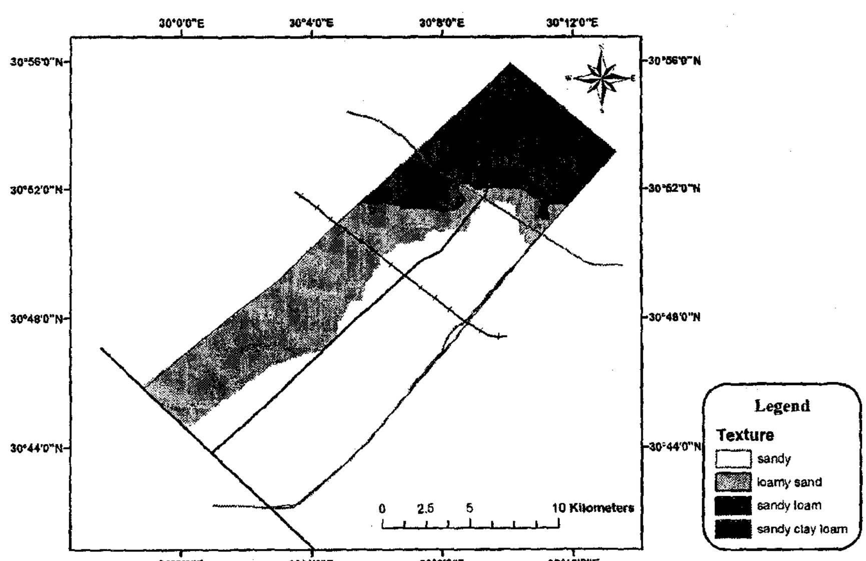
The clay content values were varied between 5-25 % with coefficient of variation 50.1 % and that is show that there are a specific high variation in clay content. Map 11 show the spatial distribution of texture in the study area. The map was classified into 4 zones as sandy, loamy sand, sandy loam, and sandy clay loam. These zones have an areas about 24004.1, 14155.7, 10874.9, 965.3 fed., Respectively.



Map 9. Spatial variability of potassium



Map 10. Spatial variability of active sodium



Map 11. Spatial variability of texture

Management Zones Delineation Technique

The question that must be resolved is: which approach for locating zones boundaries produced the best fertilizer recommendation? At least three different criteria for assessing management zones. These criteria are:

1. The ability to group areas with similar soil test results into the same zone;
2. The ability to group areas with similar yields into the same zones; and
3. The ability to improvement fertilizer recommendation.

The delineation of management zones is simply a way of classifying the spatial variability within a field. The most meaningful factors to include in a management zone strategy will be those with the most direct effect on crop yield. So, the delineation strategy should be based on true cause and effect relationships between site characteristics and crop yield.

Data can't depend on the yield in the field to make a decision support map because this fields doesn't managed and operated with the same farmer, then the yield variability across the study area not under a controllable conditions and based on the soil potentiality and farmer management; that is the reason which this matter requested for make a pot experiment.

A pot experiment was conducted to study the effect of variation in soil parameters on the yield to determine which of analyzed soil parameters influenced positively or negatively on the yield and then make a successful management zones map based on the layers weighed overlay in GIS. Plastic pots were packed with the soil samples at a weight of one and half kg per each. 50 seeds of Barley plant (*Hordium vulgaris*) were grown in each pot as an indicator plant. Three cuts of barley plants were taken, the first cut was collected after 40 days from planting, while the others cuts were taken every 30 days of after the first, and second. The experiment was done under nutrient stress to maximize the potentiality of soil on the yield, then the correlation with every soil parameters. After each cut the plant samples were dried and then weighed like guideline for the yield.

The relation between each parameter and barley dry weight (pot experiment)as a guideline for the yield were conducted to select the most parameters which effecting on the yield under the condition of the studied area, then take it in consideration at layers overlay and weighed in GIS.

As a result, most of the soil properties associated with the soil texture, it will survive on an error in the results of the crop yield with the properties of the soil. To reduce the error rate, it should be differentiate between the two sets of soil depending on the texture, and then taking the average correlation to obtain the correct value, which will be relied upon. Therefore, the area has been divided into two, the first part (sandy soils), while the second (loamy sand, sandy loam, and sandy clay loam).

Spatial analysis data have been excluded for organic matter and saturation percentage because they could not be classified into a clear category and the variations in its values very small, also the high correlation with the texture, and already the layer of texture represented strongly. Also the overlay data have been exclude the nutrients layers because basically those nutrients are the result of fertilizers and this may vary from year to year, taking into consideration the other properties that have potential on the nutrients like texture and already it is represented strongly.

Results indicated that the texture correlation value gives amount 0.59, while salinity gives correlation value in the first part -0.22, and in the second part -0.39, To give the average value in all the area -0.31. $CaCO_3$ gives correlation value in the first part -0.3, and in the second part -0.29, To give the average value in all the area -0.30, and pH gives correlation value in the first part -0.15, and in the second part -0.30, To give the average value in all the area -0.22 (Table 3).

Table 3. Correlation coefficient between soil properties and barley with and without put texture class variation into consideration

Soil properties	All area	First part	Second part	True value
EC	0.21	-0.22	-0.39	-0.31
pH	-0.23	-0.15	-0.30	-0.22
$CaCO_3$	-0.18	-0.30	-0.29	-0.30
N	0.32	0.11	0.33	0.22
P	0.43	0.29	0.41	0.35
K	0.62	0.38	0.55	0.47
Na	0.44	0.15	-0.05	0.05
texture (Clay %)		0.59		

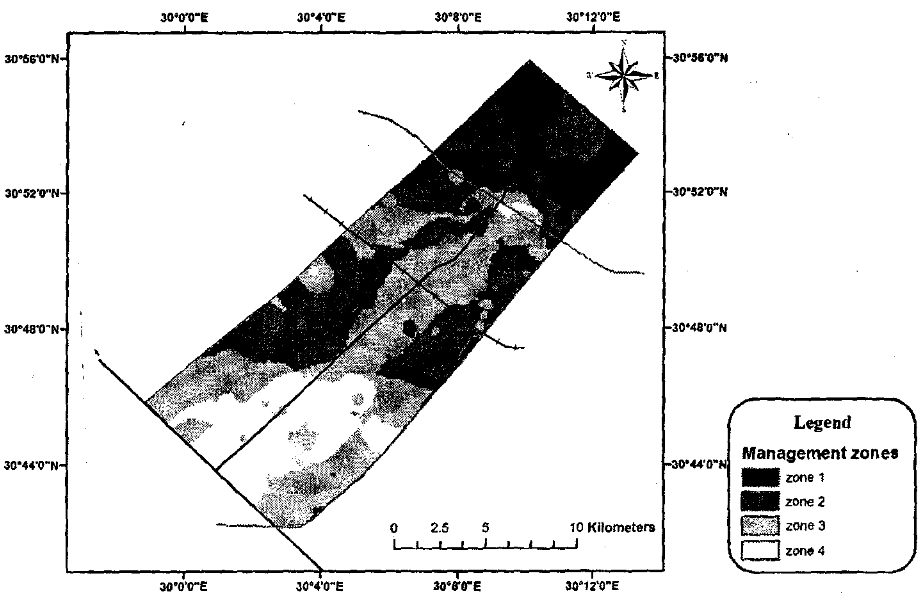
It has become clear that the soil texture, salinity, $CaCO_3$, and pH the most factors that must be taken into account in zone delineation to create management zones map.

The data has been transferred to a percentage (Table 4), taking into account the priority of each layers where texture have a positive value and other properties negative values. So, a priority reclassification were done for each attribute layers.

The weighed overlay was done by ArcGIS software and there are a distinguished 4 management zones as shown in Map 12. In the 4 management zones, the arrangement of the zones from 1 to 4 take the same direction of its priority, these zones have an areas about 5941.9, 17653.4, 18004, 8400.7 fed., Respectively.

Table 4. Weighed overlay codes for selected soil properties

Soil properties	Overlay value %
Texture class	41.50
EC	21.83
$CaCO_3$	21.16
pH	15.51



Map 12. Four management zones categories of the study area

The Potentiality of Management Zones on Wheat Plant Parameters

Subsequent to demonstrating the value of using management zones for characterizing soil properties, we were interested in confirming if this same approach could be used to characterize the spatial variability of grain yield and nutrition across the study area. It was observed distinct spatial patterns for wheat yield, which resembled spatial patterns of the management zones map, with the highest average yield in management zone 1 and take the same arrangement of the others. Table 5 explain statistical descriptive analysis for wheat plant parameters in the 4 management zones categories.

Wheat plant yield

Yield ultimately integrates all variability factors and gives us a composite measurement of their impact. Yield variability provides a compilation of the variability of all the physical, chemical, and management factors. By carefully analyzing yield data along with the site-specific data from the other layers of information, the components of yield variability may eventually be determined and used as a guide to improve management. Once variability is identified and measured, action can be taken to manage that variability to increase profits through increasing yield, reducing expenses, or both.

The investigation has been based on the results of (Hassan, 2003), which can be extract from his study that the average high yield of wheat grain in Nubaria area was 3.07 ton grain/fed. with the average concentration of NPK nutrients 3.29, 0.67, and 0.59 %, respectively. The average high yield of straw were 6.15 ton/fed. With average concentration of NPK nutrients 0.97, 0.37, and 3.46 %, respectively. The average high biological yield were 9.21 ton/fed. And that is the data which compared with our data.

The observed changes in spatial yield patterns from zone to zone were likely due to the interaction of soil factors that influencing on crop yield. It is confirm the results of management zones because the average crop yield takes the same direction of zones regularly. Figure 2 show the average yield data of wheat .

Table 5. Statistical descriptive analysis for wheat parameters in the 4 management zones categories

Zones		Plant parameters	Mini.	Maxi.	Range	Mean	SD	CV %
Zone 1	Grain	yield, (ton/fed.)	2.10	3.06	0.95	2.56	0.46	17.90
		N, %	1.37	2.02	0.65	1.72	0.29	16.90
		P, %	0.30	0.40	0.10	0.35	0.05	14.00
		K, %	0.15	0.27	0.12	0.22	0.05	22.60
	Straw	yield, (ton/fed.)	3.58	5.02	1.44	4.28	0.70	16.25
		N, %	0.43	0.64	0.21	0.54	0.09	17.09
		P, %	0.13	0.18	0.05	0.15	0.02	15.89
		K, %	0.43	1.09	0.66	0.84	0.28	32.95
Zone 2	Grain	yield, (ton/fed.)	1.88	3.00	1.12	2.33	0.33	14.00
		N, %	1.22	2.00	0.78	1.53	0.23	14.80
		P, %	0.21	0.42	0.21	0.34	0.06	18.44
		K, %	0.13	0.27	0.14	0.21	0.05	22.40
	Straw	yield, (ton/fed.)	3.24	4.94	1.69	3.92	0.49	12.57
		N, %	0.39	0.63	0.25	0.48	0.07	14.90
		P, %	0.08	0.19	0.10	0.15	0.03	20.47
		K, %	0.32	1.09	0.77	0.76	0.26	34.04
Zone 3	Grain	yield, (ton/fed.)	1.29	2.68	1.39	2.01	0.43	21.20
		N, %	0.82	1.77	0.95	1.31	0.29	22.20
		P, %	0.20	0.38	0.18	0.29	0.05	15.90
		K, %	0.14	0.27	0.13	0.21	0.01	5.70
	Straw	yield, (ton/fed.)	2.35	4.45	2.10	3.44	0.64	18.99
		N, %	0.26	0.56	0.30	0.42	0.09	22.37
		P, %	0.08	0.17	0.09	0.13	0.02	17.69
		K, %	0.37	1.09	0.72	0.75	0.21	28.01
Zone 4	Grain	yield, (ton/fed.)	1.07	1.47	0.40	1.32	0.17	13.00
		N, %	0.67	1.10	0.43	0.88	0.18	19.90
		P, %	0.25	0.28	0.03	0.27	0.01	4.70
		K, %	0.20	0.23	0.03	0.21	0.02	7.10
	Straw	yield, (ton/fed.)	2.02	2.62	0.60	2.39	0.26	10.85
		N, %	0.21	0.35	0.14	0.28	0.06	20.31
		P, %	0.10	0.12	0.01	0.11	0.01	5.43
		K, %	0.70	0.87	0.17	0.77	0.08	10.74

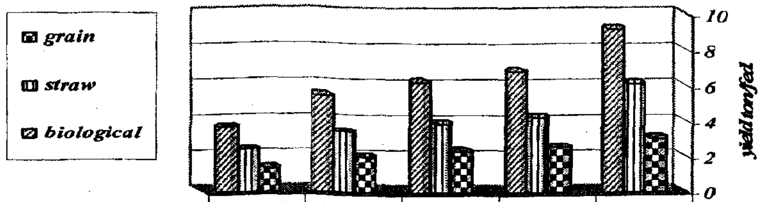
Wheat nutritional status

Two methods were done for wheat nutrient diagnosis, the first approach was the critical value methods, and for more credibility under the conditions of the study area, the study were based on the results of (Hassan, 2003). The second method was CND model (Compositional Nutrient Diagnosis), As indicated by Parent and Dafir (1992).

Nutrient status assessment using critical value method

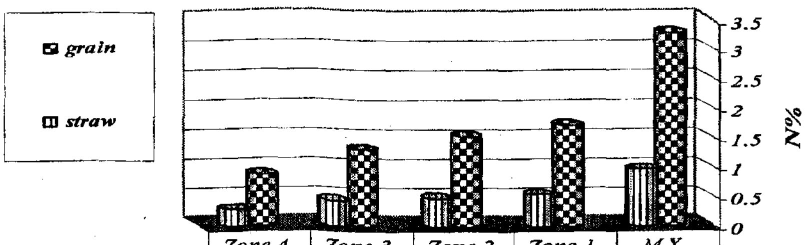
Critical nutrient concentration is defined as the concentration of a specific nutrient within a specific plant part at which growth or yield begins to decline (Ulrich and Hills, 1967).

The following Figures 3,4,5 illustrate the average concentration of NPK nutrient in the grain and straw compared with its average concentration in the high yield.



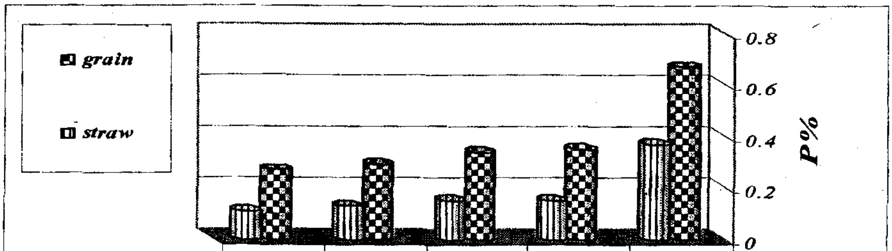
	Zone 4	Zone 3	Zone 2	Zone 1	M.Y.
grain	1.32	2.01	2.33	2.56	3.07
straw	2.39	3.44	3.92	4.28	6.15
biological	3.71	5.45	6.25	6.84	9.21

Fig. 2. The average yield of wheat in the 4 management zones categories in contrast with maximum yield (M.Y.)



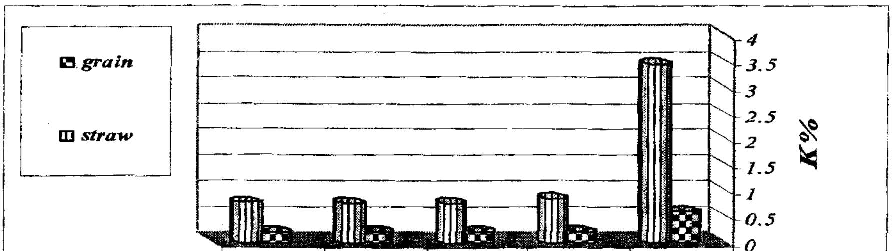
	Zone 4	Zone 3	Zone 2	Zone 1	M.Y.
grain	0.88	1.31	1.53	1.72	3.29
straw	0.28	0.42	0.48	0.54	0.97

Fig. 3. The potentiality of zones delineation on Nitrogen status in wheat grains and straw compared with the maximum yield



	Zone 4	Zone 3	Zone 2	Zone 1	M.Y.
grain	0.27	0.29	0.34	0.35	0.67
straw	0.11	0.13	0.15	0.15	0.37

Fig. 4. The potentiality of zones delineation on phosphorus status in wheat grains and straw compared with the maximum yield



	Zone 4	Zone 3	Zone 2	Zone 1	M.Y.
grain	0.21	0.21	0.21	0.22	0.59
straw	0.77	0.75	0.76	0.84	3.46

Fig. 5. The potentiality of zones delineation on Potassium status in wheat grains and straw compared with the maximum yield

It is clear that the concentration of nitrogen takes the same direction ranges regularly of the zones and that is indicating that the nitrogen is the most important nutrient limited plant yield. There are a little variation between zones in plant phosphorus and potassium. But in general, all the nutrients are far from optimal concentrations.

Nutrient status assessment using CND model

CND model (Compositional Nutrient Diagnosis) have great importance in the identification of nutrient limited-yield and more clarification is also for nutrients balance in plant.

As indicated by Parent and Dafir (1992), plant tissue composition forms and dimensional nutrient arrangement, i.e., simplex (S^d) made of d+1 nutrient proportion including d nutrients and a filling value defined as follows:

S^d = [(N,P,K,...,Rd): N>0, P>0, K>0.....Rd>0,
N+P+K+....+Rd=100] (1)

where 100 is the dry matter concentration (%) ; N,P,K,.... are nutrient proportion (%); and Rd is the filling value between 100 % and the sum of d nutrient proportion computed as follows:

[Rd=100-(N+P+K+...)] (2)

The nutrient proportions become scale invariant after they have been divided by the geometric mean (G) of the d+1 components including Rd (Aitchison, 1986) as follows:

$G=[N*P*K*....*Rd]^{1/d+1}$ (3)

Row-centered log ratios are computed as follows:

VN = ln(N/G), VP = ln(p/G), VK = (K/G),...VRd =ln (Rd/G) (4)

and

VN + VP + VK + ...+VRd = 0 (5)

Were Vx is the CND row-centered log ratio expression for nutrient X. this operation is a control to insure that Vx computation have been conducted properly.

By definition, the sum of tissue components is 100% (Eq. 1), and the sum of their row-centered log ratio including the filling value must be zero (Eq. 5).

let V^*_N, V^*_P, V^*_K,...V^*_{Rd} and SD^*_N, SD^*_P, SD^*_K,... SD^*_{Rd} be the CND norms as means and standard deviations of row-centered log ratios of d nutrients, respectively.

The row-centered log ratios of independent specimens are standardized as follows:

$I_N= (V_N-V^*_N)/SD^*_N$, $I_P= (V_P-V^*_P)/SD^*_P$, $I_K= (V_K-V^*_K)/SD^*_K$, $I_{Rd}= (V_{Rd}-V^*_{Rd})/SD^*_{Rd}$ (6)

Where I_N,........,I_{Rd} are the CND indices.

As a result of the equations calculation the values closest to zero are the values more balanced, while negative values indicate that this element minus and need to add, and positive values indicate that this component redundant or there are highly application of it. the CND indexes calculated in the 4 management zones categories Figures 6,7.

It is observed that the nitrogen is negative nutrient and its arrangement upward with the zones and that is show that the nitrogen is the most nutrient limited yield in all the area and attention should be given to the management of nitrogen fertilization. phosphorus was found to be positive nutrient and that is due to the heavy applications of phosphorus fertilizers compared with the other nutrients especially nitrogen fertilizers. But in general there are a little variations in its concentration between the zones. Potassium was found negatively nutrient; furthermore, there are a little variations in its concentration between the zones and that is due to fertilization is not totally with this nutrient.

The fertilizer use is away from optimum and still marginal and nutrient balance are often not in balance. Serious note should be taken of the damage which unbalanced fertilizer use. The fertilizer policies which encourage the use of only one type of fertilizer alone can lead to decline in productivity.

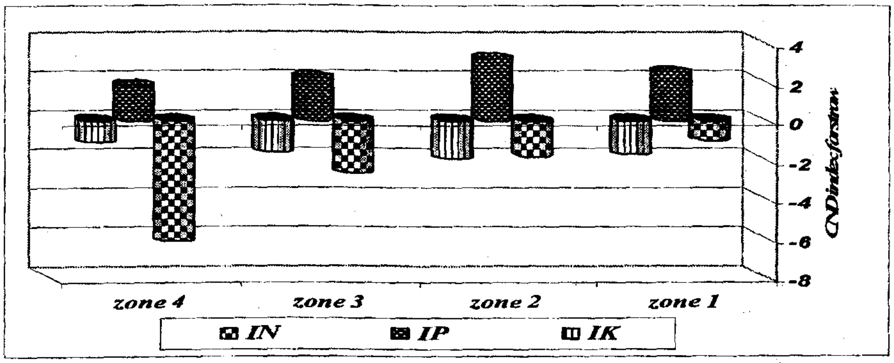


Fig. 6. CND indexes for nutrient status in wheat straw for 4 zones categories

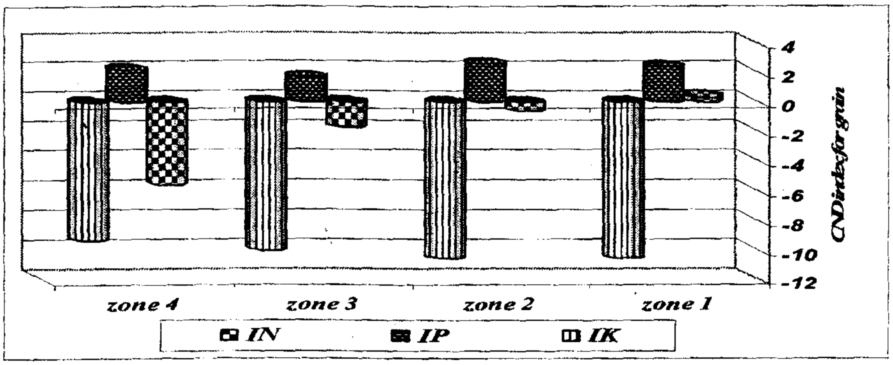


Fig. 7. CND indexes for nutrient status in wheat grains for 4 zones categories

Guidelines for Fertilizers Management Planning

Fertilizer recommendation typically are based on soil test results and yield goals (Gerwing and Gelderman, 2001). Soil test do not provide information on how farmers should apply their fertilizers. To be used efficiently, fertilizers should be applied property and at the appropriate time. The different maps generated will serve as guide for technicians and farmers on the effective management of their farms by using the right kind and amount of fertilizers. Placement and timing of fertilizers application are management decisions within a producer's production system. Soil characteristics, irrigation, tillage system and fertilizer source affect the efficacy of application.

The yield of wheat took the same arrangement ranges, Regardless of the overlaps of soil characteristics in each zone. Thus, the plant needs a specific nutrition conditions in each zone depending on their productivity, and that is which called site-specific management and our study achieve it clearly.

As a deep view, the zones which specified as a management zones in the original a zones of nitrogen fertilization, as noted in the nutritional status of wheat, the nitrogen took the same arrangement of the zones. Therefore, attention should be given to nitrogen fertilization and management to enhance its efficiency.

The spatial information can be use to manage the effects of inherent soil heterogeneity on plant growth. Instead of applying a single rate of input throughout an entire field, lesser amounts of input can be applied where they are not needed and saved for zones within the field that require greater amounts of input. Consequently, this will be economically beneficial and also limit the unwanted release of chemicals into the environment. Also that is beneficial to arrive at judicious decisions on where to establish the trial sites. Such governing operations occur at nearly all phases of the crop-growth cycle.

To develop a fertilization strategy in the study to achieve high yield, it should be take two major approaches, quantitative and qualitative. Quantitative by modify the quantities of fertilizers in each zone depending on their productivity, so it can reliable on the management zones map to put the fertilization requirement in each zone. qualitative method by management fertilization in order to overcome the various qualities of soil characteristics which impeding the nutrient availability, so it can not depend on the management zones map in this case, put each soil properties map consider a decision map in its issue.

It is recommended that should follow an integrated approaches to soil fertility maintenance to enhance the productivity based on the relative variations on soil properties and its potentiality on the availability of nutrients and should be taking into account the following principles:

Principle 1: Maximize use of organic material,

Principle 2: Judicious use of inorganic fertilizers, and

Principle 3: minimize losses of plant nutrient.

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تقييم حالة خصوبة التربة بمنطقة غرب الدلتا باستخدام نظم المعلومات الجغرافية

علي محمد محمد علي[1]– خالد جودة سليمان[2]

– عطيات السيد نصر الله[2]– رجب نبيه قمح[1]

1. قسم خصوبة وميكروبيولوجيا الأراضي – مركز بحوث الصحراء – مصر.

2. قسم علوم الأراضي – كلية الزراعة – جامعة الزقازيق – مصر.

تعتبر منطقة غرب الدلتا وبالأخص النوبارية من المناطق التي ساهمت في الإنتاج الزراعي المكثف منذ فترة طويلة، وهي من المناطق التي يجب استغلالها بشكل كبير نظرا لتوفر المياه حيث يوجد مصدرين للمياه هما؛ ترعة النوبارية وترعة النصر. والقمح هو المحصول السائد في المنطقة وتنتشر زراعته بدرجة كبيرة، ووجد أن هناك تفاوت كبير في الإنتاجية من منطقة لأخرى. ولهذا فقد صُممت تلك الدراسة الهدف الأساسي منها هو تحسين استخدام الأسمدة وهي من أهم المدخلات الزراعية والتي لها دور كبير في رفع الإنتاجية خاصة الأسمدة النتروجينية والفسفورية والبوتاسية، وذلك بالاعتماد علي

الاختلافات النوعية في خصائص التربة عن طريق استخدام نظم المعلومات الجغرافية (GIS).

ولهذا الغرض تم جمع عينات تربة ونباتية (قمح) من منطقة الدراسة لموسمي ابريل 2006 و 2007، حيث تم جمع 200 عينة تربة بعمق 30 سم ، و 75 موقعا لحقول القمح تمثل منطقة الدراسة، وتم تسجيل موقع كل عينة بواسطة GPS . وقد توصلنا إلي:-

تراوحت قيم ملوحة التربة بين 0.66 – 32.22 ديسيسمنز/م، بمعامل الاختلاف قدره 118.65 %، تراوحت قيم درجة الحموضة pH بين 7.4-9.23، بمعامل اختلاف قدره 87.14 %، تراوحت قيم كربونات الكالسيوم بين 3.01-27.07 % ، بمعامل اختلاف قدره 29.32 %، تراوحت قيم النتروجين الميسر بين 5-160 جزء في المليون، بمعامل اختلاف قدره 55.93 %، تراوحت قيم الفسفور الميسر بين 0.64-184 جزء في المليون، بمعامل اختلاف قدره 80.58 %، تراوحت قيم البوتاسيوم الميسر بين 19.78-520.79 جزء في المليون، بمعامل اختلاف قدره 54.55 %، تراوحت قيم الصوديوم النشط بين 26.49-1259.9 جزء في المليون، بمعامل اختلاف قدره 91.5 %، وتراوحت قيم نسبة الطين بين 5-25 %، بمعامل اختلاف قدره 50.1 %، تراوحت قيم السعة التبادلية الكاتيونية بين 2.85-23.02 مليمكافىء/100جم تربة، بمعامل اختلاف قدره 59.09 %، تراوحت قيم المادة العضوية بين 0.45-2.1 % ، بمعامل اختلاف قدره 47.8 %، تراوحت قيم السعة التشبعية بين 18-52.3 %، بمعامل اختلاف قدره 23.35 %.

تم تمثيل خصائص التربة المختلفة والمتعلقة بعمليات إدارة خصوبة التربة علي هيئة خرائط بواسطة GIS حيث تم توضيح الاختلافات المكانية لكل خاصية بشكل منفصل.

تم تصميم تجربة أصص تمت فيها زراعة الشعير تحت ظروف إجهاد عنصري، وتم تحديد خريطة القرار (مناطق الإدارة) وذلك بالاعتماد علي دمج خرائط التربة دمجا مرجحا بواسطة GIS وذلك بالاعتماد علي ارتباط كل خاصية من خصائص التربة مع إنتاج المادة الجافة للشعير، وقد دلت النتائج علي أن طبقة القوام تؤثر بشكل كبير قدره 41.5 % ذو تأثير موجب، والملوحة بقدر 21.83 % ذو تأثير سلبي، و كربونات الكالسيوم بقدر 21.16 % ذو تأثير سلبي، ودرجة الحموضة بقدر 15.51 % ذو تأثير سلبي. تم استبعاد الخصائص الأخرى إما لنقص الاختلافات في توزيعها بالمنطقة، أو كنتيجة للارتباط الشديد بينها وبين القوام، وبالتبعية طبقة القوام ممثلة بشكل قوي. وبهذا قد تم دمج تلك

الخصائص في خريطة القرار بواسطة GIS والتي سميت بخريطة مناطق الإدارة، وأمكننا تمييز 4 نطاقات للإدارة.

أوضحت النتائج أن حالة محصول القمح يأخذ نفس ترتيب النطاقات مما يؤكد بدرجة كبيرة صحة المنظور الذي تم علي أساسه تحديد مناطق الإدارة حيث أعطى النطاق الأول متوسط محصول حبوب قدره 2.56 طن/فدان، ومحصول قش قدره 4.28، ومحصول بيولوجي قدره 6.84، بينما النطاق الثاني أعطى متوسط محصول حبوب قدره 2.33 طن/فدان، ومحصول قش قدره 3.92 طن/فدان، ومحصول بيولوجي قدره 6.25 طن/فدان، أما النطاق الثالث فقد أعطى متوسط محصول حبوب قدره 2.01 طن/فدان، ومحصول قش قدره 3.44 طن/فدان، ومحصول بيولوجي قدره 5.45 طن/فدان، والنطاق الرابع أعطى متوسط محصول حبوب قدره 1.32 طن/فدان، ومحصول قش قدره 2.39 طن/فدان، ومحصول بيولوجي قدره 3.71 طن للفدان.

أتضح أن تركيز النتروجين في النبات بصفة عامة يأخذ نفس ترتيب نطاقات الإدارة التي تم تحديدها مما يدل وبشكل واضح أن النتروجين هو العنصر المحدد للإنتاج في منطقة الدراسة، بينما كانت الاختلافات اقل بالنسبة للفسفور والبوتاسيوم. وبصفة عامة فان تركيزات كل العناصر في النبات بعيدة عن التركيزات المثلى.

تم استخدام نموذج التشخيص المتعدد للعناصر (CND model) لتوصيف حالة التوازن العنصري في النبات. أوضحت النتائج أن النتروجين ذو توازن سلبي وترتيبه يأخذ نفس ترتيب النطاقات المحددة مما يؤكد أن النتروجين هو العنصر المحدد للإنتاج في منطقة الدراسة، بينما الفسفور كان توازنه ايجابي نتيجة للإضافات العالية من التسميد الفسفوري على حساب الأسمدة الأخرى خاصا الأسمدة النتروجينية ،أما البوتاسيوم فقد كان توازنه سلبيا. وبصفة عامة فان الاختلافات قليلة في تركيزات الفسفور والبوتاسيوم بين نطاقات الإدارة عكس النتروجين.