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SUSTAINABILITY OF SOIL FERTILITY STATUS AS AFFECTED BY WATER QUALITY, FERTILIZER LEVELS AND CROP ROTATION

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ABSTRACT

A moderately long-term field trial was carried out at East North Delta of Egypt (El Serw Res.Station) since 1996/1997 season up to 2003/2004 season to study sustainability of soil fertility status under different resource managements, i.e. 4 levels of NP (0, low, recommended and high), water quality (fresh and drainage) and 3 crop rotations;Rot.1(wet), Rot.2(very wet) and Rot. 3(dry) . The collected data of the first 3-years crop rotation showed that:

1-The available N&P residuals were significantly increased with increasing fertilizer rates while that of K was not affected.

2-The residual N was increased under drainage water application by about 31% over fresh water, which may be due to the leached NO3 anions in drainage water, while the residuals P and K were not affected by water quality.

3-The micronutrient residuals were decreased with increasing NP fertilizer levels.

4-Drainage water application caused significant reduction in the residual Fe, whereas those of Mn and Zn were slightly increased with drainage water application.

5-Crop rotation 2(very wet) and 3(dry) caused significant increase in Zn residual only by about 42% and 31% respectively, while Fe and Mn were not affected.

6- Crop rotation 2 recorded also significant increase in organic matter content compared to rotations 1(wet) and 3(dry), which may be due to that winter crop was berseem(Egyptian clover) during the 3-years crop rotation.

7-The highest relative contribution(R C%) of water quality was for Fe residual (79.22%) followed by N residual (25.55%) , while the highest RC% of crop rotation were 24.76% and 21.24% for OM and P respectively.

8-The added N recorded remarkable RC% for N residual (47%) followed by Zn (10.38%), and the RC%of the added P was 69% for residual P and 22.99% for residual Zn.

9-The total RC% of all tested factors were pronounced for the available P (90.29%), Fe (81.07) and N (79.98%) and to some extent for Zn (33.37%), Mn (41.97%) and organic matter (24.76%) whereas, it was the least for K (7.82%), which may be due to the heavy clay soils with high K content at this location.

Keywords: NPK fertilizers; soil fertility; water quality, crop rotation

INTRODUCTION

The greatest challenge for the coming decades lies in the fact that many production environments are unstable and degrading. Land degradation is proceeding so fast that unless policies and approaches change, many countries will not be able to achieve sustainable agriculture in the foreseen future.

In North delta in Egypt, relatively saline water is commonly used for the agriculture expansion due to the limited Nile water supply in such areas.

However, the uses of saline water reflected in increasing soil salinity which pass a serious threat to irrigated agriculture in such areas thus, may result in deteriorating the soil from the long continued use of such water in irrigation (Wassif *et al.*, 1997).

A part from the effect on water availability to plants, and the possible toxic effect of some constituents, excess neutral soluble salts in soils may also interfere with the normal nutrients of crops in saline soils. At moderate salt concentrations in the soil solution, plants generally try to exclude unwanted ions, as far as possible, and promote the uptake of nutrients. With increasing salt concentration, the uptake of sodium and chloride ions increases sharply. This luxury consumption of ions is essential for the plants to compensate for the increased outside osmotic pressure but is responsible for growth retardation. Excessive uptake of certain ions, in turn, often results in reduced uptake of some essential plant nutrients, causing nutrient imbalances and deficiencies (Krauss, 2000).

Management of salt affected soils requires a combination of agronomic practices, depending on a careful definition of the requirements, based on a detailed, comprehensive prior investigation of soil characteristics, water quality and local conditions including climate, crops, human aspects, political and cultural environment and existing farming systems. There is usually no single way to control salinity, particularly in irrigated agriculture. However, several practices can be combined into an integrated system that functions satisfactorily (Mashali, 1997).

Crop rotation have positive effect on yield, even when soil fertility is at a measured optimum, and when pests and diseases are controlled, the phenomenon has come to be called " the rotation effect ". Agriculture production systems in Egypt are very intensive, due to the favourable conditions that allow cropping during the whole year. The rotation effect alleviates the yield depression associated with continuous cultivation (Crookston et al., 1998 and selim, 1998).

Change in the Zn and Mn status of soil after its use for six crop cycles of maize – wheat rotation supplied with different N- P-K levels were studied by Kapur and Talukdar (1986). They found that the available Mn and Zn content of the plow layer decreased considerably from its initial level. The greatest available Mn content depletion was at the highest N application rate. Zn and Mn content also decreased with increased P rates.

Numerous long –term field trials prove that the initial level of soil fertility and thus crop yield can be maintained provided the nutrient balance in equilibrium. The introduction of modern high yielding varieties affects the nutrient balance by removing more nutrients with higher biomass (Karpenstein et al., 1986). To ensure the sustainability of the high productivity in the Nile Delta, more researches for better management of natural resources (soil and water) are needed.

The main objective of the present work is to promote sustainability of soil fertility of salt affected soils under balanced NP fertilizers, water quality and intensive cropping systems in North East Delta (Manzalla lake area).

MATERIALS AND METHODS

A moderately long-term trial (LTT) was conducted in 1996/1997 growing season and lasted until 2003/2004 season at East North Delta of Egypt (El Serw Research Station, under tile drainage system), to study sustainability of soil fertility status under the following resource managements:

1-**Irrigation water quality**: (a) Fresh water (FW) from irrigation canal and (b) Drainage water (DW) from the main EL- Serw drainage.

2-**Crop rotation**: Three types of crop rotation were applied as follows:

Year	Prevailing (wet) Rot. 1	Very wet Rot. 2	Dry Rot . 3
1st	Egyptian clover followed by Rice	Egyptian clover followed by Rice	Faba bean followed by Rice
2nd	Wheat Followed by Sunflower	Egyptian clover followed by Rice	Sugar beet followed by Sunflower
3rd	Egyptian clover Followed by Rice	Egyptian clover followed by Rice	Egyptian clover followed by Cotton

3- **Chemical fertilizers**: Balanced rates of NP fertilizers according to crop requirements (Table 1) were added at 4 levels i. e. Zero (0), Low (L), recommended or medium (M) and high (H). P fertilizer was added preplanting for all crops, while N fertilizer was applied at the proper time for all crops. The experimental design was split - split plot design in 4 replicates with plot area of 350 m^2. The main plots were arranged for irrigation water quality. The sub plots were devoted to the crop rotation. While, the sub-sub plots were assigned to NP fertilizers levels.

Table (1): Fertilizer rates for all crops in the rotation

Crops	Low levels, Kg/fed.		Medium level, Kg/fed		High level, Kg/fed	
	N	P_2O_5	N	P_2O_5	N	P_2O_5
			Winter crops			
Wheat	30	10	60	20	90	30
Clover	10	10	20	20	30	30
Faba bean	10	15	30	30	45	45
Sugar beet	30	10	20	20	30	30
			Summer crops			
Sunflower	15	10	30	20	45	30
Rice	25	10	50	20	75	30
Cotton	30	10	60	20	90	30
Rot. 1	115	60	230	120	345	180
Rot. 2	105	60	210	120	315	180
Rot. 3	120	65	240	130	360	195

Feddan = 0.42 hectare

Soil analysis: Soil surface samples (0-30 cm.) were collected from each plot individually before planting (0-time) and after 3 – years crop rotation and subjected to chemical analysis such as OM % and the available macro – nutrients (N, P and K) according to Jackson (1973) and micronutrients (Fe, Zn and Mn) according to Lindsay and Novell (1978).

Water analysis: Water samples also were collected monthly from the middle of the stream of the main El-Serw drain. These samples were analyzed to study their suitability for irrigation according to U.S . Salinity Laboratory Staff(1954).

Statistical Analysis: Average values from the four replications of each treatment were interpreted using the analysis of variance (ANOVA) with separation of means accomplished by using LSD at 5 % according to Gomez and Gomez (1984).

Table (2): Some physical and chemical properties of the experiment soil before planting (Zero-time).

Soil properties	Fresh water s site	Drainage water s site
Particle size distribution		
Coarse sand %	1.56	1.6
Fine sand %	12.52	12.32
Silt %	21.78	20.1
Clay %	64.14	66.2
Texture class	Clayey	Clayey
C.E.C., meq/100 g soil	51	53
EC, ds/m at 25^0 c	4.5	4.4
PH of soil (1:2.5 suspension)	8.3	8.3
Organic matter %	1.65	1.68
Available N ppm	32	38
Available P ppm	7.8	8.1
Available K ppm	450	462
Available Zn ppm	1.4	1.6
Available Mn ppm	14.6	13.9
Available Fe ppm	8.4	8.1

RESULTS AND DISCUSSIONS

As shown from Table (3), it can be concluded that water of El-Serw drain can be used in soil with high permeability and adequate drainage. Special management for salinity control may be needed, moderately and high tolerant plants should be selected and moderate amount of water leaching must be occurs.

Soil fertility status was examined after 3 years crop rotation under some resource management, i.e. crop rotation (prevailing–wet Rot.1, very–wet Rot.2 and dry Rot.3), irrigation water quality (fresh and drainage) and NP fertilizer levels (zero, low, medium and high). After 3 years crop rotation, soil surface samples (0-30 cm) were taken from each plot and subjected to chemical analyses individually. The available soil macronutrients (N, P and K) and micro nutrients (Fe, Zn and Mn) as well as soil organic matter content was analyzed using the conventional methods.

Table(3):Irrigation water characteristics during winter and summer seasons of El-Serw Farm

Irrigation source	EC ds/m	T.S.S ppm	SAR	Souluble cations persentage			
				SCaP	SMgP	SSP	SKP
Winter season							
Canal water	0,64	410	3.00	30.76	15.44	50.93	2.86
Drainage water							
January	2.48	1587	9.67	12.78	19.64	66.11	1.47
February	2.64	1690	10.00	12.92	19.46	66.39	1.23
March	2.07	1325	9.78	10.55	18.46	69.52	1.46
April	2.41	1542	9.84	12.42	18.85	67.32	1.41
Summer season							
Canal water	0.65	416	3.58	24.16	18.31	55.28	2.25
Drainage water							
May	2.62	1677	11.74	5.94	18.67	74.03	1.36
June	3.22	2061	11.96	6.64	20.69	71.62	1.05
July	3.30	2112	12.21	6.49	20.51	71.85	1.15
August	2.42	1549	11.07	4.31	21.04	73.53	1.11
September	2.02	1293	9.84	12.36	14.68	71.74	1.22
October	2.28	1459	10.59	8.86	17.18	72.69	1.27
November	2.36	1510	10.19	8.08	19.25	71.01	1.67
December	2.25	1408	10.42	8.28	17.93	72.68	1.11

A- Macronutrients:

(1) Nitrogen:

The obtained data in Table (4) indicated that the residual available N content was significantly increased by using all fertilizer application levels over the zero fertilizer levels with no significant difference between the low and the medium levels. It is worth to mention that the available N content was low under the lower fertilizer levels (0, L and M) comparing with the zero-time samples, showing that these levels were not sufficient for growing crops, specially the high yielding varieties, which remove more amounts of N. However the high fertilizer level (H) showed slight increase over the initial N status (Zero – time).

On the other hand, insignificant increase in the available N content was detected by about 31% under the drainage irrigation water treatment compared to the fresh water irrigation water treatment. This could be attributed to the leached NO3 anions in the drainage water. Similar results were obtained previously by Selim (1998) and Krauss (2000). However, El Kholy (1993) noted that N- uptake by plants decreased as a result of the competition between chlorides in large amount existing in drainage water and the nitrate anions needed for plant growth. Concerning the effect of crop rotation on the available N content, the Rot.2 (Very - wet rotation) showed slight superiority over the other two crop rotations as a result of Egyptian clover occurrence (legume crop) in this rotation. Similar results were obtained by Bowman et al (1999) and carpenter et al (2000). No significant interaction effects were found on the available soil N content among the studied factors.

Table (4): Residual soil available N and organic matter contents (O.M%) as affected by crop rotation, fertilizer levels and water quality after 3-years crop rotation.

Crop rotation	Fertilizer level	Fresh water		Drainage water		Fertilizer Mean N ppm
		N (ppm)	O.M %	N (ppm)	O.M %	
Zero – Time		38.3	1.68	41.4	1.76	39.8
Rot. 1	O	25.2	1.97	34.1	1.93	27.7 a
	L	23.6	2.00	39.0	2.05	34.3 b
	M	26.9	2.09	47.7	1.95	36.9 b
	H	31.7	1.91	54.2	2.01	47.1 c
Mean		26.9	1.91	43.8	1.99	
Rot. 2	O	27.9	2.23	35.7	2.13	
	L	29.3	2.11	40.6	2.22	
	M	39.1	2.19	39.8	2.15	
	H	47.8	2.04	55.2	2.14	Rotation mean O.M %
Mean		36.0	2.14	42.8	2.16	1.72
Rot. 3	O	17.4	2.13	26.0	1.66	Rot.1 1.99 a
	L	32.6	1.74	40.6	2.10	Rot.2 2.15 b
	M	31.3	1.95	36.8	1.95	Rot.3 1.94 a
	H	46.7	1.94	47.1	2.04	
Mean		32.0	1.94	37.6	1.94	
Water quality		31.6	2.02	41.4	2.03	

(2) Phosphorus:

The obtained results in Table (5) illustrated that the residual available soil P content increased significantly with increasing NP fertilizer levels up to the higher levels, however the higher level only showed superiority over the initial P status since the zero and low fertilizer levels showed P content less than zero – time samples and the medium levels was nearly the same as zero time level.

Regarding the crop rotation effect on available phosphorus content, application of the dry rotation (Rot.3) gave the higher P content than the other two rotations, since there was significant difference between both Rot.1 and Rot.2 regardless of the other tested factors. Similar results were obtained by Ebelhar (1997), Aynehband and Rashed (2003) and Reddy and Surekha (2000).

Table (5): Residual soil available P and K contents as affected by crop rotation, fertilizer levels and water quality after 3- years crop rotation.

Crop rotation	Fertilizer Level	Fresh water		Drainage water		Fertilizer Mean P
		P (ppm)	K (ppm)	P (ppm)	K (ppm)	
Zero - time		19.0	630	18.6	628	18.8
Rot. 1	O	14.7	670	10.8	669	12.4 a
	L	16.5	666	14.6	667	16.2 b
	M	18.6	677	20.7	658	19.7 c
	H	22.7	661	21.0	672	23.6 d
Mean		18.1	669	16.8	667	
Rot. 2	O	10.5	627	8.8	629	Rotation mean
	L	12.2	630	12.9	614	P
	M	15.9	612	18.5	646	Rot.1 17.5 a
	H	19.5	679	22.1	616	Rot.2 15.1 a
Mean		14.5	637	15.6	626	Rot.3 21.7 b
Rot. 3	O	16.6	753	13.1	687	K
	L	19.2	702	21.9	671	Rot.1 668 a b
	M	23.4	733	21.1	657	Rot.2 632 a
	H	27.0	648	29.5	669	Rot.3 690 b
Mean		22.0	709	21.4	671	
Water quality		18.2	672	17.9	655	

On the other hand, the water quality did not show significant effect on the available P content as apart from the other factors. This could be attributed to the low mobility and leached P to the drainage water. Withal, no significant effects were detected for the interactions among the studied factors.

(3) Potassium:

Data presented in Table (5) showed no significant effect of fertilizer application and water irrigation quality on the available K content in the soil. This could be attributed that El Serw location is characterized by its heavy clay soils with high K content. Therefore, potassium fertilization was not included in this study (El Kholy, 1993 and Laxman and Pal, 2001).

On the other hand, the available K content was affected significantly by crop rotation, since the dry rotation recorded the highest value (690 ppm) Similar results were obtained by Ebelhar (1997) and El Kholy (1997).

B- Micronutrients:

(1) Iron:

The obtained data in Table (6) showed that the available Fe content was decreased with increasing NP fertilizer levels up to the higher levels, since the higher fertilizer level showed inferiority value of Fe content less than that of the other NP levels. This is due to the high yielding crops remove more amounts of Fe. On the other hand, high significant reduction in Fe content was detected under drainage irrigation water and the reduction reached 50 % less than that of fresh water. This may be due to the salinity of drainage water, which reduces the Fe availability.

Worth mentioning that Fe content was not affected by crop rotation. However, Fe content after 3- years crop rotation decreased in comparing with the zero – time samples especially under drainage water used for irrigation.

(2) Manganese:

As shown in Table (6), Mn content recorded higher values than that of zero-time samples after 3-years crop rotation. While the studied factors, i. e. Water quality and crop rotation showed no significant effect on the available soil Mn content.

Concerning the effect of NP fertilizer levels on Mn content the same trend of that for Fe status was found.

The present results are in agreement with those obtained by Kapur and Talukdar (1986).

(3) Zinc:

Data in Table (6) showed that the available soil zinc content after 3-years crop rotation was not also affected by water quality. However, crop rotation showed significant effect on Zinc content since, Rot.2 (Very-wet) and Rot. 3 (dry) increased Zn content by about 31 % and 42 % respectively.

Concerning the effect of NP fertilizer, the obtained data revealed negative relationship between increasing NP levels and available Zinc content after 3-years crop rotation. These results may be due to that the high yielding crops remove more amount of Zn, and the reaction between Phosphorus and Zinc, which reduce the Zn. Availability.

Table (6): Soil available contents of Fe, Mn and Zn (ppm) as affected by crop rotation, fertilizer levels and water quality after 3-years crop rotation.

Crop rotation	Fertilizer level	Fresh water			Drainage water		
		Fe	Mn	Zn	Fe	Mn	Zn
Zero-time		17.35	6.27	0.77	14.3	6.27	0.83
Rot. 1	O	15.89	13.62	1.16	9.18	16.42	1.24
	L	13.46	12.27	1.04	7.22	16.23	1.03
	M	13.09	11.39	0.80	7.01	15.49	0.92
	H	13.35	11.85	0.69	6.75	14.90	0.91
Mean		13.45	12.41	0.92	7.54	15.76	1.03
Rot. 2	O	15.55	12.31	1.43	8.48	16.54	1.71
	L	14.19	11.95	1.31	8.13	16.33	1.64
	M	11.19	11.08	1.21	7.48	15.54	1.34
	H	11.09	9.03	1.20	6.37	15.16	1.21
Mean		13.01	11.09	1.29	7.62	15.89	1.48
Rot. 3	O	18.49	19.07	1.27	7.57	17.95	1.89
	L	16.47	14.68	1.13	6.82	16.36	1.74
	M	14.02	12.90	1.10	4.90	15.50	1.38
	H	13.82	12.21	0.85	4.28	11.22	0.85
Mean		15.70	14.72	1.09	5.89	15.26	1.47
Water quality		13.50 b	12.74	1.10	7.02 a	15.64	1.33

Many researchers pointed out that the problem related to Phosphorus and Zinc are common, and has become known as P-induced Zn deficiency, especially in soils having relatively high PH values such as salt affected soils in the northern part of Egypt (Boawn and Brown, 1968 and El Kholy and El Ziki, 2003). Generally, the available Zn content was improved after 3-years crop rotation compared to the zero-time samples.

C- Soil organic matter:

Data recorded in Table (4) showed that soil organic matter was significantly affected by crop rotation since, the very-wet crop rotation (Rot.2) recorded significant increase by about 8 % and 11 % over Rot.1 and Rot.3, respectively. This could be due to that berseem (Egyptian clover) was included as a winter crop during the 3-years in this rotation. In this respect, Bowman *et al.* (1999) pointed out that the biggest organic matter content was registered in the crop rotation containing alfalfa. The other factors, i.e. fertilizer levels and water quality showed no significant effects on organic matter content.

C- Relative contribution (RC%) of the tested factors in soil fertility:

Data in Table (7) indicated that water quality had the highest RC% for Fe (79.22%) followed by Mn (36.59%), N (25.55%) and K (6.25%). Meanwhile, the highest RC% for water quality was recorded in organic matter (214.76%) followed by P (21.24%) and N (7.43%), while it was the least in Mn content (5.38%).

The added N fertilizer showed the highest RC% for N (47%) followed by Zn (10.38%), while the added P fertilizer recorded the best RC% for P (69.05%) and Zn (22.99)

Table (7): Relative contribution (R C %) of studied treatments and factors for soil residuals after 3- years crop rotation.

Treatments	N	P	K	OM	Fe	Mn	Zn
Water quality	25.55	-	6.25	-	79.22	36.59	-
Crop rotation	7.43	21.24	-	24.76	-	5.38	-
Added N	47.00	-	1.57	-	1.85	-	10.38
Added P	-	69.05	-	-	-	-	22.99
Total	79.98	90.29	7.82	24.76	81.07	41.97	33.37

Summing up to the obtained results, it could be concluded that, more studies must be done on the results of the second and the third three years of crop rotation to summarize all available informations on past and on going researchs and development activities related to issues of natural – resource management at East North Delta.

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تأثير التعاقب ألمحصولي ونوعية ماء الري ومستويات التسميد المعدني على استدامة خصوبة التربة

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** معهد بحوث المحاصيل الحقلية- جيز- همصر

أقيمت تجربة متوسطة المدى في محطة بحوث السرو الزراعية بشمال الدلتا (تربه طينية ثقيلة) مع بداية الموسم الزراعي ١٩٩٦ – ١٩٩٧ وتستمر مع الموسم الزراعي ٢٠٠٣ – ٢٠٠٤ لتقييم خصوبة التربة وعلاقتها بعوامل الدراسة التالية بعد ثلاث سنوات من التعاقب ألمحصولي:

١- أربعة مستويات من التسميد المعدني الأزوتي والفوسفاتي (كنترول بدون تسميد- مستوى منخفض – المستوى الموصى به في المنطقة – مستوى مرتفع). وقد استبعد التسميد البوتاسى حيث أن التربة في هذه المنطقة طينية ثقيلة ذات محتوي عالي من البوتاسيوم.

٢- نوعية مياه الري (ماء عذب – ماء صرف زراعي) .

٣- ثلاث حالات للتعاقب ألمحصولي: تعاقب رطب, تعاقب رطب جدا, تعاقب جاف.

أخذت عينة تربه من كل قطعة تجريبية قبل بداية التجربة ثم بعد كل ثلاث سنوات من التعاقب ألمحصولي لمتابعة محتوى التربة من الصورة الميسرة من عناصر النتروجين, الفسفور، البوتاسيوم والعناصر الصغرى (زنك- حديد- منجنيز) وأيضا المحتوى من المادة العضوية.

كانت النتائج المتحصل عليها كما يلي:

١ – كانت هناك زيادة معنوية للصورة الميسرة لعنصري النتروجين والفسفور بزيادة مستويات التسميد المعدني بينما لم يتأثر المحتوى من البوتاسيوم الميسر.

٢- زاد محتوى التربة من النتروجين الميسر تحت ظروف استخدام مياه الصرف الزراعي في الري بنحو ٣١ % عما في حالة استخدام الماء العذب, وربما يرجع ذلك إلى احتواء ماء الصرف على أملاح النيرات الذائبة, بينما لم يتأثر المحتوى من الفوسفور والبوتاسيوم بنوعية ماء الري.

٣- أدى استخدام ماء الصرف الزراعي إلى انخفاض محتوى التربة من الحديد الميسر, بينما كانت هناك زيادة معتدلة في محتوى التربة من المنجنيز والزنك نتيجة استخدام ماء الصرف عنه في حالة استخدام الماء العذب.

٤- كانت هناك زيادة معنوية في محتوى التربة من الزنك الميسر نتيجة تطبيق التعاقب ألمحصولي الرطب جدا والتعاقب الجاف بنسبة ٤٢ %, ٣١ % على التوالي بينما لم يتأثر محتوى التربة من الحديد والمنجنيز.

٥- ا أدى أيضا التعاقب ألمحصولي رطب جدا إلى زيادة محتوى التربة من المادة العضوية بالمقارنة بالتعاقب الرطب والتعاقب الجاف وذلك لوجود محصول البرسيم المصري في الموسم الشتوي لمدة ثلاث سنوات تعاقب محصولي.

٦- كانت هناك مساهمة نسبية لنوعية ماء الري على المحتوى من الحديد الميسر بنسبة ٧٩,٢٢ % وللنتروجين بنسبة ٢٥,٥٥ % بينما كانت المساهمة النسبية للتعاقب المجصولي على المحتوى من المادة العضوية والفسفور بنسبة ٢٤,٧٦ %, ٢١,٢٤ % على التوالي.

٧- أحرز النتروجين المضاف زيادة نسبية ملحوظة على المحتوى من النتروجين الميسر بنسبة ٤٧ % وعلى الزنك بنسبة ٢٢,٩٩ %.

٨- كانت النسبة المئوية للمساهمة النسبية الكلية للعوامل المدروسة واضحة على المحتوى من الفسفور (٩٠,٢٩ %), الحديد (٨١,٠٧ %) والنتروجين (٧٩,٩٨ %) ولمدى محدود على كل من الزنك (٣٣,٣٧ %) والمنجنيز (٤١,٩٧ %) والمادة العضوية (٢٤,٧٩ %) بينما كان التأثير أقل على المحتوى من البوتاسيوم (٧,٨٢ %), وذلك يرجع إلى أن التربة في هذه المنطقة طينية ثقيلة ذات محتوى عالي من البوتاسيوم.