RESULTS & DISCUSSION

4- RESULTS AND DISCUSSION

4.1. Soil Available Phosphorus:

Values of available phosphorus in the investigated soils are presented in Table (1). These values ranged from 7.0 ppm to 18.0 ppm (averaging 11.0 ppm) and from 5.0 ppm to 17.0 ppm (averaging 8.46ppm) in surface and subsurface layers, respectively.

Data reveal that high values of available phosphorus were recorded in the surface soil layers and lower values in the subsurface ones . This may be due to the high organic matter content in the surface layers relative to the subsurface ones where organic matter is considered as a main source of available phosphorus in soils. These results are in agreement with that obtained by **Soltan (1985)** who found that addition of organic matter to the soils positively affected the availability of phosphorus in soils. Data presented in Table (3) reveal also that, the relationship between soil available phosphorus and organic matter content was highly significant (r = 0,500**). **Pandey et al. (2000),** reported that available phosphorus in some Indian soils ranged from 3.2 ppm to 22.4 ppm and significantly correlated well with both organic matter and clay content of these soils.

4.2. Soil Available Zinc:

Data obtained for available zinc are presented in Table (1). These values varied from 0.47 to 2.64 ppm with an average of 1.28 ppm and from 0.41 to 1.75 ppm with an average of 0.75 ppm in surface and subsurface layers, respectively. It is clear

Table (2) Correlation coefficients (r) of available phosphorus and zinc with soil properties.

No	Y variables / X variableS	Soil available P	Soil available Zn
1	Clay %	0.262	0.187
2	$CaCO_3$ %	0.074	-0.282
3	Organic matter	0.500**	0.370*
4	pH	0.309	-0.087
5	CEC	0.270	0.174
6	Surface area	0.243	0.142
7	Fe Ox.	0.079	0.021

Where * , ** significant at 0.05 and 0.01 respectively that, the higher values were in the surface layers while the lower ones were in the subsurface layers. Such finding agree with **Kuldeep et al. (1997)** who found that DTPA-extractable soil zinc had a decreasing trend with increased in depth of Indian soils. This may be due to the effect of organic matter in increasing zinc availability in the top soil **(Orabi et al. 1981** and **Abd-Latif et al., 1985).**

Correlation coefficients values (Table, 3) show a significant correlation between soil available zinc and organic matter content (0.370*). However the relationships with the other soil characteristics are insignificant . Similar results were obtained by **Sorensen et al .(1971)** who reported a positive correlation between soil available zinc and organic matter content. **El-Bagouri** (1974) found a negative correlation between calcium carbonate and available zinc. Also, **Saxena et al. (1993)** reported a negative correlation between soil pH and available zinc.

4.3. Phosphate Potential and Buffering Capacity (PBC):

4.3.1. Soil phosphate potential:

Soil phosphate potential i.e. **0.5 pCa + $pH_2PO_4^-$**, was suggested by **Aslyng (1954)** and **Schofield (1969)** as a parameter representing the soil available P fraction, which may be considered as an intensity factor.

The use of phosphate potential as an index of phosphate availability is supported by the results of **Le Mare (1960)** and **Rinno (1966)**

However, while the phosphate potential was determined according to **Aslyng (1954)** by equilibrating the soil samples with $CaCl_2$ solution for short periods, or few hours(**White and Beckett (1964)**, it was recommended by **Barrow et al. (1965)** to use longer shaking periods (17 hours) particularly with addition of relatively large amounts of phosphate to the soil. From the total concentration of phosphate (^{C}P) the values of $^{C}H_2PO_4^-$ is calculated using the equation given by **Aslyng (1954)**

$$^{C}H_2PO_4^- = {}^{C}P \times 10^{-pH} / 10^{-pK2} + 10^{-pH}$$

in which pK_2 is the negative logarithm of the second dissociation constant of phosphoric acid. The concentration of H_2PO_4- ranged from 0.62 to $13.44 \times 10^{-6} M$ and the values of phosphate potential (depending on soil pH) for the investigated soils ranged from 5.92 to 7.38 according to Aslyng equation.

Larsen (1965) suggested that, for alkaline soils values of $^{C}H_2PO_4^-$ can be calculated as follows:

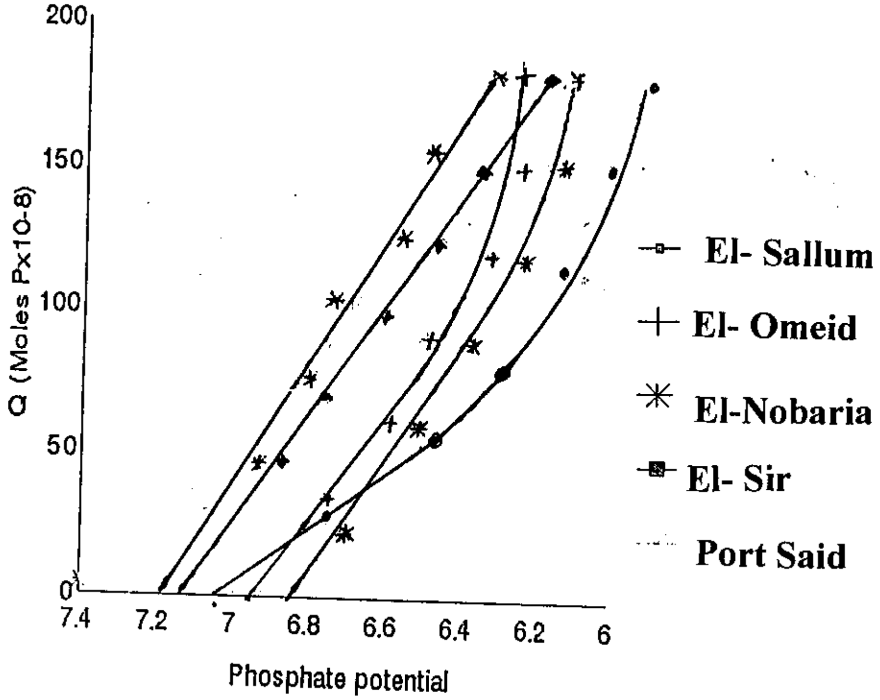
$$^{C}H_2PO_4^- = {}^{C}P \times 1/ 1+10^{pH-pK2} + {}^{C}Ca^{++} \times 10^{pH+pKc-pK2}$$

where

pKc : is the negative logarthim of the dissociation constant of calcium phosphate complex.

$^{C}Ca^{++}$: is the concentration of Ca^{++} in the filtrate (*M*).

Data obtained in Table (3) show that the concentrations of $H_2PO_4^-$ are ranging from 0.42 to $8.40 \times 10^{-6} M$. The total phosphate extractable by $CaCl_2$ (^{C}P) varied from 2.60 to $42 \times 10^{-6} M$ and from 4.38 to 5.59 for $-\log {}^{C}P$. The values of soil phosphate potential ranged from 6.12 to 7.50 according to



Fig(1) Phosphate potential

Larsen equation . Data revealed that, the highest values were those of heavy textured soils . However, almost similar trend was found by using both **Aslyng's** and **Larsen's** equations.

Data also show that the phosphate potential parameter correlated significantly with soil clay content ($r = 0.898^*$), but negatively correlated with the $CaCO_3$ **White and Taylor (1977)** indicated that, the mechanism by which the intensity, quantity and capacity factors are regulated is particularly influenced by soil properties such as, Al and Fe-oxides, soil pH, clay content, organic matter and the prevailing froms of soil P.

4.3.2.Capacity factor (Q):

Schofield (1955) emphasized that soils having identical phosphate potential may differ in their capacity to maintain the phosphate potential against the removal or application of phosphate. He concluded that the phosphate determined at the beginning of the period of growth did not give sufficient informations on the supply of phosphate to plants during this period. Then capacity factor (Q) used by **Jensen (1970)** represents the difference between the initial phosphate concentration of each soil solution and the phosphate concentration after shaking the solution with the soil. ($Q =$ mole $Px10^{-8}$ per gram of soil) gained or lost. The capacity factor as identified by **Lindsay (1972)** and **(1979)** represent the ability of the soil solid phase to replenish the soil solution concentration of a given element (intensity factor, I) .

The values obtained for Q in Table (3) ranged from 2.6 to $193x10^{-8}$ per gram soil, data reveal that the values of this

Table (3) Average values of phosphorus intensity , quantity and H_2PO_4 ion concentration in the $CaCl_2$ extract of the selected soils

Location	P-conc. $Mx10^{-6}$	-Log P-Conc.	Q Moles $Px10^{-8}$per gram soil	Phosphorus potential					
				Aslyng equation			Larsen equation		
				$H_2PO_4x10^{-6}$	$-LogH_2PO_4$	$0.5 pca + H_2PO_4$	$H_2PO_4x10^{-6}$	$-LogH_2PO_4$	$0.5 pca + pH_2PO_4$
Ell-Sallum	3.4-42.0 20.36	4.38-5.47 4.81	3.4-168 97	1.25-13.44 6.52	4.87-5.90 5.30	5.92-6.95 6.35	0.78-8.30 4.06	5.07-6.17 5.51	6.12-7.16 6.56
El-Omeid	9.6-39.0 24.35	4.41-5.02 4.66	8.8-171 94	0.62-2.73 1.71	5.56-6.21 5.82	6.58-7.23 6.84	0.83-3.50 2.19	5.45-6.10 5.71	6.47-7.10 6.73
El-Nobaria.	4.3-20.9 12.28	4.68-5.37 4.96	4.3-188 107	1.46-7.11 4.20	5.15-5.83 5.43	6.21-6.89 6.48	0.99-4.80 2.83	5.32-6.0 5.60	6.38-7.06 6.66
El-Sir	2.7-21.0 10.46	4.68-5.54 5.07	2.7-189 109	0.87-6.30 3.15	5.44-6.06 5.62	6.57-7.19 6.75	0.67-4.83 2.41	5.31-6.21 5.71	6.45-7.50 6.84
Port Said	2.6-17.0 8.46	4.77-5.59 5.15	2.6-193 111	0.75-4.76 2.38	5.32-6.14 5.07	6.32-7.14 6.70	0.42-2.72 1.42	5.56-6.38 5.95	6.56-7.38 6.95

Table (4) Values of equilibrium phosphate potential (I_e) and differential potential buffering capacity (DPBC) of the studied soils.

NO.	Location	P-potential eq. (I_e)	DPBC*
1	El-Sallum	7.19	83
2	El-Omeid	7.09	125
3	El-NobariaII	6.99	118
4	El-Sir	7.32	154
5	Port Said south plain	7.39	250

- These values, x10^{-8} express mole P per gram of soil per phosphate potential unit.

Table (5) Correlation coefficients (r) between different parameters of phosphorus and studied soil properties.

No	Parameter	Correlation coefficients (r)		
		Phosphate potential (I)	Equilibrium phosphate potential (Ie)	DPBC
1	**Clay %**	0.898*	0.694	0.991***
2	**$CaCO_3$ %**	-0.813	-0.518	-0.882*
3	**Organic matter**	0.517	-0.134	0.626
4	**pH**	0.039	-0.256	-0.083
5	**CEC**	0.859	0.627	0.980**
6	**Surface area**	0.827	0.674	0.965**
7	**Fe Ox.**	0.735	0.699	0.893*

Where * , **,*** mean that theos values are significant at 0.05,0.01 and 0.001, respectively parameter increased with increasing the added phosphorus to soils,

The (Q/I) illustrated in Fig (1) was developed according to **Jensen (1970)** by plotting Q (moles of $Px10^{-8}$) per gram soil against I (0.5 pCa + $pH_2PO_4^-$).

The results for the tested five soils samples assembles those of **(Jensen, 1970)** in a curvilinear relationship for the Q/I. and dependence on the concentration of $CaCl_2$ as will as soil pH.

4.3.3.Differential potential buffering capacity (DPBC):

Jensen (1970) defined the differential potential buffering capacity (DPBC) as the necessary amount of phosphate to be added or removed per gram of soil in order to obtain a certain alteration to the phosphate potential evaluated for the soil by the following equation

$$\mathbf{DPBC = (\Delta Q / \Delta I)_{Ie}}$$

Where: Ie is the phosphate potential at Q = 0, The DPBC values being thus positive due to the inverse relationship between I and Q.

The values of DPBC and Ie for the studied soil samples presented in Table (4) show large variations ranging from 83 to 250units with a tendency to be increased with increasing the clay content of soil whereas the concentration of P in the soil solution tended to be lower. The highest DPBC value was that of Port Said Plain containing high clay value (45%) while the lowest was of El-Sallum of low clay content (6.9%). Almost similar results were obtained by **Sazida et al. (1995)** who suggested that, the high

DPBC values may be due to a high clay content, and/ or a higher phosphate adsorption capacity of the soil.

Data of statistical analysis presented in Table (5) show that values of DPBC correlated high significantly with clay content ($r = 0.991^{***}$), CEC ($r = 0.980^{**}$), surface area ($r = 0.965^{**}$) and Fe Ox ($r = 0.893^{*}$), but negatively with the $CaCO_3$ content ($r = -0.882^{*}$).

The DPBC value makes it possible to estimate the change in the phosphate potential upon removal of phosphate from the soil by plants. Under field condition the removal of phosphate from the root zone by a crop only causes a small overall decreases of the phosphate potential, which apparently diminishes the importance of determining the DPBC. However, the root volume of the plants is in general very small comparing to the soil volume, and as diffusion of phosphate ions in soil is known to be a slow process, plants may be supplied mainly with phosphate from a reactive limited soil volume (**Jensen, 1970**).

4.3.4. Equilibrium phosphate potential (Ie):

Equilibrium phosphate potential, $(0.5\ pCa + pH_2PO_4^-)_{eq.}$, i.e. the soil gains or looses of P to the equilibrated solution (**White** and **Beckett, 1964**).

Results obtained in Table (4) showed that the values of equilibrium phosphate potential (Ie) varied from 6.99 to 7.39. The highest value was shown by Port Said Plain, having the lowest phosphate concentration in the $CaCl_2$ soil extract. However, values of equilibrium phosphate potential did not show

Table (7) Correlation coefficient “r” foe P-adsorption parameters and soil properties in absence and presence of added citrate before P adsorption .

Citrate rate	Parameters	Langmuir parameters		Vao Huay parameters	
		P -max.	K	n	b
0.0	Clay %	-0.919*	0.995***	0.996***	0.875
	CaCO3%	0.634	-0.806	-0.805	-0.853
	Organic matter	-0.381	0.530	0.560	0.629
	pH	0.378	-0.266	-0.275	-0.058
	CEC	-0.860	0.982**	0.985**	0.928*
	Surface area	-0.861	0.986**	0.988**	0.934*
	Fe-ox	-0.885*	0.965**	0.968**	0.859
$5x10^{-3}$	Clay %	-0.861	0.985**	0.899*	0.875*
	CaCO3%	0.560	-0.777	-0.883*	-0.574
	Organic matter	-0.356	0.470	0.654	0.347
	pH	-0.494	-0.279	0.038	-0.375
	CEC	-0.786	0.959**	0.949*	0.803
	Surface area	-0.784	0.962**	0.950*	0.810
	Fe-ox	-0.819	0.949*	0.867	0.829
$5x10^{-2}$	Clay %	-0.902*	0.948*	-0.314	0.966**
	CaCO3%	0.629	0.780	0.250	-0.772
	Organic matter	-0.409	0.468	-0.274	0.595
	pH	0.346	-0.282	-0.109	-0.223
	CEC	-0.837	0.965**	-0.214	-0.264
	Surface area	-0.833	0.967**	-0.159	0.919*
	Fe-ox	-0.849	0.954**	-0.150	0.882*

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (8) Different parameters of phosphorus adsorption isotherms in presence and absence of oxalate ligand added before phosphorus adsorption.

Location	Conc. Of oxalate ML^{-1}	Parameter of Langmuir equation			Parameter of Van-Huay equation			
		Bonding energy “K” L/kg	Max. adsorp. “b” $mgkg^{-1}$	“r” for C vs. C/x/m	Bonding energy “n” $\sqrt{mgL/kg^2}$	Theo.Pdesorp. “b” mg/kg	P-conc. of soil sol. mgL^{-1}	“r” for 1 vs. Q
Ell-Sallum	0.0	0.022	3205	0.929**	275	-261	0.90	0.990***
El-Omeid		0.026	3174	0.963**	289	-257	0.79	0.992***
El-Nobaria		0.039	2865	0.972**	335	-260	0.60	0.995***
El-Sir		0.067	2141	0.982***	370	-281	0.58	0.983***
Port Said		0.15	1715	0.976***	565	-162	0.08	0.996***
Ell-Sallum	$1x10^{-5}$	0.022	3012	0.915*	256	-237	0.86	0.985***
El-Omeid		0.022	2832	0.831*	275	-222	0.65	0.979***
El-Nobaria		0.030	2558	0.862*	267	-233	0.76	0.982***
El-Sir		0.058	1908	0.868*	288	-211	0.54	0.975***
Port Said		0.098	1695	0.855*	312	-172	0.30	0.978***
Ell-Sallum	$1x10^{-3}$	0.021	2908	0.857*	239	-233	0.95	0.987***
El-Omeid		0.022	2717	0.821*	256	-246	0.92	0.985***
El-Nobaria		0.031	2273	0.817*	249	-228	0.84	0.978***
El-Sir		0.054	1838	0.900*	267	-198	0.55	0.979***
Port Said		0.093	1543	0.907*	280	-152	0.29	0.986***

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (9) Correlation coefficient “r” for P-adsorption parameters and soil properties in absence and presence of oxalate before P adsorption .

Oxalate rate	Parameters	Langmuir parameters		Van Huay parameters	
		P -max.	K	n	b
0.0	Clay %	-0.919*	0.995***	0.996***	0.875
	CaCO3%	0.634	-0.806	-0.805	-0.853
	Organic matter	-0.381	0.530	0.560	0.629
	pH	0.378	-0.266	-0.275	-0.058
	CEC	-0.860	0.982**	0.985**	0.928*
	Surface area	-0.861	0.986**	0.988**	0.934*
	Fe-ox	-0.885*	0.965**	0.968**	0.859
$1x10^{-5}$	Clay %	-0.880*	0.997***	0.956*	0.997***
	CaCO3%	0.607	-0.752	-0.873	-0.901*
	Organic matter	-0.406	0.442	0.562	0.528
	pH	0.338	-0.310	-0.241	-0.040
	CEC	-0.809	0.948*	0.931*	0.972**
	Surface area	-0.800	0.952*	0.939*	0.958**
	Fe-ox	-0.818	0.949*	0.823	0.878*
$1x10^{-3}$	Clay %	0.887*	0.983**	0.916*	0.957*
	CaCO3%	0.598	-0.760	-0.841	-0.681
	Organic matter	-0.498	0.473	0.562	0.393
	pH	0.375	-0.309	0.020	-0.416
	CEC	-0.189	0.955*	0.880*	0.926*
	Surface area	-0.813	0.956*	0.850	0.941*
	Fe-ox	-0.835	0.954*	0.759	0.971**

Table (10) Different parameters of phosphorus adsorption isotherms in presence and absence of acetate ligand added before phosphorus adsorption.

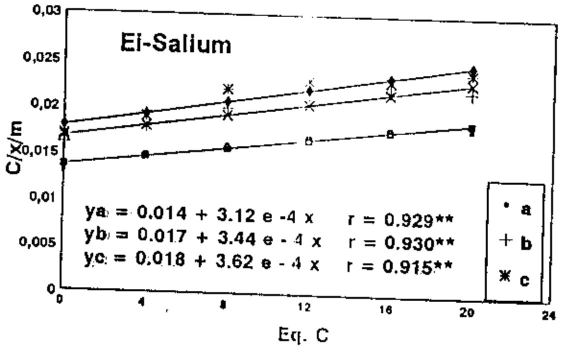
Location	Conc. Of oxalate ML^{-1}	Parameter of Langmuir equation			Parameter of Van-Huay equation			
		Bonding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{mgL/kg^2}$	Theo.Pdesorp. "b" mg/kg	P-conc. of soil sol. mgL^{-1}	"r" for I vs. Q
Ell-Sallum	0.0	0.022	3205	0.929**	275	-261	0.90	0.990***
El-Omeid		0.026	3174	0.963**	289	-257	0.79	0.992***
El-Nobaria		0.039	2865	0.972**	335	-260	0.60	0.995***
El-Sir		0.067	2141	0.982***	370	-281	0.58	0.983***
Port Said		0.15	1751	0.976***	565	-162	0.08	0.996***
Ell-Sallum	$5x10^{-2}$	0.021	2941	0.878*	250	-251	1.0	0.984***
El-Omeid		0.024	2833	0.834*	247	-228	0.82	0.981***
El-Nobaria		0.030	2762	0.887*	275	-259	0.89	0.970***
El-Sir		0.051	1876	0.864*	282	-204	0.52	0.986***
Port Said		0.12	1600	0.883*	334	-157	0.22	0.986***
Ell-Sallum	$15x10^{-2}$	----------	----------	0.763	232	-232	0.99	0.981***
El-Omeid		0.021	2932	0.893*	239	-231	0.93	0.986***
El-Nobaria		0.028	2590	0.861*	251	-228	0.83	0.983***
El-Sir		0.050	1789	0.833*	260	-200	0.59	0.983***
Port Said		0.11	1565	0.882*	325	-169	0.27	0.983***

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

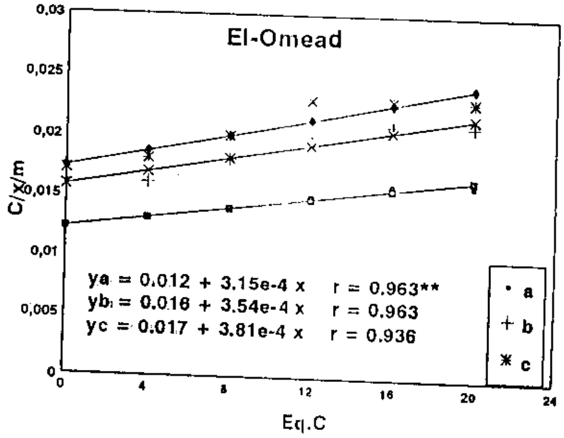
Table (11) Correlation coefficient "r for P-adsorption parameters and soil properties in absence and presence of acetate added before P adsorption.

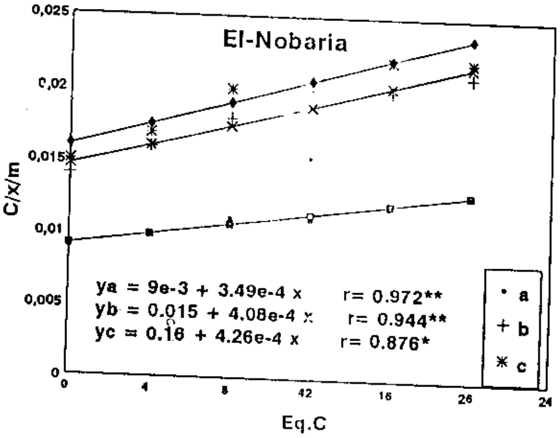
Acetaate rate	Parameters	Langmuir parameters		Van Huay parameters	
		P -max.	K	n	b
0.0	Clay %	-0.919*	0.995***	0.996***	0.875
	CaCO3%	0.634	-0.806	-0.805	-0.853
	Organic matter	-0.381	0.530	0.560	0.629
	pH	0.378	-0.266	-0.275	-0.058
	CEC	-0.860	0.982**	0.985**	0.928*
	Surface area	-0.861	0.986**	0.988**	0.934*
	Fe-ox	-0.885*	0.965**	0.968**	0.859
$5x10^{-2}$	Clay %	-0.892*	0.994***	0.981**	0.926*
	CaCO3%	0.646	-0.825	-0.730	-0.864
	Organic matter	-0.311	0.529	0.542	0.391
	pH	0.292	-0.237	-0.403	0.031
	CEC	-0.831	0.988**	0.958**	0.911*
	Surface area	-0.826	0.992***	0.967**	0.896*
	Fe-ox	-0.883*	0.964**	0.978**	0.850
$15x10^{-2}$	Clay %	----------	----------	0.997***	0.967**
	CaCO3%	----------	----------	-0.792	-0.750
	Organic matter	----------	----------	0.612	-0.696
	pH	----------	----------	-0.021	-0.289
	CEC	----------	----------	0.992***	0.936*
	Surface area	----------	----------	0.993***	0.939*
	Fe-ox	----------	----------	0.962**	0.934*

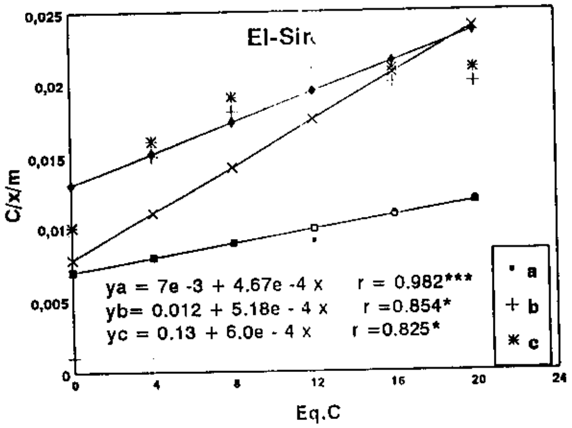
Fig (2) Effect of citrate on P adsorption added before P (Langmuir isotherm)



a = 0 citrate, b = 0.005 M citrate, c = 0.05 M citrate






El-Sin
C/x/m
0,025
0,02
0,015
0,01
0,005
0
0
4
8
12
16
20
24
Eq.C
ya = 7e -3 + 4.67e -4 x r = 0.982***
yb= 0.012 + 5.18e - 4 x r =0.854*
yc = 0.13 + 6.0e - 4 x r =0.825*
a
+ b
* c

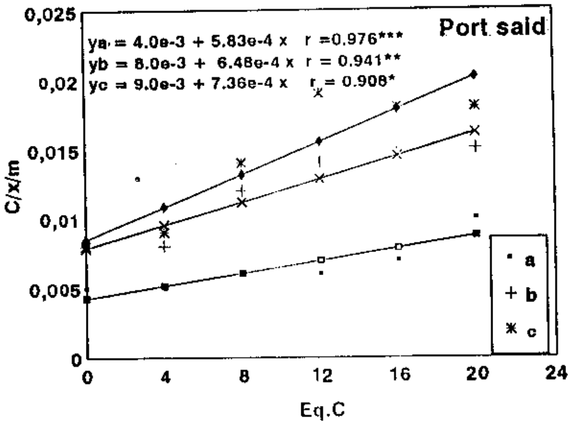
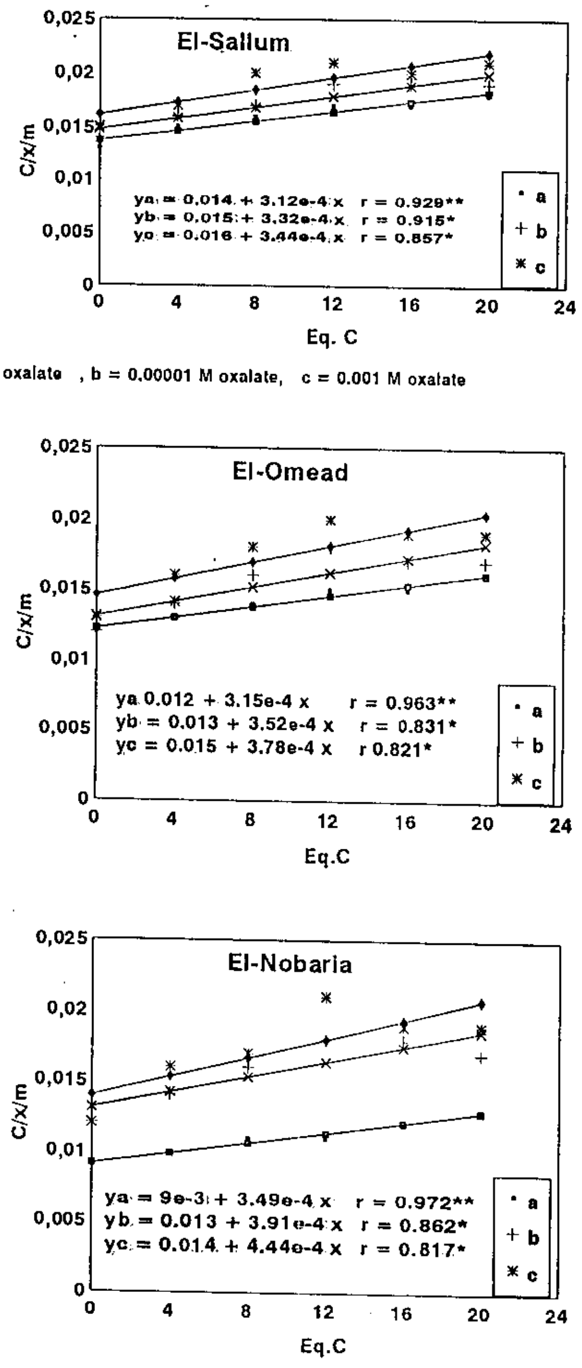
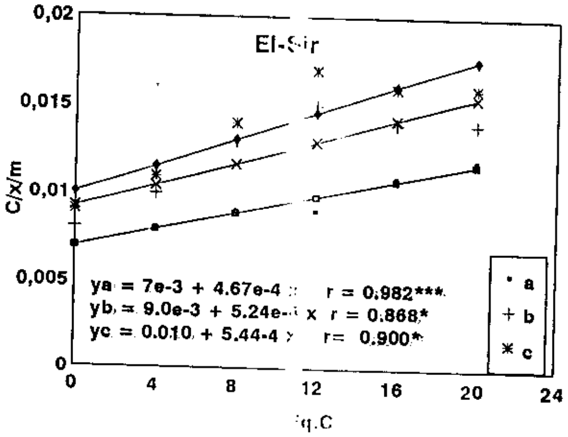

Port said
ya = 4.0e-3 + 5.83e-4 x r =0.976***
yb = 8.0e-3 + 6.48e-4 x r = 0.941**
yc = 9.0e-3 + 7.36e-4 x r = 0.908*
C/x/m
0,025
0,02
0,015
0,01
0,005
0
0
4
8
12
16
20
24
Eq.C
a
+ b
* c

Fig (3) Effect of oxalate on P adsorption added before P
(Langmuir isotherm)



a = 0 oxalate , b = 0.00001 M oxalate, c = 0.001 M oxalate


El-Sir
0,02
0,015
0,01
0,005
0
C/x/m
ya = 7e-3 + 4.67e-4 x r = 0.982***
yb = 9.0e-3 + 5.24e-4 x r = 0.868*
yc = 0.010 + 5.44-4 x r = 0.900*
a
b
c
0
4
8
12
16
20
24
Eq.C

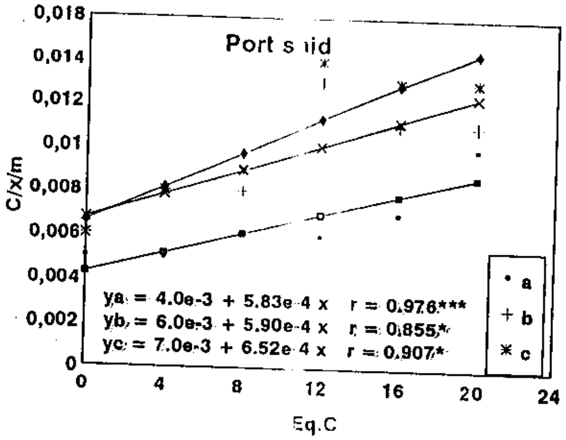
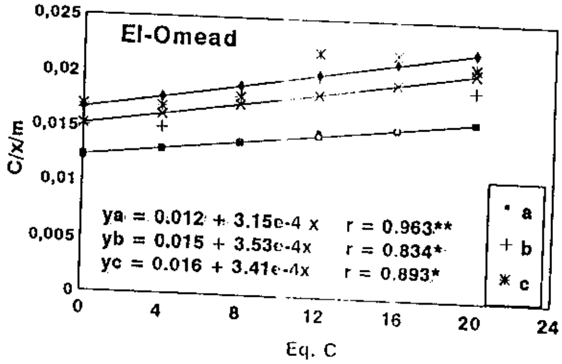
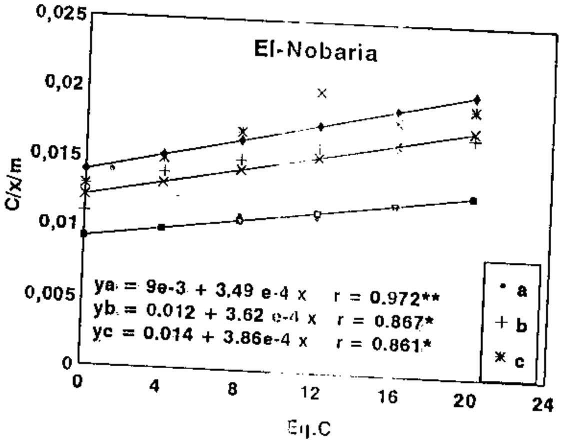
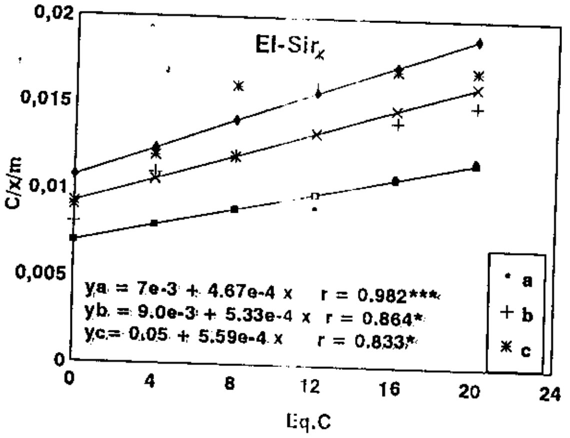

Port said
0,018
0,014
0,012
0,01
0,008
0,006
0,004
0,002
0
C/x/m
ya = 4.0e-3 + 5.83e-4 x r = 0.976***
yb = 6.0e-3 + 5.90e-4 x r = 0.855*
yc = 7.0e-3 + 6.52e-4 x r = 0.907*
a
b
c
0
4
8
12
16
20
24
Eq.C

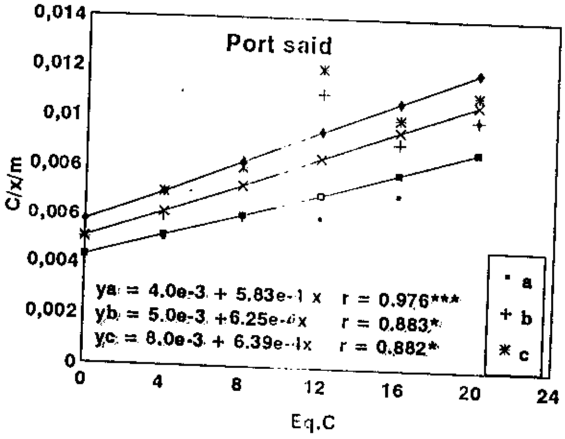
Fig (4) Effect of acetate on P adsorption added before P (Langmuir isotherm)



a = 0 acetate, b = 0.05 M acetate, c = 0.15 M acetate




El-Sir
0,02
0,015
0,01
0,005
0
C/x/m
ya = 7e-3 + 4.67e-4 x r = 0.982***
yb = 9.0e-3 + 5.33e-4 x r = 0.864*
yc= 0.05 + 5.59e-4 x r = 0.833*
a
b
c
0
4
8
12
16
20
24
Eq.C


Port said
0,014
0,012
0,01
0,006
0,006
0,004
0,002
0
C/x/m
ya = 4.0e-3 + 5.83e-1 x r = 0.976***
yb = 5.0e-3 +6.25e-4x r = 0.883*
yc = 8.0e-3 + 6.39e-4x r = 0.882*
a
b
c
0
4
8
12
16
20
24
Eq.C

mg Pkg^{-1}. While values of P-max at the second rate ranged from 1359to 2762 mg Pkg^{-1} with an average 2153 mg Pkg^{-1}. Data show that, the decrease in P-adsorption was 12% and 18% at the first and second rate of citrate compared with the control (no added citrate), respectively. P-adsoption maxmum was reduced at the second rate of citrate added before P-adsorption. This may be due to a concomitant change in charge due to organic ligand (citrate) adsorption as suggestd by **Nagarajah et al. (1968)** However, **Earl et al. (1979)** found that the reduction in P-adsorption observed in the presence of citrate resulted primarily from the elimination of a signifcant proportion of P-sorbing sites rather than from the competitive specific sorption of citrate.

In case of oxalate ligand (Table, 8) and graphically illustrated in Fig(3), the values obtained for P-max at trhe first rate ranged from 1695 to 3012 mgPkg^{-1} with an average of 2401 mgPkg^{-1} whereas at second rate ranged from 1534 to 2908 mg Pkg^{-1} with an average of 2254 mg Pkg^{-1} .

Data obtained show that the decrease in P-adsorption was about 8% - 14% at the first and second rate of oxalate compared with the control (P-max. without oxalate application), respectively. This may be due to effect of oxalate in reducing P-adsorption besides oxalate anions may be considered as an effective chelator of iron, aluminum and calcium ions. **He et al. (1990)** found that the effect of organic ligands (oxalate – citrate) on P-adsorption by geothite, amorphus Al-oxide, kaolinite and acid soils, were significantly reduced by the complex reaction of the organic ligands with Fe and Al ions.

In the case of acetate ligand, the values obtained for P-max (Table, 10 and Fig, 4), at the first rate ranged from 1600 to 2941 mg Pkg^{-1} with an average of 2402 mg Pkg^{-1}, while at second rate of applied ligand ranged from 1565 to 2932 mgPkg^{-1} with an average of 2219 mgPkg$^{-1.}$ Reduction of P-adsorption ranged from 8% and 10% at the first and second rate compared with P-max without acetate, respectively.

The organic ligands are able to occupy the bonding places of phosphate by ligand exchange **(Appelt et al. 1975).**

Accordingly, organic ligands are more efficiently (and rapidly) adsorbed to the soil surface than the phosphate. However, soil pH has an important role in the extent of phosphate adsorption reduction. pH increment indicates a change of charge affecting the adsorption by the soils **(Siegert, 1975).**

Noteworthy referring that, the highst value of P-adsorption maximum in the presnce of organic lignands(added before or after P-adsorption) was that of the heavy - textured soil of Port Said Plain of high clay content, whereas the lowest one was that of the light- textured calcareous soil of El-Sallum.

4.4.3. P-max with organic ligands addition after P-adsorptipon:

In the case of citrate (Table, 12 and Fig. 5), the values of P-max at the first rate of citrate ranged from 1704 to 3096 mg Pkg^{-1} with an average of 2523 mg Pkg^{-1}, while at the second rate it ranged from 1645 to 3021 mg Pkg^{-1} with an average of 2403 mg Pkg^{-1}. Data show that, P-max decreased with increasing the rate of applied citrate . The decrease in P-adsorption was 6% and 11% at the first and second rate compared with the control

Table (12) Different parameters of phosphorus adsorption isotherms in presence and absence of citrate ligand added after phosphorus adsorption.

Location	Conc. Of oxalate *M*L^{-1}	Parameter of Langmuir equation			Parameter of Van-Huay equation			
		Bonding energy "K" L/kg	Max. adsorp. "b" mgkg^{-1}	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{mgL/kg^2}$	Theo.Pdesorp. "b" mg/kg	P-conc. of soil sol. mgL^{-1}	"r" $\sqrt{\text{for}}$ I vs. Q
Ell-Sallum	0.0	0.022	3205	0.929**	275	-261	0.90	0.990***
El-Omeid		0.026	3174	0.963**	289	-257	0.79	0.992***
El-Nobaria		0.039	2865	0.972**	335	-260	0.60	0.995***
El-Sir		0.067	2141	0.982***	370	-281	0.58	0.983***
Port Said		0.15	1751	0.976***	565	-162	0.08	0.996***
Ell-Sallum	5x10^{-2}	0.018	3096	0.815*	251	-233	0.86	0.986
El-Omeid		0.026	2770	0.845*	257	-232	0.81	0.987
El-Nobaria		----------	----------	0.663	283	-279	0.97	0.976
El-Sir		----------	----------	0.659	296	-269	0.83	0.577
Port Said		0.084	1704	0.916*	312	-190	0.37	0.992
Ell-Sallum	15x10^{-2}	0.019	3021	0.816*	236	-235	0.99	0.983
El-Omeid		0.024	2625	0.870*	236	-228	0.93	0.983
El-Nobaria		----------	----------	0.757	278	-284	1.0	0.972
El-Sir		----------	----------	0.785	262	-248	0.90	0.981
Port Said		0.076	1645	0.925**	268	-159	0.35	0.998

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (13) Correlation coefficient "r" for P-adsorption parameters and soil properties in absence and presence of citrate added after P adsorption.

Citrate rate	Parameters	Langmuir parameters		Van Huay parameters	
		P -max.	K	n	b
0.0	Clay %	-0.919*	0.995***	0.996***	0.875
	CaCO3%	0.634	-0.806	-0.805	-0.853
	Organic matter	-0.381	0.530	0.560	0.629
	pH	0.378	-0.266	-0.275	-0.058
	CEC	-0.860	0.982**	0.985**	0.928*
	Surface area	-0.861	0.986**	0.988**	0.934*
	Fe-ox	-0.885*	0.965**	0.968**	0.859
$5x10^{-3}$	Clay %	---------	---------	0.880	0.617
	CaCO3%	---------	---------	-0.529	-0.778
	Organic matter	---------	---------	0.570	0.269
	pH	---------	---------	-0.490	0.238
	CEC	---------	---------	-0.870	0.701
	Surface area	---------	---------	0.812	0.703
	Fe-ox	---------	---------	0.847	0.579
$5x10^{-2}$	Clay %	---------	---------	0.252	0.779
	CaCO3%	---------	---------	-0.157	-0.860
	Organic matter	---------	---------	0.573	0.302
	pH	---------	---------	0.586	0.150
	CEC	---------	---------	0.427	0.831
	Surface area	---------	---------	0.465	0.828
	Fe-ox	---------	---------	566	0.673

Table (14) Different parameters of phosphorus adsorption isotherms in presence and absence of oxalate ligand added after phosphorus adsorption

Location	Conc. Of oxalate ML^{-1}	Parameter of Langmuir equation			Parameter of Van-Huay equation			
		Bonding energy "K" L/kg	Max. adsorp "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{mgL/kg^2}$	Theo.Pdesorp . "b" mg/kg	P-conc. of soil sol. mgL^{-1}	"r" for I vs. Q
Ell-Sallum	0.0	0.022	3205	0.929**	275	-261	0.90	0.990***
El-Omeid		0.026	3174	0.963**	289	-257	0.79	0.992***
El-Nobaria		0.039	2865	0.972**	335	-260	0.60	0.995***
El-Sir		0.067	2141	0.982***	370	-281	0.58	0.983***
Port Said		0.15	1715	0.976***	565	-162	0.08	0.996***
Ell-Sallum	$1x10^{-5}$	0.023	3077	0.947**	262	-242	0.85	0.991***
El-Omeid		0.026	3145	0.959**	285	-246	0.75	0.993***
El-Nobaria		--------	--------	0.754	325	-258	0.63	0.988***
El-Sir		0.068	2096	0.960**	276	-148	0.29	0.956***
Port Said		0.12	1703	0.959**	350	-173	0.24	0.996***
Ell-Sallum	$1x10^{-3}$	--------	-------	0.713	257	-258	1.00	0.983***
El-Omeid		0.026	2976	0.924**	272	-243	0.80	0.992***
El-Nobaria		--------	-------	0.719	319	-276	0.75	0.986***
El-Sir		0.057	1957	0.964**	301	-210	0.49	0.993***
Port Said		0.099	1680	0.947**	335	-183	0.30	0.990***

Where * , ** ,***significant at 0.05, 0.01 and 0.001. respectively

Table (15) Correlation coefficient "r" for P-adsorption parameters and soil properties in absence and presence of added oxalate after P adsorption.

Oxalate rate	Parameters	Langmuir parameters		Van Huay parameters	
		P-max.	K	n	b
0.0	Clay %	-0.919*	0.995***	0.996***	0.875
	CaCO3%	0.634	-0.806	-0.805	-0.853
	Organic matter	-0.381	0.530	0.560	0.629
	pH	0.378	-0.266	-0.275	-0.058
	CEC	-0.860	0.982**	0.985**	0.928*
	Surface area	-0.861	0.986**	0.988**	0.934*
	Fe-ox	-0.885*	0.965**	0.968**	0.859
$1x10^{-5}$	Clay %	0.780	0.656	----------	----------
	CaCO3%	-0.672	-0.406	----------	----------
	Organic matter	-0.179	-0.075	----------	----------
	pH	-0.178	-0.285	----------	----------
	CEC	0.797	0.571	----------	----------
	Surface area	0.790	0.570	----------	----------
	Fe-ox	0.745	0.607	----------	----------
$1x10^{-3}$	Clay %	0.803	0.852	----------	----------
	CaCO3%	-0.557	-0.774	----------	----------
	Organic matter	0.753	-0.734	----------	----------
	pH	-0.388	-0.021	----------	----------
	CEC	0.760	0.828	----------	----------
	Surface area	0.755	0.815	----------	----------
	Fe-ox	0.774	0.753	----------	----------

Table (16) Different parameters of phosphorus adsorption isotherms in presence and absence of acetate ligand added after phosphorus adsorption.

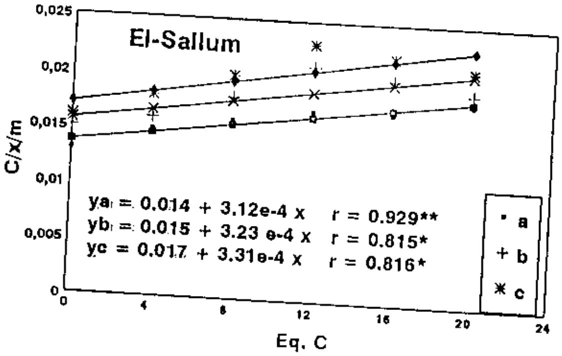
Location	Conc. Of oxalate ML^{-1}	Parameter of Langmuir equation			Parameter of Van-Huay equation			
		Bonding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{mgL/kg^2}$	Theo.Pdesorp. "b" mg/kg	P-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
Ell-Sallum	0.0	0.022	3205	0.929**	275	-261	0.90	0.990***
El-Omeid		0.026	3174	0.963**	289	-257	0.79	0.992***
El-Nobaria		0.039	2865	0.972**	335	-260	0.60	0.995***
El-Sir		0.067	2141	0.982***	370	-281	0.58	0.983***
Port Said		0.15	1751	0.976***	565	-162	0.08	0.996***
Ell-Sallum	$5x10^{-2}$	----------	----------	0.722	246	-239	0.94	0.979***
El-Omeid		0.022	3039	0.842*	255	-242	0.90	0.984***
El-Nobaria		0.030	2705	0.840*	293	-270	0.85	0.989***
El-Sir		----------	----------	0.721	334	-296	0.79	0.989***
Port Said		0.12	1712	0.956***	353	-173	0.24	0.998***
Ell-Sallum	$15x10^{-2}$	----------	----------	0.768	221	-184	0.69	0.966***
El-Omeid		----------	----------	0.753	240	-222	0.86	0.986***
El-Nobaria		----------	----------	0.772	274	-259	0.89	0.987***
El-Sir		----------	----------	0.713	319	-292	0.84	0.991***
Port Said		0.096	1736	0.920**	334	-168	0.25	0.993***

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

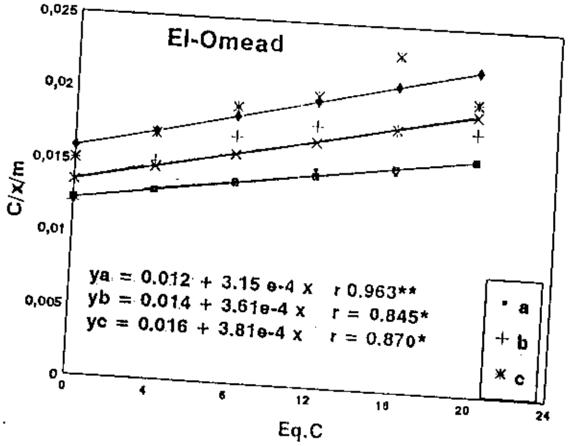
Table (17) Correlation coefficient "r" for P-adsorption parameters and soil properties in absence and presence of acetare added after P adsorption.

Acetate rate	Parameters	Langmuir parameters		Van Huay parameters	
		P –max.	K	n	b
0.0	Clay %	-0.919*	0.995***	0.996***	0.875
	CaCO3%	0.634	-0.806	-0.805	-0.853
	Organic matter	-0.381	0.530	0.560	0.629
	pH	0.378	-0.266	-0.275	-0.058
	CEC	-0.860	0.982**	0.985**	0.928*
	Surface area	-0.861	0.986**	0.988**	0.934*
	Fe-ox	-0.885*	0.965**	0.968**	0.859
$5x10^{-2}$	Clay %	----------	----------	0.865	0.660
	CaCO3%	----------	----------	-0.552	-0.767
	Organic matter	----------	----------	0.435	0.468
	pH	----------	----------	-0.418	0.111
	CEC	----------	----------	0.712	0.839
	Surface area	----------	----------	0.787	0.761
	Fe-ox	----------	----------	0.827	0.660
	Clay%	----------	----------	0.856	0.332
	CaCO3%	----------	----------	-0.568	-0.470
	Organic matter	----------	----------	0.456	0.140
	PH	----------	----------	-0.340	0.215
	CEC	----------	----------	0.780	-0.203
	Surface area	----------	----------	0.771	0.472
	Fe-ox	----------	----------	0.793	0.410

Fig (5) Effect of citrate on P adsorption added after P (Langmuir Isotherm)



a = 0 citrate, b 0.005 M citrate, c = 0.05 M citrate



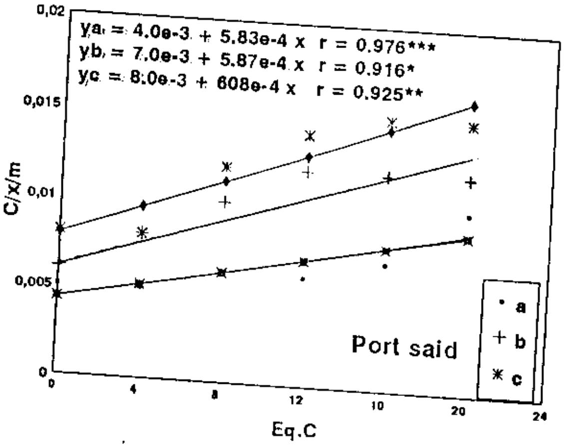
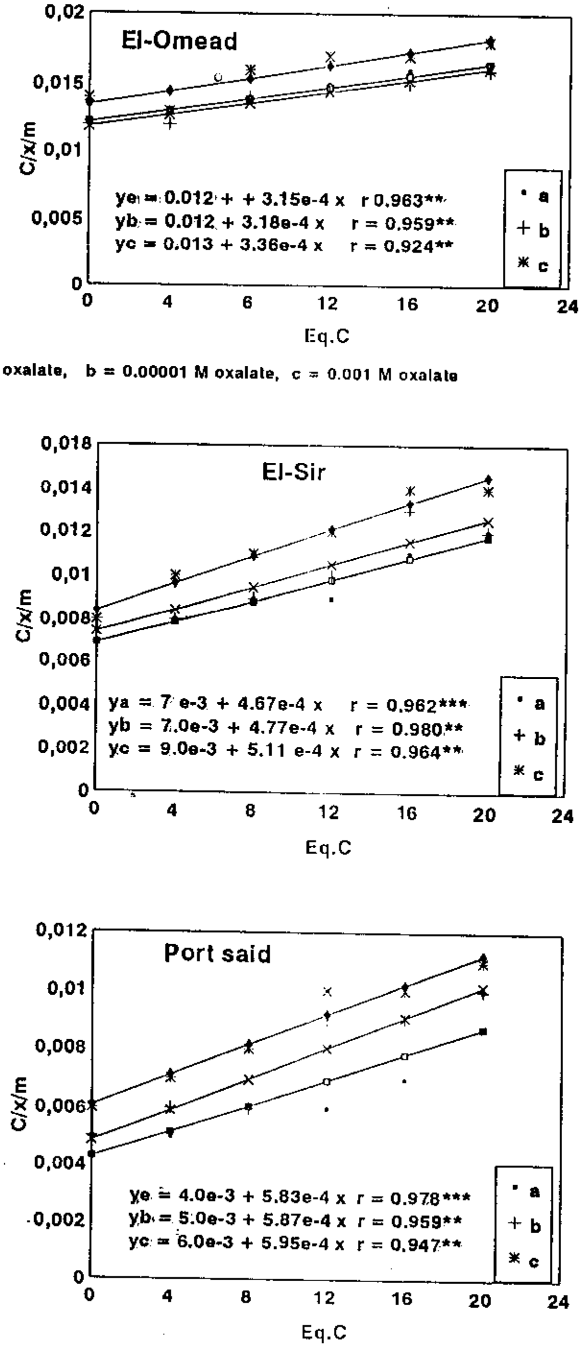
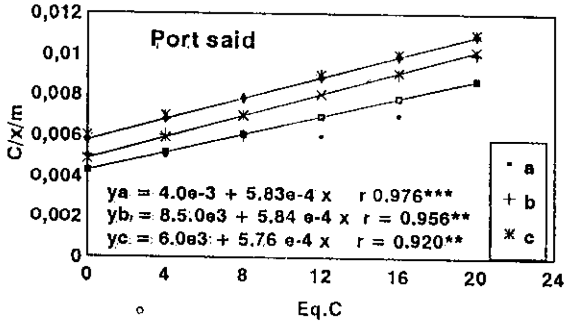


Fig (6) Effect of oxalate on P adsorption addede after P (Langmuir isotherm)



a = 0 oxalate, b = 0.00001 M oxalate, c = 0.001 M oxalate

Fig (7) Effect of acetate on P adsorption added after P (Langmuir isotherm)



a = 0 acetate, b = 0.05 M acetate, c = 0.15 M acetate

(P-max without citrate), respectively. This finding may be attributed mainly to the formation of more stable citrate metal chelates than the corresponding metal phosphate precipitates **(Karim et al., 1989)**

In the case of oxalate (Table, 14 and Fig, 6), values of P-max at the first rate of oxalate ranged from 1703 to 3077 mg Pkg^{-1} with an average of 2505 mg Pkg^{-1}, while at second rate it ranged from 1680 to 2976 mg Pkg^{-1} with an average of 2204 mg Pkg^{-1}. Data show that the decrease in P-adsorption was about 4% and 6% at the first and second rate of oxalate compared with P-max without oxalate, respectively. This may be induced through the exchange between organic ligands and phosphate ions on soil surfces **(Nagarajah et al., 1968** and **Lopez-Hernandez,et al 1979 and 1986).**

In the case f acetate (Table, 16) and Fig (7), values of P-max at the first rate of acetate ranged from 1712to3039 mg Pkg^{-1} with an average of 2485 mg Pkg^{-1}, while at second rate it was insignificant . Data show that the decrease in P-adsorption 4% at the first rate compared to the control,. However, **Earl et al., (1979)** found that, acetate had litte effect on P-adsorption (1% reduction). A high propotion was sorbd by the sorbents indicating that the sorption mechanism or site of binding acetate differs from that of phosphate.

Data obtained show the unsuitability of Langmuir equation in describing P-adsorption onto the studied soils in the presence of organic ligands , where the correlation coefficient values "r" between C and C/x/m were insignificant, and hence , no parameters were calculated in such cases. This may be because the concentration of soil solution exceeded the limits controlled by solubility product and P-precipitation may take place with a resultant removal from the system. The disappearance of soil solution P was supposed to be due only to adsorption reaction as proposed by Langmuir isotherm (**Olsen** and **Watanabe, 1957**). Consequently, one may conclude that while the ascending trend of the Langmuir plotting of P-sorption data may refer P-adsorption reactions, the descending trend may refer to other types of reactions such as P-diffusion, isomophus replacement and/ or P-precipitation..

In conclusion, organic ligands reduced P-asorption by soils and this effect seems to accompany the way by which phosphate or the ligands were added to soil.

A maximum reduction in phosphate adsorption occurred when the organic ligands were added before the P-adsorption specially at the second rate of organic ligands. Also, citrate had more pronounced effect on P-sorption than both oxalate and acetate.

4.4.4. Bonding energy without application of organic ligands:

Values of bonding energy ranged from 0.022 to 0.15 mgPL^{-1} with an average of 0.061 (L/mg). Data obtained (Table, 7) reveal that soil properties such as clay content, CEC, surface area and Fe-oxides play an important role in increasing P-bonding energy. This was documented by the positive correlation observed between bonding energy and each of clay content, CEC, surface area and Fe-oxides.

4.4.5.Bonding energy with organic ligands addition before P-adsorption:

In the case of citrate, values of the bonding energy were very close at both the first and second rate of added citrate ranging from 0.020 to 0.082 with an average of 0.040 (L/mg) and from 0.020 to 0.081 (L/mg) with an average of 0.039(L/mg)for the1st and 2nd rate,respectively. The decrease in bonding energy at the second rate was more obvious compared with the first rate of citrate which shows the competitive effect between citrate added before phosphate on the exchange sites. This may be due to blocking the adsorption sites by citrate ions befor P-addition.

Data also (Table, 7) show that, P- bonding energy significantly correlates with clay content (r=0.984**), CEC (r=0.963**), Fe-oxides (r=0.954**) and surface area (r= 0.967**).

In case of oxalate, values of the bonding energy at the first rate of oxalate ranged from 0.022 to 0.098 (L/mg) with an average of 0.046 (L/mg) and at the second rate ranged from 0.021 to 0.093 with an average of 0.046 (L/mg).

Noteworthy referring that, increasing the level of oxalate added to the soil will decrease the P-bonding energy onto the tested soil samples. Also, data in Table (9) show that the P-bonding energy significantly correlated with each of clay content (r=0.983**), CEC (r=0.955**), Fe-oxides (r=0.959**) and surface area (r=0.954*).

In case of acetate, values at the first rate of acetate rengad from 0.021 to 0.12 with an average of 0.049 (L/mg). At the second rate rengad from 0.021 to 0.11 with an average of 0.052 (L/mg). Data show much decrease in P-bonding energy with increasing acetate rate. Data in Table (11) also showed that, P-bonding energy is significantly correlated with clay content (r=0.994***), CEC (r=0.988**), Fe-oxides (r=0.964**) and surface area (r=0.992***).

4.4.6. Bonding energy with organic ligands addition after P-adsorption:

In case of citrate, data in Table (12) show that values of this constant were less than those of P-bonding energy without citrate added. Increasing the rate of citrate application decreased the bonding energy as compared with the other tested levels.

With addition of oxalate after P-adsorption , the decrease in P-bonding energy was observed .This may be due to the competitive effect between oxalate ligand and phosphorus on the exchange sites.

Data in Table (16) show that there was a decrease in P-bonding energy with increasing acetate compared with the control.

In conclusion, organic ligands markedly decreased P-bonding energy in soils which significantly correlated with soil properties especially clay content, CEC and surface area. Also, the decrease in P-bonding energy depended on the concentration of ligands and on the way in which phosphorus or ligands were added to soil. Data also show that citrate had more effect than oxalate and acetate.

4.5.P-Adsorption Parameters According to Van-Huay Isotherm :

4.5.1 Affinity constant without application of organic ligands

The affinity constant "n" which is realted to the bonding energy, could be calculated from the linear form of the Van-Huay equation $Q = n\sqrt{I} + b$ as the slope of the linear form.

Values of affinity constant ranged between 275and 565 mgPL^{-1} with an average of 367 . The "n" constant tended to be higher as clay content increases.

4.5.2. Affinity constant with organic ligands addition before P-adsorption:

Data show that, the affinity constant was affected by clay content,CEC,Fe-oxides and surface area of the studied soils. The decrease in affinity constant was 34% at the first and second rate of applied citrate compared with affinity constant without citrate added.

In case of oxalate, data show that the decrease in affinity constant was24% and 30% at the first and second rate of applied oxalate respectively, compared without oxalate application .

With application of acetate data reveal that, the decrease in affinity constant amounted to 24% at the first rate and 29% at the second one compared with affinity constant without acetate application.

4.5.3.Affinity constant with organic ligands addition after P-adsorption:

Data show that, the decrease in affinity constant was 24% and 29% at the first and second rate of applied citrate compared with affinity constant without citrate application, with the application of oxalate the decrease in affinity constant was 18% and 19% at the first and seconed rate,comperred with the control. The decrease in affinity constant was 19% and 24% at the fist and second rat of acetate compared with the control.

4.5.4. Theoretical P-desorption without application of organic ligands:

This constant was calculated as the intercept of the linear form of Van-Huay equation. The values obtained for this constant ranged between –162 and –281 mg /kg. Data reveal that the theoretical P-desorption was relatively higher at the higher level of clay content and lower $CaCO_3$ contents in the studied soils. Data also, show that P-desorption parameter significantly correlated with CEC (r=0.928*) and soil surface area (r=0.934*)

4.5.5. Theoretical P-desorption with organic ligands addition before P-adsorption:

case of citrate, values of P-desorption were relatively high in the calcareous soils and the "b constant" correlate with clay contente in soil,while with oxalate application, data show a decrease in values of "b constant" at both rates of applied oxalate. The "b constant" negatively correlated (r= - 0.901*) with $CaCO_3$ content of soils .

In case of acetate there was a decrease in values of this parameter with increasing applied acetate rate, while this parameter positively correlated with clay content, CEC and surface area.

4.5.6.Theoretical P-desorption with organic ligands addition after P-adsorption:

In case of citrate, the decrease in values of this parameter at the first rate was more than that in the second one. With oxalate addition there was a decrease in the value of this parameter with increasing added oxalate rate. In case of acetate, this parameter was decreased with increasing the rate of added acetate.

Data also, show that values of P-desorption were relatively higher with higher clay content particularly in Port Said Plain.

In conclusion, organic ligands decreased the values of P-desorption. This effect depended on the concentration of organic ligands and the way of phosphorus and organic ligands addition.

4.6. Zn-Adsorption Parameters According to Langmuir Isotherm:

4.6.1. Zn- adsorption without application of organic ligands:

The values obtained for the maximum adsorption of Zinc are presented in Table (18). This values ranged from 0.588 to 0.676 µg/g with an average of 0.625 µg/g. Data obtained show that Zn – max .adsorption was high in the alluvial soil (Port Said) as compared to the calcareous ones (El-Sallum, El-Omeid , El-Nobaria and El – Sir soils).These resultes are in agreement

Table (18) Different parameters of zinc adsorption isotherms for the studied soils.

Location	Parameter of Langmuir equation			Parameter of Van-Huay equation			
	Bonding energy "K" L/kg	Max. adsorp. "b" $Mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" mgL/kg^2	Theo.Pdesorp. "b" $\sqrt{mg/kg}$	P-conc. of soil sol. mgL^{-1}	"r"for 1 vs. Q
Ell-Sallum	9.0	0.588	0.986**	971	-38	0.002	0.991***
El-Omeid	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Nobaria	26.0	0.621	0.981**	1826	-49	0.0007	0.995***
El-Sir	29.0	0.640	0.962**	1872	-37	0.0004	0.990**
Port Said	67.0	0.676	0.974**	3162	-51	0.0003	0.999***

Where , ** ,***significant at, 0.01 and 0.001, respectively.

Table (19) Correlation coefficient "r" between different parameters of Zn-adsoption and studied soils properties

Parameters	Langmuir parameters		Van Huay parameters	
	P -max.	K	n	b
Clay %	0.960**	0.983**	0.968**	0.509
$CaCO_3$%	-0.624	-0.754	-0.663	0.657
Organic matter	0.570	0.613	0.646	-0.962**
pH	-0.329	-0.344	-0.352	-0.247
CEC	0.912*	0.966**	0.943*	-0.570
Surface area	0.908*	0.973**	0.946*	-0.559
Fe-ox	0.907*	0.970**	0.948*	-0.395

Where , ** ,***significant at, 0.01 and 0.001, respectively.

with those obtained by **Jahiruddin et al (1989)** and **Abbas et al (1996)**

Data in Table(19) show that, Zn adsorption max was positively correlated with soil clay content (r=0.960**), CEC (r=0.912*), Fe-oxides (r=0.902*) and surface area (r= 0.908*). Such "r" values may reflect the role of clay content in soil as well as CEC and surface area as significant factors determining the availability of soil zinc to plants. Similar results were obtained by **Maftoun et al. (2000).** However, **Prasad** and **Agarwar (1991)** reported that the adsorption maximum of Zn in Indian calcareous soils decreased as the percentage of clay decreased. They added that, Zn-max were significantly related to clay content, free $CaCO_3$ and CEC of the soils.

4.6.2. Zn-adsorption maximum with organic ligands addition before Zn-adsorption:

In case of citrate (Table, 20 and Fig, 8) show that, values of Zn-max ranged from 0.552 to 0.556 µg/g at the first rate with an average of 0.554 µg/g.,while at second rate it ranged from 0.564 to 0.617 with an average of 0.564 µg/g . Data show that, Zn-adsorption decreased by about 8% and 11% at the first and second rate, respectively, compared with the control. This may be due to the positive effect of citrate on Zn-adsorption. **Chairidchai and Ritchie (1993)** reported that, changes in Zn-adsorption was related to changes in pH and Zn-complexation being greater in the non-sterile soil particularly in the presence of citrate.

In case of oxalate (Table, 21 and Fig, 9) show that, values of Zn-max at the first rate ranged from 0.629 to 0.787µg/g with

Table (20) Different parameters of zinc adsorption isotherms in presence and absence of citrate ligand added before zinc adsorption.

Location	Conc. of acetate Ml^{-1}	Parameters of Langmuir Equation			Parameters of Van-Huay equation			
		Onding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{MgL/kg^2}$	Theo.Znde sorp. "b" Mg/kg	Zn-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
El-Omeid	0.0	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Sir		29.0	0.640	0.962**	1872	-37	0.0004	0.990***
Port Said		67.0	0.676	0.974**	3162	-51	0.0003	0.999***
El-Omeid	$5x10^{-3}$	0.40	0.552	0.881*	210	-54	0.07	0.976**
El-Sir		0.42	0.556	0.940*	200	-47	0.05	0.981**
Port Said		-------	-------	0.379	1237	-130	0.01	0.939*
El-Omeid	$5x10^{-2}$	0.34	0.549	0.895*	191	-57	0.09	0.976**
El-Sir		0.28	0.617	0.878*	199	-64	0.10	0.981**
Port Said		-------	-------	0.233	1101	-113	0.01	0.879*

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (21) Different parameters of zinc adsorption isotherms in presence and absence of oxalate ligand added before zinc adsorption.

Location	Conc. of acetate Ml^{-1}	Parameters of Langmuir Equation			Parameters of Van-Huay equation			
		Onding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{MgL/kg^2}$	Theo.Znde sorp. "b" mg/kg	Zn-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
El-Omeid	0.0	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Sir		29.0	0.640	0.962**	1872	-37	0.0004	0.990***
Port Said		67.0	0.676	0.974**	3162	-51	0.0003	0.999***
El-Omeid	$1x10^{-5}$	1.29	0.787	0.919*	578	-87	0.02	0.981**
El-Sir		6.20	0.769	0.979**	1088	-61	0.003	0.999***
Port Said		55.0	0.629	0.902*	2718	-51	0.0004	0.993***
El-Omeid	$1x10^{-3}$	-------	-------	0.149	619	-155	0.06	0.940**
El-Sir		3.32	0.709	0.969**	785	-66	0.007	0.995***
Port Said		44.50	0.725	0.940*	2665	-46	0.0003	0.991***

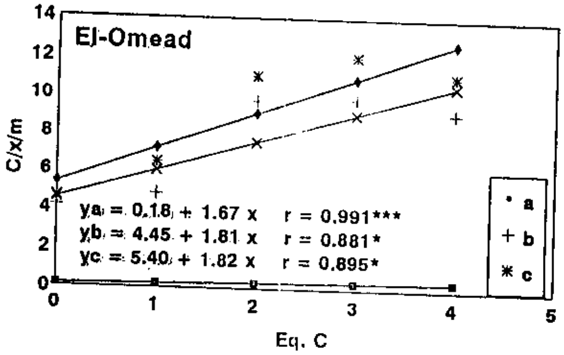
Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (22) Different parameters of zinc adsorption isotherms in presence and absence of acetate ligand added before zinc adsorption.

Location	Conc. of acetate Ml^{-1}	Parameters of Langmuir Equation			Parameters of Van-Huay equation			
		Onding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{MgL/kg^2}$	Theo.Znde sorp. "b" mg/kg	Zn-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
El-Omeid	0.0	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Sir		29.0	0.640	0.962**	1872	-37	0.0004	0.990***
Port Said		67.0	0.676	0.974**	3162	-51	0.0003	0.999***
El-Omeid	$5x10^{-2}$	-------	-------	0.490	189	-95	0.25	0.891*
El-Sir		-------	-------	0.441	-------	-------	-------	0.833
Port Said		45.0	0.735	0.891*	2646	-34	0.0002	0.991***
El-Omeid	$1.5x10^{-1}$	-------	-------	0.425	-------	-------	-------	0.843
El-Sir		-------	-------	0.588	184	-83	0.20	0.895*
Port Said		30.0	0.833	0.995***	2725	-63	0.0005	0.999***

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Fig (8) Effect of citrate on Zn adsorption added before Zn (Langmuir isotherm)



a = 0 citrate, b = 0.005 M citrate, c = 0.05 M citrate

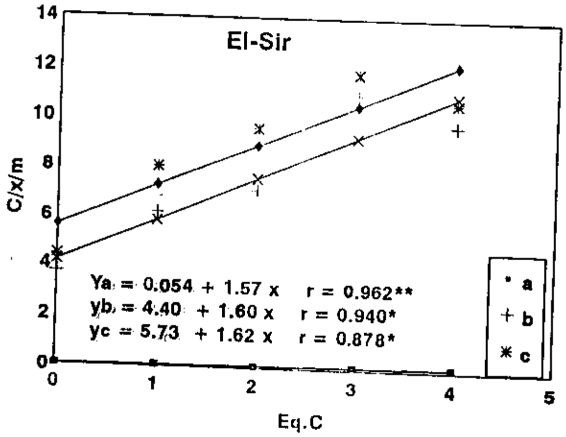
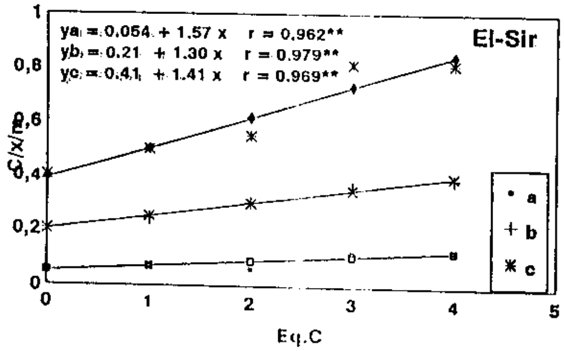


Fig (9) Effect of oxalate on Zn adsorption added before Zn (Langmuir isotherm)



a = 0 Oxalate, b = 0.00001 M oxalate, c = 0.001 M oxalate

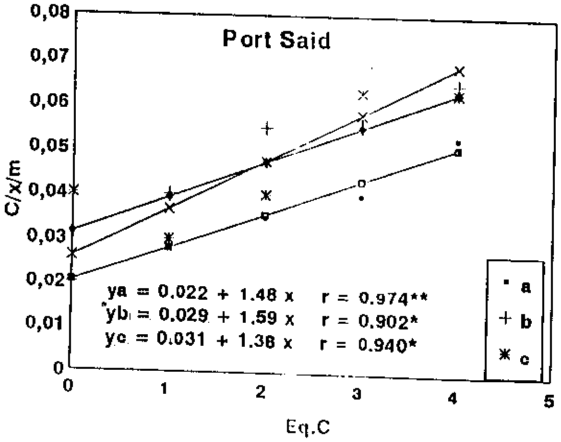
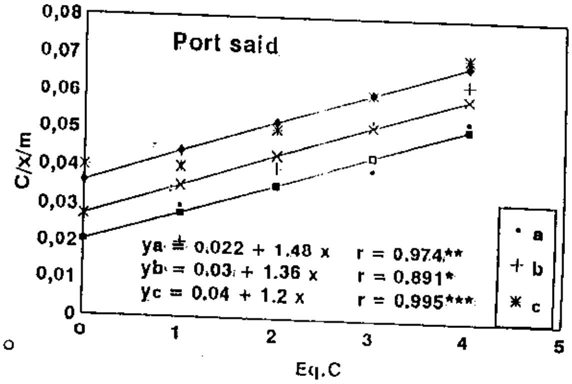


Fig (10) Effect of acetate on Zn adsorption added before Zn



a = 0 acetata, b = 0.05 M acetate, c = 0.15 M acetate an average of 0.735 μg/g, and at the second rate from 0.709 to 0.725μg/g with an average of 0.728 μg/g. Data also show that, Zn-adsorpion was increased by about 10% at the first and second rates compared with Zn-max without oxalate application . This may be explained on the basis that adsorption of oxalate may increase the negative charge on the soil surface, and hence increase Zn-adsorption. These results are in agreement with those reported by **Parfit** and **Russell (1977)** and **Barrow (1985).** On the other hand , in the case of acetate it was insignificant (Table, 22) and Fig (10).

4.6.3. Zn- adsorption maximum with organic ligands addition after Zn-adsorption:

Values of Zn-max at the first rate of citrate ranged from 0.495 μg/g to 0.610 μg/g with an average of 0.564 μg/g. At the second rate ranged from 0.490 μg/g to 0.602 μg/g with an average of 0.551μg/g (Table, 23) and graphically illustrated in Fig (11). Data show that the decrease in Zn-adsorption was 12% and 14% at the first and second rate, respectively, compared with the control. **Norvell (1972)** reported that presence of organic ligands in the rhizosphere may influence the concentration of Zn in soil solution thereby its availability to plants. The important of this ligands, however, is that they are able to form complexes with micro-nutrients and the complexes are more soluble than the free ion **(Broadbent** and **ott, 1957; Hodgson et al, 1965, Norvell, 1972** and **Prasad et al., 1976).**

With application of oxalate Zn-max values ranged from 0.562 to 0.621 μg/g at the first rate with an average of 0.595 μg/g. While at the second rate ranged from 0.625 to 0.685 μg/g

Table (23) Different parameters of zinc adsorption isotherms in presence and absence of citrate ligand added after zinc adsorption.

Location	Conc. of acetate Ml^{-1}	Parameters of Langmuir Equation			Parameters of Van-Huay equation			
		Onding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{MgL/kg^2}$	Theo.Znde sorp. "b" mg/kg	Zn-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
El-Omeid	0.0	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Sir		29.0	0.640	0.962**	1872	-37	0.0004	0.990***
Port Said		67.0	0.676	0.974**	3162	-51	0.0003	0.999***
El-Omeid	$5x10^{-3}$	0.78	0.495	0.964**	255	-29	0.01	0.985**
El-Sir		0.63	0.588	0.884*	281	-61	0.05	0.972**
Port Said		16.0	0.610	0.951*	1388	-49	0.001	0.992***
El-Omeid	$5x10^{-2}$	0.54	0.490	0.939*	194	-37	0.04	0.984**
El-Sir		0.49	0.562	0.921*	239	-57	0.06	0.989**
Port Said		0.99	0.602	0.990**	370	-48	0.02	0.999***

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (24) Different parameters of zinc adsorption isotherms in presence and absence of oxalate ligand added after zinc adsorption.

Location	Conc. Of acetate Ml^{-1}	Parameters of Langmuir Equation			Parameters of Van-Huay equation			
		Onding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{MgL/kg^2}$	Theo.Znde sorp. "b" mg/kg	Zn-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
El-Omeid	0.0	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Sir		29.0	0.640	0.962**	1872	-37	0.0004	0.990***
Port Said		67.0	0.676	0.974**	3162	-51	0.0003	0.999***
El-Omeid	$1x10^{-5}$	5.20	0.562	0.973**	633	-14	0.0005	0.963**
El-Sir				0.757	1934	-107	0.003	0.988**
Port Said		4.0	0.621	0.980**	705	-56	0.006	0.997***
El-Omeid	$1x10^{-3}$	3.0	0.641	0.976**	645	-58	0.008	0.996***
El-Sir		18.0	0.685	0.987**	1788	-59	0.001	0.996***
Port Said		6.0	0.625	0.880*	928	-62	0.004	0.968**

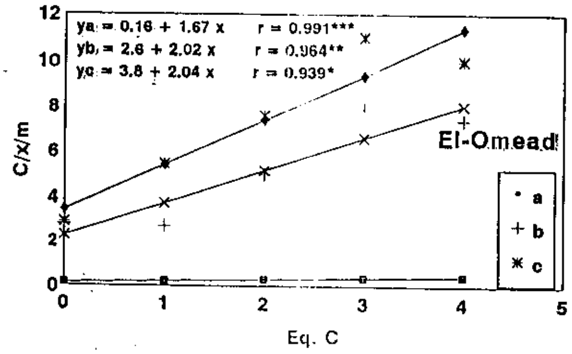
Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Table (25) Different parameters of zinc adsorption isotherms in presence and absence of acetate ligand added after zinc adsorption.

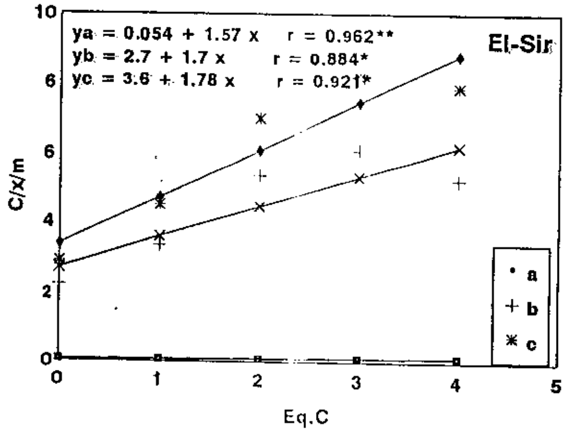
Location	Conc. Of acetate Ml^{-1}	Parameters of Langmuir Equation			Parameters of Van-Huay equation			
		Onding energy "K" L/kg	Max. adsorp. "b" $mgkg^{-1}$	"r" for C vs. C/x/m	Bonding energy "n" $\sqrt{MgL/kg^2}$	Theo.Znde sorp. "b" mg/kg	Zn-conc. of soil sol. mgL^{-1}	"r" for $\sqrt{I}$ vs. Q
El-Omeid	0.0	10.0	0.599	0.991***	1107	-47	0.002	0.992***
El-Sir		29.0	0.640	0.962**	1872	-37	0.0004	0.990***
Port Said		67.0	0.676	0.974**	3162	-51	0.0003	0.999***
El-Omeid	$1x10^{-5}$	-------	-------	0.549	188	-90	0.23	0.893*
El-Sir		-------	-------	0.620	-------	-------	-------	0.845
Port Said		-------	-------	0.770	199	-82	0.17	0.954**
El-Omeid	$1x10^{-3}$	-------	-------	0.506	178	-97	0.30	0.878*
El-Sir		-------	-------	0.570	-------	-------	-------	0.863
Port Said		-------	-------	0.664	145	-22	0.02	0.883*

Where * , ** ,***significant at 0.05, 0.01 and 0.001, respectively

Fig (11) Effect of citrate on Zn adsorption added after Zn (Langmuir isotherm)



a = 0 citrate, b = 0.005 M citrate, c = 0.05 M citrate



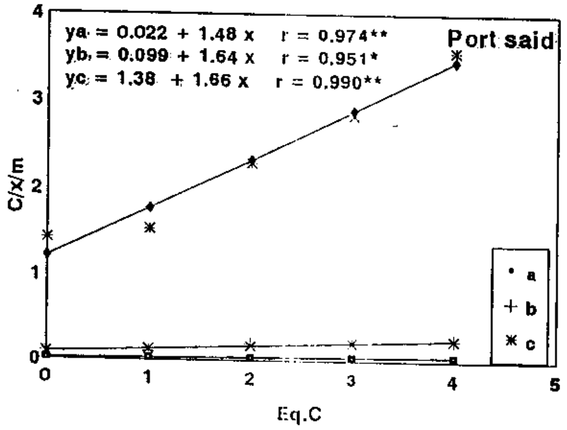
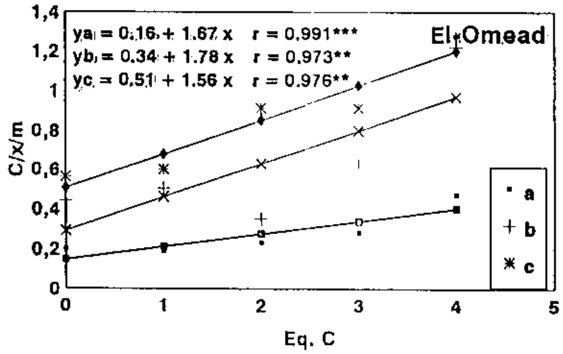
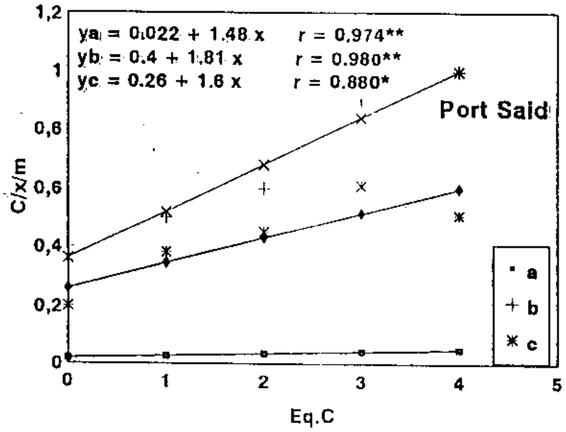


Fig (12) Effect of oxalate on Zn adsorption added after Zn (Langmuir isotherm)



a = 0 oxalote, b = 0.00001 M oxalate, c = 0.001 M oxalate



with an average of 0.62µg/g (Table, 24). and graphically illustrated in Fig (12) . Data show that oxalate had little effect on Zn-adsorption and the decrease in Zn-adsorption was 7% at the first rate while at the second rate , the increase in Zn adsorption was 5% compared with the control.On the other hand , in the case of acetate(Table ,25) it was insignificant .

Langmuir adsorption isotherm was not fit the date of Zn-adsorption with addition of acetate either before or after Zn-adsorption process. Noteworthy referring that sorbed Zn at low Zn concentration in equilibrium solution confirmed to Langmuir equation, yet at high Zn equilibrium concentration, Langmuir failed to describe Zn retention.

These results may suggest that retention of Zn by soil at high Zn concentration follows another mechanism other than the adsorption. **Mc Bride** and **Blasiak (1979)** reported that precipitation as well as adsorption may take place at high concentration of an element in the equilibrium solution. **Brummer et al.(1983)** concluded that an adsorption-desorption or a precipitation-dissolution may control Zn in soil solution as the former mechanism operates in soils of pH >7, thus in soils of neutral to alkaline, pH precipitation-dissolution mechanism may be of more importance

In conclusion, results indicate that the variable effect of organic ligands on zinc adsorption dependes upon concentration of both zinc and the organic ligand and such effact varies from one ligand to another.

Zn-adsorption in the presence of orgianic ligands was decreased when citrate or oxalate were added after Zn adsorption while it increased when oxalate was added before Zn

Maximum reduction in Zn- adsorption was occurred when organic ligands was added after Zn- adsorption.

4.6.4.The bonding energy without application of organic ligand:

Table (18) show the values of this constant as calculated from the linear form of Langmuir isotherm. This values ranged from 9.0 to 67.0 L/kg with an average of 28.0 L/kg .This parameter significantly correlated with each of clay content (r=0.983**), surface area (r=0.973**), Fe-oxides (r=0.970**) and CEC (r=0.966**). These results are in accordance with the results reported by **(Shuman, 1975** and **Hazra et al. 1995).**

4.6.5. Bonding energy with organic ligands ddition before Zn-adsorption:

the decrease in bonding energy of Zn caused by citrate was about 99% at both first and second rates compared with Zn-bonding energy without citrate application , while the decrease was 40% and 7% at the first and second rates of added oxalate compared with bonding energy without oxalate application .

4.6.6. Bonding energy with organic ligands addition after Zn-adsorption:

The decrease in bonding energy of Zn was 84% and 98%at the first and second rates of citrate compared with the control, while the decrease in it amounted 88% and 74% at the

In conclusion data obtained may indicate that the effect of organic ligands on Zn-bonding energy is dependent on the concentration of organic ligands and type of this ligand.

4.7. Zn- Adsorption Parameter According to Van – Huay isotherm:

4.7.1. The affinity constant without application of organic ligands :

Data presented in Table (18) show that the affinity constant of Zn- adsorption by soil was affected by the content of clay in the studied soils. Therefore, affinity constant significantly correlated with soil clay content (r=0.968**), CEC (r=0.943*), surface area (r=0.946*) and Fe-oxides (r=0.948*).

4.7.2. Affinity constant with organic ligands addition before Zn-adsorption:

Data reveal that the affinity constant values were affected by clay content of the studied soils. The decrease in Zn-bonding energy was 73% and 75% at the first and second rate of applied citrate, respectively as compared with the control.

In case of oxalate, data show that the decrease in affinity constant was 28% and 23% at the first and second rate, respectively, compared with no oxalate addition.

On the application of acetate, data revealed that, the decrease in affinity constant amounted to 34% at the first rate and 29% at the second rate compared with Zn-affinity constant without acetate application.

4.7.3. Affinity constant with organic ligands addition after Zn-addition:

Data show that, the decrease in affinity constant was 71% and 86% at the first and second rate of citrate compared with affinity constant bonding energy without citrate. With the application of oxalate the decrease in affinity constant was 47% and 45% at the first and second rate, respectively. The corresponding values in case of acetate application were 91% and 92%, respectively .

4.7.4.Theoretical Zinc-desorption without application of organic ligands:

Data (Tabl, 18) reveal that values of the theoretical Zn-desorption were high in soils of the rlatively lower $CaCO_3$ content, but were lower in soils of high clay content. However, values of theoretical desorption of zinc were insignificantly correlated with all of the soil properties. **(Abbas et al 1996).**

4.7.5.Theoretical Zinc-desorption with organic ligands application before Zn-adsorption:

Vales of Zn-desorption parameter calculated at the first rate of citrate addition ranged between –130 and – 47 while at the second rate ranged from –113 to –57. Data obtained show a decrease in values of this parameter with increases of added citrate rate. In the case of oxalate, values at first rate ranged between – 87 and –51, while at the second rate ranged between –155 and -46. The decrease in values of this constant corresponded with increasing oxalate rate. Values at the first rate of acetate ranged between –95 and -34, while at the second rate varied between –83 and –63. The decrease in this parameter was in accordance with the increase of acetate of application rate.

4.7.6.Theoretical Zinc desorption with organic ligands addition after Zn-adsorption:

Theoretical Zn-desorption at the first rate of citrate ranged between –61 and –29, while at second rate ranged between –57 and –37. The decrease in this parameter with increasing citrate rate added after Zn – adsorption was less than when citrate was added before Zn-adsorption. Values at the first rate of oxalate ranged between –107 and –14, while at the second rate raged between –62 and -58. The decrease in values of this parameter accompanied the increased rate of oxalate. Values at the first rate of acetate ranged between –90 and -82, and at second rate between –97 and –22. There was a decrease in values of "b" parameter accompanied corresponding to increased rate of acetate.

In conclusion, organic ligands decreased the values of constant "b". This effect seem to depend on the concentration of the ligand.

4.8.Greenhouse Experiment:

4.8.1 Effect of organic matter, phosphorus and zinc application and their interaction on dry matter yield of barley:

The dry weight of the two cuts of barley in both tested soils are given in Table (26)and Figs (12 &13) . The data show that the values varied significantly with phosphorus. zinc and organic matter application.However, the main effect are that due to P, Zn and organic matter .Also, phosphorus x organic matter. Effects of phosphorus x Zinc, Zinc x organic matter and phosphorus x zinc x organic matter on dry matter yield of barley were significant.

4.8.1.1. Organic matter

The data in Table (27) show that the application of organic matter, irrespective of other variables, increased the dry matter yield of barley in both tested soils. The increase averaged 33% and 26% compared to non organic matter application treatment for El-Nubaria and El-Sir soils, respectively. The magnitude of increase in dry matter yield was higher in the second cut more than the first one in El-Nobaria but lower by than the first cut in El-Sir soil.

It could be concluded that application of organic matter to barley plants induced plant growth and yield of dry matter. This may be due to the ability of organic manure to supply the plants with nutrients needed for their growth. Also, it may activate the microflora of plant root rhizosphere which could result in the release of needed nutrients in readily available form to plants. Change of soil pH by O.M. towards slight acidity could increase nutrients absorbed by plants . All of these could result in more growth activity and consequently increase dry matter yield. **El-Leboudi et al(1976)** showed that application of organic manure generally, had positive effect on physical and chemical features of calcareous soils.

Table (26) Dry matter (g/pot) of barley plants grown in calcareous soils and affected by phosphorus, Zinc and organic matter treatments.

		El-Nobaria soil						El-Sir soil					
		- OM			+ OM			- OM			+ OM		
No	treatments	1st cut	2nd cut	total	1st cut	2nd cut	total	1st cut	2nd cut	total	1st cut	2nd cut	total
1	control	1.97	0.89	2.86	2.80	1.09	3.89	1.88	1.12	3.00	3.42	1.77	5.21
2	OP*	3.20	1.45	4.65	3.50	1.95	5.45	2.88	1.83	4.71	3.85	2.22	6.07
3	PP**	2.87	1.25	4.12	3.20	1.58	4.78	2.60	1.47	4.07	3.57	2.00	5.57
4	Zinc	2.60	1.15	3.75	3.25	1.60	4.85	2.32	1.35	3.67	3.69	2.04	5.73
5	OPxZn	2.37	1.39	3.76	3.66	2.00	5.66	3.03	2.54	5.57	3.77	3.28	7.05
6	PPxZn	3.00	1.28	4.28	3.20	1.86	5.06	3.50	2.63	6.13	3.86	2.99	6.85
7	ZnxOP	2.56	1.42	3.98	3.99	2.09	6.08	3.58	2.38	5.96	3.82	2.48	6.30
8	ZnxPP	2.30	1.22	3.52	3.42	1.95	5.37	3.05	2.23	5.28	3.48	2.28	5.76

* OP = Orthophosphate, ** PP = Pyrophosphate

Fig (13)Dry matter (g/pot) of barley plants grown in calcareous soils and affected by phosphorus, Zinc and organic matter treatments (El-Nobaria- soil)

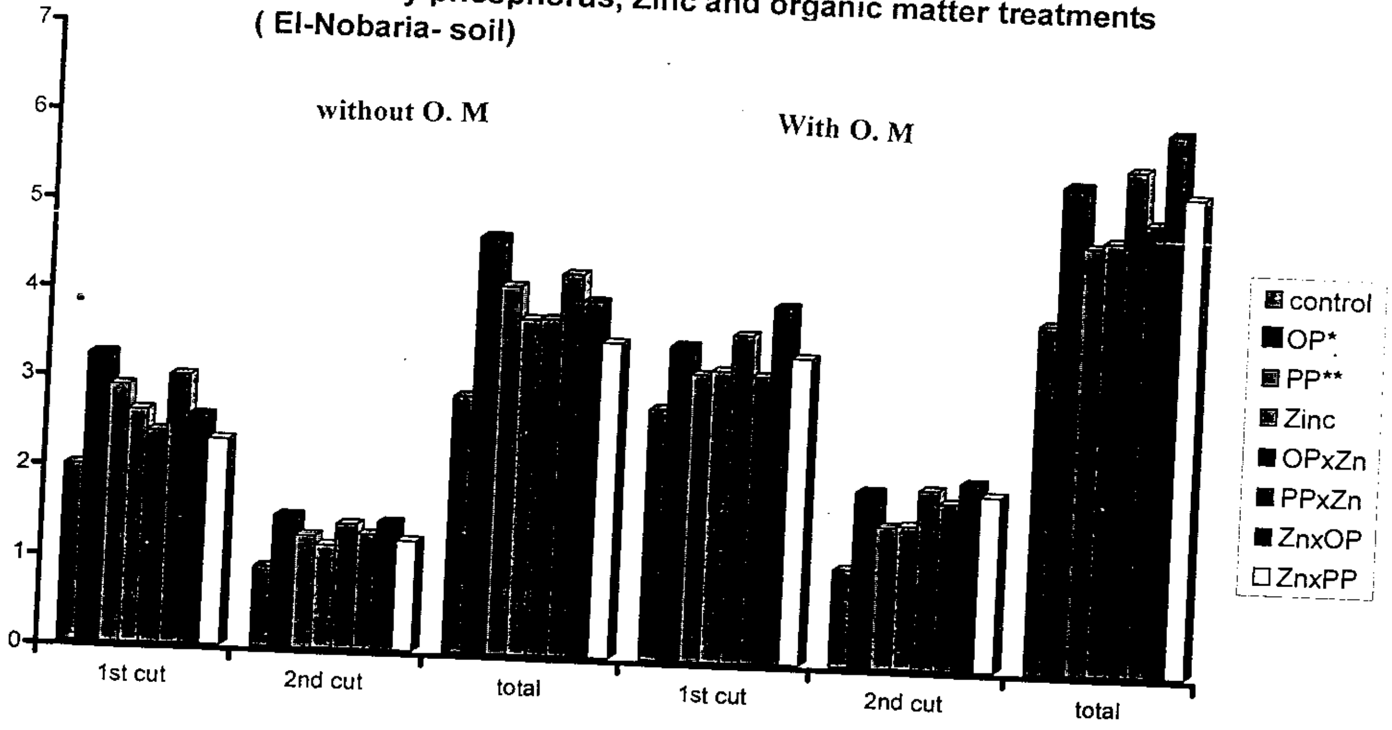


Fig (14)Dry matter (g/pot) of barley plants grown in calcareous soils and affected by phosphorus, Zinc and organic matter treatments (El-Sir- soil)

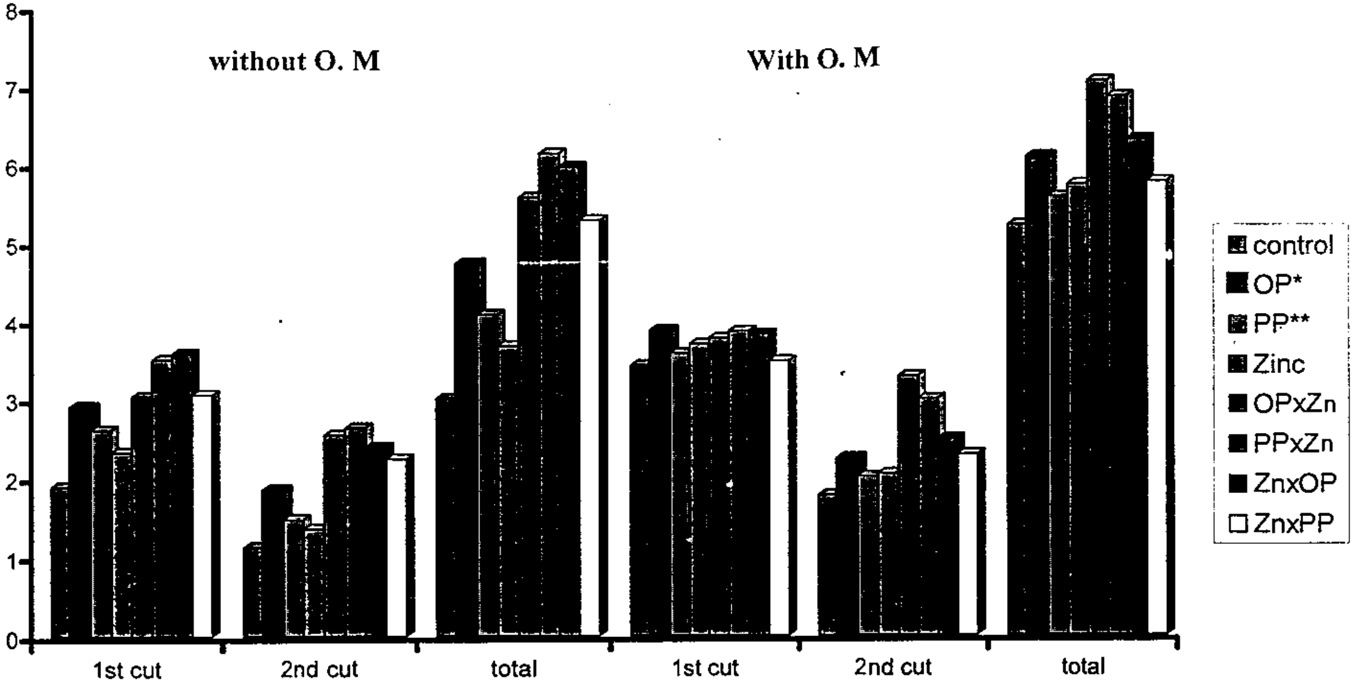


Table (27) Effect of organic matter, zinc and phosphorus application on dry matter yield of barley grown (g/pot) in calcareous soils.

Treatments / Soils		Organic matter		Zinc		Phosphorus		
		-	+	-	+	-P	+OP	+PP
El-Nobaria	1st	2.61	3.38	2.92	3.04	2.66	3.21	3.10
	2nd	1.26	1.77	1.37	1.60	1.18	1.72	1.52
	total	3.87	5.15	4.29	4.64	3.84	4.93	4.52
El-Sir	1st	2.86	3.68	3.03	3.41	2.83	3.49	3.34
	2nd	1.94	2.38	1.74	2.42	1.57	2.46	2.27
	total	4.80	6.60	4.77	5.83	4.46	5.95	5.61

Table (28) Effect of P x organic mater interaction on dry matter yield (g/pot) of barley grown in calcareous soils

OM treatment / P-treatment	-	+	-	+	-	+
	1st cut		2nd cut		total	
El-Nobaria soil						
-P	2.29	3.03	1.02	1.35	3.31	4.38
+OP	2.71	3.72	1.42	2.01	4.13	5.73
+PP	2.72	3.27	1.25	1.80	3.97	5.07
El-Sir soil						
-P	2.10	3.56	1.24	1.91	3.43	5.47
+OP	3.16	3.81	2.25	2.66	5.41	6.47
+PP	3.05	3.64	2.11	2.42	5.16	6.06

Table (29) Effect of Zn x organic mater interaction on dry matter yield (g/pot) of barley grown in calcareous soils

OM treatment / P-treatment	-	+	-	+	-	+
	1st cut		2nd cut		total	
			El-Nobaria soil			
-Zn	2.68	3.17	1.21	1.54	3.88	4.71
+Zn	2.57	3.51	1.29	1.90	3.86	5.41
			El-Sira soil			
-Zn	2.43	3.61	1.47	2.00	3.90	5.61
+Zn	3.10	3.72	2.23	2.61	5.33	6.33

Table (30) Effect of Phosphorus and Zinc on dry matter yield of barley plants(g/pot)

Treatment	1st cut		2nd cut		Total	
	-Zn	+Zn	-Zn	+Zn	-Zn	+Zn
			El-Nobaria soil			
-P	2.39	2.93	0.99	1.38	3.38	4.31
+OP	3.35	3.15	1.70	1.73	5.05	4.88
+PP	3.04	2.98	1.42	1.58	4.46	4.56
			El-Sir soil			
-P	2.65	3.01	1.45	1.70	4.10	4.71
+OP	3.37	3.55	2.03	2.67	5.40	6.22
+PP	3.01	3.47	1.74	2.35	4.83	6.00

4.8.1.2. Phosphorus :

The data of dry matter yield of barley as affected by phosphorus application irrespective of other variables are presented in Table (27) . The results indicate that, the application of phosphorus either in the form of orthophosphate or pyrophosphate increased the dry matter yield significantly.The increases were greater with use of orthophosphate than pyrophosphate. For example, the average increases were 28% and 35% over no-P treatment in case of orthophosphate rates, while the increases were 18% and 28% with pyrophosphate fertilizer rates, respectively.

It seems that the pyrophosphate is not an efficient source of plant P fertilizer as orthophosphate. The lower P-yield obtained with pyrophosphate treatment could be due to its lower uptake by plant from solution. This finding agreed with the data of phosphorus content in plant and the results obtained by **El-Nennah et al. (1976)**. However, plants grown in El-Sir soil was more respondent to P application than El-Nobaria . The average increase was 23% in El-Nobaria while it was 31% in El-Sir over no P-treatment. Similar results were found by **El-Nennah et al. (1976)**, who compared the relative availability of pyrophosphate and orthophosphate to alfalfa plants in short term greenhouse experiment. They found that orthophosphate was more efficient as P-source for plants than pyrophosphate.

The results in Table (27) indicate that plant response to phosphate fertilizers and its residual effect varied with advance in time and according to the number of cut. In case of orthophosphate application, the percent increase in dry matter yield varied between 21% and 46% in El-Nobaria; 23% and 57% in El-Sir over the control treatment at the first and second cut, respectively. The corresponding values for pyrophosphate were 13% and 29% and 18% and 45% over control in El-Nobaria and El-Sir soils, respectively. Similar results were obtained by **Wassif et al. (1986)** for alfalfa. In this respect, **Ridley** and **Taya Kepisuthte (1974)** reported that the solubility of applied P was always greater than the solubility of P in the untreated soils. The a vailability of octacalcium phosphate was about 80% of that of monocalcium phosphate, **(Lindsay** and **Taylor, 1960)**. Such reasoning may explain the response of the second cut to phosphate application more than the first one.

4.8.1.3. Zinc:

It is quite evident from the obtained results in Table (27) that irrespective to other variables, barley plants responded significantly to Zinc application. The average increases were 8% and 22% over no-Zinc treatment for El-Nobaria and El-Sir soils, respectively. The increase in dry matter yield of barley plants with application of Zn was due to increased available Zn in soil .

Yield increases due to Zn application were much greater in El-Sir soil having initially low available Zn compared to El-Nobaria having initially higher available Zn. In this respect, **Kamh (1981)** reported that, soils of light texture can be considered low in supply power for Zn. Similar response with added Zn was observed by **Kamh et al. (1986)** for corn plants grown in Sinai soils. Their results agree with the soil test information and with Zn content of barley plants from cheek treatments.

The crop response to Zn application increased as the plants advanced in age. For example, the percent increase in dry matter yield increased from 4% to 17% in El-Nobaria and from 13% to 39% in El-Sir for the first and the second cut respectively.

4.8.1.4. Organic matter vs. phosphorus :

The results of organic matter and phosphorus effect on the yield of barley dry matter are given in Table (28) .

From such results it could be concluded that the mixture of organic matter and phosphorus fertilizer increased significantly the dry matter yield of barley. Such effect was more pronounced (highly significant) in the second cut than in the first one. Moreover, the average of dry matter yield of barley was greater when the manure was mixed with P fertilizer than the solely application of phosphorus or organic matter. Also, the effect of interaction between phosphorus and organic matter was higher with orthophosphate than with pyrophosphate. This may be due to the better utilization and more efficiency of phosphorus under the mixed application with organic matter. In this respect **Thomas (1964)** and **May** and **Martin (1966)** indicated that the yield response to phosphorus added with organic matter was better than response to commercial phosphorus fertilizer as available P increased for each of four year cropping. **Nafady et al. (1993)** indicated that the capacity of the soil to supply phosphorus increased with increasing the amount of organic manure or Nile sediment added to the soil as a result of reduction of P-fixation capacity caused by addition of organic matter or Nile sediment. However, the increase in dry matter yield of plant diferred from one soil to another being dependent on the source of phosphorus fertilization. Generally, the percent increase in dry matter yield was 73% and 53% over control for El-Nobaria soil with orthophosphate and pyrophosphate application, respectively. The corresponding increase in case of El-Sir soil was 94% and 81% over the non-treated soil for orthophosphate and pyrophosphate, respectively. The higher response resulted from phosphorus and organic matter interaction in El-Sir soil may be due to the low P-availability and hence low P supplying power compared with El-Nobaria soil. Similar results were obtained by **Wassif et al (1986)** and **Sakr et al. (1990)**

4.8.1.5. Organic matter vs. Zinc:

Data in Table (29) show that Zinc application to soil in the presence of organic manure interacted positively in increasing the dry matter yield of barley plants. Moreover, the crop response to Zn application in the presence of organic matter in El-Nobaria soil was less than that of Zn alone in El-Sir soil and the opposite was observed in El-Nobaria soil.

The low response to Zn application in the presence of organic matter could be attributed to sorption of Zn on the surface of organic matter and inactivation of soil Zn during the decomposition of organic matter. In this respect **Misra (1975)** concluded that application of organic matter to barley yieled an increase in the soil acidity and consequently increases the concentration of Fe, Mn and P which may reduce the available Zn in soil. Similar conclusion was reported by **Yadov** and **Girdhar (1980)** and **Singh** and **Dahiya (1980)** . They found that the response of oat plants to Zn decreased with increasing the levels of added organic matter. Also, **Kumar and Awasthi (1977)** found the same results with sorghum and rice. However, the total increases in dry matter yield by combined application of Zn and organic matter were 39% and 62% over untreated soil for El-Nobaria and El-Sir soils, respectively. The data also, revealed that the increase in dry matter yield was more pronounced in the second cut than in the first one and in El-Sir than in El-Nobaria soil. For example, the increases were 31% and 58% for El-Nobaria while for El-Sir the values were 53% and 78% over untreated soil for the first and second cut, respectively. Increasing response of plants due to Zn and organic matter interaction with time can be attributed to the immobilization / mineralization ratio of zn in the presence of organic manure was high at first and decreased with time progressing. The data agree with the finding reported by **Kamh (1981)** who found that the availability of Zn in soils decreased with the application of organic matter at first and increased with time progress. Headed that availability of native and applied Zn decreased with increasing the rate of organic matter up to 2%. Also, **Halder** and **Mandal (1979)** found that the available Zn content in soils recorded marked decrease due to organic matter application and the trend generally changed at the end of incubation since, the treated soil recorded an increase in the available Zn. They explained this observation on the base of microbiological immobilization and antagonistic effect of increased concentration of available Fe, Mn and P.

4.8.1.6. Phosphorus vs. Zinc:

Table (30) shows the effect of the interaction between P and Zn application on dry matter yield of barley. The data indicates that such effect diferred from soil to another depending on the number of cut and source of P fertilization.

In case of El-Sir soil, the data indicate that application of P and Zn together led to increase the dry matter yield. The dry matter increase due to P and Zn application was higher than with Zn or P alone. Also, The crop response to P application increased in the presence of Zn. The magnitude of increase was more pronounced with orthophosphate fertilizer than with pyrophosphate. For example, the percentage of increase was 52% and 46% over the control for orthophosphate and pyrophosphate application, respectively. Also, the increase were higher in the second cut than in the first ones which was 34% and 84% for orthophosphate and 31% and 74% over control for the first and second cut, respectively.

The data in Table (30) reveal that the magnitude of response due to P-Zn application was less in El-Nobaria than El-Sir. In some cases, the application of Zn led to decrease the magnitude of crop response to P fertilization especially in the first cut in which the dry matter yield decreased by about 6% due to Zn application. However, the average increases in the dry matter yield due to PxZn interaction were 44% and 34% over control for ortho and pyrophosphate, respectively. As previously mentioned the increases in the second cut was higher than the first cut which the values were 31% and 25% in the first cut and 75% and 60% in the second one over control for ortho and pyrophosphate fertilization, respectively. The differences in the behavior of PxZn interaction on dry matter yield in both soils could be attributed to the difference in the amount of native P and Zn and that orthophosphate fertilizer is considered the preferable form of P by plant.

With regard to the sequent application of P and Zn (Table , 30) data indicate that application of P followed by Zn seemed to encourage the growth and increase the dry matter yield and thus may considered as the best management for P and Zn fertilization, with some few exceptionals. For example, application of P followed by Zn increased the yield of barley by about 5% and 17% over Zn x P treatment for El-Nobaria and El-Sir soils, respectively. An opposite trend was observed in El-Nobaria soil `when orthophosphate form was used. The positive effect of applied P before Zn application may be due to a decrease in P-concentration in soil solution and consequently a decrease in the precipitation reaction of Zn and hence increased Zn availability to plant.

4.8.1.7. Organic matter vs. phosphorus vs. zinc:

Data in Table (26) indicate that interaction effect of OM x Zn x P application on dry matter yield was positive. The increases in dry matter yield resulted from this interaction were 105% and 83% over control in El-Nobaria soil with ortho and pyrophosphate, respectively. The corresponding values were 123% and 110% over control for El-Sir soil. The differences in crop response due to Zn x O.M x P interaction in both soils may be due to the differences in the amount of O.M and available P and Zn in soil

4.8.2. Effect of organic matter, phosphorus and zinc application and their interaction on P and Zn content in barley plants:

4.8.2.1.Organic matter:

The effects of organic matter application on the content of P and Zn in barley plants are shown in Table (31)and Figs (15 &16). It is apparent from the data that, P concentration recorded an increase as organic matter increased in both soils. The average increase was 47% and 54% over no organic matter treatment for El-Nobaria and El-Sir soil, respectively. Similar results were obtained by **Mongia et al (1979)** for wheat, **Abd El-Latif** and **Abdel-Fattah (1983)** for barley and **Soltan (1985)** for soybean

It was noted that the concentration of P in the second cut was much more than the first one especially with P application. This may be due to the reduction of dry matter yield in the second cut compared with the first one.

The total uptake of P by barley (Table, 31) increased with addition of organic matter. The magnitude of increase varied with the soil type. For example, the increases were 93% and 87% over no organic matter treatment for El-Nobaria and El-Sir soil, respectively. The differences in P uptake may be partly due to the difference in dry matter yield and/or P-concentration in barley plants. In this respect, **Sinha (1975)** suggested that the application of organic matter exert a favorable effect on the phosphate regime of soils. This effect of organic matter in augmenting the availability of phosphates in soils include some processes such as the solvent action of the organic matter

Table (31) Effect of treatments on phosphorus content (%) and total uptake (mg/pot) of barley grown in calcareous soil.

No	Treatments	-OM					+OM				
		1st cut		2nd cut		Total	1st cut		2nd cut		Total
		%	TU*	%	TU	uptake	%	TU	%	TU	uptake
		El-Nobaria Soil									
1	**Control**	0.061	1.20	0048	0.43	1.63	0.121	3.39	0.116	1.26	4.65
2	**OP***	0.103	3.30	0.110	1.60	4.90	0.145	5.08	0.156	3.04	8.12
3	**PP****	0.108	3.10	0.119	1.49	4.59	0.136	4.35	0.160	2.53	6.88
4	**Zinc**	0.068	1.77	0.100	1.15	2.92	0.117	3.80	0.153	2.45	6.45
5	**OpxZn**	0.114	2.70	0.176	2.45	5.15	0.157	5.75	0.185	3.70	9.45
6	**PPxZn**	0.100	3.00	0.087	1.11	4.11	0.152	4.86	0.186	3.44	8.30
7	**ZnxOP**	0.145	3.71	0.090	1.28	4.99	0.162	6.46	0.228	4.77	11.23
8	**ZnxPP**	0.140	3.22	0.140	1.71	4.93	0.161	5.51	0.184	3.59	9.10
		El-Sir soil									
1	**Control**	0.053	0.996	0.063	0.717	1.71	0.137	4.69	0.126	2.23	6.92
2	**OP***	0.139	4.0	0.107	1.96	5.96	0.185	7.12	0.152	3.37	10.49
3	**PP****	0.125	3.63	0.144	2.12	5.75	0.207	7.39	0.189	3.78	11.17
4	**Zinc**	0.055	1.28	0.067	0.91	2.19	0.156	5.76	0.168	3.43	9.19
5	**OpxZn**	0.113	3.42	0.106	2.69	6.11	0.163	6.15	0.178	5.84	11.99
6	**PPxZn**	0.130	4.55	0.133	3.50	8.05	0.177	6.83	0.207	6.19	13.02
7	**ZnxOP**	0.145	5.19	0.154	3.67	8.86	0.169	6.46	0.180	4.46	10.92
8	**ZnxPP**	0.132	4.03	0.117	2.61	6.64	0.195	6.79	0.173	3.94	10.73

*TU = total uptake

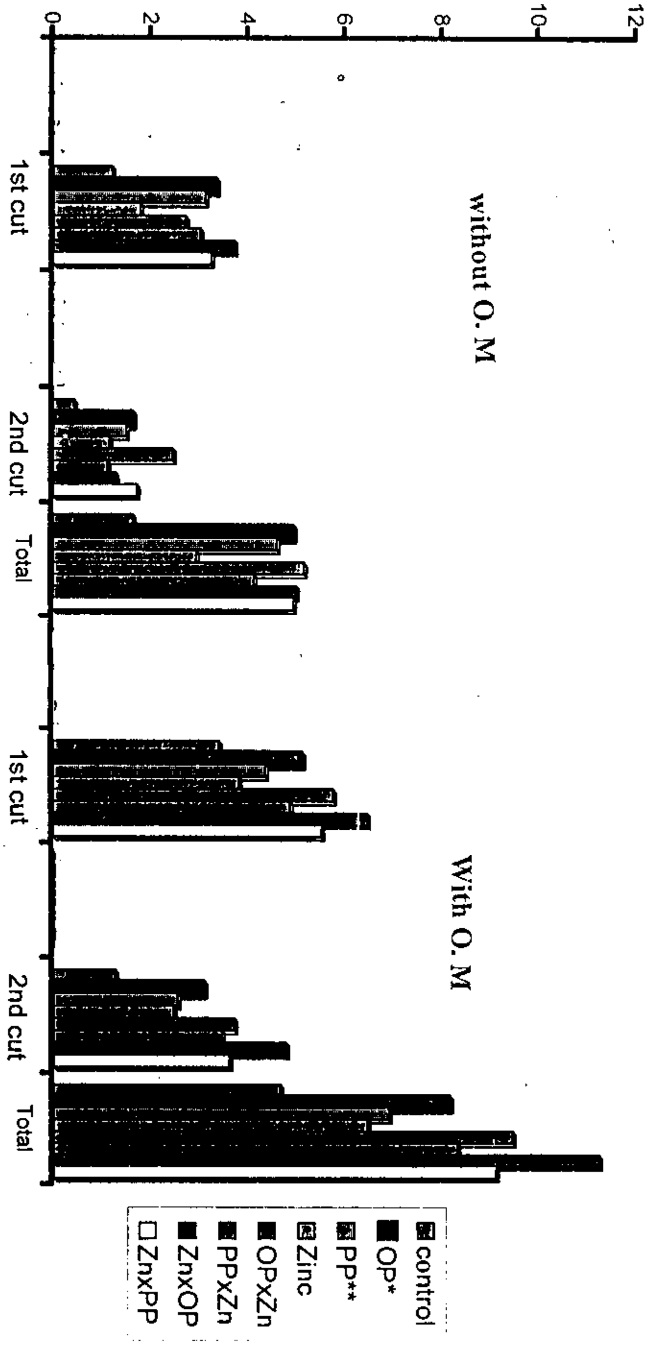


Fig (15) Effect of treatments on total phosphorus uptake(mg/pot) of barley grown in El-Nobaria soil.

Fig(16)Effect of treatments on total phosphorus uptake(mg/pot) of barley grown in E-Sir soil.

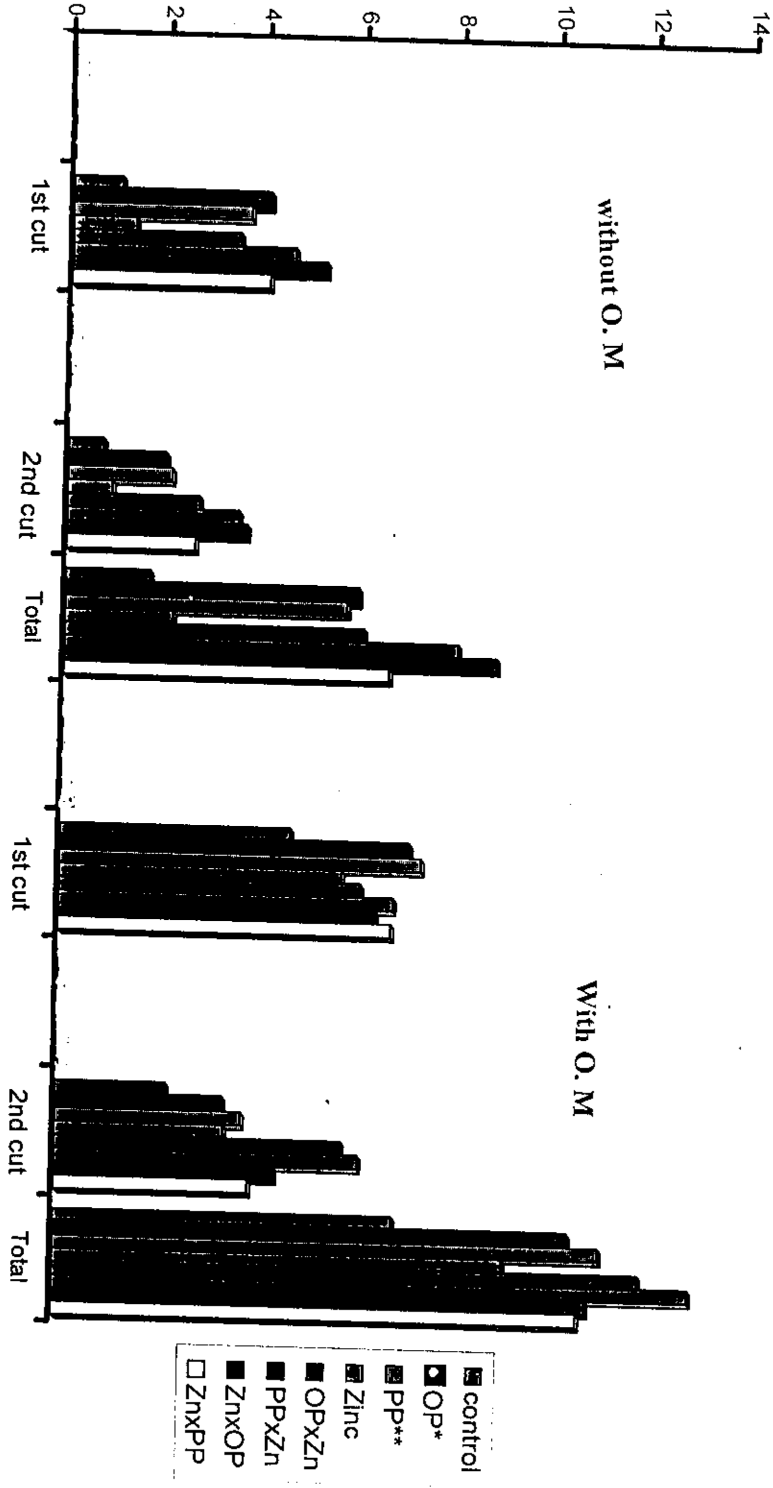
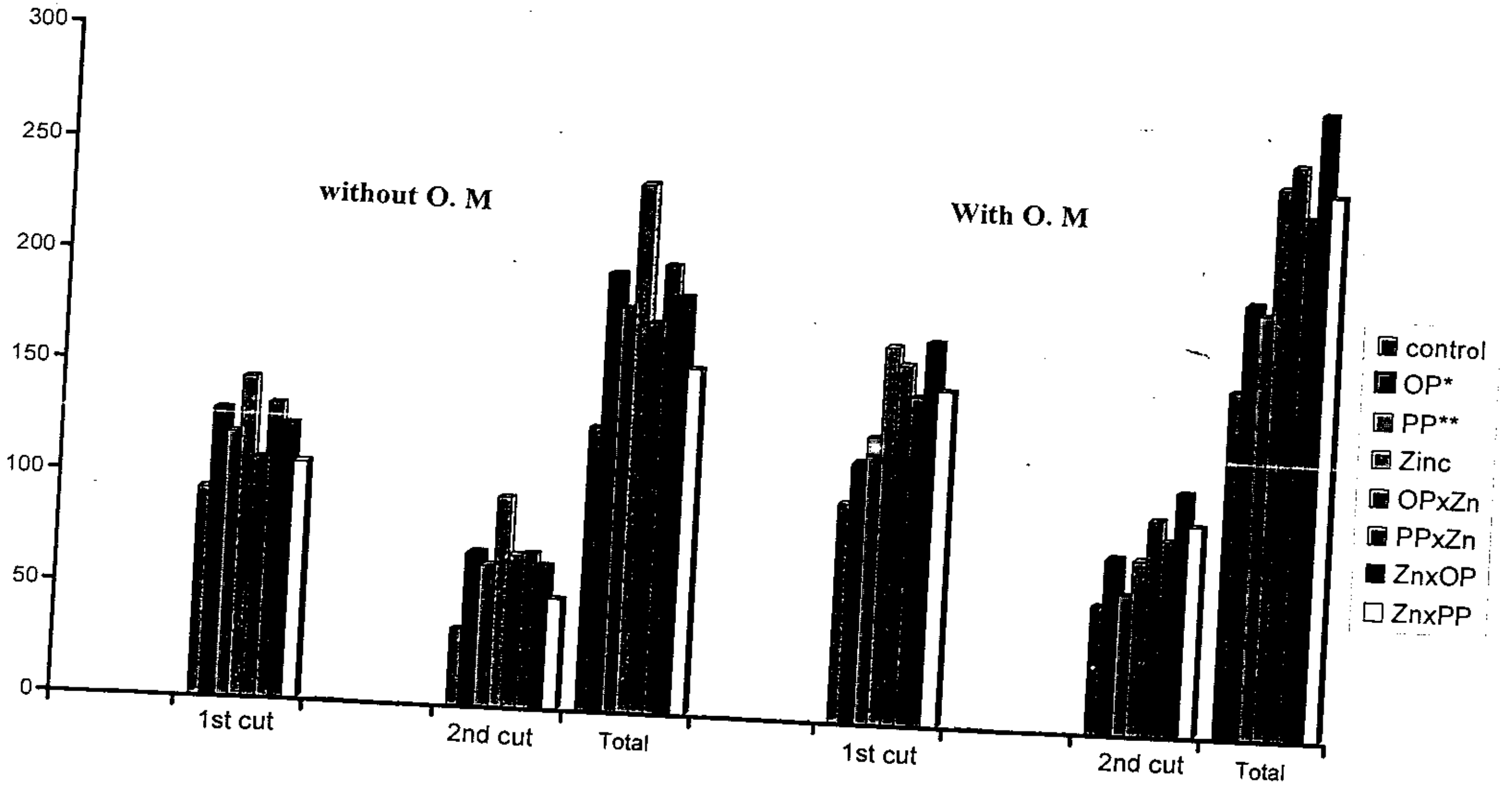


Table (32) Effect of treatments on zinc content and total uptake (µg/pot) of barley grown in calcareous soil.

No	Treatments	-OM					+OM				
		1st cut		2nd cut		Total	1st cut		2nd cut		Total
		ppm	TU*	ppm	TU	uptake	ppm	TU	ppm	TU	Uptake
					El-Nobaria Soil						
1	Control	47	93	38	34	127	35	98	52	57	155
2	OP*	40	128	47	68	196	33	116	40	78	194
3	PP**	41	118	50	63	181	40	128	39	62	190
4	Zinc	55	143	82	94	237	52	169	49	78	247
5	OPxZn	45	107	49	68	175	44	161	48	96	257
6	PPxZn	44	132	54	69	201	46	147	47	87	234
7	ZnxOP	48	123	45	64	187	43	172	52	109	281
8	ZnxPP	46	106	40	49	155	44	150	48	94	244
					El-Sir Soil						
1	Control	32	60	34	38	98	41	140	32	57	197
2	OP*	29	84	24	44	128	33	127	29	64	191
3	PP**	23	67	22	32	99	35	125	33	66	191
4	Zinc	48	111	57	77	188	44	162	51	104	266
5	OPxZn	64	194	69	175	369	48	181	50	164	345
6	PPxZn	60	210	73	192	402	43	166	49	147	313
7	ZnxOP	67	240	65	155	395	37	141	51	126	267
8	ZnxPP	58	177	63	140	317	44	153	62	141	294

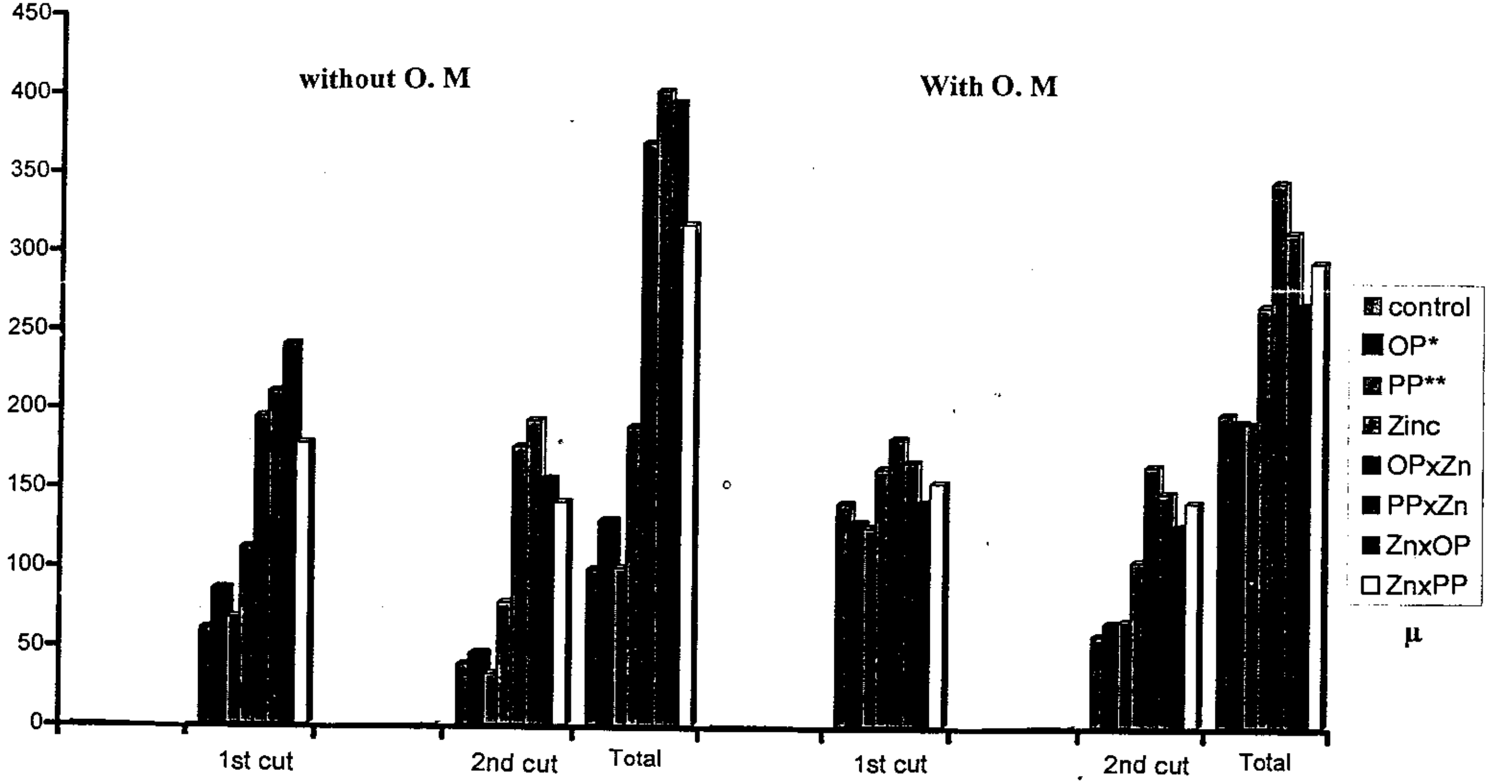
*TU = total uptake

Fig (17) Effect of treatments on total Zinc uptake(mg/pot) of barley grown in El-Nobaria soil.



Effect of
treatments
on total

Fig (18)Effect of treatments on total Zinc uptake(mg/pot) of barley grown in E-Sir soil.



decomposition on phosphates solubility, the protective action of humus substance on the retrogradation of the applied phosphates into relatively difficulty available forms, formation of a coating on $CaCO_3$ in soil that retard the reaction with soil P, chelation of Ca, Fe and Al ions principal cations involved in P fixation and formation of soluble phosphate which is readily available for plants . The simulating effect on the newly synthesized humid substances on rooting and other physiological processes of plants could also explain the effect of organic matter.

In contrarily, application of organic matter slightly decreased Zn concentration of barley plants. The percent decrease was15%and 5% below no organic matter treatment for El-Sir and El-Nobaria soils, respectively. This sort of behavior could be due to dilution effect because dry matter yield and Zn uptake increased with increasing organic matter level, adsorption of native and applied Zn in soil on organic matter surfaces, converting Zn in soil to unavailable form to plants i.e. Zinc carbonate and hydroxide and competition of Fe and Mn for chelating agents. Inactivations of soil Zn by composting organic matter and antagonistic effect of excess Fe, P and Mn and the microbiological immobilization resulting from organic matter decomposition. **Halder** and **Mandal (1979)** referred, P content in plant increased Zn concentration with time in both soils and either in the absence or presence of applied organic matter.

Data in Table (32) and Figs (17 &18) reveal that total Zn uptake in barley plant increased with organic matter application, the increases were pronounced in El-Nobaria soil compared in

El-Sir one. For example, the increase in Zn uptake by barley plant was 23% over no organic matter treatment in El-Nobaria while the value was 3% only in El-Sir.

4.8.2.2. Phosphorus:

It is obvious from the data in Table (33) that P application to both soils either in the form of orthophosphate or pyrophosphate increased P content in plant. The improvement in P content diferred from soil to other and increased in most cases with time. However, in the case of orthophosphate the percent increase in P-content in barley plant was 52% and 33% in El-Nobaria and 50% and 52% in El-Sir over no P treatment for the first and second cut, respectively,. The corresponding values in case of pyrophosphates were 61% and 46% in El-Nobaria and45% and 40% in El-Sir over no P application for the first and second cut, respectively.

The data in Table (33) show that the average increase in the availability of P to plants , ranged from 10-15% with time. Also, there is not significant difference between the two sources of P in increasing P-content in plants. This may be due to the dilution effect due to the reduction of dry matter yield in second cut compared to the first one.

With regard to the total uptake of P by barley plant. Table (32) show .that application of P either in the form of orthophosphate or pyrophosphate increased total P-uptake by barley plants. The magnitude of increase was more pronounced with orthophosphate than pyrophosphate as the total uptake of phosphorus increased by about 89% and 81% over no phosphorus

Table (33) Effect of phosphorus application on P and Zn contents in barley plants grown in calcareous soils.

P-treat. / Cut No.	P-content						Zn-content					
	-P		+OP		+PP		-P		+OP		+PP	
	%	mg/ pot	%	mg/ pot	%	mg/ pot	ppm	µ g/pot	ppm	µ g[*1]/p ot	ppm	µ g[*2]/p ot
El-Nobaria soil												
1st cut	0.092	2.54	0.138	4.50	0.133	4.01	47.3	126	42.2	135	43.5	130
2nd cut	0.104	1.32	0.158	2.81	0.146	2.31	55.3	66	46.8	81	46.3	71
Total		3.86		7.31		5.32		192		216		201
El-Sir soil												
1st cut	0.10	3.18	0.152	5.39	0.161	5.54	41.30	118	46.3	161	48.8	150
2nd cut	0.11	1.82	0.146	3.67	0.161	3.69	43.50	69	48.0	121	50.3	119
Totol		5.00		9.06		9.23		187		282		269

Table (34) Effect of Zinc application on phosphorus and Zinc content in barley plants grown in calcareous soils

Zn level / Cut No.	0.0		10ppm		0.0		10ppm	
	P-content				Zn-content			
	%	mg/pot	%	mg/pot	ppm	µ g/pot	ppm	µ g[*3]/p ot
El-Nobaria soil								
1st cut	0.112	3.40	0.132	4.08	39.3	114	46.7	141
2nd cut	0.118	1.73	0.153	2.57	44.3	60	51.4	81
Total		5.13		6.65		170		222
El-Sir Soil								
1st cut	0.141	4.64	0.144	5.05	32.2	101	51.3	174
2nd cut	0.130	2.36	0.148	3.72	29	50.2	59	142
Total		7.0		8.77		151.2		316

treatment in El-Nobaria and El-Sir respectively. But in the case of pyrophosphate, the increase was 38% for both El-Nobaria and El-Sir, over no P treatment. Again the increase in total uptake of P in general could be attributed to the increase in dry matter yield due to application of P. However, it seems that the pyrophosphate ion was not apparently an efficient source of plant fertilizer compared with orthophosphate.

The lower P-uptake from pyrophosphate can be due to either a lower rate of release from soil to solution or once in solution to a lower availability to the plant. **El-Nennah et al. (1976)** found that the dry matter Alfalfa and total P-uptake tended to increase in all treatments in which orthophosphate was used compared to those with pyrophosphate. They concluded that the lower P-uptake by plant from pyrophosphate could be due to the slow conversion of pyrophosphate to orthophosphate as well as to formation of rather insoluble reaction products in the soil. In this respect, **Blanchar** and **Hossner(1969)** and **Sutton** and **Larsen(1964)** found that hydrolysis of pyrophosphate in aerobic soil systems varies with the soil and requires from 4 to 100 days for hydrolysis 50% of the pyrophosphate. In addition, **Gilliam** and **Sample (1968)** and **Hossner** and **Melten (1970)** indicated that 10 to 20% of the applied pyrophosphate has been observed to be quite resistant to hydrolysis due to the formation of insoluble products.

Its clear from Table (33) that fertilization of barley plants with P has significant effect on Zn content in plants. This effect depends on soil type and sources of phosphate. However, in El-Nobaria soil, application of P either orthophosphate or pyrophosphate decrease Zn content of barley plants. The percent of decrease ranged from 11% and 16% below the control. No significant difference between the two sources of P on Zn content of plants was observed.

The decrease of Zn content in barley due to P application, may be due to the decrease of Zn availability in soil resulted from zincphosphate formation and/or the physiological effect of P on Zn adsorption by plants.

Similar results were obtained by **Prabhakaran** and **Baru (1975)** for maize. They found that enhanced P application reduced Zn concentration in shoots by more than half as compared to roots. This was attributed to the antagonistic effect of P on Zn movement within the plants.

Brown et al. (1970) found that P application increased Zn deficiency in maize with no Zn treatment and Zn increased P deficiency in plant with no P treatments. The deficiency in both cases was readily corrected by applying the appropriate element.

Data in Table (33) show slight increase in Zn uptake in plant due to P application, the increase did not exceeded 12% and 5% over no P treatment for orthophosphate and pyrophosphate, respectively. Contrarily to El-Nobaria soil, application of P to El-Sir soil of relatively higher plant Zn content, the increase was more pronounced with pyrophosphate than orthophosphate application.

In case of orthophosphate, the magnitude of increase was 12% and 10% over no P treatment for first and second cut, respectively. Meanwhile the values of increases were 18% and 16% over no P treatment in first and second cut, respectively, for pyrophosphate source. With respect to Zn uptake in El-Sir soil Table (33) the data showed markedly increase in Zn with P application with no significant difference between the two P sources. However, increase in total Zn uptake was 50% and 44% over no P treatment for orthophosphate and pyrophosphate, respectively.

Similar results were obtained by **Orabi et al. (1981)**who found that, in pot experiment application of P increased the Zn content of corn plants and application of Zn increased that of P.

4.8.2.3. Zinc:

Regardless of other variables, it was observed from the data presented in Table (34) that the application of Zn to both soils resulted in an increase in both Zn and P concentration in barley plants .

However, the increase in both elements in the second cut was much more higher in the first one in El-sir soil than in El-Nobaria ones. The increase in Zn content in plants due to the application of Zn was much more pronounced than P. For example, the percentage increase in Zn content in plant due to Zn application was 59% and 103% over no Zn treatment for El-Sir in the first and second cut, respectively.

For El-Nobaria , the corresponding values were 161% and 19% over no Zn treatments in the first and second cut, respectively. Moreover, Zn content in plants improved time in the fertilized soil with Zn. The increased in Zn content in second cut was 15% more than Zn content in the first cut.

With regard to the total uptake of Zn (Table , 34) as affected by Zn application, the data shows that the uptake of Zn increased markedly by 105% in El-sir soil and 35% in El-Nobaria over no Zn treatment. This differences in Zn uptake in both soils can be attributed to the differences in the dry matter yield which was higher in El-Sir soil than in El-Nobaria one. Similar results were obtained by **Pathak et al., (1975).** who found that the concentration of Zn in rice plant tissue increased with increasing its supply.

As previously mentioned, Zn application to soil improved P content in barley plants both in concentration and uptake (Table ,34). The maximum increase in P concentration was 29% and 14% over no Zn treatment in El-Nobaria and El-Sir soil, respectively. Also, the availability of P to plant due to Zn application was more pronounced with time progress. The corresponding values in P uptake was 30% and 25% over no Zn treatment for El-Nobaria and El-Sir, respectively. The positive correlation between Zn application and P content in plant may be attributed to the increase in Zn content in plant which improved Zn/P ratio and Favoured nutrient balance that increased P utilization by. barley plants, (**Boawn** and **Leggett, 1964** and **Rosell, Ulrich, 1964).** On the other hand, the obtained results are in agreement with that reported by **Sharma et al. (1968),** on rice.

4.8.2.4 Organic matter Vs. Phosphorus:

From Table (35) the data show that both P concentration and uptake by barley plants significantly increased by the application of mixed P and organic matter. The magnitude of increase was more pronounced in El-Sir soil than El-Nobaria ones. This may be due to the low level of organic matter and available P in El-Sir compared with El-Nobaria soil. For

Table (35) Phosphorus and organic matter interaction effect on phosphorus content in barley plants grown in calcareous soils.

OM treatment / P-treatment	1st cut				2nd cut				Total	
	-		+		-		+		-	+
	%	mg/pot	%	mg/pot	%	mg/pot	%	mg/pot	%	mg/pot
El-Nobaria soil										
-P	0.065	1.49	0.119	3.60	0.074	0.79	0.135	3.71	2.28	5.45
+OP	0.121	3.24	0.155	5.76	0.125	1.78	0.190	3.84	5.02	9.60
+PP	0.116	3.11	0.150	4.91	0.115	1.44	0.177	3.19	4.54	8.10
El-Sir soil										
-P	0.054	1.14	0.147	5.23	0.066	0.81	0.147	2.83	1.95	8.06
+OP	0.132	4.21	0.172	6.58	0.122	2.77	0.170	4.56	6.98	11.14
+PP	0.129	4.07	0.193	7.00	0.131	2.74	0.190	4.64	6.81	11.64

Table (36) Phosphorus and organic matter interaction effect on Zinc content in barley plants grown in calcareous.

OM treatment / P-treatment	1st cut				2nd cut				Total	
	-		+		-		+		-	+
	ppm	µg/pot	ppm	µg/pot	ppm	µg/pot	ppm	µg/pot	ppm	µg/pot
El-Nobaria soil										
-P	51	118	44	134	60	64	51	68	182	202
+OP	44	119	40	150	47	67	47	94	186	244
	44	119	43	142	48	60	81	81	179	223
El-Sir soil										
-P	40	86	43	151	46	58	81	81	144	232
+OP	53	173	39	150	53	125	118	118	248	268
+PP	47	151	41	148	53	121	118	118	272	266

example, the average of increases in P concentration was 148% and 135% over control in El-Sir, when orthophosphate and pyrophosphate were used respectively. For El-Nobaria, the corresponding values were 188% and 173% over control in case orthophosphate and pyrophosphate, respectively. However, P uptake by plants was synergestically influenced by the interaction of P and organic matter, as it increased by about 321% and 255% in El-Nobaria and 470% and 497% in El-Sir over control for orthophosphate and pyrophosphate, respectively.

From Table (36) the data reveal that P and organic matter interaction effect on Zn content in barley plants diferred from soil to another based on the P source . In El-Nobaria, the interaction of P and organic matter decreased Zn concentration in plant by 22% and 16% in the first cut and 22% and 25% in the second below control treatment for orthophosphate and pyrophosphate, respectively. The decreases could be attributed partly to dilution effect resulted from the positive response to P and organic matter application. On the other hand, Zn uptake by plant increased due to P and organic matter interaction. The percentage of increase ranged from 20-46% with an average value 29% over control treatment. The magnitude of increase was more higher with orthophosphate than pyrophosphate fertilizer. The increases in Zn uptake could be attributed to an increase in plant growth caused by P and organic matter application.

In El-Sir, of P and organic matter interaction on Zn content in plant was insignificant, while Zn uptake was increased. The percentage of uptake increase ranged from 78-

103% with an average 85% over control treatment. The magnitude of increase was higher in the second cut than in the first . In this respect, no significant difference between the two sources of P was observed.

4.8.2.5 Organic matter Vs. Zinc:

Data in Table (37) show that application of Zn and organic matter together increased Zn content in both soils. The magnitude of increase was more higher in El-Sir soil than in El-Nobaria ones, and in the second cut than in the first cut. The increases due to Zn and organic matter interaction were 7% and 9% in El-Nobaria and 54% and 96% in El-Sir for the first and second cut, respectively. The percent increase in total Zn uptake by plant due to Zn and organic matter interaction was 51% and 175% over control treatment for El-Nobaria and El-Sir soils, respectively. The high response in El-Sir soil could be due to its low inherent fertility compared to El-Nobaria soil.

P concentration and total P uptake by plant Table (38) increased significantly in both soils with little difference between them due to the differences in their content of P and organic matter. However the percent was 65% and 103% in El-Nobaria and 62% and 72% in El-Sir over control for the first and second cut, respectively. The corresponding increase in P uptake was 140% and 150% over control for El-Nobaria and El-Sir soils, respectively.

4.8.2.6 Phosphorus Vs. Zinc:

The data in Table (39) revealed that, application of phosphorus in the form of ortho or pyrophosphate to barley

Table (37) Zinc and organic matter interaction effect on Zinc content in barley plants grown in calcareous soils.

OM-level Zn-level	Zinc content								Total	
	1st cut				2nd cut					
	-		+		-		+		-	+
El-Nobaria soil										
-Zn	43	113	36	114	45	55	44	66	168	180
+Zn	48	122	46	160	54	69	49	93	191	253
El-Sir soil										
-Zn	28	70	36	131	27	38	31	62	108	193
+Zn	59	186	43	161	56	148	53	136	334	279

Table (38) Zinc and organic matter interaction effect on phosphorus content in barley plants grown in calcareous soils.

OM-level Zn-level	Phosphorus content								Total	
	1st cut				2nd cut					
	-		+		-		+		-	+
El-Nobaria soil										
-Zn	0.091	2.53	0.134	4.27	0.092	1.17	0.144	2.28	3.70	6.55
+Zn	0.113	2.88	0.150	5.28	0.19	1.54	0.187	3.59	4.42	8.87
El-Sir soil										
-Zn	0.106	2.88	0.176	6.40	0.105	1.60	0.156	3.13	4.47	9.53
+Zn	0.115	3.69	0.172	6.40	0.115	2.68	0.181	4.77	6.37	11.17

Table (39) Effect of Phosphorus and Zinc on Phosphorus content of barley plant

Zn- treatment / P-treatment	-				+			
	1st cut		2nd cut		1st cut		2nd cut	
	ppm	µgpot^{-1}	ppm	µgpot^{-1}	ppm	µgpot^{-1}	ppm	µgpot^{-1}
El-Nobaria soil								
-P	0.091	2.20	0.082	0.85	0.093	2.79	0.127	1.80
+OP	0.124	4.19	0.133	2.32	0.145	4.66	0.170	3.05
+PP	0.122	3.73	0.121	2.01	0.138	4.15	0.149	2.46
El-Sir soil								
-P	0.095	2.84	0.095	1.47	0.106	3.52	0.118	2.17
+OP	0.162	5.56	0.130	2.67	0.148	5.31	0.155	4.17
+PP	0.166	5.51	0.167	5.95	0.159	5.55	0.158	4.06

Table(40) Effect of Phosphorus and Zinc on Zinc content of barley plant

Zn- treatment / P-treatment	-				+			
	1st cut		2nd cut		1st cut		2nd cut	
	ppm	µgpot^{-1}	ppm	µgpot^{-1}	ppm	µgpot^{-1}	ppm	µgpot^{-1}
El-Nobaria soil								
-P	41	46	45	46	54	156	66	86
+OP	37	122	44	73	45	141	49	85
+PP	41	123	45	63	45	143	47	75
El-Sir soil								
-P	37	100	33	48	46	137	54	91
+OP	31	106	27	54	54	189	59	155
+PP	29	96	28	49	51	177	62	153

plants increased P content in barley plants gown in treated or untreated soils.

The interaction effect of P Vs. Zn on P content is presented in Table (39). The data show that application of P and Zn increased P content in plant either concentration or uptake. The increases were pronounced in the second cut and no significant difference between two P-sources. However, the percentage of increases ranged from 52-67% for El-Nobaria and El-Sir soils, respectively.

The data presented in Table (40) show that application of P generally decreased Zn content in barley plants grown in El-Nobaria soil treated or untreated with Zn. However, the magnitude of decreases were more pronounced with soil treated with Zn. The percentage of decrease was 20 and 38% for untreated and treated soil with Zn, respectively. The decreases of Zn content in plant grown in untreated soil can be due to the dilution effect resulted from increasing the growth. But the same decrease in treated soil can be due to the antagonistic effect between P and Zn in soil. This obvious from the decreases in total Zn uptake by plant. However, The application of both Zn and P together had a positive effect on Zn content in barley plants compared with control treatment. No significant difference between the two P-source in reducing Zn content in plant.

With ranged to total Zn uptake Table (40) the data show that ZnxP interaction increased Zn uptake by plant. The average increases were 59 and 47% over control for ortho and pyrophosphate, respectively.

For El-Sir soil, the effect of ZnxP interaction diferred from El-Nobaria. The results indicate that application of P decreased Zn content in plants only from unfertilized soil with Zn. This may be attributed to the antagonistic effect between P and Zn in soil .It is an opposite trend was noticed when Zn was applied. The Zn content in plant either concentration or uptake increased with P application. This may be attributed to the favorable effect of P on Zn content when the status of Zn in soil was higher. However, the application of P and Zn together resulted an increase in Zn content. In plant. The average increase in Zn content due to P and Zn interaction was 46 and 79% and 38 and 55% over control for ortho and pyrophosphate, respectively. Also, the corresponding percent increase of total uptake of Zn was 132 and 124% over control for ortho and pyrophosphate, respectively.

It is evident from the data (Tables, 31& 32) that application of zinc and phosphorus together led to increase the content of both elements in plant either zinc applied at first followed by phosphorus or the opposite.

The increases percent were improved with time . The increases were higher in the second cut than in the first one. However, no definite trend for the sequence effect of applied P and Zn on Zn content in plant in both soils could be detected. However, there are performance to applied phosphorus either as orthophosphate or pyrophosphate at first followed by zinc. Concerning zinc content in barley plants, the average increases in zinc content in plant were 9% and 11% over the control treatment in the first and second cut, respectively, for El-Nobaria soil.

The corresponding values in El-Sir soil were 42% and 82% over control of the first and second cut , respectively.

With respect to total Zn uptake by barley, the data in Table (32) show that the Zn uptake generally increased as the result of zinc and phosphorus application together even Zn applied before phosphorus or not. The increases in Zn uptake can be concluded to the increase in dry matter yield to application of both elements and/or Zn concentration due to Zn application to plant.

It is clear from Table (31) that for both soils, application of P and Zn together increased P content either as concentration or total uptake by plant. The improvement in P nutrition increased with time and when Zn applied first followed by P than when P applied first followed by Zn. The orthophosphate-P source was superior in increasing P content in plant. For example, for El-Nobaria the percent of increase were 40 and 51% and 262 % over control when phosphate applied first followed by Zn for ortho and pyrophosphate, respectively. The corresponding values were 68 and 126% over control in the second cut, respectively. When Zn was applied at first followed by P, the increases were 68 and 84% in the first cut and 103% and 262% in the second once over control for PPxZn and ZnxPP treatments, respectively. Also, the increases in P uptake were 132, 158, 97 and 123% over control for OPxZn, ZnxOP, PPxZn and ZnxPP treatments, respectively.

Similar results, were obtained in case of El-Sir soil but the magnitude was less than El-Nobaria soil. However, the increases in P content were 45, 65, 62 and 73% in the first cut and 49, 76, 79 and 53% in the second one over control for OPxZn, ZnxOP, PPxZn and ZnxPP treatments, respectively. The corresponding increases in P uptake were110, 118, 144 and 102%, respectively.

4.8.2.7. Organic matter Vs. Phosphorus Vs. Zinc:

Data in Tables (31) reveal that the interaction effect on P, Zn and organic matter on P content followed the same trend of dry matter yield which increased significantly with P, Zn and organic matter application. The magnitude of increase was in average of 2.5 and 4.1 times relative to the control treatment, for the first and second cut respectively in El-Nobaria soil. For El-Sir soil, the average increase due to the interaction effect of P, Zn and organic matter was 3.1 times over control treatment. These data coincided with the data obtained for dry matter yield and Zn and P content ion plant as effected by Zn or P or organic matter .

Data in Tables (31&32) shows no significant effect of P, Zn and organic matter interaction on Zn content in plant grown in El-Nobaria soil. However, there was a little decrease in Zn content not exceeding 6% below control treatment. On the other hand, Zn uptake was doublled by the interaction of their variables.

In case of El-Sir soil, the data revealed that Zn content increased significantly due to the interaction of the three variables. The magnitude of increase ranged from 34-65% over control depending on number of cut and source of P fertilizer.

As to El-Nobaria soil, Zn uptake increased due to the interaction effect of the three variables. The increase was 212%

over control. P content in plant increased by P, Zn and organic matter interactions effect. The increase ranged from 2.5-4.1 fold in compassion with the control depending on soil and cut number. However, the magnitude of increase was more pronounced in El-Nobaria than El-Sir soil. Similar trend was noticed in P-uptake which increased 6 times compared to the control treatment. Again, the differences between soils in their response to P, Zn and organic matter interaction can be attributed to the differences in their content from organic matter, and available Zn and P.