RESULTS AND DISCUSSIONS

4- RESULTS AND DISCUSSION

4-1. Factors controlling availability of some nutritive elements in soils:

Among the many factors that affect availability of plant nutrients in soils, $CaCO_3$ and the interaction between these nutrients will be of special concern in this part of study.

4.1.1. Effect of $CaCO_3$:

$CaCO_3$ is thought to affect availability of most if not all elements in soil. The $CaCO_3$ effect may involve physical and/or chemical reactions such as adsorption and precipition . The following is a trial to clarify the effect of $CaCO_3$ on availability of P, Zn, Fe, Mn and Cu in the sandy and Nile alluvial soils.

4.1.1.1. Phosphorus availability:

The effect of $CaCO_3$on availability of P in both the studied sandy and Nile alluvial soils can be deduced from data presentend in Table (2) and illustrated graphically in Figure (1).

It is quite clear that values of the available P were markedly decreased as $CaCO_3$was solely applied to the studied soils. The decrease seemed to be more obvious by increasing rate of the applied $CaCO_3$ where increasing this rate from 0 (control) to 30 % was associated with sharp decrease in available P contents from 9.32 to 1.50 ppm and from 13.2 to 3.1 ppm in the sandy and Nile alluvial soils, respectively.

Table (2): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the availability of P (ppm).

Rate of applied	Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
$CaCO_3$ (%)	0	5	10	0	5	10
The sandy soil						
0	9.32	7.11	5.30	9.32	6.20	4.22
10	6.61	5.80	4.20	6.61	5.10	3.80
20	3.20	2.92	2.31	3.20	2.20	1.85
30	1.50	1.10	0.95	1.50	0.95	0.81
Mean	5.15	4.23	3.19	5.15	3.61	2.67
The Nile alluvial soil						
0	13.20	10.10	7.42	13.20	8.55	6.33
10	9.88	7.30	5.11	9.85	6.10	4.00
20	5.32	3.95	2.62	5.32	3.10	2.02
30	3.10	2.55	1.20	3.10	1.92	0.98
Mean	7.86	5.97	4.08	7.86	4.91	3.33

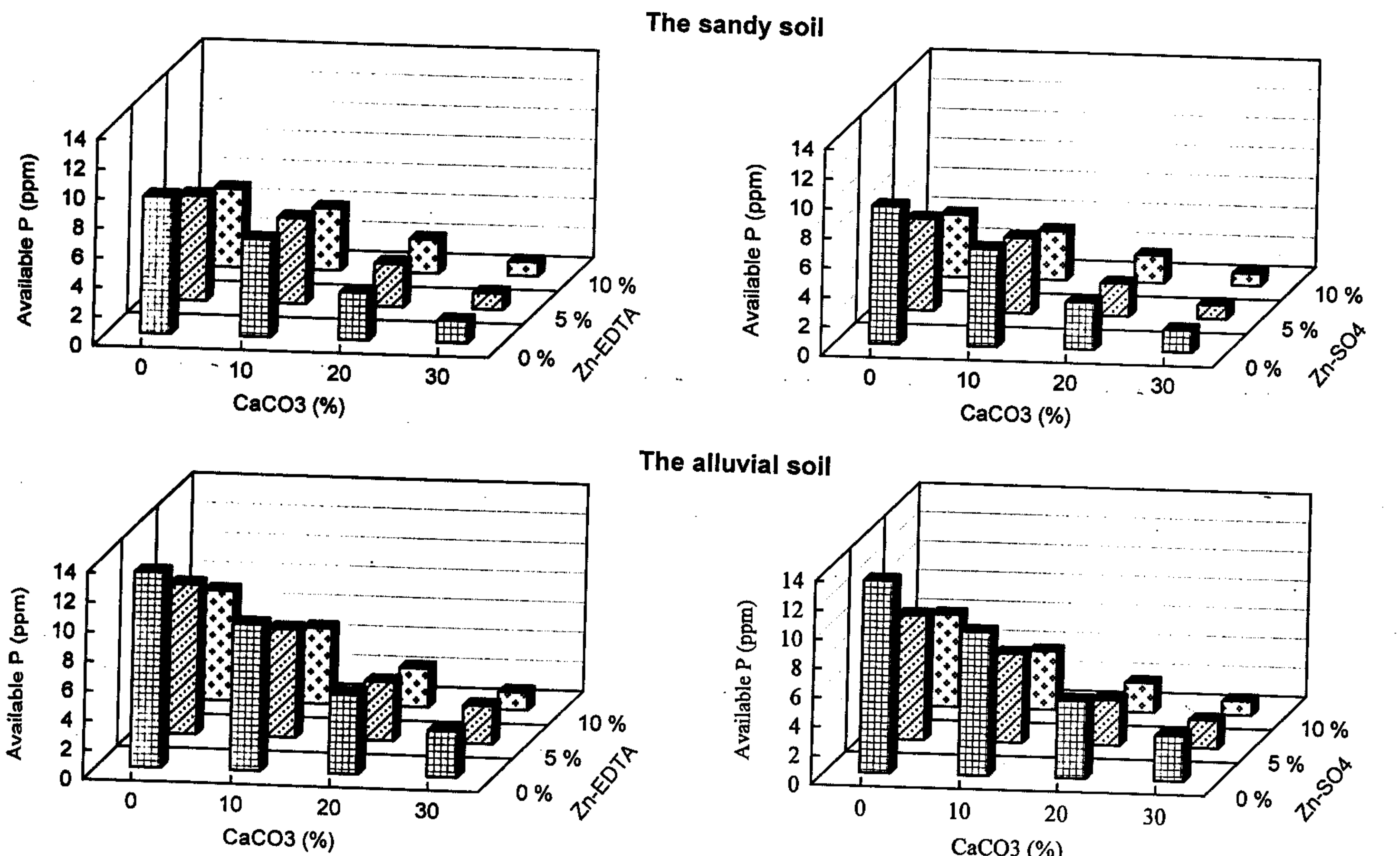


Fig. (1): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on the availability of P (ppm).

When the $CaCO_3$ was applied to the sandy soil associated with application of Zn at a rate of 5 ppm in either of its studied froms i.e. the cheleted (ZnEDTA) or the sulfate form ($ZnSO_4$) ,the available P content decreased from 7.11 to 1.1 ppm and from 6.20 to 0.95 ppm , respectively upon rising the applied rate of $CaCO_3$ from 0 up to 30%.

When the Nile alluvial soil was treated in a way such like the abovemtioned one i.e application of Zn at a rate of 5 ppm in either the chelated or the sulfate form associated with increasing rate of the applied $CaCO_3$ from 0 up to 30 % , the available Pcontent decreased from 10.10 to 2.55 ppm and from 8.55 to 1.99 ppm , respectively.

Rising rate of Zn applied to the sandy soil to 10 ppm whether in the chelated form or the sulfate one was associated with corresponding decreases in its contents of available P from 5.30 to 0.95 ppm and from 4.22 to 0.81 ppm , respectively upon increasing the applied rate of the $CaCO_3$ up to 30 %. The same aforementioned treatment resulted in decreases in the Nile alluvial soil contents of available P from 7.42 to 1.20 ppm and from 6.33 to 0.98 ppm, respectively.

The decrease in availability of P may be attributed to adsorption of P on surfaces of the $CaCO_3$particles. Such a conclusion might be confirmed by the results obtained herein which showed that the availability of P was reduced and the reduction was more obvious by increasing rate of the $CaCO_3$applied to the studied soils. Similar findings were achieved by **Amer (1965), Holford and Mattingly (1975 a), Abbas (1980), Soltan (1992)** and **Balba (1995)** who indicated that phosphate sorption at a given level in the low range of P concentration is directly propartional to the amount of $CaCO_3$ present.

However, **Black(1968)** reported that active calcium whether it was in the soil solution or as $CaCO_3$ is considered to be the principal agent responsible for reducing P availability in soils.

4.1.1.2. Zinc, iron, manganese and copper availability:

Data presented in Tables (3, 4, 5 and 6) and illustrated graphically in Fig. (2, 3, 4 and 5) reveal the effect of $CaCO_3$ on availability of Zn, Fe, Mn and Cu in the studied sandy and Nile alluvial soils.

a- Zinc availability:

It is clearly noticed from data presented in Table (3) and illustrated in Fig. (2) that applying $CaCO_3$ solely to either of the studied soils was associated with a decrease in soil content of DTPA - extractable Zn. The decrease seemed to be dependent on rate of the $CaCO_3$ applied to the soils i.e., the higher the applied rate of the $CaCO_3$ the less the DTPA-extractable Zn content from the studied soils. Such finding was observed also when the $CaCO_3$ was applied in combination with Zn at different rates.

DTPA-extractable Zn content of the untreated sandy and Nile alluvial soils were 0.55 and 1.98 ppm, respectively. The sole application of $CaCO_3$ at a rate of 10 % decreased these contents to 0.32 and 1.20 ppm, respectively. When the rate of the applied $CaCO_3$was raised to 20 %, the corresponding DTPA -extractable Zn contents were decreased to 0.19 and 0.90 ppm, respectively, whereas, at the highest rate of 30 % $CaCO_3$, the DTPA-extractable Zn contents

Table (3): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the availability of Zn (ppm).

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
	0	5	10	0	5	10
The sandy soil						
0	0.55	3.10	6.35	0.55	2.82	6.10
10	0.32	2.00	3.22	0.32	1.72	3.02
20	0.19	1.92	2.20	0.19	1.63	1.90
30	0.08	1.10	1.50	0.08	0.95	1.33
Mean	0.28	2.03	3.31	0.28	1.78	3.08
The Nile alluvial soil						
0	1.95	5.95	8..80	1.95	5.30	7.90
10	1.20	4.72	6.11	1.20	4.55	5.92
20	0.90	2.90	4.20	0.90	2.70	3.94
30	0.50	1.62	3.12	0.50	1.39	2.82
Mean	1.13	3.79	5.55	1.13	3.48	5.14

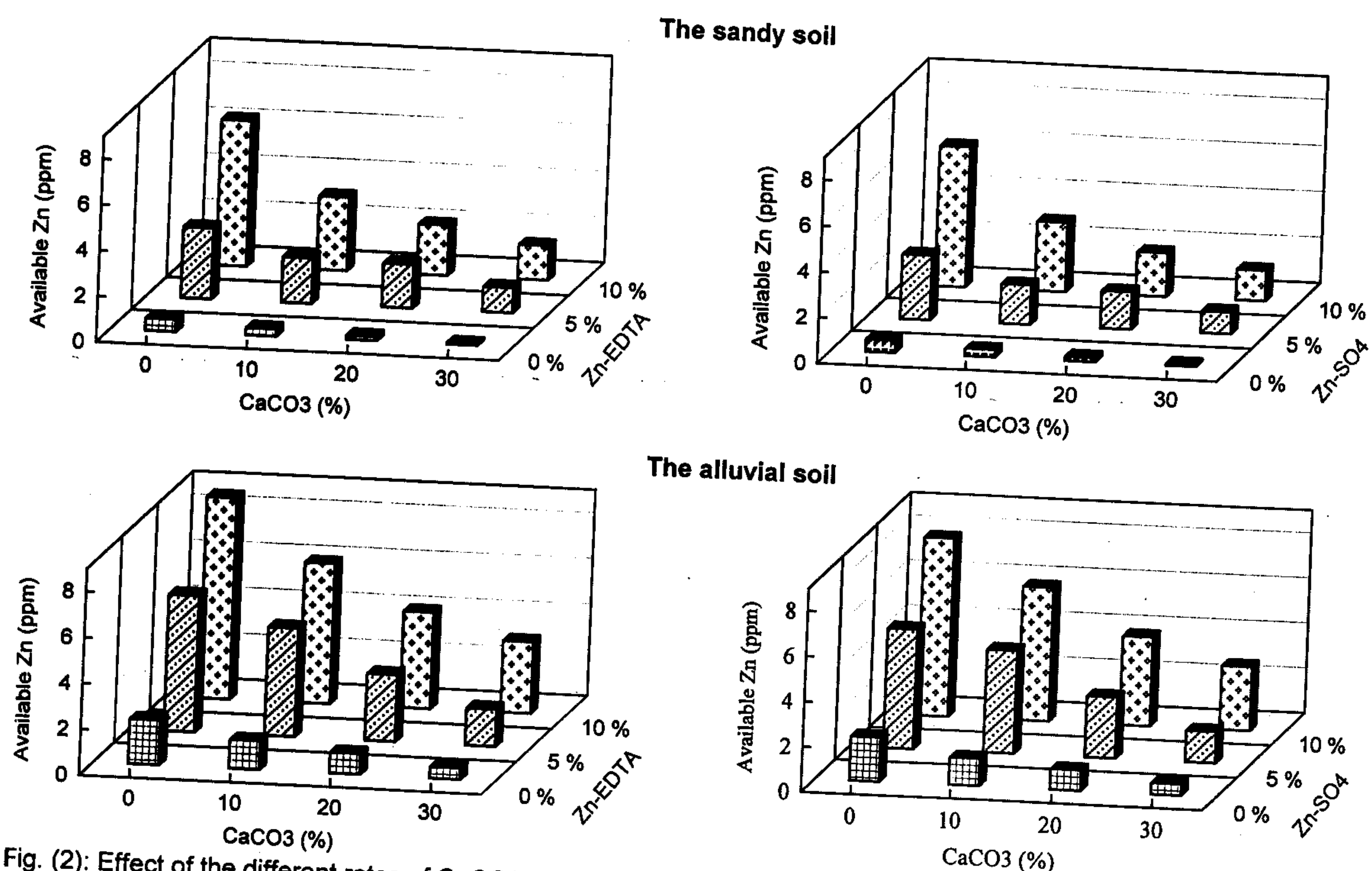


Fig. (2): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on the availability of Zn (ppm).

of the studied soils attained their lowest values reached 0.08 and 0.50 ppm, respectively.

It is worthy to note that although appling zinc in combination with the $CaCO_3$ at three different rates i.e 0, 5 and 10 ppm Zn in the form of Zn EDTA or $ZnSO_4$ resulted in an increase in the DTPA - extractable Zn in both the studied soils yet the increments of Zn due to increasing rate of the applied zinc were noticed to be reduced upon increasing rate of the applied $CaCO_3$.

Such finding assures the role played by $CaCO_3$ in decreasing avaiability of Zn whether it is originally present in soil or applied to it as a fertilizer. These findings are in agreement with those obtained by **Lindsay et al. (1966), Udo et al. (1970),Abd Allah (1973), Yasrebi et al. (1994)** who attributed the negative effect of $CaCO_3$ on availability of Zn to adsorption of Zn on surface of $CaCO_3$ particles and/or formation of Zn complexed compounds.

b- Iron availability :

Extractability of Fe by DTPA was reduced in both the sandy and Nile alluvial soils upon increasing rate of the $CaCO_3$ applied therein (Table 4 and Fig. 3). The untreated sandy and Nile alluvial soils contents of DTPA-extractable Fe were 2.29 and 4.47 ppm decreased to 1.57 and 1.43 ppm, respectively upon applying $CaCO_3$ to these soils at a rate of 10 % .

Increasing rate of the applied $CaCO_3$ to 20 % reduced the available Fe contents to 1.35 and 1.37 ppm in the sandy and Nile alluvial soils, respectively. At the highest rate of the $CaCO_3$ applied to the studied soils, the DTPA-extractble Fe contents achieved their lowest values i.e 1.25 and 1.27 ppm , respectively.

When zinc was applied to both the studied soils at different rates combined with the applied $CaCO_3$, the effect of $CaCO_3$ on DTPA-extractable Fe did not change from that exerted by $CaCO_3$ when it was applied solely. These results stands in well agreement with those obtained by **Singh and Dahiya (1976), Dahiya and Singh (1982)** who attributed the decrease in iron availability in presence of $CaCO_3$ to the conversion of soluble iron into insoluble ferric hydroxide or ferric oxide. Similar results were obtained also by **Loeppert and Hallmark (1985), Loeppert (1986), Brady (1990) and Abd El Haleem (1991)** who found that DTPA-extractable Fe correlated negatively and significanty with $CaCO_3$ content of soils. **Farid (1995)** attributed such decrease in DTPA- extractable Fe to the precipitation of Fe in the form of $FeCO_3$ whereas **Jorda etal. (1987)** concluded that the basic mechanism of Fe retention is sorption on the surface of carbonate in soil which would justify the rapid disappearance of Fe in the solution.

c- Manganese availability:

Effect of $CaCO_3$ on DTPA-extractable Mn from both the sandy and Nile alluvial soils can be demonstrated from the results presented in Table (5) and illustrated graphically by Fig. (4).

In case of applying $CaCO_3$ solely, the sandy and Nile alluvial soils contents of DTPA -extractable Mn decreased from 2.60 and 4.50

Table (4): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the availability of Fe (ppm).

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
	0	5	10	0	5	10
The sandy soil						
0	2.29	2.20	2.25	2.29	2.22	2.26
10	1.57	1.53	1.56	1.57	1.55	1.53
20	1.35	1.45	1.49	1.35	1.40	1.43
30	1.25	1.27	1.22	1.25	1.30	1.28
Mean	1.61	1.61	1.63	1.61	1.62	1.62
The Nile alluvial soil						
0	4.47	4.52	4.51	4.47	4.42	4.40
10	1.43	1.50	1.49	1.43	1.45	1.40
20	1.37	1.43	1.41	1.37	1.39	1.35
30	1.27	1.33	1.30	1.27	1.30	1.29
Mean	2.13	2.19	2.17	2.13	2.14	2.11

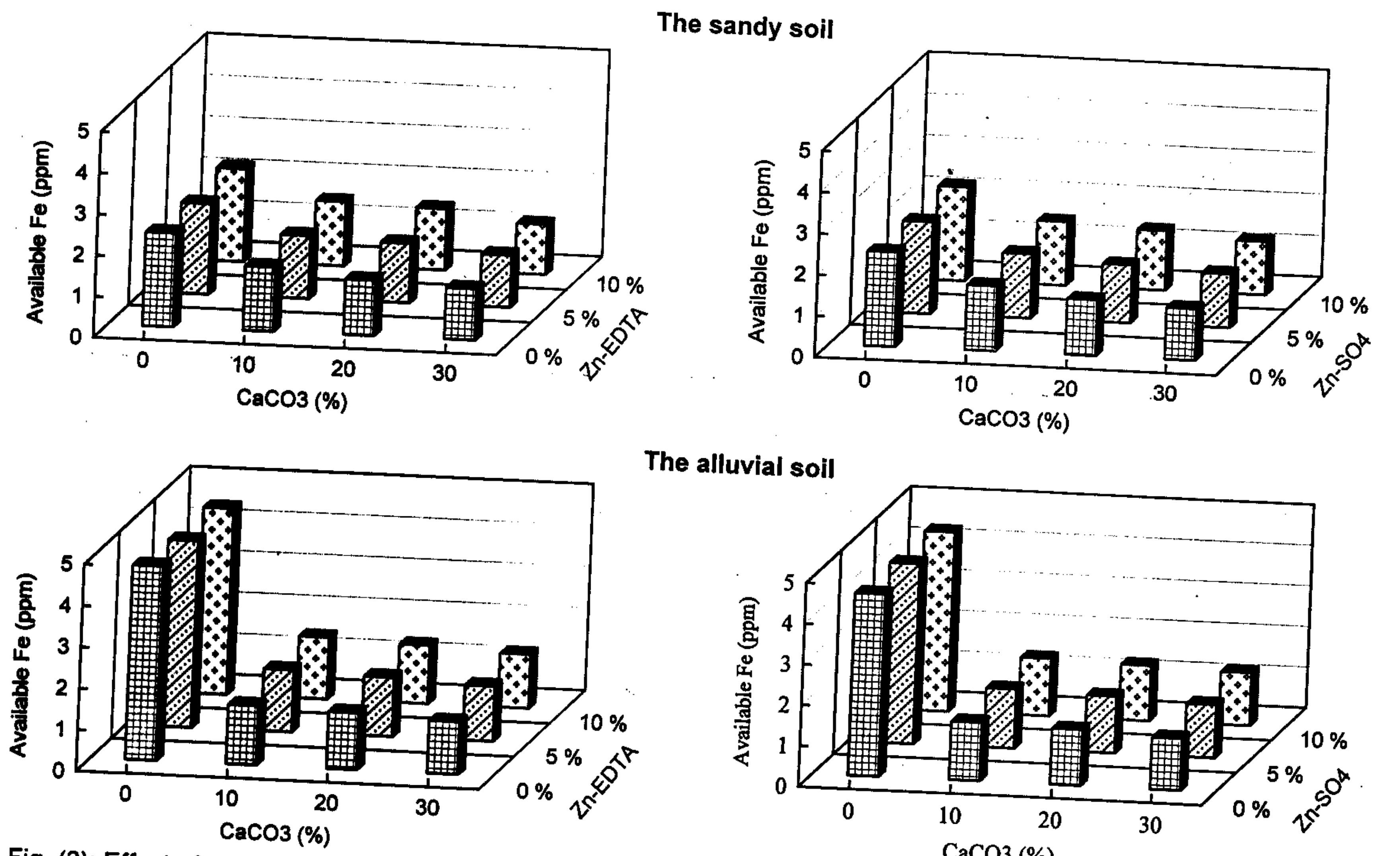


Fig. (3): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on the availability of Fe (ppm).

ppm to 1.20 and 2.80 ppm , respectively when rate of the applied $CaCO_3$ was raised from 0 up to 30 % .

The corresponding contents of Mn when Zn was applied at a rate of 5 ppm in the chelated form together with the $CaCO_3$ were 1.15 and 2.72 ppm whereas when Zn was added in its sulfate form at the same rate of application (5 ppm), the corresponding Mn contents were 1.18 and 2.70 ppm , respectively .

Rising rate of the applied Zn to 10 ppm in the chelated form caused the DTPA -extractable Mn contents from the sandy and Nile alluvial soils to decrease to 1.15 and 2.75 ppm , respectively when the $CaCO_3$ was applied at a rate of 30 % . The corresponding Mn contents when Zn was applied in the sulfate form were 1.13 and 2.7 ppm , respectively.

The aforementioned results postulate that availability of Mn (DTPA-extractable Mn) is affected by applying $CaCO_3$ to both the studied soils whether through sole $CaCO_3$ application or combinations of $CaCO_3$ with Zn in different forms and at different rates. Similar results were reported by Dahiya and Singh (1977), EL-Khomsy (1977), Mc Bride (1979), Liu et al. (1983) and Moore and Loeppert (1990).

d- Copper availability :

Data presented in Table (6) and illustrated in Fig. (5) indicate that $CaCO_3$ content applied to the sandy and Nile alluvial soils did not seem to affect the amount of DTPA -extractable Cu. This occurred

Table (5): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the availability of Mn (ppm).

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
	0	5	10	0	5	10
The sandy soil						
0	2.60	2.52	2.50	2.60	2.47	2.42
10	1.39	1.37	1.33	1.39	1.38	1.33
20	1.30	1.33	1.28	1.30	1.25	1.20
30	1.20	1.15	1.15	1.20	1.18	1.13
Mean	1.62	1.59	1.57	1.62	1.57	1.52
The Nile alluvial soil						
0	4.50	4.45	4.35	4.50	4.32	4.30
10	3.80	3.60	3.52	3.80	3.62	3.45
20	3.12	3.00	2.92	3.12	2.92	2.85
30	2.80	2.72	2.75	2.80	2.70	2.70
Mean	3.55	3.44	3.38	3.55	3.39	3.32

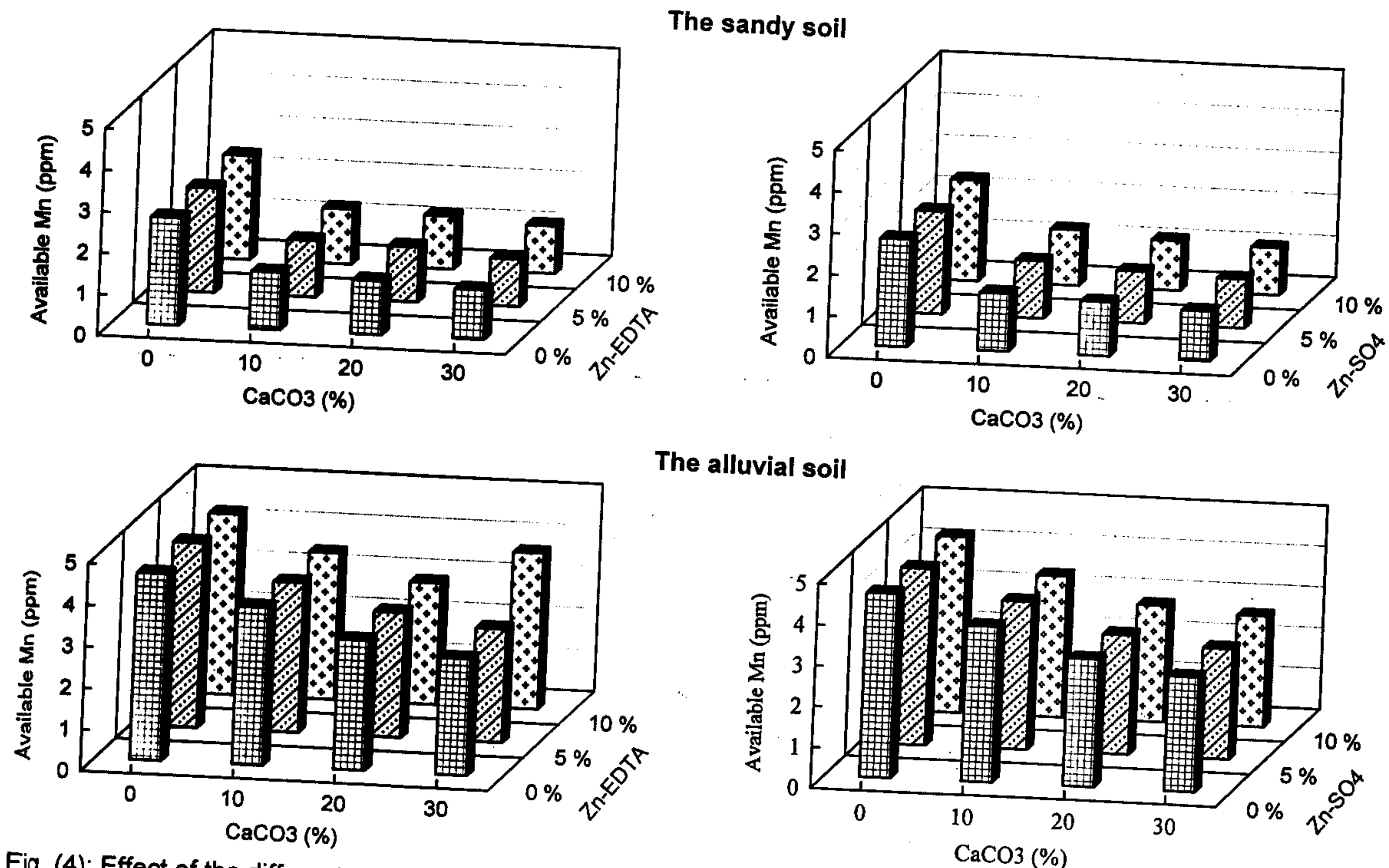


Fig. (4): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on the availability of Mn (ppm).

Table (6): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the availability of Cu (ppm).

$CaCO_3$ %	Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
	0	5	10	0	5	10
The sandy soil						
0	0.20	0.22	0.25	0.20	0.20	0.21
10	0.19	0.20	0.22	0.19	020	0.20
20	0.17	0.18	0.20	0.17	0.19	0.19
30	0.15	0.16	0.19	0.15	0.17	0.18
Mean	0.17	0.19	0.21	0.17	0.19	0.19
The Nile alluvial soil						
0	1.95	1.99	2.00	1.95	1.90	1.95
10	1.80	1.82	1.87	1.80	1.75	1.80
20	1.75	1.79	1.80	1.15	1.77	1.72
30	1.39	1.41	1.56	1.39	1.40	1.50
Mean	1.72	1.75	1.80	1.72	1.70	1.74

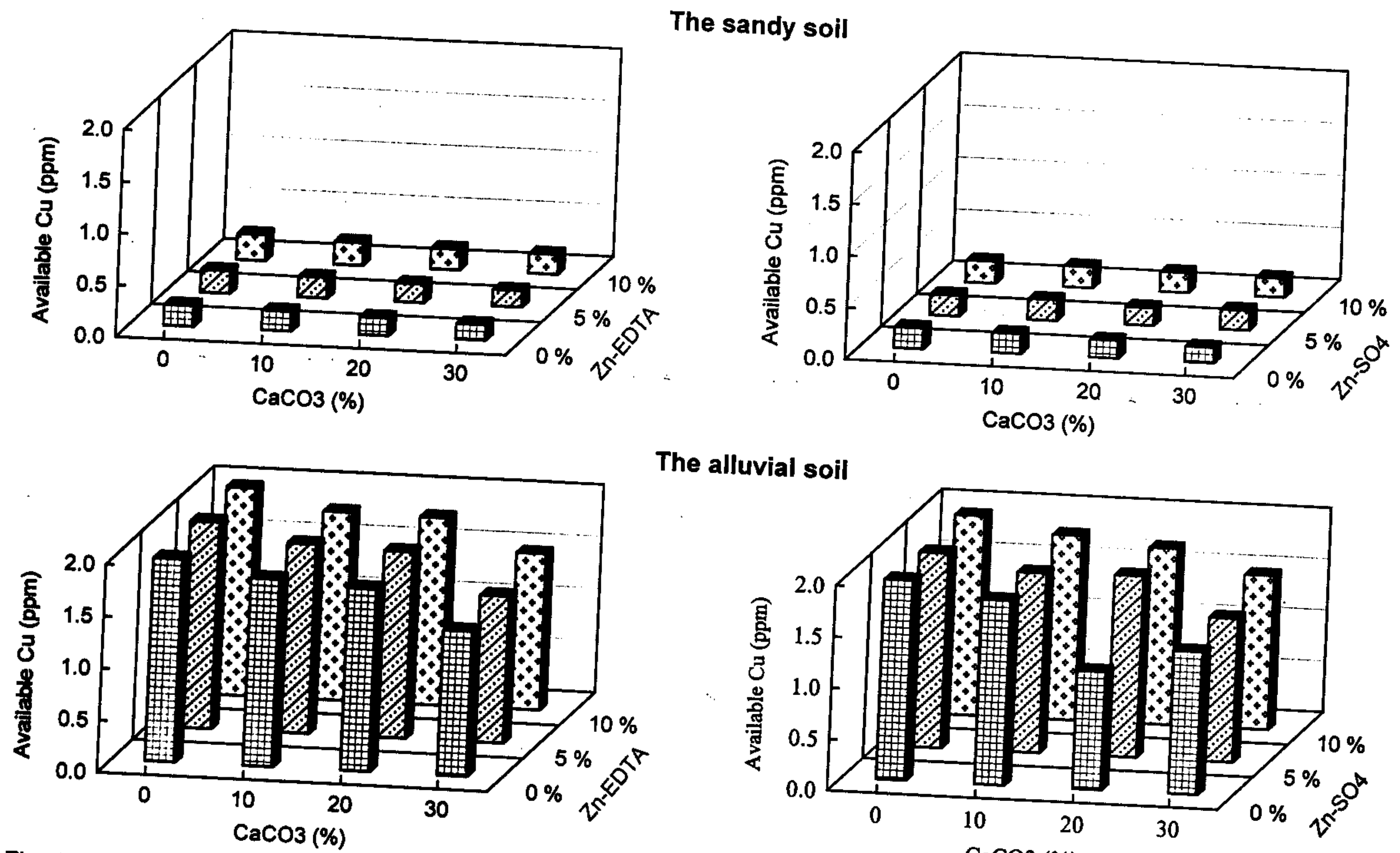


Fig. (5): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on the availability of Cu (ppm).

when $CaCO_3$ was applied solely as well as when it was combined with different rates and forms of Zinc. These results are in agreement with those obtained by Wassif (1973). On the other hand, Yu et al. (1991) found a negative correlation between soil contents of $CaCO_3$ and their Cu contents whereas Abd EL-Hamid (1981) and Pendias and Pendias (1992) reported a negative effect of the $CaCO_3$ content on soil content of the available Cu.

4.1.2. Effect of zinc:

4.1.2.1. Phosphorus availability:

It is obvious from data presented in Tables (3,4 and 6) and Fig. (2,3,4 and 5) that increasing rate of applied Zn could affect slightly the sandy and Nile alluvial soils, contents of available P . This occurred whether zinc was applied solely or in combination with different rates of $CaCO_3$. These results agree, to a great extent, with those achieved by **Verma and Kochroo (1984)** who indicated that the applied zinc could depress availability of P in soils very slightly.

Data in Table (3) reveal also that the depressive effect of the chelated form of the applied zinc on P availability seems to be relatively less than that of its sulfate form.

4.1.2.2. Zinc, Iron, Manganese and Copper availability:

Taking into consideration effect of zinc application on its DTPA -extractable amount, the results in Table (4) show that application of Zn resulted in an increase in the DTPA extractable Zn content in both the studied soils. The increase was more obvious by increasing rate of the applied Zn at all rates of the applied $CaCO_3$. It is worthy to mention, however, that the chelated form of the applied Zn was slightly more efficient in enriching both the studied soils with the available Zn. This occurred whether Zn was applied solely or combined with $CaCO_3$. Such finding assures the superiority of using the chelated Zn fertilizers rather than the sulfate ones. Similar conclusions were attained by Farid (1995) and Basyouny (1996).

The results in Table (5) and Fig. (4) reveal that the application of zinc either lowered very slightly increased or even did not affect the amount of DTPA -extractable Fe .

The decrease in extractability of Fe was observed in the sandy soil and may be attributed to ionic competition between Zn and Fe for chelating ligands **(Norvell, 1972)** or the ability of the colloidal Zn sulfate to form a coating on the adsorbed Fe and thus make it less extractable **(Venkata Subrahamanyam and Mehta, 1975)** . The limited number of the exchange sites in the sandy soil in the absence of the applied $CaCO_3$ or even under the its lowest rate of application (10 %) may account for such finding.

The decrease in availability of Fe due to application of Zn was observed also by **Mandal and Haldar (1980), Pulford (1982) and Alloway (1991).**

The slight increase in Fe extractability in both the sandy soil (under the higher rates of the applied $CaCO_3$) and the Nile alluvial soil might be attributed to a replacement of Fe by Zn on the exchange sites with a consequent release of Fe .

The results in Table (6) and Fig. (5) reveal that application of Zn resulted in slight decreases in the extractable Mn content. This occurred in both the studied soils and at all rates of the applied $CaCO_3$ and Zn ,yet the decreases seemed more obvious by increasing rate of the applied $CaCO_3$ as well as that of the applied Zn regardless of form of the applied Zn. Such finding is contradictory to these of **Venkata Subrahmanyam** and **Mehta (1973), Bear** and **Sekhon (1976)** and **Mandal** and **Haldar (1980).**

Finally data in Table (7) and Fig. (6) indicated that neither rate of the applied Zn nor its form seemed to have a certain effect on availability of Cu. Hulagur et al. (1975) and Mandal and Haldar (1982) however, found a negative relation between application of Zn extractability of Cu.

4.2. Effect of $CaCO_3$ applied solely or in combination with Zn on dry matter yield and nutrient contents of barley plants:

4.2.1. Dry matter yield:

Dry matter yields of barley plants grown on the sandy or the Nile alluvial soils whether untreated or treated with $CaCO_3$ solely or in combination with Zn either in its chelated from (Zn-EDTA) or the sulfate one ($ZnSO_4$) are presented in Table (7) and illustrated in Figs. (6a and 6b). It is evident that application of different levels of $CaCO_3$ up to 30% markedly decreased the dry matter yield of shoots and roots of barley plants grown on the sandy and the Nile alluvial soils as compared with the untreated ones. This finding is quit true for the plants grown on all the soils received $CaCO_3$ whether solely or in combination with Zn in both of its studied forms. Similar results have been observed by **Kleining and loveday (1962), Hutton and Fiskell (1963), Pauli et al. (1968)** and **Fayed (1993)** who reported that $CaCO_3$ addition significantly decreased total dry matter weight. In this connection, **Fathi (1978)** found that in highly calcareous soils in Egypt, the dry matter yield of corn plants was markedly reduced by the increase in their $CaCO_3$ content. Also, **Farid (1995)** reported that the dry matter yield of soybean plant grown on a calcareous soil was less than the corespondents in an Nile alluvial soil.

The decrease in the dry matter yield of both shoots and roots of barley plants as a result of addition of $CaCO_3$ was more pronounced in the sandy soil than in the Nile alluvial one. The relative decrease in the dry matter yield of shoots of the plants grown on the sandy and the Nile alluvial soils that were treated with only $CaCO_3$ at a rate of 30%

Table (7): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the dry yield of barley plants grown in the investigated soils.

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	2.14	1.62	2.65	1.82	3.09	1.98	2.14	1.62	2.61	1.69	2.85	1.75
10	2.07	1.59	2.60	1.80	3.09	1.92	2.07	1.59	2.50	1.58	2.80	1.71
20	1.95	1.32	2.42	1.63	2.75	1.75	1.95	1.32	2.32	1.52	2.55	1.65
30	1.42	1.15	2.15	1.41	2.52	1.59	1.42	1.15	2.05	1.35	2.28	1.41
Mean	1.89	1.42	2.45	1.66	2.85	1.81	1.89	1.42	2.37	1.53	2.62	1.63
The Nile alluvial soil												
0	3.29	1.81	3.68	1.95	3.98	2.20	3.29	1.81	3.49	1.83	3.65	1.90
10	3.20	1.72	3.62	1.89	3.87	2.00	3.20	1.72	3.29	1.75	3.56	1.81
20	3.00	161	3.43	1.75	3.59	1.90	3.00	1.61	3.09	1.65	3.30	1.74
30	2.30	1.35	2.85	1.55	3.15	1.75	2.30	1.35	2.65	1.39	2.92	1.43
Mean	2.94	1.62	3.30	1.78	3.64	1.96	2.94	1.62	3.13	1.65	3.35	1.72

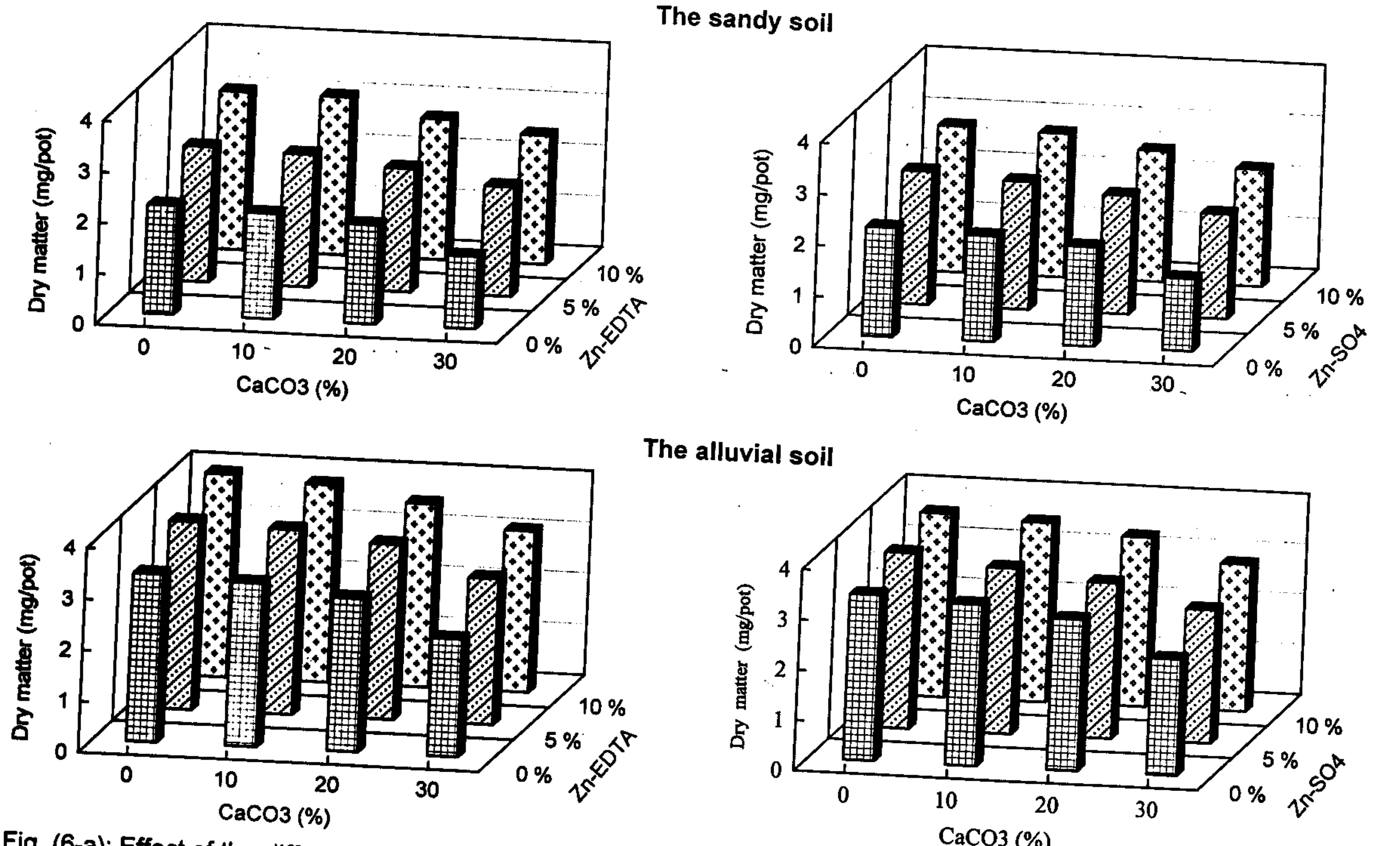


Fig. (6-a): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on dry matter yield of shoots of barley grown on the investigated soils.

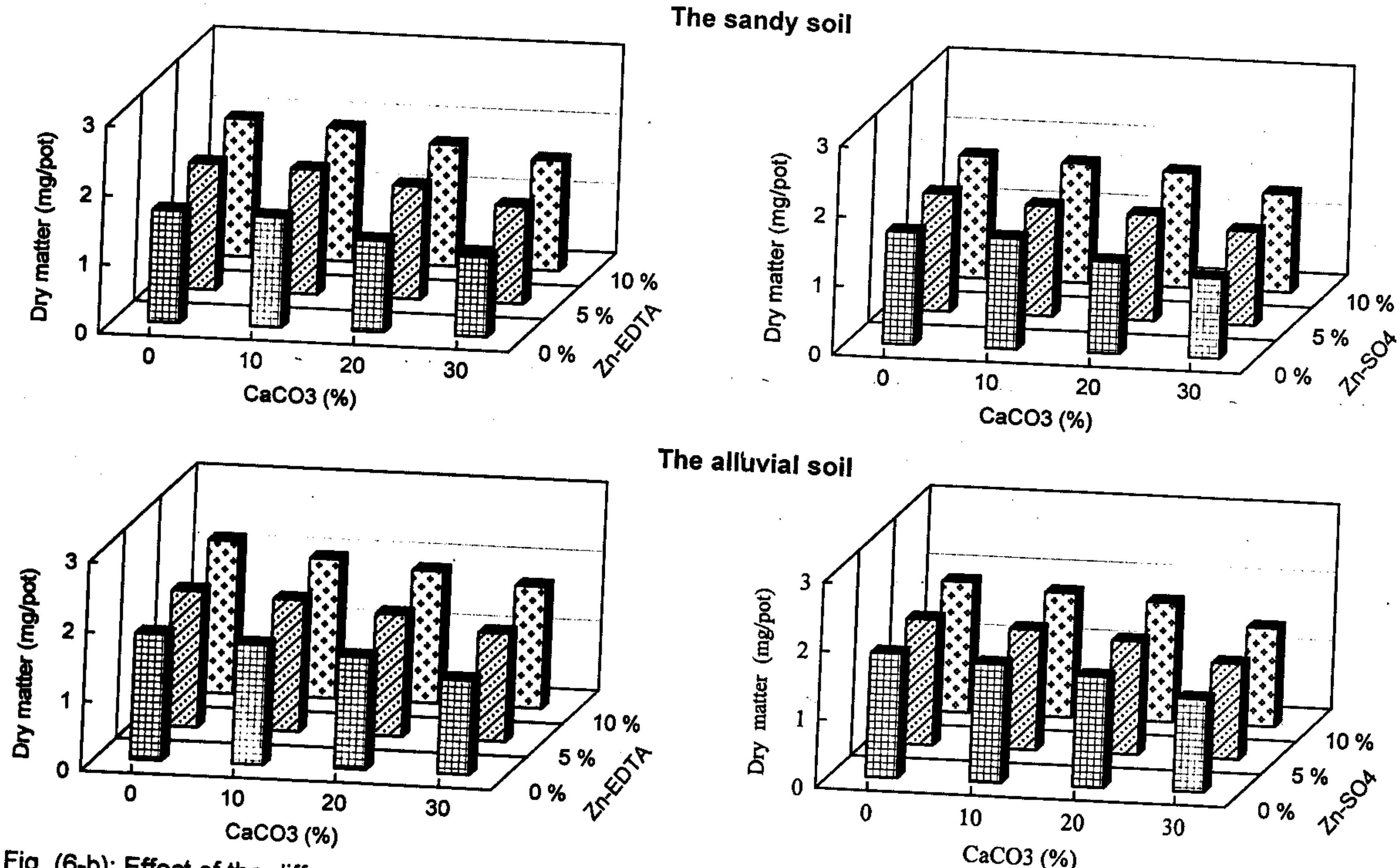


Fig. (6-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on dry matter yield of roots of barley grown on the investigated soils.

reached about 34% and 30%, respectively of the corresponding shoots dry matter yield of the plants grown on the untreated ones.

The relative decrease in the dry matter yield of roots of the plants treated as abovementioned was about 29% in both two soils under study.

With regard to effect of Zn application to the studied soils, the obtained results indicate that additions of Zn in both the forms up to a rate of 10 ppm resulted in a progressive increase in the dry matter yield of shoots and roots of barley plant grown on both the two soils. A positive response of barley plants to Zn application may be attributed to the enhancing effect of Zn on the plant growth in both the studied soils. Similar results were obtained by **Rathere et al. (1978)** who reported that application of Zn at 5 and 10 ppm levels increased grain and straw yields significantly over the control. **Singh and Singh (1980), Haldar and Mandal (1981)** and **Farid (1995)** went almost to similar results.

Taking into consideration effect of form of the applied Zn, data indicate that Zn-EDTA was relatively more efficient than $ZnSO_4$ on dry matter yield of both shoots and roots of the barley plants grown on both the sandy and Nile alluvial soils. This result indicates that Zn applied in a chelated form such as Zn-EDTA is of more beneficial effect on dry matter yield of shoots and roots of barley plants than Zn applied in an inorganic form ($ZnSO_4$). This result is in harmony with those obtained by **Anderson (1972), Prasad** and **Sinha (1981)** and **Farid (1995)** who found that the chelated form of Zn (Zn-EDTA) was more efficient than the mineral form in increasing dry matter yield of shoots and roots of soybean plant. He added that the difference between the two forms was highly significant.

4.2.2. Content and uptake of some nutritive elements by plants:

4.2.2.1. Phosphorus:

Data presented in Tables (8 and 9) and illustrated in Figs. (7a, 7b, 8a and 8b) show that P concentration and uptake by shoots and roots of the barley plants grown on the sandy and Nile alluvial soils were progressively decreased due to application of the $CaCO_3$. The decrease seemed more obvious with increasing rate of the applied $CaCO_3$ up to 30% where the magnitudes of reduction in both concentration and uptake were greatest at the highest rate of the applied $CaCO_3$. This occurred whether $CaCO_3$ was singly applied or in combination with Zn in both used forms and at all rates of its application. Similar results were obtained by **Orabi et al. (1985)** and **Fayed (1993).**

The decreases in both uptake and concentration occurred herein can be attributed to reduction in availability of P in soils as indicated by the results previously shown in Table (8) and illustrated in Figs. (7a & 7b).

With respect to the effect of rising level of Zn applied in both two forms to the sandy and the Nile alluvial soils on P concentration and uptake by both shoots and roots of the barley plant, data revealed a slight or even no reduction, in both uptake and concentration due to application of Zn. Rate of the applied Zn as well as its applied form seemed to be a neglected effect on both uptake and concentration of P in plant. These results agree, to some extent, with those obtained by

Table (8): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on P concentration (ppm) in barley plants grown on the investigated soils.

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	0.18	0.16	0.16	0.13	0.15	0.12	0.18	0.16	0.15	0.11	0.14	0.10
10	0.15	0.13	0.12	0.11	0.10	0.09	0.15	0.13	0.11	0.09	0.10	0.08
20	0.11	0.09	0.10	0.09	0.08	0.07	0.11	0.09	0.08	0.07	0.09	0.06
30	0.09	0.07	0.08	0.06	0.06	0.05	0.09	0.07	0.06	0.05	0.06	0.04
Mean	0.13	0.11	0.11	0.09	0.09	0.08	0.13	0.11	0.10	0.08	0.09	0.07
The Nile alluvial soil												
0	0.25	0.22	0.22	0.20	0.19	0.17	0.25	0.22	0.20	0.19	0.18	0.15
10	0.20	0.18	0.19	0.17	0.16	0.12	0.20	0.18	0.18	0.17	0.16	0.12
20	0.18	0.15	0.16	0.13	0.13	0.10	0.18	0.15	0.15	0.12	0.12	0.10
30	0.13	0.11	0.11	0.10	0.09	0.07	0.13	0.11	0.10	0.09	0.08	0.06
Mean	0.19	0.16	0.17	0.15	0.14	0.11	0.14	0.16	0.15	0.14	0.13	0.10

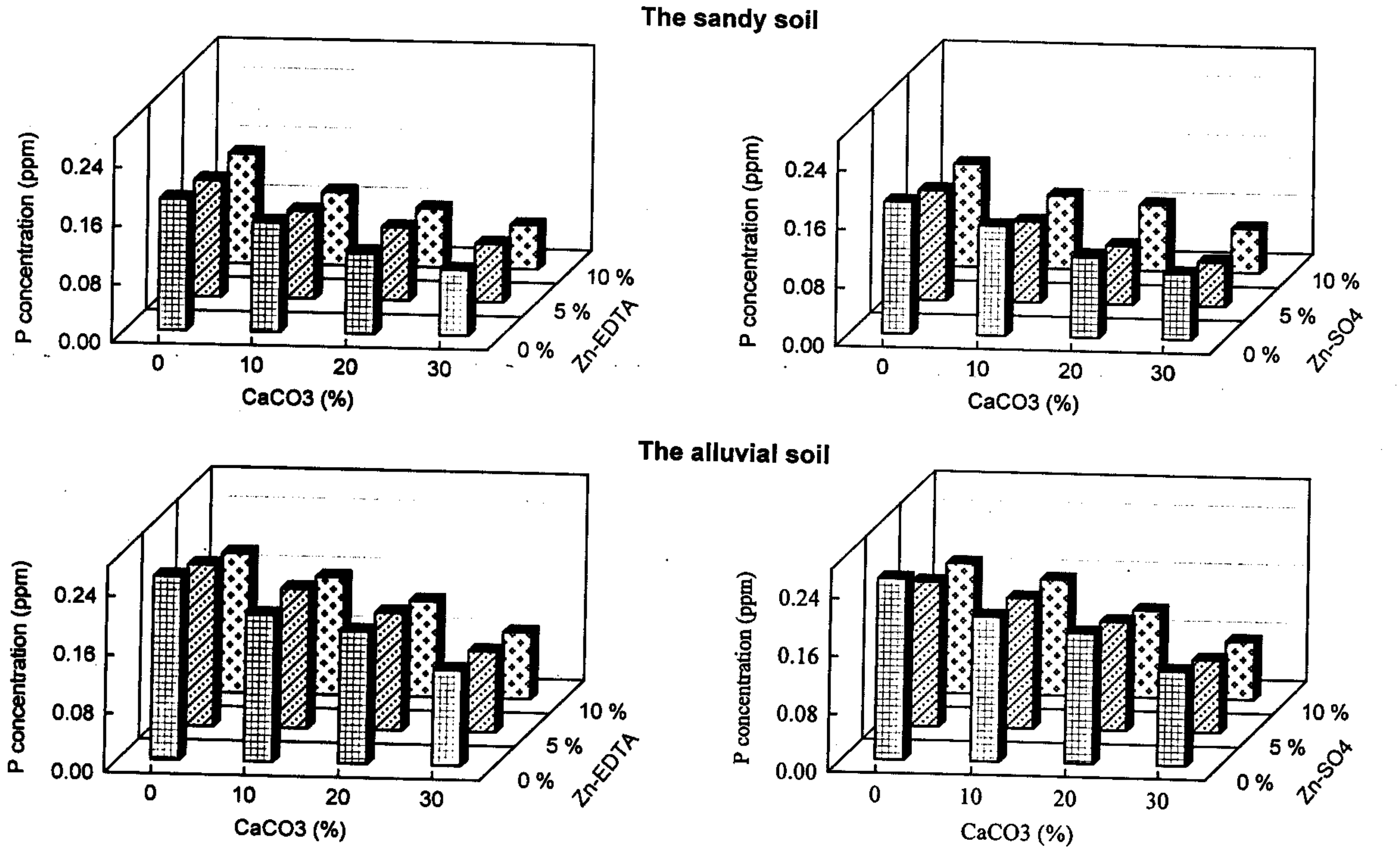


Fig. (7-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on P concentration (ppm) in shoots of barley plants grown on the studied soils.

The sandy soil

The alluvial soil

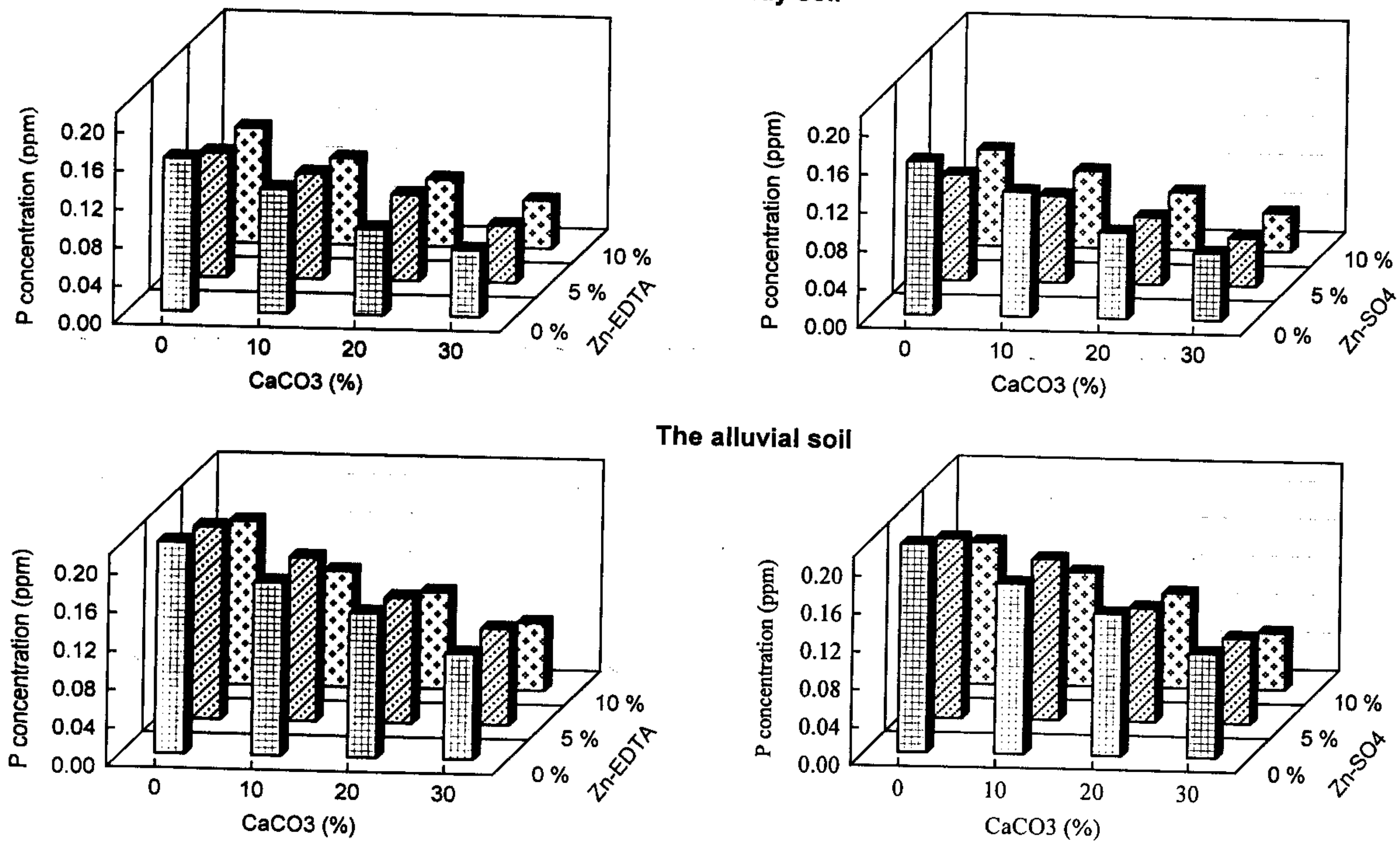


Fig. (7-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on P concentration (ppm) in roots of barley plants grown on the studied soils.

Table (9): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on P uptake (µg/pot) by barley plants grown on the investigated soils.

Rate of	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
applied	0		5		10		0		5		10	
$CaCO_3$ (%)	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	0.30	0.20	0.40	0.20	0.40	0.20	0.30	0.20	0.30	0.10	0.30	0.10
10	0.30	0.20	0.30	0.10	0.30	0.10	0.30	0.20	0.20	0.10	0.20	0.10
20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.10	0.01	0.20	0.09
30	0.10	0.08	0.10	0.08	0.10	0.07	0.10	0.08	0.10	0.06	0.10	0.05
Mean	0.20	0.10	0.20	0.01	0.20	0.10	0.20	0.10	0.10	0.09	0.20	0,08
The Nile alluvial soil												
0	0.80	0.30	0.80	0.30	0.70	0.30	0.80	0.30	0.60	0.30	0.60	0.20
10	0.60	0.30	0.60	0.30	0.60	0.20	0.60	0.30	0.50	0.20	0.50	0.20
20	0.50	0.20	0.50	0.20	0.10	0.10	0.50	0.20	0.40	0.10	0.30	0.10
30	0.20	0.10	0.30	0.10	0.10	0.10	0.20	0.10	0.20	0.10	0.20	0.08
Mean	0.50	0.20	0.50	0.20	0.20	0.20	0.50	0.20	0.40	0.10	0.40	0.10

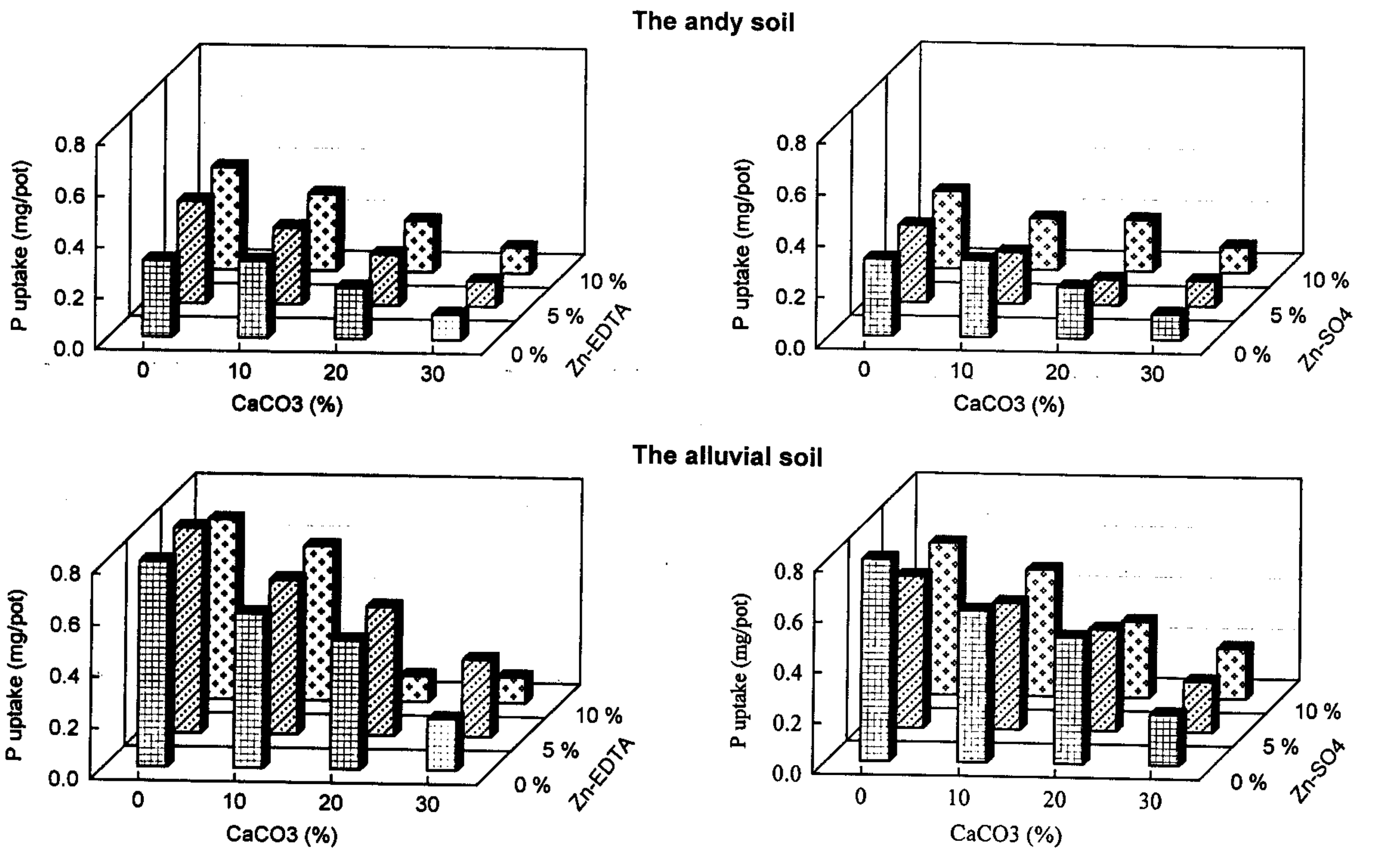


Fig. (8-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on P uptake (mg/pot) by shoots of barley plants grown on the studied soils.

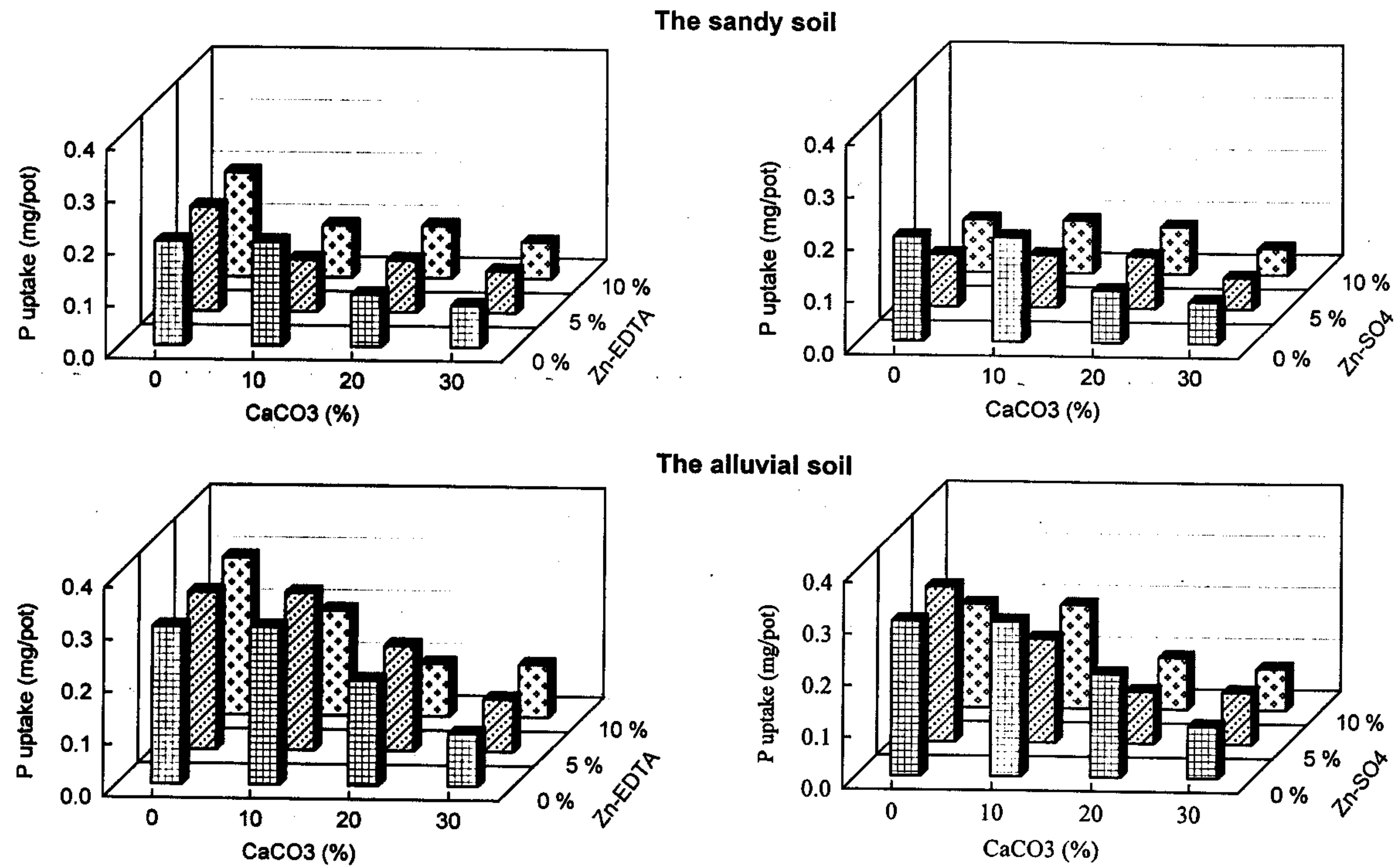


Fig. (8-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on P uptake (mg/pot) by roots of barley plants grown on the studied soils.

Verma and Kochroo (1984) who reported that higher levels of Zn depressed slightly availability of P and consequently decreased its uptake by plant. Also, Orabi et al., (1985) found that application of Zn at rates ranging from 0 to 10 ppm had no effect on P uptake by corn plants grown on soils varying in their content of $CaCO_3$ from 4% to 28%. **Safaya and Gupta (1979)** and **Ali (1985)** concluded that Zn, perhaps, intefers with P absorption and/or translocation within the plants. On the other hand, **Farid (1995)** found that increasing rate of Zn applied to a calcareous soil was accompanied with an increase in P concentration. The source of Zn did not show any obvious effect on P concentration in plant or its uptake either.

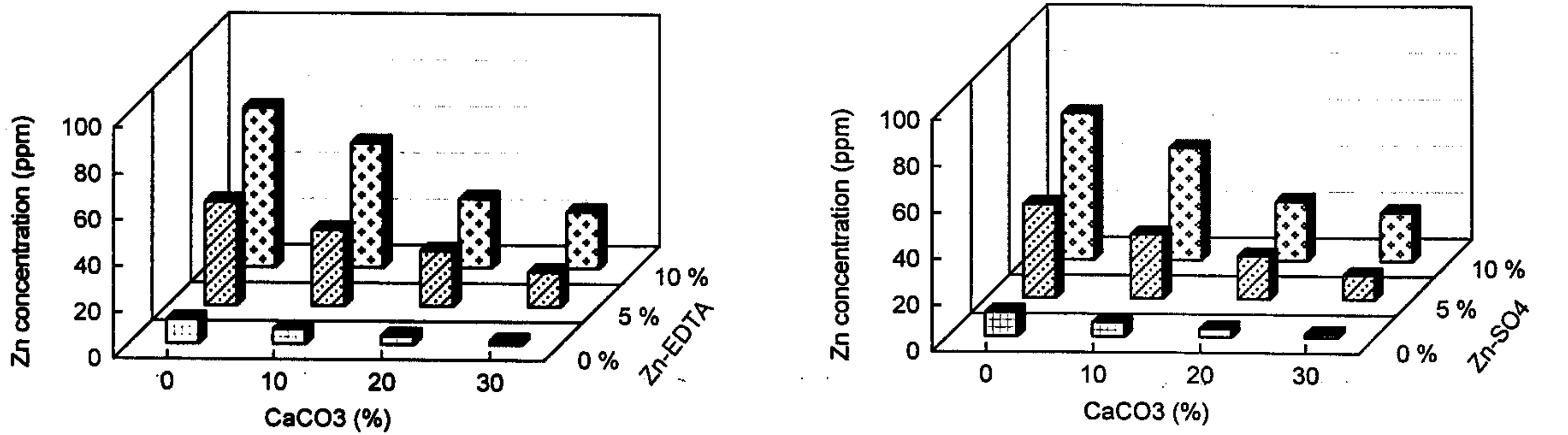
4.2.2.2. The micronutrients:

The effect of $CaCO_3$ and Zn treatments on Zn concentration and uptake by barley plants grown on the sandy and the Nile alluvial soils can be shown by the data presented in Tables (10) and (11) and illustrated in Figs. (9a, 9b, 10a and 10b). Application of different levels of $CaCO_3$ to both the soils progressively decreased Zn concentration and uptake by shoots and roots of barley plants grown thereon compared with the untreated soils. This finding holds true when Zn was also added in combination with the $CaCO_3$ in the form of Zn-EDTA or Zn SO_4 at different levels of Zn, however, the effect of $CaCO_3$ on Zn concentration and uptake was more pronounced when Zn was added in the form of Zn SO_4 than when it was added in the chelated form. In this connection, **Singh** and **Singh (1980)** observed that concentration and uptake of Zn were lower in the presence of $CaCO_3$ than in its absence. Also, **Fayed (1993)** revealed that $CaCO_3$ addition significantly decreased Zn concentration and uptake. The decrease in Zn concentration and uptake by shoots and roots of barley

Table (10): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Zn concentration (ppm) in barley plants grown on the investigated soils.

Rate of applied	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
$CaCO_3$ (%)	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	10.50	8.40	45.00	33.60	69.00	63.00	10.50	8.40	40.50	32.70	63.00	60.00
10	6.30	5.40	33.00	30.50	54.00	54.00	6.30	5.40	27.60	11.40	48.30	42.30
20	3.60	2.40	24.00	18.00	30.00	27.00	3.60	2.40	18.60	15.60	25.50	23.70
30	1.50	0.90	15.00	11.70	24.60	22.50	1.50	0.90	10.50	9.30	21.00	18.00
Mean	5.47	4.27	29.25	23.32	44.40	41.62	5.47	4.27	24.30	17.25	39.45	36.00
The Nile alluvial soil												
0	36.00	24.60	66.00	57.00	93.00	84.60	36.00	24.60	63.30	54.30	90.00	81.30
10	30.00	27.30	48.60	43.50	84.30	79.50	30.00	27.30	46.50	39.90	81.00	75.00
20	24.00	21.60	33.00	28.50	57.00	51.60	24.00	21.60	30.00	27.00	51.00	43.50
30	18.30	16.50	27.00	22.32	45.00	40.50	18.30	16.50	24.60	19.50	39.60	39.00
Mean	27.07	22.50	43.65	37.83	69.82	64.05	27.07	22.50	41.10	35.17	65.40	59.70

The sandy soil



The alluvial soil

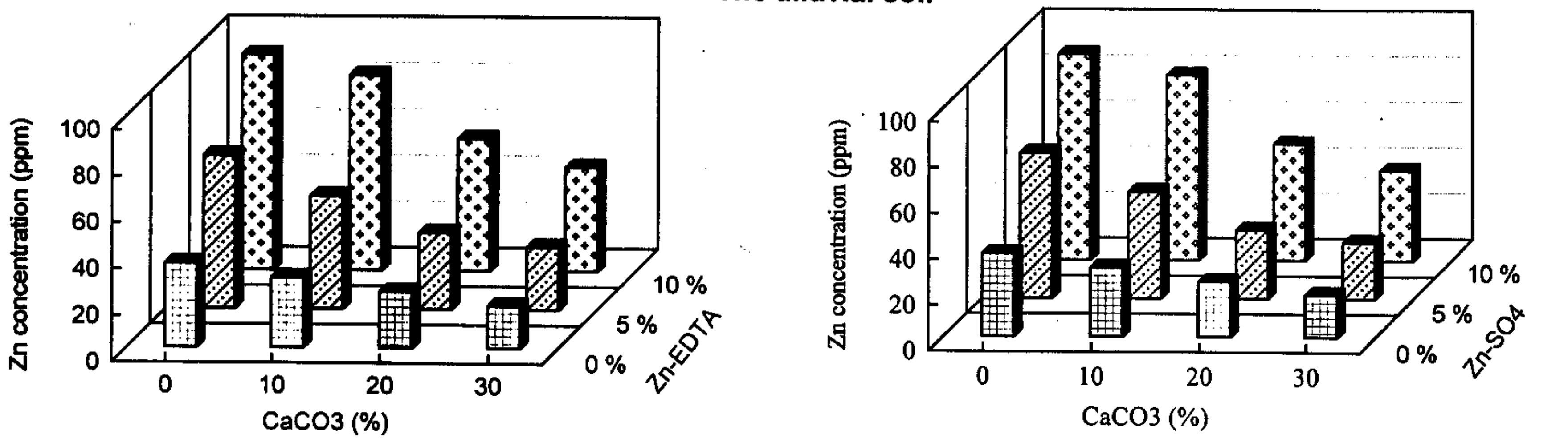


Fig. (9 -a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Zn concentration (ppm) in shoots of barley plants grown on the studied soils.

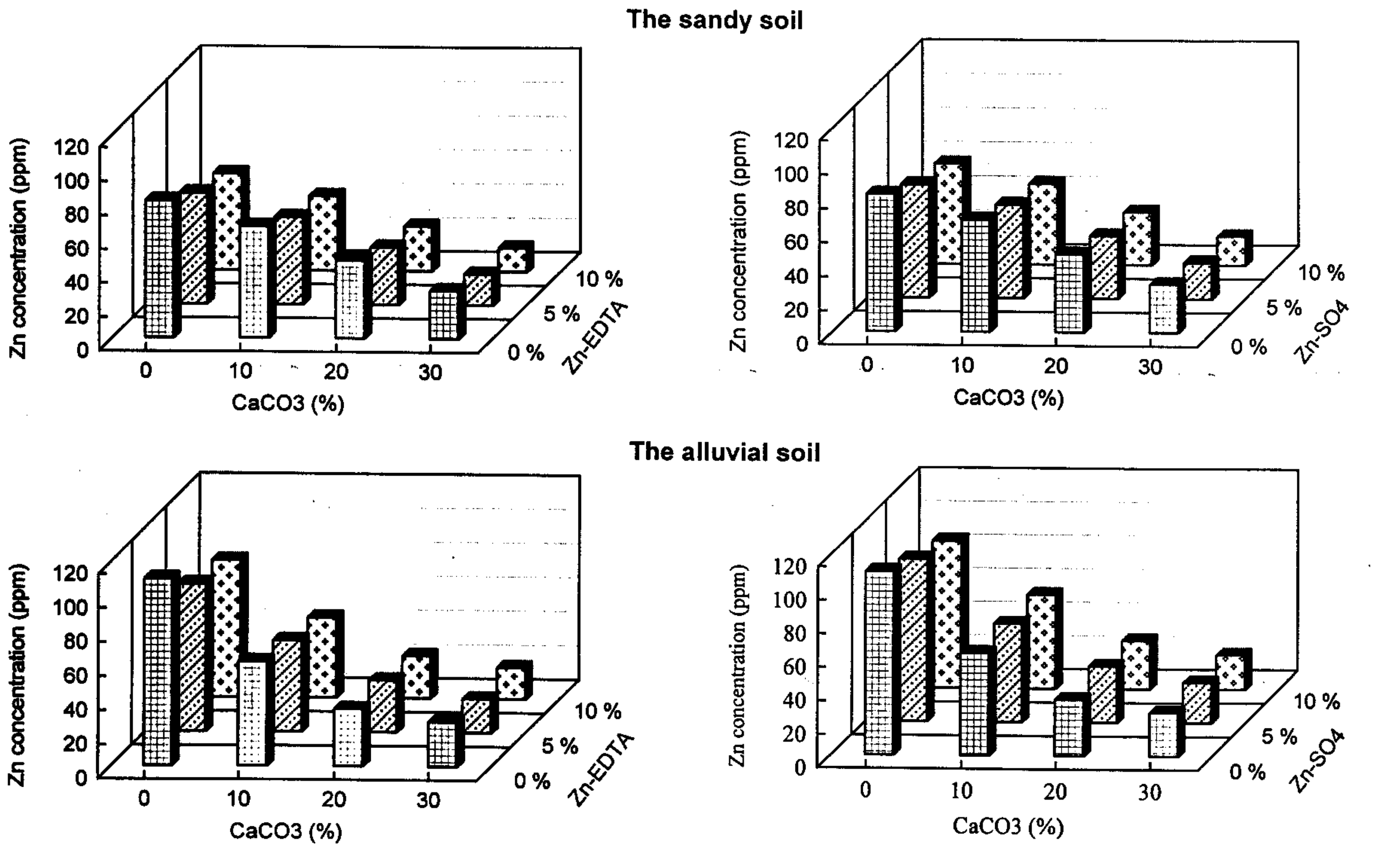
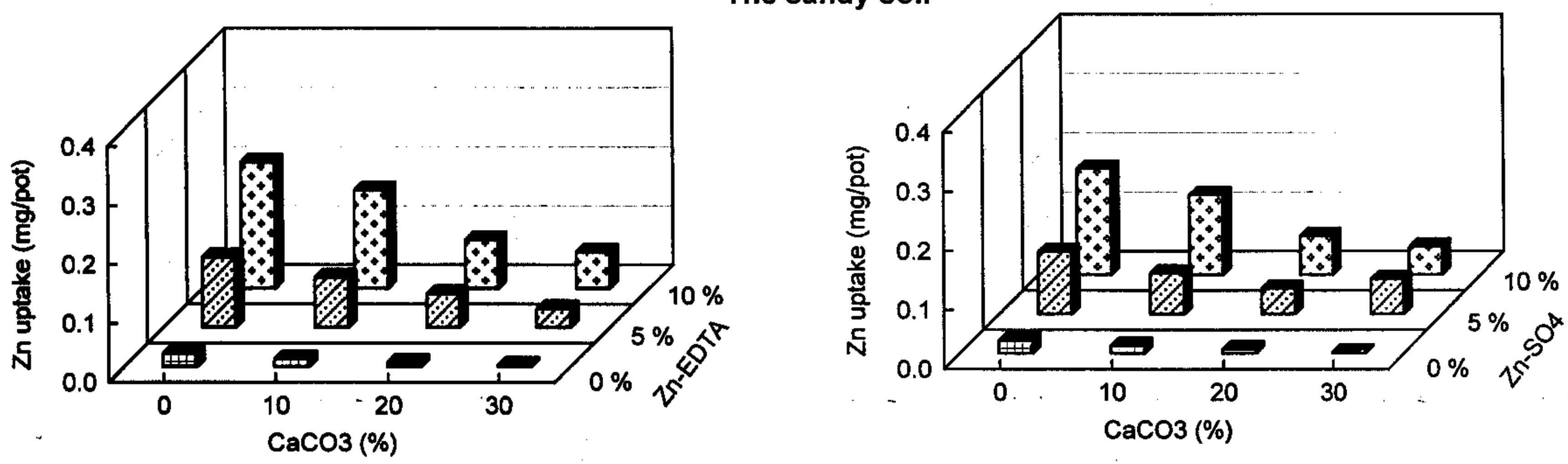


Fig. (9 -b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Zn concentration (ppm) in roots of barley plants grown on the studied soils.

Table (11): Effec of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two source on Zn uptake mg/plot.

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
	Shoc	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	0.02	0.013	0.119	0.061	0.213	0.124	0.022	0.013	0.105	0.055	0.179	0.105
10	0.01	0.008	0.085	0.054	0.166	0.103	0.013	0.008	0.069	0.018	0.135	0.072
20	0.00	0.003	0.057	0.029	0.082	0.047	0.007	0.003	0.043	0.023	0.065	0.039
30	0.00	0.001	0.032	0.016	0.061	0.035	0.002	0.001	0.021	0.012	0.047	0.025
Mean	0.01	0.006	0.073	0.040	0.130	0.077	0.013	0.006	0.059	0.027	0.106	0.060
The Nile alluvial soil												
0	0.11	0.044	0.242	0.111	0.370	0.186	0.118	0.044	0.220	0.099	0.328	0.154
10	0.09	0.046	0.175	0.082	0.326	0.159	0.096	0.046	0.152	0.069	0.288	0.135
20	0.07	0.034	0.113	0.049	0.204	0.098	0.072	0.034	0.092	0.044	0.168	0.075
30	0.05	0.022	0.076	0.034	0.141	0.070	0.054	0.022	0.065	0.027	0.115	0.055
Mean	0.08	0.036	0.097	0.069	0.260	0.128	0.085	0.036	0.132	0.059	0.224	0.104

The sandy soil



The alluvial soil

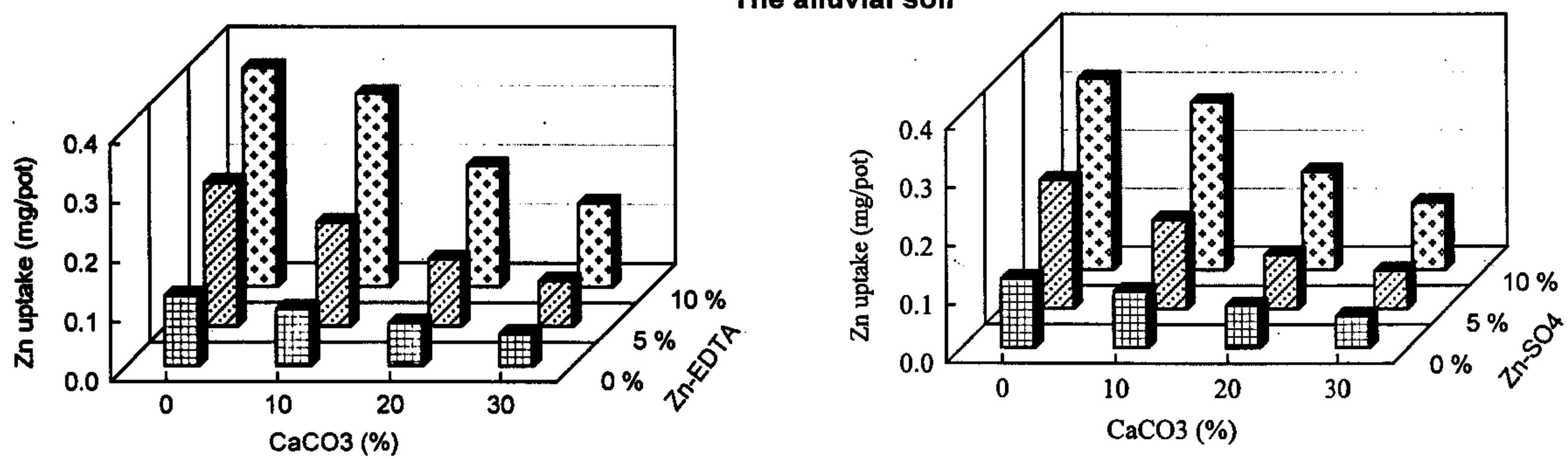
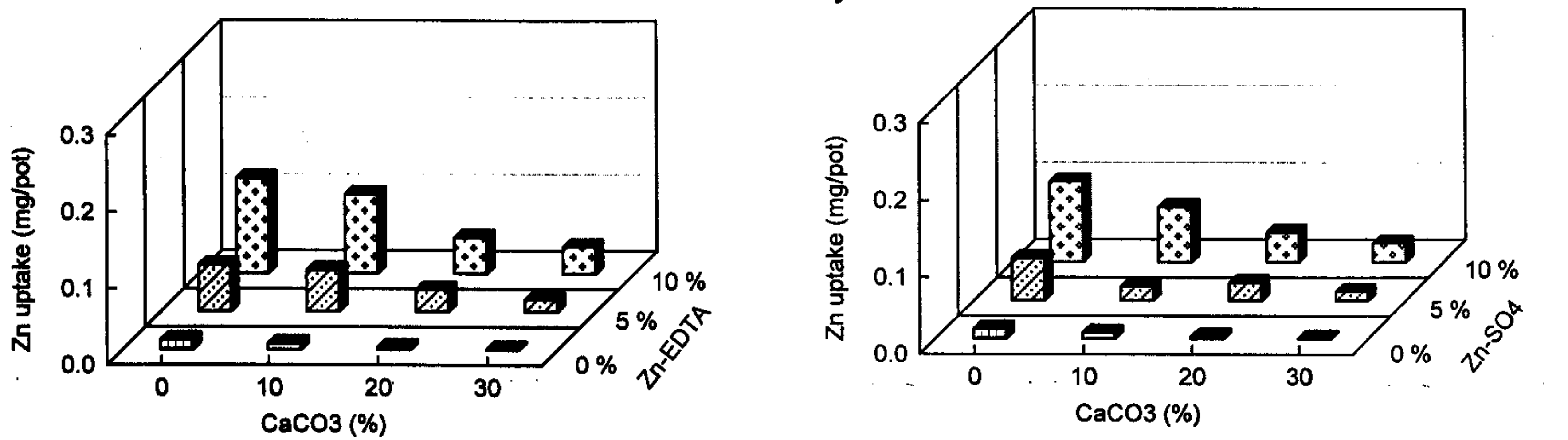


Fig. (10-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Zn uptake (mg/pot) by shoots of barley plants grown on the studied soils.

The sandy soil



The alluvial soil

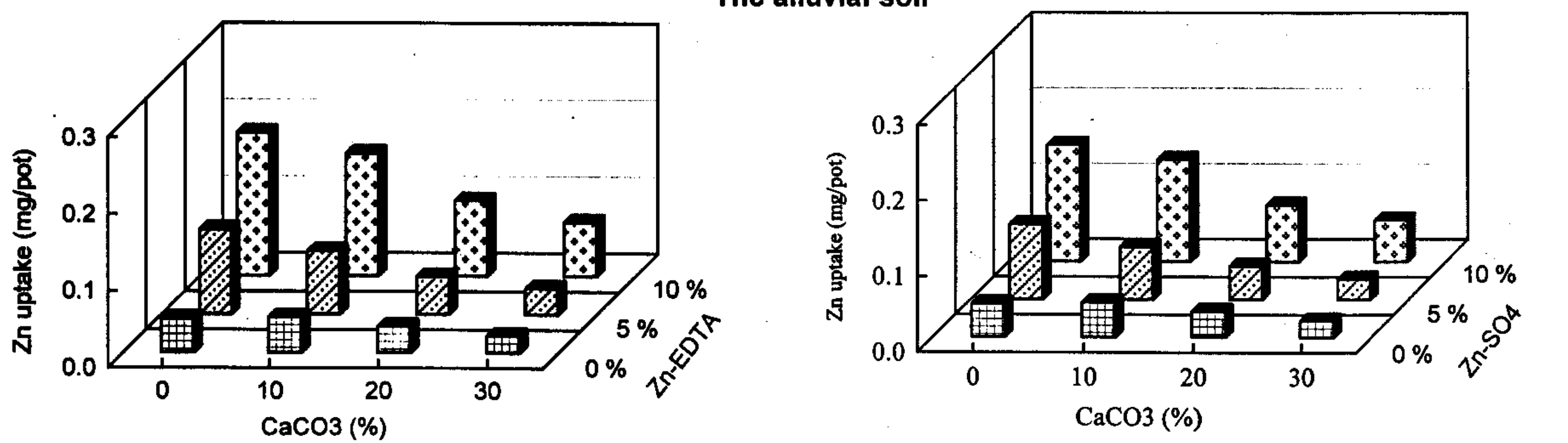


Fig. (10-b): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Zn uptake (mg/pot) by shoots of barley plants grown on the studied soils.

plants may be attributed to the reducing effect of $CaCO_3$ on Zn availability and consequently its uptake by the barley plants. This conclusion stands in well agreement with that of **Orabi et al. (1985)** who stated that the higher the total carbonate content of the soil was, the lower was Zn uptake- **Balba (1995)** achieved a similar conclusion.

Regarding the effect of application of Zn to both the studied soils, data reveal that the concentration and uptake of Zn by shoots and roots of barley plant increased progressively with increasing rate of the applied Zn in both of its forms. The increases seemed to be highest when Zn was applied at its highest rate (10 ppm Zn). This holds true for all plants grown on both the sandy and the Nile alluvial soils. These results are in good agreement with those obtained by **Fathi et al., (1992) Fayed (1993), Farid (1995)** and **Eskandar (1997)** who found a positive significant relation between rate of the applied Zn and its concentration and uptake by plant.

It is worthy to note also that Zn concentration in the plants grown on the Nile alluvial soil was generally higher than the corresponding concentration in the plants grown on the sandy one.

Comparison between the effect of the chelated form of the applied Zn (Zn EDTA) with that of the sulfate form ($ZnSO_4$) on Zn concentration and uptake by shoots and roots of barley plants grown on both the sandy and the Nile alluvial soils, data reveal that Zn concentration and uptake by the plants treated with its chelated form (Zn EDTA) were higher than the corresponding ones of those treated with ZnSO4. These results are similar to those obtained **by Wallace and Romeny (1970), Boawn (1973) Prasad** and **Sinha (1981) Maftoun** and **Karimian (1989)** and **Farid (1995)** who postulated that

Zn EDTA was generally more effective than $ZnSO_4$ in increasing Zn concentration and uptake by plants.

Regarding the effect of $CaCO_3$ on both concentration and uptake of Fe and Mn by the barley plants grown on both the studied soils (Tables 12, 13, 14 and 15 and Figs. 11a, 12a, 13a, 14a and 14b), it can be said that both of them were reduced and the reduction seemes to be more obvious by increasing rate of the applied $CaCO_3$. This occurred whether $CaCO_3$ was applied solely or in combination with the applied Zn in either of its forms and at all rates of its application. Such results are expected due to the reducing effect of $CaCO_3$ on availability of these elements in soils as it has been shown elsewhere in this investigation. Similar results were attained by **Hartzook et al. (1974), Singh** and **Dahiya (1976)** and **Dahiya** and **Singh (1982)** who found that increasing amounts of $CaCO_3$ decreased concentration and uptake of iron in roots drastically. They attributed such a result to the effect of $CaCO_3$ on conversion of soluble Fe into insoluble ferric hydroxide or Ferric oxide.

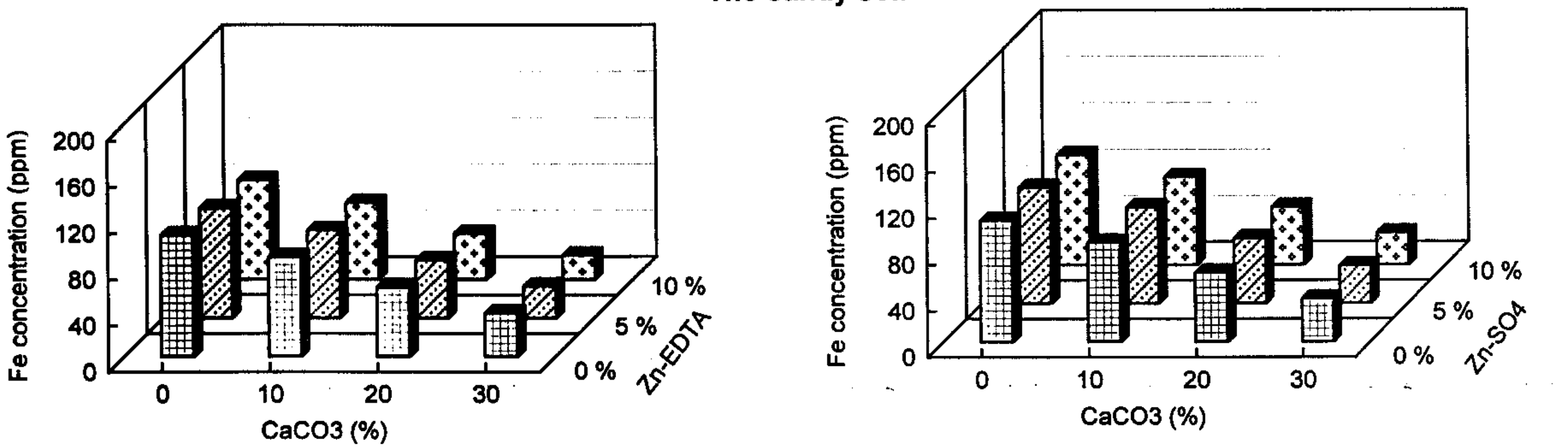
Taking into consideration effect of the applied Zn on uptake of Fe, it is obvious that increasing rate of the applied Zn in both forms caused decrease in Fe uptake by roots of the barley plants grown on both the studied soils. This is may be attributed to Zn-Fe antagonism **(Wallace** and **Romeny, 1970; Olsen,1972; Pendias** and **Pendias, 1992 and Farid, 1995).** On the other hand, shoots uptake of Fe was increased by increasing rate of the applied Zn in both applied forms.

Fe concentration in shoots of the barley plants grown on the sandy soil was not affected markedly by increasing rate of the applied Zn or even its applied form. On the other hand, Fe concentration in shoots of the plants grown on the Nile alluvial soil was reduced upon

Table (12): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Fe concentration (ppm) in barley plants grown on the investigated soils.

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	105.0	81.0	95.0	65.5	86.0	57.0	105.0	81.0	100.0	66.5	95.0	59.0
10	86.0	66.0	76.0	51.5	66.5	44.0	86.0	66.0	83.0	55.0	76.0	47.5
20	60.0	46.0	50.0	34.0	40.0	26.5	60.0	46.0	56.0	37.0	50.0	31.0
30	37.5	28.5	27.5	18.5	21.0	14.0	37.5	28.5	32.5	21.5	27.5	17.0
Mean	72.12	55.37	62.12	44.37	53.37	95.0	72.12	55.37	67.87	45.0	62.12	38.62
The Nile alluvial soil												
0	197.5	109.5	156.0	86.5	145.0	80.5	197.5	109.5	165.0	97.0	150.0	88.0
10	110.0	61.0	96.5	53.6	85.0	47.0	110.0	61.0	100.0	58.5	96.0	56.0
20	61.0	33.5	55.0	30.5	45.0	25.0	61.0	33.5	57.5	33.5	50.0	29.0
30	47.5	26.0	36.0	20.0	30.0	18.5	47.5	26.0	41.5	24.0	35.5	20.5
Mean	104.0	57.50	85.87	47.5	76.25	42.75	104.0	57.5	91.00	53.25	82.87	48.37

The sandy soil



The alluvial soil

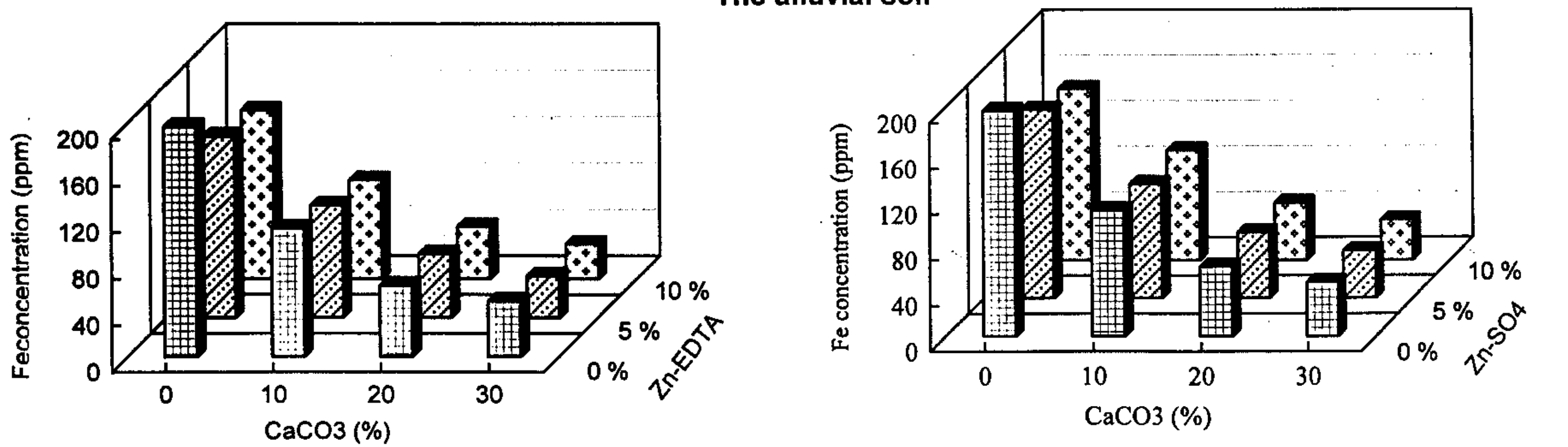
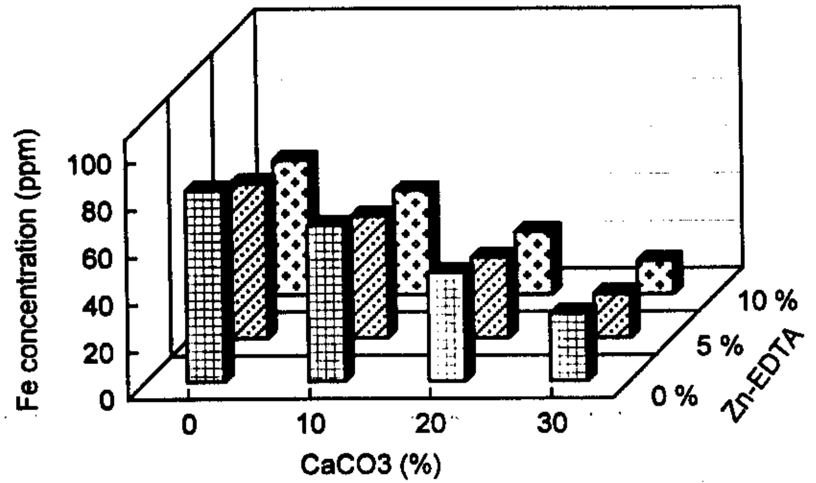
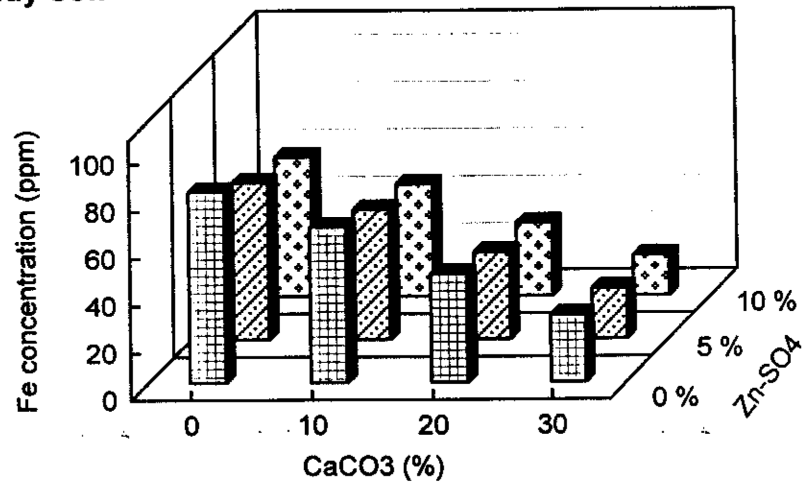


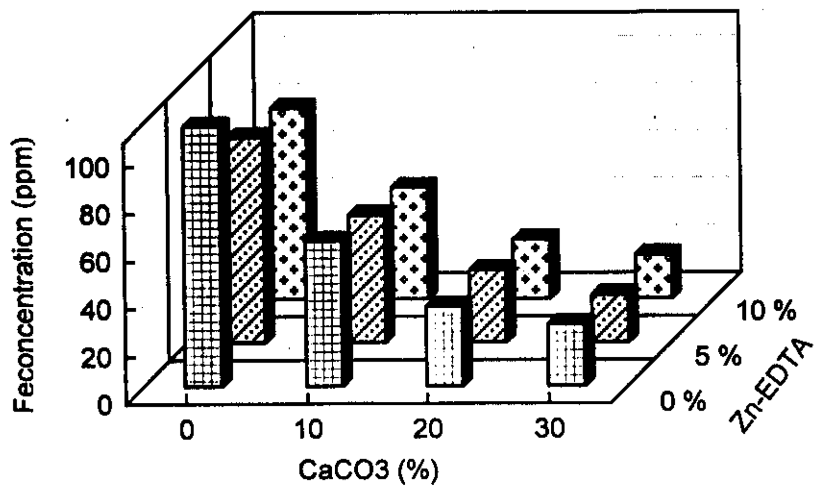
Fig. (11-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Fe concentration (ppm) in shoots of barley plants grown on the studied soils.

The sandy soil





The alluvial soil



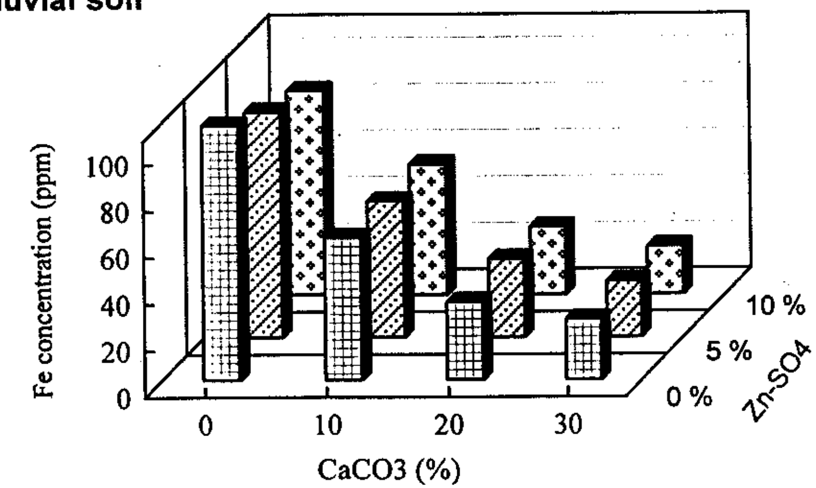


Fig. (11-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Fe concentration (ppm) in roots of barley plants grown on the studied soils.

Table (13): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Fe uptake mg/pot by barley plants grown on the investigated soils.

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	0.224	0.131	0.251	0.119	0.265	0.112	0224	0.131	0.261	0.112	0.270	0.103
10	0.178	0.104	0.197	0.092	0.205	0.084	0.178	0.104	0.207	0.086	0.212	0.081
20	0.117	0.060	0.121	0.055	0.110	0.046	0.117	0.060	0.129	0.056	0.127	0.051
30	0.053	0.032	0.059	0.026	0.052	0.022	0.053	0.032	0.066	0.029	0.062	0.023
Mean	0.143	0.081	0.157	0.073	0.158	0.066	0.143	0.081	0.165	0.044	0.167	0.064
The Nile alluvial soil												
0	0.649	0.198	0.574	0.168	0.577	0.177	0.649	0.198	0.575	0.177	0.547	0.167
10	0.352	0.104	0.349	0.100	0.328	0.094	0.352	0.104	0.329	0.102	0.341	0.101
20	0.183	0.053	0.188	0.053	0.161	0.047	0.183	0.053	0.177	0.055	0.165	0.050
30	0.109	0.035	0.102	0.031	0.094	0.032	0.109	0.035	0.109	0.033	0.103	0.029
Mean	0.323	0.097	0.303	0.088	0.290	0.087	0.323	0.097	0.297	0.091	0.289	0.086

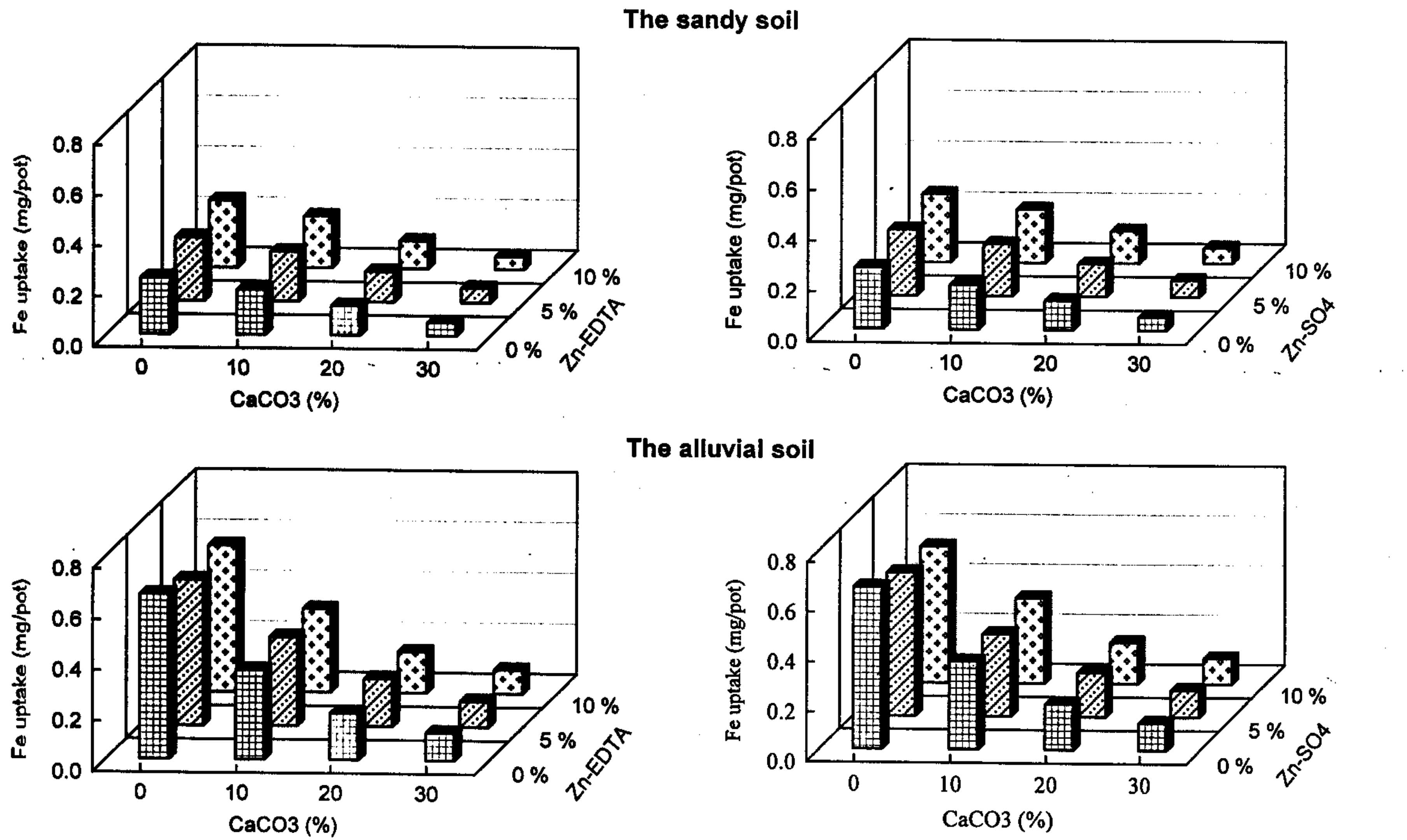


Fig. (12-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Fe uptake (mg/pot) by shoots of barley plants grown on the studied soils.

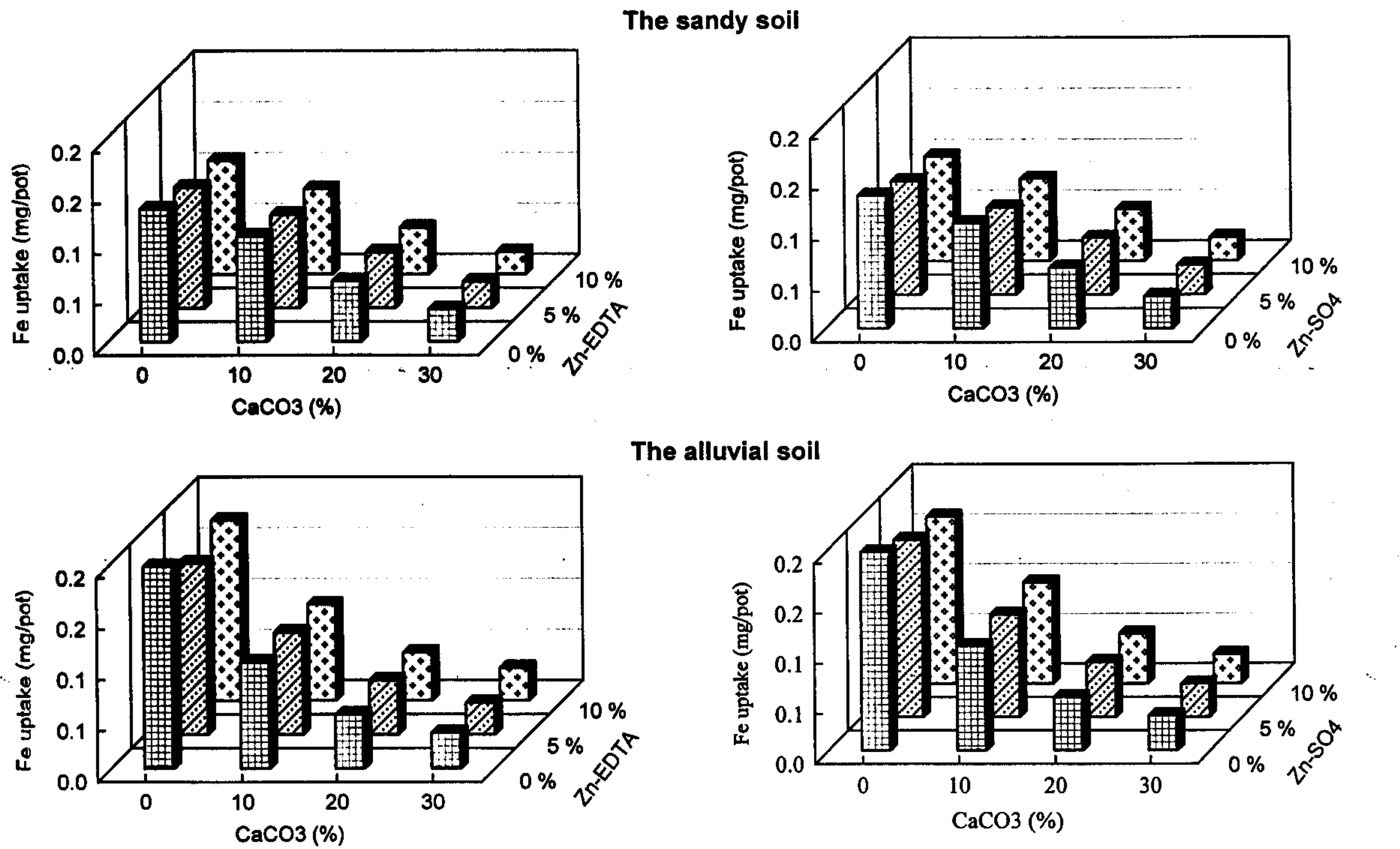


Fig. (12-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Fe uptake (mg/pot) by roots of barley plants grown on the studied soils.

increasing rate of the applied Zn. The effect of the applied Zn on decreasing concentration of Fe in roots of the barley plants grown on both the studied soils was obvious especially with increasing rate of the applied Zn. These results agree to, some extent with **Alloway (1991)** and **Farid (1995).**

Contradictory effects were observed due to increasing rate of the applied Zn on Mn concentration in both shoots and roots of the plants grown on both the sandy and the Nile alluvial soils. This contradiction is confirmed by the results obtained by each of **Wallace (1971), White et al. (1979) Haldar** and **Mandal (1981)** and **Wallace (1989).**

Forms of the applied Zn differed very slightly in their effect on Fe and Mn concentration and uptake.

Data presented in Tables (16 and 17) and illustrated in Figs. (10a & 10b) illustrate that both Cu concentration and uptake by shoots and roots of barley plants were slightly decreased by the application of the $CaCO_3$ whether solely or in combination with Zn, especially at the highest rate of the applied $CaCO_3$ (30 %).

Applying Zn to the investigated soils seemed to have no effect on Cu concentration in the barley plants grown on both the studied soils. On the other hand, Zn application affected negatively uptake of Cu and the effect was shown to be obvious by increasing rate of the applied Zn. This result stands in well agreement with those of **Giordano et al (1974), Kausar et al. (1976), Haldar** and **Mandal (1981)** and **Brown et al. (1983).** Such results are attributed to competition between Zn and Cu on the assume absorption sites on plant root.

Table (14): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Mn concentration (ppm) in barley plants grown on the investigated soils.

Rate of applied $CaCO_3$ (%)	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	22.00	16.60	21.20	14.00	19.50	13.00	22.0	16.60	21.50	12.50	21.00	11.60
10	21.00	16.10	20.00	12.90	19.20	12.80	21.0	16.10	20.50	11.80	19.80	11.00
20	19.50	15.00	19.20	12.80	19.00	12.50	19.5	15.00	19.60	11.50	19.60	10.80
30	19.20	14.10	19.00	12.50	19.00	12.50	19.2	14.10	19.30	11.30	19.50	10.80
Mean	20.42	15.45	19.85	13.05	19.17	12.70	20.42	15.45	20.22	11.77	19.97	11.05
The Nile alluvial soil												
0	41.20	27.30	40.00	25.00	38.00	21.10	41.20	27.30	40.36	28.20	39.00	21.60
10	41.00	26.00	39.50	24.50	37.50	20.80	41.00	26.00	39.80	28.40	38.00	21.10
20	40.00	26.00	38.20	23.80	38.00	21.10	40.00	26.00	38.50	27.50	38.80	21.20
30	39.00	25.50	38.50	24.00	37.90	21.00	39.00	25.50	38.70	27.20	38.20	21.10
Mean	40.30	26.20	39.05	24.32	37.85	21.00	40.30	26.20	39.32	27.82	38.50	21.25

The sandy soil

The alluvial soil

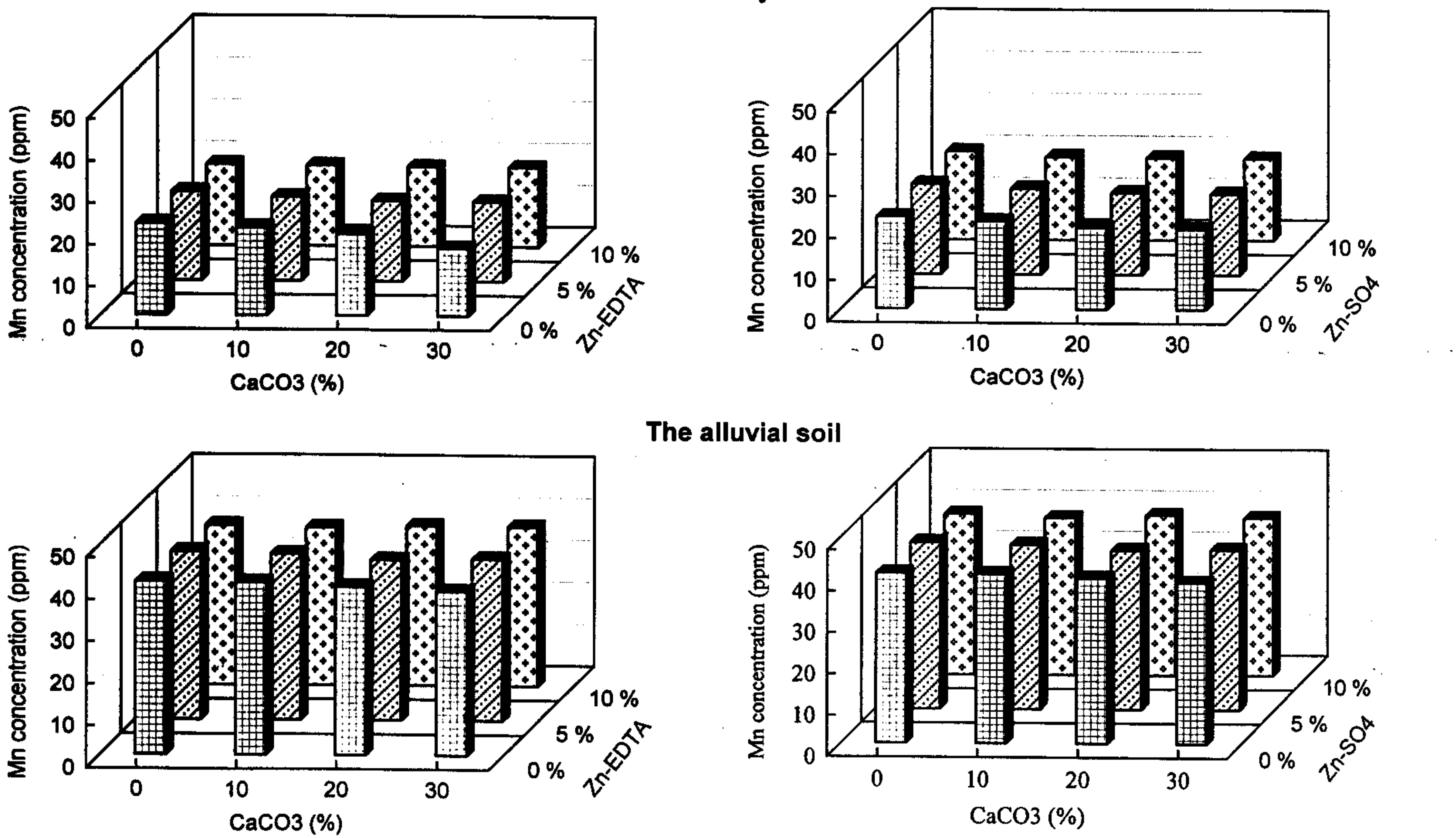


Fig. (13-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Mn concentration (ppm) in shoots of barley plants grown on the studied soils.

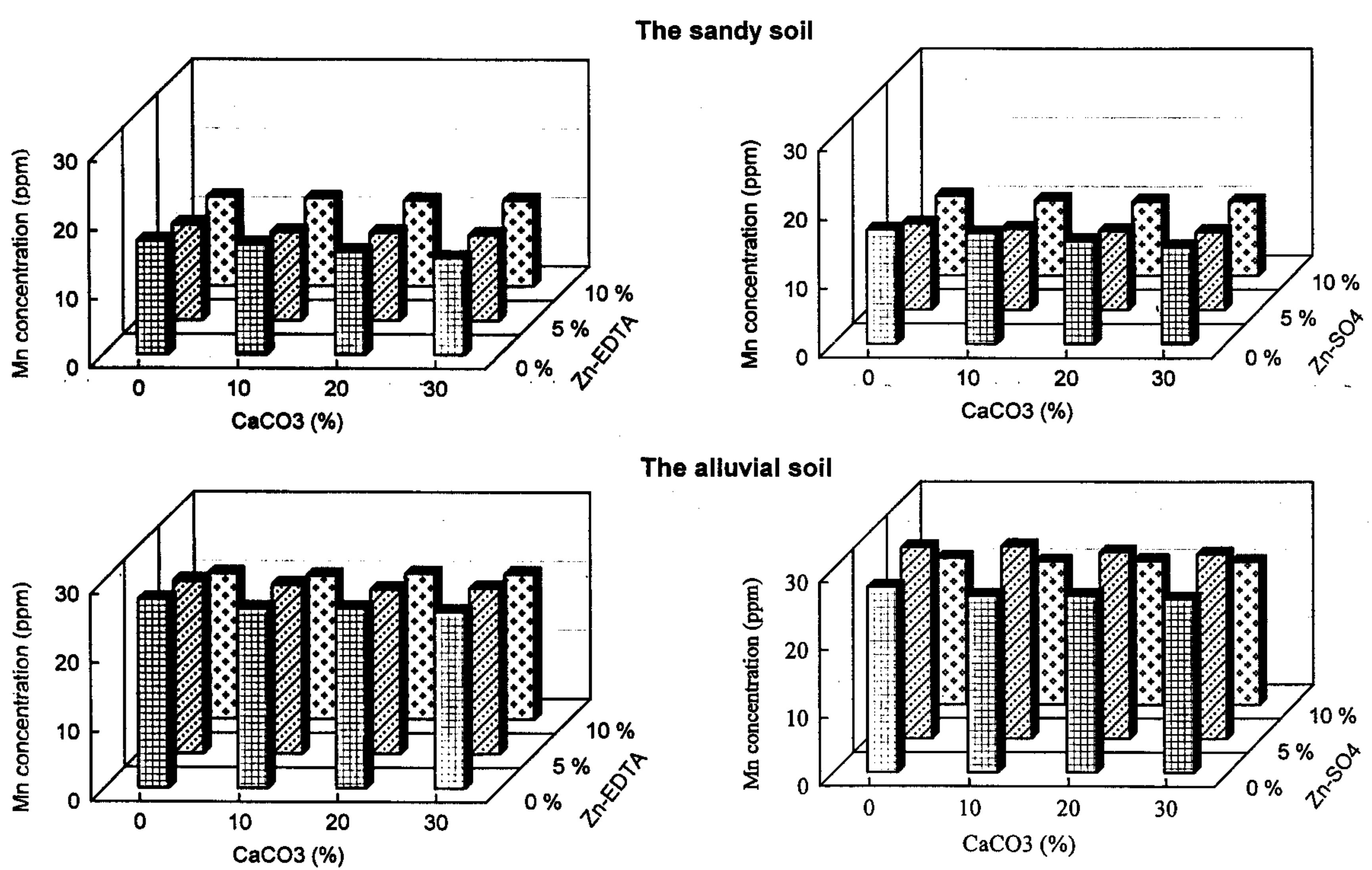


Fig. (13-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Mn concentration (ppm) in roots of barley plants grown on the studied soils.

Table (15): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Mn uptake mg/pot by barley plants grown on the investigated soils.

Rate of applied	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
$CaCO_3$ (%)	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	0.047	0.026	0.056	0.025	0.060	0.025	0.047	0.026	0.056	0.021	0.059	0.020
10	0.043	0.025	0.052	0.023	0.059	0.024	0.043	0.025	0.051	0.018	0.055	0.018
20	0.038	0.019	0.046	0.020	0.052	0.021	0.038	0.019	0.045	0.017	0.049	0.017
30	0.027	0.016	0.040	0.017	0.047	0.019	0.027	0.016	0.039	0.015	0.044	0.015
Mean	0.038	0.020	0.048	0.021	0.054	0.022	0.038	0.020	0.044	0.017	0.051	0.017
The Nile alluvial soil												
0	0.135	0.049	0.147	0.048	0.151	0.046	0.135	0.049	0.140	0.054	0.142	0.041
10	0.131	0.044	0.142	0.046	0.145	0.041	0.131	0.044	0.130	0.049	0.135	0.038
20	0.120	0.041	0.131	0.041	0.136	0.040	0.120	0.041	0.118	0.045	0.128	0.036
30	0.089	0.034	0.109	0.037	0.119	0.036	0.089	0.034	0.102	0.037	0.111	0.030
Mean	0.118	0.042	0.132	0.043	0.137	0.040	0.118	0.042	0.122	0.046	0.129	0.036

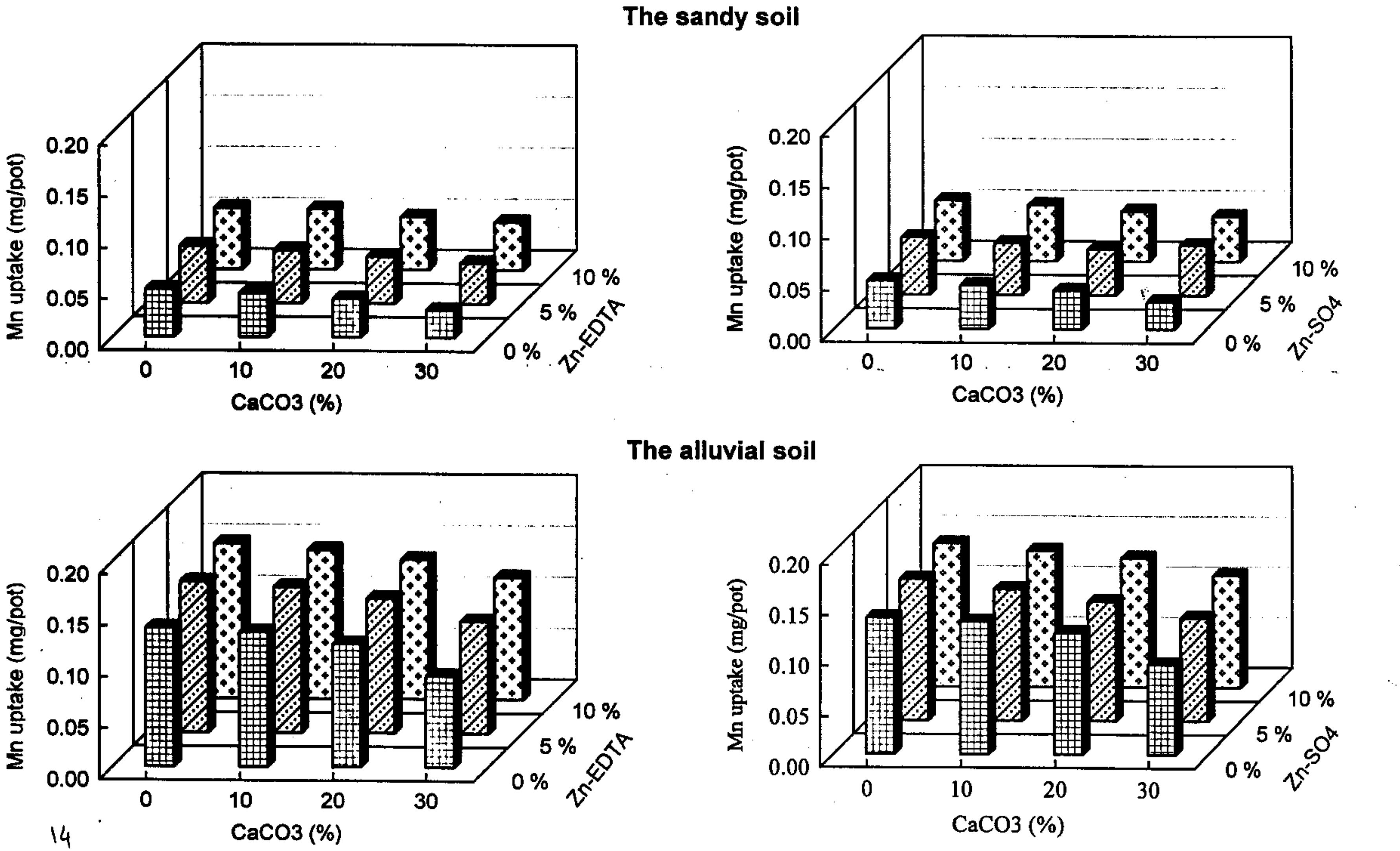


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Fig. (6-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Mn uptake (mg/pot) by shoots of barley plants grown on the studied soils.

The sandy soil

The alluvial soil

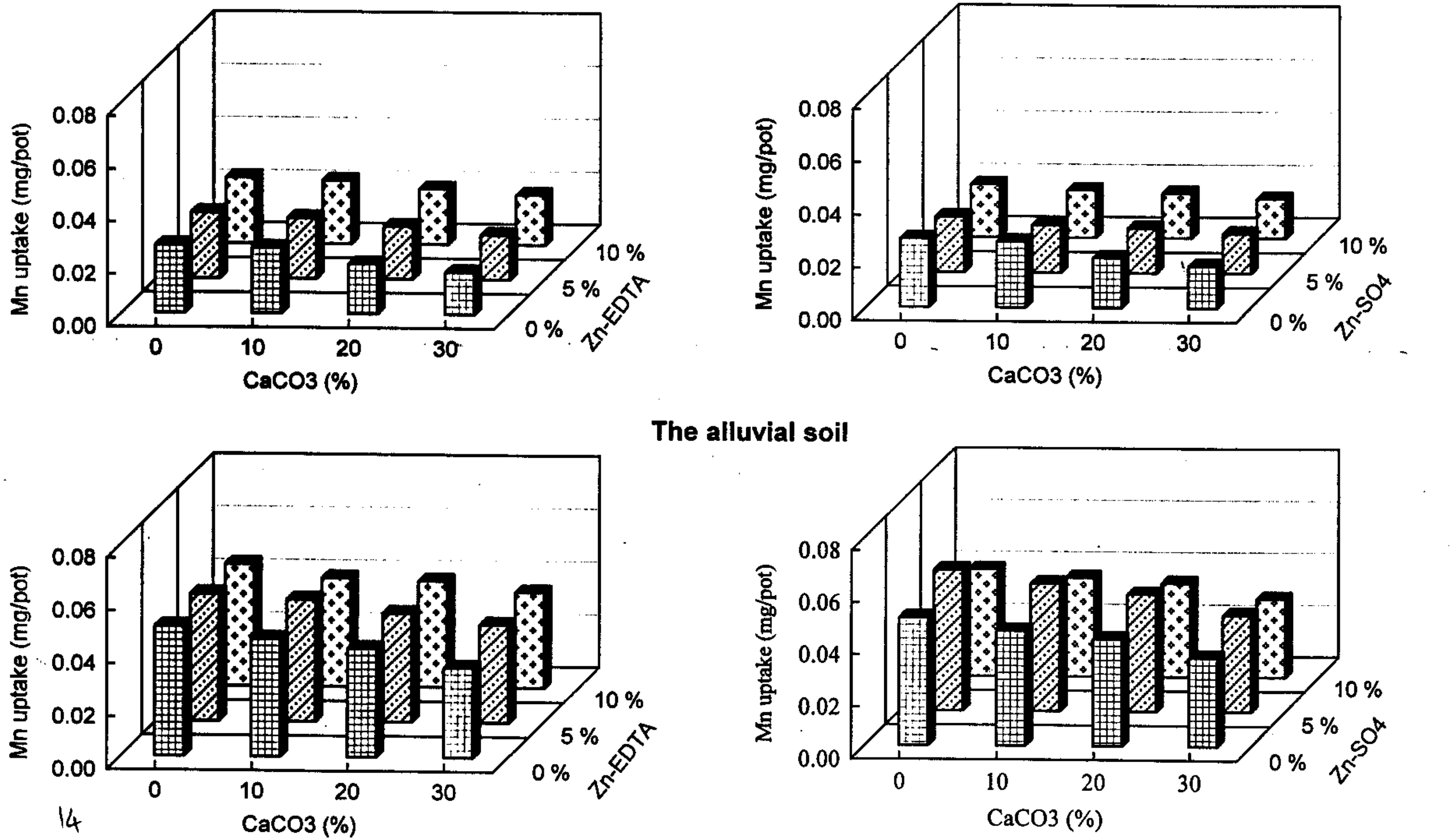

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Fig. (-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Mn uptake (mg/pot) in roots of barley plants grown on the studied soils.

Table (16): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Cu concentration (ppm) in barley plants grown on the investigated soils.

Rate of applied	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
$CaCO_3$ (%)	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	15	13	14	12	14	12	15	13	14	11	14	10
10	14	13	13	12	13	11	14	13	13	10	13	10
20	14	13	12	11	13	10	14	13	12	10	11	9
30	13	12	12	10	12	10	13	12	10	10	11	9
Mean	14	12.75	12.75	11.25	13	10.75	14	12.75	12.25	10.25	12.25	9.50
The Nile alluvial soil												
0	16	14	16	13	15	13	16	14	15	13	15	13
10	16	13	15	13	15	13	16	13	14	13	14	13
20	15	12	15	11	14	12	15	12	13	11	13	11
30	13	10	13	10	13	10	13	10	13	10	13	10
Mean	15	12.25	14.75	11.75	14.25	12	15	12.25	13.75	11.75	13.75	11.75

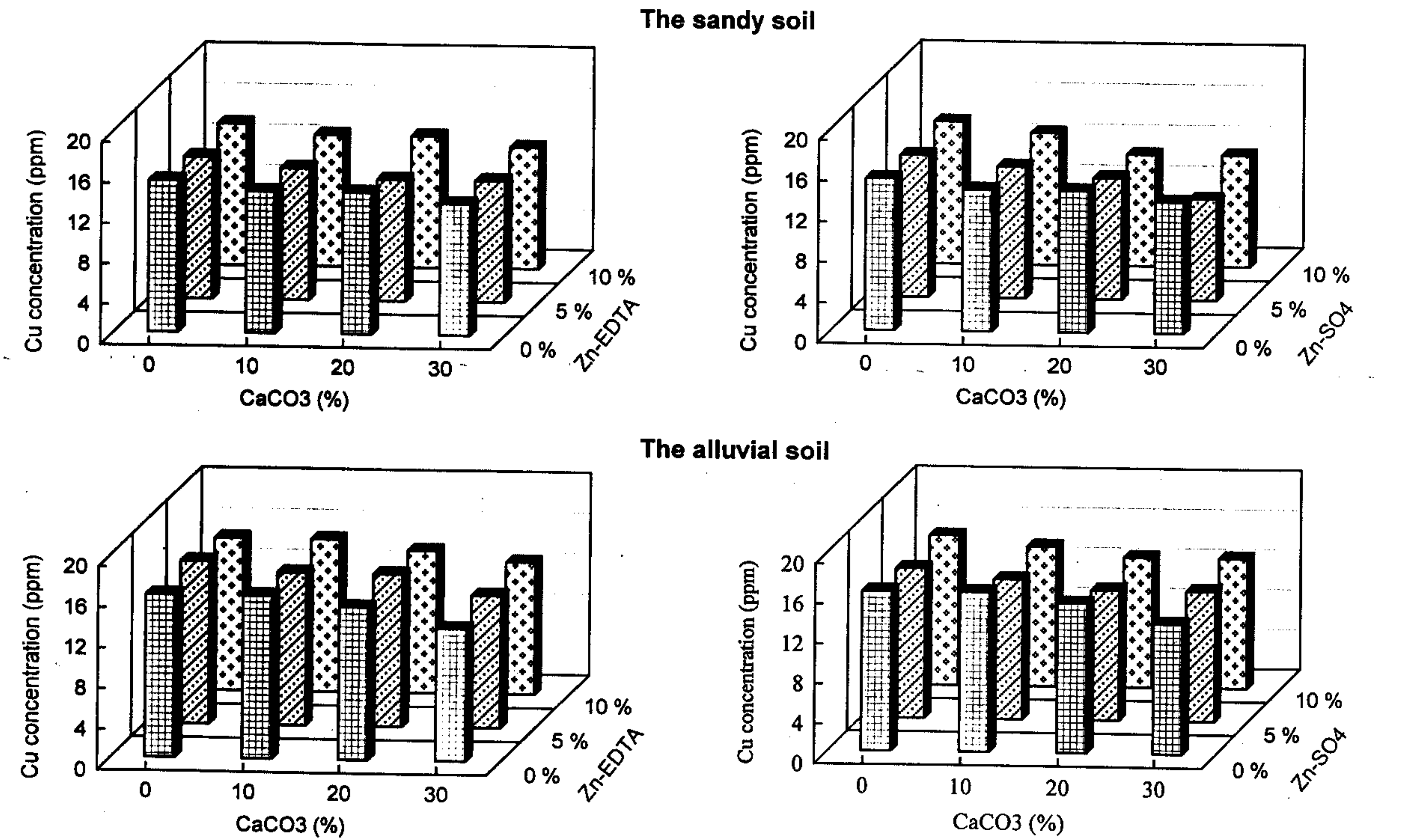
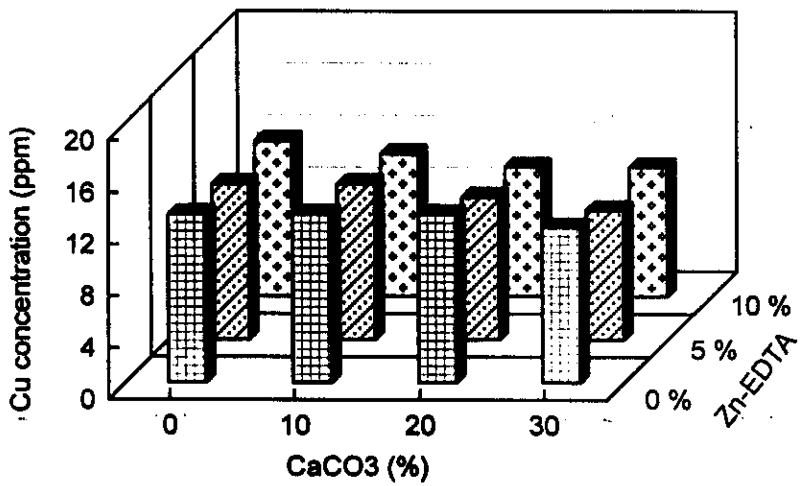
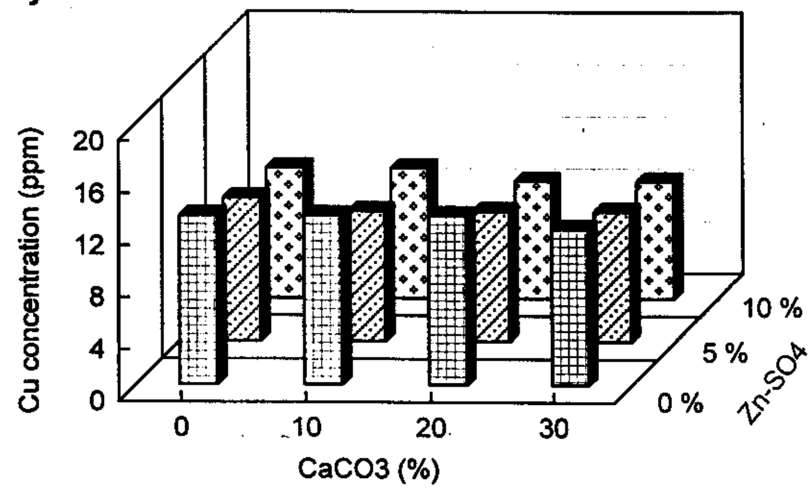


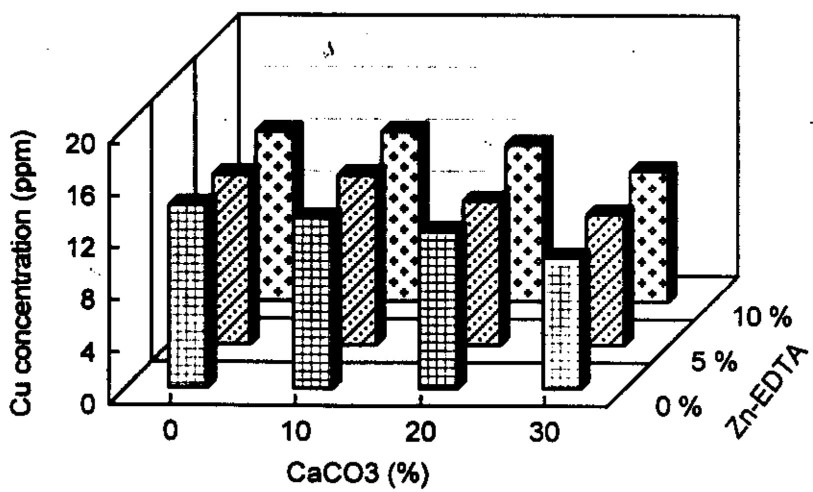
Fig. (15-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Cu concentration (ppm) in shoots of barley plants grown on the studied soils.

The sandy soil





The alluvial soil



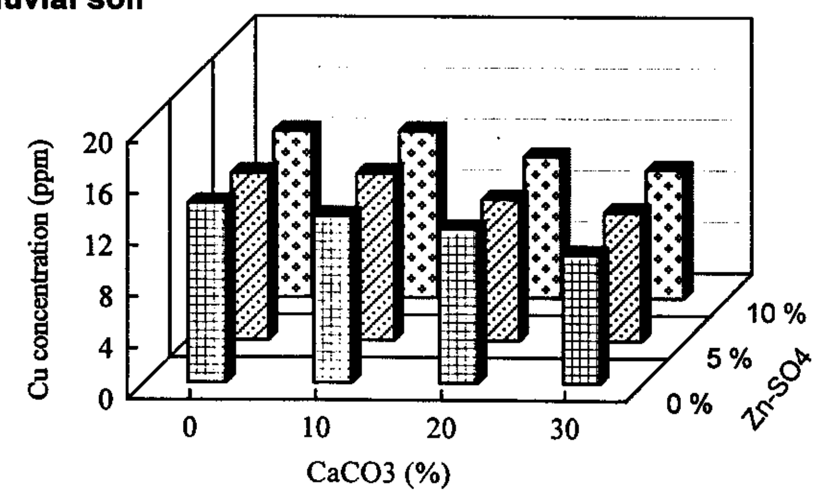


Fig. (15-b): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Cu concentration (ppm) in roots of barley plants grown on the studied soils.

Table (17): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on Cu uptake mg/pot by barley plants grown on the investigated soils.

Rate of applied	Zn ppm (Zn EDTA)						Zn ppm ($ZnSO_4$)					
	0		5		10		0		5		10	
$CaCO_3$ (%)	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
The sandy soil												
0	0.032	0.021	0.037	0.021	0.043	0.023	0.032	0.021	0.036	0.018	0.039	0.017
10	0.028	0.020	0.033	0.021	0.040	0.021	0.028	0.020	0.032	0.015	0.036	0.017
20	0.027	0.017	0.029	0.017	0.035	0.017	0.027	0.017	0.027	0.015	0.028	0.014
30	0.018	0.013	0.025	0.014	0.030	0.015	0.018	0.013	0.020	0.013	0.025	0.012
Mean	0.026	0.017	0.031	0.018	0.037	0.019	0.026	0.017	0.023	0.015	0.032	0.015
The Nile alluvial soil												
0	0.052	0.025	0.058	0.025	0.059	0.028	0.052	0.025	0.052	0.023	0.054	0.024
10	0.051	0.022	0.054	0.024	0.058	0.026	0.051	0.022	0.046	0.022	0.049	0.023
20	0.045	0.019	0.051	0.019	0.050	0.022	0.045	0.019	0.040	0.018	0.042	0.019
30	0.029	0.013	0.037	0.015	0.040	0.017	0.029	0.013	0.034	0.013	0.037	0.014
Mean	0.044	0.019	0.050	0.020	0.051	0.023	0.044	0.019	0.043	0.019	0.045	0.020

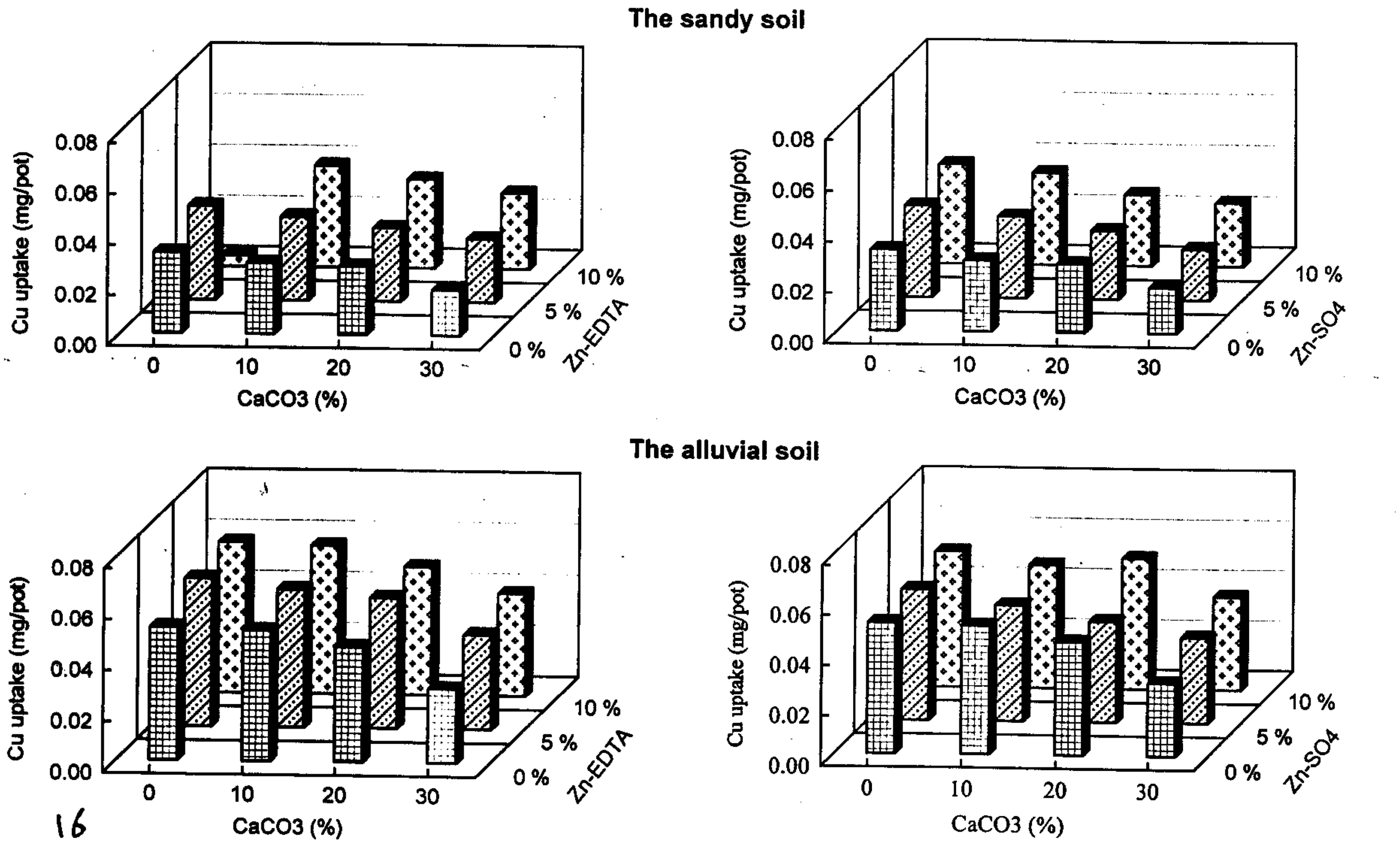


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Fig. (10-a): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Cu uptake (mg/pot) in shoots of barley plants grown on the studied soils.

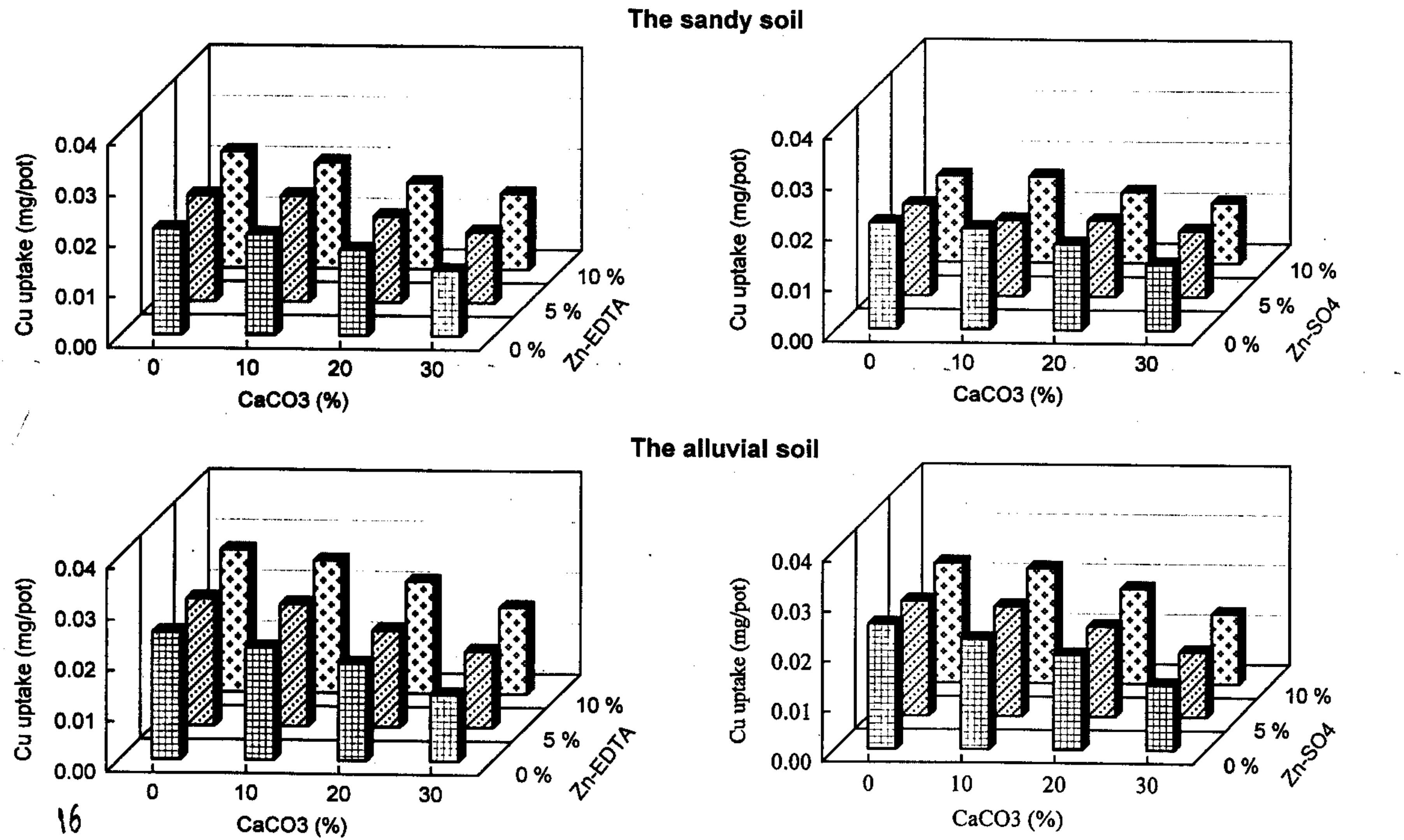

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Fig. (10-b): Effect of the different rates of CaCO3 applied solely or in combination with different rates of Zn in two sources on Cu uptake (mg/pot) by roots of barley plants grown on the studied soils.

4.3. Effect of $CaCO_3$ applied solely or in combination with zinc on mobility of P and Zn through the different layers of the investigated soils:

4.3.1. Phosphorus mobility:

The effect of the different rates of $CaCO_3$ applied solely or in combination with different rates and forms of Zn on mobility of P within the different depths of the studied soils is shown by the data presented in Table (18) and illustrated in Figs. (17a, b, c).

Available P was found in the surface layers of the studied soils in markedly higher amounts than the layers below. The lowest soil depth showed the lowest available P contents. This pattern of P distribution with depth characterized both the studied soils whether $CaCO_3$ was applied solely or combined with Zn at any rate of application. Yet, it is worthy to mention that, increasing rate of the applied $CaCO_3$ was of more obvious reducing effect on the amount of the available P in the surface layers of both the studied soils than the layers below.

The decrease in availability of P in all the different depths of the sandy and the Nile alluvial soils is generally attributed to adsorption of P on active sites of $CaCO_3$, precipitation by Ca in the system and reaction with the exchangeable Ca (**Abbas, 1980, Ali, 1985, Soltan, 1992** and **Balba, 1995**).

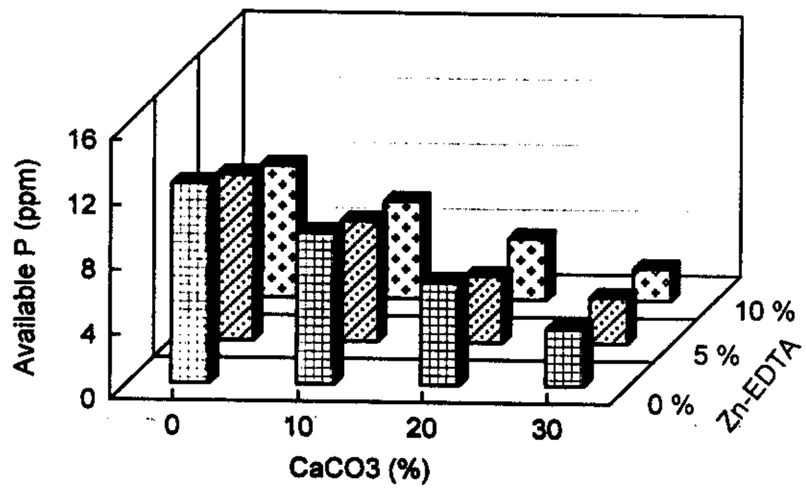
The comparison between P availability of the sandy soil and the Nile alluvial one shows that upon applying $CaCO_3$ only at a rate of 10 %, the available P content of the surface layers of these soils was reduced by 24.3 and 27.6 %, respectively. The corresponding

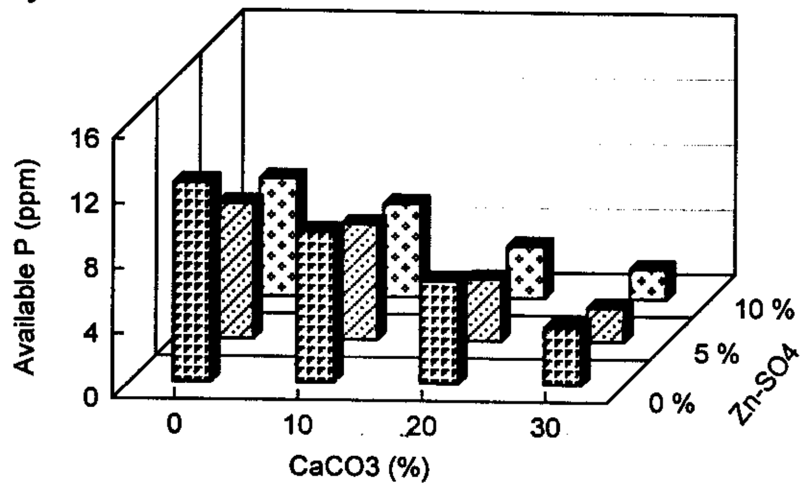
Table (18): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the distribution of P (ppm) in different layers of the investigated soils.

Rate of applied $CaCO_3$ (%)	Soil depth (cm)	Sandy soil						Nile alluvial soil					
		Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)			Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
		0	5	10	0	5	10	0	5	10	0	5	10
	0-10	12.32	10.22	8.12	12.32	8.35	7.25	15.33	12.62	10.10	15.33	11.50	9.30
0	10-20	9.11	7.42	5.60	9.11	7.20	5.00	11.72	8.22	6.92	11.72	7.41	5.33
	20-30	6.20	4.52	3.10	6.20	3.92	2.92	8.81	6.31	5.20	8.81	5.00	4.40
	Mean	9.21	7.38	5.60	9.21	6.49	5.05	11.95	9.05	7.40	11.95	7.97	6.34
	0-10	9.33	7.42	6.00	9.33	7.11	5.75	11.10	10.20	8.62	11.10	9.22	8.33
10	10-20	6.10	5.30	4.10	6.10	5.12	3.95	7.62	6.92	6.12	7.62	6.31	5.62
	20-30	3.20	2.72	2.20	3.20	2.50	1.92	4.31	4.10	3.75	4.31	3.70	3.11
	Mean	6.21	5.14	4.10	6.21	4.91	3.87	7.67	7.07	6.16	7.67	6.41	5.68
	0-10	6.32	4.11	3.80	6.32	3.82	3.20	7.80	6.10	5.00	7.80	5.80	4.73
20	10-20	3.50	2.75	2.10	3.50	2.51	2.00	4.20	3.00	2.90	4.20	2.92	2.75
	20-30	2.00	1.70	1.50	2.00	1.50	1.35	2.80	1.83	1.70	2.80	1.75	1.50
	Mean	3.94	2.85	2.46	3.94	2.61	2.18	4.93	3.64	3.20	4.93	3.49	2.99
	0-10	3.52	2.30	2.00	3.52	2.10	1.83	4.02	4.21	3.62	4.02	4.00	3.23
30	10-20	2.50	1.22	1.10	2.50	1.00	0.90	3.20	2.50	2.12	3.20	2.30	2.00
	20-30	0.90	0.81	0.72	0.90	0.75	0.62	1.10	0.95	0.81	1.10	0.85	0.75
	Mean	2.30	1.44	1.27	2.30	1.28	1.11	2.77	2.55	2.18	2.77	2.38	1.99

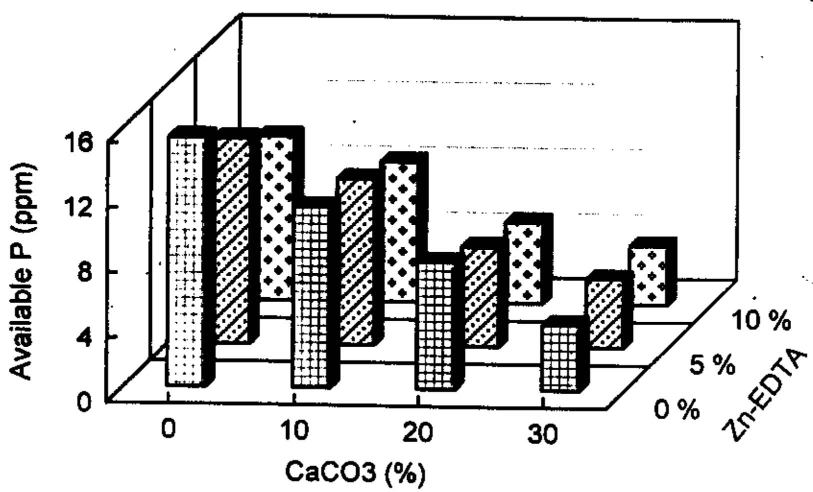
(0-10 cm)

The sandy soil





The alluvial soil



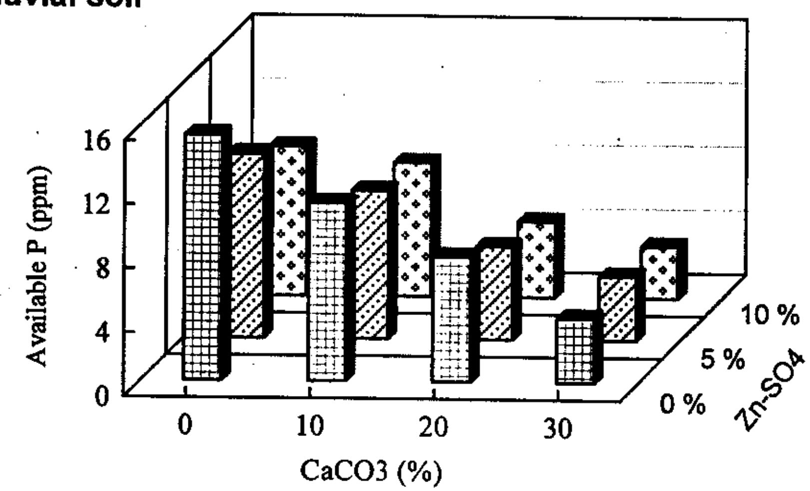


Fig. (17-a): Effect of the different rates of CaCO3 applied soley or in combination with different rates of Zn in two sources on the availability of P (ppm) in the (0-10 cm)layer of the investigated soils.

(10-20 cm)

The sandy soil

The alluvial soil

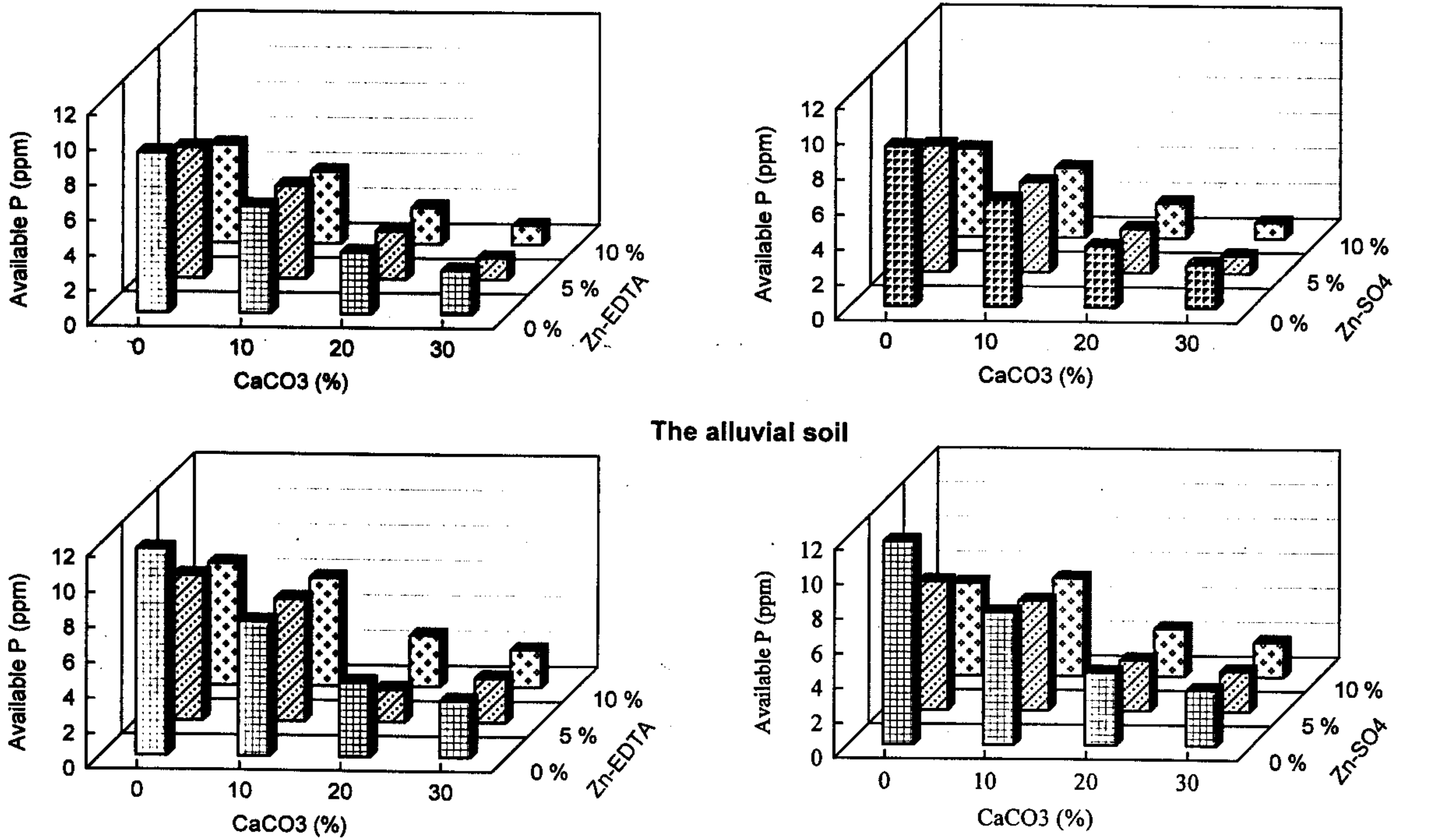
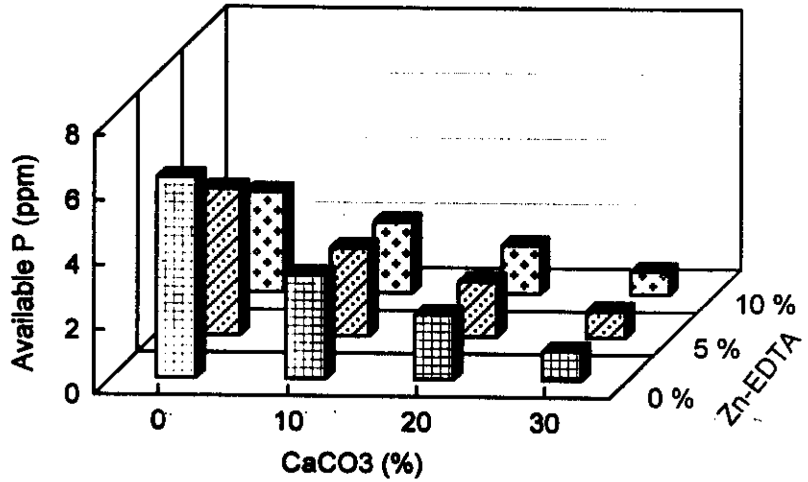
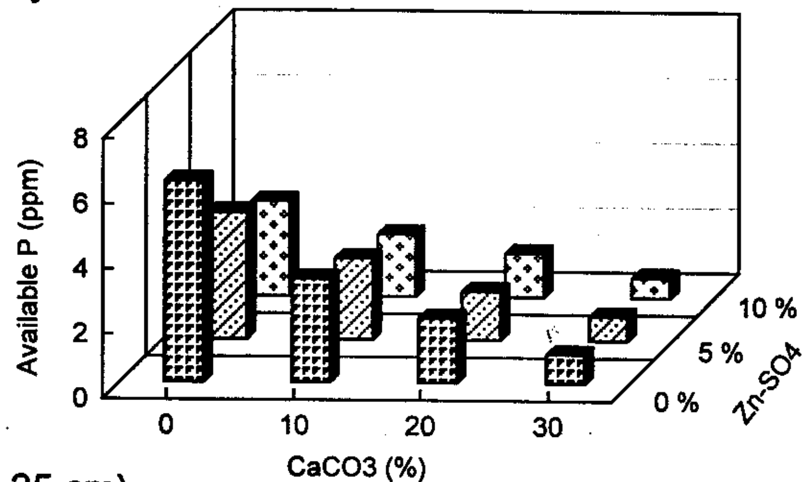


Fig. (17-b): Effect of the different rates of CaCO3 applied soley or in combination with different rates of Zn in two sources on the availability of P (ppm) in the (10-20 cm)layer of the investigated soils.

(>20 cm)

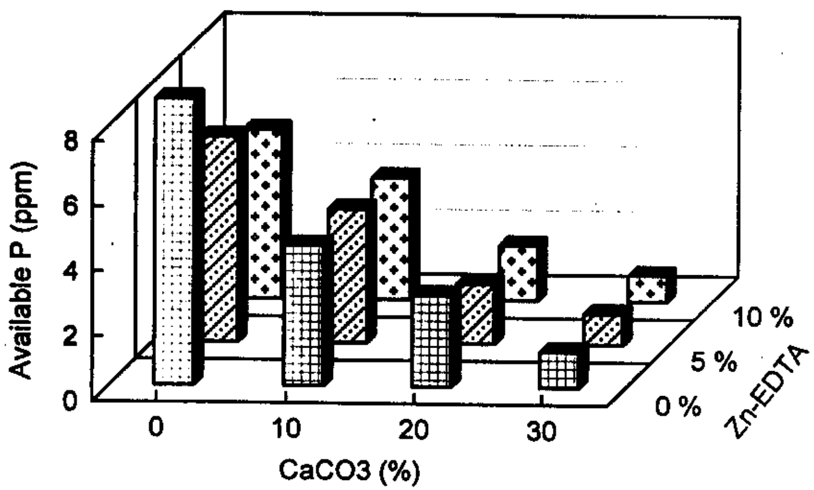
The sandy soil





(20-25 cm)

The alluvial soil



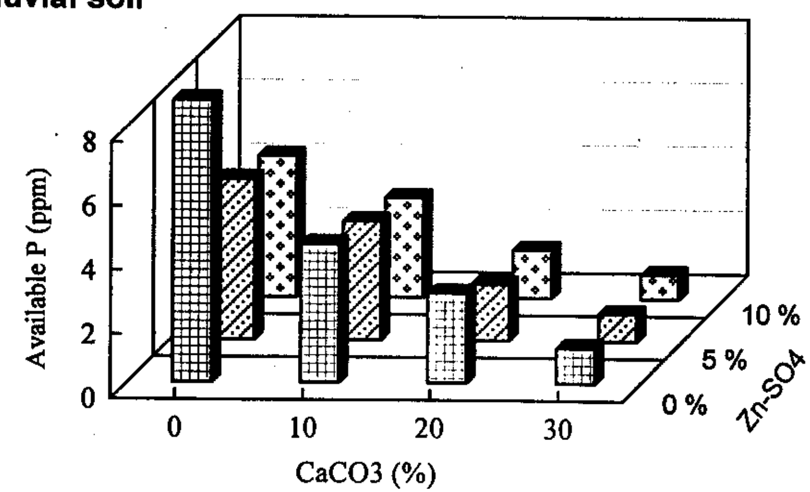


Fig. (17-c): Effect of the different rates of CaCO3 applied soley or in combination with different rates of Zn in two sources on the availability of P (ppm) in the (>20 cm)layer of the investigated soils.

reductions in the available P content were 33.0 and 34.9 % in the intermediate layer (20-30 cm) and raised up to 48.4 and 51.1 %, respectively in the deepest layers (> 20 cm depth).

Increasing rate of the applied $CaCO_3$ to 20 % increased the reduction in available P content to 48.7, 61.6 and 67.7 %, respectively in the three successive layers of the sandy soils, whereas the corresponding reductions in the Nile alluvial soil were 49.1, 64.2 and 68.2 %, respectively.

Maximum reductions in the available P content occurred when rate of the applied $CaCO_3$ was further raised up to 30 %, i.e., 71.4, 72.6 and 85.5 % in the sandy soil corresponding to 73.8, 72.7 and 87.5 %, respectively in the Nile alluvial one.

Thus, it can be deduced from the above mentioned results that $CaCO_3$ effect on P reduction, at any rate of its application, was slightly higher in the Nile alluvial soil than the sandy one. These results might be attributed, besides of the effect of $CaCO_3$ on adsorption of P, to the role played by the clay minerals, which are found in higher percentage in the Nile alluvial soil than the sandy one, in retention of P and consequently decreasing its availability.

The depthwise distribution of available P may be attributed to the effect of the depthwise distribution of soil moisture on solubility of $CaCO_3$. The soil moisture content is supposed to be highest in surface layers of the soils and tends to decrease with depth. This might enhance, to some extent, solubility of $CaCO_3$ in the upper layers and consequently its movement downwards. This means more accumulation of $CaCO_3$ in the deeper soil depths than the ones above, which, on the other hand, causes more retention of P in the surface layers that are higher in their $CaCO_3$ content than the ones below which are lower in their contents of $CaCO_3$.

Concerning effect of the applied Zn on mobility of P through the different soil depths, data revealed that applying Zn decreased P availability and the decrease was more obvious by increasing rate of the applied Zn regardless of its form or rate of application. The reducing effect of the applied Zn on P availability was noticed in all the depths of both the studied soils.

It is of a relative importance to indicate that the combined effect of the applied $CaCO_3$ and Zn is higher than the effect of the single application of $CaCO_3$ or Zn on P availability. Also, effect of the chelated form of the applied Zn seemed to be lower on reducing P availability than that of the mineral one. This finding indicates and assures the superiority of the chelated form of Zn over the mineral one upon application of zinc fertilizer, especially for the soils rich in their content of $CaCO_3$.

4.3.2. Zinc mobility:

Data presented in Table (19) and Figs. (18a, b, c) show that no or very slightly detectable changes could be observed in DTPA-extractable Zn among the different depths of both the sandy and Nile alluvial soils, respectively that did not receive any application of $CaCO_3$ solely or with Zn. Data illustrate also that applying $CaCO_3$ although affected markedly Zn availability in the different depths of the studied soils, yet it seemed to affect slightly the depthwise distribution of DTPA-extractable Zn in these soils when it was applied

Table (19): Effect of the different rates of $CaCO_3$ applied solely or in combination with different rates of Zn in two sources on the distribution of Zn (ppm) in different layers of the investigated soils.

Rate of applied $CaCO_3$ (%)	Soil depth (cm)	Sandy soil						Nile alluvial soil					
		Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)			Zn ppm (Zn EDTA)			Zn ppm ($ZnSO_4$)		
		0	5	10	0	5	10	0	5	10	0	5	10
0	0-10	0.95	5.33	10.10	0.95	5.00	9.95	2.50	6.53	10.95	2.50	6.42	10.82
	10-20	0.82	4.20	9.20	0.82	4.10	9.00	2.00	5.32	9.55	2.00	5.22	9.30
	20-30	0.93	3.10	8.72	0.93	2.95	8.50	1.75	4.50	8.31	1.75	4.30	8.12
	Mean	0.88	4.21	9.34	0.88	4.01	9.15	2.08	5.45	9.60	2.08	5.31	9.48
10	0-10	0.62	3.10	7.12	0.62	3.00	6.90	2.00	5.02	8.35	2.00	5.00	8.30
	10-20	0.40	1.92	4.22	0.40	1.75	4.15	1.30	3.10	5.62	1.30	2.91	5.53
	20-30	0.30	0.95	2.30	0.30	0.90	2.20	0.85	2.72	3.00	0.85	2.60	2.90
	Mean	0.44	1.99	4.54	0.44	1.88	4.41	1.38	3.61	5.65	1.38	3.50	5.57
20	0-10	0.41	2.40	5.20	0.41	2.32	5.00	1.72	3.96	5.52	1.72	3.90	5.50
	10-20	0.25	1.10	3.30	0.25	1.08	3.10	0.90	2.70	3.10	0.90	2.70	3.00
	20-30	0.11	0.70	1.92	0.11	0.62	1.85	0.52	1.90	1.95	0.52	1.82	1.90
	Mean	0.25	1.40	3.47	0.25	1.34	3.31	1.04	2.85	3.52	1.04	2.80	3.46
30	0-10	0.25	1.91	2.50	0.25	1.85	2.35	0.90	2.50	3.10	0.90	2.35	3.00
	10-20	0.13	0.60	1.95	0.13	0.55	1.82	0.52	1.22	2.12	0.52	1.12	1.95
	20-30	0.07	0.20	0.92	0.07	0.18	0.90	0.25	0.70	1.15	0.25	0.66	1.09
	Mean	0.15	0.90	1.79	0.15	0.86	1.69	0.55	1.47	2.12	0.55	1.37	2.01

(0-10 cm)

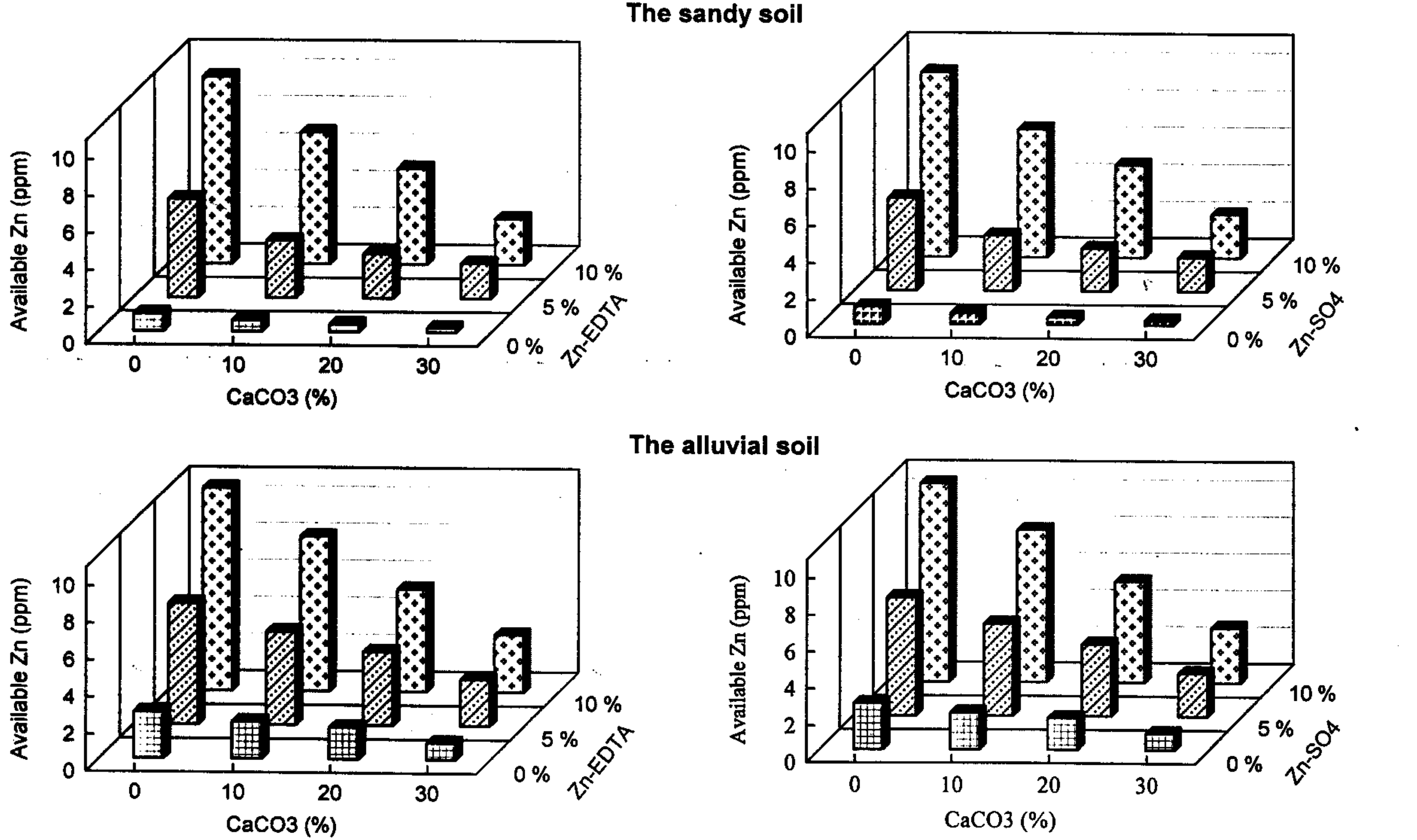
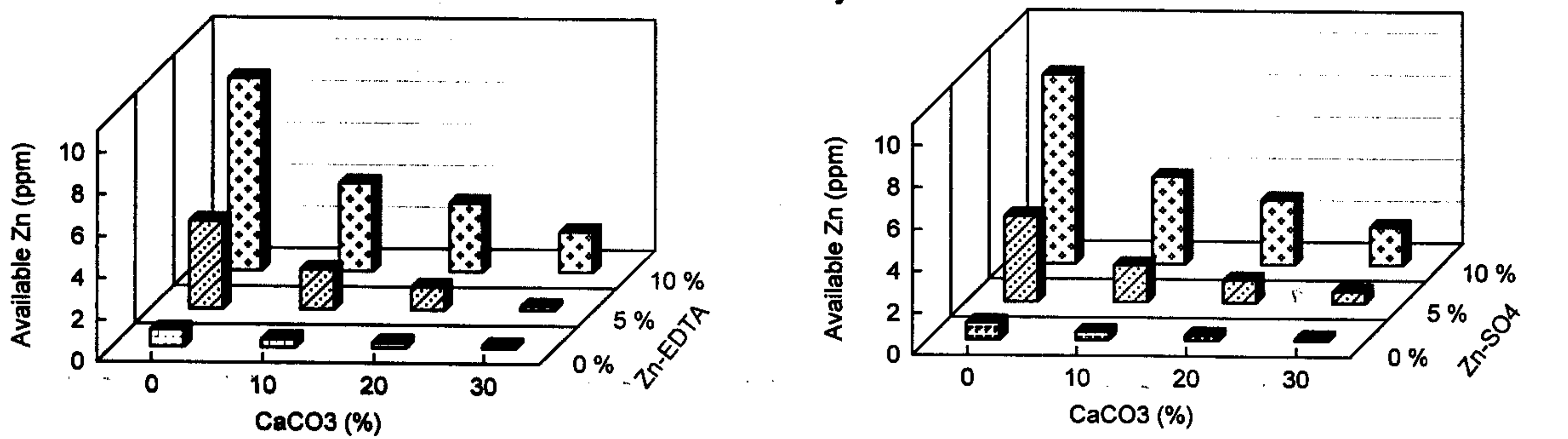


Fig. (18-a): Effect of the different rates of CaCO3 applied soley or in combination with different rates of Zn in two sources on the availability of Zn (ppm) in the (0-10 cm)layer of the investigated soils.

(10-20 cm)

The sandy soil



The alluvial soil

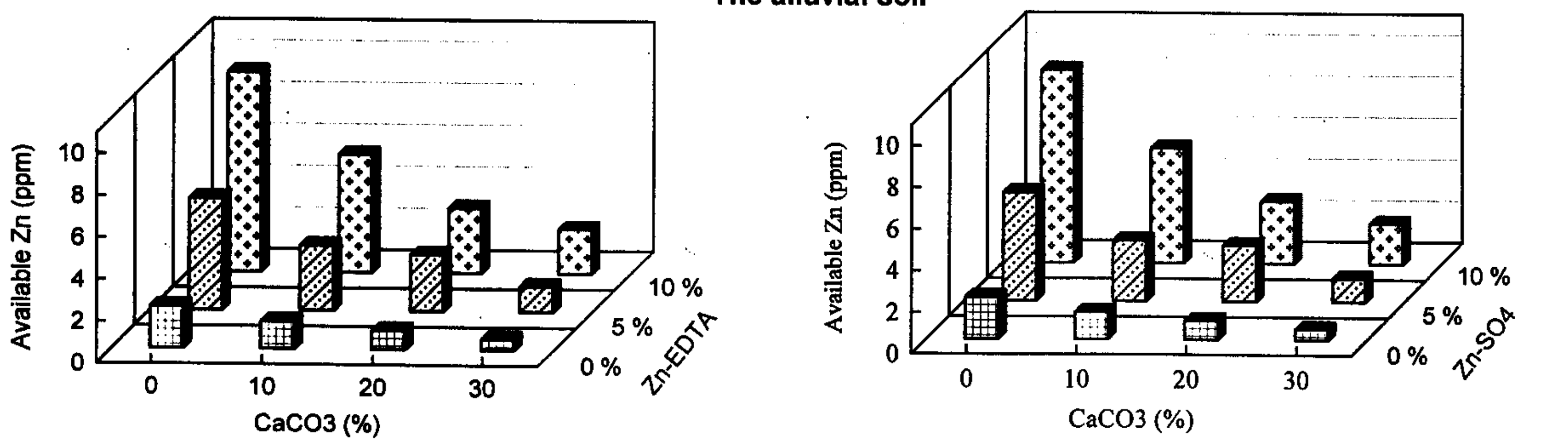
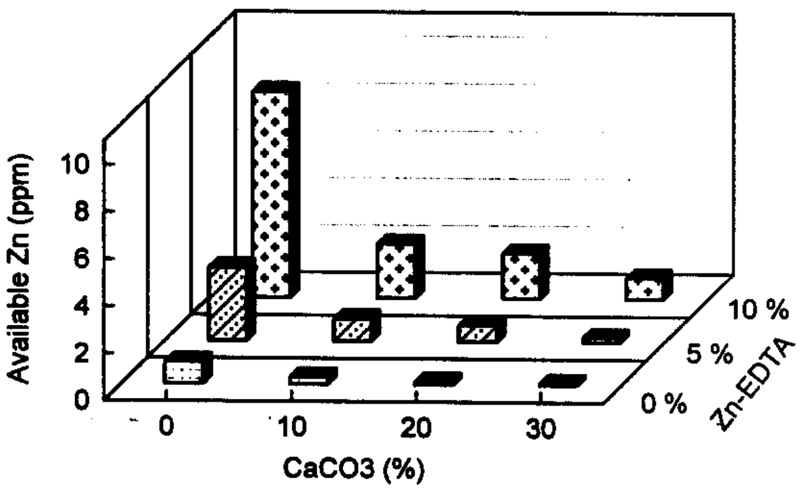
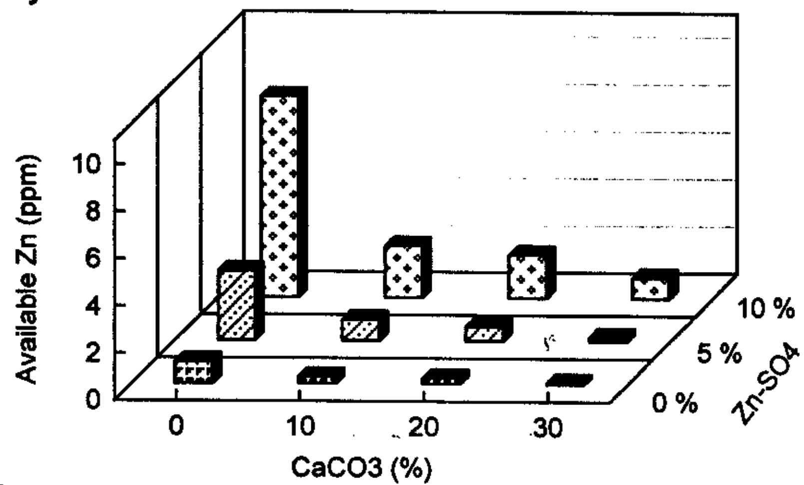


Fig. (18-b): Effect of the different rates of CaCO3 applied soley or in combination with different rates of Zn in two sources on the availability of Zn (ppm) in the (10-20 cm)layer of the investigated soils.

(>20 cm)

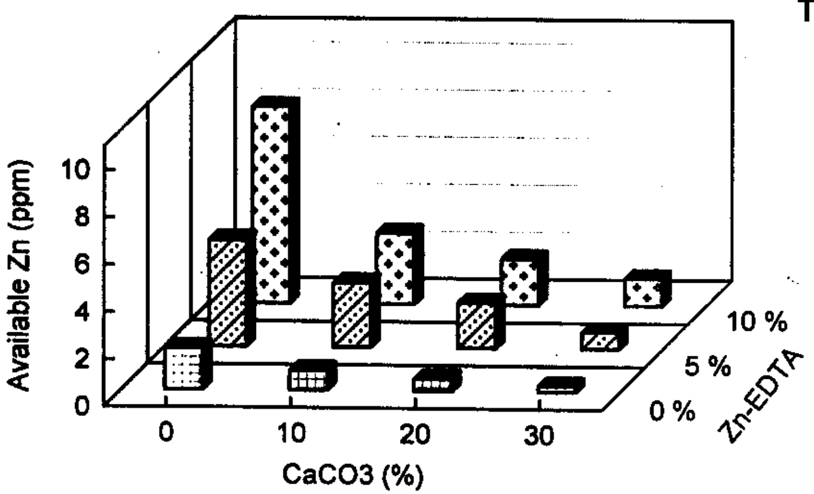
The sandy soil





(20-25 cm)

The alluvial soil



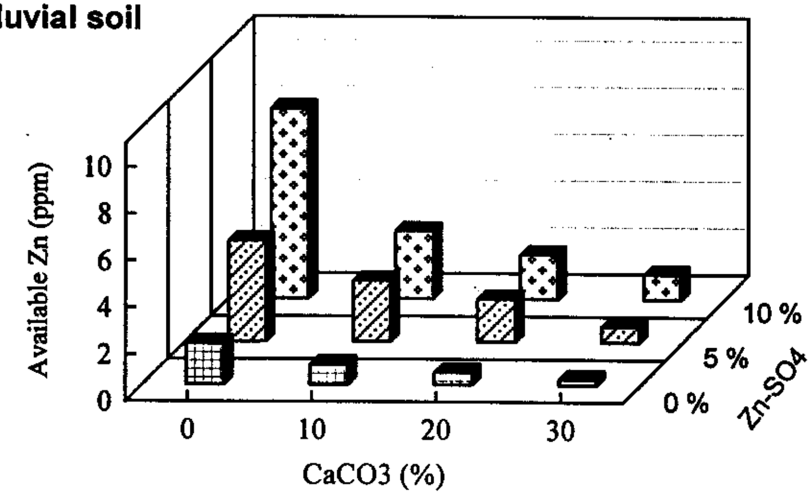


Fig. (18-c): Effect of the different rates of CaCO3 applied soley or in combination with different rates of Zn in two sources on the availability of Zn (ppm) in the (>20 cm)layer of the investigated soils.

at lowest rate (10%). The effect was enormoused with increasing rate of the applied $CaCO_3$ in all cases, it could by noticed that the upper layers of the studied soils were characterized by relatively high content of the DTPA-extractable Zn than the layer below.

More remarkable changes in DTPA extractable Zn occurred when Zn was applied together with $CaCO_3$. The decrease in Zn availability was more pronounced by increasing rate of applying $CaCO_3$. The variation in DTPA-extractable Zn throughout the different depths of the studied soils seemed to be inversely proportional to the soils content of $CaCO_3$ which is expected according to the amount of moisture retained by the different soil depths to affect dissolution of $CaCO_3$ in the upper layer and causes its movement downward to be highest in the deepest soils layers and tends to decrease upwards.

Application of Zn in the chelated form was slightly more efficient than the mineral form for enriching the different depths of the studied soils with the DTPA-extractable Zn.

The comparison between movement of Zn through the different depths of the sandy soil with its movement in the Nile alluvial soil reveals that upon application of Zn in both studied forms, its downward movement in the sandy soil seemed relatively further than that in the Nile alluvial soil. This result agrees with that reported by Joyce et al (1988) who found that Zn moved appreciably and consistently further in the sandy than in the clay soil. **Basyony (1996)** reported that the slower movement of Zn in the clay soil than in the sandy one might attributed to the innumerably cation exchange sites in the clay soil which contribute to the relative higher sorption of the clay soil for Zn that the sandy soil.