Effect of Organic Wastes and Incubation Periods on the Availability of Iron, Manganese, Copper and Zinc in a Calcareous Soil

Hager AL. Farhat, Magda A Hussien, Wafaa H. Mahmud and Hoda A Mahmoud
Soil and Agric. Chemistry Department, Faculty of Agriculture, (Saba Basha), Alexandaria University

Corresponding author: Hager, e-mail: sirtgirl69@yahoo.com

ABSTRACT: A calcareous soil incubation experiment for four tasting of 16 weeks was carried out to ascertain the effect of compost, olive waste and lemon waste, on the amounts of extractable iron, manganese, copper and zinc in a calcareous soil. The rates of organic materials added were 0, 0.5, 1.0, 1.5 and 2 % of the air-dried soil on dry weigh. The periods of sampling affected soil pH and were the lowest (pH = 7.32) was produced at the fourth time of sampling with olive waste. Decreasing pH values with increasing rate of applied organic waste were observed at each time of sampling and with increasing time of sampling. The compost gave the highest values of available Fe, Mn and Zn at the fourth time of incubation (5.41, 22.04 and 5.02 mg/kg soil, respectively), while, the olive waste gave the highest value of available Cu (5.11 mg/kg soil) at the fourth time of incubation. Generally, the available Fe, Cu, Mn and Zn were increased with increasing organic materials rate and increasing time of sampling. The highest values of available Fe (6.16 mg/kg soil), available Zn (6.21 mg/kg soil), available Mn (23.87 mg/kg soil) and available Cu (6.71 mg/kg soil) were recorded for 2% organic material application, rate at the fourth time of sampling.

Key words: Heavy metals, pH, DTPA- extractant, olive waste, lemon waste, compost

INTRODUCTION

Application of organic wastes as a source of organic matter is a common practice to improve soil properties (Baran, 2001). Land disposal of organic waste materials may directly or indirectly alter the trace element status of the soil by affecting elements solubility or dissociation kinetics (Del *et al.*, 1993). Distribution of trace element between soil and solution is the key to evaluated the environmental impact of the metals. Despite the complexity of possible reaction, several important soil factors controlling the distribution of heavy metals between soil and solution have been identified (Sposito, 1989 and Temminghoff *et al.*, 1998).

The effect of soil pH on soil solution concentrations and extractability of metals have been studied. He and Singh (1993) found that peat addition increased DTPA-extractable Cd in soil due to decrease in soil pH caused by peat application. Arnesen and Singh (1999) found that the lowing of pH in peat-amended soil decreased the sorption of Cd, Cu, Zn and Ni in the soil. Organic matter makes strong complexes with heavy metals (Krogstad, 1983). The amount of organic matter in soils affects the binding of heavy metals in soil and speciation in soil solution (Lo *et al.*, 1992). High organic matter content or addition of organic matter increases the extractability of Zn (Arnesen and Singh, 1999). Amendment with organic matter and the resulting degradation may change the soil pH and thereby indirectly affect the bio-availability of metals. Many authors have found that all types of organic material increased the extractability of Zn in soil (Arnesen and Singh 1999). Also, Hossien, (2008) stated that the pH of treated soils with lemon waste was decreasesd slightly with increasing with the amount of lemon waste and time of sampling. Moreover, Gigliotti *et al*. (1996) observed significant increase with Cu, Zn, Pb and Cr concentrations in clay-loam calcareous soil amended with urban waste compost. Furthermore, Romero *et al*. (2005) found that the mount of soluble and AB-DTBA extractable Pb and Zn the mine tailing were increased by application of the olive-mill solid waste and to a lesser degree, by the compost from the olive waste. Addionally, Hamidpour *et al*. (2012) in 3-years field study, conducted to assess effects of composted municipal waste on some properties, distribution of Zn, Cu in a calcareous soil and uptake of these metals by wheat, showed that application of composted municipal waste decreased the soil pH and a significant increaseed the concentrations of Zn and Cu with increasing number and rate of compost application. Also, Bloomfileld and Pruden (1975) stated that the availability of Cu, Zn, Mn, Fe and P in soils increased with increasing the applied amount of lemon waste and time of incubation.

The objective of this study was, therefore, to evaluate the effect of three organic materials (compost, olive waste and lemon waste) on the availability of (Fe, Mn, Cu and Zn) as a function of pH in calcareous soil.

MATERIALS AND METHODS

The Used Soil and Organic Wastes: Soil was collected from surface horizon (0-30 cm) from Matruh city at north western coast of Egypt. The soil was air-dried, ground and passed through a 2-mm sieve.

The tested organic materials were combost , olive waste and lemon waste which were ground and passed through 6.35 mm sieve. The main properties of the soil and the organic materials were determined according to the methods outlined by page *et al*. (1982). Some physical and chemical properties and the amounts of heavy metal of the sample and organic materials are given in Tables (1 and 2).

Incubation trial: The rates of organic material added the soil were 0, 0.5, 1.0, 1.5 and 2 % of the air-dried soil on dry weight basis. The soils were homogenized with the dry organic materials and filled in plastic pots (4 cm deep and 10 cm diameter). Each pot consisted of 100 g soil with the various rate of organic materials. During the incubation periods (4, 8, 12 and 16 weeks) and the ambient temperature was 23 to 30 C° at the summer, the distilled water was added to each pot to keep the moisture content close to the filed capacity. Each treatment was repeated three times and the experimental layout was split plot design. Soil samples were taken on the 4th (1st time), 8th (2nd time) 12th (3rd time) and 16th (4th time) weeks after incubation and analyzed for pH and DTPA extractable Fe, Mn, Cu and Zn. (Lindsay and Novvell, 1978).

Sample analysis: Soil pH and electrical conductivity (EC) was measured in 1:2, soil: water ratio according to Jackson (1973). Organic matter content in soil was determined by the method of Walkley and Black (Jakson, 1973). Particle size distribution was determined according the method outlined in Black (1965). Available Fe, Mn, Cu and Zn in soils were extracted with a DTPA method (0.005 M DTPA + 0.005M $CaCl_2$+ 0.1M TEA, pH 7.3), according to Lindsay and Novvell, (1978). The organic materials were tested by digestion in H_2SO_4 and H_2O_2 (Lowther, 1980) for total heavy metals determination. The concentration of Fe, Mn, Cu and Zn were measured by atomic absorption spectrophotometer (AAS).

The obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) and the least significant difference (L.S.D) was used to test the difference between the treatment means, as described by Gomez and Gomez (1984).

Table (1): some physical and chemical properties of the used soil

soil properties	means
Particle size distribution (%)	
Clay	25
Sand	42
Silt	33
Textural class	Loam
EC (dS/m) 1:2	0.29
pH 1:2	8.13
O.M (%)	1.30
$CaCO_3$(%)	25.4
Water Soluble anions (mg/kg)	
HCO_3^-	5.600
Cl^-	2.800
$SO_4^=$	0.029
Water Soluble cations (mg/kg)	
Na^+	14.0
K^+	9.33
Ca^{+2}	9.40
Mg^{+2}	5.40
Available micronutrients (mg/kg)	
Fe	0.202
Cu	0.145
Zn	0.746
Mn	1.335

Table (2): Some chemical properties of the used organic materials

Chemical property	organic materials		
	Olive waste	compost	Lemon waste
pH (1:2)	5.6	7.02	3.26
EC(dS/m), 1:2	7.3	7.10	7.20
O C (%)	40.7	17.4	86.0
Total N (%)	5.16	5.32	6.68
Total P (%)	0.042	0.013	0.044
Soluble cations (mg/kg)			
K^+	38.7	23.5	40.7
Na^+	22.5	27.5	15.0
Ca^{+2}	24. 0	16. 0	14.0
Mg^{+2}	7.80	4.0	2.30
Soluble anions (mg/kg)			
$SO_4^=$	40.5	49.11	51.25
Cl^-	20. 0	22. 0	21. 0
Available micronutrients (mg/kg)			
Fe	0.427	2.634	1.923
Zn	2.500	3.146	1.079
Cu	0.006	0.226	0.437
Mn	0.180	3.284	0.600

RESULTS AND DISCUSSION

Soil pH: Table (3) showed a significant effect of organic material type at each time of sampling, on the soil pH except at the second time of sampling.

Table (4) indicated a significant effect by decrease as results of present of organic material, whether with respect to the type or the rate and their interaction, except at the second time of sampling on soil pH. The decreases in pH were noted with increasing time of sampling. The fourth time of sampling was significant lower soil pH.

Table (4) showed also significant effects of the different organic materials on soil pH all incubation periods, except at the second time of sampling for pH.

The lowest value of pH (averaged 7.32) was recorded at the fourth time of sampling with olive waste. Soil pH has decreased slightly due to the acidity indicated by the disposal of raw olive waste. It can be concluded, therefore, that due to the carbonate content of the soil, the surface application of olive waste does not markedly affect soil pH (Mechri *et al*., 2007).

Regarding to the effect of organic material rate on soil pH, the data presented in (Table 4) indicated that the rate of organic material has significant effect on pH at each time of sampling, except at that of the second time. Decreasing pH values with increasing rate of organic material were observed at each time of sampling and with increasing time of incubation. These results are agree with those obtained by Hossien (2008), Claudia *et al*. (2012) and Kavvadias *et al.* (2012).

The interaction effect of organic waste types and rate of application the results showed significant decreased of soil pH, except at the second time of sampling (Table 3). The highest value of soil pH was observed at the first time of sampling without organic material (8.05). On the other hand, the lowest values of pH were found at the fourth time of sampling using 2% olive waste (pH=7.01).

Table (3): soil pH as affected by type and rate of organic materials and incubation periods

Organic material		Time of Soil Sampling			
Type	Rate, %	1st time	2nd time	3rd time	4th time
Olive Waste	0.0	8.05	8.00	7.80	7.79
	0.5	8.00	7.94	7.65	7.40
	1.0	7.94	7.91	7.60	7.26
	1.5	7.89	7.80	7.52	7.16
	2.0	7.80	7.76	7.04	7.01
Compost	0.0	8.05	7.80	7.80	7.79
	0.5	8.00	7.98	7.71	7.50
	1.0	7.96	7.90	7.60	7.31
	1.5	7.92	7.80	7.55	7.12
	2.0	7.90	7.78	7.25	7.09
Lemon Waste	0.0	8.05	8.00	7.80	7.79
	0.5	7.96	7.90	7.63	7.54
	1.0	7.87	7.80	7.56	7.25
	1.5	7.73	7.69	7.40	7.12
	2.0	7.70	7.50	7.15	7.07
Statistical significance ($LSD_{0.05}$)					
O.M type (M)		1.65E-07	N	9.53E-08	0.032
Rate of O.M (R)		2.13E-07	N	1.23E-07	0.042
M x R		0.412	N	2.38E-08	8.348E-3

Table (4): Mean values of soil pH at each time of sampling as affected by the type and rate of organic materials

Treatments	Time of Sampling 1st time	2nd time	3rd time	4th time
	Organic material type			
Olive Waste	7.80	7.76	7.04	7.01
Compost	7.90	7.78	7.25	7.09
Lemon Waste	7.70	7.50	7.15	7.07
$LSD_{0.05}$	1.65E-07	N	9.53E-08	0.03
	Rate of organic material, %			
0.0	8.05	7.93	7.89	7.79
0.5	7.99	7.94	7.66	7.48
1.0	7.92	7.87	7.59	7.27
1.5	7.85	7.76	7.49	7.13
2.0	7.80	7.68	7.15	7.06
$LSD_{0.05}$	2.13E-07	N	1.23E-07	0.04

Available Trace Elements in soil:

Table (5) showed that the organic material types, rates of application and their interactions significantly influenced the amounts of available Fe, Cu, Zn and Mn in soil at all time of samplings, except those of available Cu at the fourth time of sampling and available Zn at the first and third time of sampling. Also, the means of available Fe, Cu, Zn and Mn (Table 6) showed that the compost gave the highest values of available Fe, Mn and Zn at the fourth time of sampling (5.41, 22.04 and 5.02 mg/kg soil, respectively). However, the olive waste gave the highest value of available Cu (5.11 mg/kg soil) at the fourth time of sampling and the lemon waste gave the lowest value of available Zn at the first time of sampling (1.80 mg/kg soil). It is also leas that, the olive waste gave the lowest value of available Fe and Mn at the first time of sampling (0.67 and 16.32 mg/kg soil, respectively), while the compost gave the lowest value of available Cu at the first time of sampling (1.30 mg/kg soil).

Generally, the amounts of available Fe, Cu, Mn and Zn were increased with increasing organic material application rates and increasing time of sampling (Table 5). The highest values of available Fe (6.16 mg/kg soil), Zn (6.21 mg/kg soil), Mn (23.87 mg/kg soil) and Cu (6.71 mg/kg soil) were recorded for 2% organic materials rate at the fourth time of sampling. The increases of available micronutrients could be explained by the production of CO_2 and forming H_2CO_3 during organic material decomposing. Nader *et al*. (2008) reported that the solubility increased of micronutrients in the soil may be due to lowering pH and air water balance. The compost applied causes high amount of O.M, and its oxidation and degradation would increase the micronutrients availability in soil (Gallardo-lara and Nogales, 1987). Increasing concentrations of Zn and Fe after organic waste application were also reported by Ageel and Hamed (2007). According to Piotrowska *et al*. (2006), the increase of extractable Fe can be attributed to the fact that this metal catalyze the oxidative transformation of phenols present in soil.

The interaction between organic waste type and rates of application had significant effect on the amounts of available Fe, Cu, Zn and Mn at all time of sampling, except available Cu at fourth time of sampling and Zn at first and third sampling, (Table 5). The highest values of available Fe, Zn and Mn were obtained at the fourth time of sampling with 2 % compost (7.10, 7.44 and 24.88 mg/kg soil, respectively). On the other hand, the highest value of available Cu was obtained at the fourth time of sampling with 2% olive waste (7.45 mg/kg soil). However, the lowest values of available Fe, Cu, Zn and Mn were obtained at the first time of sampling without organic materials.

Table (7) showed regression equations for the relation between the available Fe (Y_1), Cu (Y_2), Zn (Y_3) and Mn (Y_4) and the organic material rate (X).

Table (5): The amounts of available Fe, Cu, Zn and Mn in the soil (mg/kg) at each time of sampling as affected by type and rate of material application

Organic material		Fe				Cu				Zn				Mn			
		Time of Sampling				Time of Sampling				Time of Sampling				Time of Sampling			
Type	Rate, %	1st time	2nd time	3rd time	4th time	1st time	2nd time	3rd time	4th time	1st time	2nd time	3rd time	4th time	1st time	2nd time	3rd time	4th time
Olive Waste	0.0	0.31	0.34	0.34	0.34	0.73	1.30	1.30	1.30	1.41	1.47	1.47	1.47	15.22	15.53	15.53	15.53
	0.5	0.39	0.75	0.8	4.49	1.02	1.89	3.49	4.48	1.64	1.96	2.64	2.95	15.6	15.88	15.96	18.74
	1.0	0.44	1.05	1.43	5.9	1.36	2.57	5.14	5.41	2.33	2.55	2.87	3.02	15.9	16.52	18.00	18.79
	1.5	0.65	1.61	2.19	6.19	1.37	2.59	5.78	6.91	2.74	2.86	3.29	3.84	16.84	17.98	19.80	20.33
	2.0	1.54	3.11	3.22	6.48	2.03	3.9	7.01	7.45	2.96	3.56	3.73	4.19	18.09	21.00	21.12	22.48
Compost	0.0	0.31	0.34	0.34	0.34	0.73	1.30	1.30	1.30	1.41	1.47	1.47	1.47	15.22	15.53	15.53	15.53
	0.5	0.56	0.61	0.96	6.32	0.96	1.76	2.27	3.11	1.86	1.87	2.19	4.76	15.93	16.67	17.98	22.88
	1.0	0.77	0.86	1.14	6.45	1.09	2.03	3.21	3.75	2.10	2.49	3.00	5.03	16.21	18.00	19.80	22.90
	1.5	1.15	1.54	2.21	6.83	1.46	2.76	3.5	5.33	2.53	3.2	3.8	6.38	18.14	21.24	19.93	24.00
	2.0	1.28	1.74	3.39	7.1	1.61	3.07	5.25	6.23	3.72	4.08	5.43	7.44	20.38	23.8	23.96	24.88
Lemon Waste	0.0	0.31	0.34	0.34	0.34	0.73	1.30	1.30	1.30	1.41	1.47	1.47	1.47	15.22	15.53	15.53	15.53
	0.5	0.41	0.65	0.85	3.22	1.46	2.76	3.32	4.12	1.34	1.68	3.08	3.14	15.86	15.89	16.92	18.2
	1.0	0.83	0.73	1.22	4.01	1.75	3.35	3.86	4.74	1.81	2.08	3.35	3.64	16.13	17.22	18.61	20.00
	1.5	1.16	1.42	1.28	4.18	2.02	3.89	3.91	5.77	2.05	2.54	3.73	6.75	16.9	19.06	20.91	24.00
	2.0	1.35	1.52	2.18	4.90	2.17	4.19	4.52	6.45	2.4	2.86	4.81	7.01	17.74	20	49	24.25
STATISICAL SIGNIFICAN LSD, $_{0.05}$																	
O.M type (M)		0.005	0.0046	0.0019	0.0062	0.0033	0.002	0.037	N	N	3.37E-08	N	4.77E-08	0.137	0.126	1.155	0.031
Rate of O.M (R)		0.006	0.0036	0.0025	0.0079	0.0043	0.003	0.047	N	N	4.35E-08	N	6.15E-08	0.176	0.162	1.492	0.04
M x R		1.181	8.93E-04	1.52E-04	1.54E-03	8.38E-04	4.82E-04	9.15E-03	N	N	8.40E-09	N	1.19E-08	7.69E-03	0.288	0.031	0.01

Table (6): Means of Fe, Zn, Mn and Cu (mg/kg) at each time of sampling as affected by the type and rate of organic materials

	Fe (mg/kg)				Cu (mg/kg)				Mn (mg/kg)				Zn (mg/kg)			
	Time of Sampling				Time of Sampling				Time of Sampling				Time of Sampling			
Treatments	1st time	2nd time	3rd time	4th time	1st time	2nd time	3rd time	4th time	1st time	2nd time	3rd time	4th time	1st time	2nd time	3rd time	4th time
Organic material type																
Olive Waste	0.67	1.37	1.59	4.68	1.30	2.45	4.54	5.11	16.32	17.38	18.08	19.17	2.22	2.48	2.8	3.09
Compost	0.81	1.02	1.61	5.41	1.17	2.18	3.11	3.94	17.18	19.05	19.44	22.04	2.32	2.62	3.18	5.02
Lemon Waste	0.81	0.93	1.17	3.33	1.63	3.1	3.38	4.48	16.37	17.54	24.19	20.4	1.8	2.12	3.29	4.4
$LSD_{0.05}$	0.005	0.005	0.0019	0.006	0.003	0.002	0.035	N	N	3.37E-08	N	4.77E-08	0.137	0.126	1.155	0.031
Rate of organic material, %																
0.0	0.32	0.34	0.34	0.34	0.73	1.30	1.30	1.30	15.21	15.53	15.53	15.53	1.41	1.46	1.47	1.47
0.5	0.45	0.67	0.87	4.68	1.15	2.14	3.03	3.90	15.8	16.15	16.95	19.94	1.61	1.84	2.64	3.62
1.0	0.68	0.88	1.26	5.45	1.4	2.65	4.07	4.63	16.08	17.25	18.8	20.56	2.08	2.37	3.07	3.9
1.5	0.99	1.52	1.89	5.73	1.62	3.08	1.40	6.00	17.29	19.43	20.23	22.78	2.44	2.87	3.61	5.66
2.0	1.39	2.12	2.93	6.16	1.94	3.72	5.95	6.71.	18.74	21.6	31.36	23.87	3.03	3.5	4.66	6.21
$LSD_{0.05}$	0.006	0.004	0.0025	0.008	0.004	0.003	0.047	N	N	4.35E-08	N	6.15E-08	0.176	0.162	1.492	0.04

A specific relationship was found between Fe, Cu, Zn or Mn and organic material rate for the three materials at the first or fourth time of sampling. The comparison of the slopes of Fe, Cu, Zn and Mn regression equations gives a quantitative expression of the efficiency of organic waste rates for each organic material type. The comparison of slopes at the first time of sampling and at the fourth time of sampling with olive waste for Fe showed that, the efficiency of organic material rates was 513.97 %, while for Zn, the efficiency was 150.71 %. On the other hand, with olive waste for Cu, the efficiency of organic material rates were 499.32 %, but for Mn, the efficiency of organic material rates was 221.92%.

The comparison of slopes at the first time of sampling and at the fourth time of sampling with compost for Fe showed that, the efficiency of organic material rates were 554.55 %, while for Zn, the efficiency of organic material rates were 362.07 %. On the other hand, the efficiency of organic waste rates was 534.51 % for Cu, but the efficiency of organic material rates was 158.18 % for Mn. The comparison of the slopes at the first time of sampling and at the fourth time of sampling with lemon waste for Fe; the efficiency of organic material rate was 356.18 %, while for Zn, the efficiency was 546.1 %. On the other hand for Cu, the efficiency of organic material rate was 347.38 %, but the efficiency of organic material rate was 53.28 % for Mn.

Conclusion:

The application of compost increased the amounts of DTPA- extractable Fe, Mn and Zn with different degrees. The concentrations of micro elements in the present study were higher after 16 weeks of incubation than in the first period of incubation, probably due to degradation of the organic materials and release of metals, which were complexes with organic matter at the beginning of incubation. Organic matter content and the pH value of the soil are relatively easy to change due the application of the organic waste materials. Therefore, the effect of organic matter and pH on the extractability of micro elements deserves special attention.

Table (7): The liner regression between the available Fe, Zn, Mn and Cu and organic material rates after 4 and 16 weeks of incubation

Time of Sampling	Organic material	Regression Equation							
		Fe		Cu		Zn		Mn	
After4 weeks	olive waste	Y_1=0.122+0.544 X	R^2=0.852	Y_2=0.712+0.590 X	R^2=0.960	Y_3=1.364+0.84 X	R^2=0.984	Y_4=14.934+1.396 X	R^2=0.958
	compost	Y_1=0.308+0.506 X	R^2=0.992	Y_2=0.718+0.452 X	R^2=0.989	Y_3=1.418+0.754 X	R^2=0.996	Y_4=14.670+2.506 X	R^2=0.947
	lemon waste	Y_1=0.246+0.566 X	R^2=0.986	Y_2=0.938+0.688 X	R^2=0.955	Y_3=1.264+0.538 X	R^2=0.959	Y_4=15.154+1.216 X	R^2=0.987
After16 weeks	olive waste	Y_1=1.884+2.796 X	R^2=0.869	Y_2=2.164+2.946 X	R^2=0.950	Y_3=1.828+1.266 X	R^2=0.952	Y_4=16.076+3.098 X	R^2=0.962
	compost	Y_1=2.602+2.806 X	R^2=0.778	Y_2=1.528+2.416 X	R^2=0.991	Y_3=2.268+2.73 X	R^2=0.955	Y_4=18.074+3.964 X	R^2=0.840
	lemon waste	Y_1=1.314+2.016 X	R^2=0.898	Y_2=2.860+2.390 X	R^2=0.950.	Y_3=1.464+2.938 X	R^2=0.967	Y_4=15.748+0.648 X	R^2=0.978

Y_1=Fe Y_2=Cu Y_3=Zn Y_4=Mn X == Rate of O.M

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الملخص العربى

تأثير المخلفات العضوية وفترات التحضين على تيسر الحديد ، المنجنيز ، النحاس و الزنك فى أرض جيرية

هاجر القذافى فرحات و ماجدة أبو المجد حسين و وفاء محمد على و هدى عبدالفتاح محمود
قسم الأراضى والكيمياء الزراعية –كلية الزراعة – سابا باشا – جامعة الإسكندرية

أجريت تجربة تحضين تربة جيرية لأربعة فترات تراوحت من 4 الى 16 أسبوع لدراسة تأثير كل من الكمبوست ، مخلفات الزيتون والليمون على الكميات الميسرة من الحديد ،المنجنيز ، النحاس والزنك فى أرض جيرية. وكانت معدلات المخلفات العضوية المضافة للتربة 0.0 ,0.5 ,1.0 ,1.5 و2.0 % على أساس الوزن الجاف. ولقد أوضحت النتائج انخفاض فى pH تربة بزيادة معدل المواد العضوية عند كل فترة من فترات التحضين و بزيادة فترة التحضين. ولقد أعطى الكمبوست أعلى قيم من الحديد ،المنجنيز والزنك الميسر عند فترة التحضين الرابعة (بعد 16 أسبوع) وكانت هذه القيم هى (5.02 ، 22.04 و5.41 ملجرام/ كجم تربة) على التوالى.
وقدأعطت مخلفات الزيتون أعلى قيمة للنحاس الميسر (5.11 ملجرام/ كجم تربة) عند فترة التحضين الرابعة . عامة فالحديد و المنجنيز و النحاس و الزنك الميسر يزداد مع زيادة معدل اضافة المواد العضوية وبزيادة فترة التحضين.

وأيضا كانت أعلى قيم للحديد الميسر (6.16 ملجرام/ كجم) والزنك (6.21 ملجرام/ كجم) والمنجنيز (23.87 ملجرام/ كجم) والنحاس (6.71 ملجرام/ كجم)عند معدل اضافة 2 % من المواد العضوية عند فترة التحضين الرابعة (16 أسبوع).