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Effect of Three Organic Materials on Soil Soluble Cations in Calcareous Soil

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Abstract

A calcareous soil incubation experiment for four tasting of 16 weeks was carried out in governorate of Etnoh city, Egypt to ascertain the effect of compost, olive waste and lemon waste on the amounts of extractable sodium, potassium, calcium and magnesium 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 the lowest value was produced at the fourth time of sampling with olive waste [pH = 7.16]. Decreasing pH values with increasing rate of applied organic waste observed at each time of sampling and with increasing time of sampling. The compost gave the highest value of soluble cation Na at the fourth time of incubation [125 meq/Kg soil], while the lemon waste gave the highest values of soluble cations K, Ca and Mg at the fourth time of incubation [135, 92 and 55 meq/Kg soil, respectively]. Generally, Soluble cations Na, K, Ca and Mg were increased with increasing organic materials rate and increasing time of sampling. The highest values were recorded for 2 % organic material application, rated at the fourth time of sampling.

Keywords: *Soluble cation, pH, olive waste, lemon waste, compost, calcareous soil.*

1. Introduction

Calcareous soils are highly buffered and remain in the $CaCO_3$ buffering range of pH until all carbonate is removed from the fine fraction and weathering of silicate minerals and associated acidification begins [1]. The soil solution and cation exchange complex of calcareous soils are dominated by Ca [2]. Magnesium is more readily leached from dolomite-derived soils than Ca [1]. Calcite and aragonite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), and magnetite ($MgCO_3$) are the calcium and magnesium carbonate minerals found in calcareous soils. They are mainly present as calcite, and to a lesser extent as dolomite [3 and 4]. The actual carbonate content, expressed as the $CaCO_3$ equivalent, must be determined by laboratory analysis [5].

Calcareous soils have a wide range of pH due to the type and nature of their constituent, calcium carbonate content and rainfall, and they vary from 7.8 to 8.2. One of the important roles of pH is controlling nutrient solubility in soil. Solubility of most nutrients usually decreases with increasing pH [6]. The carbonate minerals may be either primary carbonates originating from carbonate-rich parent materials, or secondary carbonates formed by partial re-precipitation of dissolved carbonates. The pH range of calcareous soils (determined in water) is from 7.0 to 8.5 [7]. Calcareous soils are sometimes referred to as alkaline (high pH) soils, but they are distinguishable from other soils with high pH [8 and 9]. Composts are widely used to improve soil physical properties and valuable source of organic matter[6]. Many of the composts have relatively high pH ranging from seven to eight. High pH of the composts is one problem that limits its usage in alkaline soils.

Calcareous soils are distinguished from saline soils, which contain high concentrations of neutral salts more soluble than Ca and Mg carbonates [10]. In calcareous soils, 19 months after initial application, organic amendments decreased soil pH [11]. However, the increase in soil pH due to compost addition depends on the soil and the compost characteristics as well as on the dose and time applied[10].

Increasing the soil organic matter improves soil properties, enhances soil quality, and reduces soil erosion, and increases plant productivity and soil microbial biomass. Thus, in the regions where organic matter content of the soil is low, agricultural use of organic compost is recommended for increasing soil organic matter content and consequently to improve and maintain soil quality. Composts are widely used to improve soil physical properties and valuable source of organic matter.

Soil organic matter plays a major role in maintaining soil quality [12]. Also, increasing soil organic matter, improves soil properties, enhances soil quality, reduces soil erosion, increases plant productivity and soil microbial biomass [13]. Thus, in the regions where organic matter content of the soil is low, agricultural use of organic compost is recommended for increasing soil organic matter content and consequently to improve and maintain soil quality.

Soil amendment includes any material added to soil to improve its properties which can be physical, chemical or biological to allow healthy crop growth. They improve soil properties and processes such as structure, water retention, permeability, infiltration of water, drainage, aeration, nutrient supply and biological activities which are important for proper functioning of soil to support sustainable agricultural production [7].

Use of organic composts in agricultural areas is increasing because these improve soil health and nutrient status. [14 and 15] Reported that, incorporation of organic compost decreased P adsorption, maximum buffering capacity, bonding energy, and increased P concentration in solution. [16 and 17] Demonstrated that long-term use of organic compost in greenhouse soil improved soil fertility, the use of organic fertilizer resulted in higher soil organic matter, soil N content, and available P and reported that olive mill waste (OMW) application to soil can result to some beneficial of soil chemical and physical characteristics, such as increase in organic matter, organic carbon, major nutrients (e.g N, K), water-holding capacity and porosity.

Addition of compost improved the physical properties of the soil, and increased the supplying power of available nutrients to plants [18]. Organic materials rates significantly affected soluble Na^{+} and K^{+} at each time of incubation, except at the second time of incubation significantly effected soluble Ca^{+2} at the first or fourth time of incubation and significantly affected soluble Mg^{+2} at the fourth time of incubation. On the other hand, 2% of organic materials, produced the highest value of soluble Na^{+}, K^{+}, Ca^{+2} and Mg^{+2}, while 1.5% of organic materials produced the highest value of soluble K^{+} at the fourth time of incubation. In general, the application of OMW resulted positive effects on soil fertility which confirmed by other pertinent studies as well [9].

Increased plant available nutrients due to organic fertilization were also observed in soils. Previous studies mention that application of OMW on soils increases available Mg [19] and to a lesser degree Ca^{2+} [20].

The objective of this study was to evaluate the effect of three organic wastes [compost, olive waste and lemon waste] on some soil chemical properties and the Soluble cations [Na, K, Ca and Mg] as a function of pH tested in calcareous soil.

2. Materials and Methods

2.1 Study area, soil and organic wastes: The soil samples analyzed were collected from the surface horizon [0 - 30 cm] from Etnoh city governorate at north western coast of Alexandria ,Egypt. The study area is the climate of the Mediterranean, which is characterized by rainy winters and dry summers. Some physical and chemical properties, the amounts of heavy metal of the samples and organic materials are given in Tables [1and 2]. The data was collected and handled in duration of six months.

The soil was air-dried, ground and passed through a 2 mm sieve. The tested organic materials were compost, 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[21].

Table 1. Some physical and chemical properties of the tested soil

Particle size distribution			Textural class	pH	EC (dS/m)	O.M(%)	$CaCO_3$ (%)	Soluble Anion (meq/kg)			Soluble cation (meq/ kg)				Available micronutrient (mg/kg)		
Clay %	Silt %	Sand %						HCO_3^-	Cl^-	$SO_4^=$	Na^+	K^+	Ca^{+2}	Mg^{+2}	Fe	Zn	Cu
25	52	23	Salty Loam	8.21	0.41	1.29	29.44	3.0	2.80	0.441	15.5	27.5	11.0	8.60	0.142	0.928	0.927

Table 2. Some chemical properties of the tested organic materials

Soilamendments	pH	EC (dS/m)	N (%)	P (%)	Total Cations (mg/kg)				Total Anion		Total Micronutrients (mg/kg)		
					K^+	Na^+	Ca^{+2}	Mg^{+2}	Cl^-	$SO_4^=$	Fe	Zn	Cu
Olive waste	5.6	7.3	5.16	0.042	38.7	22.5	24. 0	7.8	20. 0	40.5	0.427	2.5	0.006
compost	7.02	7.1	5.32	0.013	23.5	27.5	16. 0	4.0	22. 0	49.11	2.634	3.146	0.226
Lemon waste	3.26	7.2	6.68	0.044	40.7	15.0	14.0	2.3	21. 0	51.25	1.923	1.079	0.437

2.2 Incubation trial: The rates of organic materials 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. Each pot consisted of 100 g soil with the various rate of organic materials. During the incubation periods (4, 8, 12 and 16 weeks). 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.

2.3 Sample analysis: The Soil pH and electrical conductivity (EC) were measured in 1:2, soil: water ratio according to [22]. Organic matter content in soil was determined the method by [21]. Particle size distribution was determined according the method outlined in [22]. The Soluble cations, water soluble sodium and potassium were determined in soil-water extract by using a flame photo meter as mentioned by [22]. In addition water soluble calcium and magnesium were determined in soil-water extract (1:2) by titration with Ethylene diamine tetra acetic acid (EDTA), according to [22].

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 [23].

Table 3. The effect of soil type, type and rate of organic material on soil pH at each time of incubation

O.M		Time of Incubation			
Type	Rate	1st time	2nd time	3rd time	4th time
Olive Waste	0.0	8.17	8.10	8.00	7.95
	0.5	8.12	7.93	7.90	7.40
	1.0	8.00	7.90	7.88	7.30
	1.5	7.95	7.89	7.70	7.20
	2.0	7.69	7.75	7.35	7.16
Compost	0.0	8.17	8.10	8.00	7.95
	0.5	8.08	8.00	7.95	7.92
	1.0	7.97	7.90	7.86	7.85
	1.5	7.90	7.82	7.80	7.81
	2.0	7.82	7.79	7.50	7.27
Lemon Waste	0.0	8.17	8.10	8.00	7.95
	0.5	8.00	7.97	7.90	7.87
	1.0	7.95	7.87	7.81	7.81
	1.5	7.87	7.82	7.70	7.50
	2.0	7.78	7.70	7.64	7.41
STATISICAL SIGNIFICAN LSD, 0.05					
O.M type (M)		1.86E-01	1.86E-01	0.211	3.38E-02
Rate of O.M (R)		1.44E-01	1.44E-01	0.163	2.62E-01
M*R		2.67E-02	2.67E-02	0.345	8.86E-02

Table 4. The 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	8.00	7.92	7.78	7.42
Compost	8.00	7.92	7.84	7.78
Lemon Waste	7.98	7.90	7.80	7.72
$LSD_{0.05}$	2.80E-02	2.80E-02	3.60E-02	9.30E-02
Rate of organic material, %				
0.0	8.20	8.10	8.00	8.00
0.5	8.07	7.97	7.93	7.73
1.0	8.00	7.90	7.87	7.67
1.5	7.93	7.83	7.73	7.50
2.0	7.77	7.77	7.50	7.30
$LSD_{0.05}$	3.70E-02	3.70E-02	4.70E-01	1.20E-01

3. Results and Discussions

The effect of organic material type at each time of sampling, on the soil pH except at the time of sampling Table [3]. 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. The fourth time of sampling was significant lower soil pH Table [4].

The lowest value of pH (averaged 7.16) 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 [24].

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. These results agree with those obtained by [25, 26 and 27].

Soluble cation in soil: The organic material types, rates of application and their interactions significantly influenced the amounts of soluble Na, K, Ca and Mg in soil at all time of samplings, except those of at the time of sampling. The highest values of soluble Na was given with the compost at the fourth time of sampling (125 meq/kg soil). And the highest values of soluble K, Ca and Mg was given at the fourth time of sampling with lemon (135, 92 and 55 meq/kg soil), Table [5]. Generally, the amounts of soluble Na, K, Ca and Mg in soil were increased with increasing organic material application rates and increasing time of sampling Table [5].

The highest values were recorded for 2% organic materials rate at the fourth time of sampling. Also, the means of soluble Na, K, Ca and Mg ,Table [6] showed that the compost gave the highest values of available Na and Ca at the fourth time of sampling (90 and 68 meq/kg soil). However, lemon waste gave the highest values of available K and Mg at the fourth time of sampling (95 and 39.40 meq/kg soil) and the lemon waste gave the lowest value of available Na, K, Ca and M Mg at the first time of sampling (21.88, 45.66, 20.00 and 13.92 meq/kg soil, respectively).

Table 5. The amounts of available Na^{+}, K^{+}, Ca^{+2} and Mg^{+2}(meq/kg soil) in the soil at each time of sampling as affected by type and rate of material application.

Organic material		Na+ (meq/kg)				K+ (meq/kg)				Ca+2 (meq/kg)				Mg+2 (meq/kg)			
		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	15.0	50.0	50.0	50.0	30.0	45.0	45.0	45.0	12.0	28.0	28.0	28.0	8.6	17.0	17.0	17.0
	0.5	27.5	65.0	70.0	75.0	40.0	50.0	60.0	70.0	22.0	40.0	44.0	52.0	10.0	24.0	29.0	36.0
	1.0	32.5	70.0	80.0	85.0	45.0	60.0	75.0	95.0	24.0	48.0	52.0	64.0	17.0	31.0	34.0	38.0
	1.5	40.0	75.0	90.0	95.0	60.0	65.0	90.0	105.0	26.0	52.0	60.0	68.0	19.0	36.0	38.0	43.0
	2.0	45.0	95.0	100.0	105.0	75.0	105.0	115.0	130.0	31.0	56.0	64.0	72.0	22.0	41.0	46.0	48.0
Compost	0.0	15.0	50.0	50.0	50.0	30.0	45.0	45.0	45.0	12.0	28.0	28.0	28.0	8.6	17.0	17.0	17.0
	0.5	25.0	55.0	60.0	85.0	45.0	50.0	55.0	75.0	17.0	32.0	44.0	48.0	14.0	29.0	36.0	38.0
	1.0	27.5	60.0	75.0	90.0	50.0	55.0	65.0	81.7	19.0	44.0	52.0	60.0	19.0	34.0	38.0	41.0
	1.5	35.0	80.0	95.0	100.0	55.0	65.0	70.0	90.0	26.0	48.0	56.0	68.0	22.0	38.0	43.0	46.0
	2.0	40.0	90.0	110.0	125.0	60.0	70.0	75.0	95.0	29.0	60.0	64.0	72.0	24.0	46.0	48.0	50.0
Lemon Waste	0.0	15.0	50.0	50.0	50.0	30.0	45.0	45.0	45.0	12.0	28.0	28.0	32.0	8.6	17.0	17.0	17.0
	0.5	20.0	55.0	60.0	65.0	40.0	50.0	60.0	70.0	24.0	48.0	60.0	64.0	12.0	26.0	31.0	36.0
	1.0	22.5	65.0	70.0	75.0	45.0	55.0	75.0	100.0	26.0	52.0	64.0	72.0	14.0	29.0	34.0	41.0
	1.5	30.0	75.0	75.0	80.0	55.0	65.0	80.0	125.0	31.0	56.0	76.0	80.0	16.0	34.0	38.0	48.0
	2.0	32.5	80.0	85.0	90.0	58.3	80.0	95.0	135.0	34.0	64.0	80.0	92.0	19.0	36.0	48.0	55.0

STATISTICAL SIGNIFICAN LSD$_{0.05}$

O.M type (M)	1.326	1.787	2.13	2.163	1.828	2.38	2.404	2.808	1.115	1.553	1.759	1.598	1.046	1.208	1.072	1.118
Rate of O.M (R)	2.70E-02	1.84E-01	1.15	1.676	1.416	1.844	1.862	2.175	8.63E-01	1.204	1.363	1.238	8.10E-01	9.36E-01	8.30E-01	8.66E-01
M x R	1.361	2.473	3.515	3.624	2.589	4.389	4.476	6.108	9.63E-01	1.870	2.397	1.978	8.49E-01	1.131	8.89E-01	9.67E-01

Table 6. Means of Na^{+}, K^{+}, Ca^{+2} and Mg^{+2}(meq/kg soil) at each time of sampling as affected by type and rate of organic materials.

Treatments	Na+ (meq/kg)				K+ (meq/kg)				Ca+2 (meq/kg)				Mg+2 (meq/kg)			
	Time of Sampling				Time of Sampling				Time of Sampling				Time of Sampling			
	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	32.0	71.0	78.0	82.0	50.0	65.0	77.0	89.0	23.0	44.8	49.6	56.8	15.3	29.8	32.8	36.4
Compost	28.5	76.0	78.0	90.0	48.0	57.0	62.0	77.3	25.5	49.6	61.6	68.0	17.5	32.8	36.4	38.4
Lemon Waste	21.9	65.0	68.0	72.0	45.7	59.0	71.0	95.0	20.0	42.4	48.8	55.2	13.9	28.4	33.6	39.4
$LSD_{0.05}$	1.431	2.59	3.696	3.811	2.722	4.613	4.706	6.421	1.012	1.966	2.2	2.079	0.891	1.19	9.35E-01	1.018
Rate of organic material, %																
0.0	15.0	50.0	5.0	50.0	30.0	45.0	45.0	45.0	12.0	28.0	28.0	29.3	8.6	17.0	17.0	17.0
0.5	24.2	58.3	63.3	75.0	41.7	50.0	58.3	71.7	21.0	40.0	49.3	54.7	12.0	26.3	32.0	36.7
1.0	27.5	65.0	75.0	83.3	46.7	56.7	71.7	92.3	23.0	48.0	56.0	65.3	16.7	31.3	35.3	40.0
1.5	35.0	76.7	86.7	91.7	56.7	65.0	80.0	106.7	27.7	52.0	64.0	72.0	19.0	36.0	39.7	45.7
2.0	39.2	88.3	98.3	106.7	64.4	85.0	95.0	120.0	31.3	69.3	69.3	78.7	21.7	41.0	47.3	51.0
$LSD_{0.05}$	1.848	3.356	4.772	4.92	3.514	5.956	6.075	8.29	1.306	2.538	3.25	2.685	1.15	1.536	1.207	1.314

These results are in agreement with those of [17]. In this respect [13] found that increasing the soil organic matter improves soil properties enhances soil quality.

Addition of compost improved the physical properties of the soil, and increased the supplying power of available nutrients to plants [18]. Organic materials rates significantly affected soluble Na^{+} at time of incubation, except at the third time of incubation, and K^{+} at time of incubation, except at the second, third and fourth time of incubation, significantly soluble Ca^{+2} at the first or fourth time of incubation and significantly affected soluble Mg^{+2} at the fourth time of incubation. On the other hand, 2% organic materials, produced the highest value of soluble Na^{+}, K^{+}, Ca^{+2} and Mg^{+2}, while 1.5% organic materials produced the highest value of soluble K^{+} at the fourth time of incubation. Generally, the application of OMW accrued positive effects on soil fertility that confirmed by other pertinent researches such as [8].

The regression equations for the relation between the soluble Na^{+} (Y_1), K^{+} (Y_2), Ca^{+2} (Y_3) and Mg^{+} (Y_4) and the organic material rate (X) Table [7]. A specific relationship was found between Na^{+}, K^{+}, Ca^{+2} and Mg^{+} and organic material rates for the three materials at the first or fourth time of sampling. The comparison of the slopes of Na^{+}, K^{+}, Ca^{+2} and Mg^{+} regression equations give a quantitative expression of the efficiency of organic waste rates for each organic material type.

Table 7. The relationship between the available Na^{+}, K^{+}, Ca^{+2} and Mg^{+2} and organic material rates after 4 and 16 weeks of sampling.

Time of Sampling	Organic material	Regression Equation							
		Na^{+}		K^{+}		Ca^{+2}		Mg^{+2}	
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=2.272+1.089 x	R^2=0.936	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=1.324+0.634x	R^2=0.978	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=2.138+1.025 x	R^2=0.962	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=2.462+1.180 x	R^2=0.988	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	Y3=0.870+0.417 x	R^2=0.999	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.	Y3=5.903+2.830 x	R^2=0.959	Y_4=15.748+0.648 x	R^2=0.978

Y_1= Na^{+} Y_2=K^{+} Y_3=Ca^{+2} Y_4=Mg^{+2} X= Rate of O.M

4. Conclusion

Soluble cations were increased with increasing time of incubation for the soil. The lemon waste induced the highest values of soluble K, Ca^{+2} and Mg^{+2} (135, 92 and 55 meq /Kg soil, respectively), The compost gave the highest value of soluble Na^{+} (125 meq /Kg soil) compared with those of the other organic materials types. compared with those of the other organic materials types. Organic materials 2 %, produced the highest value of soluble Na^{+}, K^{+}, Ca^{+2} and Mg^{+2} at the fourth time of incubation. In conclusion, compost, olive waste and lemon waste are three organic materials that can improve the physical, chemical and biological characteristics of the soils.

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