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IMPROVING SOME PHYSICAL PROPERTIES OF A CALCAREOUS SOILS BY USING DILUTED SULFURIC ACID AND ORGANIC MANURE

S.F. Mansour
Soils, Water and environment Res. Instit., ARC, Giza, Egypt
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ABSTRACT: ***This study was carried out on Wadi Kahali in Ras Sudr, south Sinai Governorate, during summer season 2005 to evaluate a calcareous soil at the efficiency of two amendments i.e. diluted sulfuric acid and organic manure for ameliorating some properties of the studied soil.***

The used two types of soil amendments were used at different rates, i.e. 0, 0.5% (25 kg S.A + 5 m^3 water/fed) and 1.0% (50 kg D.S.A + 5 m^3 water/fed) for diluted sulphuric acid and (0, 10, 20, 30 m^3/fed) for organic manure then planted summer tomato.

The obtained results can be summarized as follows:

The values of soil bulk density, penetration resistance, instability index, total $CaCO_3$ and active $CaCO_3$ tended to decrease with increasing the applied rates of both soil amendments. On the other hand, total porosity, quickly drainable pores, available water, stability index, hydraulic conductivity were increased.

Key words: ***physical properties, soil compaction, total $CaCO_3$, active $CaCO_3$, calcareous soils.***

INTRODUCTION

Slow water penetration, or slow infiltration is a major problem in calcareous soils and effect negatively the production of crops (LAWR, 1984). Poor water infiltration causes applied water, to stand in fields, causing a decrease in both annual and perennial crop yields, increasing irrigation costs due to additional irrigation (more frequent irrigation) requirements, and consequently, increased labor costs.

Slow water infiltration reduces crop yields if plants become water stressed due to insufficient available water. Standing water also increases the incidence of soil and plant diseases due to water stagnation.

Slow water penetration can result in a reduction of water-use efficiency. It can lead to either longer irrigation periods or more frequent irrigations. Both of the aforementioned cases result in an increase in the time of water ponding on the soil surface, which increases water loss by evaporation. Water penetration problems are widespread over all soil textures ranging from sandy loam to clay.

There are many several factors could be cause water penetration problems. Some of the important factors are: soil compaction, excessive

sodium absorbed on the soil, high clay content, low organic matter that decreases aggregate stability, and soil crusting. Chemical composition of irrigation water is an additional factor that can affect infiltration rates. Water that contain sodium bicarbonate as the predominant salt increase the tendency for crust formation, and reduce permeability below the soil surface due to clay swelling and dispersion(LAWR, 1984).

Dense and cemented soil layers lead to infiltration problem. These layers can occur naturally (cemented pan) or can be created by farming practices (plow pan, compaction) or by irrigation (surface crusts) (Upadhyaya *et al*., 1988).

The aim of this study was therefore to evaluate the beneficial effects of both diluted sulfuric acid and organic manure, as soil amendments, on improving some properties of a calcareous of wadi Kahli in Ras Sudr, south Sinai Governorate.

MATERIALS AND METHODS

A field experiment was conducted on a calcareous soil during summer season at Wadi Kahali in Ras Sudr, south Sinai governorate A.R.E. The initial physical properties of the studied soil are shown in Table (1).

Table (1): Some initial soil physical properties of the studied soil site

Soil characteristics	Depth (cm)	
	0-15	15-30
Particle size distribution (%):		
Coarse sand	17.1	15.2
Fine sand	20.2	20.4
Silt	23.5	14.7
Clay	39.2	49.9
Textural class	Clay loam	Clay
Organic matter (%)	0.93	0.51
Total $CaCO_3$ (%)	36.4	36.5
Total porosity (%)	52.8	54.53
Bulk density (g cm^{-3})	1.29	1.32
Available water (%)	13.27	14.65
Soil penetration (kg cm^2)	6.93	5.71
Instability Index	1.58	1.41
Stability Index	0.63	0.70
ECe in dS/m (soil paste)	14.6	12.8
pH (soil paste)	8.41	8.32

To fulfill this experimental, two treatments, i.e. diluted sulfuric acid and organic manure were chosen. The current experiment was designed as a randomized complete block design with four rates of organic manure (0, 10, 20, and 30 m^3/fed) and three concentration of diluted sulfuric acid (0, 0.5, 1%), and three replicates were used for each treatment. Experimental plots, an area of 10m^2 for each one were used in the field experiment, however diluted sulfuric acid was added as foliar spray with a total volume of 5000 L/fed. And then organic manure was added after soil dried followed by tillage

operations, then were planted of summer tomato and irrigated with flooding irrigation system.

Penetration resistance and other physical properties were measured before any treatment (initial) and after tomato harvest.

Disturbed and undisturbed soil samples were taken from the studied two (0-15, 15-30 cm) layers. The disturbed soil samples were dried and sieved through a 2mm. sieve, mixed and stored for the following determination:

1) **Particle size distribution analyses, according to the international method, (Gee and Bauder, 1986) using the sodium hexametaphosphate as a dispersing agent.**
2) **Bulk density was determined at field moisture content by using the core method according to (Vomocil, 1965).**
3) **Soil moisture desorption curve was determined by pressure cooker, (Stakman *et al,* 1962).**
4) **Pore size distribution, instability index and stability index were calculated according to (De Leenheer and Deboodt, 1965).**

$$\text{Instability Index} = \left[\begin{array}{c}\text{Mean weight diameter}\\ \text{of air dry soil before}\\ \text{wet sieving}\end{array}\right] - \left[\begin{array}{c}\text{Mean weight diameter}\\ \text{of same soil after}\\ \text{wet sieving}\end{array}\right]$$

$$\text{Stability Index} = \left[\frac{1}{\text{Instability Index}}\right]$$

5) **Active carbonate content, was determined according to the methods described by (Yaalon, 1957).**
6) **Penetration resistance was measured using the Eijke Kamp hand penetromenter model 06.01 set A (Davidson, 1965).**

RESULTS AND DISCUSSION

Total and active calcium carbonate:

Data present in Tables (2 and 3) shows the effect of diluted sulfuric acid application on calcareous soil. The data reveal that increasing the applied rate led to decrease total calcium carbonate values, and consequently decrease of active carbonate comparing with untreated soil where, the highest reduction are recorded at the treatment 1% diluted sulfuric acid. These results may be attributed to adding of diluted sulfuric acid which enhanced increasing of soluble $CaCO_3$ and consequently alleviateits districtive effect.

Statistical analysis indicated that the simple correlation was carried out between total calcium carbonate, active carbonate and the application rate of diluted sulfuric acid (D.S.A) are positive and significant, where the values were 0.626 and 0.723** respectively.**

Table (2

Table (3): Relative decrease of $CaCO_3$ (%) from each of total carbonate and active carbonate.

Soil depth (cm)	Added D.S.A (%)	Total $CaCO_3$ (%)	Active $CaCO_3$ (%)
0-15	0.0	-------	-------
15-30		-------	-------
0-15	0.5	14.3	11.3
15-30		12.1	7.03
0-15	1.0	31.6	27.8
15-30		22.7	20.7

Pore size distribution

Pore size distribution is responsible for the limitation of water retention and movement in the soil and it is strongly affected by soil texture and structure. Moreover, the ability of the plant root to find space in which to grow is often the most important factor limiting plant growth.

Calcareous soil is characterized by its low moisture retention capacity, low aeration capacity and slow water movement, therefore any attempt to improve calcareous soil should take these properties into consideration.

The influences of two amendments at different application rates on pore size distribution in calcareous soil are represented in Table (4). Data indicate that the values of fine capillary pores (F.C.P) were decreased while other pores categories were increased with increasing the applied rates of both used amendments diluted sulfuric acid and organic manure either alone or together.

This behaviour may be attributed to decrease of $CaCO_3$ and formation of stable aggregates. Statistical analysis indicated that there was a highly significant negative correlation between fine pores (F.C.P) and the application rate of any or two amendments (-0.892**) while it was significant correlation and positive between others pores (Q.D.P, S.D.P and W.H.P) and addition (0.788**, 0.721** and 0.748**).

Soil compaction:

The term soil compaction has been used to mean both a state of soil dry bulk density and a change in dry bulk density of soil (Chancellor 1971). Changing B.D may be caused by forces that originate either from mechanical sources, such as machines or from natural sources such as dying and wetting (Harris 1971).

The decreases in pore volume and pore size results in slower water penetration and decreased root penetration (LAWR, 1984) Increasing soil compaction lead to increasing soil strength and the rate of seedling

emergence or rate of root elongation will be reduced. A compacted layer may lead to a reduction in crop yields since the plant may undergo substantial additional stress for water and or nutrients (Taylor 1971).

Table (4): Pore size distribution under different rates of applied diluted sulfuric acid and organic manure

Soil depth cm)	Acid Conc. (%)	O.M. (m^3/fed)	Q.D.P. >28.8 µ	S.D.P 28.8-8.6 µ	W.H.P 8.6-0.19 µ	F.C.P <0.19 µ
0-15	0.0	0.0	9.5	4.50	10.8	28.0
15-30			6.9	5.03	11.5	37.1
0-15	0.5		10.5	5.73	11.2	26.0
15-30			7.1	5.43	12.2	31.0
0-15	1.0		10.7	6.23	12.4	24.9
15-30			8.5	5.60	12.8	29.3
0-15	0.0	10	12.5	5.23	11.3	25.6
15-30			9.1	5.80	12.9	29.5
0-15	0.5		13.4	6.10	12.5	22.9
15-30			10.0	6.60	12.8	30.5
0-15	1.0		13.8	6.33	13.0	22.3
15-30			11.1	6.57	13.4	27.0
0-15	0.0	20	13.9	5.60	12.8	23.6
15-30			11.4	5.95	15.6	27.5
0-15	0.5		14.3	6.90	13.0	21.8
15-30			11.5	7.80	13.4	25.9
0-15	1.0		14.6	7.10	13.7	21.0
15-30			11.6	6.60	13.9	26.8
0-15	0.0	30	15.4	6.10	12.1	23.0
15-30			11.6	7.55	14.7	25.2
0-15	0.5		15.6	7.50	13.9	20.2
15-30			11.7	8.10	14.8	24.7
0-15	1.0		17.9	7.80	15.2	18.7
15-30			12.0	7.40	16.6	25.0

The results obtained from the applied of D.S.A. and O.M either individually or in combination are shown in Table (5). Soil bulk density and soil compaction decreased while total porosity (T.P), Hydraulic conductivity (K_s) and available water (A.W) were increased comparing with the untreated soil. The best treatment was found at the treatment of (1% D.S.A and 30 m^3/fed. O.M) and (0.5% S.A + 30 m^3/fed.O.M) respectively. Such increases or decreases were more pronounced in the surface layer (0.15cm). These results are more related to the nature of the organic manure as it has low B.D and higher A.W (Baver *et al.,* 1972) and the higher efficiency of diluted sulfuric acid (D.S.A) in improving K_s of calcareous soils was attributed by (Mace *et al*. 1999) to one or more of some affecting factors, i.e.,

Table (5): Effect sulfuric acid and organic matter application to calcareous soils on some physical properties.

Soil depth (cm)	Applied D.S.A.	O.M. (m^3/fed)	Soil strength (kg/cm^2)	Bulk density (g/cm^3)	T. Porosity (%)	Ks (cm/h)	A.W (%)	Instability index	Stability index
0-15	0.0	0.0	6.95	1.29	52.80	2.32	10.8	1.58	0.63
15-30			5.7	1.32	54.43	1.86	11.5	1.41	0.70
0-15	0.5		55	1.25	53.43	2.61	11.2	1.25	0.80
15-30			67	1.31	55.73	1.93	12.2	1.37	0.72
0-15	1.0		51	1.22	54.23	2.65	12.4	1.31	0.76
15-30			65	1.29	56.20	1.95	12.8	1.29	0.77
0-15	0.0	10	58	1.20	54.63	2.71	11.3	1.36	0.74
15-30			67	1.28	57.30	1.98	12.9	1.27	0.79
0-15	0.5		53	1.19	64.90	2.87	12.5	1.15	0.86
15-30			64	1.28	57.90	2.06	12.8	1.21	0.82
0-15	1.0		48	1.18	55.43	2.96	13.0	1.12	0.89
15-30			62	1.26	58.07	2.13	13.4	1.20	0.83
0-15	0.0	20	56	1.17	55.90	2.99	12.8	1.25	0.80
15-30			66	1.29	58.45	2.14	13.6	1.22	0.82
0-15	0.5		50	1.17	56.00	3.18	13.0	1.13	0.88
15-30			61	1.28	58.60	2.15	13.4	1.18	0.85
0-15	1.0		43	1.18	56.40	3.51	13.7	1.10	0.90
15-30			59	1.25	58.90	2.20	13.9	1.17	0.95
0-15	0.0	30	53	1.19	56.60	3.61	12.1	1.21	0.83
15-30			62	1.25	59.05	2.21	14.7	1.16	0.86
0-15	0.5		47	1.16	57.20	4.15	13.9	1.06	0.94
15-30			58	1.25	60.50	2.27	14.8	1.09	0.91
0-15	1.0		38	1.16	59.60	4.68	15.2	1.03	0.97
15-30			56	1.24	61.00	2.42	16.6	1.05	0.95

Lower SAR values, higher soluble Ca^{2+} and Mg^{2+}, lower pH and greater EC (Miyamoto and Stroehlein, 1986). In addition, other specific beneficial effects of diluted sulfuric acid (D.S.A) i.e., increased dissolution of stabilizing agent such as Fe, Al and P, development of CO_2 escape channels to the

atmosphere and high sulfate concentrations that will limit the dissolution of $CaCO_3$ due to the common ion effect.

Simple significant correlations was found between soil strength, bulk density (B.D), total porosity (T.P), saturated hydraulic conductivity (K_S), available water (A.W) and the application rate of any of two amendments (-0.867, -0.881**, 0.784**, 0.791** and 0.881**) respectively.**

Stability index

The stability of the aggregates was determined by the dry and wet sieving technique. The lower value mean better instability of the aggregates, this index is therefore called "the instability index" as presented in Table (5). The best instability index (lowest value) occurs at addition (1% D.S.A + 30 m^3/fed. O.M), which contains the highest O.M content and highest of D.S.A. Looking to the date in Table (5), the instability index is largely determined by the O.M content, one of the most important factors in the formation of stable aggregates and addition D.S.A due to increased dissolution of $CaCO_3$ and decreased $CaCO_3$ content in soil.

The statistical analysis show that there is a highly positive significant correlation between stability index and the application rate of any these amendments. Where the values of simple correlation coefficients were 0.486, 0.626**, 0.715** and 0.854**, respectively.**

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تحسن بعض الخواص الطبيعية للأراضى الجيرية
بأستخدام حمض الكبريتيك المخفف والمخصب العضوى

صبحى فهمى منصور
معهد بحوث الأراضى والمياه والبيئة – الجيزة – مصر

الملخص العربي

أقيمت هذه التجربة فى وادى كحله بمنطقة رأس سدر بمحافظة جنوب سيناء خلال عام ٢٠٠٥ حيث الأراضى تتميز بالطبيعة الجيرية والقوام الطمى الطينى ذات الطبقات المندمجة لذا تهدف الدراسة إلى أضافة محسن طبيعى ممثل فى السماد العضوى وآخر كيماوى ممثل فى حمض الكبريتيك المخفف فى صورة منفردة أو مجتمعة تحت ظروف الرى بمياه مالحة ودراسة التغيرات فى الخواص الطبيعية لهذه الأراضى وخاصة فيما يتعلق باندماج التربة.

أجريت التجربة بأضافة حمض الكبريتيك فى تركيزات هم صفر، ٠.٥، ١% ثم رى الأرض رية خفيفة بغرض التخلص من أثار الحمض وبعد الجفاف أضيف السماد العضوى فى أربعة معدلات مختلفة صفر،١٠، ٢٠، ٣٠ م^{٣}/فدان مع الخلط جيداً بالتربة وتجهيزها لزراعة طماطم صيفى. والنتائج المتحصل عليها يمكن تلخيصها فيما يلى:

- أنخفاض محتوى التربة من الكربونات الكلية من ٣٦.٤ إلى ٣١.٢، ٢٦.٩% عند أضافة الحمض بتركيز ٠.٥، ١% على التوالى بينما انخفضت الكربونات النشطة من ٢١.٢ إلى ١٨.٨، ١٥.٣% عند إضافة الحمض بالتركيزات السابقة على التوالى.
- أنخفاض قيم معامل إندماج التربة من ٦.٩٣، ٥.٧٢ كجم/سم^{٢} فى الطبقتين السطحية وتحت السطحية إلى ٢.٣٥، ٢.٩٧ كجم/سم^{٢} عند أضافة الحمض بتركيزات ١% ومادة عضوية بمعدل ٣٠ م^{٣}/ فدان على التوالى.
- حدوث انخفاض تدريجى فى قيم الكثافة الظاهرية للتربة مع الزيادة فى معدلات إضافة المادة العضوية وزيادة تركيز الحامض المضاف.
- أرتفاع فى قيم المسامية الكلية للتربة وزيادة نفاذية التربة حيث زادت مسام الصرف Q.D.P على حساب المسام الضيقة مع زيادة محتوى الماء الميسر للنبات. إستجابة إلى التأثير المفيد لكلا المحسنين (حمض الكبريتيك المخفف والمخصب العضوى).
- تحسنت قيم دليل التجمع .A.I حيث كانت أفضل قيمة عند المعاملة بحامض الكبريتيك بتركيز ١% ومعدل ٣٠ م^{٣}/فدان من المادة العضوية.

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Table (2): Soil particle size distribution with and without the removal of $CaCO_3$, the fraction, total content (%) and active of $CaCO_3$ (%).

Soil depth (cm)	Added diluted sulfuric acid	Particle size distribution (%) with $CaCO_3$				Texture class	Particle size distribution (%) without $CaCO_3$				Distribution of carbonates				Total $CaCO_3$ (%)	Active $CaCO_3$ (%)
		C. sand	F. sand	Silt	Clay		C. sand	F. sand	Silt	Clay	C. sand	F. sand	Silt	Clay		
0-15	0.0	17.1	20.2	23.5	39.2	C.L	10.1	12.0	12.6	28.9	7.0	8.2	10.9	10.3	36.4	21.2
15-30		15.2	20.4	14.7	49.9	C.	10.1	14.6	4.9	34.1	5.2	5.8	9.8	15.8	36.5	25.6
0-15	0.5	20.3	28.2	11.6	39.9	C.L	14.2	21.9	7.3	25.4	6.1	6.3	4.3	14.5	31.2	18.8
15-30		15.3	20.1	14.1	50.5	C.	12.2	15.9	8.6	32.2	3.1	4.2	5.5	18.3	31.1	23.8
0-15	1.0	20.4	27.3	14.6	39.7	C.L	15.1	21.0	10.9	28.1	5.3	6.3	3.7	11.6	26.9	15.3
15-30		18.1	21.2	13.9	46.8	C.	14.7	16.7	9.1	31.3	3.4	4.5	4.8	15.5	28.2	20.3

C.L. = Clay loam C = Clay