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Research Article

Effect of Adding Dilute Sulphuric Acid on Calcareous Soil Properties in Jordan Valley

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Abstract

Calcareous soil that contains enough free calcium carbonate to effervesce visibly, releasing carbon-dioxide gas, when treated with diluted sulfuric acid. Analysis of calcareous soil in Jordan valley after treatment with aqueous low concentration sulfuric acid shows some change in the physical prosperities of the soil such as reduction of calcium carbonate from 66% to 30%, soil density from 1.60 g/cm^3 to 1.19 g/cm^3. Soil texture is convert from silt clay loam to silt loam this physical changing makes soil permeability is easier so it could be suitable for agricultural without effect in plant growth also we show reduce soil PH and increasing in soil filtration tare. We showed several changes in the plants, which planted in the treated soil by sulfuric acid as increasing in the product from 10 - 25 %, would reduce in using chemical fertilizers from 15-30% and absence of soil diseases.

Introduction

Calcareous soils contain solid mineral $CaCO_3$, exhibit surface soil pH ≥ 7.2, and occur in regions of < 500 mm annual precipitation. Increasing rainfall increases depth to $CaCO_3$ where no $CaCO_3$ exists in the rooting zone at > 800–1000 mm annual rainfall. If $CaCO_3$ exists, all of it must be dissolved or neutralized before soil pH could decrease. In most situations, reducing soil pH by neutralizing $CaCO_3$ is not practical. High soil pH caused by presence of $CaCO_3$ can reduce availability of P and several micronutrients [1,2].

Generally, plants absorb nutrients from the soil, and soil contains nutrients in various forms such as organic, inorganic matter and depending upon the soil physical and chemical properties it contains a mixture of sand, silt, and clay. The nature and acidity of soil can be represented using its pH, which gives the availability of nutrients useful for the plants.

Many studies are carried out on the practice of acids affect the plant growth, its yield, and consistency of soils. We report on the effects of addition of sulfur to soil in Jordan valley [2].

Soil that is rich in fine clay particles are called 'heavy soils', while this type of soil is hard to manage. It is potentially very fertile (rich with fertilizers elements) when treated in the right way. When planting on clay soils, the bottom of the planting hole should be broken up before planting and the sides of the hole broken down using a garden fork, to increase the soil permeability if not loosened, a sump may be formed in that water can collect, resulting in probable plant death from water logging. Calcium carbonate is one of the cementing agents the participate in the binding of soil particles together through physico-chemical mechanisms and presumably create a stable soil structure [3].

Since both organic matter and clay possess overall negative charges, they will tend to disperse isolate and lead to rapid loss. When multitude charged cationic ions are available the cation acts to flocculate the clay and organic matter. This leads to conversion of the fine material into heterogeneous aggregated complexes. These aggregates are favorable for soil structure. The equilibrium soil carbon is related to content of clay plus lime. Lime is the most favorable acid soil remediation and the benefits of aggregation in alkaline conditions might be addressed with gypsum calcium sulfate which is a remedy for saline sodic soil situations where pH is alkaline [4,5].

Material and Methods

Site Studies (location of soil sample source)

The soil samples are collected from farm No. 115 demand area No. 22 in Jordan valley, the location is as shown below in Figure 1.

Preparation of Sample

Table 1: Percent of added sulfuric acid to soil.

Sulfuric acid (N)	weight of soil (g)	volume of sulfuric acid(mL)
0.00	25	50
0.10	25	50
0.50	25	50
1.00	25	50
2.00	25	50

Bring soil samples from farm in Jordan valley, dry the sample at 40° C then grinding the sample and Sieve using a sieve 0.2 mm, the treated the sample with different concentration of sulfuric acid, as shown in Table 1 below.

Figure 1: location of the soil sample and present study.

Methods of Analysis

Calcium carbonate ($CaCO_3$) test

Calcium carbonate ($CaCO_3$): pressure CO_2 gases was made as an alternative to Schreiber calcimeter which is the conventional method of soil $CaCO_3$ content analyses. The measurement of $CaCO_3$ by pressure volume, as in Schreiber instrument, is done by measuring pressure of CO_2 gas produced from reaction of $CaCO_3$ in soil with HCl.

The determination of $CaCO_3$ (%) is based on the volumetric analysis of the carbon dioxide CO_2, which is liberated during the application of hydrochloric acid solution HCl 4 N in soil's carbonates and is described with the following reaction:

$(CaCO_3 + MgCO_3 \text{ etc.}) + 2HCl \rightarrow (CaCl_2 + MgCl_2 \text{ etc.}) + H_2O + CO_2 \uparrow$

During the application of the acid into the soil sample a characteristically foaming is observed, evidence of carbon dioxide's liberation and the existence of carbonate salts consequently [6] (Figure 2).

Figure 2: Schreiber calcimeter.

Bulk density test

The bulk density test gives the weight of dry soil per unit of volume typically expressed in grams/cm^3. It very is important to know the Bulk density as it indicates the soil compaction and soil health. This important to soil infiltration, rooting or depth and restrictions, also to available water capacity, soil porosity, plant nutrient availability, soil microorganism activity, which has great influence on soil processes and productivity. [7]

Soil permeability test

Soil permeability measured the rate of water flow through the soil in a given period of time. It is usually expressed as either a permeability rate in centimeters per hour (cm/h), millimeters per hour (mm/h), or centimeters per day (cm/d), or as a coefficient of permeability k in meters per second (m/s) or in centimeters per second (cm/s).

Structure may greatly modify the permeability rates, the average permeability for different soil textures in cm/hour as follows; Sand: 5.0; Silty clay: 0.25; Clay loam: 0.8; Clay: 0.05. A pond built in impermeable soil will lose little water through as shown in Figure 3 below [8].

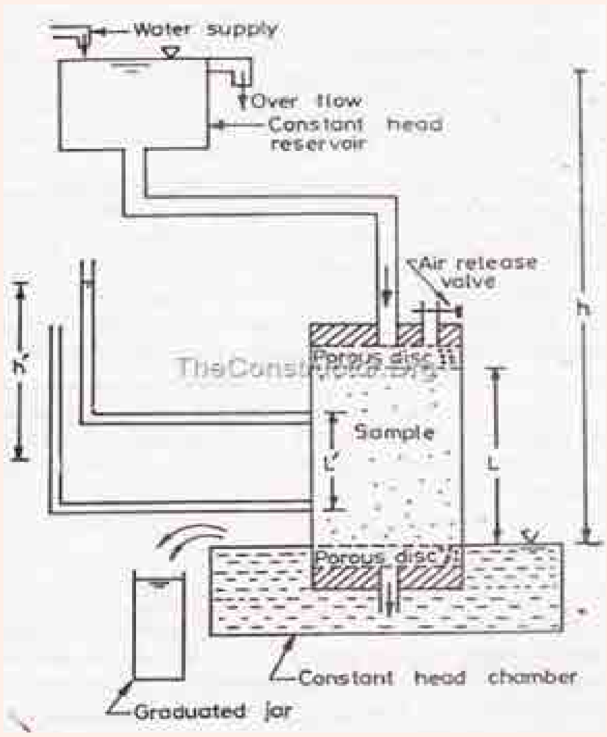

Figure 3: Constant Head Permeability Test.

Acidity test of soil

a) Prepare a 1:2 soil to water suspension ratios, weigh 10 g air-dry soil (< 2 mm) into a bottle and add 50 mL deionized water. (Other amounts can be used e.g. 20 g:100 mL provided the 1:5 ratios are maintained.) Mechanically shake for one hour at 15 r.p.m.

b) Calibrate the pH meter according to manufacturer's instructions using the buffer at pH 6.86 and either the 4.0 or 9.18 buffer depending on the expected values for the soils. Stir these solutions with a mechanical stirrer during measurement. Thoroughly wash the electrode between measurements with deionized water.

c) Immerse the electrode into the soil suspension. Record the pH value obtained when the equilibrium is reached while stirring with a mechanical stirrer.

Soil texture test (Mechanical Analysis by the Pipette Method)

The pipette method was developed independently by Robinson in Wales, Krauss in Germany, and Jennings, Thomas, and Gardner in the United States. It is used in soil analysis by the Bureau of Chemistry and Soils of the U. S. Department of Agriculture and is readily adaptable to the analysis of molding sands. An advantage of this method is that determinations of many size classes can be easily performed on one sample.

A Mechanical Analysis by the Pipette Method to determine the relative masses of sand, silt and clay in the soil sample (thus, the texture) the combined mass of silt plus clay in the first aliquot and the mass of clay in the second must be determined. Also, the initial total volume of suspension and aliquot volume must be known. Pipetting a known fraction of suspension to an evaporating dish and boiling off the water is all that is done beyond dispersing the soil sample in water [9].

For an accurate mechanical analysis of soil, the soil sample must be completely dispersed so that each particle settles individually rather than as part of a aggregated clump. Addition of Na^+ to the soil-water suspension forces exchange of Na^+ for adsorbed flocculating cations such as Ca_2^+. Soil particles with a diffuse layer saturated with Na^+ tend to act as individual particles in suspension and settle at rates dependent on their radii.

Soil Texture Triangle: The first classification, the International system, was first proposed by Albert Atterberg in1905 and was based on his studies in southern Sweden. Atterberg chose 20μm for the upper limit of silt fraction because particles smaller than that size were not visible to the naked eye, the suspension could be coagulated by salts, capillary rise within 24 hours was most rapid in this fraction, and the pores between compacted particles were so small as to prevent the entry of root hairs. Commission One of the International Society of Soil Science (ISSS) recommended its use at the first International Congress of Soil Science in Washington in 1927. Australia adopted this system, and its equal logarithmic intervals are an attractive feature worth maintaining. The United States Department of Agriculture (USDA) adopted its own system in 1938, and the Food and Agriculture Organization (FAO) used the USDA system in the FAO-UNESCO world soil map and recommended its use [10,11] (Figure 4).

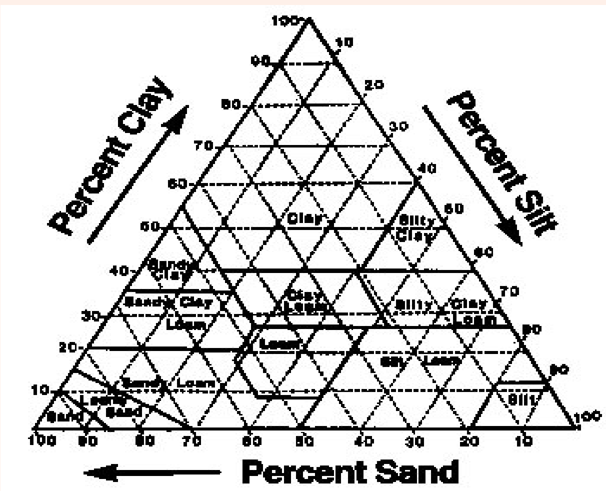

Figure 4: Soil texture triangle.

Result and Discussions

Soil texture

Table 2: Results of Soil texture studies.

Sample with Sulfuric Acid (N)	Clay%	Sand%	Silt%	Texture
0.00	35.76	0.11	64.13	silt clay loam
0.10	32	0.11	67.89	silt clay loam
0.50	27	0.11	72.89	silt clay loam
1.00	20	0.11	79.9	slit loam
2.00	17	0.11	82.89	slit loam

The soil texture for the treated and untreated soil sample with sulfuric acid are compared as shown in Table 2, soil texture is analyzed by using pipette method. It is clear that adding dilute sulfuric acid reduce the calcium carbonate percentage in calcium carbonate soil layer from 66% to 30%, this leads to change soil texture silt clay loam to slit loam and this increase soil permeability.

Calcium carbonate % and Soil Permeability

Sulphuric acid addition moisturizes the soil by reducing soil salinity and pH, also enhance chemical reactions for lime and oxides in the soil, which leads to reduce soil density and enhance the availability of the essential nutrients for plant growth and production as shown in Table 3 below.

Table 3: Characterization of Soil density, Calcium carbonate % and Soil Permeability after treatment with sulfuric acid.

Density (g/cm^3)	Permeability (mL/5 min.)	% $CaCO_3$	CONC. H_2SO_4 N (25 mL)	Soil (g)
1.64	12.5	66	0.0 N	25
1.53	14	45	0.05 N	25
1.40	16	41	0.1 N	25
1.31	18	39	0.5 N	25
1.25	20	34	1.0 N	25
1.19	23	30	2.0 N	25

The analysis result after treating the collation soil sample show decreasing in calcium carbonate ($CaCO_3$) percent from 66% to 30 and decreasing in soil density from 1.64 b/cm^3 - to 1.19g/cm^3. These result lead to increase soil permeability from 12.5 mL/5 min to 23 mL/5 min and convert soil texture from silt clay loam to slit loam which that mean the soil became more suitable for agriculture by reducing the effect of $CaCO_3$ in plant growth and decreasing in soil diseases [12].

Analysis of water used for irrigation

This study was carried out to assess the suitability of water sources for irrigation in Jordan Valley. Analysis of water used for irrigation is reported in Table 4. While This study was conducted in Jordan Valley which is fairly flat area, with an average slope of less than 2%. Generally monitoring irrigation water quality is very important to the sustainability of crop production and productivity. Table 4 shows the effects of sulfuric acid addition on selected crops production.

Effect of sulfuric acid addition on plant crops and plant growth

Addition of Sulphuric acid to calcareous soil does not increase the salinity as compared to the fertilizers, it increases the availability of nutrients, these nutrients are more significant for plant growth and crops production amounts, as in Table 5.

Table 5: Effects of adding 1000 mL to 1000m^2 area of concentrated sulfuric acid to planted soil.

Effects on Product	Effects on Growth	Plant or crops
20%	Increase 10%	Egg plant
25%	Increase 10%	Tomato
25%	Increase 10%	Pepper
20%	Increase 10%	Cucumber
10%	Increase 5%	Palm
10%	Increase 5%	lemon

Thus, it is recommended to apply sulphuric acid to the nutrient solution as part of the nutritional management of several plants.

Conclusion

The present study shows the effect of adding dilute sulfuric acid to agricultural soil to give improve soil conditions and plants and crops quality and quantity.

The addition of sulfuric acid to calcareous soil can improve the alkalinity of soil, which results in increased soil permeability and efficiency of water availability to plants

Table 4: Analysis (ppm), EC and PH of water used for irrigation in Jordan valley.

Analysis	EC/Cm	PH	Na	Cl	Mg	Ca	K	HCO_3^-	CO_3^{2-}	SO_4^{2-}	NO_3^-
Soil	2.03	8.66	238.0	315	52.2	93.0	31.0	305.0	0	276.2	8.7

and crops release impeded unwanted particulate in soil. Adding 2.0 N sulfuric acid reduce the calcium carbonate percentage in calcium carbonate soil layer from 66% to 30%, this leads to change soil texture silt clay loam to slit loam and this increase soil permeability, and Improves plant growth, and can reduces soil diseases such as fungi and nematodes.

Adding acid to irrigation water will decrease or reverse the gradual alkalization of arid land soils, and thus maintain a more permanent agriculture and Improves absorption of micronutrients.

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References

1. Ammari1 TG, Tahhan R, Abubaker S, Al zubi1 Y, Tahboubi A, et al. (2013) Soil Salinity changes in the Jordan valley potentially threaten Sustainable irrigated agriculture. Pedosphere 23(3): 376-384.
2. Stroma L, Andrew GO, Douglas LG, David LJ (2005) Organic acid behavior in a calcareous soil implication for rhizosphere nutrient cycling. Soil Biology & Biochemistry 37(11): 2046-2054.
3. Zohuir A Al-B, Ideisan IAA (2019) The Effect of Sulfur powder Addition on the Chemical and Physical Properties of Soil in Jordan Valley. Journal of Agriculture and Environmental Sciences 8(2): 42-48.
4. Pankaj S, Tapas B, Dilip K (2002) Significance of the formation of calcium carbonate minerals in the pedogenesis and management of cracking clay soils *(vertisols)* of india. Clays and clay minerals 50(1): 111-126.
5. Donald LS (2003) The Chemistry of Soil Acidity, chapter 9. Environmental Soil Chemistry (Second Edition). pp. 267-283.
6. (2020) Standard operating procedure for soil calcium carbonate equivalent Titrimetric method. Food and Agriculture Organization of the United Nations Rome.
7. MF Hossain, Chen W, Zhang Y (2015) Bulk density of mineral and organic soils in the Canada's arctic and sub-arctic. Information processing in agriculture 2(3-4): 183-190.
8. Western state laboratory proficiency testing program soil and plant analytical methods (1997) version 4.00.
9. Annual book of ASTM standards. (2002) ASTM International. Publisher: West Conshohocken, PA: ASTM International.
10. (1951) Department of Agriculture Handbook No. 18 august.
11. Artemio A, Martin Jr (2014) Land Resource Information System of Cagayan Valley A Guide for A Sustainable Agricultural Production System. International journal of scientific & technology research, 3(11): 2277-8616.
12. Wilt KH, Shui YY, Hong L, Han W, Zhen LL (2014) Effects of calcium carbonate on the survival of *Ralstonia Solanacearum* in soil and control of tobacco bacterial wilt. European Journal of Plant Pathology 140(4): 665-675.