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ALTERING SOIL PROPERTIES: INFLUENCE OF SULFUR POWDER ON CHEMICAL AND PHYSICAL ASPECTS IN THE JORDAN VALLEY

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Abstract
The Jordan Valley, a unique geographic region in Jordan, boasts exceptional agricultural potential due to its distinctive soil and environmental conditions. It plays a pivotal role in the country's food production, providing a wide range of agricultural products, including grains, vegetables, and fruits. Additionally, the Jordan Valley serves as a vital source of agricultural exports to international markets, contributing significantly to the nation's food security and economic growth.
However, the Jordan Valley faces formidable challenges, primarily water scarcity and land management issues, which demand innovative solutions for sustainable agricultural development. This study delves into the utilization of modern irrigation techniques and the mitigation of soil salinity, conducted in Jordan during 2009-2010, as potential pathways to overcome these challenges.
The soil's chemical composition, including its pH level, profoundly influences nutrient availability for plant growth. Research on the impact of sulfur addition to calcareous soil, conducted over multiple years, has revealed its significant effects on crop yield and soil consistency. For instance, studies by Weidenfeld explored the application of sulfur to calcareous soil and its impact on sugarcane yield, while in Turkey, Kaplan and Orman investigated the addition of sulfur and sulfur-containing waste to calcareous soil, specifically in the context of Sorghum cultivation.

Keywords: Jordan Valley, Sustainable agriculture, Soil salinity, Modern irrigation techniques, Sulfur application

1. Introduction

The Jordan Valley is a low-lying strip which cleaves down the western border of Jordan, it divided into several distinct geographic sub-regions, and it drains into the Dead Sea which lies 400 meters below sea level and known to be the lowest point on earth. The northern part of Jordan Valley is known as the **AlGhor**, and it includes the **Jordan River**.
The soil and the environmental condition of this region havea greater potential of producing agriculture products. The entire country depends upon Jordan valley for its self-production of food and other needs such as grains, vegetable, and fruits. This valley is known as the food resource of the country by exporting agriculture products to international countries.
This valley is facing many challenges such as scarcity of water and lack of management of usage of farming lands and searching for a feasible solution to increase economic growth. Feasible solution modern techniques of irrigation and overcome on the salinity of the soil in forming in Jordan was studies during 2009-2010 (Ammari et al., 2013)
Generally, plants absorb nutrients from the soil, and soil contains nutrients in various forms suchorganic, 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 sulfur affect the plant growth, its yield, and consistency of soils. Weidenfeld studied on the addition of sulfur to calcareous soil and its effect on sugarcane from, over three years of period added at a rate of 1120 kg S Ha^{-1}(Weidenfeld, 2011). In Turkey, Kaplan and Orman reported in addition of sulfur and sulfur-containing waste is added to calcareous soil is treated with pH of 0-2,000 Kg Ha^{-1} of sulfur and 0100 tons Ha-1 of waste on Sorghum [Sorghum bicolor].

It grown in field and experiment was done in pots having 5 Kg soil, sulfur addition leads to increase the content of dry matter and phosphorus (P), (Iron)Fe, Zinc (Zn), manganese (Mn), and Cupper (Cu) uptake by plant, increase in EC of soil(Kaplan and Orman,1998). The pH of the soil represents the availability of various nutrients. The low pH values of soils contain a small number of micronutrients, whereas more available of micronutrients for the soils has high pH value. A three years field experiment was conducted in north-East Poland using three sulfur fertilization rates in the form of sulphate ($S\text{-}SO_4^{-2}$), and Pure ($S\text{-}S^0$), the increase rates of sulfur tend to increase the contents of $N\text{-}NH^{4+}$. The dose of 120 kg ha^{-1} $S\text{-}SO_4^{-2}$indicates a significant increase in the concentration of existing phosphorus in soil in the 0-40 and 40-80 cm layer (Skwierawska et al, 2008)

In term of the fertility of soil, addition of sulfur to the soil can enhance the physical and chemical properties of the soil and increases the concentration of soluble calcium and magnesium by converting these insoluble metallic forms to soluble ionic form, which could be useful for plants. Our study on the effects of Sulfur concentration on selected soil samples withdrawn from the Jordan Valley area, the availability of various plant nutrients will be presented. Optimum sulfur fertilization helps plants to grow and develop properly and improves the utilization of nutrients.

At present, there is a growing interest in sulfur as a component of fertilizers, especially in non-industrialized areas situated far from large cities, where deficient quantities of sulfur in plants are detected. Insufficient amount of sulfur reduces plant production in many parts of the world, and S deficit has been observed in soils and agricultural systems for the last decades. several factors influence such as depressed emission of sulfur to atmosphere, low concentration of sulfur in most of mineral fertilizers, which does not balance the loss of sulfur caused by its uptake by crops, low level of organic fertilization and migration of sulfate to deeper soil horizons and groundwater (Zhao and Hawkesford 1999, Fismes et al. 2000, Scherer 2001).

Although sulfur was significantly considered as an important element in fertilizers and is referred to as the fourth macronutrient element. Excessive amounts of sulfur can be toxic to plants, soil, and water. The purpose of the present study is to determine the effect of fertilization with increasing rates of sulfur as elementary sulfur on the content of total phosphorus, potassium, and the soil pH in the soil. The effects of sulfur and sulfur-containing waste on nutrient concentrations and growth of bean and corn plants grown on calcareous soil were studied. Muharrem et al, (2010) and Mustafa Kaplan, Sule Orman (1998).

After applying Sulfur, calcium replaced with sodium, and Exchangeable Sodium Percentage (ESP) reduced significantly. However, salinity has a negative effect on germination percentage, but sulfur addition has somewhat reduced its risks. Besharati, 1998) studies suggest that increased amounts of sulfur manure more the plant yield. Shamima and Huq (2002). The effect of the amount of Sulphur in EC of soil increased in the second and third sampling period and maximum rate of EC observed in third and fourth sampling (Table 3).

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2. Material and Methods

2.1 Study Site

The soil samples are collected from farm number 115 demand area22 in Jordan valley the location is shown below in figure 1.

2.2 Preparation of Sample

Samples were dried in open atmosphere at temperature range 25-40 °C according to Jordan valley weather conditions. Then these samples ground AgateMortar and pustule manually, weight out 500 g sample of soil batches was divided into 6 pots having capacity of 1000 ml size each, then sulfur powder was added in quantity as shown in Table**1**.

https://www.google.com/maps/place/32%C2%B013'35.0%22N+35%C2%B036'32.8%22E/@32.226844,35.611432 8,17z/data=!4m6!3m5!1s0!7e2!8m2!3d32.2263889!4d35.6091004 Figure 1. Location of samples collections.

Pot No	**1**	**2**	**3**	**4**	**5**	**6**
Weight of soil (g)	500	500	500	500	500	500
Weight of sulfur (g)	0.00	0.50	1.00	1.50	2.00	4.00

Table 1. The quantity of sulfur powder added.

Add 100 ml of distilled water to every pot. Then These samples were left to dry in several conditions (10-40 °C) for three days. After that wards, 100ml of distilled water for every pot. These previous steps are done twice. The samples were dried for three days under the same condition, then grinded to be ready for analysis.

Analysis:

Weight 10.0 g from blank sample to prepare soil extraction (1:5 extract) following the procedure in method of soil analysis, Lindsay and Norvell (1978)measure the electrical conductivity (EC) by using electron conductivity meter (Jenway type),the pH was measured using PH- meter (METROHOM). Element Mg and Ca metal ions was detected by atomic absorption (AA300 PERKIN ELEMR TYPE).

1- Weight 25.0 g from blank to extract Cu, Zn, Mn, Fe by using DTPA
2- Cu, Zn, Mn, Fe metal ions were measured by using atomic absorption (AA300 PERKIN ELEMR TYPE).
3- weight 5 g to extract Ca and Mg ions by using ammonium acetate

4- Mg and Ca ions were measured by using atomic absorption (AA300 PERKIN ELEMR TYPE).

3. Result and Discussions

Plant micronutrients tend to be less available in soils due to having high pH, and the microbial populations in the soil increases. Addition different quantities of fertilizer will improve the quality of soil and minimizing the effect of sodium. Sodium plays an adverse effect on plants and reduce production. Resulting the removing the water content of plant roots and thus weekend the plant, eventually cause its death. Also, increasing of sodium contents in the soil causes closing of the pores of the soil, and finally, the plant died.

Addition sulfur to the soil, was the economic chemical fertilizer . It helps in solving many plants problems, such as it decrease soil pH which is an advantage to the soil because the reduction of pH uptake of the trace elements Fe, Cu, Zn, Mn, change them from insoluble metallic form to soluble ionic form, these elements are very important nutrient to plant. Increasing Cu metal ion and low pH caused to damage the soil pathogen, Samanovicetal (2012).

Sulfur addition leads to increase calcium and magnesium concentration, these elements are very important to the soil and plant, and they play a role of in reducing of sodium effect in soil using The Sodium adsorption ratio (SAR) equation (1).

$SAR = Na^{+} /[(Ca^{2+} + Mg^{2+})/2]^{0.5}$ (1)

3.1. Effect of sulfur concentration on soil salinity

The effects of adding element sulfur on the soil salinity were carried out**.** The treatments consist of adding the following amount of sulfur in grams to 500 gm of soil as 0, 0.5, 1.0, 1.5, 2.0, 4.0 g. About 300 ml of water utilized for every 3 days, and the soil analysis was carried out after 10 days using Electrical conductivities meter as shown in Table 3, the results show saline water increased by adding amount of sulfur in a soil, because the liberalization of calcium and magnesium as well decreeing the amount of zinc, copper, and iron in soil.

3.2. Liberalization of Manganese, copper, zinc, and iron

Considerable amount of sulfur added to the soil leads to rising the concentration of zinc (Zn^{2+}), copper (Cu^{2+}) and Iron(Fe^{3+}) as shown in Figures 2-4, and ease of Manganese(Mg^{2+}), copper(Cu^{2+}) , zinc(Zn^{2+}) and iron (Fe^{3+}) from insoluble metallic form to soluble ionic form.

Table 2: Effect of addition sulfur on different metals present in the soil

Sulfur (g)	Cu (ppm)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Ca (ppm)	Mg (ppm)	PH 1:5	**EC 1:5(us/cm)**
0	2.78	5.93	4.62	11.71	6.25	3.91	8.86	**104.125**
0.5	2.92	6.52	4.83	26.5	7.3	6.05	8.61	**118.55**
1	2.94	7.17	4.85	30	10.25	7.95	8.33	**162.375**
2	3	7.34	5.18	48.6	14	10.65	7.97	**181.25**
4	3.28	7.91	5.84	53.09	19.5	13.35	7.68	**203.85**

3.3 Liberalization of calcium and magnesium

Adding of sulfur to the soil will lead to increase in the availability of manganese (Mg^{2+}) and calcium (Ca^{2+}) and insoluble form of magnesium; the increased amount directly correlated with the added sulfur Usually, magnesium was less absorbed by the plant compared to calcium as shown in Figures 1 and 5.

Table (3): Change in pH and Electrical conductivities with sulfur addition.

sample No	Wt. of sulfur	temp.	EC1:5(us/cm)	PH 1:5
1	0.0g	10.0	95	8.97
2	0.5g	10.0	88.2	8.79
3	1.0g	10.0	99.5	8.51
4	2.0g	10.0	105	8.3
5	4.0 g	10.0	122.4	8.05
6	0.0g	20.0	120	8.81
7	0.5g	20.0	141.1	8.77
8	1.0g	20.0	150	8.21
9	2.0g	20.0	155	8.1
10	4.0 g	20.0	173	7.57
11	0.0g	30.0	96.5	8.79
12	0.5g	30.0	123	8.5
13	1.0g	30.0	220	8.3
14	2.0g	30.0	230	7.74
15	4.0 g	30.0	250	7.48
16	0.0g	40.0	105	8.88
17	0.5g	40.0	121.9	8.37
18	1.0g	40.0	180	8.31
19	2.0g	40.0	235	7.85
20	4.0 g	40.0	270	7.7

Figure 1: Effect of Sulfur addition to soil on Mn release.

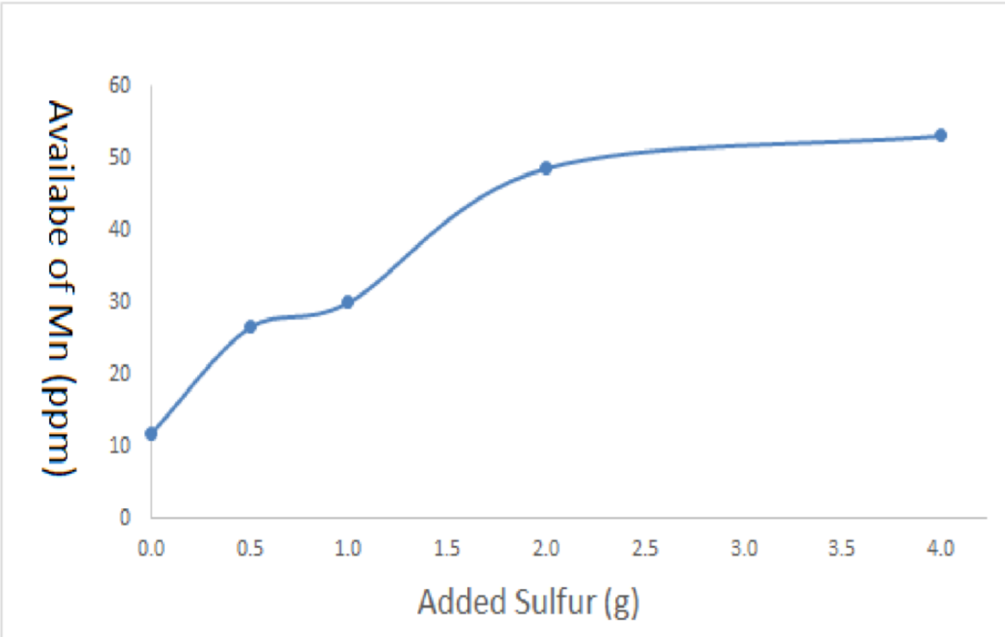


Figure 2: Effect of Sulfur addition on the release of Zn, Cu, Fe in soil

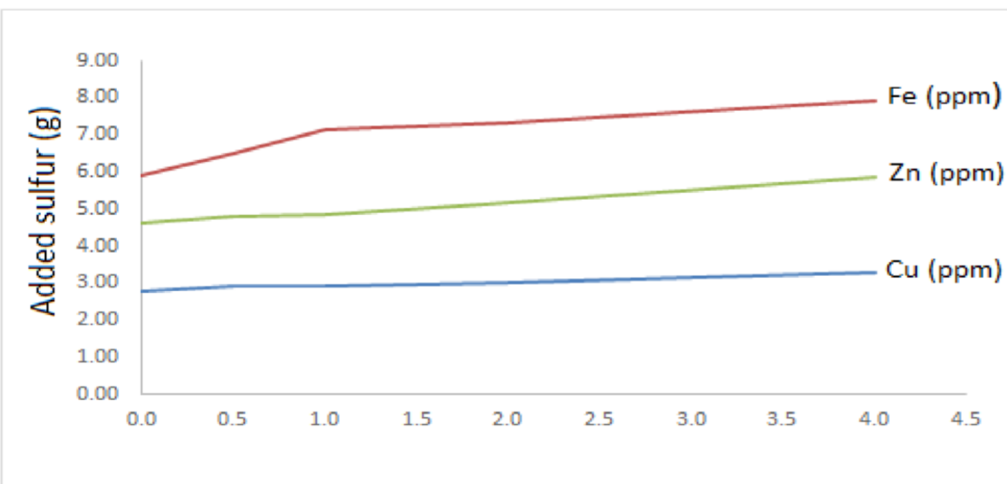
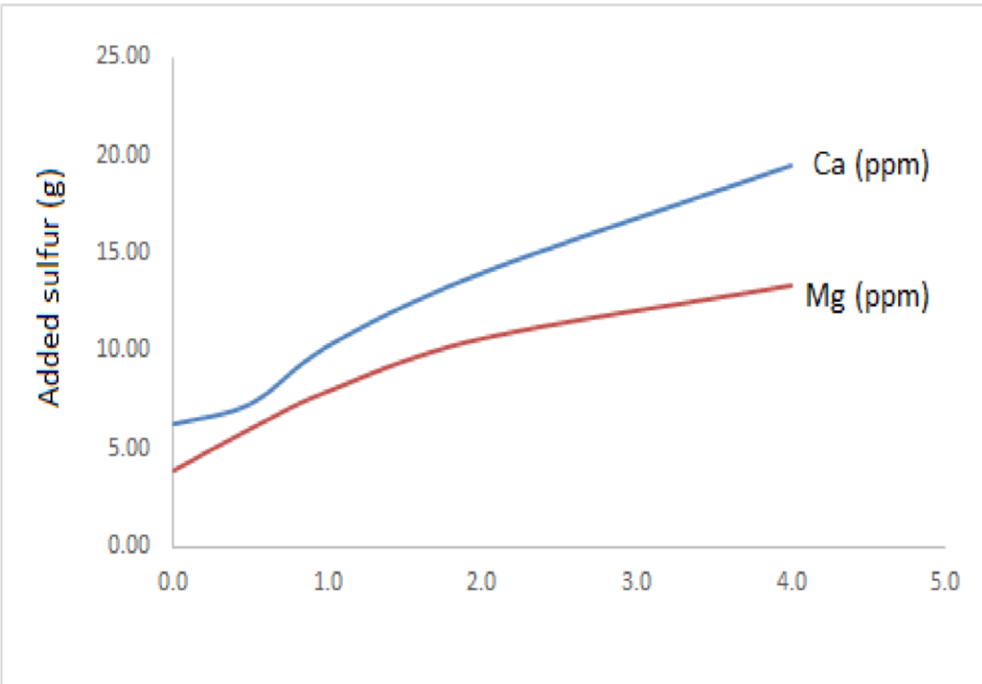


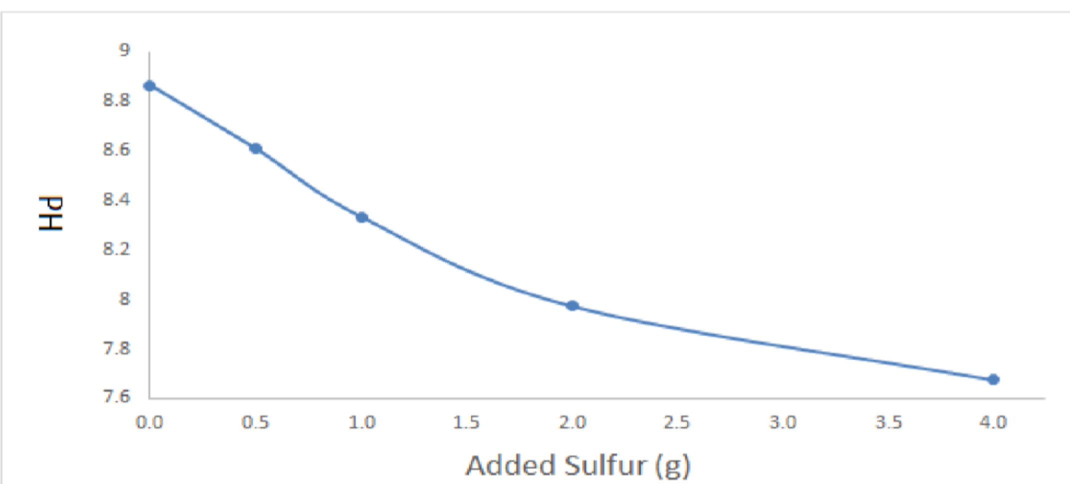
Figure 3: Effect of addition of Sulfur on Mg and Ca availability in soil.



3.4 Effect of sulfur contents in soil on pH

The economic way of lowering the soil pH by add elemental sulfur to the soil, the sulfur oxidized to sulfur oxide SO_x then change in aqueous solution into sulfuric acid (H_2SO_4), which cause a decrease in the soil pH. The obtained result in Figure 4 shows the opposite results, in which the pH values decrease when sulfur contents increase.

Figure 4: Effect of addition of Sulfur on pH in soil



4. Conclusion

Adding the considerable amount of sulfur to the soil does not increase the salinity as compared to the fertilizers. It raises the solubility of various nutrients such as Manganese, copper, zinc and iron manganese, and calcium, they were more significant for the plant growth. Adding element sulfur to moisturizing soil converted to partially sulfuric acid which reduces soil pH and this reach to many chemical reactions for lime and oxides in soil.

Which lead to forming soluble calcium, magnesium, Manganese, copper, zinc, and iron form to soluble from the element.

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