International Journal of Agriculture and Crop Sciences.
Available online at www.ijagcs.com
IJACS/2012/4-12/735-739
ISSN 2227-670X ©2012 IJACS Journal

IJACS

Influence of Elemental Sulfur and Sulfur Oxidizing Bacteria on Some Nutrient Deficiency in Calcareous Soils

Fatemeh Heydarnezhad[1], Parisa Shahinrokhsar[2], Hassan Shokri Vahed [3] and Hossein Besharati[4]

1. M.Sc. in Soil Science
2. Agricultural and Natural Resources Research Center, Engineering Research Dept., Rasht, Iran.
3. Rice Research Institute of Iran, Soil and Water science Dept., Rasht, Iran.
4. Soil and Water Research Institute, Karaj, Iran.

Corresponding Author email: fatemehheydarnezhad@yahoo.com

ABSTRACT: Sulfur-oxidizing bacteria are considered as amendments to increase the availability of phosphorus, iron and zinc in calcareous soils. This study was carried out in the laboratory to investigate the effects of sulfur (S_0, $S_{0.5}$) on nutrient availability of calcareous soils. Soils were collected from East Azarbaiejan and khorasan provinces in Iran and all soils were incubated at 28°C for 60 days. The results showed that with $S_{0.5}$ application Soil pH dropped and Sulfur concentration increased significantly with the addition of $S_{0.5}$. Elemental Sulfur application considerably increased the electrical conductivity (EC). The solubility of the P, Fe and Zn significantly increased after 60 days of incubation with the application of $S_{0.5}$ .The study suggests that $S_{0.5}$ is an effective factor for the amendment of calcareous soils. Application of $S_{0.5}$ is essential for nutrient availability in calcareous soils. The results indicated that sulfur facilitated the solubility of the P, Fe and Zn by soil microorganism.
Keywords: Bacteria, Microorganism, phosphorus, Soil.

INTRODUCTION

Most of the agricultural land of Iran is calcareous soil and S deficiency is a very common phenomenon in Iran. Poor availability of nutrients rather than low nutrient content is one of the major factors for the widespread occurrence of plant nutrient deficiency in calcareous soils. Decreasing soil pH is considered, as an effective way to deal with the stabilization of nutrients in calcareous and alkaline soil. In calcareous and alkaline Soil due to high pH and high concentration of calcium ions, some nutrients such as phosphorus, iron and zinc, that their availability are dependent on pH are established and their availability to the plants outcome (Cifuentes et al., 1993; Deluca et al., 1989; Kaplan et al., 1998; Modaihsh et al., 1989 and Tisdale et al., 1993). Common methods for dealing with these deficiencies, is the use of chemical fertilizers that in addition to the high cost and low efficiency, also have the risk of environmental pollution (Malakouti et al., 1991) The capacity of oxidized sulfur and produce sulfuric acid reduce the soil pH at least around themselves particles on a small scale and so can be effective, on the dissolution of insoluble food components and release of essential elements especially in the rhizosphere area (besharati et al., 1999; Ebadi, 1976). Sulfur is most common and cost effective acidify matter (Tisdale,1993) that after oxidizing each mole producing two moles of hydrogen ions (H^+) in the soil and reducing soil pH that leads to dissolution nutrients in the root (besharati, 1998; Deluca et al., 1989; Kaplan et al., 1998; Modaihsh et al., 1989). The use of sulfur, as a acidify matter with Thiobacillus bacteria to improve plant nutrition and providing sulfate has a long history of plant needs in calcareous soil (Lippman 1916). Applying sulfur will be effective when enough consuming in the soil lead oxidizing by micro-organisms like *Thiobacillus* bacteria (Ericsson et al 1999). Sulfur oxidation accomplished in both chemical and biological processes in the soil, *Thiobacillus* bacteria are the most important sulfur oxidizing in the soil (besharati, 2003). Main method of feeding the bacteria is chemiolithotrophic and can be achieved, vital needed energy for their activities from the sulfur oxidation reaction. Sulphoric acid from sulfur oxidation causes the solubility of insoluble phosphate compounds. A major problem of consumption of sulfur in the soil will be its oxidation. This is

possible with *Thiobacillus* bacteria that live in aerobic conditions in the soil. Unfortunately due to the low amount of organic matter in Iran cultivated soil, the number and activity of bacteria is limited in the soil of Iran. These bacteria in high organic matter and suitable moisture are able to grow and reproduce and thereby increase the biological oxidation of sulfur (Malakouti et al., 1996). The acidity produced during S oxidation increases the availability of nutrients such as P, Mn, Mg, Ca, and SO_4 in soils (Lindemann et al., 1991). The oxidation of S in calcareous soils is affected by several factors such as particle size of S, soil moisture, temperature, pH, nutrient status and microbial activity of the soils. Sulfur oxidation is the most rapid under low soil pH conditions (Havlin et al., 1999). Iron and Mn availability is directly associated with the status of soil pH. Alkaline soil conditions can render Fe unavailable to plant uptake. Zinc deficiency can occur on alkaline soils and sandy soils with poor organic matter content. The application of S often increases the availability of P in neutral or basic soils (Carl and Roger, 1996) and adequate supplies of other plant nutrients tend to increase the absorption of P in soils. Therefore, the present work was undertaken to investigate the effects of S on nutrient availability in soils from two regions in Iran.

MATERIALS AND METHODS

50 soil samples from East Azarbaijan and Khorasan provinces in Iran were collected from cultivated fields from depth of 30 cm. soil samples were moistened to FC and then each sample was in two parts. One part without sulfur (S_0) and the other after addition of 0.5% wt sulfur ($S_{0.5}$) spilled in pots with two kilograms. Sulfur consumption was micronized sulfur powder with 98% purity. The soil samples were withdrawn at 60 days of incubation at 28°C from each treatment then crushed and sieved. The soil pH, EC, available S, P, Fe and Zn were determined. The pH was measured using a pH meter. In the saturation extracts, EC was measured. Phosphorus determined with Olsen method. In the DTPA-extracts, available Fe, and Zn were determined. Sulfur (sulfate ions) was measured with Gravimetric method (Ali ehyaei, 1997). This Study performs to investigate the effects of sulfur application on the release of nutrients in the calcareous soil. In this study, investigated two sulfur treatments and replicated three times. Analysis on the parameters was performed, using SPSS 18 software. Mean values of soil chemical properties before and after treatment were determined. Measured soil properties seen in Tables 1.

Table1. Some physico chemical properties of soil samples

	Azarbayejan	Khorasan
EC ($ds.m^{-1}$)	2.58	3.27
pH	7.88	7.91
T.N.V (%)	11.28	17.86
OC (%/)	0.97	0.65
P(A.V) ($mg.kg^{-1}$)	16.35	11.09
K(A.V) ($mg.kg^{-1}$)	403.43	200.78
Fe(A.V) ($mg.kg^{-1}$)	4.52	4.58
Zn(A.V) ($mg.kg^{-1}$)	0.97	0.77
Mn(A.V) ($mg.kg^{-1}$)	8.38	6.82
Cu(A.V) ($mg.kg^{-1}$)	1.79	0.91
SO_4^{2-}(A.V) ($mg.kg^{-1}$)	33.37	35.68
soil texture	loam	loam

RESULTS AND DISCUSSION

The results of descriptive statistics include measure of average of soil properties before and after treatment with sulfur in East Azarbaijan province in Iran showed that the average electrical conductivity was 2.584 $ds.m^{-1}$ that after treatment with sulfur levels was changed to 4.833 $ds.m^{-1}$ (Fig.1). In other words, the treatment with 0.5 percent sulfur increased the average electrical conductivity that is indicating a positive effect on the Soil electrical conductivity. In khorasan province in Iran also indicated that electrical conductivity, with averaging 3.027 $ds.m^{-1}$ that after treatment with sulfur was changed to 5.427 $ds.m^{-1}$ (Fig.1). Modaihsh et al., (1989) and Cifuentes and lindermann (1993) also separately showed that consumption of 0.5% of sulfur in soils, increased significantly EC in compared to control.

pH before treatment with sulfur in East Azarbaijan province was 7.879 after treatment with sulfur decreased to 6.591 (Fig. 2). Also in the khorasan province pH was an average 7.911 that after treatment with sulfur changed to average 7.061 (Fig. 2). Kaplan and Omran (1998) found that the use of sulfur has a significant effect in reducing soil pH. In a similar study, Miller (1965) also found that sulfur intake can reduce the soil pH after 5 years. Also Mahler and Maples (1986) showed that consumption of elemental sulfur reduces soil pH and with increasing the

amount of sulfur in the soil, the pH decrease was faster. Lawrence and Germida (1988) also concluded that the oxidation of sulfur has a significant positive correlation with soil pH.

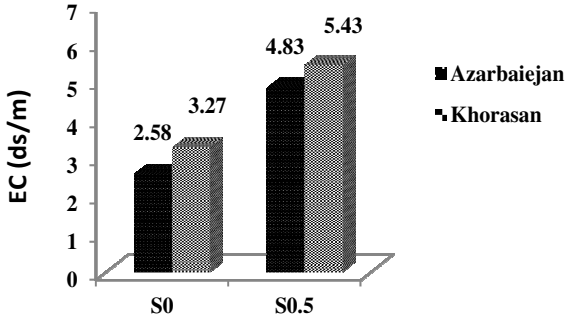

Figure 1. The effect of different sulfur levels on EC.

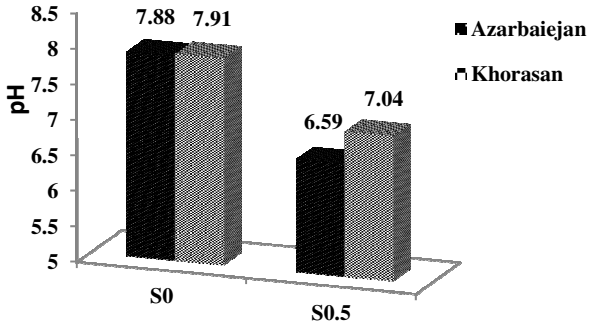

Figure 2 . The effect of different sulfur levels on pH.

Mean phosphorus from soil treated with sulfur in the East Azarbaijan Province was 16.347 mg.kg^{-1} that changed after treatment with sulfur levels to 32.567 mg.kg^{-1} (Fig. 3). In Khorasan province pretreated with sulfur, phosphorus in the soil was in average 11.264 mg.kg^{-1} the amount of sulfur after treatment with sulfur changed 16.793 mg.kg^{-1} (Fig. 3). The reason is that adding sulfur to the soil pH of calcareous soils in small areas around the roots reduced and the ability of phosphorus absorbtion increases (Besharati. 1998). Application of $S_{0.5}$ increased the availability of P and micronutrients to correct their deficiencies in alkaline and calcareous soils (Hilal and Abd-Elfattah, 1987). Power of Acid, amount of dissolved calcium, the type and location of chelate ligands are factors that can affect the amount of phosphorus released (sago et al., 1998). Goodarzi (2004) and Modaihsh et al (1989) and Kittams and Attoe (1963) during their studies found that sulfur has positive Effect on releasing phosphorus from the soil and the plant yield increase. Jaggi et al., (2005) and pasandideh et al., (2003) Concluded that the oxidation of sulfur reduced pH in alkaline Soil and thus increases the concentration of available phosphorus.

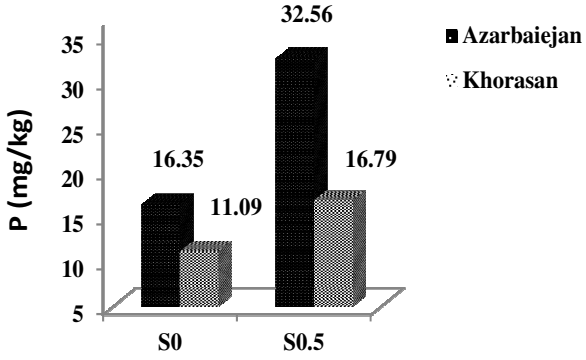

Figure 3. The effect of different sulfur levels on phosphorus availability.

Absorbable iron in the soil of East Azarbaijan province before treatment averaged 4.516 mg.kg^{-1} after treatment with sulfur increased to 12.245 mg.kg^{-1} (Fig. 4). In the khorasan province the amount of iron absorbed from the soil with sulfur-treated soil was in average of 4.575 mg.kg^{-1} that increased after treatment with sulfur levels to 11.149 mg.kg^{-1} (Fig. 4). Malakouti et al (1988) reported that consumption of sulfur in calcareous soil and with neutralizing lime increased availability of iron. And Caldwell (1969) in a greenhouse with the use of 0.5 percent (by weight) elemental sulfur, in compared with controls showed that the amount of absorbable iron in the soil increased.

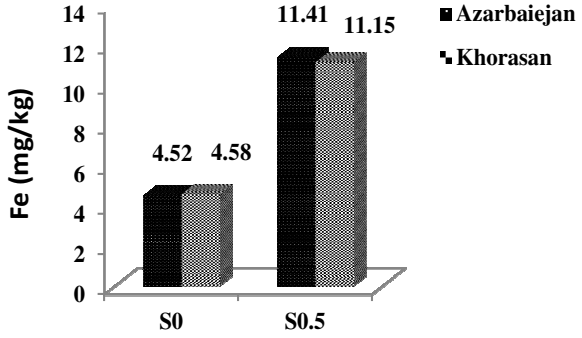

Figure 4. The effect of different sulfur levels on iron availability.

Zinc before treated with sulfur in East Azarbaijan province, averaging 0.973 mg.kg^{-1} that changed after treatment with sulfur levels to 0.991 mg.kg^{-1} (Fig. 5). Available zinc in the soil in khorasan province before treatment with sulfur, with average 0.773 mg.kg^{-1} that changed after treatment with sulfur levels 0.912 mg.kg^{-1} (Fig. 5). Kalbasi et al., (1988) also concluded that sulfur consumption increased significantly in compared to control in the soil. Elemental $S_{0.5}$ application increased the Zn and Cd solubilization in soil and increased their uptake by plants (Kayser et al., 2001).

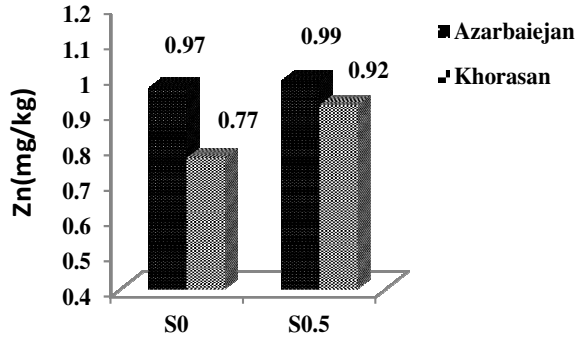

Figure 5. The effect of different sulfur levels on Zinc availability.

Without any Significant measurements in the soil can be in reason of the low oxidation of sulfur and low soil nutrient and low of sulfur oxidizing population (Wainwright, 1984; besharati, 1998) also attributed.

Results indicate that the oxidation of sulfur in the samples taken and the lower pH, the concentration of sulfur (as sulfate ion) in the samples increased. The concentration of absorbed phosphorus, iron and zinc were also increased significantly. This is related to the oxidation of sulfur in the soil and oxidizing microorganisms which cause sufficient oxidation of sulfur and release nutrient. The soil were calcareous and probably in such soil nutrients ability were low (malakouti et al., 1991) that it casuses failure to provide the nutrients needed by plants.

Thus, there is a growing interest in S applications to improve availability of nutrients and overcome nutrient deficiencies in both alkaline and calcareous soils (Dawood et al., 1985; Neilsen et al., 1993).

REFERENCES

Ali Ehyaei M. 1997. The soil chemical analysis methods. Publication No. 1024. Research Institute of Soil and water.

Besharati H. 1998. The Effect of Sulfur with Thiobacillus species to increase absorbs some soil elements. Thesis Soil Science, Faculty of Agriculture, Tehran University. 176 Pages.

Besharati H. 2003. Preparation of suitable preservative for bacteria genera Thiobacillus and study its interactions with mycorrhiza fungi.

Besharati H, Salehrastin N. 1999. The effect of sulfur inoculated with Thiobacillus bacteria to increase P uptake. Journal of Soil and Water Sciences, 13(1):23-39.

Caldwell AC, Seim EC, Rehm GW. 1969. Effects of elemental sulfur on composition of alfalfa (medicago sative) and corn (zea maize). Agronomy Journal 61:632-634.

Carl JR, Roger E. 1996. Nutrient Management for Commercial Fruit and Vegetable Crops in Minnesota, Department of Soil, Water, and Climate Minnesota Extension Service, University of Minnesota

Cifuentes FR, lindermann WC. 1993. Organic matter stimulation of elemental sulfur oxidation in calcareous soils. Siol Sci. Soc.Am.J., 57:727-731.

Dawood F, Al-Omari SM, Murtatha N. 1985. High levels of sulphur affecting availability of some micronutrients in calcareous soils. *In* Proc. Sec. Reg. Conf. on Sulphur and its Usage in Arab Countries, Riyadh, 2-5 March 1985, Saudi Arabia. pp.55-68.

Deluca TH, Skogley EO, Engle RE. 1989. Band-applied elemental sulfur to enhance the phytoavailability of phosphorus in alkaline calcareous soils. Biol. Fertile. Soils.7:346-350.

Ebadi A. 1986. Sulfur and its use in agriculture. The publications of the Jihad University.

Eriksen G, Coale F, Bollero G. 1999. Soil nitrogen dynamics and maize production in municipal solid waste amended soil. Agronomy Journal 91: 1009-1016.

Goodarzi k. 1994. Study of Sulfur and compost effects to increase ability of soil nutrients uptake and wheat yeild. New methods of wheat feeding (Articles Collections). Department of Agriculture, Office of wheat self-sufficiency. Tehran, Iran.

Havlin JL, Beaton JD, Tisdal SL, Nelson WL. 1999. Soil Fertility and Fertilizers. An Introduction to Nutrient Management. 6th ed. Prentic Hall, New Jersy, USA

Hilal MH, Abd-Elfattah AA. 1987. Effect of $CaCO_3$ and clay content of alkali soils on their response to added sulphur. Sulphur Agric. 11:15-17

Joggi RC, Aulakh MS, Sharma R. 2005. Imoacts of elemental S applied under various temperature and moisture regimes on pH and available P in acidic, neutral and alkaline sils. Biol. Fertilizer Soils. 41:52-58.

Kalbasi M, Manuchehri N, Filsoof F. 1986. local acidification of soil as a means to alleviate iven chlovosis on quince ovchards. J.Plant nutrition. 9(3-7): 1001-1007.

Kaplan M, Orman S. 1998. Effect of elemental sulfur and sulfur containing waste in a calcareous soil in turkey. J.Plant Nutr., 21(8):1655-1665.

Kayser A, Schroder TJ, Grunwald A, Schulin R. 2001. Solubilization and plant uptake of zinc and cadmium from soils treated with elemental sulfur. Int. J. Phytorem. 3:381-400.

Kittams H.A., Attoe O.J. 1965. Availibility of phosphorous in rock phosphate-sulfur fusion. Agron.J., 57:331-334.

Lawrence JR, Germida JJ. 1988. Ralationship between microbial biomass and elemental sulfur oxidation in agricultural soils. Soil Sci.Soc. Am.J., 52:672-677.

Lindemann WC, Aburtto JJ, Haffner WM, Bono AA. 1991. Effect of sulfur source on sulfur oxidation. Soil Sci. Soc. Am. J. 55:85-90.

Lipman JG, Mc lean HC, Lint HC. 1916. The oxidation of sulfur in soils as a means of increasing the availability of mineral sulphates. Soil Science 1:533-539.

Mahler RJ, Maples RL, 1986. Response of wheat to sulfur fertilization commum. Soil Sci. Plant Anal.17:975-988.

Malakouti MJ. 1996. Sustainable agriculture and increase function by optimizing fertilizer in Iran dependent the Department of Agriculture publications, publishing training manpower training and equipping the Ministry of Agriculture.

Malakouti MJ, Gheibi N. 1988. Determine the critical nutrients strategic and proper fertilizer recommendations in the country. Publication of agricultural education, training and equipping the human resources department of Tat, the Ministry of Agriculture, Karaj, Iran.

Malakouti MJ, Riazi Hamedani SAH. 1991. Fertilizer and Fertility. University of Tehran press.

Miller JR. 1965. Effect of sulfur and gypsum addition on availability of rock phosphate. Soil. Sci. 82:129-134.

Modaihsh S, Al-mustafa WA, Metwally AE. 1989. Effect of elemental sulfur on chemical changes and nutrient availability in calcareous soils. Plant & Soil 116:95-101.

Pasandideh M, Malakouti MJ, Keshavarz P. 2003. Effect of sulfur and Thiobacillus inoculum on sulfur oxidation, pH, manure pit content and availability of phosphorus from biophosphate fertilizer. National Seminar on production and consumption of sulfur in Mashhad, Iran.

Sagoe CL, Ando T, Kouno K, Nagaoka T. 1998. Residual effects of organic acid treated phosphate rocks on some soil properties and phosphate availability. Soil science and plant nutrition, 44:627-634.

Tisdale SL, Nelson WL, Beaton JD, Havlin JL. 1993. soil Fertility and fertilizers. 5th ed. Mcmillon publishing co., New York.

Wainwright M. 1984. Sulfur oxidation in soils. Advences in Agronomy., 37: 346-396.