

THE EFFECT OF N, P, K FERTILISATION AND BACTERIAL INOCULATION ON THE OXIDATION OF ELEMENTAL SULPHUR IN DANUBE ALLUVIAL SOIL

ZS. GICZI¹ – R. KALOCSAI¹ – R. SCHMIDT² – P. SZAKÁL²

¹ UIS Ungarn Laboranalytical LTD Mosonmagyaróvár, Terv Str. 92.

² University of West Hungary Faculty of Agricultural and Food Sciences

Mosonmagyaróvár 9200 Vár 2.

E-mail: krenato@uis.hu

Introduction

Sulphur is a basic nutrient both for humans and animal organisms. It is a basic nutrient that directly or indirectly plays an important role in numerous vital functions. In the past period sulphur input to agricultural lands was reduced. Therefore a reasonable sulphur fertilisation will have an increasing importance and might be the part of everyday fertilisation procedures. Research is also being done regarding the use of elemental sulphur for fertilisation purposes, since the biological activity of soils can be increased by this without additional microbial inoculation. (Kalocsai et al. 2000). Attia and Dosuky (1996) in their experiments carried out on calcareous sandy soil proved, that the yield and nutrient element content of winter wheat increased due to the application of organic manure, nitrogen and sulphur fertilisation and inoculation with *Thiobacillus sp.* Szentpéteri et al.(2005) emphasised the importance of these factors also. The favourable effect of *Thiobacillus* inoculation and elemental sulphur fertilisation was proved in experiments with maize Kabesh et al. (1989), and soybean Saber et al. (1989) respectively. Similar experiences were gathered in pot experiments with vegetables Shinde et al. (1996). Beyond plant nutrition aspects sulphur application might play a role in the amelioration and improvement of alkaline and sodic soils (Groudeva et al. 1984, Slaton et al. 1998a, 1998b) and can also be an important tool of phytoremediation (Tichy et al. 1997, Maini et al. 2000). These facts will have an impact on Hungarian agriculture as well; therefore the research activity regarding sulphur should be increased in the future. (Kalocsai et al. 2000).

Methods

For studying sulphur oxidation in the soil an experiment was launched that included sulphur fertilisation, N, P, K fertiliser application and bacterial soil inoculation. In our incubation experiments the oxidation of increasing elemental sulphur doses was studied (0,1; 1,0; 2,5; 5,0 and 10 g pot⁻¹, i.e. 50, 500, 1250, 2500 and 5000 kg ha⁻¹). In the 84 days long pot experiment the oxidation potential of the soil and the sulphur reducing micro-organisms *Thiobacillus ferrooxidans* and *T. thiooxidans* was studied in unfertilised and N, P, K fertilised soil respectively. The nutrient status of the soil was as follows: N- medium supply, P₂O₅-excellent supply, K₂O- poor supply (Table 1).

Table 1. Soil analysis values of the experimental soil

pH		Plasticity index	CaCO ₃ %	Humus %	Total N %	Nitrate mg kg ⁻¹	Sulphate mg kg ⁻¹	AL-extractable mg kg ⁻¹ (7)			nKCl extr. Mg mg kg ⁻¹	EDTA-extractable mg kg ⁻¹			
H ₂ O	KCl							P ₂ O ₅	K ₂ O	Na		Zn	Cu	Mn	Fe
7,9	7,4	37,2	4,4	2,5	0,2	37,9	13,22	176,8	92,9	13,1	65,3	1,2	2,6	53,6	24,3

After mixing the elemental sulphur into the soil it was divided into two parts. The first part was not supplemented with N, P, K fertilisers, N, P, K fertiliser in an amount calculated

according to “MÉM NAK” fertilisation system was given to the second part. After this the two soil parts were separated into another three parts. The first part was not inoculated (N), the second part was inoculated with the bacterium strain *T. ferrooxidans* (DSM No. 583) (F) and the third part with *T. thiooxidans* (ATCC 8085), too. The treatments applied in the experiment are listed in Table 2. The inoculating solution contained 1.5×10^8 ml⁻¹ bacteria. After the inoculation 10 CFU g⁻¹ values were detected in the pots on a dry soil basis.

Table 2. Treatments used in the sulphur oxidation experiment

	applied elemental sulphur doses		
	(g pot ⁻¹)	mg kg ⁻¹	kg ha ⁻¹
S0 (control)	-	-	-
S1	0,1	238	50
S2	1,0	2380	500
S3	2,5	5952	1250
S4*	5,0	11904	2500
S5*	10,0	23809	5000

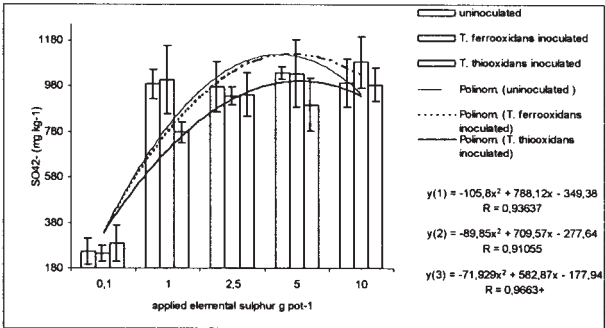
treatment	unfertilised (A)			N,P,K fertilised (B)		
	uninoculated (AN)	inoculated		uninoculated (BN)	inoculated	
		<i>T.ferrooxidans</i> (AF)	<i>T.thiooxidans</i> (AT)		<i>T.ferrooxidans</i> (BF)	<i>T.thiooxidans</i> (BT)
		quantity of fertiliser				
N	-	-	-	38 mg	91 mg kg ⁻¹	191 kg ha ⁻¹
P ₂ O ₅	-	-	-	16 mg	38 mg kg ⁻¹	80 kg ha ⁻¹
K ₂ O	-	-	-	15 mg	36 mg kg ⁻¹	75 kg ha ⁻¹

The experiment started on 24th February 2000 and the soils were incubated according to Newell and Wainwright (1987), Shukla and Singh (1992), Lan et al. (2000) at 60% of maximum water capacity in a thermostat at a temperature of 22,8±0.5°C (Ballenegger and di-Glória 1962). This temperature practically equals the maximum temperature of the upper 10 cm soil layer of Hungarian fields (Varga-Haszonits *et al.* 2000). After the incubation period the pH_{H2O}, the pH_{KCl} and the SO₄²⁻-values of the soil were measured.

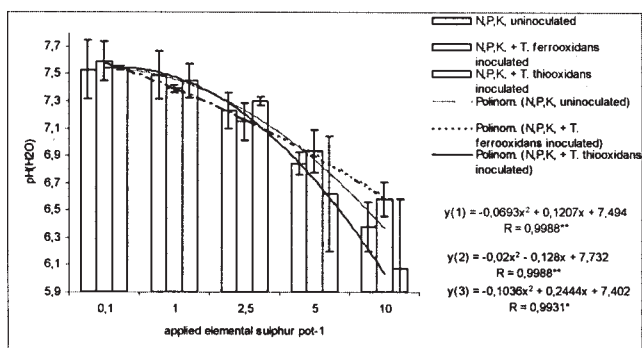
Results and discussion

In the experiment we established, that as a result of the elemental sulphur given to the soil the available sulphur content increased in every case compared to the values of treatments without sulphur application (Figure 1.)

Figure 1. The effect of elemental sulphur application on the SO₄²⁻ concentration of the soil



The bacterial soil inoculation increased the oxidation rate of the soil to a great extent, which was displayed by the decreasing pH values (Figure 2.) This effect was significant at 0.1% probability level. Between the two bacteria species used in the experiment *T. thiooxidans* was



more effective.

Figure 2. The effect of elemental sulphur application on the pH_{H2O} of the N, P, K fertilised soil

The increasing elemental sulphur doses stimulated the microbial sulphur oxidation that was also indicated by the increasing sulphate content of the soil. The N, P, K fertilisation increased the oxidation of elemental sulphur significantly in every case. This significant relationship did not show a strong correlation with the pH values of the soil. The changes of pH_{H2O} values can be explained by the sulphate concentration in 50% ($R^2=0,5056$), 44.3 % ($R^2=0,4437$) and 22.37 % ($R^2=0,2237$) in the case of uninoculated and *T. ferrooxidans* inoculated and *T. thiooxidans* inoculated group respectively. Therefore we assume that numerous physico-chemical processes might play a role in the background that require further investigations.

Conclusions

In a soil inoculation experiment we proved that the original microbial population of the calcareous Danube alluvial soil has a significant ability to oxidise sulphur.

The applicability of *Thiobacillus sp.* inoculation on calcareous, alkaline soils was proved. It was established that on the calcareous Danube alluvial soil the bacterium species *T. thiooxidans* oxidised sulphur the most efficiently.

References

- Attia, K.K., El-Dosuky, M.M. 1996 Effect of elemental sulfur and inoculation with *Thiobacillus*, organic manure and nitrogen fertilization of wheat. *Assiut J. of Agric. Sci.* 27:191-206,
- Ballenegger, R., Di Gléria, J. 1962 *Talaj- és trágyavizsgáló módszerek*. Mezőgazdasági Kiadó, Budapest pp. 411.
- Groudeva, V.I., Groundev, S.N., Szegi, J. (ed.) 1984 Prevention of soil alkalization by means of laboratory-bred chemoautotrophic bacteria. *Soil biol. and consrv. On the biosphere.* 2:847-854.
- Kabesh, M.O., Behairy, T.G., Saber, M.S.M. 1989 Utilization of biofertilizers in field crop production. 7. Effect of elemental sulphur application in the presence and absence of two biofertilizers on growth and yield of maize. *Eg. J. of Agronomy* 14:95-102.

- Kalocsai, R., Schmidt, R., Szakál, P., Kerekes, G. 2000 A kén – a környezetszennyező esszenciális makroelem (szemle) Acta Agronomica Óváriensis 42:2,261-286.
- Lan, Y.Q., Zhou, G., Liu, Z.H. Huang, X. 2000 Pyrite oxidation under different conditions. J. of Nanjing Agric. Univ. 23:1, 81-84.
- Maini, G., Sharman, A.K., Sunderland, G., Knowles, C.J., Jackman, S.A. 2000 An integrated method incorporating sulfur – oxidizing bacteria and electrokinetics to enhance removal of copper from contaminated soil. Env. Sci. and Techn. 34:6, 1081-1087.
- Newell, W. Wainwright, M. 1987 Influence of soil moisture on sulphur oxidation in brown earth soils. Biol. and Fert. of Soils 5:3, 209-214.
- Saber, M.S.M. El-Baz, F.K. Kabesh, M.O. 1989 Utilization of biofertilizers in increasing field crop production. 6. Effect of elemental sulphur application and/or biofertilization on the chemical composition of soybean seeds. Eg. J. of Agronomy 14:241-251.
- Shinde, D.B. Patil, P.L. Khade, K.K. 1996 A study on sulphur biofertilization of greengram for yield and quality. J. of Maharashtra Agric. Univ. 21:365-367.
- Shukla, A.R., Singh, R.S. 1992 Oxidation of sulphur in pyrites in relation to soil and water regime. J. of the Ind. Soc. of Soil Sci. 40:4, 848-850.
- Slaton, N.A. Ntamatungrio, S. Wilson, C.E. Norman, R.J. 1998a Field evaluation of an elemental sulfur product on rice growth. Res. Ser. Arkansas Agric. Exp. Stat. 460:322-325.
- Slaton, N.A., Ntamatungrio, S., Wilson, C.E., Norman, R.J. 1998b Influence of two elemental sulfur products applied to an alkalinesilt loam on rice growth. Res. Ser. Arkansas Agric. Exp. Stat. 460:326-329.
- Szentpéteri, Zs., Hegedüs, Z., Jolánkai, M., 2005 Impact of Agrochemicals on Yield Quality and Pesticide Residues of Winter Wheat Varieties. Cereal Res Comm 33 2-3 635-641
- Tichy, R., Fajtl, J., Kuzel, S., Kolar, L 1997 Use of elemental sulphur to enhance a cadmium solubilization and its vegetative removal from contaminated soil. Nutr. Cycl. in Agroecosys. 46:3, 249-255.
- Varga-Haszonits, Z., Varga, Z., Lantos, Zs., Vámos, O., Schmidt, R. 2000 Magyarország éghajlati erőforrásainak agroklimatológiai elemzése. Mosonmagyaróvár p. 88.
- Kádár, I. (2004): Szennyvíziszap-adagok hatása a növény (*Triticum vulgare* L.)-talaj rendszer néhány mikrobiológiai és biokémiai tulajdonságára (Impact of sludge treatments on some microbiological and biochemical properties of plant (*Triticum vulgare* L.)-soil system. – in *Hungarian*). Agrokémia és Talajtan. 53. 3-4. 331-342 pp
- Svetková, K.; Henselová, M.; Morvová, M. (2005): Effects of a carbonization product as additive on the germination, growth and yield parameters of agricultural crops. Acta Agron. Hun. 53. (3). 241-250 pp
- Tanács, L., Matuz, J., Gerő, L., Petróczi, I.M. (2005): Effect of NPK Fertilizers and Fungicides on the Quality of Bread Wheat in Different Years. Cereal Res. Commun. 33 (2-3): 627-634 pp