

COPPER ION-EXCHANGED ZEOLITE IN PLANT NUTRITION

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Introduction

Wheat is one of the most important crops of Hungarian agriculture. The good quality wheat grown in Hungary has been a produce in demand since the 18th century.

Regarding the quality of wheat a national standard contains the quality parameters, such as specific weight, baking quality, wet gluten content, raw protein content, falling number, etc. (Jolánkai et al. 2003).

In the European Union there is no such a uniform, centrally regulated requirement and the Hungarian standard is stricter and demands the measurement of more parameters. For improving the quality of wheat the Department of Chemistry and the Department of Soil Management carry out experiments for more than twenty years. For increasing the yield and improving quality we design the plant nutrition according to the chemical composition of the soil and plant analysis results (Szakál et al. 2003). Hungarian soils are often deficient in zinc and copper. For the replacement of these nutrients we produced metal complexes with different ligands and studied their potential application as foliar fertiliser. In this experiment we studied the applicability of copper ion-exchanged synthesized zeolite.

Hungarian and international researchers underline the importance of copper in improving wheat quality (Flynn et al. 1987, Szakál et al. 1997).

Younts (1963) carried out copper fertilisation experiments in high organic matter containing soils. He experienced the improvement of the quality parameters.

Reisinger et al. (1996) experienced after liming acidic soil that as soil pH raised the amount of available copper became lower.

The zeolite used in our experiments is aluminium-hydro-silicate that builds up from central tetraeders in such a way, that the tetraeders bind to each other through common oxygen ions, while they form cavities and channels of molecular size. The proportion of silicon or aluminium tetraeders determine the ion exchange capacity of the particular zeolite since due to the presence of the trivalent aluminium the grid has a negative charge that is neutralised by cations. These cations can be different ones and can be exchanged to other ions. In Hungary the largest place of occurrence of natural zeolites is in the Tokaj Mountains. These zeolites bound a huge amount of metal ions in the past and release these ions slowly into the soil solution safeguarding a permanent supply of trace elements. Using this chemical feature of zeolites it is possible to use them in agriculture at such places where continuous application of elements is necessary.

Sometimes the natural zeolites contain clay mineral inclusions and their particle distribution is heterogeneous that hinders the applicability (Mumpton 1978). These disadvantageous qualities draw the attention to the use of different synthetic zeolites (Szakál et al. 2000).

The inner surface, the cavity and channel system of zeolites is much larger than their outer surface. If we take ions onto these inner surfaces and cover them with some suitable material e.g. certain polymers, we get a material that holds the target ions for a longer time and the bound ions can be released only after longer time. By this procedure we can realize a retard ion exchange process.

Methods

In the experiments we used the ZEOLON-P4A type synthesized zeolite. On the surface and in the cavities of the zeolite we changed the Na-ions by copper-tetramine. The copper content of the zeolite produced this way was 3.8 %. The experiments were launched at a field of Solum Farm Ltd. in Komárom on Danube alluvial soil in the years 1998-2000. The size of the plots was 10 m², the arrangement of the experiment was a randomised block design with four repetitions. The grown winter wheat variety was GK-Kincső. The composition of the soil is shown in Table 1.

Table 1. Average soil composition of the experimental site at Komárom

pH		K _A	CaCO ₃ %	Humus %	AL-soluble			nKCl	EDTA-soluble			
H ₂ O	KCl				P ₂ O ₅	K ₂ O	Na	Mg	Zn	Cu	Mn	Fe
mgkg ⁻¹												
7.82	7.45	37.4	4.8	2.3	169.8	99.9	12.6	63.8	1.1	0.80	52.4	32.2

Studying the soil composition we can establish that the calcareous soil contained a low amount of available zinc and copper. For the production of good quality wheat copper administration is required in this copper deficient soil. The applied copper doses were 0.1; 0.3; 0.5; 1.0; 2.0 kg ha⁻¹. The compound was applied on the surface of the plants in the state of suspension with a high-pressure hand sprayer. The same amount of water was applied to the control plots. The applied amount was 0.6 l to a 10 m² plot. The harvest was done with a plot harvester. From the samples collected we determined the yield and the raw protein content.

Results and discussion

On the basis of the experimental results we can establish that the yield of wheat increased due to the application of the rising Cu-zeolite doses in all experimental years. The yield increase was significant at 5% probability level. Based on the results and evaluation the maximum yield can be expected at 2.0 kg ha⁻¹ copper dose.

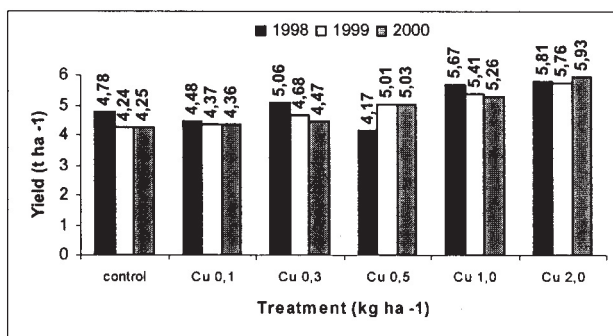


Figure 1. Effect of copper zeolite on the yield of winter wheat

Figure 2 displays the changes in the raw protein content over the three years. The rising doses of copper-zeolite in all the three experimental years increased the raw protein content of winter wheat ($P < 5\%$).

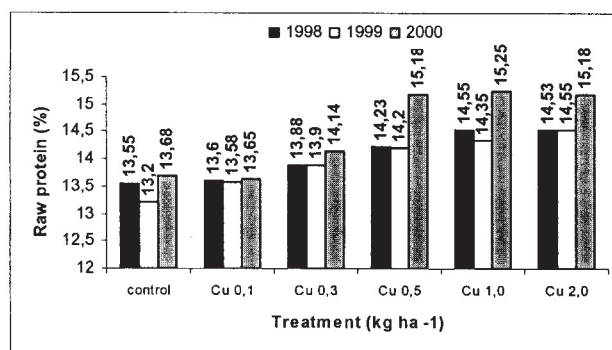


Figure 2. Effect of copper zeolite on the raw protein content of winter wheat

Studying the effect of the treatments we can establish that the raw protein values increased to a greater extent than the yield. Regarding the raw protein content 1.0 and 2.0 kg ha⁻¹ copper doses gave the best results. The highest raw protein content was detected in 2000.

Conclusions

The application of copper-ion exchanged zeolites increased the yield of wheat. The yield increased with the rising doses. Even the 2 kg ha⁻¹ copper dose did not cause any depressive effect, while at the application of other copper compounds fitotoxicity appeared sometimes already at 1.0 kg ha⁻¹ dose. The raw protein content also increased due to the application of the rising copper-zeolite doses. The highest raw protein content value was by 11.47% higher than the value of the control. The high raw protein content occurred not only due to copper fertilisation but to the fact that zeolites are able to bind the ammonium ions present in their environment and to release it afterwards, which improves the N nutrition of plants.

References

- Flynn, A.G. Panazzo, J.F Gardner, W.K. 1987. The effect of copper deficiency on the laking quality and dough properties of wheat flour. *Journal of Cereal Science*. 6. 1. 91-98.
- Jolánkai M. Szentpétery Zs. Nyárai H.F. 2003. Gluten and protein formation in wheat grain. In: *Proceedings of the 2nd Alps-Adria Scientific Workshop*. Ed.: Gyuricza Cs. Akaprint. Trogir. 76-80
- Mumpton, F. A. 1978. *Natural Zeolites, Occurrence, Properties, Use*. Pergamon Press, Oxford.
- Reisinger, P., Schmidt, R., Szakál, P. 1996. A talajmeszezés helyzete és a lehetséges megoldások hazánkban. *Integrált Növénytermesztés* 12, p.100-108.
- Szakál P., Reisinger P., Schmidt R., Hámori K., Szederkényi P. 1997. Meszezés és mikroelempótlás hatása az őszi búza termésére és lisztminőségére XIII. Országos Integrált termesztés a szántóföldi kultúrákban, Budapest. p.204-210.
- Szakál, P. Schmidt R. Barkóczi M. Kalocsai R. Giczi Zs. 2003 The effect of copper containing ion exchanged zeolite on the yield and protein content of winter wheat. *Trace elements in the food chain*. Bessenyei György Könyvkiadó. p.237-238.
- Szakál, P., Schmidt, R., Lesny, J., Vegh, D., Horak, O., Tölgyessy, J. 2000 Application of ion exchanged copper- and zinc containing zeolites in agriculture. *Analytical and Environmental Conference, Mosonmagyaróvár*, 109-113.
- Younts, S.E.: 1963. Response of Wehat to Rates, Dates of Application, and Sources of Copper and to other Micronutrients. *Agronomy Journal* 266-270.

- 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