

EFFECT OF LONG-TERM ARTIFICIAL FERTILISATION ON READILY AVAILABLE ELEMENT CONTENT OF A MEADOW CHERNOZEM SOIL AND ON CHEMICAL COMPOSITION OF WINTER WHEAT YIELD

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Introduction

Regular fertilisation can cause significant changes in the direction and the intensity of certain soil chemical and microbiological (ZSEMBELI *et al.*, 2005) processes. Additionally, it has effects on the availability of nutrients and on the nutrient supply of crops through the modification of the soil pH and the interaction of nutrients (BLASKÓ *et al.*, 2003). However, we already have wide range of information about the processes induced by fertilisation; their further examination is a very important task of the recent agro-chemistry research as well. Long-term fertilisation experiments form an important basis of these researches and provide results which are important for the development and the application of sort- and site specific fertilisation technologies. The National Uniformed Long-Term Fertilisation Experiments (NULTFE) carried out in 9 experimental sites of Hungary has a significant role in the sustainable development of crop management systems. The obtained results related to changes of soil parameters and nutrient availability were summarized by DEBRECZENINÉ *et al.* (2003), KISMÁNYOKI *et al.* (2003), BLASKÓ and ZSIGRAI (2003), HOLLÓ (2003), BLASKÓ *et al.* (2003), and by HOLLÓ and KÁDÁR (2003).

During our work the effects of long-term fertilisation on the readily available element content of the soil and on the chemical composition of winter wheat yield were examined. The correlations between the readily available element content of the soil and the nutrient content of the grain were studied in order to evaluate the impact of different nutrient supplies on the chemical composition of the grain as well.

Methods

The effect of N and P fertilisation on the readily available element content of the soil and on the chemical composition of winter wheat yield was tested on a meadow chernozem soil solonchic in the deeper layers at Karcag in 2004. The experiment was carried out in the framework of the NULTFE with the winter wheat variety *Mv Csárdás*. Eighteen fertilisation treatments with 4 replications were evaluated. The applied fertiliser doses were published previously in the following papers: ZSIGRAI (1999, 2001). The net size of the plots was about 50 m². We applied a conventional crop production technology during the vegetation period. The crop samples were taken from the harvested yield at the time of harvest and after that the soil samples. After the preparation of the soil samples, pH(H₂O), pH(KCl), humus content, AL-soluble P₂O₅, K₂O, potential acidity (y₁), NH₄-N, NO₃+NO₂-N, Na-, Mg-, Cu-, Zn- and Mn-contents were determined according to the relevant standards (MSZ-08-0206-2, MSZ 20135). We measured the total N-, P₂O₅-, K₂O-, Ca-, Mg-, Cu-, Mn-, Fe-, Zn-contents of the crop samples as well. The experimental data were processed with the statistical methods of MANOVA, linear and polynomial regression analyses.

Results and discussion

During the analysis of the effect of regular artificial fertilisation on the readily available element content of the soil we established that only the NH₄-N, AL-soluble P₂O₅-, K₂O-, Na- and Mg-contents showed significant differences among the studied elements (Table 1).

Table 1.

Effect of artificial fertilisation and liming on some readily available element contents of the soil and on the chemical composition of winter wheat yield

Parameter	Soil					Grain			
	NH ₄ -N	AL-P ₂ O ₅	AL-K ₂ O	AL-Na	AL-Mg	P ₂ O ₅	Mg	Mn	Zn
	(mg kg ⁻¹)					(%)		(mg kg ⁻¹)	
N100	3.82	111.4	298.7	27.8	343.4	0.70	1.16	41.5	23.6
N150	4.15	95.2	290.1	28.0	330.2	0.66	1.19	40.9	25.6
N200	5.17	102.6	294.7	26.8	323.0	0.65	1.20	42.0	26.8
SD _{5%}	0.60	14.5	12.7	3.0	16.6	0.03	0.05	1.8	2.2
P0	4.83	33.3	299.6	25.9	348.5	0.62	1.13	38.6	27.5
P60	4.38	88.9	291.3	28.3	333.5	0.66	1.17	41.6	25.9
P120	3.94	187.0	292.5	28.5	314.7	0.73	1.25	44.3	22.6
SD _{5%}	0.60	14.5	12.7	3.0	16.6	0.03	0.05	1.8	2.2
K0	4.60	102.3	220.6	30.3	352.9	0.67	1.18	40.5	25.3
K100	4.17	103.8	368.4	24.8	311.6	0.67	1.18	42.4	25.3
SD _{5%}	0.49	11.9	10.4	2.4	13.6	0.02	0.04	1.4	1.8
L+	3.18	114.8	286.6	26.2	285.1	0.72	1.25	38.1	20.9
L-	5.58	91.3	302.4	28.9	379.3	0.62	1.12	44.8	29.7

Increasing fertilisation rates led to higher NH₄-N content in the top soil layer. This was well observable in the case of the higher N-doses. The P-dose of 120 kg P₂O₅ ha⁻¹ resulted in a significant decrease of the NH₄-N-content that could be interpreted as the reduced adsorption rate of NH₄-ions on the soil adsorption complex caused by the high Ca-ion content of superphosphate. The liming induced decrease of the NH₄-N content values can also strengthen this opinion.

According to our expectations the higher P-rates significantly increased the AL-soluble P-content of the soil. The extent of this increase was 55.6 mg kg⁻¹ in the case of the 60 kg P₂O₅ ha⁻¹ P-rate and 153.7 mg kg⁻¹ in the case of the 120 kg P₂O₅ ha⁻¹ P-rate compared to the unfertilised control site. While the disuse of P-fertilisers reduced the soil nutrient supply from category „poor” to „very poor”, the 60 kg P₂O₅ ha⁻¹ P-rate resulted „medium”, and the 120 kg P₂O₅ ha⁻¹ P-rate a „very good” P-supply rank. In this experiment we verified the widely known positive effect (P-mobilization, reduced adsorption) of liming on the readily available P-content of the soil as well. A difference of 23.5 mg kg⁻¹ was found between the AL-soluble P-contents of the treated and the untreated plots in the 6th year after the liming.

NP-fertilisation had no effects on the K-content of the soil. K-application (100-200 kg K₂O ha⁻¹) increased the K-supply from category „medium” to „very good”. Liming - just like in the case of NH₄-N-content - significantly reduced the AL-soluble K-content, which can be explained with the antagonism of these two ions. It verifies the similar behaviour of K- and NH₄-ions in the cation adsorption processes.

Liming and K-fertilization decreased the AL-soluble Na-content due to the modified cation adsorption- and leaching conditions caused by fertilisation.

The AL-soluble Mg-content of the soil was slightly decreased by N- and P- fertilisation due to the increased Mg-uptake of the higher yields. Since K-fertilisation and liming did not lead to significantly increased yields in either of the growing seasons, the observed decrease of AL-soluble Mg-content can not be derived from the effect mentioned in the case of P-application. According to our opinion, in this case the AL-soluble Mg-content was influenced by the

competition processes mentioned above. This effect was much stronger in the case of liming than of K-fertilisation.

While fertilisation did not affect the $\text{NO}_3\text{-N}$ content of the top soil, liming decreased it contrary to the results of other authors. This phenomenon can be explained with the leaching of $\text{NO}_3\text{-ions}$ originated from the more intensive nitrification processes.

The effect of NPK-fertilisation on the P_2O_5 -, Mg-, Mn-, Fe- and Zn-contents of the yield was statistically proved, but it did not modify the content of the other tested elements (N, K_2O , Ca, Cu) significantly. While higher N-rates decreased the P_2O_5 -content of the grain, the P-fertilisation increased it significantly. In the latter case a remarkable difference was observed between the effect of the 60 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ and the 120 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ P-rates. The liming induced increase of AL-soluble P_2O_5 content of the soil resulted in a 0.1 % increase of P_2O_5 content as well.

The P-fertilisation significantly increased the grain Mg-content according to the conclusions of LOCH and NOSTICZIUS (1983) concerning the positive P-Mg interactions. Similarly, the higher P- and K-rates increased the Mn-content of the yield, while liming reduced it, which was the result of Mn-Ca ion antagonism and of the reduced Mn-solubility caused by liming. The higher P-fertiliser rate and the ameliorative liming had a negative effect on the Zn-content of the yield, which can be explained with the formation of insoluble Zn-phosphate due to the higher phosphate activity in the soil solution, and with the Ca-Zn ion antagonism. The fact, that liming increased the readily available Zn-content of the soil proves the effect of Ca-Zn antagonism.

The analysis of the readily available element content of the soil and the chemical composition of the grain showed a linear correlation between the AL-soluble P_2O_5 -content and the P_2O_5 -content of the grain ($y=0.60506+0.00067*x$; $r=0.62764^{***}$), and between the KCl+EDTA-soluble Mn-content and the Mn-content of the grain ($y=0.89537+0.08381*x$; $r=0.44972^{***}$). The increasing readily available Mg- and Zn-content of the soil decreased the Mg- ($y=1.51135-0.00099*x$; $r=0.47042^{***}$) and Zn- ($y=44.2239-15.58399*x$; $r=0.42479^{***}$) content of the yield. This phenomenon could be explained with the dilution effect, although it has to be confirmed by further investigations.

Conclusions

Effects of regular fertilisation on the readily available element content of the soil and on the chemical composition of winter wheat yield were analysed in a long-term fertilisation experiment carried out on a meadow chernozem soil. The obtained results corresponded with our expectations and the relevant publications. In the case of P and Mn, we found moderated positive correlations between the readily available element content of the soil and the chemical composition of the yield, while in the case of Mg and Zn, negative correlations were observed. The other tested element contents of the winter wheat yield were independent of the readily available element contents of the soil.

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