

RELATIONSHIP BETWEEN POTASSIUM SUPPLIES OF THE SOIL AND THE NUTRIENT CONCENTRATION OF MAIZE (*Zea Mays* L.) LEAVES

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Introduction

An important area where maize fertiliser recommendation systems need to be improved is the provision of more accurate limit levels for nutrients based on yield and quality parameters, and the investigation of factors influencing plant nutrient status, aimed at a more exact interpretation of plant analysis data. Many papers (Jones 1967, Bergmann and Neubert 1976, Kádár and Elek 1980, Kádár and Pusztai 1983, Kádár 1992, Reuter et al. 1997, Csathó 1998, Izsáki 2004, Kovacevic et al. 2004, Tuba, 2005) have reported nutrient concentration limit values in various plant organs at various stages of development for the estimation of maize nutrient status. An analysis of these research results demonstrates that great importance is still attached to background research linked with the application of plant analysis for diagnostic purposes, as this provides information on the changes in nutrient status, nutrient interactions and nutritional disturbances that may be caused in maize by the field site, fertilisation and the nutrient supplies of the soil.

The aim of the paper is to discuss the effect of K supplies on the nutrient concentrations in maize leaves at tasselling and on interactions between nutrients, based on the results of long-term experiments carried out on chernozem meadow soil. The experimental data will also be useful in the interpretation of diagnostic plant analysis at the given location.

Methods

Long-term mineral fertilisation experiments were set up at the Experimental Station of the Crop Production Department, Faculty of Agricultural Water and Environmental Management, Tessedik Sámuel College, Szarvas, in 1989. The soil of the experimental area had the following parameters: chernozem meadow soil, calcareous in the deeper layers, 85–100 cm humus layer, $\text{pH}_{(\text{KCl})}$ 5.0–5.2, humus content 3.0–3.2 %, upper limit of plasticity according to Arany (K_A) 50, clay content 32 %. Prior to the setting up of the experiment the soil contained the following nutrient supplies: $\text{AL-P}_2\text{O}_5$ 156 mg kg^{-1} , $\text{AL-K}_2\text{O}$ 322 mg kg^{-1} , AL-Na 212 mg kg^{-1} , KCl-Mg 765 mg kg^{-1} , EDTA-Mn 386 mg kg^{-1} , EDTA-Cu 5.4 mg kg^{-1} and EDTA-Zn 3.0 mg kg^{-1} .

Fertilisation was carried out in all possible combinations of four levels each of N, P and K, giving a total of 64 treatments, set up in a split-split plot design with three replications, with K fertilisation as the “A” factor, P fertilisation as the “B” factor and N fertilisation as the “C” factor. The following fertiliser rates were applied: nitrogen: $N_0 = 0$, $N_1 = 80$, $N_2 = 160$, $N_3 = 240$ $\text{kg N ha}^{-1} \text{ year}^{-1}$; phosphorus (P_2O_5): $P_0 = 0$, $P_1 = 100$ $\text{kg ha}^{-1} \text{ year}^{-1}$, $P_2 = 500$ kg ha^{-1} in 1989, 1993 and 2001, $P_3 = 1000$ kg ha^{-1} in 1989, 1993 and 2001; potassium (K_2O): $K_0 = 0$, $K_1 = 300$ $\text{kg ha}^{-1} \text{ year}^{-1}$ between 1989 and 1992, 100 $\text{kg ha}^{-1} \text{ year}^{-1}$ from 1993, $K_2 = 600$ kg ha^{-1} in 1989 and 2001, 1000 kg ha^{-1} in 1993, $K_3 = 1200$ kg ha^{-1} in 1989 and 2001, 1500 kg ha^{-1} in 1993. The high rates of P and K replenishment fertilisation were used to create clearly distinct supply levels in the soil in order to investigate plant responses to nutrient status. The Pioneer hybrid Clarica (FAO 310) was used in the maize experiments, with silage sorghum as the forecrop.

To determine the nutrient status of maize, the leaf opposite the ear was collected from 15 plants per plot at the beginning of tasselling. The leaf samples were analysed in four

experimental years (2001–2004) for the following nutrients: N, P, K, Ca, Mg, Fe, Mn, Zn and Cu.

Results and conclusions

The effect of K supplies on the nutrient concentration in maize leaves is presented by Table 1. and Figures 1-2.

The meadow soils are originally good or high K supplies. Consequently, under our soil conditions, where the K supplies of the soil ranged from 206–465 mg kg⁻¹ AL-K₂O, considerable K effect on the grain yield could not be detected. But, it is important to study that the good, high and over supply of the K how can influence the nutritional status of the maize.

An evaluation of the effect of K supplies indicated that compared with the K control level of 206–232 mg kg⁻¹ AL-K₂O, better K supplies of 321–465 mg kg⁻¹ AL-K₂O resulted in a significant increase in leaf K concentration every year, though to different extents. A similar close correlation between the AL-soluble K content in the soil and the leaf K content was reported by Csathó (1998) in National Long-Term Mineral Fertilisation Trials, where the lower limit of satisfactory K supplies for maize, indicated by 1.7% K content in the leaf at flowering, was ensured by a soil AL-K₂O content of 180 mg kg⁻¹. K fertilisation caused a slight increase in the leaf Ca concentration. No significant K-Ca antagonism was observed even in the dry year of 2003, as the leaf Ca content only declined to an extremely small extent even at the highest K supply level (465 mg kg⁻¹ AL-K₂O). By contrast, with the exception of 2001, when the water supplies were very good, K-Mg antagonism could be detected, as increasing K supplies in the soil and higher leaf K concentrations were accompanied by a reduction in the Mg content. In most of the years better K supplies (334 mg kg⁻¹ AL-K₂O or more) caused a drop in the Cu concentration and in 2002 a moderate negative correlation was observed between the K and Cu contents in the leaf. The opposite effect was recorded in the year with very good water supplies. In general the K supplies had no effect on the leaf Fe content, with the exception of drought stress in 2003, when the excessive K supplies resulted in lower Fe concentration.

Table 1. Effect of K supplies on the nutrient concentrations of maize leaf at tasselling (Szarvas, 2001-2004)

AL-K ₂ O [mg kg ⁻¹] in the ploughed layer	K [%]	Ca [%]	Mg [%]	Cu [mg kg ⁻¹]	Fe [mg kg ⁻¹]	Grain yield [t ha ⁻¹]
2001						
K ₀ = 232	1.92	0.25	0.17	2.8	85	11.01
K ₁ = 354	2.05	0.23	0.16	3.2	86	10.40
K ₂ = 352	2.16	0.35	0.22	4.3	96	10.75
K ₃ = 373	2.12	0.33	0.21	4.0	88	10.47
LSD _{5%}	0.06	0.05	0.02	0.4	NS	0.36
Average	2.06	0.29	0.19	3.5	89	10.65
2002						
K ₀ = 229	2.11	0.48	0.38	5.7	204	6.39
K ₁ = 334	2.56	0.49	0.30	5.1	206	6.57
K ₂ = 394	2.61	0.51	0.28	4.5	233	6.47
K ₃ = 465	2.61	0.51	0.30	4.6	221	6.22
LSD _{5%}	0.13	NS	0.02	0.6	NS	NS
Average	2.47	0.50	0.31	5.0	216	6.41

2003						
K ₀ = 215	1.70	0.52	0.43	8.0	195	3.28
K ₁ = 347	1.92	0.54	0.37	7.5	198	2.94
K ₂ = 394	1.80	0.52	0.30	7.0	173	3.20
K ₃ = 465	1.76	0.49	0.33	6.9	166	2.99
LSD _{5%}	0.12	0.03	0.04	0.5	18	NS
Average	1.79	0.52	0.36	7.4	183	3.10
2004						
K ₀ = 206	1.77	0.38	0.34	5.8	114	7.30
K ₁ = 321	1.97	0.42	0.29	5.9	109	7.19
K ₂ = 367	1.96	0.51	0.28	5.4	115	7.05
K ₃ = 453	1.97	0.48	0.26	5.5	113	7.05
LSD _{5%}	0.07	0.03	0.02	0.3	NS	NS
Average	1.92	0.45	0.29	5.6	113	7.14
LSD _{5%} in the average of years	0.23	0.06	0.06	0.6	17	0.29

A comparison of these leaf nutrient concentrations with the optimum nutritional levels reported by Kádár and Elek (1980) and Kádár (1992), it can be seen that at soil AL-K₂O levels ranging from 206–465 mg kg⁻¹, it was only for Cu that excessive K supplies caused a deficiency in maize leaf concentrations in some years.

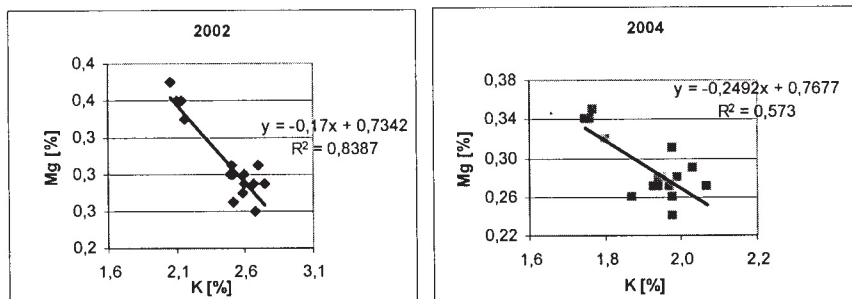


Fig. 1. Relationship between K and Mg concentration of maize leaf

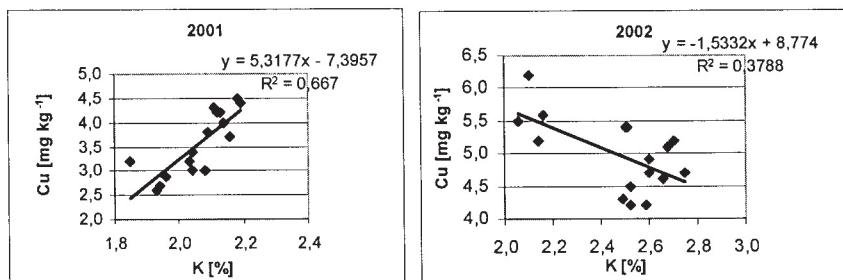


Fig. 2. Relationship between K and Cu concentration of maize leaf

Acknowledgements

This research projekt was supported by the Hungarian Scientific Research Found (OTKA-T-020578, T-048816).

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