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Triticale (XTriticosecale W.) Heavy Metal Upptake as a Possibility of Food Chain Pollution in a Long-Term Field Experiment in Hungary

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Abstract: Some trace elements are dangerous because they tend to bioaccumulate in food chain. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in they environment. Compounds accumulate in living things any time they are taken up and stored faster han they are broken down (metabolize) or extreted.

Triticale is the stabilized man-made hybrid of wheat (Triticum eastivum L.) and rye (Secale cereale L.). Wheat-rye hybrids date back to 1875, it was only in 1953 that the first North American triticale breeding programme was initiated at the University Manitoba. Globally, triticale is used primary for livestock feed today.

NPKCaMg fertilization effects were estimated on trace element bioavailability by Triticale in a long-term field experiment on a Haplic Luvisol (acidic sandy brown forest soil) at Nyírlugos in East-Hungary in 1998. Soil geochemical parameters were as follow: humus 0.6%, pH (H2O) 5.8, pH (KCl) 4.6, total N 32.8 mg . kg-1, AL (ammonium lactate soluble)- P2O5 43 mg . kg-1, AL-K2O 52 mg . kg-1.

The experiments involved 32 NPKCaMg treatments and their combinations in 4 replications giving a total of 128 plots from 1980. N levels were 0, 50, 100, 150 kg . ha-1 . yr-1, P2O5 and K2O 0, 60, 120, 180 kg . ha-1 . yr-1, CaCO3 0, 250, 500, 1000 kg . ha-1 . yr-1 and MgCO3 doses were 0, 140, 280 kg . ha-1 . yr-1. Plot brutto size was 50 m2.

The main results were as follows. Main soil chemical parameters depend on NPKCaMg treatments. Soil pH (H2O) and pH (KCl) values ranged from 4.6 to 6.3 and from 3.5 to 5.8 indicating wide range from extremely acidic to slightly acidic. Ca, Fe, Mg, Mn and Al element concentrations shown a large variability too in interaction with fertilization doses and pH values (Ca 36-594 mg . kg-1, Fe 61-90 mg . kg-1, Mg 5-42 mg . kg-1, Mn 16-36 mg . kg-1, Al 79-118 mg . kg-1). The better soil pH (H2O), pH (KCl) and Ca parameters resulted by NPKCaMg combinations [pH (H2O) 6.3, pH (KCl) 5.8, Ca 596 mg . kg-1]. Fe, Zn, B, Pb, Cr and Cd leaf+straw status was not influenced hardly by N treatments, but in case of the leaf+straw Co, concentration was significantly increasing. NP combination effects on Fe, Zn, B, Co, Pb, Cr and Cd were similar to N fertilization. Fe leafe+straw contents decreased strongly by NK effects. NPK and NPKCaMg nutrition growing up Pb accumulation to 1.5 mg . kg-1 [cereal average content (CAC) 0.3-0.6 mg . kg-1]. The experimental Zn, Cr, and Cd leaf+straw values not were on higher level than the CAC. The yield ranged from 0.9 t . ha-1 to 7.9 t . ha-1 on dependence of fertilization treatments. The NPKCaMg combinations yielded more around 9 times than the non fertilized plots. Fe, Zn, B, Co, Al, Sr and Cu grain status was not influenced significantly by N and NK treatments. The NP combination effects on Fe, Zn, B, Co, Al and Cu were similar to N fertilization, but in case of the Sr, concentration was dramatically increasing. Triticale seed Zn values not were on higher level than the CAC. Fe actual transfer index (ATI)(Márton, 2004) values are shown N and NPKCaMg fertilization plus effects on Fe translocation from soils to triticale grain. The Al ATI datas were on low level. These results shown Triticale have ability to Co, Pb and Sr accumulation from soil to crop and food chain to a different degree.

Key words: trace element, bioavailability, Haplic Luvisol, triticale
Introduction: Triticale is the stabilized man-made hybrid of wheat (Triticum eastivum L.) and rye (Secale cereale

L.). Wheat-rye hybrids date back to 1875, it was only in 1953 that the first North American triticale breeding programme was initiated at the University Manitoba. Globally, triticale is used primary for livestock feed (Oelke et al. 1989). In Mexico, which grows the crop triticale is used mostly for whole-grain triticale breads and tortillas. In the US, triticale is harvested mostly for forage but there is a small market for pancake mixes and crackers due to a savory, nutty flavor. Etanol plants will pay a premium for triticale over barley since it has more starch and no hull, making alcohol production more efficient. Germany, France, China, Poland and Hungary account for nearly 90 percent of world triticale production (Donald et al. 2001).

Heavy metals are dangerous because they tend to bioaccumulate in food chain. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical‘s concentration in they environment. Compounds accumulate in living things any time they are taken up and stored faster han they are broken down (metabolize) or extreted.

Crops have ability to heavy metal accumulation from fertilizers such as Cd, Pb, Cu, Zn etc. to a different degree (Lee et al. 2001, Scholz and Ellerbrock 2004).

The main purposes of this study was to determine the triticale toxic element upptake by the soil, triticale leaf+straw and grain element concentrations on acid sandy soil in a long-term field fertilization experiment at Nyirlugos, Hungary in 1998.

Material and Methods: Field experiments were carried out on an acidic sandy brown forest soil at Nyírlugos in East-Hungary from 1962 to 2005. Soil geochemical parameters were as follow: humus 0.6%, pH (H2O) 5.8, pH (KCl) 4.6, total N 32.8 mg/kg, AL (ammonium lactate soluble)- P2O5 43 mg/kg, AL-K2O 52 mg/kg. The experiments involved 32 NPKCaMg treatments in 4 replications giving a total of 128 plots. N levels were 0, 50, 100, 150 kg/ha/yr, P2O5 and K2O 0, 60, 120, 180 kg/ha/yr, CaCO3 0, 250, 500, 1000 kg/ha/yr and MgCO3 doses were 0, 140, 280 kg/ha/yr. Plot brutto size was 50 m2.

Composite soil samples consisting of 25 subsamples collected at before flowering time from the ploughed layer of each plot. The so-called “mobile” fraction was extracted by ammonium-acetate+EDTA (AAc+EDTA, Lakanen and Ervio 1971) and the heavy metal determination by ICP-AES technic.

Plant leaf+straw and seed samples taken at before flowering and at harvest time. Total element content measured after microwave digestion using cc. HNO3 + cc. H2O2 by ICP-AES technic. Actual translocation indexes (ATI=plant metal c./soil metal c.) determinated by Márton 2004. Datamatrixes estimated by SPSS biometrichal method.

Results: Depend on NPKCaMg treatments soil pH (H2O) and pH (KCl) values ranged from 4.6 to 6.3 and from 3.5 to 5.8 indicating wide range from extremely acidic to slightly acidic. Ca, Fe, Mg, Mn and Al element concentrations shown a large variability too in interaction with fertilization doses and pH values (Ca 36-594 mg/kg, Fe 61-90 mg/kg, Mg 5-42 mg/kg, Mn 16-36 mg/kg, Al 79-118 mg/kg). The better soil pH (H2O), pH (KCl) and Ca parameters resulted by NPKCaMg combinations [pH (H2O) 6.3, pH (KCl) 5.8, Ca 596 mg/kg].

Fe, Zn, B, Co, Pb, Cr, and Cd element contents of triticale leaf+straw before flowering time presented in Table 2. Fe, Zn, B, Pb, Cr and Cd leaf+straw status was not influenced hardly by N treatments, but in case of the leaf+straw Co, concentration was significantly increasing. NP combination effects on Fe, Zn, B, Co, Pb, Cr and Cd were similar to N fertilization. Fe leafe+straw contents decreased strongly by NK effects. NPK and NPKCaMg nutrition growing up Pb accumulation to 1.5 mg/kg [cereal average content (CAC) 0.3-0.6 mg/kg. The experimental Zn, Cr, and Cd leaf+straw values not were on higher level than the CAC.

The yield ranged from 0.9 t/ha to 7.9 t/ha on dependence of fertilization treatments. The NPKCaMg combinations yielded more around 9 times than the non fertilized plots.
Fe, Zn, B, Co, Al, Sr and Cu grain status was not influenced significantly by N and NK treatments. The NP combination effects on Fe, Zn, B, Co, Al and Cu were similar to N fertilization, but in case of the Sr, concentration

was dramatically increasing. Triticale seed Zn values not were on higher level than the CAC.

Conclusions: Depend on NPKCaMg treatments soil pH (H2O) and pH (KCl) values ranged from 4.6-6.3 and 3.5-5.8 indicating wide range from extremely acidic to slightly acidic.

The leaf+straw Co concentrations increased hardly by N treatment effects.

NPK and NPKCaMg nutrition growing up Pb accumulation to 1.5 mg/kg [cereal average content (CAC) 0.3-0.6 mg/kg) in leaf+straw.

The NPKCaMg combinations yielded more around 9 times than the non fertilized plots.

The NP combination effects in case of the grain Sr concentration was dramatically increasing.

These experimental results have demonstrated that triticale has a gerat ability to leaf+straw‘s Co, Pb and grain‘s Sr bioaccumulation. By this way Co, Pb and Sr can be enter to food chain.

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