

Zinc Uptake by Winter Wheat and Soybean in Different Tillage Systems

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INTRODUCTION

Reduced tillage is well known for higher soil compaction than mouldboard ploughing (Larney and Kladvko 1989, Stipesevic et al. 1997), which can cause serious limitation for root proliferation (Busscher and Sojka 1987). Since Zn uptake depends on direct contact of Zn in the soil matrix and the root (Marschner 1997), Zn deficiency can be more expressed after reduced tillage (Carter and Gupta 1997, Lavado et al. 2001, During et al. 2003). Lower Zn mobility can also be due to a specific soil type, such as calcareous soil (Marschner 1997). Negative interactions of soil tillage induced compaction and soil type could be a reason for lower yields. Thus, our objective is to study different tillage effects on Zn uptake in a calcareous chernozem, one of the most productive soils for crop production.

METHODS

Winter wheat (*Triticum aestivum*) and soybean (*Glycine max*) were grown under field conditions in a calcareous soil (chernozem) near Knezevo in Croatia from 2002-2005. The conventional tillage (PL; mouldboard ploughing up to 30 cm depth), reduced tillage (DH; two passes diskharroving and chiselling up to 20-25 cm depth) and no-tillage (NT) were soil tillage treatments in four repetitions in continuous sequence for both crops with a basic experimental plot of 30x60 m². Fertilization was uniform for each crop, 120 kg N + 130 kg P₂O₅ + 130 kg K₂O for winter wheat and 40 kg N + 130 kg P₂O₅ + 130 kg K₂O for soybean. Both crops were sown with a John Deere 750A no-till drill with different inter-row spacing for each crop. Inter-row spacing was regulated through opening or closing even drill depositors. Soybean seed was inoculated with *Bradyrhizobium japonicum*.

Shoots of winter wheat were sampled at the beginning of the heading stage. Soybeans were sampled in the fully developed pod stage. Three sub-samples were prepared for analysis by microwave digestion using 65% HNO₃ + 30% H₂O₂. Zinc was analysed by Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES) (Jobin-Yvon Ultrace 238).

Precipitation in May-September were 15% higher, 47% lower, 2% higher and 70% higher than reported average precipitation for 2002, 2003, 2004 and 2005, respectively.

RESULTS AND DISCUSSION

The grain yield of both crops in most years decreased in the following order: CT ≥ DH > NT (Table 1). This is in accordance with results from other authors (Larney and Kladvko 1997), whereas Lavado et al. (2001) recorded lower yields for CT than for NT. Zinc tissue concentrations generally followed the same order, which was also observed by During et al. (2003). In contrast, Lavado et al. (2001) did not find different Zn contents in leaves and stems, which may have been due to the accumulation of less mobile nutrients in the top layer of NT, thus, providing sufficient Zn at the main root growth depth (Jobbagy and Jackson 2001). The Zn content of winter wheat was low, but in the range that is found in wheat grown in Zn-deficient calcareous soils (Cakmak et al. 1997), although the genotype itself can express different Zn-uptake efficiency (Rengel et al. 1998). Lower Zn concentrations at more reduced soil tillage caused higher P/Zn ratios. It is less likely that P toxicity was expressed since P concentrations were normal and constant in treatments (2.1-2.7 g kg⁻¹ on dry matter basis). Zinc contents of soybeans were in the range of reported values (Marschner 1997).

Thus, the rather high P concentrations (2.8-4.3 g kg⁻¹ on dry matter basis) for all three tillage treatments might be the symptom of P excess in the sampled soybean stage rather than Zn deficiency (Bergman 1992).

Table 1. Zinc-tissue content and grain yield of winter wheat and soybean grown at Knezevo, Croatia, in 2002-2005.

Tillage	Winter wheat				Soybean			
	2002	2003	2004	2005	2002	2003	2004	2005
	Zn plant tissue concentration, mg kg ⁻¹ on dry matter basis							
CT	9.8a	16.7a	11.7b	9.7a	22.2a	21.1a	33.1a	26.6b
DH	10.6a	15.6a	9.2ab	9.5a	21.8a	22.9a	33.3a	26.7b
NT	8.7a	14.5a	6.4a	8.6a	20.0a	24.6a	33.3a	18.7a
	Grain yield, t ha ⁻¹							
CT	6.68a	2.73a	6.81a	6.24a	3.46a	2.54a	3.13a	2.56a
DH	6.71a	2.64a	6.80a	6.21a	3.43a	2.15b	3.07a	2.47a
NT	7.01a	2.20b	6.49a	5.90b	3.07a	1.32c	2.30b	1.99b

CONCLUSIONS

Soybean and winter wheat grown on calcareous soil (chernozem) showed decreasing concentration of Zn in plant tissues as result of the soil tillage reduction in the order CT > DH > NT, presumably due to limited root growth. Winter wheat had low Zn contents at reduced tillage treatments as result of lower Zn uptake. The recommendation for winter wheat production by reduced tillage is additional Zn fertilization. Exact amounts and application types would require further research.

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