

Effect of EDTA on the Foliar Absorption of Trace Element Fertilizers

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BACKGROUND INFORMATION AND RESEARCH PROBLEM

Foliar fertilization is an important method of supplementing soil nutrient additions, particularly on soils that readily adsorb and fix trace-element ions. A large number of fertilizer companies and extension groups have recommended that chelating agents be used to complex Fe, Mn, Mg, Zn, and Cu in foliar sprays, at considerable expense to the farmer. The scientific literature contains limited information on the use of chelates in foliar fertilizers. One recent study showed that chelates slowed Fe (III) absorption into leaves (Schonherr et al., 2005). However, published data are still limited, so it is difficult to advise farmers about the pros and cons of using chelates in a broad range of trace element sprays.

The leaf cuticle is a hydrophobic layer, comprised of high molecular weight biopolymers such as cutins and suberins, and hydrophobic C₁₄-C₇₂ epicuticular waxes (Holloway, 1993). Recent physiological studies have identified polar aqueous pores, which may facilitate the absorption of charged ions into leaf epidermal cells (Schonherr, 2000). Nutrient sorption via aqueous pores is a relatively slow process, however, as the cuticle still represents the primary barrier for foliar nutrient absorption.

We hypothesized that the negative charge of metal-EDTA complexes and their high molecular weight would reduce the rate of trace-element absorption through leaf cuticles. The narrow size (0.3 nm) and negative charge of aqueous pores (Popp et al., 2005; Schonherr and Schreiber, 2004) may hinder the diffusion of anionic, high molecular weight species such as EDTA. The aim of this investigation was to determine whether EDTA would affect trace element sorption by leaf cuticles and slow nutrient absorption into leaves.

PROCEDURES

Using a cork borer, 14 mm leaf disks were removed from Valencia orange (*Citrus sinensis*) leaves, avoiding major veins. Cuticles were excised from the leaf disks by immersing them in a 6% pectinase solution (Sigma-Aldrich P2736, 3405 units/mL), which contained mainly pectintranseliminase, polygalacturonase, and pectinesterase from *Aspergillus niger*. The solution

contained 1 mM sodium azide to reduce microbial activity and 20 mM citric acid, adjusted to pH 3.8 with NaOH (Schonherr and Riederer, 1986). Leaf disks remained in the enzymatic solution under dark conditions until the cuticles completely separated from the leaf tissue (approximately 21 days). Isolation was undertaken without agitation. The isolated cuticles were carefully removed and rinsed thoroughly in double deionised water until they were free of cellular debris.

Pre-weighed isolated cuticles were immersed in 1 mM zinc sulfate (ZnSO₄·7H₂O) and iron sulfate (FeSO₄·7H₂O) solutions, either as the sulfate salt or chelated by EDTA (1 mM). EDTA complexes divalent metal ions in a 1:1 molar ratio. Therefore, almost 100% of the Zn and Fe were complexed in the plus-EDTA treatments. After 48 hours the cuticles were removed, rinsed in double deionised water, digested in concentrated HNO₃, and analysed for total metal concentration by ICP-OES. All treatments were replicated four times.

Cotton plants (DPL444BR), one plant per pot, were grown in Sungro™ sunshine mix #1 in the glasshouse under a mixture of natural and artificial light (12 hours per day). Plants were watered every second day with Zn-free half-strength Hoaglands solution.

Five weeks after emergence, 1 mM Zn fertilizer treatments were sprayed on the foliage using a CO₂-pressurized backpack sprayer calibrated to deliver 10 gal H₂O per acre. Zinc fertilizer solutions were applied as either the sulfate salt (ZnSO₄·7H₂O) or were complexed by EDTA (1 mM). A rainfall simulator (Humphry et al., 2002) applied 12.5 mL of water to the plants over 30 minutes, at 0 (no rainfall control), 1, 3, 6, and 12 hours after fertilizer application. Each fertilizer-by-rainfall treatment was replicated four times. Whole plant shoots were harvested, dried, and ground before 1g of the leaf material was digested in concentrated HNO₃ and analysed by ICP-OES for Zn.

RESULTS AND DISCUSSION

EDTA significantly (P<0.05) reduced Fe and Zn sorption by isolated Valencia orange (*Citrus sinensis*) cuticles by 96% and 83%, respectively (Table 1). These results suggest that EDTA competed against aqueous pores (fertilizer transport sites) for Zn and Fe. EDTA also significantly (P<0.05) reduced

the rate of Zn fertilizer absorption by live cotton plants (Fig. 1). The ZnSO₄ was absorbed by cotton leaves more rapidly than ZnEDTA.

chelates to farmers. These results do not invalidate the use of chelates in soil-applied fertilizers, as chelates reduce sorption and fixation processes in soil. On leaves, sorption and fixation sites are far fewer (there is no soil). Therefore, the use of chelating agents in foliar sprays may be redundant.

PRACTICAL APPLICATION

This study showed that EDTA should not be used in trace element foliar sprays, particularly given the high cost of these

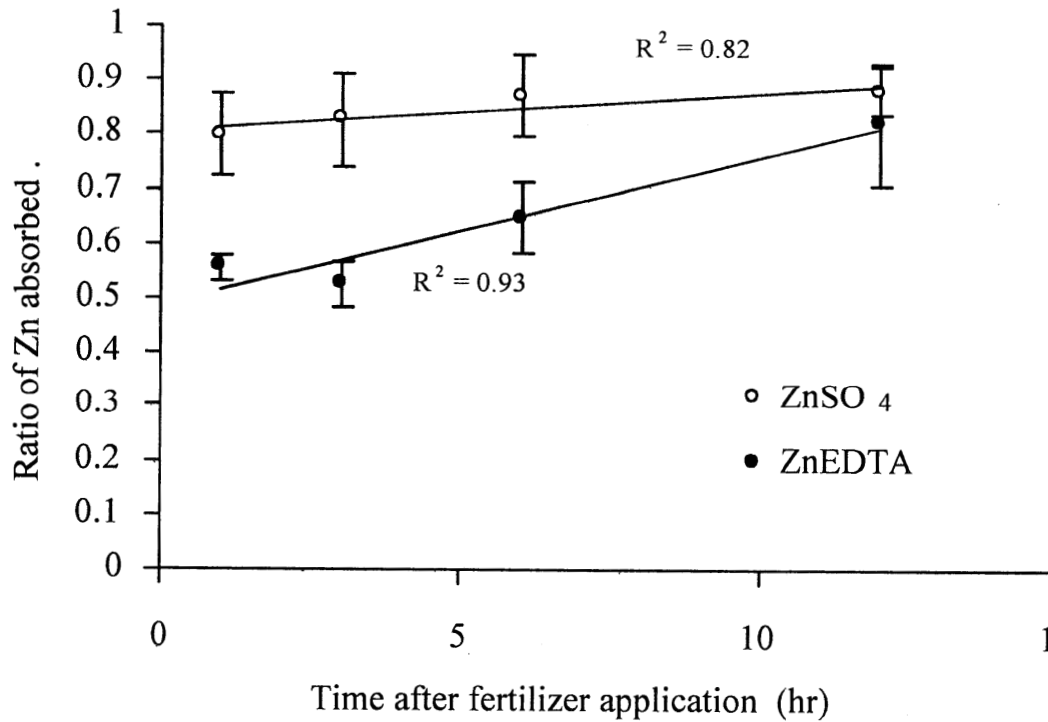


Fig. 1. Sorption of foliar-applied ZnSO₄ and ZnEDTA by cotton plants.

Table 1. Sorption of Zn and Fe fertilizers by enzymatically excised *Citrus sinensis* leaf cuticles.

Fertilizer	Sorption by leaf cuticle (µg metal/mg cuticle)	
	Fe	Zn
Chelate-free	10.72 ± 1.47	2.87 ± 0.11
Plus EDTA	0.45 ± 0.57	0.48 ± 0.05