Increased Zn Concentration in Leaf Tissue after Foliar Application of Antracol®

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INTRODUCTION

Foliar application is a challenging and at first intractable way of applying water-soluble pesticides or fertilizers to crops. Even though the aerial plant surface appears large and easy to treat with spray solutions, getting agrochemicals into the plant is difficult since the uptake route through mature leaf surfaces is limited by a lipid barrier membrane. This leaf cuticle imposes a transport barrier against the penetration of water and organic and inorganic solutes. The apparent mobility of agrochemicals is very low due to low diffusion coefficients and long pathways for diffusion (Baur, 1998). For water, the cuticle of mature leaves functions as a solubility membrane with both low mobility and solubility of water. The same holds for hydrophilic (inorganic and organic) solutes. Imperfections cause always some leaf patches and higher permeability to water and organic solute. The permeability for water and organic solute typically follows a lognormal distribution (Baur, 1997). Such high variability among patches and special pathways across the cuticle of very young plant organs or along thin water films across stomata (Eichert *et al.,* 2010) are putative pathways for foliar applied fertilizers. However, the successful use of foliar fertilizers depends then strongly on environmental conditions, the results are variable, and the efficiency is usually low even under good conditions.

It is considered that the use of Antracol reduces symptoms of zinc (Zn) deficiency (e.g. Tomlin, 2009), thus suggesting that Zn penetration occurs following the application of the product. Here we report on the results of increased Zn contents in leaf tissues after foliar application of Antracol (WP70) to the leaves of tomato plants and banana leaves. We used mature leaves that are the most difficult for fertilizer to penetrate, and our results reflect only the fraction of Zn entering the leaf interior and not any deposit of propineb on the surface.

METHODS

Tomato plants (*Lycopersicum esculentum*) at the 3-4 leaf stage were acquired by purchase and banana leaves (*Musa sapientum*) were obtained from self proliferated plants. Tomato plants were kept under greenhouse conditions or as “outdoor” plants under semi-field conditions (pot plants kept outside with exposure to sunlight and rain but controlled irrigation). Banana plants were kept under laboratory conditions with very low relative humidity (<35% rh). Dispersions of Antracol WP70 (propineb-based formulation) were prepared at concentrations corresponding to the respective crops and indication, respectively. For tomato, 2 kg Antracol WP70 in 200L was used.

The analysis of Zn concentration (Atomic absorption spectroscopy, NovAA series 300, Analytikjena, Jena) in banana and tomato leaves was done after controlled removal of surface deposits by a rinsing procedure with water and/or cellulose acetate stripping (Silcox and Holloway, 1986). The completeness of surface removal was checked analytically (atomic absorption spectroscopy) and also by scanning electron microscopy.

RESULTS AND DISCUSSION

The application of individual droplets of Antracol WP70 sprays significantly increased the leaf Zn content beneath the applied surface by 20-200% in banana leaves and up to 6-fold in tomato leaves.

All leaves treated were mature as indicated by the final leaf size, i.e. there was no further lateral leaf expansion. As shown in Fig. 1, compared to untreated tomato leaves, the Zn concentration was at least doubled within 1 day after application of Antracol WP to the adaxial surface. Application of

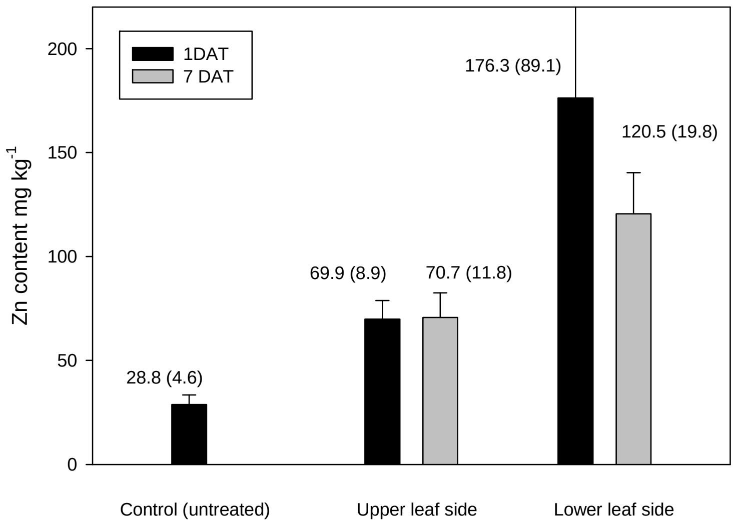

Fig. 1. Leaf Zn content (mg kg^{-1} DM) in greenhouse tomato plants after local droplet application of Antracol to the adaxial (upper) and abaxial leaf surface (DAT: days afer treatment).

Antracol to the lower leaf surface resulted in a 6-fold increase of leaf Zn concentration 1 day after application. We cannot conclude that this is due to transport across a water film along open stomata as suggested by others (Eichert *et al.,* 2010) since the relative humidity in this test was very low (<35% rh). Tomato has hypostomatic leaves and the higher permeabilty of the cuticle surrounding stomata was repeatedly reported for other plants. The increase in Zn concentration due to Antracol WP application in tomato plants grown and kept in the greenhouse or outdoor was similar and did not depend on the initial leaf Zn concentration. Thus the positive effect of Antracol becomes more evident under deficiency conditions and with values of 50-150 mg kg^{-1} dry mass, the achieved concentration was always above the deficiency level. The Zn taken up from Antracol appears to be excellently bioavailable. This was concluded from the observation that the Zn concentrtion in the treated area was not constant. There is evidence that Zn is mobile and further translocates according to local gradients in the leaf and its concentration can further increase due to subsequent release and penetration from the surface deposit. This Zn translocation was directly shown with banana leaves by an increase in Zn concentration in the leaf tissue surrounding the treated area.

CONCLUSIONS

The foliar application of Antracol to banana and tomato leaves caused an increase of Zn concentration to normal physiological values in all tests. The abaxial leaf side appears to be much more open than the adaxial one. The Zn applied is fully taken up into the plant.

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