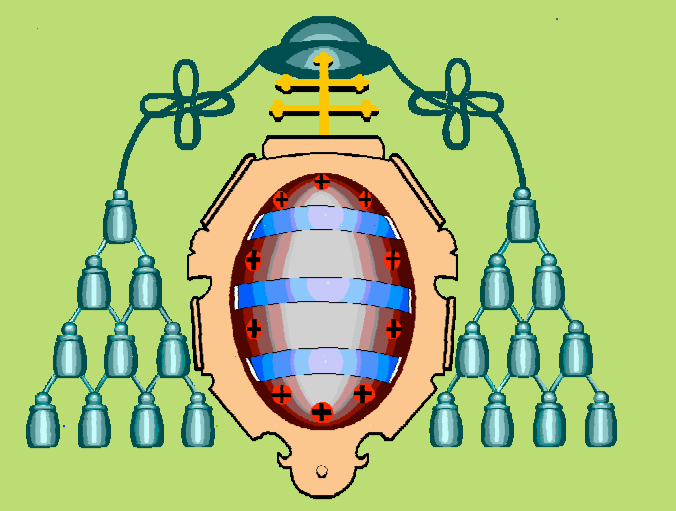




IRON UPTAKE AND DISTRIBUTION IN SUGAR BEET PLANTS TREATED WITH *racemic* AND *meso* Fe(III)-*o,o*EDDHA ISOMERS

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INTRODUCTION

The synthetic ferric chelate based on the molecule ethylenediamine-N,N'-bis(orthohydroxyphenylacetic)acid, commonly named as Fe(III)-*o,o*EDDHA, is one of the most efficient fertilizers used to correct Fe deficiency in crops growing in calcareous soils. Fe(III)-*o,o*EDDHA has two diastereoisomers, the *meso* form and the *racemic* mixture, which are present in approximately equal amounts in commercial Fe-chelate fertilizer formulations. In previous studies, evidence was presented that Strategy I plants such as tomato, pepper (Cerdán *et al.*, 2006), bean (Hill-Cottingham *et al.*, 1965; Ryeskiewich and Boka, 1962) and cucumber (Lucena and Chaney, 2006) take up Fe preferentially from the *meso* chelate than from the *racemic* one. However, these analyses were made in nutrient solutions and the determination of the Fe supplied for each isomer inside the plant was not carried out.

The aim of the present work was to determine the differences in Fe uptake and distribution inside the Strategy I plant species sugar beet between both Fe(III)-*o,o*EDDHA isomers. In order to distinguish between the Fe taken up by the plant from each Fe(III)-*o,o*EDDHA isomer and that originally present before the treatment, two stable Fe isotopes (⁵⁴Fe and ⁵⁷Fe) were used simultaneously as tracers of the Fe treatments and were quantified in plant materials by inductively coupled plasma-mass spectrometry (ICP-MS).

MATERIALS AND METHODS

Meso and *racemic* Fe(III)-*o,o*EDDHA isomers were separated by selective Mg precipitation according to Yunta *et al.* (2003), then Fe was removed and the *o,o*EDDHA acid isomers were further chelated with ⁵⁴Fe or ⁵⁷Fe.

Iron-deficient sugar beet plants were treated for 24 hours with i) 30 μM *racemic* ⁵⁴Fe(III)-*o,o*EDDHA : 30 μM *meso* ⁵⁷Fe(III)-*o,o*EDDHA or ii) 30 μM *racemic* ⁵⁷Fe(III)-*o,o*EDDHA : 30 μM *meso* ⁵⁴Fe(III)-*o,o*EDDHA. Roots, xylem sap, old and young leaves and nutrient solutions were sampled. Roots and leaves were grounded in a zirconium oxide-ball mill (MM301, Retsch) and digested with HNO₃ and H₂O₂ in a microwave (Ethos1, Milestone). Xylem sap and nutrient solution samples were digested by adding directly HNO₃ to the liquid materials. ⁵⁶Fe, ⁵⁴Fe and ⁵⁷Fe contents in all plant materials and nutrient solutions were determined by ICP-MS analysis (7500ce, Agilent Technologies) using isotope dilution analysis (IDA).

Natural Fe (having the natural Fe isotopic signature, 91.7% ⁵⁶Fe, 5.8% ⁵⁴Fe and 2.2% ⁵⁷Fe) was not found in the nutrient solutions. Therefore, we were able to estimate Fe remobilization by the increment or decrease of natural Fe in plant tissues from treated plants compared with those from non treated Fe-deficient plants.

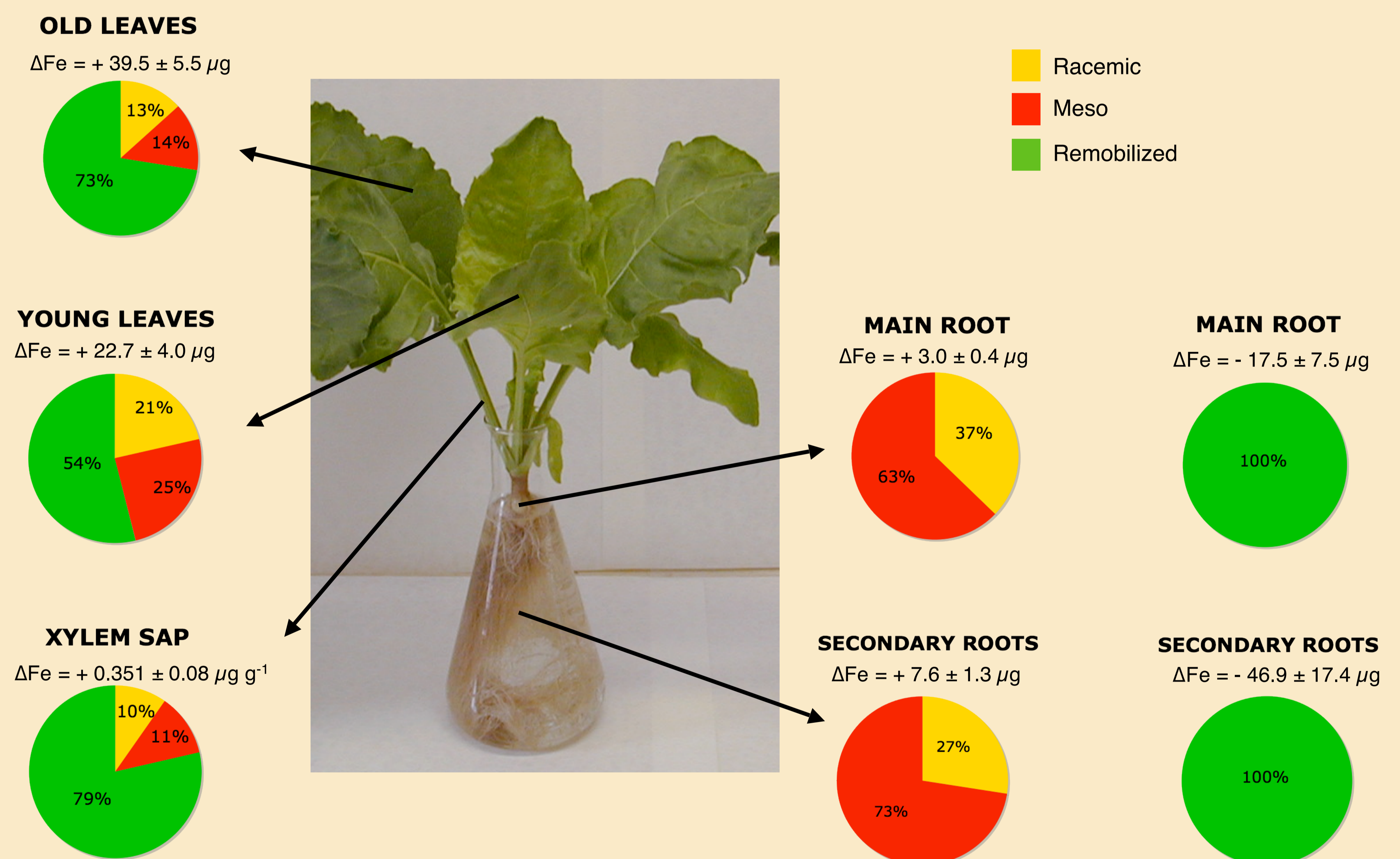
RESULTS AND DISCUSSION

The Fe isotope used as tracer of the Fe(III)-*o,o*EDDHA isomers did not significantly affect the plant Fe uptake and distribution in the different parts of the plant (data not shown).

Plants took up 32 μg Fe from the nutrient solution, with 60% being supplied by the *meso* isomer.

There was a positive mass balance of Fe in the shoots of treated plants compared with Fe-deficient plants, but a negative mass balance of Fe was found in roots as a result of root native Fe remobilization towards the shoot.

The ratio of Fe taken up from *meso* / *racemic* isomers was approximately 1.2 in aerial parts (xylem sap and leaves), 2.6 in secondary roots and 1.7 in the main root. This means that the Fe isotope supplied by the *meso* isomer accumulated preferentially in roots, whereas plant shoot materials had similar contents of the Fe isotopes provided by both isomers.



Allocation of Fe in different parts of Fe-deficient plants resupplied for 24 h with *racemic* and *meso* Fe(III)-*o,o*EDDHA in the nutrient solution. Data include uptake from the solution (⁵⁴Fe and ⁵⁷Fe) and remobilization from the root (natural Fe).

CONCLUSIONS

- The *meso* isomer of Fe(III)-*o,o*EDDHA was more effective as an Fe source than the *racemic* one.
- Fe(III)-*o,o*EDDHA treatments promoted an important remobilization of native Fe from roots to shoots.
- After resupply, shoot tissues contained similar amounts of Fe coming from both isomers, whereas in roots the pool of Fe coming from the *meso* isomer was larger than that coming from the *racemic* one.

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