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# Selected mineral interactions in two varieties of *Lycopersicum esculentum* L. produced organically and enriched naturally with Fe and Zn

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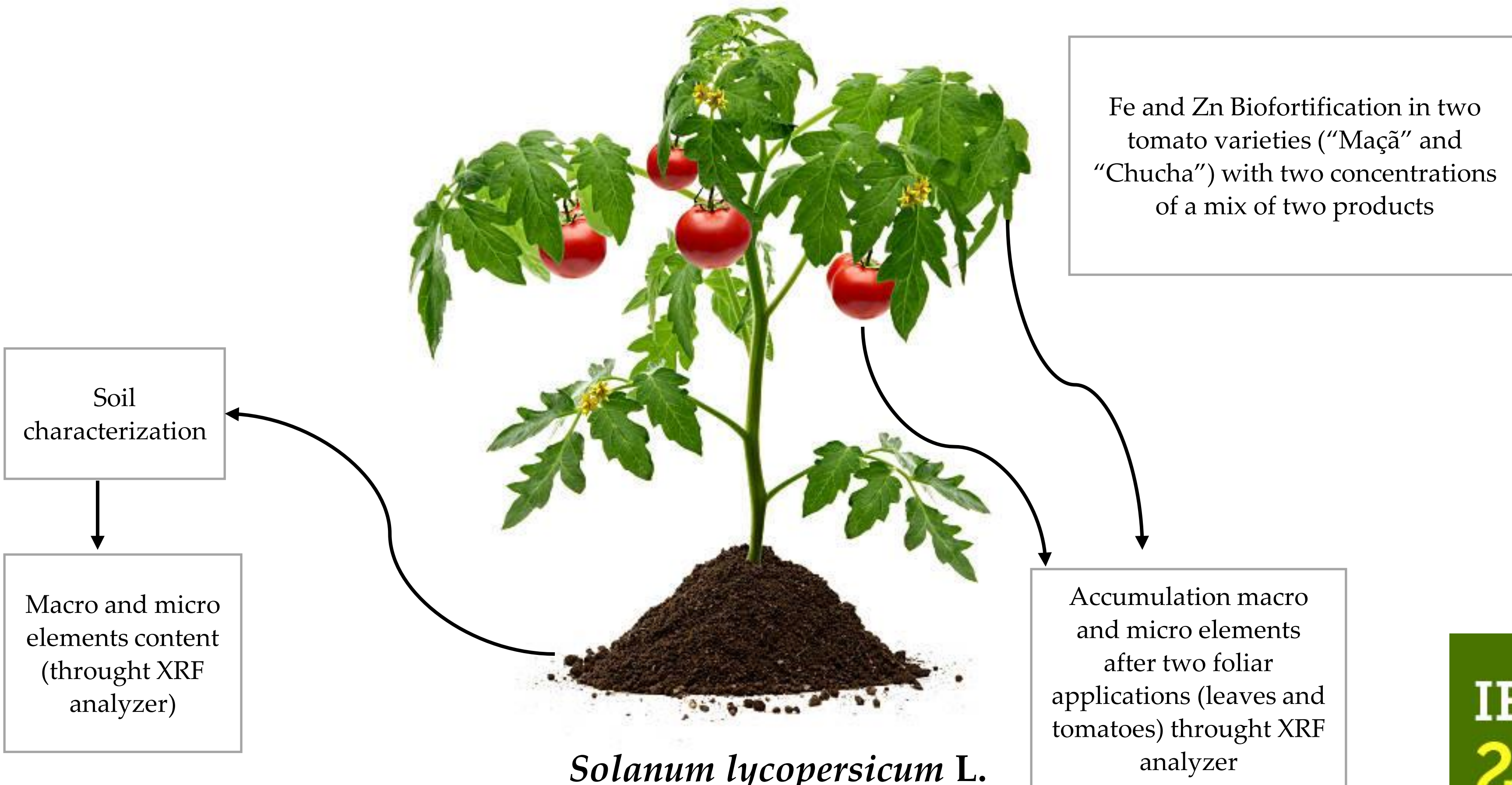
# Characterization of mineral interactions in two varieties of *Lycopersicum esculentum* L. produced organically and enriched naturally with Fe and Zn



**Abstract:** Plants need certain micronutrients for normal and healthy growth, namely iron and zinc. However, Fe and Zn have low kinetic mobility in soils and in plants. In fact, in tomatoes plants, Fe showed low mobility in phloem and due to soil interactions, that can reduce Fe uptake, foliar spraying is one of the most effective strategies to deal with this soil-plant interaction. Nevertheless, foliar sprayings with Zn presented an increase in its content in the edible part of plants. In this context, mineral interactions were monitored in two commercial varieties ("maçã" and "chucha") of *Lycopersicum esculentum* L. after two foliar sprays with a mix of two products of Fe and Zn (treatment 1 and 2), following an organic production mode. In leaves of the two varieties, Zn showed a higher content in treatment 1. Yet, considering Fe, "maçã" variety also showed a higher content in treatment 1, unlike "chucha" variety, which presented a higher content in treatment 2. Regarding tomatoes of "maçã" variety, Zn showed an antagonistic trend with Ca, K and S. In conclusion, after two foliar sprays of Fe and Zn, in tomatoes, there was possible to identify a nutrient interaction between other minerals mainly in "maçã" variety, although both varieties were produced under the same soil conditions.

**Keywords**: Biofortification; *Lycopersicum esculentum* L.; Organic tomato production.

# Materials and Methods

- Biofortification Itinerary – Foliar spraying with a mix of two products with Fe and Zn (two concentrations applied)
- Mineral contents in soils, tomatoes and leaves (throught XRF analyzer)
- Data analysis using One-Way ANOVA

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# Introduction

Plants need 16 essential nutrients for normal growth and development, being 3 of them (C, H and O) obtained from the atmosphere and soil water, whereas the remain elements are N, P, K, Ca, Mg, S, Fe, Zn, Mn, Cu, B, Mo, and Cl, are collected from soil minerals, organic matter or though fertilizers (Silva & Uchida, 200). Regarding Fe (required as $Fe^{2+}$ and/or $Fe^{3+}$) and Zn (required as $Zn^{2+}$), are classified as micronutrients based on plants requirements and fertilization needs (Pagani et al., 2013). However, some studies indicate that Zn translocation occurred though xylem (Pearson et al., 1995; Haslett et al., 2001; Broadley et al., 2007;Tsoney & Lidon, 2012) and phloem (Pearson et al., 1995; Haslett et al., 2011). Regarding Fe, presents a low mobility in tomato plants, namely in phloem (Guzmán et al., 1990; Marschner, 2012) and due to soil interactions, that can reduce Fe uptake, foliar spraying is considered one of the most effective strategies (Pagani et al., 2013; Sakya & Sulandajari, 2019). Nevertheless, in horticultural crops, foliar fertilization is widely used (Alshaal & El-Ramady, 2017), being an important agricultural practice where nutrients are applied straight through plant foliage (Carrasco-Gil et al., 2016). The application through leaves is a faster and more efficient way to provide essential nutrients for plants compared to soil applications (Alshaal & El-Ramady, 2017; Sakya & Sulandajari, 2019). In fact, considering the important roles that both Zn and Fe perform in plants and being tomato (*Lycopersicum esculentum* L.) considered one of the most important horticultural crops globally (constituting an excellent source of mineral, vitamins, and antioxidants) (Hédiji et al., 2015), this study aimed to monitor and understand nutrition interactions in two commercial varieties ("Maçã" and "Chucha") heavily consumed after two foliar sprays carried out with a mix of two products of Fe and Zn, following an organic production mode.

# Results and Discussion

Soil is the original supply of nutrients to grow plants, being an essential part of agriculture success. As such, the chemical composition of soil of the tomato-growing field was analyzed (Table 1). The mineral composition of the soil showed a higher content of Ca, followed by K and Fe. Regarding the minerals presented in smaller quantities, S showed a higher content followed by Zn. However, it was verified the presence of contaminating mineral elements: Pb and As.

**Table 1.** Mean values ± S.E. (n = 33) of mineral elements of the soil of the experimental tomato-growing field selected for Fe and Zn biofortification *Lycopersicum esculentum* ("maçã" and "chucha" varieties).

| Ca | K | Mg | P | Fe | S | Zn | Pb | As |
|---|---|---|---|---|---|---|---|---|
| % | | | | | ppm | | | |
| 9.96 ± 1.53 | 2.28 ± 0.16 | 0.21 ± 0.06 | 0.17 ± 0.01 | 1.14 ± 0.15 | 56.6 ± 3.80 | 29.4 ± 4.56 | 16.1 ± 2.71 | 17.1 ± 1.6 |

The acquisition of nutrients (namely, macro and micro elements) by plants is affected by soil, type of plant and environment (Frageria et al., 2002). However, mineral structure and the state of dispersion also influences soil properties, beyond the chemical composition of soil (Kabata-Pendias, 2000). The tomato-growing field (organic soil) showed a higher content of Ca, followed by K, Fe, Mg, P, S, Zn, As and Pb (Figure 1). The higher Ca content in the soil is due to field being in a limestone unit, corresponding to the Terunian Cretaceous (C2-3) with alternations of limestone and marl (Manupella et al., 2000).

# Results and Discussion

Additionally, mineral content of tomatoes was also assessed after two foliar sprays with Fe and Zn (Table 3). Regarding “maçã” variety, Zn showed a significantly higher content in high mix treatment and control, despite the highest content were obtained in high mix treatment. Yet, also showed an antagonistic trend with Ca, K, and S, considering that in low mix treatment (lowest Zn content), these minerals presented a significantly higher content compared to the remain treatments and showed a de-crease of content in high mix treatment and control (where Zn content was higher). Regardless, control showed a higher content of Zn in “chucha” variety and there is no clear trend regarding the mineral interaction between Zn, Ca, K and S.

**Table 3.** Mean values ± S.E. (n = 4) of Zn, Ca, K and S in dry tomatoes of *Lycopersicum esculentum* (“maçã” and “chucha” varieties), after the 2nd foliar spraying with Fe and Zn. Different letters indicate significant differences, between treatments, in each variety (statistical analysis using the single factor ANOVA test, P ≤0.05). Foliar spray was carried out with two concentrations (Low mix and High mix). Control was not sprayed.

| Variety | Treatments | Fe (ppm) | Zn (ppm) | Ca (%) | K (%) | S (%) |
|---|---|---|---|---|---|---|
| “Maçã” | Control | <35 | 16.7a ± 0.76 | 0.14c ± 0.00 | 4.78c ± 0.01 | 0.14b ± 0.00 |
| | Low mix | <35 | 14.2b ± 0.25 | 0.28a ± 0.00 | 5.60a ± 0.02 | 0.17a ± 0.00 |
| | High mix | <35 | 17.1a ± 0.45 | 0.24b ± 0.01 | 5.33b ± 0.03 | 0.14b ± 0.01 |
| “Chucha” | Control | <35 | 14.8a ± 0.77 | 0.15b ± 0.00 | 4.81b ± 0.01 | 0.13a ± 0.00 |
| | Low mix | <35 | 10.2b ± 1.05 | 0.16a ± 0.00 | 3.82c ± 0.02 | 0.11b ± 0.01 |
| | High mix | <35 | 13.0ab ± 0.34 | 0.15b ± 0.00 | 5.16a ± 0.02 | 0.13a ± 0.01 |

Regarding Fe content in tomatoes of both varieties, was below the device’s detection limit (<35 ppm), not being possible to concluded about the treatments applied (Table 3). Yet, considering Zn, in both varieties showed significantly lower content in low mix treatment and in “maçã” variety presented a higher content in high mix treatment, unlike “chucha” variety that showed a higher content in control. Nevertheless, in both varieties, Ca, K (except in “chucha” variety”) and S (except in “chucha” variety”) showed a higher content in low mix treatment. Additionally, “maçã” variety showed a Zn antagonistic relationship with Ca, K and S. This relationship can be due to the low mobility of Ca and S (Pagani et al., 2013), due to antagonism with one of the cations Ca, Fe and Zn or probably due to synergetic interactions between N x K in the soil (the increased of K uptake can be related to the increase of N) (Rietra et al., 2017). Considering high mix treatment in “maçã” variety, seems that Zn are redistributed by xylem and phloem (Pearson et al., 1995; Haslett et al., 2001).

# Conclusions

Through two foliar sprays with Fe and Zn, at concentrations reported in this study, leaves and tomatoes of “maçã” and “chucha” varieties can be enriched, following an organic production mode. However, despite both varieties were produced under the same soil conditions, was possible to observe an antagonistic relationship with Zn between Ca, K and S in tomatoes of “maçã” variety. Additionally, in “chucha” variety there were no clear trend regarding the mineral interaction between the minerals analyzed.

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