果 树 学 报 2017,34(6):692-697
Journal of Fruit Science

DOI:10.13925/j.cnki.gsxb.20160359

叶面铁肥对浙江海涂地缺铁‘瓯柑’叶片及果实的影响

郭秀珠[1],刘冬峰[1],陈 巍[1,2*],黄品湖[1],徐文荣[1],林绍生[1]

([1]浙江省亚热带作物研究所,浙江温州 325005;[2]江苏农林职业技术学院,江苏句容 212400)

摘 要:【目的】针对浙江海涂地种植柑橘易出现缺铁的症状,筛选出适合海涂地条件下矫正‘瓯柑’缺铁失绿症的铁肥。【方法】采用叶面喷施法,对8 a(年)生‘瓯柑’树分别施用相同浓度的$FeSO_4$和3种自配铁肥EDTA-Fe、Vc-Fe、有机液-Fe,研究不同叶面铁肥对‘瓯柑’叶片和果实铁含量、叶片叶绿素含量及果实品质的影响。【结果】浙江海涂地种植条件下,叶面喷施铁肥可显著增加‘瓯柑’叶片和果实中有效铁含量,提高幅度分别为53.9%~91.6%和28.7%~83.2%,其中以Vc-Fe肥效果最明显,叶片和果实分别比对照提高91.6%和83.2%,达到113.91 mg·kg^{-1}和11.38 mg·kg^{-1},叶片含量位列柑橘叶片诊断标准的适量水平。喷施铁肥可增加‘瓯柑’叶片叶绿素含量,叶绿素a、b及总量增加幅度分别为4.1%~24.7%、6.8%~32.2%、4.7%~26.5%,其中Vc-Fe肥处理分别比对照提高24.7%、32.2%、26.5%。叶面喷施铁肥还可提高‘瓯柑’果实品质,果实可溶性固形物含量和可溶性糖含量比对照分别增加4.6%~11.6%和6.2%~13.4%,其中以有机液-Fe肥处理效果最佳,可溶性固形物含量和可溶性糖含量分别比对照提高1.10和0.93个百分点。【结论】本研究中Vc-Fe肥提高‘瓯柑’叶片和果实铁含量幅度最大,这与维生素C抑制铁离子氧化、延长二价铁的有效时间有关,有机液-Fe肥处理对于提高‘瓯柑’果实可溶性固形物含量和可溶性糖含量及叶片复绿具有明显作用,其原因除了有机液-Fe肥中的铁元素外,还可能与含有大量的有机质可促进叶片生长和吸收有关。此研究结果可为研发适合浙江海涂地条件的柑橘专用铁肥提供参考。

关键词:‘瓯柑’;浙江海涂地;缺铁;叶面铁肥

中图分类号:S666.1 **文献标志码**:A **文章编号**:1009-9980(2017)06-0692-06

Effects of foliar iron fertilizers on iron-deficient leaves and fruit of ‘Ougan’ (*Citrus reticulata*) planted in the tideland in Zhejiang

GUO Xiuzhu[1], LIU Dongfeng[1], CHEN Wei[1,2*], HUANG Pinhu[1], XU Wenrong[1], LIN Shaosheng[1]

([1]Zhejiang Institute of Subtropical Crops, Wenzhou 325005, Zhejiang, China; [2]Jiangsu Polytechnic College Agriculture and Forestry, Jurong 212400, Jiangsu, China)

Abstract:【Objective】Iron is one of the essential microelements for plant growth and development. As a main component of electron carriers or catalysts, it plays an important role in many physiological processes. However, iron deficiency is a common problem in most areas of China. Leaf chlorosis is the main symptom of iron deficiency because iron is an essential element for chlorophyll biosynthesis. Young leaves usually show chlorosis first since iron is immobile. However, when iron deficiency continues, the entire leaves turn yellow, develop necrotic spots and gradually die. Leaf chlorosis in fruit trees causes slow growth, yield reduction and quality decline. However, plants have developed a complicated mechanism of iron-deficiency tolerance during long-term evolution. Morphologically, roots become shorter with increased apical diameter and root hairs and formation of transfer cells in root epidermis and cortex under iron deficiency stress. Physiologically, rhizosphere acidification, synthesis of organic acids and phytosiderophore are

收稿日期:2016-11-18 接受日期:2017-03-23

基金项目:浙江省农业(果品)新品种选育重大科技专项(2012C12904-1);温州市科技局项目(N20080019,N20140035,X20150015)

作者简介:郭秀珠,女,高级实验师,主要从事植物营养与果树品质提升技术研究。Tel:0577-88534792,E-mail:wzguoxiuzhu@aliyun.com

*通信作者 Author for correspondence. Tel:0511-87290567,E-mail:carchen110@163.com

enhanced. These changes contribute to iron absorption under iron deficiency condition. *Malus xiaojinensis* is resistant to chlorosis associated with iron deficiency, and its special root structures decrease the pH of the rhizosphere, which increases the affinity to and thus the absorption of iron. In orange, a large of number lateral roots are formed to increase the absorption area under iron deficiency stress. ‘Ougan’ is a major citrus cultivar in Wenzhou, where there is a tendency of developing the crop in tidelands. However, the high soil pH results in leaf chlorosis and impacts growth and development and fruit quality of ‘Ougan’, because the ferric ion in the soil is less available for the plant. In this study, foliar-spraying of iron fertilizers was conducted to choose an appropriated iron fertilizer to solve the problem of iron deficiency, which is an urgent research task. 【Methods】Foliar-sprays of the same concentration of iron fertilizers including $FeSO_4$, self-prepared EDTA-Fe, Vc-Fe and organic-Fe were conducted on 8-year-old ‘Ougan’ trees. The contents of iron and chlorophylls in leaves were measured at fruit maturing period, and fruit quality was evaluated. 【Results】The available iron content in ‘Ougan’ leaves and fruit was significantly increased by 53.9%-91.6% and 28.7%-83.2%, respectively, after foliar-spraying of iron fertilizers. Vc-Fe was much more effective than the other iron fertilizers, increasing the iron content in leaves (113.91 $mg \cdot kg^{-1}$) and fruit (11.38 $mg \cdot kg^{-1}$) by 91.6% and 83.2% compared with the control, respectively. After EDTA-Fe treatment, the ion contents in leaves and fruit reached 101.51 $mg \cdot kg^{-1}$ and 10.21 $mg \cdot kg^{-1}$, respectively, which fell within the appropriate levels based on the diagnostic criteria. The content of chlorophylls increased after iron spraying, and chlorophyll a, b and total chlorophylls were increased by 4.1%-24.7%, 6.8%-32.2% and 4.7%-26.5%, respectively. However, compared with the control, chlorophyll a, b and total chlorophylls in Vc-Fe treatment were significantly increased by 24.7%, 32.2% and 26.5%, respectively. Fruit quality was also improved by iron sprays, and the total soluble solids and soluble sugars in fruit were increased by 4.6%-11.6% and 6.2%-13.4%, respectively. In organic-Fe treatment, the total soluble solids and soluble sugars were 10.57% and 7.85%, respectively, which were 1.10 and 0.93 folds higher than that of control, respectively. 【Conclusion】Ferrous sulfate fertilizer had no obvious effect in preventing leaf chlorosis due to its high susceptibility to oxidation. Although chelated iron was superior to ferrous sulfate, it is more costly. Vc-Fe was most effective in increasing the iron content both in the leaves and the fruit, and its effectiveness might be relate to the inhibition of ferrous oxidation by vitamin C. Organic-Fe was obviously effective in increasing the total soluble solids and the soluble sugars and the treatment also induced re-greening in yellowed leaves. The effect might be related to abundant organic matter in addition to effective ferrous iron. The results provide a reference for the preparation of special iron fertilizer used for citrus planted in the tidelands in Zhejiang.

Key words: ‘Ougan’; Zhejiang tideland; Iron deficiency; Foliar iron fertilizer

据统计全世界约有40%的土壤缺铁，我国大部分地区都存在缺铁现象，果树缺铁失绿成为果树生产中常见的生理性病害之一[1-2]。铁是植物必需的微量营养元素，在植物体内参与光合作用、氧化还原反应和电子传递以及呼吸作用等众多的生理过程[3-4]。植物缺乏铁元素时表现出叶片黄化、生长缓慢、果实产量和品质下降。Larbi等[5]研究表明，缺铁导致桃果实数量和单果质量的减少，影响果实着色和品质。缺铁胁迫不仅显著降低草莓幼苗叶绿素含量、光合速率、叶片铁等含量，还降低了柑橘砧木的株高、叶片数量、叶面积及根系的总根长、总根数、总根表面积等，并且不同品种（种质）间存在显著差异[6-7]。

在长期的进化过程中一些植物形成了适应缺铁环境的机制，如根际还原与酸化作用、有机酸分泌和植物高铁载体的合成、分泌等[8]。对抗缺铁黄叶病的苹果基因型——小金海棠研究发现，缺铁胁迫下根表有大量密集根毛产生，根表皮形成“转移细胞”，根