Improving Zn nutritional status using amino acids and orthosilicic acid in strawberry plants

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Abstract

Optimal conditions for micronutrients availability should be guaranteed to plants to avoid nutrient deficiencies. Despite their poor environmental sustainability, the use of synthetic metal chelators (e.g. EDTA) is therefore rather common in horticultural crops. In this study we evaluated the potential use of amino acids and orthosilicic acid as valid metal carriers in strawberry plants. Results showed a significant increase of photosynthetic rate, Zn and Si leaf content in plants treated with amino acids or orthosilicic acid combined with Zn. The use of amino acids in combination with Zn was therefore proved useful to optimize the physiological and nutritional conditions of strawberry plants.

Keywords: *Fragaria x ananassa*, zinc, silicon, metal carriers, nutrient deficiencies

Introduction

Metal chelating agents such as EDTA is a standard way to solve problems related to micronutrient deficiencies. Considering its persistence in the environment (i.e. low biodegradability) (Oviedo & Rodríguez, 2003), more eco-friendly substances should be identified, especially when considered for the organic farming production systems. Selected organic substances (e.g. amino acids) have shown good potentiality as metal carriers in plants (Ghasemi et al., 2012; Yuan et al., 2013; Popko et al., 2018). The aim of this study was therefore to examine the influence of a mix of amino acids and orthosilicic acid as carriers of zinc in strawberry plants.

Material and Methods

The experiment was carried out at the Research Centre Laimburg (South Tyrol, Italy). Cold stored strawberry tray plants cv. Elsanta were grown in greenhouse under soilless conditions. Amino acids combined with zinc (2.0%) and orthosilicic acid with zinc (1.8%) were sprayed to the plant canopy starting from pre-flowering until the end of harvest (one application per week, seven in total). Plants treated with water were used as control. The trial was arranged in a randomized block design with 4 replicates per treatment (4 plants per replicate). The net photosynthetic rate was determined on two healthy, young, fully expanded leaves per plant using a LCpro-SD ADC open system portable infrared gas analyser (ADC, Hoddesdon, UK). Plant biomass (as g DW plant^{-1}) was measured at the end of production cycle on four plants per treatment. Zinc and silicon leaf content (as mg kg^{-1} DW) were analysed with microwave-assisted acid digestion using the ICP-OES. Data were subjected to one-way analysis of variance (ANOVA), and the means were separated by the least significant difference test ($p<0.05$).

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Results and Discussion

Results indicated that the net photosynthetic rate was significantly higher in treated plants (about +20%). The leaf Zn concentration was found higher in treated plants (+340% in AA+Zn and +189% in Si+Zn) as compared to control (Tab.1). As reported by Köksal et al. (1999), the application of Zn in combination with amino acids improved Zn concentration (+132%) in pear leaf tissues, therefore representing a valuable method to enhance the availability of this micronutrient for plants.

The observed enhanced photosynthetic rate could be linked to the increased Zn concentration in leaves, giving the involvement of this element in the photosynthetic process (Brown et al., 1993; Mattiello et al., 2015; Tavallali, 2017). Although foliar applications induced higher photosynthetic rates in leaves, no significant differences in final biomass was observed in treated plants. Regarding the leaf silicon content, it was also increased in treated plants (+50% as compared to untreated plants).

These preliminary results indicate the use of amino acids and orthosilicic acid as promising metal-chelating agents to improve zinc and silicon nutritional status in strawberry plants.

Table 1: Effects of alternative metal carriers on plant growth performances.

Treatment	Net rate of photosynthesis ($\mu mol\ m^{-2}\ s^{-1}$)	Plant biomass (g DW $plant^{-1}$)	Micronutrient content (mg kg^{-1} DW)	
			Zn	Si
Control	18,73 ± 1,41[1] **b**	13,81 ± 2,46	28,93 ± 3,01 **c**	416,88 ± 61,75 **b**
AA + Zn	21,36 ± 0,86 **a**	13,24 ± 1,51	127,43 ± 13,95 **a**	624,68 ± 98,52 **a**
Si + Zn	22,64 ± 0,53 **a**	15,03 ± 3,10	83,8 ± 13,61 **b**	689,13 ± 41,81 **a**

[1] Means ± SD. Values followed by a different letter are significantly different ($P<0.05$) ($n = 4$). Treatments legend: Control; AA+Zn, amino acids combined with zinc; Si+Zn, orthosilicic acid with zinc.

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