Different Root Morphological Responses to Phosphorus Supplies in Grafted Pepper

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Abstract

Grafting technique is increasing thanks to its potential to produce plants more efficient and tolerant to biotic and abiotic stresses. Likewise, there is a growing interest in reducing inputs of fertilizers. The development of rootstocks suitable for low input agriculture is conditioned to the understanding of the changes on the root when facing such stresses. Our aim was to evaluate the morphological root response to Phosphorus (P) starvation of a rootstock selected for its good performance under low P conditions. Adige was grafted onto the selected rootstock and grown hydroponically in two different P concentrations, the selft-graft was done as control. Plants were then collected and analysed. Results showed that despite the differences in terms of P concentration among treatment the stress was not enough to cause a great biomass loss. However, there is evidence that individuals showed different root adaptations, modifiying root length, mass and volume, etc, under stress conditions, having the selected rootstock higher root length and volume under low P nutrient solution

Keywords*:* root architecture, nutrient deficiency, *Capsicum annuum,* rootstock

Introduction

Nowadays, there is a growing interest in reducing fertilizer's inputs, both for economic and environmental reasons. This is particularly true in the case of phosphate fertilization since it causes eutrophication of the waters and also all P-fertilizers come from P-rock, a non-renewable source (Cordell *et al.*, 2009; Vance *et al.*, 2003). Therefore, the development of more efficient plants in terms of acquiring P is a new breeding goal (DenHerder *et al.*, 2010; Lynch, 2007). This objective can be achieved by the use of more efficient rootstocks (Nawaz *et al.*, 2016).

Pepper (*Capsicum sp.*) is one of the most relevant vegetable crop worldwide and an important area of soil is dedicated to its production (FAO, 2014). Grafting technique is used more and more in pepper to different objectives. (Penella *et al.*, 2013) thanks to the potential of this technique to produce plants more efficient and resistant to biotic and abiotic stresses (Rivero *et al.*, 2003). Recently some sources of tolerance to low P conditions have been identify as suitable for its use as rootstock in pepper (Pereira-Dias *et al.*, 2016). However, the development and release of rootstocks suitable for low input in fertilizers is conditioned to the understanding of the changes on the root (plasticity) when facing such stresses.

Aims. In order to evaluate the morphological root response to phosphorus (P) starvation, a selected rootstock and the self-graft of a pepper variety were evaluated, under two different concentrations of phosphorus (P), for their root morphology and P content.

Table 1. Mean values for P concentration and dry biomass recorded on grafted plants (A and R rootstocks) under HP (1.5 mM P) and LP (0.5 mM P)

	P (%) leaves		P (%) roots		Dry biomass (g)	
	HP	LP	HP	LP	HP	LP
A	0,38	0,35*	1,85	0,80*	33,7	31,2
R	0,38	0,33*	1,01	0,71*	30	**27,2**

Note: Numbers of the same row with * indicate a significant difference with P-value <0.05. Numbers of the same column in bold indicate a significant difference with P-value <0.05Mean values for P concentration and dry biomass recorded on grafted plants.

Table 2. Mean values for P concentration and dry biomass recorded on grafted plants (A and R rootstocks) under HP (1.5 mM P) and LP (0.5 mM P)

	LDW (g)[1]		L (m)		D (mm)		V (cm3)		$L_{d<1}$ (m)		$L_{d>1}$ (m)	
	HP	LP	HP	LP	HP	LP	HP	LP	HP	LP	HP	LP
A	4,01	2,68*	219	155*	0,77	0,78	104	74*	178	126*	40	29*
R	3,92	**4,29**	**260**	**305***	0,76	0,74	117	**130**	**216**	256*	44	**48**

Note: Numbers of the same row with * indicate a significant difference with P-value <0.05. Numbers of the same column in bold indicate a significant difference with P-value <0.05

[1]LDW: lateral roots dry weight, RDW: total root dry weight, L: root length, D: root diamenter, V: root volume, Ld<: length of roots of diameter less or equal 1mm, Ld>1: length of roots of diameter more than 1mm.

Materials and methods

Adige, a Lamuyo type pepper, was grafted onto a rootstock (R) - selected in previous assays of grafting and low fertilization with P (data not shown). In addition, the self-graft of Adige was included as control (A). All grafted plants were grown hydroponically in two different concentrations of phosphorus (0.5 and 1.5 mM, named LP and HP, respectively). Size sample was 6 plants per genotype and per treatment. After 28 days of treatment all roots and shoots were collected and weighted (fresh and dry weight). Additionally, roots were spread in a transparent sheets, scanned and digitally analysed with WinRHIZO™ Pro (Regent Instruments Inc.) in order to evaluate possible changes in root morphology. P content in shoots and roots were analysed with ICP. Statistical analysis was performed using STATGRAPHICS Centurion XVI (StatPoint Technologies, Inc.)

Results and discussion

There were significant differences among treatments in terms of P concentration. The effect of the low concentration of P was observed more intensively in the roots (Tab. 1). However the treatment was not enough stressful to produce differences in terms of plant biomass. Despite of that, our findings indicate a differential response under LP conditions between grafts (Tab. 2). 'A' and 'R' showed different root length (L) in HP conditions, in addition they respond in a different way to the LP condition: 'A' individuals suffer a significant reduction of lateral roots dry weight (LDW), length (L), root volume (V) and length of roots of any diameter ($L_{d<1}$ and $L_{d>1}$) under low P treatment. On the other hand, 'R' individuals increased L and $L_{d<1}$ and under low P treatment. It has to be pointed out that these genotypes have different strategies to adapt to low P in the environment; 'A' reduces its expenses while 'R' tries to expand its foraging capacity by increasing roots volume. Different root morphologies in pepper have been reported previously (Fita *et al.*, 2014; Fita et al., 2013; Pereira-Dias e*t al.,* 2016) but there is little previous information of the rootstock response to low P stress (Lopez-Serrano *et al.*, 2017). In this experiment, the increased root system of 'R' under LP conditions does not induce higher biomass of the scion. It needs to be

noted that in hydroponic conditions increasing root length gives no advantage since the space is limited and the concentration of nutrient constant. However, in the soil an increased foraging capacity through longer roots can increase the nutrient uptake (Hodge, 2004). In this experiment, we did not reach flowering time nor harvest time. However, preliminary results in other experiments showed that sweet pepper grafted onto R had higher production in fields with low concentration of P (data not shown) which could be a result of 'R' higher root length under LP.

Conclusions

Our results evidence a different response to low P input in terms of root architecture. Despite in our case the differences in terms of root architecture do not correlate with higher biomass in the scion, we believe that higher root length and volume would be advantageous in the field.

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