The Expression of Phosphate Transporter Genes and the Functional Diversity of Arbuscular Mycorrhizal Fungi Associated with Maize (*Zea mays* L.)

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Abstract

• A greenhouse experiment was conducted to investigate the relationship between the expression of P transporter genes and the functional diversity of phosphate uptake in maize root associated with different arbuscular mycorrhizal fungi.

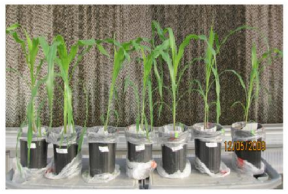
• Maize roots associated with no mycorrhizal fungi, *Glomus mosseae*, *Glomus intraradices*, *Gigaspora gigantean*, *Glomus deserticola* and the mixture of these 4 species were established. Two phosphate levels (0 and 1mM) was also established.

• Root length colonized by AM fungi, shoot dry weight and shoot P content were measured. Expressions of two root P transporter genes, ZEAma;Pht1;3 and ZEAma;Pht1;6 (AM specific induced), were quantified by Real-time RT-PCR

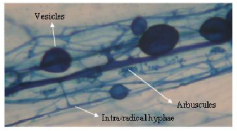
• All five AM inoculations significantly increased the expression of AM specific induced P transporter ZEAma;Pht1;6 in maize roots, and decreased the expression of ZEAma;Pht1;3. Different AM species influenced the degree of expression of the two P transporters. In general, the expression of ZEAma;Pht1;6 among different AM inoculations was consistence with their functional diversity in P uptake.

Introduction

Functional diversity in arbuscular mycorrhizas (AM) refer to the differences observed between fungi in how they help host plants resist biotic and abiotic stress (Smith and Read, 1997), although it is often defined in terms of plant growth responses or nutrient uptake, especially phosphate (P) (Burleigh et al., 2002). AM plants are potentially able to acquire phosphate (P) via two pathways: (1) directly via root epidermal cells and root hairs and (2) via the AM fungi (Smith et al., 2003). P transporters are important to the P transfer process in both pathways (Benedetto et al., 2005; Javot et al., 2007). There are three types of P transporters involved plant P uptake regulation, namely AM fungal P transporters, plant P transporters and AM specific induced plant P transporters. Several studies have been focused on the expression of P transporters in maize root colonized by AM fungi (Wright et al., 2005; Nagy et al., 2006), however, the influence of different AM fungi on the expression of P transporter genes and the relationship between P transporter genes expression and the functional diversity of AM fungi are still unknown.



Culture of maize plants colonized by different AM inoculations in greenhouse



AM (Glomus intraradices) colonization structures in maize root

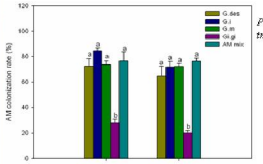
Aims

• Elucidate the influence of different AM species on the expression of two P transporter genes (ZEAma;Pht1;3 and ZEAma;Pht1;6) in maize roots

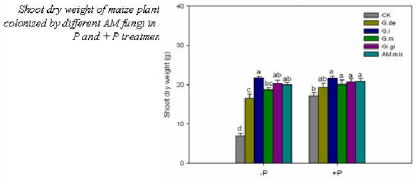
• Determine whether the expression of P transporter genes is related to the functional diversity of AMF colonizing maize roots

Materials and Methods

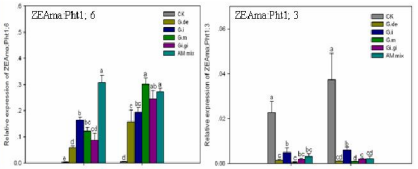
- Maize plants colonized with *Glomus deserticola* (CA113), *G. mosseae* (CA201), *G. intraradices* (IA506) and *Gigaspora gigantean* (MN922A) and non-mycorrhizal plants were cultured for 9 weeks in greenhouse
- Hoalgland's nutrient solution with 1 mM P and without P was watered into the pots once a week to set up +P and –P treatments
- Percent root colonized by AM fungi, AMF fatty acid biomarkers (C16:1*cis*11 and C18:1*cis*11), Shoot dry weight and P uptake of maize and were measured
- Real-time RT-PCR was applied to estimate the expression of P transporter genes in maize roots



Percent root colonized by AM fungi in –P and + P treatment



Shoot dry weight of maize plant colonized by different AM fungi in P and +P treatment



Relative expression of P transporters in maize roots quantified by Real-time RT-PCR

Results

• The percent of root colonized by AMF was significant lower for *Gi.gigantean* in both P levels. Non-mycorrhizal treatment (CK) was not colonized by AMF.

• The amount of AMF fatty acid biomarker C16:1*cis*11 was significant higher in roots colonized by *G. intraradices* or AM mix, and lowest in non-mycorrhizal plants. A second (less specific) biomarker, C18:1*cis*11, was higher for *G.deserticola* and lower for *Gi.gigantean*. The adding of P decreased the amount of C16:1*cis*11 for *G.deserticola* but increased for AM mix, and decreased the amount of C18:1*cis*11 only for *G.deserticola*.

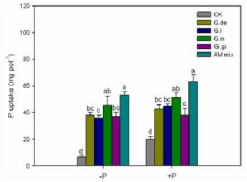
• In –P treatment, maize roots colonized by *G.intraradices* had higher shoot dry weight, while shoot weight was lower for *G.deserticola*. In +P treatment, there was no significant differences among AM plants. The adding of P significantly increased the dry weight of CK, but had no influence on AM plants.

• The shoot P uptake in plants inoculated with AM mix or *G.mosseae* was significant higher in both P treatments. The adding of P significantly increased the P uptake of CK and *G.intraradices*.

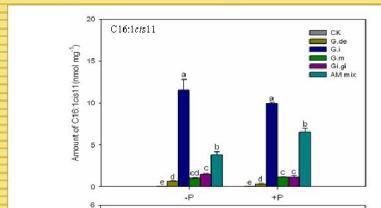
• The relative expression of ZEAma:Pht1;6 was significantly increased by the colonization of AMF in both P treatments. The expression in roots inoculated with AM mix was highest in –P treatment, and higher than *G.deserticola* and *G.intraradices* in +P treatment. The expression in roots colonized by *G.deserticola* was lower in both P treatments. The adding of P significantly increased the expression of ZEAma:Pht1;6 for *G.mosseae* and *Gi.gigantean*.

• The colonization of AMF decreased the expression of ZEAma:Pht1;3 in both P treatments. The expression was significant higher in roots colonized by *G.intraradices* and lower for *G.mosseae*. There was a trend that adding P increased the expression of ZEAma:Pht1;3 in CK, but not significant due to high variation. P treatment did not influenced the expression of ZEAma:Pht1;3 for AM plants.

• The inoculation of AM mix and *G.mosseae* resulted in higher P uptake in plant shoots, and also resulted in higher expression of AM specific induced P transporter and lower expression of plant P transporter, especially in +P treatment. By contrast, the inoculation of *G.deserticola*, *G.intraradices* or *Gi.gigantean* resulted in lower P uptake and also lower expression of AM specific induce P transporter.



P uptake of maize shoot in different AM and P treatments



AM fatty acid biomarkers in maize root in different AM and P treatments

Conclusion

AM species differ in their ability to up-regulate AM specific induced P transporter gene and down-regulate plant P transporter gene.

Increase diversity of AMF in roots increased up-regulation of AM specific induced P transporter gene as well as plant P uptake

Increased diversity of AMF in roots in general, leads to greater functional diversity of AMF in terms of plant P uptake. One contributing factor is through increased up-regulation of the AM specific induced P transporter gene, however, other mechanisms relating to the ecology of the fungus and it's interaction with the plant host may also be important

Acknowledgements

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