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Effects of High Phosphorus Supply on the Interaction of Soybean Roots with *Glomus Mosseae* and *Rhizoctonia Solani*: Degree of Infection and Accumulation of the Phytoalexin Glyceollin*

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Abstract

High phosphorus supply strongly reduced the extent of infection of soybean roots by the mycorrhizal fungus, *Glomus mosseae*, but did not affect or slightly stimulated infection by the pathogen, *Rhizoctonia solani*. Pathogen infected roots accumulated the phytoalexin glyceollin. Mycorrhizal roots had the same low levels of glyceollin as uninfected control roots under conditions of both low and high phosphorus supply, indicating that the inhibition of mycorrhizal infection at high phosphorus levels is not due to defense reaction of the type displayed against pathogens.

Introduction

Phytoalexins are thought to play an important role in the active defense reaction of plants against incompatible pathogens. While they rapidly accumulate in response to necrotrophic or incompatible biotrophic pathogens, they are formed only at late stages in interactions with compatible biotrophic pathogens (Habereder et al., 1989). The vesicular-arbuscular mycorrhizal symbiosis resembles a compatible plant-pathogen interaction with regard to the intimate cell-to-cell contact and the apparent absence of plant cell damage (Smith and Gianinazzi-Pearson, 1988). In line with this, we have recently found that in soybean roots, the phytoalexin glyceollin does not accumulate during the first phase of infection with the mycorrhizal fungus *Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trappe (Wyss et al., 1990 and submitted for publication).

Under conditions of high phosphorus supply, the degree of mycorrhizal infection is known to be drastically reduced (Schwab et al., 1983). The question arises whether the

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system shifts to an incompatible interaction under these conditions. We therefore examined the effect of high phosphorus supply on phytoalexin accumulation in mycorrhizal plants, using plants infected with a weak incompatible pathogen, *Rhizoctonia solani* Kühn, for comparison.

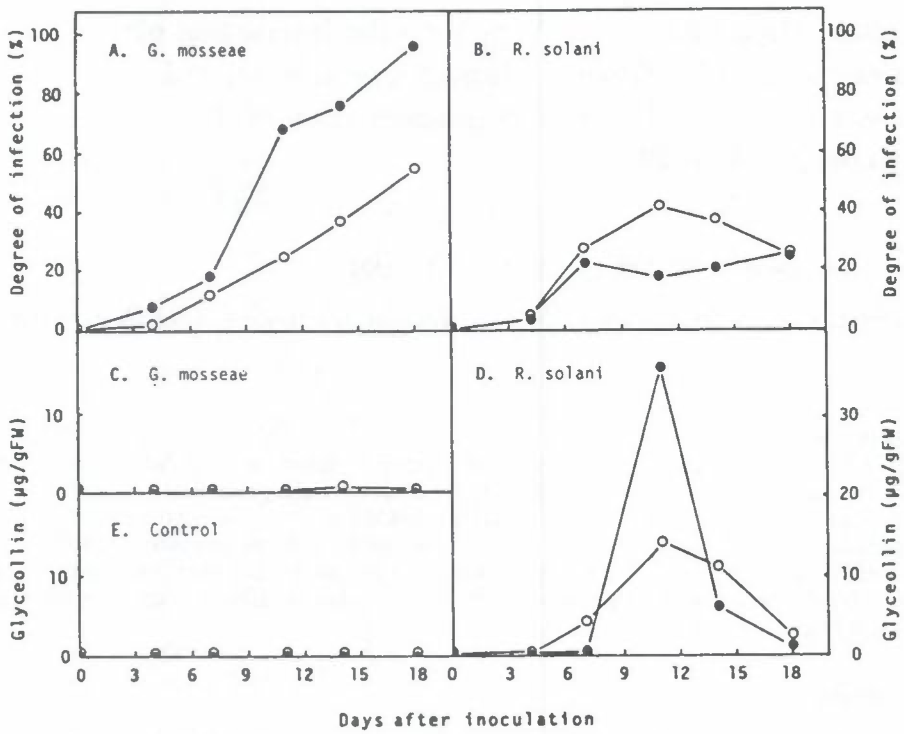

Figure 1. KH_2PO_4 addition from the beginning.

Materials and Methods

Eight days old seedlings of *Glycine max* L. Maple Arrow, grown in a low phosphorus sandy loam mixture after germination in Vermiculit, were either inoculated with the mycorrhizal fungus *G. mosseae* or the incompatible pathogenic fungus *R. solani* or mock inoculated in a recently developed container system (Wyss et al., 1990). Test-plants were watered daily with tap-water (low P supply) or with a KH_2PO_4-solution (0.4 g/180 ml tap-water = 0.4 g/kg soil dry weight) either from day 0 or 15 after inoculation. The experiments were carried out twice, using two replicate samples for each determination. Glyceollin was extracted from the roots with ethanol (Classen and Ward, 1985) and measured by HPLC. The three isomers of glyceollin were separated.

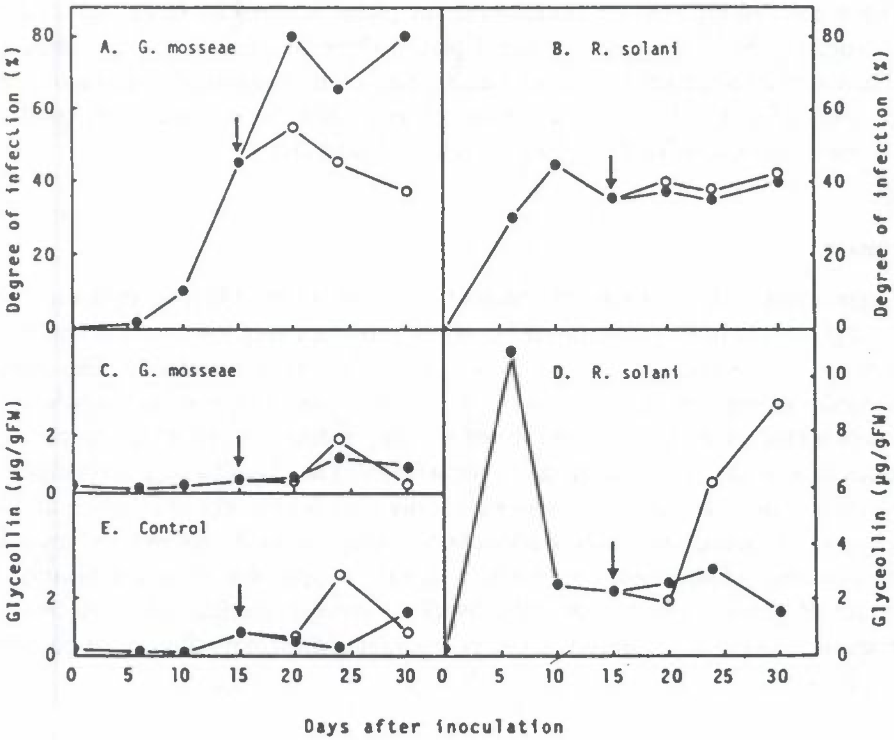

Figure 2. KH_2PO_4 addition after 15 days of inoculation (arrow).

Figures 1 and 2. Time course of infection (A,B) and of glyceollin accumulation (C,D) in roots infected with *Glomus mosseae* (A,C) or *Rhizoctonia solani* (B,D) treated (○) or not (●) with KH_2PO_4 Glyceollin levels of mock inoculated roots are shown in E.

Glyceollin I, II and III occurred in a ratio of 15:1:1. The values in the results section correspond to the sum of the three isomers.

For the determination of the degree of infection the root segments from which glyceollin had been extracted were cleared and stained after the method of Phillips and Hayman (1970), omitting phenol, and evaluated using the gridline intersect method (Giovannetti and Mosse, 1980).

Results

The soybean plants were rapidly mycorrhized in the low phosphorus soil (Fig. 1A and 2A). The degree of mycorrhization finally reached was much reduced after P-fertilization (Fig. 1A) and the progress of infection was rapidly stopped upon addition of P (Fig. 2A). Conversely, the degree of infection by *R. solani* was little influenced by P supply (Fig. 1B and 2B).

With respect to glyceollin accumulation, the plants infected by *G. mosseae* did not differ from the mock inoculated control plants: there was almost no accumulation, irrespective of P-fertilization (Fig. 1C, 1E, 2C and 2E). In contrast, *R. solani* inoculated roots accumulated substantial amounts of glyceollin both under conditions of P-deficiency and excessive P-fertilization (Fig. 1D and 2D).

Discussion

In agreement with our previous observations (Wyss et al., 1990) we measured high levels of glyceollin in *R. solani* infected soybean roots but very low levels in uninfected control roots or *G. mosseae* infected roots up to 30 days after inoculation. This pattern of glyceollin accumulation was similar under conditions of high P supply, where the degree of mycorrhization was found to be strongly reduced. These data complements the work of Morandi and Gianinazzi-Pearson (1986). They found a slight accumulation of glyceollin I in mycorrhizal soybean roots only after 6-12 weeks of infection and did not observe any significant effect of phosphorus nutrition on glyceollin I accumulation at this late stage of infection. We conclude that the suppression of mycorrhization by abundant P supply is not controlled by plant defense mechanisms and that the interaction under this condition is not comparable to incompatible plant-pathogen interactions.

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