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Effects of pH and aluminum and manganese toxicity on mycorrhizal associations with sorghum and maize

Medeiros, Carlos Alberto Barbosa, Ph.D.

The University of Nebraska - Lincoln, 1991

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

EFFECTS OF pH AND ALUMINUM AND MANGANESE TOXICITY ON MYCORRHIZAL ASSOCIATIONS WITH SORGHUM AND MAIZE

by

Carlos Alberto Barbosa Medeiros

A DISSERTATION

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EFFECTS OF pH AND ALUMINUM AND MANGANESE TOXICITY ON MYCORRHIZAL ASSOCIATIONS WITH SORGHUM AND MAIZE

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Adviser: Ralph B. Clark

Effects of H-ions (pH) and high Al and Mn on vesicular-arbuscular mycorrhiza (VAM) associations are not completely understood. Effects of pH and high Al and Mn on VAM associations were studied in plants grown in hydroponic sand culture experiments under greenhouse conditions.

Initial experiments consisted of adding 2.0 mM 2-(N-morpholino)-ethanesulfonic acid [MES] buffer to stabilize pH at 4.0, 5.0, 6.0 and 7.0 for testing effectiveness of *Glomus intraradix* colonization in maize (*Zea mays* L.). The MES buffer had no effect on VAM colonization at pH 4.0, but enhanced colonization at higher pH values. Addition of MES buffer reduced shoot and root dry matter yields, increased Ca, Mg, Mn, and Zn shoot concentrations, but had no effect on shoot P concentrations. Colonization with VAM increased shoot Fe and Cu concentrations, but the VAM effect on P varied with pH.

In other experiments, the VAM species *Glomus etunicatum*, *Glomus intraradix*, and two VAM isolates (A and B) were evaluated to determine their effectiveness in improving sorghum [*Sorghum bicolor* (L.) Moench] growth and

nutrition at pH 4.0, 5.0, 6.0 and 7.0. The VAM species showed differential responses to pH, but VAM colonization generally increased as pH increased. *Glomus etunicatum* was the most effective VAM species regardless of pH, but VAM effectiveness was not related to root colonization.

Amelioration of Al toxicity effects on sorghum by VAM and effects of Al on VAM colonization were determined in other experiments. Plants were grown with and without *G. etunicatum* and *G. intraradix* using nutrient solution at pH 4.8 with 0, 35, 70, and 105 μM Al. The VAM colonization increased with increasing Al. *Glomus etunicatum* was more effective in reducing Al toxicity symptoms than *G. intraradix*. Amelioration of Al toxicity symptoms showed an association with P and K nutrition.

The effects of high Mn on VAM colonization and effectiveness on sorghum were determined. Sorghum was grown with and without *G. etunicatum* and *G. intraradix* in sand irrigated with nutrient solution at pH 4.8 with 18, 270, 540, and 1080 μM Mn. Manganese toxicity symptoms were more pronounced in VAM than in non-VAM plants, and toxicity symptoms were more evident in plants colonized with *G. intraradix* than with *G. etunicatum*. Increasing amounts of Mn in solution reduced VAM colonization.

DISSERTATION TITLE

Effects of pH and aluminum and manganese toxicity

on mycorrhizal associations with sorghum and maize

BY

Carlos Alberto B. Medeiros

SUPERVISORY COMMITTEE:

	APPROVED	DATE
Signature	Ralph B. Clark	6/28/91
Typed Name	Ralph B. Clark	
Signature	Dale T. Lindgren	6/28/91
Typed Name	Dale T. Lindgren	
Signature	Jerry D. Eastin	6/28/91
Typed Name	Jerry D. Eastin	
Signature	Max D. Clegg	6/28/91
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TO THE MEMORY OF

MY FATHER

NARDY MEDEIROS

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INTRODUCTION

The most common mycorrhizal association with plant roots is with the vesicular-arbuscular type (VAM). The dramatic effects of this association on host plant nutrition, particularly through modifications of P deficits, are well known. Because of the physiological benefits conferred to crops by this symbiotic relationship, VAM studies are important in agricultural research.

Colonization and effectiveness of VAM is affected by environmental factors and by morphological and physiological aspects associated with the host plant. Of these factors, host plant nutritional status, nutrient availability in the growth medium, and presence of toxic elements are of special interest. The effects of pH modifying the availability of beneficial and toxic elements to host plants and VAM make the VAM-growth medium relationships more complex.

Soil acidity it is a common problem in agriculture, particularly in tropical regions. Exchangeable Al, and to a lesser extent Mn, are often associated with low pH soils. Adverse soil acidity and toxic element effects on plant development also reduce the beneficial effect of VAM colonization. Root colonization by VAM represents the "normal" condition (Rhodes, 1984).

Information on the effect of toxic elements such Al and Mn on VAM are unknown, and a better understanding of these relationships is needed. Knowledge of VAM responses to pH and mineral status of the growth medium may allow for the selection of more adapted and effective endophytes to specific soil conditions.

These studies attempted to minimize the chance for interaction between

pH, Al, and Mn, and to better understand the relationships of VAM to these elements. These studies had two major objectives: first, to evaluate VAM effects on plant growth under relatively stable pH conditions with reduced interference of toxic elements; and second, to evaluate plant responses to VAM inoculation under high Al and Mn in the growth medium along with the effect of these toxic elements on VAM colonization and effectiveness.

LITERATURE REVIEW

I - INTRODUCTION

Endomycorrhizae are generally associated with herbaceous angiosperms and are characterized by fungal penetration of root cells. In most cases, the anatomical and cytological changes caused by endomycorrhizae in the host do not induce root alterations recognizable with the naked eye (Bonfante-Fasolo, 1984). While mycorrhizae grow in the soil and form extramatrical mycelia, the hyphae penetrate the root cell epidermis and spread between and into the cortical cells to form an intramatrical phase (Barber, 1984). The extramatrical mycelia may form interconnected bridges between roots, making possible direct nutrient transfer between plants (Read et al., 1985). Within the root, the fungus can form globose or oval terminal swellings called vesicles and intracellular branched tree-like structures called arbuscules. Such endomycorrhizae are called vesicular-arbuscular (VA) mycorrhizae, VAM, or VAM fungi (VAMF).

The arbuscule is the most significant structure in the VAM complex, especially from a functional viewpoint (Bonfante-Fasolo, 1984). This is because it is the site where metabolite exchanges between plant and fungus take place (Scannerini and Bonfante-Fasolo, 1983). The vesicles can be intercellular or intracellular, and their function is not well known. Some evidence indicates they are resting or storage organs (Bonfante-Fasolo, 1984).

By far the most common mycorrhizal association is the vesicular-arbuscular