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Mycorrhizal Corn Growth in Response to Different Iron Levels

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Abstract. The growth of mycorrhizal and non-mycorrhizal corn plants at six concentrations of iron was monitored by visual observation after two weeks and by measuring their fresh and dry weights and heights after eight weeks of growth in a green house. The results showed that *Glomus mosseae* – inoculated corn plants displayed better growth responses than non-mycorrhizal corn plants at relatively low soil iron concentrations namely (3, 10, 20, 40 $mgkg^{-1}$), while at high concentrations (80, 160 $mgkg^{-1}$) there were no pronounced effects. In addition, high iron concentrations lessened the infection percentage of mycorrhizal corn plants. The best concentration that gave good growth and high percentage of infection was 3 $mgkg^{-1}$.

Introduction

Mycorrhizal fungi, vesicular-arbuscular mycorrhizal (VAM) fungi are obligate symbionts and must be grown on roots of living host plants. They may play a role in mineral availability to many plant species and increase yields of several crops or increase plant tolerance to toxic heavy metals [1-2]. Powell *et al.* [3] have shown that ectomycorrhizal fungi may play a major role in iron availability by producing specific microbial iron transport molecules, the hydroxamate siderophores (HSs). Lambert *et al.* [4] and Killham and Firestone [5] support the observation that VAM formation enhances the growth of plants by improving the ability of plant roots to absorb and translocate P and other nutrients i.e. Cu, Pb, Zn, Fe and Ca. These elements were found to be higher in the roots and shoot of *Ehrhurta calycina* associated with mycorrhizal fungi than in non-mycorrhizal counterparts.

The low solubility of inorganic iron in alkaline and neutral soils has stimulated research to understand the natural mechanism by which iron is made available to higher plants in soils. In general, little work has been done on mycorrhizal fungi growth in response to iron. This work tests the relationship between iron levels, mycorrhizal formation and corn growth responses to applied iron levels.

Materials and Methods

The substrate soil was formulated by mixing vermiculite with clay soil at a ratio of 1:2 (v/v). Three sample replicates of this soil mixture were analyzed after autoclaving to determine the base line iron content as described by Lindsay and Norvell [6]. Phosphorus was determined colometrically [7]. The native P content was found to be 2.82 $mgkg^{-1}$. The mixture was autoclaved for one hour, under pressure 1.05 kg/cm^2 and 121°C, allowed to set for 24 hours and then re-autoclaved for another hour. The pH of the soil mixture after autoclaving was 7.80.

The six iron fertility levels were: (1). 3$mgkg^{-1}$; (2). 10 $mgkg^{-1}$; (3). 20 $mgkg^{-1}$; (4). 40 $mgkg^{-1}$; (5). 80 $mgkg^{-1}$ and (6). 160 $mgkg^{-1}$. Iron was added to the soil/vermiculite mixtures as hydrated ferric nitrate. Soil mixtures were placed in 750 ml plastic pots. Experimental soil pots including the controls received soil solution sieved through a series of screen culminating with openings of a 35-μm to remove any native mycorrhizal spores. The VAM fungus *Glomus mosseae* maintained on Sudan grass (Sorghum vulgare Pers) in sand was the source of inoculum. Five grams of the VAM Sudan grass root-sand mixture were placed in a 5 cm deep hole made in the surface soil of each of 60 pots. Ten replicated pots were used as counterpart check control for each treatment. Each experimental control pot (60 pots) received 5 g of autoclaved Sudan grass root-sand mixture. The pots were planted with germinated seeds of *Zea maize* var. Golden cross bantam, obtained from Avco Seed Co., U.S.A. The pots were placed in a green house with a 12/12 hours light/dark photoperiod at 1000 lux and 27°C and watered with distilled water and/or with half standard Hoagland's solution without phosphorus and iron once a week [8].

Plant heights were recorded after 8 weeks and plants were harvested at soil level after an 8 week growing period and weighed (fresh and dry weights). The roots were washed free of soil and fixed in FAA (Formalin-acetic acid-ethylalcohol) for at least one day. Fixed roots were cut into 1 cm segments, cleared in 10% KOH and stained with trypan blue in fresh Lactophenol [9] and examined for presence of VA mycorrhizae.

Data were analyzed by a student's t-test for single comparison of means of mycorrhizal and non-mycorrhizal plants of the same treatment (within treatment means) and by Duncan's multiple range test for multiple comparison of means of mycorrhizal and non-mycorrhizal plants for all treatments.

Results and Discussions

No visual differences between mycorrhizal plants and non-mycorrhizal plants could be seen during the first 14 days but after 8 weeks considerable difference was observed (plate 1A-B). The growth response similarities between mycorrhizal and non-mycorrhizal plants in the first 2 weeks were attributed to some minerals not being depleted from the soil mixture and mycorrhizal infection not being well enough established. After eight weeks there were growth response differences between mycorrhizal plants and non-mycorrhizal plants. This can be explained on the basis of high mycorrhizal colonization (Table 3) which allows the mycorrhizal plants to transport more nutrients beyond the rhizospheric zone.

Plant height decreased as iron concentration increased (Table 1), as did average fresh and dry weight for both mycorrhizal and non-mycorrhizal plants (Table 2 and Plate 1). The average fresh and dry weights at the six levels of iron were much greater for mycorrhizal corn plants than for nonmycorrhizal. Fungus *G. mosseae* may stimulate the growth of mycorrhizal plants by allowing tolerance to high iron concentrations. Mycorrhizal colonization decreased as iron concentration increased, but the differences were not significant between 3 and 10 $mgkg^{-1}$, and 20 and 40 $mgkg^{-1}$, and 40 and 80 $mgkg^{-1}$ (Table 3 and Fig. 1).

Table 1. Mean height of both mycorrhizal (M^+) and non-mycorrhizal (M^-) corn plants grown at 6 iron levels ($mgFeKg^{-1}$) for 8 weeks (n=10).

parameter \ $mgFeKg^{-1}$		3	10	20	40	80	160
Plant height	M^+	a1 *2 33.463	b * 29.000	bc * 27.513	cd * 25.800	de * 24.750	e 22.750
	M^-	a * 31.442	b * 27.962	bc * 26.25	cd * 23.57	de * 22.413	e * 20.563

1. Mean for a given row followed by the same letter are not significantly different at the P=0.05 level according to Duncan's multiple range test.
2. Mean pairs in a single column with an * are not significantly different at the P=0.05 level according to student's t-test.

Table 2. Statistical analysis for fresh and dry weight for mycorrhizal (M^+) and non-mycorrhizal corn plants (M^-)

parameter \ mgFeKg^{-1}		3	10	20	40	80	160
Fresh weight	M^+	a1 *2 7.625	b 6.750	c 4.875	d* 3.500	e 2.375	f * 1.750
g/Pot	M^-	a * 7.125	b 6.125	c 4.125	d * 3.375	e 2.125	f * 1.625
Dry weight	M^+	a * 1.125	b 0.937	c 0.750	d 0.625	e 0.475	f * 0.265
g/Pot	M^-	a* 1.00	b 0.750	c * 0.625	d 0.500	e * 0.437	f * 0.250

1. Mean in a single row followed by the same letter are not significantly different at the P=0.05 level according to Duncan's Multiple Range Test.
2. Mean pairs in a single fresh weight and dry weight column with an * are not significantly different at the P=0.05 level according to a student's test.

Table 3. Statistical analysis of colonization percentage of mycorrhizal (M^+) and non-mycorrhizal plant (M^-)

parameter \ mgFeKg^{-1}	3	10	20	40	80	160
	a	a	b	bc	c	d
M^+	51	49	41	37	39	35
M^-	00	00	00	00	00	00

* Mean followed by the same letter are not significantly different at the P=0.05 level, according to Duncan's Multiple Range Test.

The low infection percent at high iron concentration might be attributed to the adverse affect of iron on the fungal growth which in turn reduces the uptake of P from the soil and it results in the poor growth of corn plants.

From the results of this work, we can conclude that *G. mosseae* has enhanced growth of corn plants in phosphorus deficient soil and it gave more tolerance to the plants against high concentration of iron in the soil.

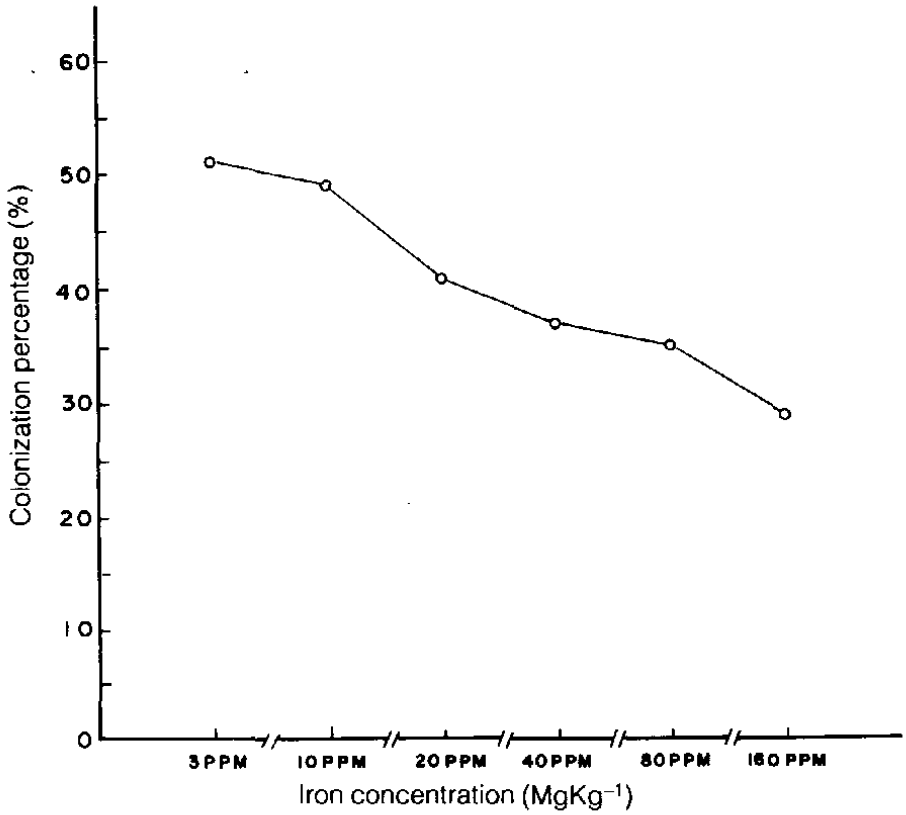
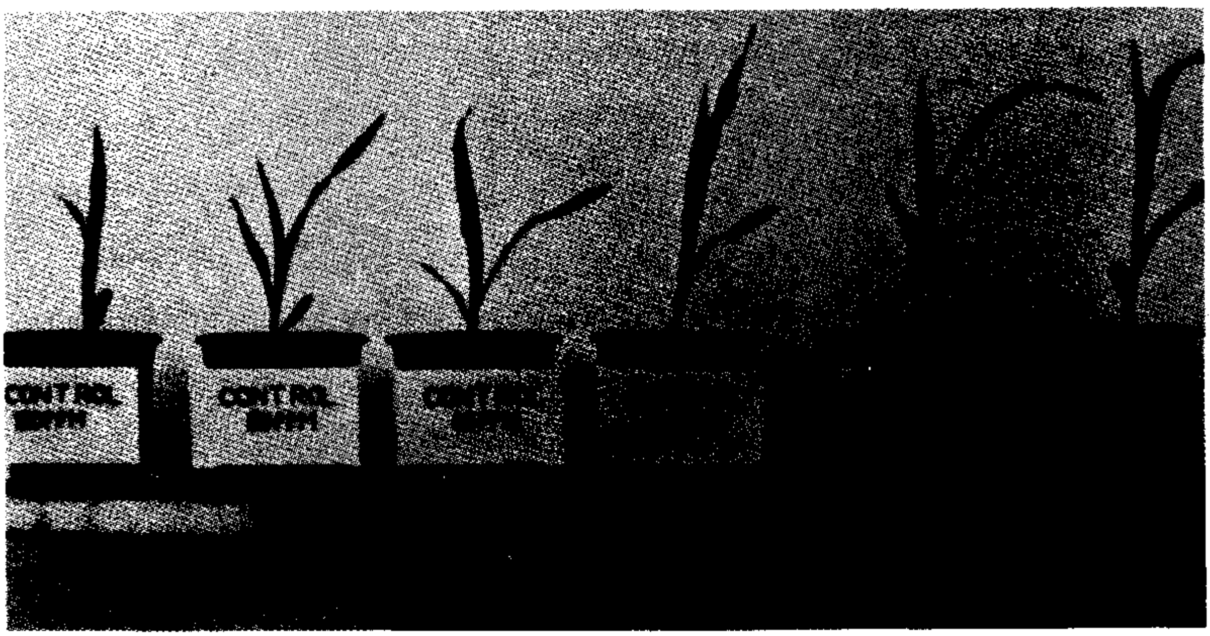


Fig. 1. Relationship between iron concentration and colonization percentage.



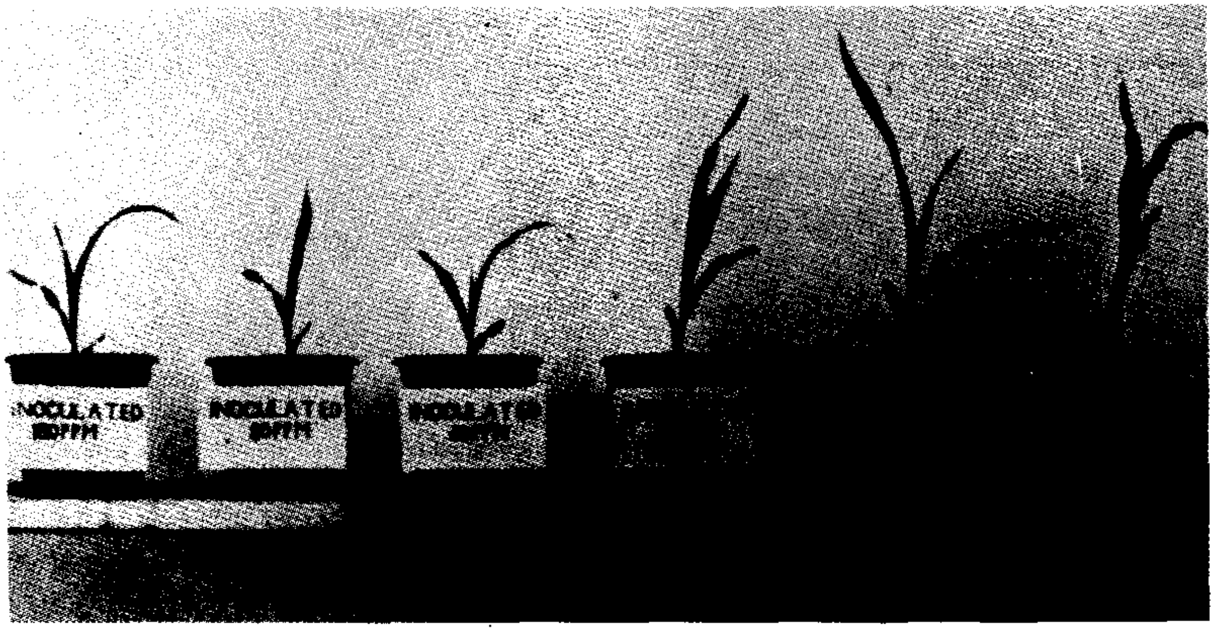


Plate 1. Comparision between inoculated (A) and noninoculated (B) corn plants after eight weeks.

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نمو نبات الذرة المُلقَّحْ بفطرة جلومس عند مستويات مختلفة من الحديد

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(سُلِّمَ في ٢ ربيع أول ١٤١٢هـ، وقُبل للنشر في ١٦ محرم ١٤١٤هـ)

ملخص البحث. تمت مراقبة نمو نبات الذرة المُلَقَّح بفطرة جلومس موسى وغير المُلَقّح عند ستة تراكيز من الحديد داخل البيت الزراعي المحمي خلال الإسبوعين الأولين، أما في الأسابيع الثمانية التالية فقد تم قياس الوزن الجاف والرطب وارتفاع النبات، وأظهرت النتائج أن نبات الذرة المُلَقَّح بهذه الفطرة أعطى نموًا يفوق ما أعطاه النبات غير المُلَقَّح وخاصةً عند التراكيز المنخفضة من الحديد (٣، ١٠، ٢٠، ٤٠ جزء من المليون) بينما عند التراكيز العالية (٨٠، ١٦٠ جزء من المليون) ليس هناك فرق بينهما بالإضافة إلى أن التراكيز العالية من الحديد أعطت انخفاضًا من معدّل نسبة الإصابة بهذه الفطرة. وبشكل عام أظهرت النتائج أن أنسب تركيز من الحديد الذي أعطى نموًا مناسبًا ونسبة عالية من الإصابة هو ٣ جزء من المليون.