Effect of Liquid Phosphorus (P) Fertilizer on Arbuscular Mycorrhizal Fungi (AMF) Association with Corn (*Zea mays* L.) Roots in the Field.

Binita Thapa[1], Jake E. Mowrer [1], Dennis L. Coker[1], Tony L. Provin[1] and Ronnie W. Schnell[1]

[1]Soil and Crop Sciences, Texas A&M AgriLife Extension Service

Abstract

Fertilization practices necessary to maintain current levels of intensive agriculture production are projected to result in eventual depletion of the primary phosphorus (P) fertilizer source, rock phosphate. There is an emerging recognition of the need to investigate techniques that enhance P uptake efficiency by crops. No-till field trials were conducted to assess the effect of P fertilizer rate and depth of placement on arbuscular mycorrhizal colonization (AMF) of corn roots to increase the access to plant available soil P to the plant. The result showed that significantly higher AMF colonization was found on no P applied treatment (control). Significant differences in AMF communities were observed between control (no addition of P fertilizer) and P treatment on 0 cm (surface), 10 cm and 20 cm below the soil surface. Our results indicated that P fertilization rate and depth may lead to root responses that affect interactions with AMF.

Introduction

Agriculture is one of the largest consumer of fertilizers. However, only a small percentage of applied phosphorus (P) from fertilizer is taken by the plants while remaining P is converted to insoluble complexes. Frequent and heavy dose of P fertilizer application are gradually depleting the non-renewable P reserve. This could threaten projected needs for providing food to a substantially increased population by the 21st century. On the other hand, excess P loading to natural water causes severe environmental pollution known as eutrophication of surface water. Hence, appropriate P management technology for sustainable agriculture is necessary to increase P-use efficiency in order to reduce environmental pollution while avoiding the rapid depletion of P reserves .

The application of soluble fertilizers in a localized zone or 'band' has been shown to increase P-use efficiency(1,2). And Arbuscular Mycorrhizal fungi (AMF) have symbiotic association with our major agricultural crops which are capable of mining the P nutrients that are attached to soil particles(3). It is well documented that growth of AMF is adversely affected by higher dose application of P fertilizer(4,5,6). The better understanding of AMF responses to P fertilizer is therefore a promising pathway to improving the use-efficiency of fertilizer and better P management in agricultural ecosystems.

The main objective of this study was to access the effect of banded soluble P fertilizer on arbuscular mycorrhizal fungi association in corn root in field condition.

Materials and Methods

- Experiments were conducted at Brazos Bottom farm and Stiles Foundation Farm in Texas. The soil at Brazos farm was a silty clay and at Stiles farm was heavy clay in texture.
- Experiments followed randomized complete block design (RCBD) using 3 depths (surface, 10cm and 20cm), 3 rates of P fertilizer (recommended, half and 1.5 times of recommended dose) and 5 replicates of each treatments.
- Field Sampling: Leaf tissue sample and corn roots were excavated at V10 stage.
- Leaf phosphorus was analyzed by using ICP-AES at Soil, Water and Forage Testing Laboratory.
- AMF colonization on both fertilizer-banded and non-banded side was quantified by ink-vinegar staining(7).
- Root density was measured using Image J software.
- Grain yield measured by combine-equipped yield monitor.
- Statistics: Data sets were analyzed by using SAS software. Means compared by Tukey's Honestly Significant Differences test.

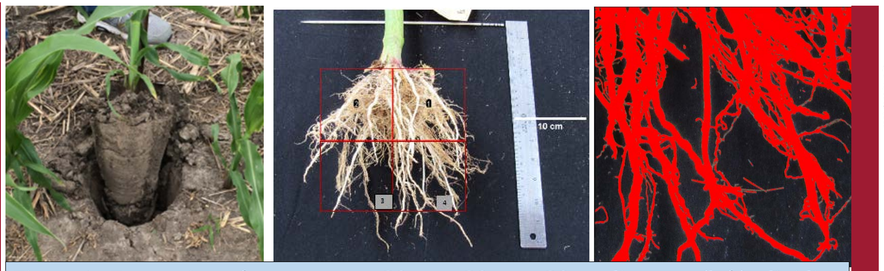

Figure 1: Excavation of corn root on 20cm x 20cm x 20cm diameter (left), dividing roots into four quadrants of rectangle size 10cm x 10cm (middle) and color threshold of one quadrant used for root density measurement (right).

Results and Discussion

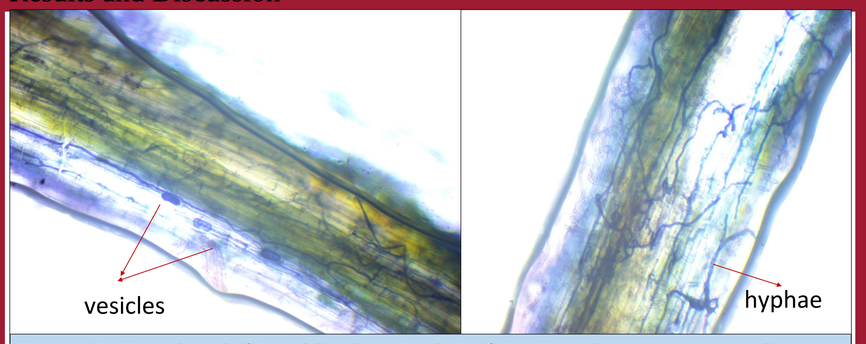

Figure 2: Vesicles (left) and hyphae (right) of AMF under microscope showing AMF colonization on corn root

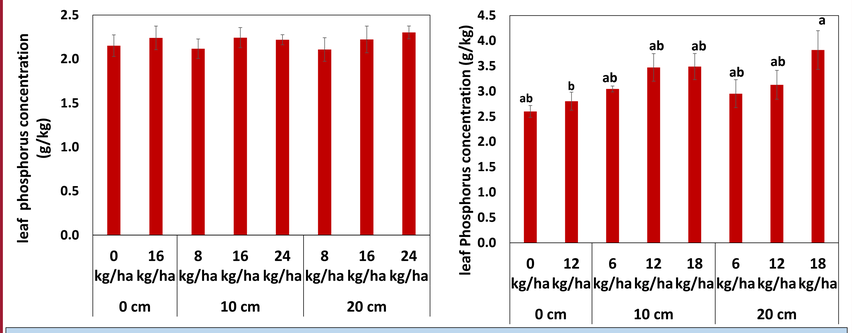

Figure 3: Leaf P concentration on Brazos farm (left) and Stiles Farm (right)

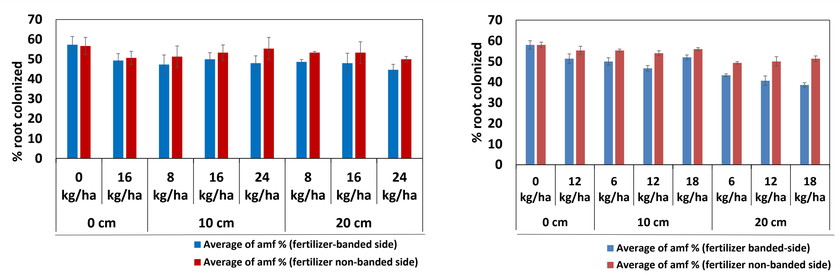

Figure 4: AMF colonization on fertilizer banded-side and non-banded side of Brazos farm (left) and Stiles farm (right)

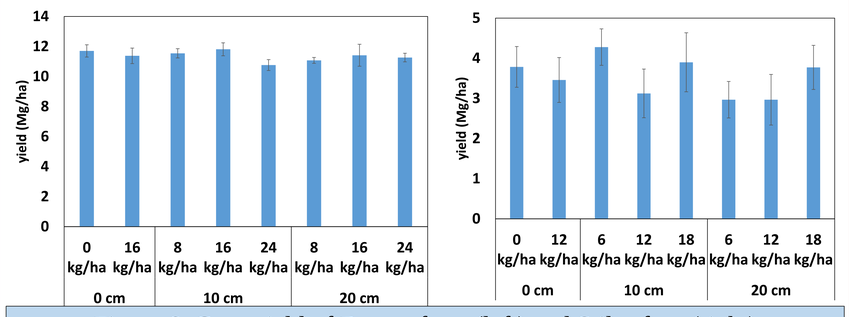

Figure 6: Corn yield of Brazos farm (left) and Stiles farm(right)

Acknowledgement

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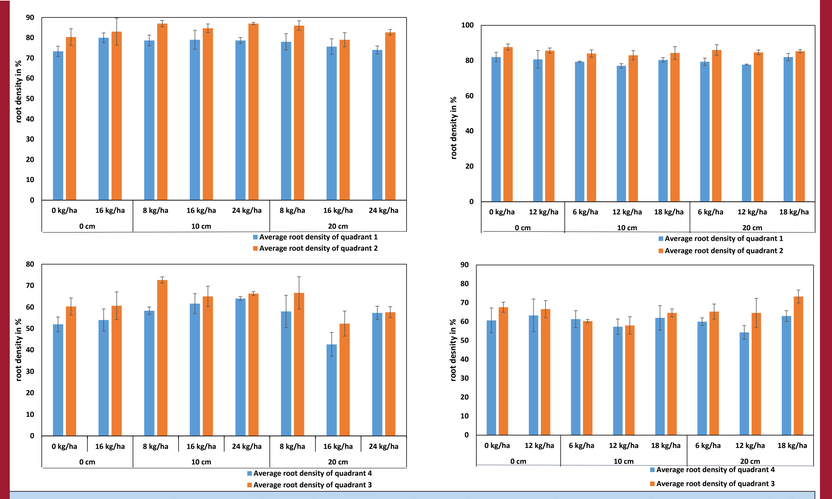

Figure 5: Root density of quadrant 1 and quadrant 2 of Bottom farm (upper left) and Stiles farm (upper right) and root density of quadrant 4 and quadrant 3 in Brazos farm (lower left) and Stiles farm (lower right).

Results and Discussion

Leaf P concentration (Figure 3):

- Lowest P concentration was found no P added treatment.
- Leaf P concentration increased with increased P rate.
- Significantly higher P concentration was observed on treatments receiving P at the rate of 18kg/ha applied at 20cm deep.

AMF colonization on root (Figure 4):

- Colonization of AMF percentage was higher in no P application treatment compared to other higher rates.
- With the increase on depth and P rate application AMF colonization was reduced.
- Paired t-test comparing roots of fertilizer-banded side and non-banded side were significantly different.

Root density (Figure 5):

- Higher root density was observed on quadrant 2 (fertilizer non-banded side) compared to quadrant 1 (fertilizer banded side) on both farms.
- Higher root density was observed on quadrant 3 (fertilizer non-banded side) compared to quadrant 4 (fertilizer banded side) on both farms.
- Root density differences from banded side to non-banded side of each corn plant was highly significant as tested by paired t-test.

Yield (Figure 6):

- Higher yield was observed in Bottom farm and lower yield was found in Stiles farm. As rainfall was very low at Stiles farm and 5.6 Mg/ha yield goal was not met
- No significant differences were observed with the rate and different depth placement of P fertilizer.

Conclusion

- Significant higher AMF root colonization was found on no application of P fertilizer.
- Significant differences were found on different rate and different depth of liquid P fertilizer application.

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