Versatility of Mycorrhizal Fungi Applications to Increase Maize Productivity

Crop Physiology

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OBJECTIVE: ***Identify mycorrhizal fungi application methods with the greatest efficacy on maize grain yield and fertilizer nutrient use efficiency.***

INTRODUCTION

- Phosphorus (P) is one of the most important mineral nutrients for maize growth; however, extensive P fertility applications can result in environmental losses and P fertilizer reserves are being depleted.
- Agricultural soils contain large amounts of total P, but only a small fraction is in plant-available forms. Also, fertilizer P use efficiency is low due to high rates of P-fixation with soil cations. By striving for higher grain yields, US maize growers have continually increased planting densities each year, resulting in smaller rooting systems.
- Future challenges of accumulating immobile nutrients like P, indicate the need for improved management practices associated with P fertilization.
- Mycorrhizal fungi are a potential way to increase plant-available P levels in the rhizosphere by acting as an extension of the maize root system to improve grain yields in a sustainable manner.

MATERIALS AND METHODS

Three field experiments were conducted at Champaign, Illinois during the 2018 and 2021 growing seasons. All trials were planted at a density of 89,000 plants ha^{-1} following soybean under conventional tillage. Experimental units were plots, four rows wide and 11.4 m in length with 0.76 m row spacing, arranged in a randomized complete block experimental design with six replications.

Trial 1

- **Base Fertility:** 200 kg N ha^{-1} pre-plant broadcast as urea ammonium nitrate (UAN; 32-0-0) to ensure adequate N availability.
- **Experimental Treatments:** Untreated control (UTC) compared to *MycoApply EndoPrime SC* (*MycoApply*; Valent U.S.A. LLC) applied in-furrow (Figure 1) at planting at 0.15 L ha^{-1} with water as a carrier.

Trial 2

- **Base Fertility:** 200 kg N ha^{-1} pre-plant broadcast UAN to ensure adequate N availability.
- **Experimental Treatments:** UTC, ammonium polyphosphate (APP; 10-34-0), and *MycoApply* at 0.15 L ha^{-1} with APP as a carrier applied in-furrow at planting. APP was applied at 22 kg P_2O_5 ha^{-1}.

Trial 3

- **Experimental Treatments:** UTC, slow-release polymer-coated urea (SR urea; 46-0-0; Pursell Agri-Tech), and *MycoApply* impregnated inside polymer coating of SR urea at 0.15 L ha^{-1}. SR urea treatments applied at 168 kg N ha^{-1}.

Figure 1. Applying *MycoApply* in-furrow at planting.

Figure 2. Mycorrhizal fungi mycelia on maize roots.

RESULTS AND DISCUSSION

Effects of *MycoApply* in a Standard Management System

Fungal colonies did not form on the untreated plant roots, but did in all plots receiving *MycoApply* in-furrow (Table 1). Mycorrhizal mycelia on maize roots are shown in Figure 2.

Although *MycoApply* led to mycorrhizal growth on maize roots, there were minimal effects of this inoculant on grain yield or yield components (Table 1).

Table 1. The effect of *MycoApply* in-furrow treatment on V8 root mycorrhizal fungi colonization, grain yield, and yield components for maize at Champaign, IL in 2018. Grain yield and kernel weight expressed at 0% moisture.

Treatment	Mycorrhizal Colonies	Grain Yield	Kernel Number	Kernel Weight
	% mycelia coverage	Mg ha^{-1}	kernels m^{-2}	mg kernel^{-1}
UTC	0	12.6	4689	268
MycoApply	15	12.7	4702	273
LSD (0.10)	2	NS	NS	NS

Table 2. The effect of APP and *MycoApply* in-furrow treatment on grain yield and yield components for maize at Champaign, IL in 2021. Grain yield and kernel weight expressed at 0% moisture.

Treatment	Grain Yield	Kernel Number	Kernel Weight
	Mg ha^{-1}	kernels m^{-2}	mg kernel^{-1}
UTC	14.4	5112	281
APP	14.7	5362	274
APP + *MycoApply*	15.0	5456	281
LSD (0.10)	0.6	194	NS

Synergies of *MycoApply* with Phosphorus Fertility

There was a synergistic effect of combining *MycoApply* with APP, resulting in a yield increase of 0.6 Mg ha^{-1} compared to the UTC (Table 2).

Maize treated with APP and *MycoApply* produced the greatest number of kernels with the same average kernel weight as the UTC (Table 2). However, APP treatment alone tended to result in lower kernel weight (Table 2). This finding infers that *MycoApply* treatment had a season-long effect on P availability, resulting in improved plant health during grain fill.

Innovative *MycoApply* Application Method

There was a synergistic effect of treating *MycoApply* in the SR urea polymer coating, resulting in a yield increase of 0.4 Mg ha^{-1} compared to SR urea alone (Table 3).

Grain yield increases due to *MycoApply* application were a function of greater kernel production, with a similar kernel weight compared to SR urea alone (Table 3).

Table 3. The effect of slow-release urea and *MycoApply* in-furrow treatment on grain yield and yield components for maize at Champaign, IL in 2021. Grain yield and kernel weight expressed at 0% moisture.

Treatment	Grain Yield	Kernel Number	Kernel Weight
	Mg ha^{-1}	kernels m^{-2}	mg kernel^{-1}
UTC	7.9	3339	237
SR Urea	13.5	5303	255
SR Urea + *MycoApply*	13.9	5522	253
LSD (0.10)	0.4	426	NS

CONCLUSIONS

- **The positive effects of mycorrhizal fungi on maize grain yields are greater when applied in close proximity to concentrated fertilizer applications.**
- **Mycorrhizal fungi may keep fertilizer in plant-available forms.**
- **Yield responses from various application methods show the versatility of mycorrhizal fungi inoculants in maize production.**

Special thanks to Valent U.S.A and Pursell Agri-Tech for supporting this research.