Jump Starting Mycorrhizal Colonization in Corn Following Non-host Crop – First Trial Year

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Introduction

Corn is dependent on root association by vesicular arbuscular mycorrhizal (VAM) fungi to maximize its nutrient uptake from the soil. These fungi take up residence within the root tissue and extend their hyphae out into the soil. Through their hyphae, the fungi supply the plant with additional minerals and water as if they were an extension of the plant's own root hair system. In return, the plant supplies the fungi with carbohydrates built through photosynthesis. The majority of plant species are known to form such associations and the level of dependence varies. However, some crops like canola and beets are not hosts to mycorrhizal fungi. The active population of these beneficial organisms decreases when there is not a host crop present for an extended period of time. It has been observed that corn performance may decrease if the soil is left fallow (Kabir et al 1999). Some producers also observed decreased yields after non-host crops like sugar beets (Field Facts 2005). Though the spores of the mycorrhizal fungi can be found even after a decade of the absence of a host crop, in such circumstances it takes longer for the association between host plant and fungi to form, during which time the crop may not produce its full yield potential. It is hypothesized that by growing a mycorrhizal winter cover crop after the non-host crop, the population of active VAM fungi can be increased by the time of corn planting. There are also commercially available mycorrhizal inoculants that can be applied with the seed. Currently, the cover crop option is by far the cheaper method, however the timeframe in which a cover crop can be grown after a cash crop is relatively short in our climate and may not be enough to substantially increase the population of mycorrhizal fungi. For this reason it's also worth looking at inoculants as a means of boosting yield, in the hope that they might be cheaper in the future. This research aims to answer questions regarding these two options.

Table1. Treatment structure

Trt no.	Previous Crop	Inoculant	Cover Crop	Trt Name
1	Soybean	no	no	soy
2	Soybean	yes	no	soy+I
3	Soybean	no	yes	soy+C
4	Soybean	yes	yes	Soy+I+C
5	Canola	no	no	canola
6	Canola	yes	no	canola+I
7	Canola	no	yes	canola+C
8	Canola	yes	yes	canola+I+C
9	Beet	no	no	Beet
10	Beet	yes	no	Beet+I
11	Beet	no	yes	Beet+C
12	Beet	yes	yes	Beet+I+C

Trial description

In this study corn was planted after canola or sugarbeet, which are both non-mycorrhizal crops that are commonly grown in North Dakota. As a comparison, corn was planted after soybeans as well. Soybean has a strong association with VAM fungi. For each of these crop histories, there were four treatments meant to impact the corn roots' mycorrhizal associations: 1) a rye cover crop planted in the fall after harvest of the previous crop and terminated two weeks prior to corn planting 2.) a mycorrhizal inoculant planted with the seed, 3.) a combination of the rye cover crop and the inoculant 4.) no mycorrhizal treatment as a control. The complete treatment structure is displayed in Table 1. At the 6-leaf stage corn roots were collected from each plot for mycorrhizal quantification using the grid intersect method (Giovannetti and Mosse 1980). Above-ground plants were also collected at this time for tissue nutrient analysis. Plant heights and NDVI readings were taken at the 6-leaf stage as well.

Results

Data collected at the 6-leaf stage of corn showed that corn planted after soybeans was taller, more vigorous and contained more phosphorus, zinc and copper in its tissue than corn grown after the two non-mycorrhizal crops (Fig. 1-4). The roots of those plants were also colonized by VAM fungi at a higher rate (Fig. 5). There was a strong correlation between the level of mycorrhizal root colonization and phosphorous content in the above-ground biomass of corn at this stage (Fig. 6). It was expected that the greener and more robust plants at this stage would translate into increases in yield as well. However, this was not the case (Fig. 7). In fact, the yields from the soybean plots were slightly lower than those from the other plots, albeit not significantly. Within each previous crop treatment, the ones with the rye cover crop and no-inoculant had the highest yield numerically, but the difference was very small. Grain phosphorus content also did not show a significant response to treatments, but numerically the P content of grain from the soybean plots was higher for each of the respective mycorrhizal management treatments than for the other two crops. There was no obvious effect of the commercial inoculant on either mid-season growth or yield.

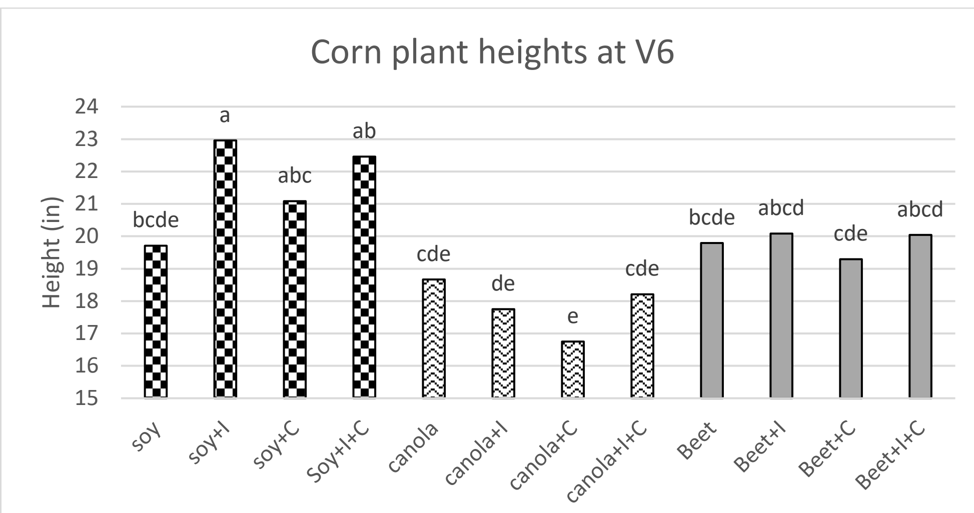

Figure 1. Corn plant heights taken at the 6-leaf stage.

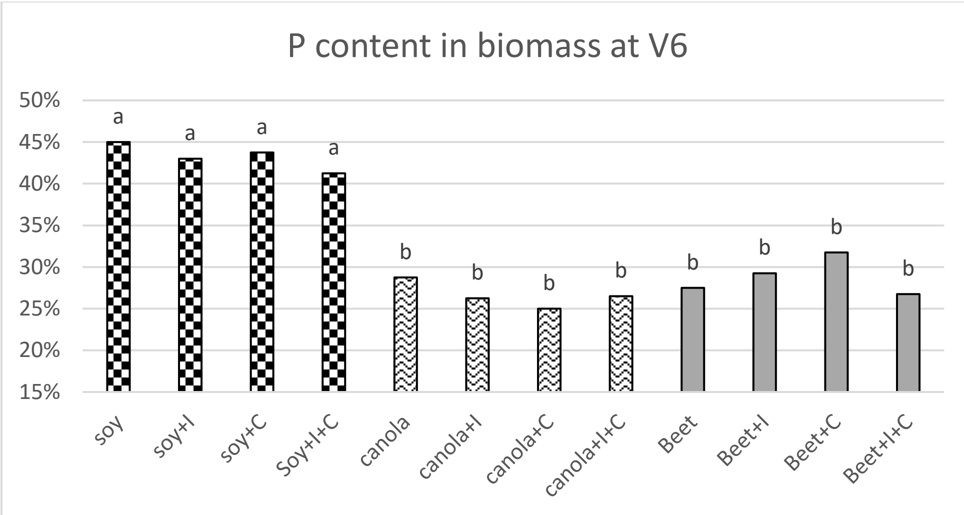

Figure 2. Corn biomass phosphorus content at the 6-leaf stage.

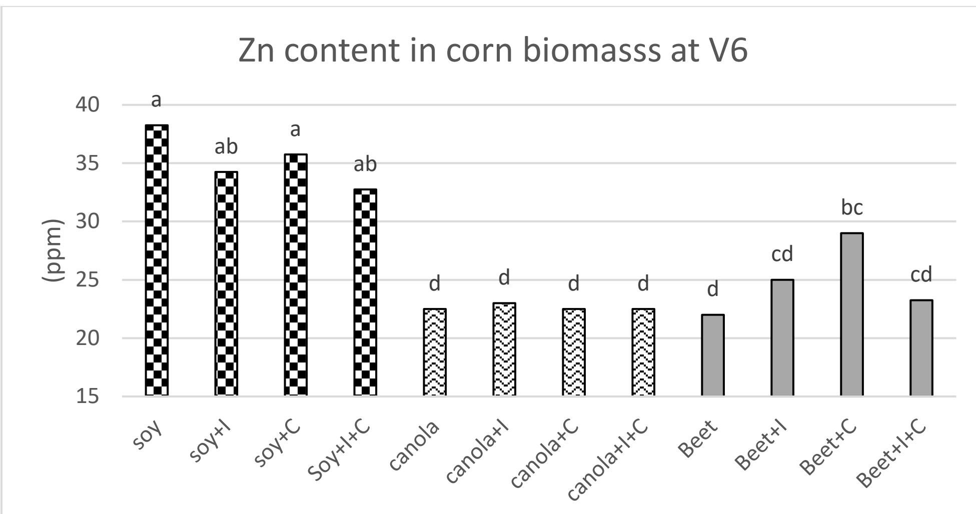

Figure 3. Corn biomass zinc content at the 6-leaf stage.

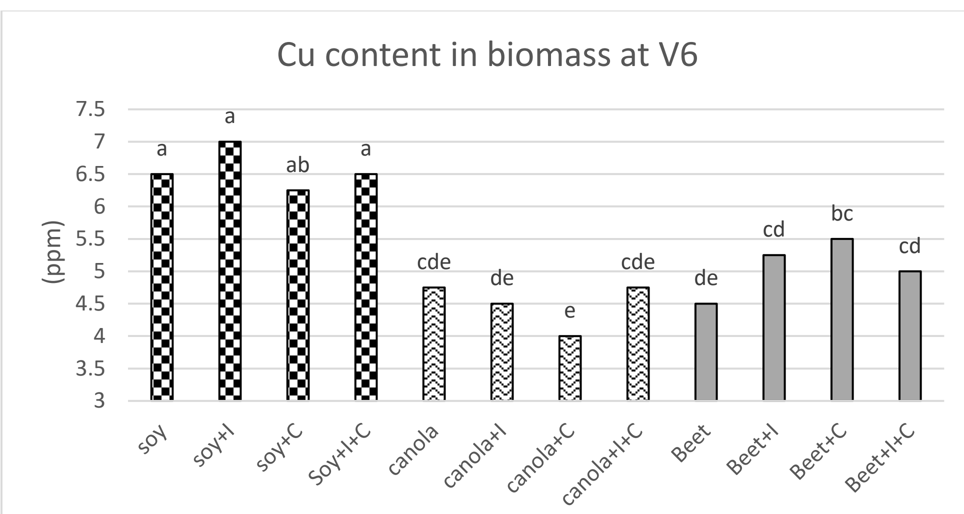

Figure 4. Corn biomass copper content at the 6-leaf stage.

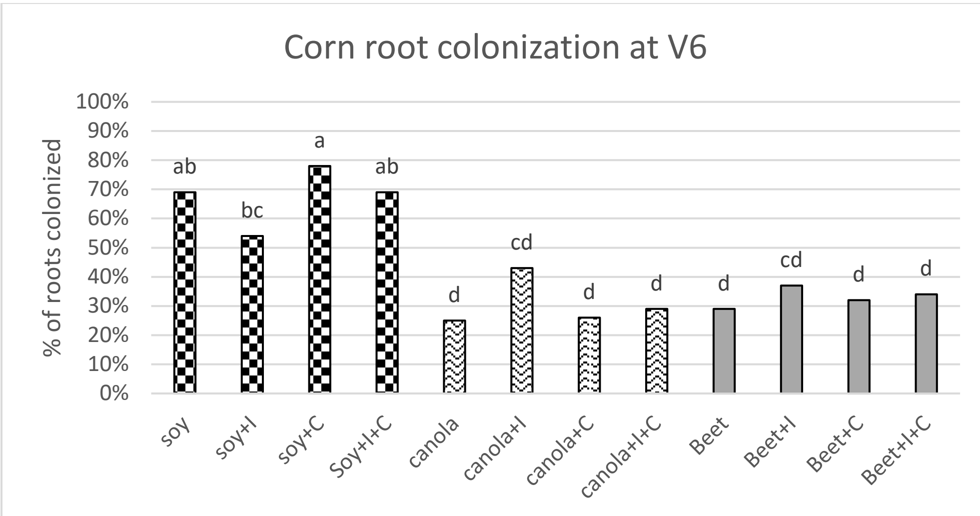

Figure 5. Rate of corn root colonization by VAM fungi at the 6-leaf stage of corn.

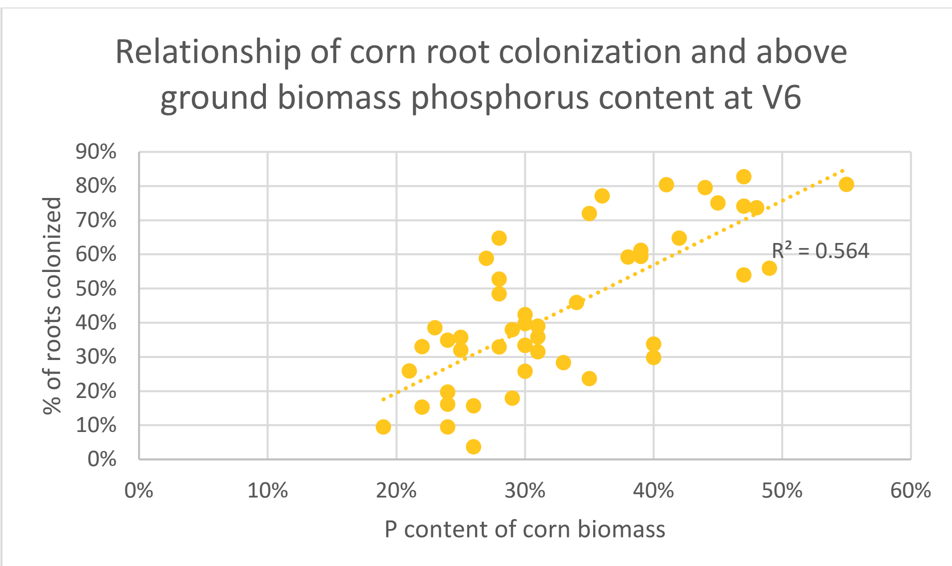

Figure 6. Relationship of the observed VAM fungi colonization of corn roots to the phosphorus content of the above-ground biomass at the 6-leaf stage of corn.

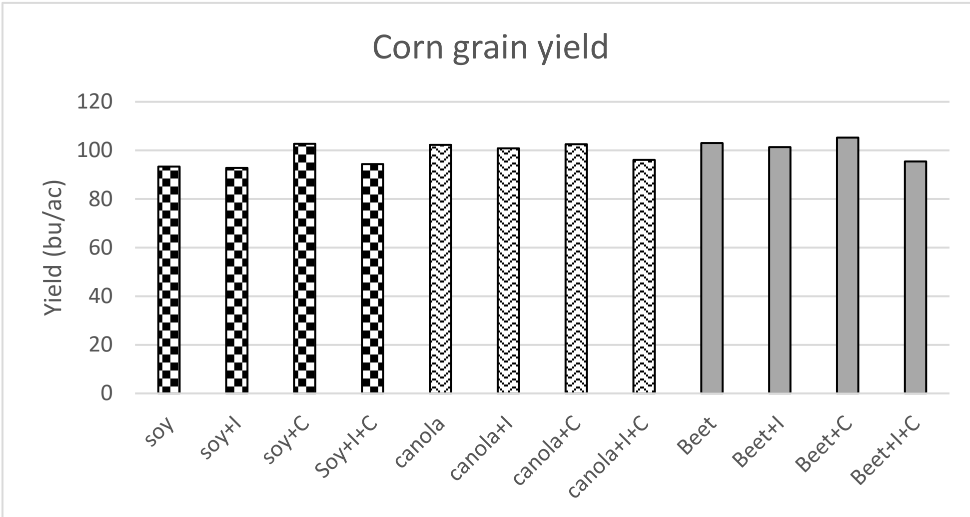

Figure 7. Corn grain yield.

Mycorrhizal symbiosis is a two-way street between the fungi and the plants. The plant has to support the fungi in exchange for the extra nutrients they provide. Corn roots from all the treatments and all the plots were colonized. The root colonization difference was not in the presence or absence of the symbiosis, but in the magnitude. It is possible that the level of colonization to maximize corn yield was achieved by even the least colonized corn plants and there was no added yield benefit to a higher density of VAM fungi in the roots, despite the boost in growth they gave the plants early in the season.

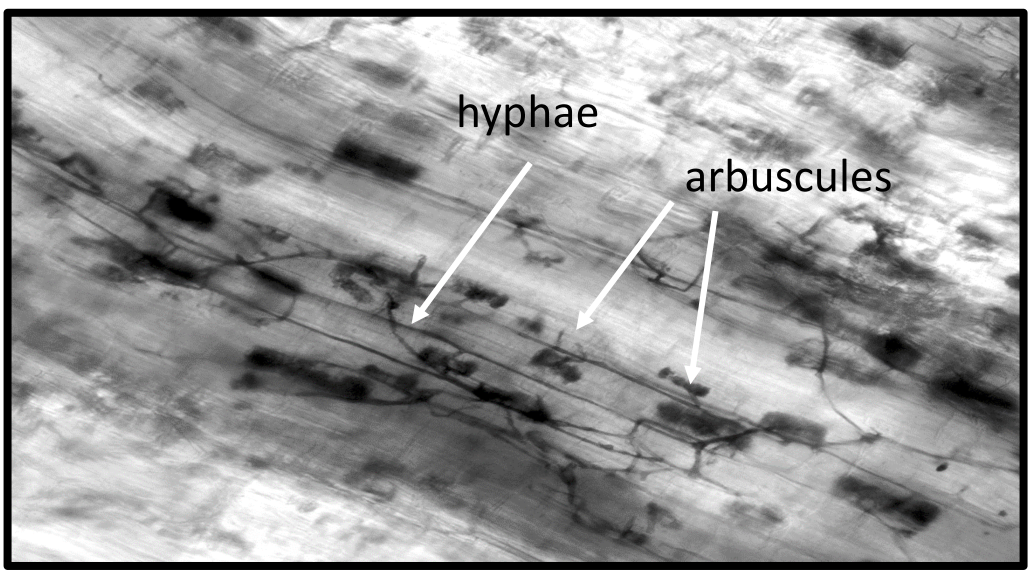

Figure 8. Ink staining reveals mycorrhizal structures in corn root colonized by VAM fungi.

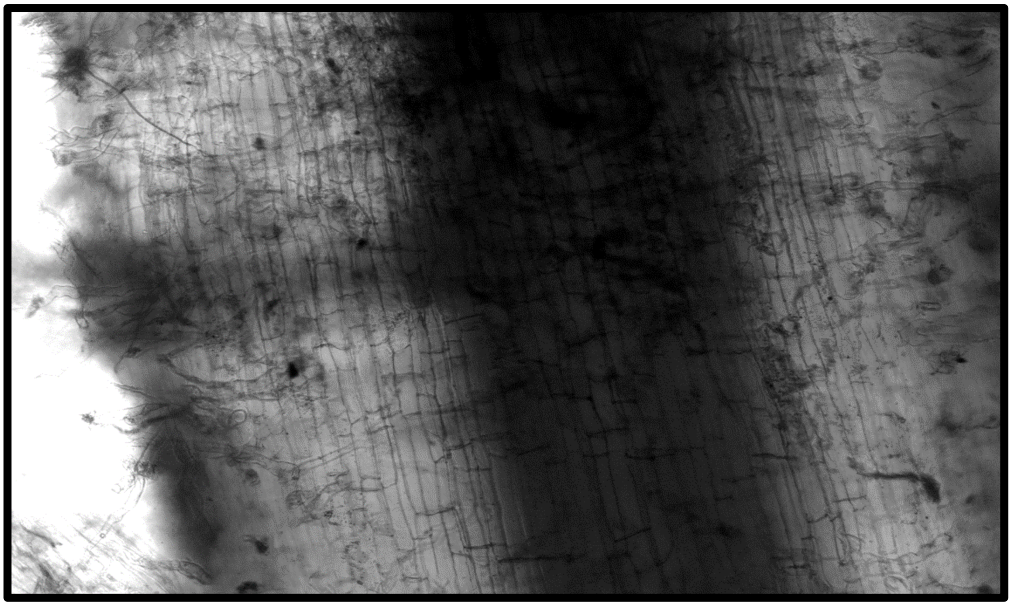

Figure 9. Ink-stained corn root showing no colonization.

This was the first year of this trial and the results are not conclusive. It is likely that the effects of mycorrhizal colonization on corn vary with environmental conditions related to soil and climatic factors. For this reason, the trial will be repeated in the 2021 growing season.

References

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