Mycorrhizae Effects Measured by Plant Growth and Plant Stress in *Sorghum Bicolor* and *Sorghastrum Nutans*

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Introduction

- Plants and arbuscular mycorrhizae have a symbiotic relationship in which both plants and fungus benefit. Plants feed the mycorrhizae and the mycorrhizae help increase nutrients and water absorption in the plant.
- Plant stress plays a role in both the production of chlorophyll and the overall amount of biomass a plant produces. In this study, chlorophyll content was used to indicate how much stress a plant was under based on the assumption that, the more stress a plant is under, the more chlorophyll a plant will produce. Meaning that more stress on a plant will yield greater chlorophyll and less biomass.
- Synthetically produced mycorrhizae or "commercial mycorrhizae" is more effective than mycorrhizae that has developed in the wild. The effectiveness of synthetic mycorrhizae has been improved through years of experiments that have allowed higher yields in plant growth and nutrient uptake putting the plant under less stress.
- The growth rate in the stems of the plants will be highest in the presence of both commercial and wild mycorrhizae because the mycorrhizae will provide assistance in growth of the plants; when separated, growth rate will be higher when in the presence of only the commercial rather than only the wild.
- The presence of mycorrhizae will lower the chlorophyll content in the plants due to the expectation that the stress levels being exerted on the plants will be lowered with the help of mycorrhizae.

Methods

- 48 pots total of *Sorghastrum Nutans* (Sn) and *Sorghum bicolor* (Sb) were separated under the four different categories shown below.

6 Sb Live soil Inoculated	6 Sn Live soil Inoculated
6 Sb Live soil Non inoculated	6 Sn Live soil Non inoculated
6 Sb Sterilized soil Inoculated	6 Sn Sterilized soil Inoculated
6 Sb Sterilized soil Non inoculated	6 Sn Sterilized soil Non inoculated

- Live = Live Mycorrhizae
- Sterilized = No Live Mycorrhizae
- Inoculated = Commercial Mycorrhizae
- Non Inoculated = No Commercial Mycorrhizae

- Measurements of stem height (cm) and chlorophyll content were recorded weekly for three weeks using a ruler and SPAD meter.
- On the last week, we also extracted the plants from the pots and bagged them to further measure biomass.
- We performed ANOVA tests to compare groups using the software SPSS.
- We calculated growth rate using the following formula and dividing the outcome by N (number of total weeks):

$$PR = \frac{(V_{Present} - V_{Past})}{V_{Past}} x\,100$$

- Vpresent = 1st week stem height measurement
- Vpast = 3rd week stem height measurement

Literature Cited

[1] ABDEL-FATTAH, G.M., A.H. MOHAMEDIN. 2000. Interactions between a vesicular-arbuscular mycorrhizal fungus (Glomus intraradices) and Streptomyces coelicolor and their effects on sorghum plants grown in soil amended with chitin of brawn scales. *Biology and Fertility of Soils* 32: 405-409. **[2]** ALLEN, M.F., W.K. SMITH, T.S. MOORE, M. CHRISTENSEN. 1981. Comparative Water Relations And Photosynthesis Of Mycorrhizal And Non-Mycorrhizal Bouteloua Gracilis H.b.k. Lag Ex Steud. *New Phytologist* 88: 683–693. **[3]** BARBANTI, L., A. SHER, G.D. GIROLAMO, E. CIRILLO, M. ANSAR. 2015. Growth and Physiological Response of Two Biomass Sorghum (Sorghum Bicolor (L.) Moench) Genotypes Bred for Different Environments, to Contrasting Levels of Soil Moisture. Italian Journal of Agronomy. Available at:http://www.agronomy.it/index.php/agro/article/view/673/783 **[4]** KINDSCHER, K., L. TIESZEN. 1998. Floristic and Soil Organic Matter Changes after Five and Thirty-Five Years of Native Tallgrass Prairie Restoration. *Restoration Ecology* 6: 181-196. **[5]** NISSEN, S.J., T.M. STERLING, D. NAMUTH. n.d. Foliar Absorption and Phloem Translocation. *Plant and Soil Sciences eLibrary.* Available at: http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1056648673&topicorder=4&maxto=5 **[6]** PATERSON, A., J. BOWERS, R. BRUGGMANN, I. DUBCHAK, J. GRIMWOOD. 2009. The Sorghum bicolor genome and the diversification of grasses. *Nature* 457: 551-556. **[7]** PAVLOVIC, DANIJELA, B. NIKOLIC, S. DUROVIC, H. WAISI, A. ANDELKOVIC, D. MARISAVLJEVIC. 2014. Chlorophyll as a measure of plant health: Agroecological aspects, *Pestic. Phytomed/ (Belgrade), 29(1), 21-34.* **[8]** RESENDES, M.L., D.R. BRYLA, D.M. EISSENSTAT. 2008. Early events in the life of apple roots: variation in root growth rate is linked to mycorrhizal and nonmycorrhizal fungal colonization. *Plant and Soil* 313: 175–186.

Graphs and Tables

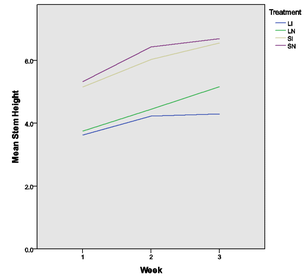

Figure 1: Growth rate calculated over a time period of three weeks using mean stem height in centimeters for each treatment (LI, LN, SI, SN).

TREATMENT	CALCULATED GROWTH RATE
LI	8.21%
LN	14.26%
SI	9.57%
SN	6.93%

Table 1: Calculated numerical growth rate for each treatment (LI,LN,SI,SN)

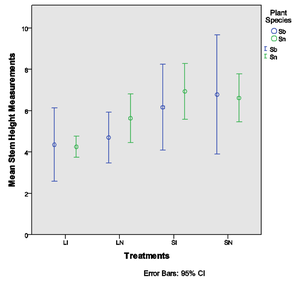

Figure 2: Mean stem height and range of stem heights in centimeters of each species (Sb, Sn) for each treatment (LI,LN,SI,SN).

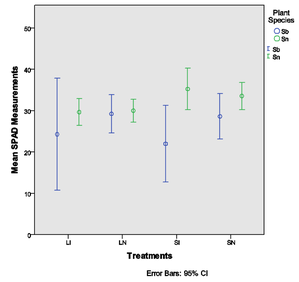

Figure 3: Mean SPAD measurements and range of measurements of each species (Sb, Sn) for each treatment (LI,LN,SI,SN).

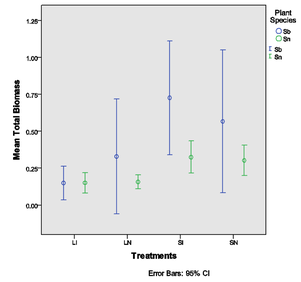

Figure 4: Mean total biomass measurements and range of measurement of each species (Sb, Sn) for each treatment (LI,LN,SI,SN).

TRAIT	F STATISTIC	P-VALUE: OVERALL	P-VALUE: PLANT SPECIES	P-VALUE: SOIL TREATMENT	P-VALUE: SOIL AND INOCULUM TREATMENT INTERACTION
STEM HEIGHT	3.360	0.007	0.408	<0.001	0.408
SPAD MEASUREMENTS	2.690	0.023	0.003	0.428	0.961
TOTAL BIOMASS	4.026	0.002	0.007	<0.001	0.221

Table 2: Calculated P-values and F-values for the overall measurements and specific interactions of each variable (stem height, SPAD measurements, above/below ground biomass). P-value of 0.05 or less constitutes a significant difference.

Species Sn; treatments from left to right are: LN, LI, SI, SN

Species Sb; treatments from left to right: LN, LI, SI, SN

Results

- Growth rate (Figure 1 and Table 1)
  - Similar growth rates were found between treatments (LI=8.21%, LN=14.26%, SI=9.57%, SN=6.93%)
  - LN had highest percent growth at 14.26%
- Stem Height (Figure 2 and Table 2)
  - A two-way ANOVA found significant difference overall (0.007) and between soil treatments (<0.001) yet not for plant species (0.408) nor interaction between soil and inoculum treatments (0.408)
  - Soil containing wild mycorrhizae produced smaller (on average) plants than the sterilized soil
- SPAD (Figure 3 and Table 2)
  - A two-way ANOVA found significant difference overall (0.023) and between plant species (0.003) but not for soil treatment (0.428) nor interaction between soil and inoculum treatments (0.961)
  - Species Sn expressed higher chlorophyll content (on average) regardless of treatment
- Biomass (Figure 4 and Table 2)
  - A two-way ANOVA found significant difference overall (0.002), between plant species (0.007) and between soil treatment (<0.001) but not for the interaction between soil and inoculum treatments (0.221)
  - Species Sb expressed larger total biomass for every treatment and was largest in the sterilized soil treatments
- Within and between group variance (Table 2)
  - F-values for each trait measured were all less than five; smallest was SPAD measurements (3.360) and largest was total biomass (4.026)
  - High degree of within group variance clearly visible in species Sb compared to Sn (Figures 2,3, and 4)

Discussion

- Our hypotheses concerned the relationship between increased growth and decreased stress when in the presence of both wild and commercial mycorrhizae; however the interactions between the soil and inoculum treatment produced insignificant results for each plant trait measured.
- Across the board, our data collected did not support either of our hypotheses. For stem height, it actually resulted in being the opposite as we predicted; the SN treatment produced the tallest plants and LI produced the smallest; possibly due to the time constraint the experiment was under.
- For stress level, there was no clear interpretation of the effect of mycorrhizae on SPAD measurements per treatment; however, we can slightly take away from Figure 3 that Sn had a higher amount of chlorophyll production than Sb. As a comparison for species, the prairie grass (Sn) seemed to be undergoing more stress [5] to grow at a similar rate to the agricultural species (Sb).
- The biggest effect recorded stemmed from the type of soil used: sterile vs. live. There was a significant difference in two of the three traits measured, stem height and biomass, when focusing only on the p-value of soil treatment. For both traits, the sterile soil had the greatest positive effect maybe due to the possibility that harmful elements contaminated the natural soil, so when sterilized it was cleared of hindrances to growth.
- Further investigation can be to experiment with a variety of agricultural and prairie species to determine if there is a clear difference of effect from mycorrhizae on the specie types specifically; this can be done by manipulating mycorrhizae presence in multiple species of each agricultural and prairie type.

Acknowledgements

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