Mycorrhizal Relations in Sweet Sorghum

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ABSTRACT

Sorghum has world-wide importance because of its significance in food, feed, and energy production. Mycorrhizal relations in sorghum help in adaptation to harsh environments such as high salt and draught conditions. We examined the natural tolerance of sorghum for salt and observed the formation of endomycorrhizae in roots. Five varieties of sorghum (Keller, M8IE, Della, Dale, and DK28E) were grown in greenhouse using soil and Hoagland's solution as media. Salt levels ranged from 0 to 200 mM NaCl that were added during watering periods. After two months of growth, sorghum roots were rinsed with tap water to remove adhering soil particles. Roots were cut to 1 inch in length and placed in petri-dishes containing 2% acetic acid solution. Staining was done by initially blanching the roots in 10% KOH solution for 3 minutes followed rinsing with deionized water for 30 seconds. Cleaned roots were placed in a 30 mL beaker containing 5% Parker® red ink in acetic acid solution and boiled for 3 minutes. The excess red ink was removed by washing the roots with deionized water. Four pieces of root were placed on a microscope slide where they were gently pressed with slide cover, sealed and labeled. Such prepared slides were observed under a Hitachi microscope at 2000-4000µm magnification and pictures were taken. Analysis of pictures indicated that mycorrhizae have formed in all varieties tested. Growth analysis results indicated that sorghum growth was enhanced by increasing salt level.

INTRODUCTION

Sorghum is an important crop, especially in countries of the semiarid tropics of Asia, Africa and the Middle East where it is used as a cash crop and staple food source. In 2010, world-wide production of sorghum exceeded 556 million tons; and the United States ranked first with an output of 9.7 million tons. Other growers including Nigeria, India, the Sudan, Ethiopia, Australia, Brazil, China (in total 15 counties) produced a substantial amount of the crop. Although the U.S. exports most of its sorghum, most developing counties consume all of what they produce internally. In sub-Saharan nations sorghum is used for making bread, porridge, syrup, cake, cuscus, tortilla, cereal, etc.; most recently the U.S is exploring its value as a source of "bio-energy" for the production of gasohol.

The influence of mycorrhizal symbiosis in host plant adaptation to temperature and water stress in agronomic crops has not been explored to a great extent. Sorghum (Sorghum vulgaris) is known to form mycorrhizal relations with at least two soil-borne fungi, Glomus intraradices and Gigaspora margarita. However, the symbiotic association of sweet sorghum (Sorghum bicolor L.) with fungi has not been recorded. This is in light of the fact that the osmotic relations and draught tolerance assessment of various mycorrhizal crop plants has been detailed in the literature. This research explored the potential of mycorrhizal sweet sorghum to withstand extreme salt conditions. Since sweet sorghum is grown in many parts of the world that have arid to semi-arid climate, and serves as a staple diet in those regions, it would be significant to explore how mycorrhizae would improve adaptation of the host plant to various environmental stressors while maintaining acceptable yield. The study further examined the salt tolerance of two-month old mycorrhizal and non-mycorrhizal sweet sorghum plants by assessing their growth patterns in a controlled environment.

MATERIALS AND METHODS

Five varieties of sorghum (Della, Dale, Keller, Sugar Drip, and M81E) were challenged to grow in pots under greenhouse conditions with soil media containing incremental amounts of salt (0 to 80 mM). Results indicated that salt served as a stimulant to sorghum growth regardless of variety or mycorrhizal treatment. On average, there was a 50% increase in growth at the highest salt addition; and an incremental growth was observed with amount of salt added to the growth media. Literature citations have indicated that mycorrhizal treatment may help sweet sorghum adapt to high salt, and our study supports that finding; however, maximum benefit was observed at 80 mM. These results indicate that sweet sorghum may be grown in salt-affected agricultural soils where other crops may not grow as well; and it could serve as a cover crop for remediation of such soils.

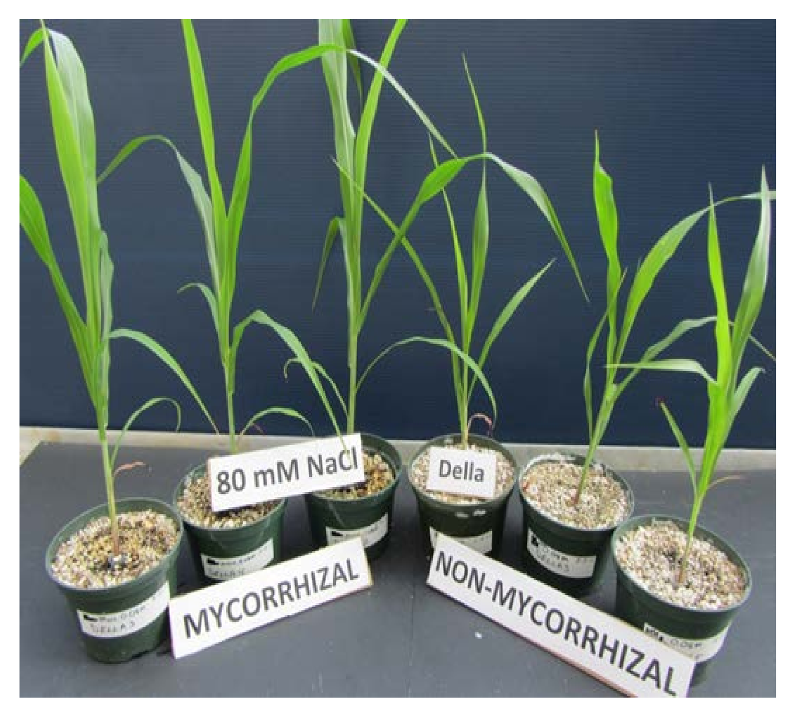
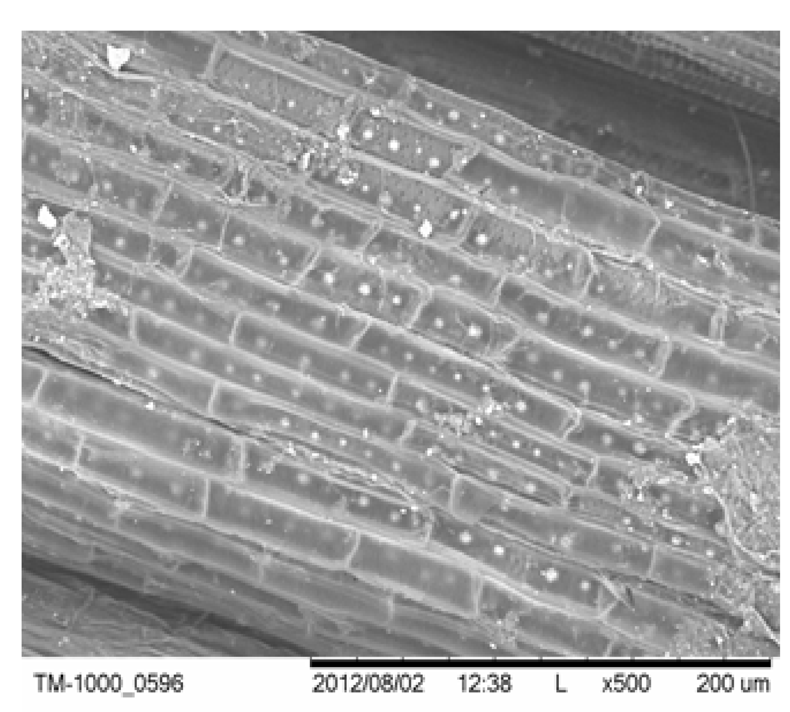


Figure 1a: Differences in growth of mycorrhizal and non-mycorrhizal sorghum (var. Della) treated with 80 mM NaCl.

Figure 1b: Root harvesting; sorghum was grown using tall pots to allow extended root growth.



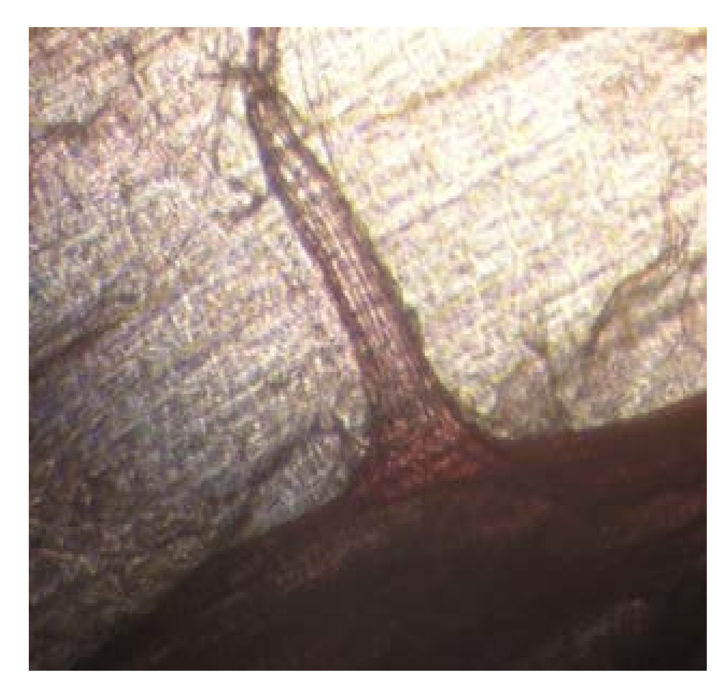


Figure 2a: electron microscope picture showing root cells infected by mycorrhizal fungi.

Figure 2b: Electron microscope picture showing hyphae extension from the main root.

RESULTS AND DISCUSSION

At the Randolph farm of Virginia State University, scientists have been exploring the possible interaction between soil fungi and sorghum plants which could benefit sorghum by helping it adapt to dry and salty environments. The interaction produces a "fungus-root" mass termed mycorrhizae; which defines the symbiotic relationship that forms between specific fungus and plant species. It is a natural process whereby both parties benefit without causing harm to each other. In this case, the fungus-root system helps the sorghum plant absorb more nutrients and water by increasing the surface area of the root, while the fungus benefits from the sugar that the sorghum plant provides through photosynthesis. Both greenhouse and field studies conducted at Randolph Farm indicated that mycorrhizae does form in sorghum plants, which helped sorghum to tolerates salt concentrations up to 200 mg/L. In fact, low level of salt (80 ppm) had stimulating effect in sorghum growth regardless of inoculation. Demonstration plots in the field also indicated better growth and yield in mycorrhizal than in non-mycorrhizal sorghum.

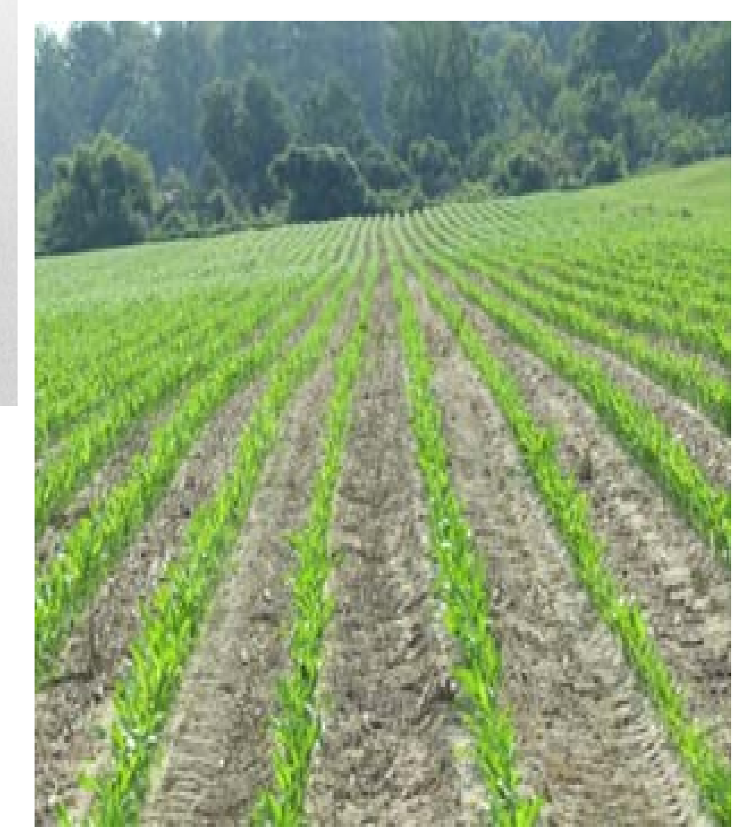


Figure 3a: Sorghum plot at Virginia State University's Randolph Research Farm.

Figure 3b: Mature sorghum crop before harvest.

CONCLUSIONS

- Sorghum has a world-wide importance as a food and fiber source in developing countries and as animal feed and bioenergy production in developed countries.
- Mycorrhizae in sorghum showed promise not only in salt and draught tolerance, but also in increasing yield.
- This preliminary study indicates the potential to exploit the natural symbiosis that occur between soil fungi and specific host plants for agronomic purposes.
- It further shows sorghum as a potential candidate for remediation of slat-affected soils and in dry-land agriculture.