The most important microorganism, that you’ve never heard about

THE FUTURE

Mycorrhiza
Old as Dirt
The Solution to the South’s Drought Problem

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The once submerged Okeechobee Lake lay empty in 2007, following one of the worst droughts in the history of southern Florida. 

Life, Liberty, and the Pursuit of Sustainability

I turn the pages of my history book, studying the farmers of humanity’s past. From the stair-step terraces of Chaco Canyon, to the awe-inspiring ruins of the Mayan empire, I admire their success. From the barren land, and vacant homes they left behind, I acknowledge their failure. Visions of pain and suffering cloud my otherwise analytical state. Looking across my family’s land, I imagine the harsh truths that would lead to the inexplicable demise of entire races of people. I feel the fear felt by the Anasazi; the Mayans; and now the American public. This fear corrodes us, instilling panic from which aimless judgment follows. Yet, from the confines of fear comes hope; a hope for a sustainable future where the threats of drought and famine are no longer measured by our population.

Population Penalty

Population in the south has soared from 25 to 100 million over the last century. As of the year 2000, southern states consist of over one-third of the U.S. population (See Figure 1). As the U.S. percentage of southern population increases, so does its need for energy. This excess energy is attained through the installation of thermoelectric power plants, which account for approximately 65% (See Figure 2) of the south’s freshwater withdrawals.

Southern states such as Texas, Tennessee, and Alabama expend as much as 10 billion gallons of freshwater a day in supplying thermoelectric energy to the general public. Couple the south’s increasing need for public supply of water with the exponential amounts of freshwater needed to thermoelectrically power our large population, and you have already accounted for over 75% of the south’s freshwater withdrawals. This in turn leaves very little water for food, feed, and fiber production within the agricultural field.
The increasing demand for the supply of energy in the south heavily impacts the allocation of water for use in agriculture. With such a high percentage of the south’s freshwater going towards energy production, little can make its way into food, feed, and fiber. Because the need for this exponential energy production in the south is currently greater than its agricultural importance, southern farmers are left to endure heavy irrigation restrictions. The solution to this problem can manifest itself in one of two ways. Southern states can either implement strategies that can reduce plant water consumption without reducing yield, or discover a water-friendly energy solution capable of sustaining a large population of people. Because sustainable energy solutions are currently unavailable and would require national support, plant utilization of water must be improved until a sustainable energy solution can be implemented.
**Fig. 3.** In 2000, southern agriculture felt the impact of what would be one of the most detrimental droughts in decades. In evaluating the economic impacts of these droughts over the recent years, multiple models predicting the impacts of climate change over the next decade have predicted an even harsher reality. Potential adaptations in agricultural were measured for their ability to sustain yield through these water starved periods. The yields for all U.S. regional crops increased exponentially, voiding any need for adaptation at all. The only exceptions in this scenario were the South and Southeast regions, which are predicted to incur significant yield reductions, even in light of any possible adaptations with crop type, irrigation, and input expenditure.
True to our Roots

The fungal root pathogen known as mycorrhiza has been found in fossils dating back as early as 460 million years. This relationship, as ancient as plants themselves, can easily be attributed with the development of the world as we know it, and continues to exist in almost every environment on the planet. Mycorrhizal fungi has been associated with numerous benefits to host plants, including, but not limited to, plant growth and mineral nutrition, improved tolerance of disease, and reduced impact of abiotic stresses like drought, chilling, and salinity.

Due to the unwavering ability of mycorrhiza to form symbiotic relationships with a variety of different plant species, it is considered one of the most important attributes in our soil’s ability to both produce and sustain life. Mycorrhiza continues to sustain life across the world, without the use of fertilizers, fungicides, or excess irrigation.

Considering the benefits through the utilization of these microorganisms, potential for an increase in plant production could also be supplemented with a reduction in input cost. Such an attribute would prove invaluable in the continued sustainability of southern agriculture. Unfortunately, not only do we fail to incorporate these beneficial organisms into our crops, we play a direct role in eliminating them from our soils.
Every day, millions of mycorrhiza hyphae are killed, and eradicated from the soil as a direct result of agricultural practices. Studies undertaken over the past 30 years have shown that common management practices such as cultivation of non-mycorrhizal crops\textsuperscript{12,13}, excess Phosphorus fertilizer applications\textsuperscript{14,15}, fallow periods\textsuperscript{12,16}, and intensive tillage\textsuperscript{17,18}, have fatal effects on the abundance and availability of mycorrhiza within our soils\textsuperscript{19}. Other practices such as compaction, erosion, fire, grading, topsoil removal, paving, pollution, and heavy pesticide use can severely impact mycorrhiza populations\textsuperscript{20}. Our southern population’s high reliance on crops is only furthered by our increasing need to supply more and more inputs of fertilizer, water, and fungicides to grow them.

In doing so, we have eliminated the one relationship that plants have come to rely on for millions of years. Consequently, plants are robbed of one of their most basic means of withstanding the environmental extremes that continue to wreak havoc on southern agriculture. Now, in the face of another decade of harsh drought, our soils will stand void of both crops and mycorrhiza alike.

*A stained arbuscule of mycorrhiza within a root cell. The ancient symbiosis between plants and mycorrhiza is so primitive, that plants will actually rearrange their root cell components to allow for the colonization of these exchange structures\textsuperscript{21}.***
Reviving Mycorrhiza

Recent advances in our understanding of how mycorrhiza works have led to methods of easier, faster, and more efficient inoculation of agricultural crops. Mycorrhiza inoculums contain highly concentrated spores of only the most efficient species of mycorrhiza, tested for maximum compatibility with each crop. Methods for re-establishment of mycorrhiza back into our soils requires little beyond soil contact. Once in the presence of a viable root system, mycorrhizae will colonize, and begin providing nutrients for the plant. Mycorrhiza can be applied at any point in the life of the plant, and will continue to reproduce below the surface, for a more functional and sustainable “living” soil.

The incentivisations for the use of mycorrhiza speak for themselves. Improved yield, better drought tolerance, and improved nutrient and water use efficiency will motivate farmers to take advantage of a highly economical product that will continue to act as a permanent investment in the future. Issuing tax credits for the purchase of these products can provide further incentive. However, the most efficient promotion for the use of this product comes in the form of knowledge. By providing farmers with the knowledge needed to confidently invest in mycorrhiza, the results can have a chance to make an impression on the future of the farmer and today’s agriculture. In light of the ever-present struggles associated with climate change, drought, and population increase, mycorrhiza’s potential role in southern agriculture is now greater than ever. As an advocate and researcher of the fascinating relationship that is mycorrhiza, I will continue to advocate, educate, and reiterate the use of a product that our plants, soils, and farmers are not meant to live without. I do this in hopes that the next 10 years will not be hindered with drought and depression, but with growth.

About the Author

Keith is a graduate research assistant and student in Plant Sciences at The University of Tennessee. His research is currently looking at the application of natural plant products to improve plant photosynthetic efficiency.


