



Successful Truffle Cultivation Runs on Science




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Introduction

Truffles are a prized fungal delicacy due to their unique organoleptic and culinary qualities. Production of truffles in traditional producing nations has been declining steadily for over half a century, while worldwide truffle consumption continues to rise (Hall et al. 1994). According to the USDA Foreign Agricultural Service, imports of truffles more than doubled from \$6.6 in 2008 to \$16.8 million dollars in 2015. Significant investment is currently being made into growing truffles as a specialty crop in the United States (e.g., the [NC Biotechnology Center](#) and the [NC Tobacco Trust Fund](#)). Many factors beyond culinary use contribute to the desirability of the truffles, specifically the white spring truffle, *Tuber borchii*. They include:

Forest preservation and conservation	Co-cropping trees with truffles provides additional income for land owners	Variety of host trees: pine, oak, hazel, poplar, beech, chestnut, linden, alder, and cedar
Accelerated host plant growth and development		Improved host plant health and drought resistance
Fruiting occurs at a wide range of pH (pH 5 – 8)	Imports more than doubled- \$6.6 million in 2008 to \$16.8 million in 2015. (USDA Foreign Agricultural Service)	Harvest: Specially trained dogs (opportunity to save shelter dogs)

There are a multitude of obstacles to successful truffle production outside their native geographic areas. The three biggest obstacles to maintaining vibrant thriving orchards with bountiful harvests are seedling/mycorrhization quality, contamination, and cost.

- **Seedling quality/Confirmation** - Confirming whether a seedling has the correct truffle fungus (e.g. *Tuber borchii*) inhabiting its root system is key to successful truffle production. Until recently truffle farmers and seedling producers in North America depended on the unreliable morphological characteristics of roots to “guess” whether their trees have the intended truffle fungus on them.

Contamination - The major problems in truffle cultivation are contamination by competing fungi/micro-organisms, poor quality nursery stock, or replacement of truffle mycorrhizae by indigenous mycoflora after planting.

- **Cost** – Regular loblolly pine seedlings cost \$0.16 through state nurseries, while mycorrhized seedlings cost \$33 - \$35. Through our efforts to maximize the production process and streamline our protocols we have been able to reduce the price to \$30, but it still remains comparatively high.

Using innovative DNA-based diagnostics for truffle detection and mycorrhized seedling propagation, Mycorrhiza Biotech provides a unique and crucial science-based protocol and orchard management system for successful truffle cultivation for the growing truffle industry in North America.

“Contamination, poor quality nursery stock, or replacement of truffle mycorrhiza by indigenous mycoflora after planting are all possible detriments to truffle orchards that could easily go unnoticed by a truffle farmer.”

– [Dr. Omon Isikhuemhen](#), Professor and Researcher working on truffles at NC A&T State University

Background

Mycorrhiza Biotech, LLC is an agribusiness that develops products and services that improve plant production. Our patent-pending technology that uses a natural resource, loblolly pine (*Pinus taeda*), to cultivate a high-value crop, gourmet truffles, while simultaneously improving the tree's productivity has wider implications for overall forest health. Most people are unaware of the crisis threatening our nation's trees, but Mycorrhiza Biotech is a step ahead. The Guardian newspaper carried an article on September 19, 2016, "[An American tragedy: why are millions of trees dying across the country?](#)" Describing "A quiet crisis playing out in US forests as huge numbers of trees succumb to drought, disease, insects and wildfire – much of it driven by climate change"

The benefits of mycorrhiza extend beyond truffle income. Highly mycorrhized trees encourage plant health, keep pathogenic organisms at bay, and help trees survive in harsh conditions. Other benefits of mycorrhizae include:

- Enhanced plant efficiency in absorbing water and nutrients from the soil
- Reduced fertility and irrigation requirements
- Increased drought resistance
- Increased protection/resistance to pathogens
- Enhanced plant health and stress reduction
- Enhanced seedling growth

"Forestry officials and scientists are increasingly alarmed, and say the essential role of trees – providing clean water, locking up carbon and sheltering whole ecosystems – is being undermined on a grand scale." (The Guardian, 2016).

Mycorrhiza Biotech's successful endeavor to cultivate gourmet truffles parallels the ongoing effort in the scientific community to address the crisis decimating America's forests. Highly-mycorrhized trees are better prepared to withstand the damage from climate change and pests many forests are currently experiencing. To maintain control, avoid contamination, and ensure our trees are highly-mycorrhized, we propagate our truffle colonized seedlings under stringent nursery conditions. The mycorrhized seedlings are later planted in orchards that have been meticulously prepared. Careful cultivation and management has led to truffle production after only 2 years and 3 months – much faster than the typical 4 – 6 years for previously recorded harvests.

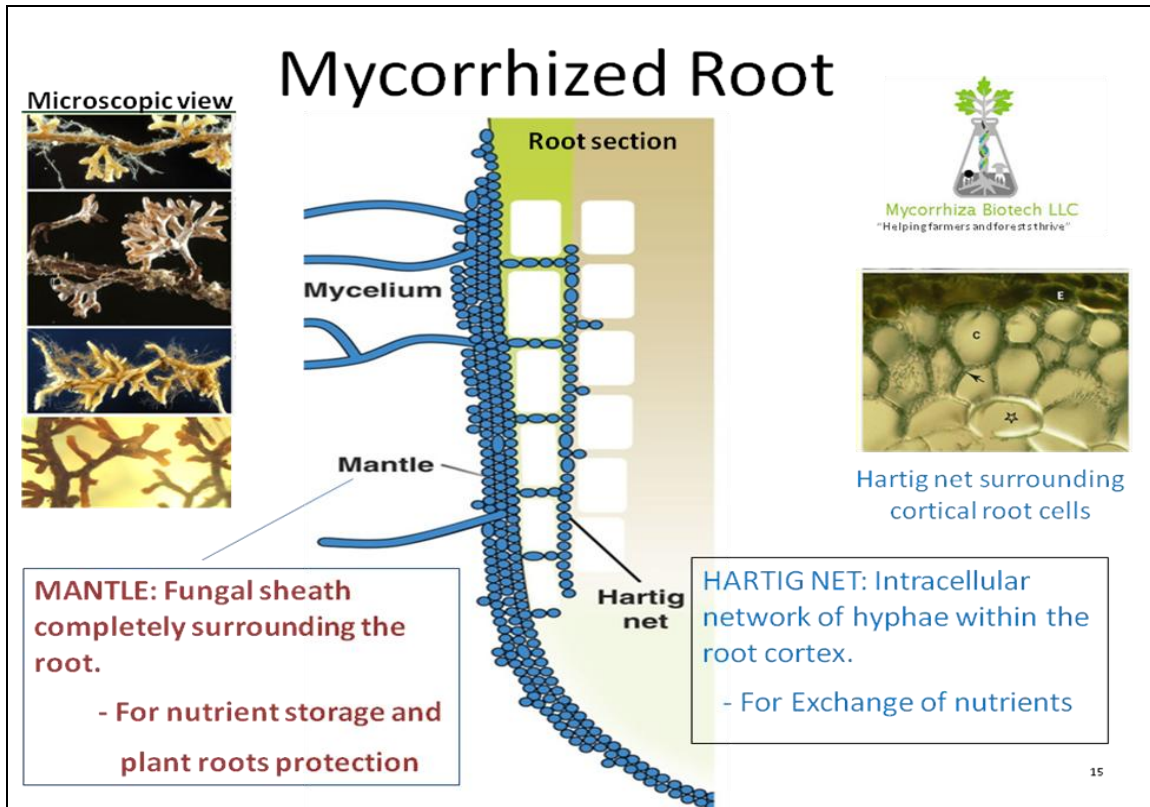
The ability to detect the truffle fungus under cultivation and competitor fungi on host roots and in the rhizosphere is vital to successful truffle farming. Plants that have either no truffle or the wrong fungi in its roots should not be planted. Heavily colonized root systems in nursery and out-planted seedlings are indicative of good management practices. Many truffle farmers and seedling producers in North America have depended on the unreliable morphological characteristics of roots to "guess" whether their trees have the intended truffle fungus on them. However, Mycorrhiza Biotech's protocols for mycorrhized seedling production and farm management systems have added the necessary layer of science to pivotal points on the truffle cultivation process mitigating risk and adding certainty. The advent of our recent early harvest of *Tuber borchii* establishes proof that our proprietary systems are solid, effective, and reliable.

"Confirming whether or not a tree has the correct truffle fungus inhabiting its root system has critical orchard management implications."

- Dr. Omon Isikhuemhen

Solution

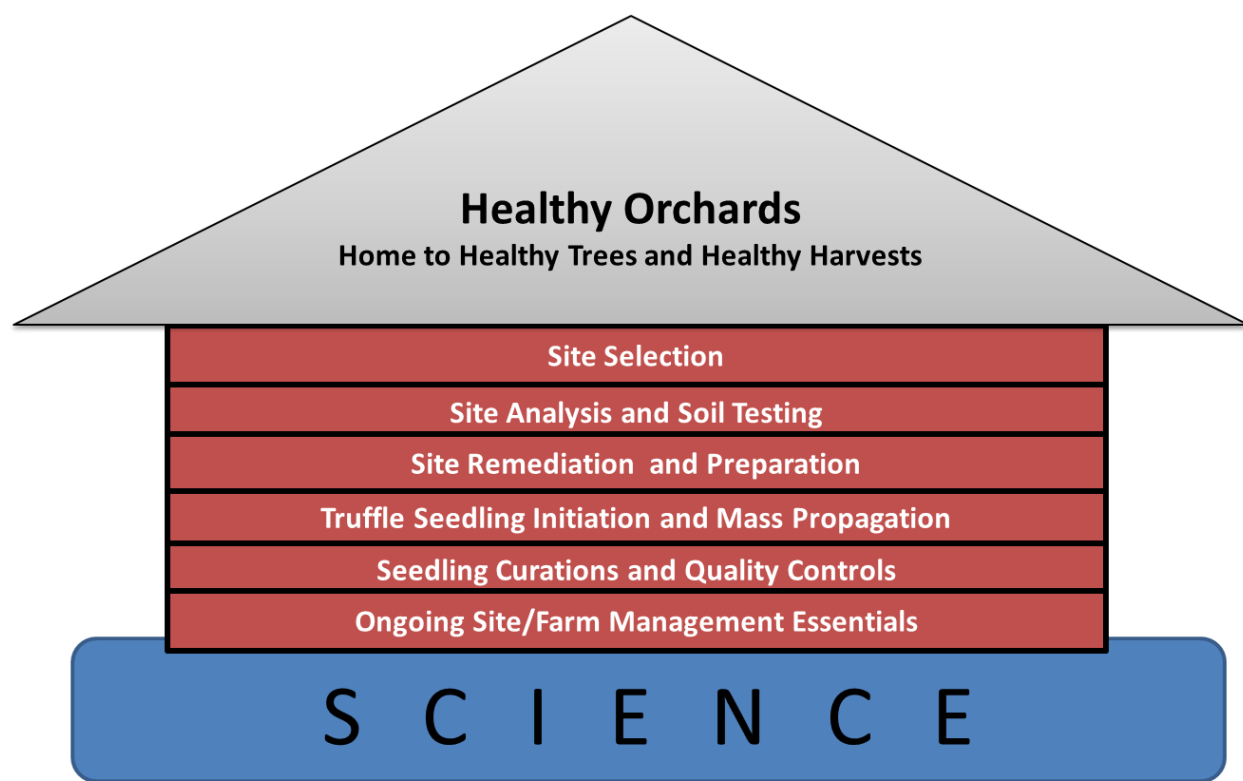
The benefits of mycorrhizae are well known. The image below describes how the fungus “protects” the host plant roots literally acting as a shield preventing pathogenic organisms from gaining access to and harming the tree.



Source - NC A&T State University, Mushroom Biology and Fungal Biotechnology Lab

We have demonstrated that the cultivation of truffle inoculated pine trees can be an alternative to traditional forestation, whereby the truffles serve as a value added crop that will generate additional income for the forest owners while keeping the orchard healthy and vital. This co-cropping practice will increase reforestation, enhance plant growth and development through symbiotic association between the plants and the truffle fungi, as well as improve microbial diversity in pine forest environments.

Mycorrhiza Biotech’s solution includes a comprehensive approach to truffle farm management specifically for timber management companies and land owners that use pine. Our methods use science as the foundation for the **6 Steps to Successful Truffle Farming**:



Mycorrhiza Biotech’s solution facilitates the long-term goal to integrate truffle farming into agroforestry practices as a means of reforestation, and soil conservation, and to determine optimal silviculture practices for truffles in the forest environment of North Carolina specifically and in North America in general.

Commercial Viability

Mycorrhiza Biotech is the only company with established orchards producing truffles on *Pinus taeda* in North America. Mycorrhiza Biotech is the only company with truffle inoculated seedlings in production in 2 years and 3 months after planting. Our protocols and management systems are unique because we confirm the presence of the truffle fungus on the seedling prior to planting thereby reducing risk. Our technology uses micro-propagation and biotechnology tools to propagate truffle mycorrhized seedlings. Our trees are evaluated and determined to have high rates of colonization before being released to our customers.

Co-cropping timber with gourmet truffles capitalizes on an opportunity and is a win-win for farmers, foresters, foodies, and state revenue offices. *Tuber borchii*, a white spring truffle has a current market price of \$500/lb. Nearly 1 billion loblolly pine seedlings were planted in 2015 in the Southeastern United States (Scott Enebek, 2017) with over 12 million in NC alone (Drew Hinnart, 2017). Each acre can generate approximately \$3000 in wood products over 36 years. Co-cropping *Tuber borchii* with loblolly pine will provide growers with an additional \$50,000 of income per acre over the truffle production cycle starting as early as year 4. There is a huge opportunity to reforest our nation with highly-mycorrhized trees that are better prepared to withstand climate change and pest damage our forests are currently experiencing. Our product helps farmers and forests thrive.

Conclusion

This white paper is designed to outline the best approach to establishing healthy truffle orchards. Applying scientific principles and protocols to the truffle production process greatly increases the harvest opportunities. Mycorrhiza Biotech's scientific approach to truffle farming addresses the three primary obstacles to successful truffle cultivation which include Cost, Contamination, and Seedling quality/Confirmation. Our trees have produced truffles in nearly half the time as other measured orchards. Additionally, our production systems have the potential to mitigate the current threats to America's forests. Successful truffle cultivation is an exact science. Mycorrhiza Biotech's orchard establishment and management systems remove all guesswork from the process.

If you want to be successful, trust the science behind our fruitful orchards.

Works Cited

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- 3 – Scott Enebak, Southern Forest Nursery Management Cooperative at Auburn University, January 2017, Personal Communication.
- 4 – Drew Hinnant, NC Forest Service, Claridge Nursery, January 2017, Personal Communication.