Subsoil Inoculation with Specialized Arbuscular Mycorrhizal Fungi to Increase Rate of Soil Repair for Agricultural Use

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Abstract:

My proposed project will evaluate the evaluate the effectiveness of arbuscular fungi for increasing the rate of subsoil repair. Certain specialized species of subsoil arbuscular mycorrhizal fungi will be inoculated into test patches of exposed subsoil in Vermont. It is **hypothesized** that subsoil patches that contain subsoil-specialized fungus will increase the rate of succession through breakdown of minerals into accessible form for plants, increase organic matter, increase size of aggregate particles, and increase plant growth. These factors combined ultimately will speed the rate of restoration and accumulate topsoil faster than plots of exposed subsoils that were not inoculated.

Hypothesis:

The rate of soil repair in terms of organic matter, nutrient availability and growth rate of agricultural plants will be faster in subsoil patches inoculated with *Clariodeoglomus sp.* than patches that were not inoculated.

Background:

Loss of topsoil is one of the largest problems the world faces today. Modern industrial agriculture practices provide a high yield of food, but deteriorate the soil that they use to grow by over-tilling and over-fertilizing. By diminishing the integrity of topsoil, its infiltration capacity decreases and it washes away with heavy rains and pollutes waterways (Agriculture). This deteriorates the soil's ability to retain water and slowly creates drought conditions, which has a lasting effect on weather patterns. Many industrial agriculture firms leave these plots of exposed subsoil as 'dead zones' and move on to another plot. Regeneration of diminished agricultural plots, specifically in industrial output zones is a lengthy and difficult process. Since these areas lack in the biotic factors needed for succession – organic matter, moisture, and nutrients – natural regeneration would take decades (Wubs et. al). By restoring these plots of exposed subsoil, the land can be used for agriculture once again. New research on the arbuscular fungal family Clariodeoglomeraceae leads to exciting opportunities in the agricultural realm because they are specialized for subsoil conditions, which are more compact, less oxygenated, and extremely low in organic matter (Sosa-Hernandez et al). These fungi break down minerals in B horizon (subsoil) and provide these as nutrients in a form plants can uptake. Theoretically, when these exposed subsoil patches are inoculated with this fungus, a symbiotic relationship will form with the plants, trading mineral nutrients for carbon sugars, allowing increased plant growth, which can be incorporated as organic matter into newly formed topsoil. This should lead to more rapid agriculture restoration.

Figure 1. Geographical distribution of soil moisture across the United States. The zones in the green gradient have high levels of soil moistures and topsoil, while white, yellow and red have lower levels.

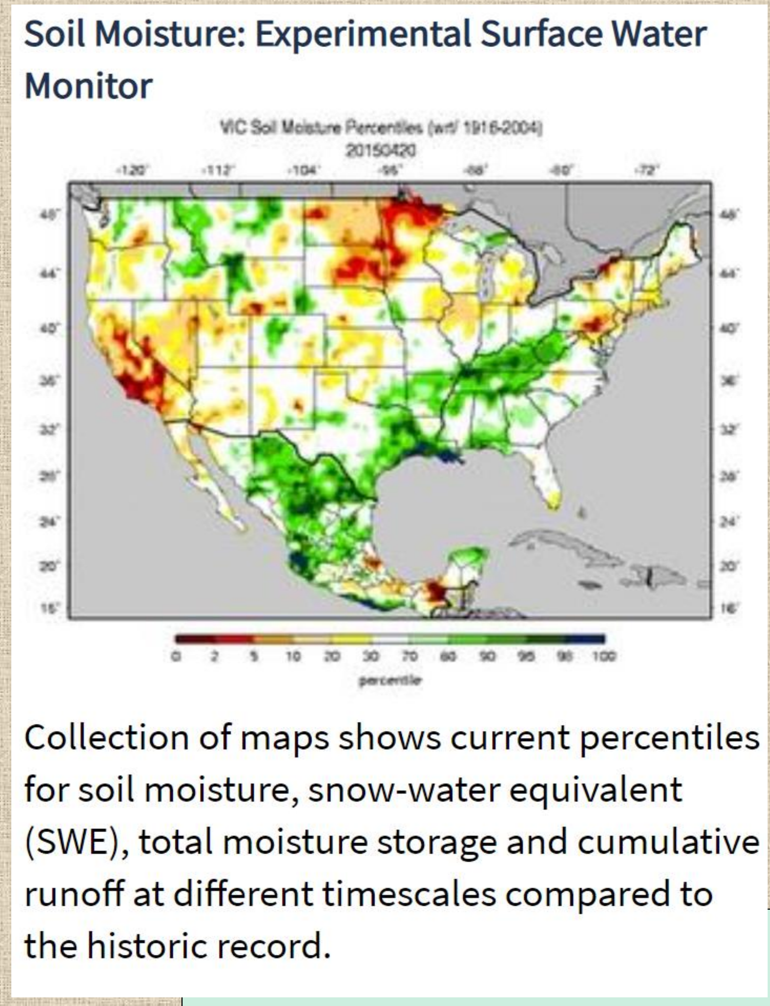
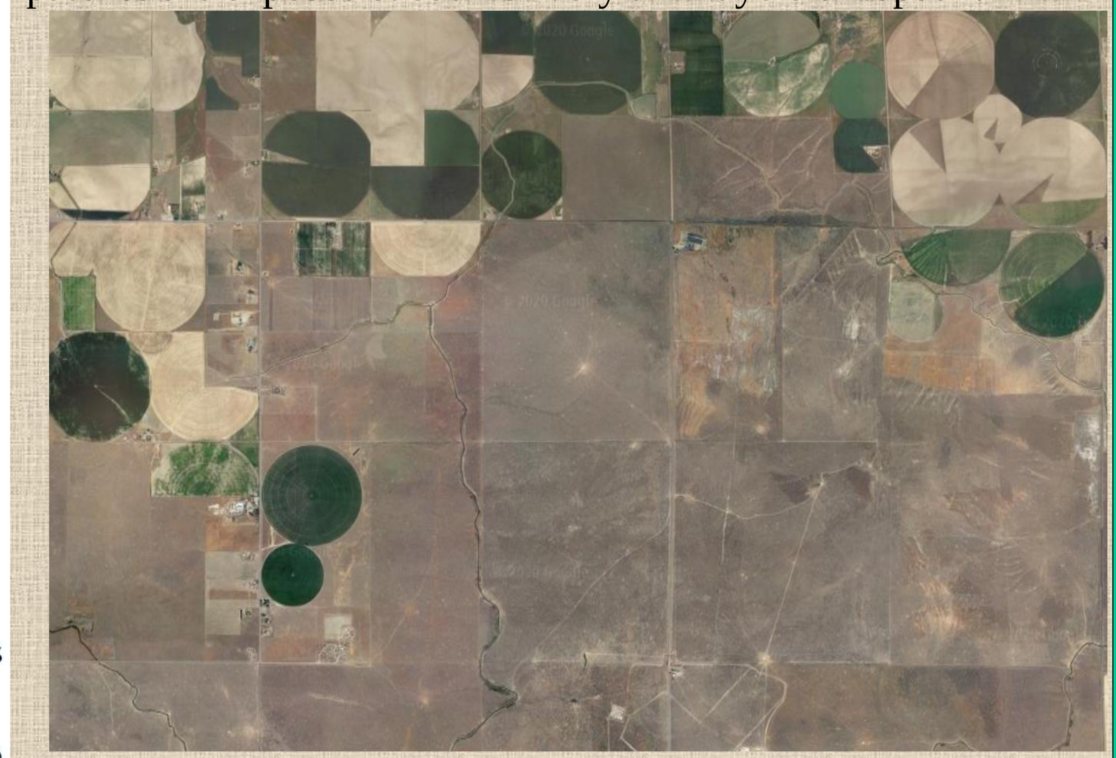


Figure 2. Arial photograph of farmland in Kansas. The green patches are current farmland, and the very light brown patches are exposed subsoil or very thin layers of topsoil.



Study Design:

Sixty square yards of exposed subsoil will be divided into twelve plots, each of which will be five square-yards. Each individual plot will be surrounded by four foot deep non-reactive metal partitions to prevent the intrusion of confounding variables, such as outside nutrient sources. Six of the 12 plots will be randomly chosen for the test (inoculation) group. At the last frost date, usually around April or May, the plots will be inoculated with *Clariodeoglomus sp.* fungal spores, using six-inch deep inoculation holes cut with a cylindrical soil tube. Eight inoculation holes will be distributed evenly through each plot 12 inches apart, and one teaspoon of *Clariodeoglomus sp. spores* will be placed in each. The holes will then be filled in loosely, and the plots will be watered at uniform time intervals. The patches will then be seeded with an annual barley cover crop. The six control plots will be punctured and seeded the same way but will not be inoculated. Every month, measurements will be taken of plant growth, organic matter, nutrient levels, and Net Primary Production (NPP). In addition, there will be some subjective observations to assess the overall plant and soil health. Plant color, soil color, and plant turgor will also be observed and recorded. When the plants die in September or October, the dead plant matter will be left to decompose over the winter and new seeds of a different cover crop will be planted in the spring. The year two cover crop will be beans, year three will be oats, year four will be lentils, and year five will be sunflower. Each year during the growing season, identical monthly measurements will be taken as specified above.

Study Site:

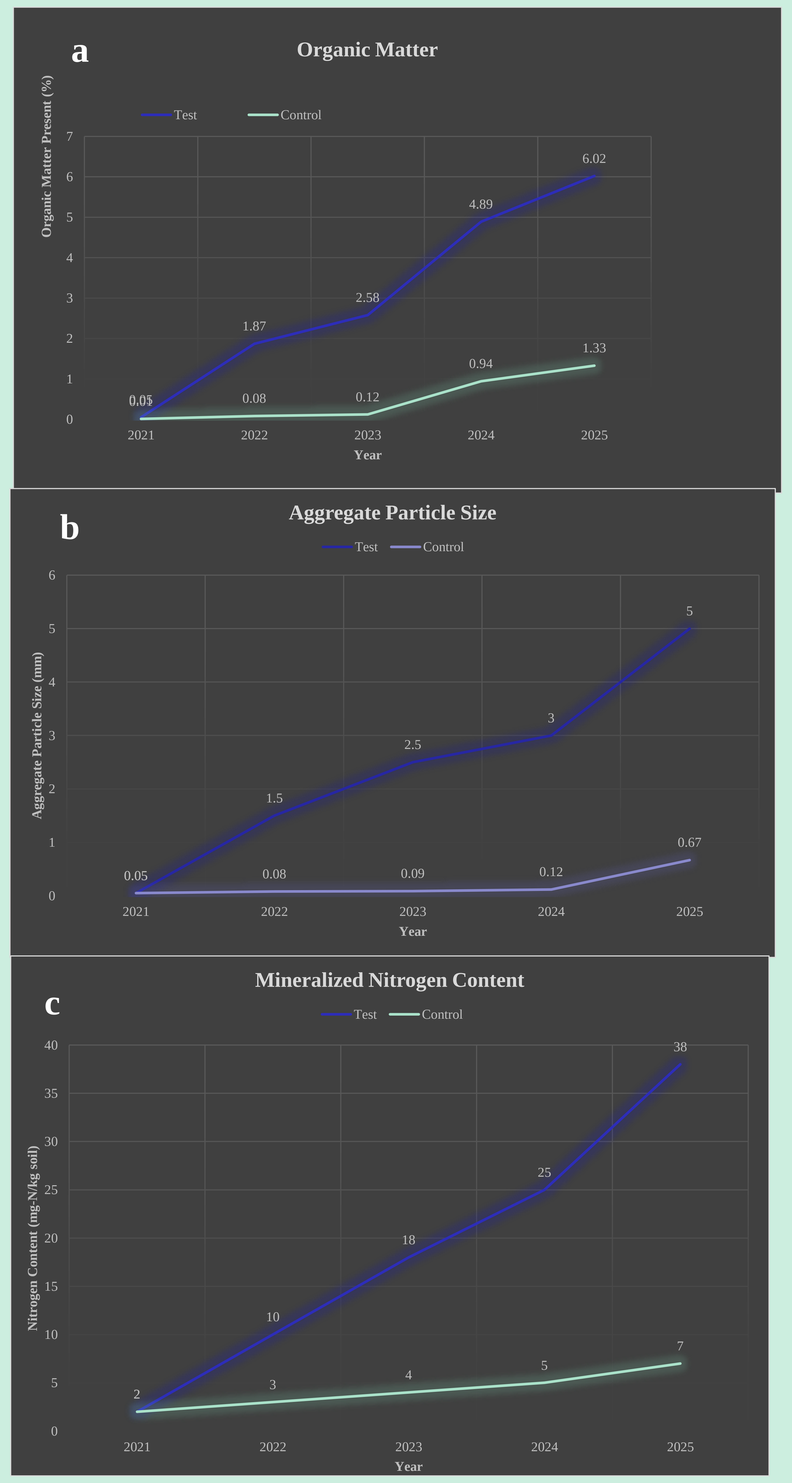
The site chosen for this experiment is the Common Roots farm in South Burlington, VT. The farm is built directly on top of a construction site, and the upturned earth is mainly subsoil. It will therefore be easy to gain the amount of exposed subsoil needed for this experiment. In further trials of this design, different locations will be used in industrial agricultural zones in the Midwest.

Timeline:

This is a minimum 5 year long study. It's important to observe the succession of the land over time. Soil repair is a lengthy process, and it's important to honor that.

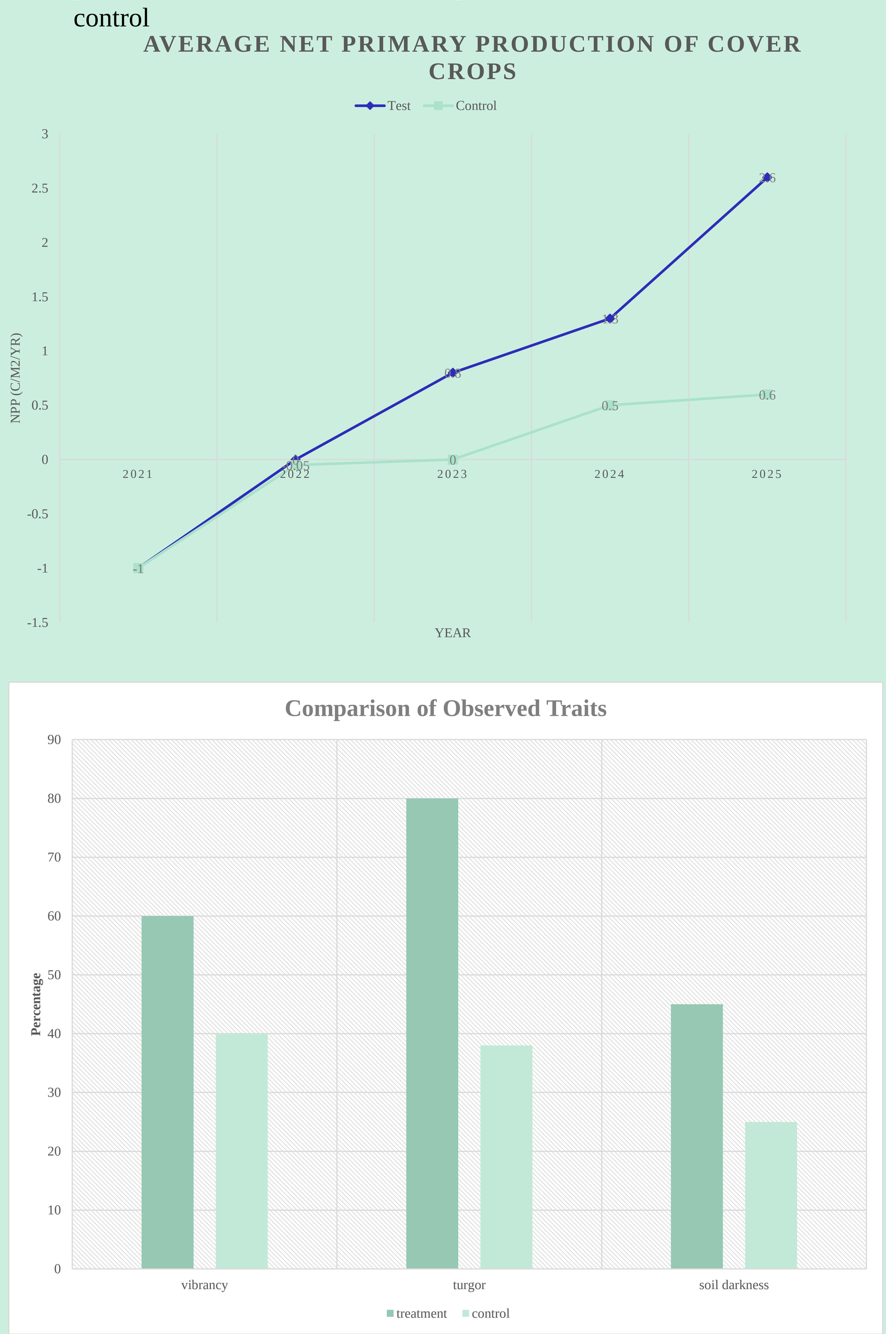
INTENDED DATA ANALYSIS

Figure 3: Hypothesized effect of fungal inoculation on soil quality. (a) Average per cent organic matter in soil (p= .07), (b) Average aggregate particle size (p= .05), (c) Average mineralized nitrogen content (p= .08), for treatment and control.



* Both treatment and control lines demonstrates the average of the 6 plots measured and observed.

Figure 4: Hypothesized effect of fungal inoculation on crop production (a) Net Primary Production of Cover crops– average over 5 years, (b) average percentiles of observable traits compares between treatment and control



* All data is hypothesized data– what it should look like if hypothesis is assumed to be true

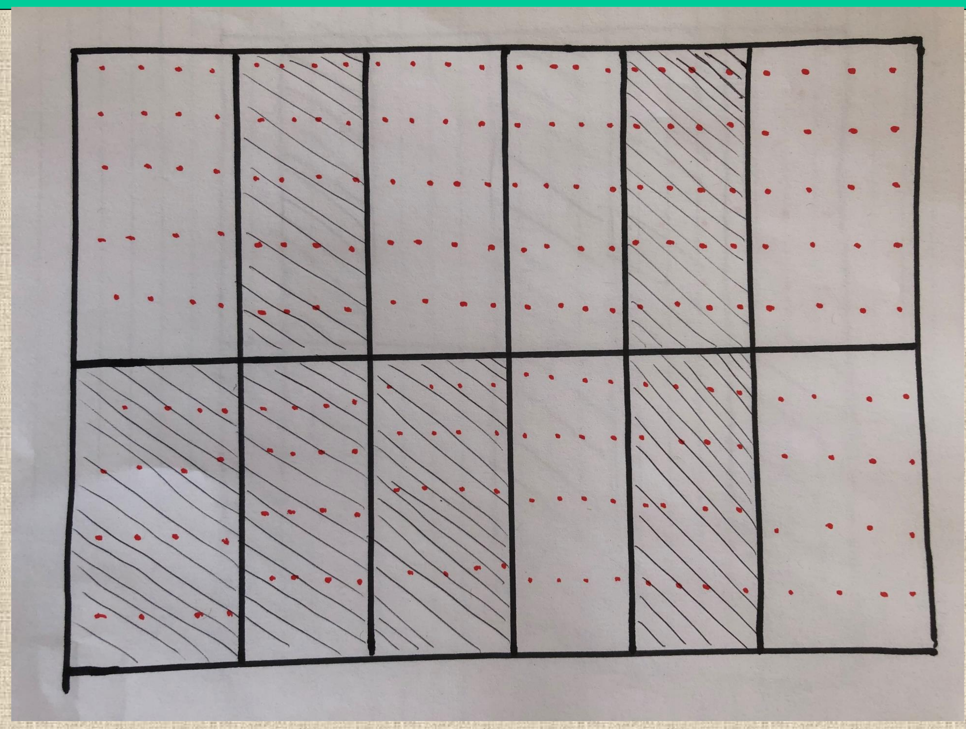


Figure 5: 60 square yards split into the five plots. The shaded plots represent the randomly selected treatment groups. The red dots represent the small holes punctured to inoculate the soil, and the dark black lines represent the deep partitions between each sub-patch to avoid confounding variables.

Discussion & Implication:

If this study demonstrates a significant effect of fungal inoculation on soil quality, the next logical step would be to replicate the experiment in locations more representative of industrial agricultural, such as the central valley of California and Nevada, and midwestern regions such as Kansas and Oklahoma. The ideal settings for future experiments would be on industrial agriculture plots that have been degraded down to subsoil. I wanted to keep this pilot experiment more local because I may have the chance to actually conduct it at Common Roots farm in South Burlington. If the hypothesis is supported, this could eventually lead to a significant change in the way food is grown all over the world.

Literature Cited

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