The Relationship Between Fungi and the Level of Magnesium in the Soil.

A study of the enviroment by Blair Warren, June Liu, Maddie Muth, and Marjorie Howard.

Abstract:

Studies show that plants with the absence of mycorrhizae grow much slower and die faster than those who have had help in their roots from the mycorrhizae. The annual 2010 E.S.S.R.E. biota survey showed unexpected differences in magnesium levels between E.S.S.R.E. Microclimate Research Sites 1-4. Corresponding data on fungal data led us to hypothesize that the density, of fungi is directly proportional to the levels of magnesium in the soil in these sites and that as the yeast to mold ratio increases in favor of yeast, then the levels of magnesium shall decrease. We took soil from around the roots of the spicebushes in Sites 1-4 and tested for magnesium levels, and yeast and mold density. Our specific hypothesis was proven incorrect. However, we observed a statistically significant inverse relationship between yeast density and magnesium levels. For further research, we would examine the Sites to see if environmental stress is the source of this observed inverse relationship.

Introduction:

Fungi are heterotrophs that play numerous important roles in the natural environment. One such is the symbiotic relationship known as mycorrhizae that certain fungi form with plants. 90% of the world's plants share this mutual relationship between their roots and various fungi (Gregory, 2006), and four such relationships have been identified: arbuscular mycorrhizas, ectomycorrhizas, ericoid mycorrhizas, and orchid mycorrhizas. These four types of mycorrhizal differ solely in their varying degrees of interaction between the fungi and a plant root, with the ectomycorrhizal fungi forming only a dense network of hyphae that surrounds a plant's roots while the arbuscular mycorrhizal fungi penetrate the actual root cells (Gregory, 2006). Since all fungi cannot produce their own nutrients, most soil fungi usually acquire food through the decomposition of dead organic matter. But in the case of mycorrhizae the plant root shelters the fungus by providing it with sugar from photosynthesis while, in return, the fungus breaks down and absorbs important nutrients and minerals for the plant. Consequently, mycorrhizae actively enhance the availability of nutrients to plants and have, in fact, been shown to increase the yield of crop plants such as potatoes and peppers (Sayre, 2003). Hence mycorrhiza are important for the health and well being of plants in general.

One nutrient essential to plants is magnesium. Magnesium is critical for use in the manufacture chlorophyll for photosynthesis (NCDA&CS, 2010), and it has been shown that plants with mycorrhizae grow better and faster because of the magnesium their fungal partner supplies (Jentschke, Brandes, Kuhn, Schröder, Becker, Goldbold, 2000).

The fact that mycorrhizae significantly impact the levels of magnesium in the soil available to plants means that significant changes in this relationship can have a huge potential impact on the environment. One such possible change is the form a soil fungus species can take at a given moment in an ecosystem: as a yeast or as a mold. Yeasts are single-celled fungi that are in protective states and do not interact readily with plants, while molds, on the other hand, form dense networks of filaments known as hyphae (Brock, 2006). These hyphae are the mycorrhizal structures that can interact with a plants' roots, and thus, plants with little or no mold in the soil are likely to have less magnesium available to them and are accordingly more likely to become stunted in growth.

In the 2010 E.S.S.R.E Biota Survey (E.S.S.R.E, 2010), we observed an interesting anomaly between the levels of magnesium available in the soil and the plant life in the various E.S.S.R.E. Research microclimates (E.S.S.R.E, 2010). The magnesium level in Site 3 (N 39.35797; W 076.63836) was the highest at an average of 50ppm, while the average levels in Sites 1 (N 39.35794; W 076.63977), 2 (N 39.35740; W 076.63893), and 4 (N 39.35733; W 076.63840) were all statistically significantly lower (7.92ppm, 24.4ppm, & 11.25ppm respectively). Interestingly, these differences in magnesium levels strongly correlated with the survey of plant life in the research sites. In Site 3, where the magnesium is the highest, the plant life has stabilized according to this year's survey, while the plants in the other three sites with the lower magnesium levels are undergoing the dramatic changes.

We believe the role of mycorrhizae in the environment may reflect the cause of this observed anomaly. Yeast and mold are both fungi that can be found on all four sites. Sites 1, 2, 3, and 4 all have varying yeast-to-mold ratios (4:1, 2:1.5, 2:1, & 1:1 respectively), and we believe that the yeast to mold ratio and the level of magnesium may have an inverse relationship. Site 1 with the highest yeast average, 46, 3000 per cc of soil, had the lowest average levels of magnesium (7.92 ppm), and we believe the lower activity levels of yeast could be causing this low level of magnesium and accounting for the disruption of plant life in this site. In Site 4, on the other hand, we believe the high average density of mold, 2683.33 per cc of soil, illustrates mycorrhizae activity, producing the extra magnesium found in that soil, potentially explaining the stabilized the plant life located there. Thus, we hypothesize that the levels of magnesium will fluctuate based on the different densities of yeast and mold in the soil. Mycorrhizae's beneficial interaction with plants will increase levels of magnesium in sites with a higher density of mold, while sites with a ratio favoring yeast will show a decrease in the level of magnesium.

Methods:

3 soil separate cores, 15 cm in depth and 2.4 cm in width, were taken within the 80 cm diameter of the root beds of 4 separate spicebushes, each one located respectively in Quadrat 3 of E.S.S.R.E. Site 1, Quadrat 2 of E.S.S.R.E. Site 2, Quadrat 4 of E.S.S.R.E. Site 3, and Quadrat 3 of E.S.S.R.E. Site 4 (E.S.S.R.E., 2001). The soil extractions were then tested for fungal density using serial dilutions. Each dilution was performed to the 10^{-2} dilution on each of the samples using sterile water, and 100 µL of the 10^{0}, 10^{-1}, and 10^{-2} dilutions were plated on their own individual 3M Petrifilm™ Yeast and Mold Count Plate. Plates were allowed to grow for a minimum of 48 hours, and individual colonies of yeast and mold were then counted to calculate the total fungal density for each sample. Simultaneous with the performance of the serial dilutions, each soil sample was tested for magnesium levels in ppm using a LaMotte STH Series Model STH-14 chemical test. The entire protocol was repeated each day for 4 days in July 2010, for a total of 46 samples.

Results:

Figure 1 Comparison of Average Magnesium Levels Between the Research Sites

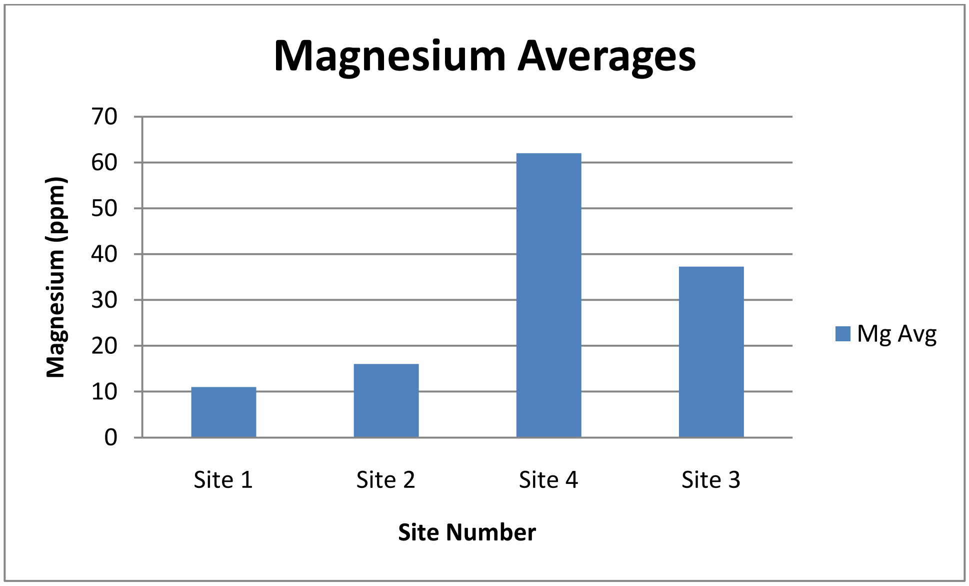


Figure 2 Comparison of Average Fungi Densities Between the Research Sites

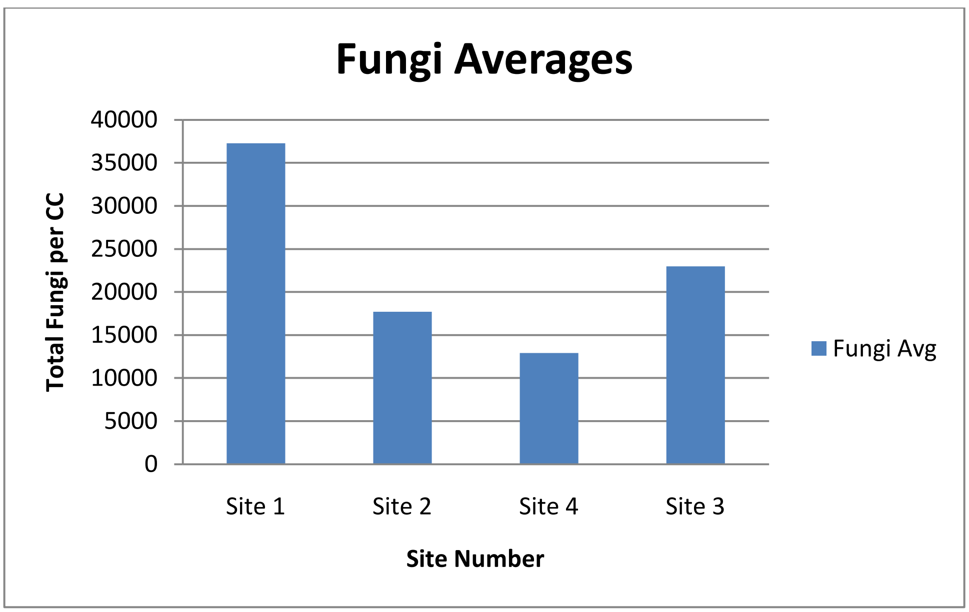


Figure 3 Comparison of Average Mold Densities Between Research Sites

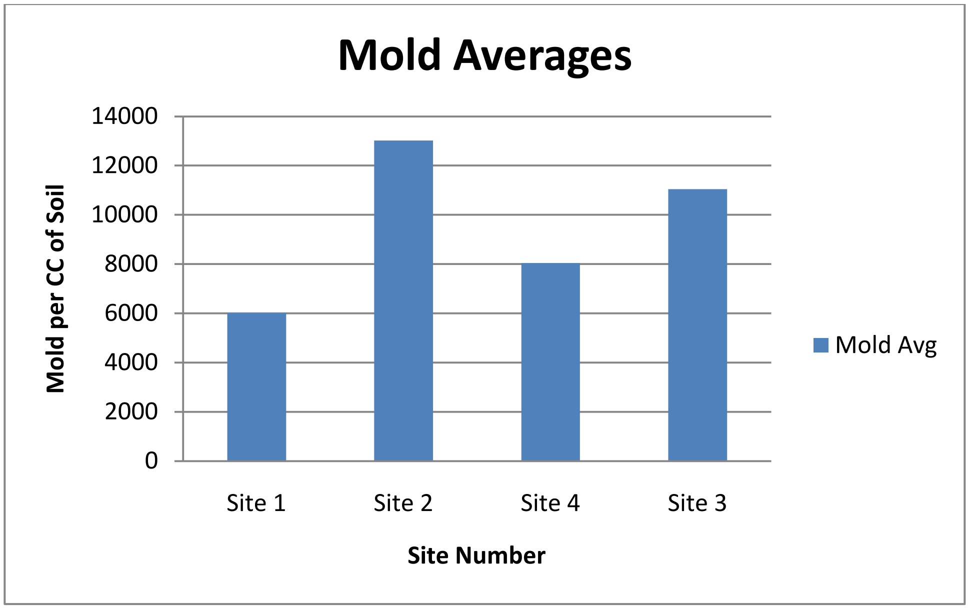


Figure 4 Comparison of Average Yeast Densities Between Research Sites

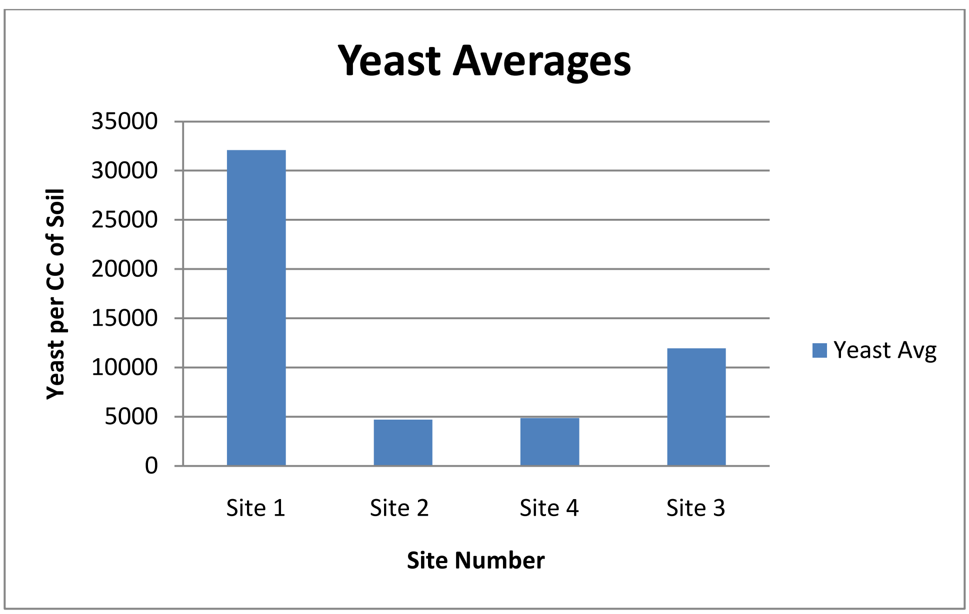


Figure 5 Comparison of the Yeast to Mold Ratios Between the Research Sites

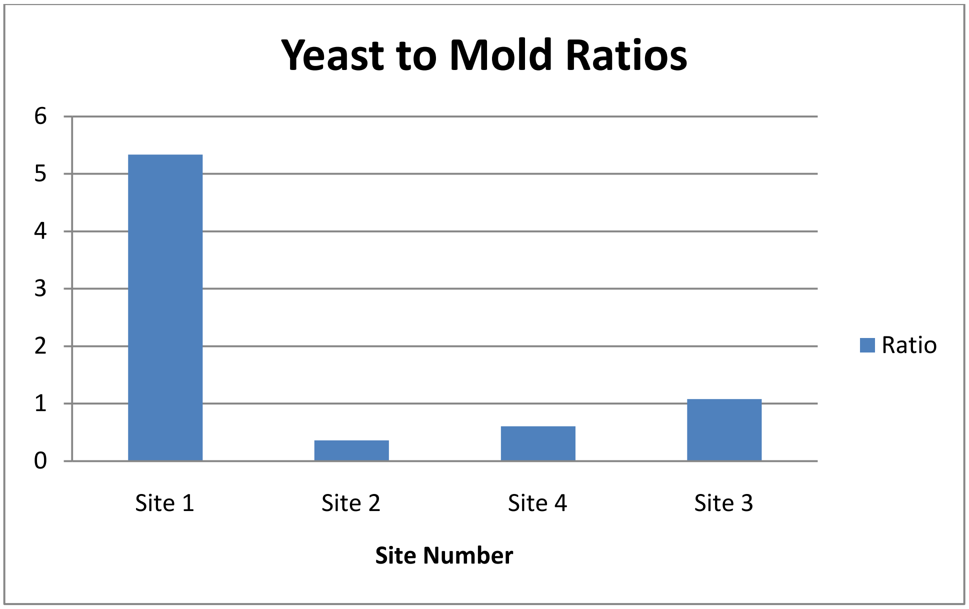


Figure 6 Location of Each Site Versus the Levels of Magnesium in the Soil

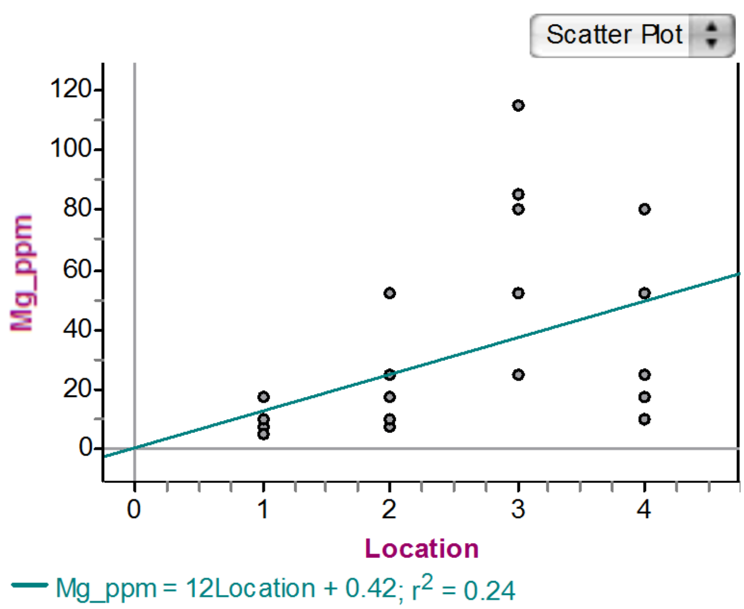
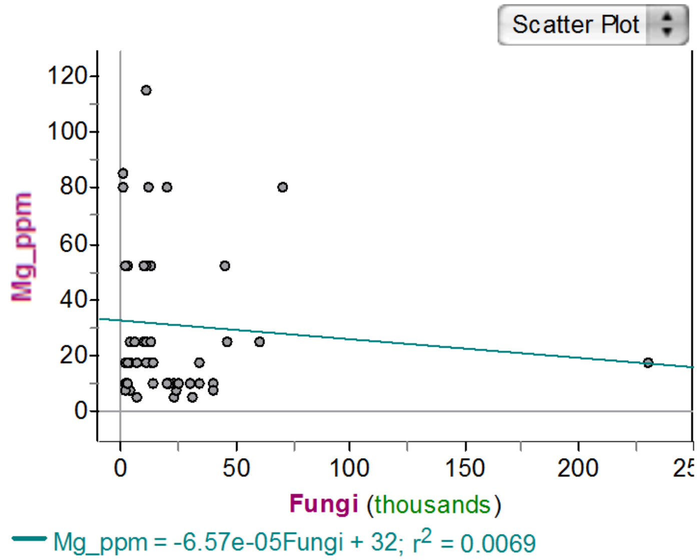


Figure 7 Densities of Fungi Versus Levels of Magnesium in the Soil



Discussion:

We originally hypothesized that as fungal density in soil increases, soil magnesium levels would also increase, and we further hypothesized that the hyphae of mycorrhizae would provide the soil with a higher level of magnesium, therefore causing the magnesium levels to increase as the mold density in soil increases.

However, figures 1 and 3 clearly show that our hypothesis was incorrect. In figure 1, the magnesium level for Site 1 is shown to be low, while in figure 3, the mold density for Site 1 is shown to be much higher. Site 2 is shown to have an only slightly higher level of magnesium than Site 1, while the mold density in Site 2 increases by a large amount. The magnesium level increases dramatically from Site 2 to Site 4, but the mold density decreases from Site 2 to Site 4. Finally, the magnesium level decreases significantly from Site 4 to Site 3, while the mold density increases. These results disprove our original hypothesis completely; the magnesium levels did not increase as the mold density increased.

However, our data do display an interesting relationship between the magnesium levels (Figure 1) and the total fungal density of the soil (Figure 2). The two appear to have an inverse relationship with each other, and when a statistical analysis was performed on the data, we discovered an inverse relationship between yeast density and magnesium levels that was statistically significant. The differences in average yeast density between sites 1 and 4 had a p value of 0.1297 and the differences between sites 3 and 4 had a p value of 0.0998. The differences in the magnesium levels between the various sites were also found to be statistically significant.

Because magnesium is known to be a critical element in the process of fermentation (Pleshchitser, 1958), this may account for this inverse relationship we observed. Hence, while ultimately our hypothesis was disproved and the magnesium in the soil did not increase as the total fungal density increased, nor did it specifically increase as the density of mold increased, we did find that the yeast and magnesium were inversely related. Therefore, our data suggest that further research about the relationship between magnesium levels and yeast density in the E.S.S.R.E. research sites is in order.

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