Compost vs. Soil

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Background Research

Fungi are eukaryotic heterotrophs that include the mushrooms, molds, and yeasts (Card, Carter, Moravec, Reeder, Whiting, and Wilson, 2015), and they help maintain the ecology of the soil in many ways. First, they help improve soil quality by decomposing complex carbon compounds, increasing the accumulation of organic matter, helping the soil hold its nutrients by binding soil particles together into aggregates, competing against plant pathogens, and decomposing pollution so it doesn't harm plants (Card, Carter, Moravec, Reeder, Whiting, and Wilson, 2015). Second, Fungi help play vital roles in the lives of plants by making nutrients more accessible to their roots and conditioning the soil to make air passageways to improve aeration and drainage (Smith, n.d.).

One particular group of fungi that help plants in this way are the Mycorrhizae. "Mycorrhizae are symbiotic relationships that form between fungi and plants" (Pace, 2003), and these type of fungi colonize the roots of plants, where they help the plant acquire the nutrients the plant needs by (National Science and Technology Center, 2001) releasing enzymes that help the fungi digest their food externally (Ussery, 2010). The Fungi then absorb these nutrients into their cells, and the excess goes to the plants (Ussery, 2010). In return, the plant gives back to the fungi, providing energy in the form of sugars (National Science and Technology Center, 2001) and other carbohydrates (Pace, 2003). "Nearly all plants on earth rely on mycorrhizal fungi for nutrients and moisture," (Bio Organics, 2015) and without the presence of mycorrhizae, many plants would find it extremely hard to survive. Other benefits of mycorrhizal fungi "include enhanced rooting of cuttings, increased root generation, increased drought resistance, increased salt tolerance, reduced transplant shock, and enhancement of other valuable organisms in the soil" (Bio Organics, 2015).

However, mycorrhizae are not the only fungi that live in the soil. Other types of fungi decompose organisms instead, and as these fungi break down dead organisms and other organic matter, they create a substance known as compost. “Composting is nature’s process of recycling decomposed organic materials” (San Mateo County RecycleWorks, 2016), and the fungi species involved in it are most active during the mesophilic and thermophilic stages of the composting process (Olynciw and Trautmann, 1996). Just about anything that has organic material in it can be composted, including fruit scraps, newspaper, the cobs of corn, veggie scraps, broken up eggshells, and coffee grounds (Seaman, 2014), and by deliberately composting, people do not need to use synthetic fertilizers. Composted material can feed all different kinds of organisms that live in the soil, enabling them to do their ecological roles more effectively allowing for better and healthier soil. This keeps all of the plants healthy. Furthermore, Composted material also decreases the chance of runoff and soil erosion, allowing the soil to obtain more water. (Washington State University, 2016).

In addition to the nutrients compost releases into the soil which plants can use, compost also releases material which is useful to the mycorrhizae, enhancing the mycorrhizae’s mineral production for the plant roots. Since compost adds extra nutrients to the soil and mycorrhizae allows for a larger surface area on the plant to absorb nutrients, adding the extra nutrients from the compost will force more mycorrhizae to grow in order to compensate for the newly added extra nutrients (Olynciw and Trautmann, 1996).

For our project, we have asked the question, “Does the presence of compost increase or decrease the density of fungi in the soil?” We plan to answer this question by running tests on bags of soil with a certain percentage of compost (0%, 25%, 50%, and 75%) mixed in to see if the density of the fungi increases. We chose this question because we wanted to see if an everyday action of composting actually makes a difference on our school's property and what those benefits are. We have taken soil from our school's front lawn and we are going to take compost from our school's finished compost pile. When we have finished our experiment, we hope that the tests show that the presence of compost will increase the density of the fungi in the soil.

Experiment

Problem: Does the percentage of compost in the soil increase or decrease the density of the fungi in the soil?

Hypothesis: A higher percentage of compost in the soil will increase the density of fungi in the soil.

Independent Variable: the percentage of compost added to the soil

Dependent Variable: the density of the fungi in the soil

Negative Control: soil without compost added

Controlled Variables:

- Type of water used
- Location of where soil samples are taken
- The amount of time the compost and soil are together in the plastic bag
- The type/size of pipette used
- Size of plastic bags (16.5 cm x 14.9 cm)
- Types of plants near the soil being extracted
- Method used to mix compost with soil
- Number of times plastic bag is shaken
- Day and time that all samples are taken
- Degree to which the soil/water mixture is diluted to
- Amount of sterile water added to each extraction tube
- Amount of soil added to each extraction tube
- Amount of soil water mixture put onto nutrient agar dishes

- Type of nutrients on agar dishes
- Amount of time fungi is given to grown
- Temperature at which the fungi is grown (room temp.)
- Size of soil samples collected (15 cm deep by 2 cm wide)

Procedure:

1. Go to N 39˚ 21.464', WO 76˚ 38.207' located on the RPCS lawn and collect 4 different samples of soil that are 15 cm deep and 2 cm in diameter from an open area with only grass growing there and place each sample into separate plastic bags, labelled A, B, C, or D respectively. Repeat this until you have three bags per letter. (e.g. A1, A2, A3; B1, B2, B3 etc.….) Make sure that all of the samples are collected on the same day at as close to the same time as possible.
2. Make sure that steps 3-13 are performed on the same day at as close to the same time as possible.
3. Use a clean, new transfer pipette to add 10 ml of sterile water to a 15 ml culture tube. Label the tube "10^0 sample A1."
4. Use the same pipette to add 9 ml of sterile water to a second 15 ml culture tube. Label the tube "10^{-1} sample A1."
5. Repeat step 3 one more time to an additional 15 ml culture tube. Label the tube "10^{-2} sample A1."
6. Place 1-cc of soil from bag A1 into the "10^0 sample A1" culture tube.
7. Cap the tube and shake vigorously.
8. Using a new clean pipette, remove 1 ml of the soil/water mixture from the "10^0 sample A1" tube and place into the "10^{-1} sample A1" tube.
9. Cap and shake vigorously.
10. Using the same pipette in step 11, remove 1 ml of the soil/water mixture from the "10^{-1} A1" tube and place into the "10^{-2} sample A1" tube.
11. Cap and shake vigorously.
12. Plate 100 µl samples from all three culture tubes separately onto their own 3M Petrifilm™ Yeast and Mold Count Plate. Label each plate to match its source. (e.g. sample from culture tube "10^0 sample A1" should be labeled "10^0 sample A1")

13. Repeat steps 2-12 until all the bags of soil have been tested. Make sure to test all bags on the same day and as close to the same time as possible. Each time a new bag is tested, make sure to label the culture tubes in accordance with the bag that is being tested. For example, if bag A2 is being tested label the culture tube "10^0 sample A2" and so on.

14. Allow to grow for 48 to 72 hours.

15. Go to the lowest dilution that was plated and using a magnifying glass, count the number of yeast and or mold on it. If the lowest dilution plated does not have yeast or mold on it, move to the next dilution and count the amount of mold and or yeast present there. Once you have collect all of data for each set of plates, following the formula: **# microbes in 1-cc of soil = # colonies on sheet x 10^2 x 10** $^{|\text{absolute value of dilution that was used}|}$

16. Have one bag 100% soil (label A1). Make sure that steps 16-20 are completed on the same day at as close to the same time as possible.

17. Weigh soil in bag B. Multiply the mass of the soil in bag B by 25%. Take the 25% of the mass of the soil out of the bag. Weigh the compost until its mass is equal to the mass of soil taken from bag B. Add the newly weighed compost to bag B. Mix the compost and soil by breaking it up with your hands into the smallest particles possible.

18. Weigh soil in bag C. Multiply the mass of the soil in bag C by 50%. Take the 50% of the mass of the soil out of the bag. Weigh the compost until its mass is equal to the 50% of soil taken from bag C. Add the newly weighed compost to bag C. Mix the compost and soil by breaking it up with your hands into the smallest particles possible.

19. Weigh soil in bag D. Multiply the mass of the soil in bag D by 75%. Take the 75% of the mass of the soil out of the bag. Weigh the compost until its mass is equal to the 75% of soil taken from bag D. Add the newly weighed compost to bag D. Mix the compost and soil by breaking it up with your hands into smallest particles possible.

20. Repeat steps 15-19 two more times for a total of 3 bags per percentage being tested. (A-D) Make sure that all the bags are weighed and mixed on the same day at as close to the same time as possible.

21. Allow the compost and soil mix to sit for 60 hours.

22. Repeat steps 2-14 for each bag making sure to test each bag on the same day at as close to the same time as possible.

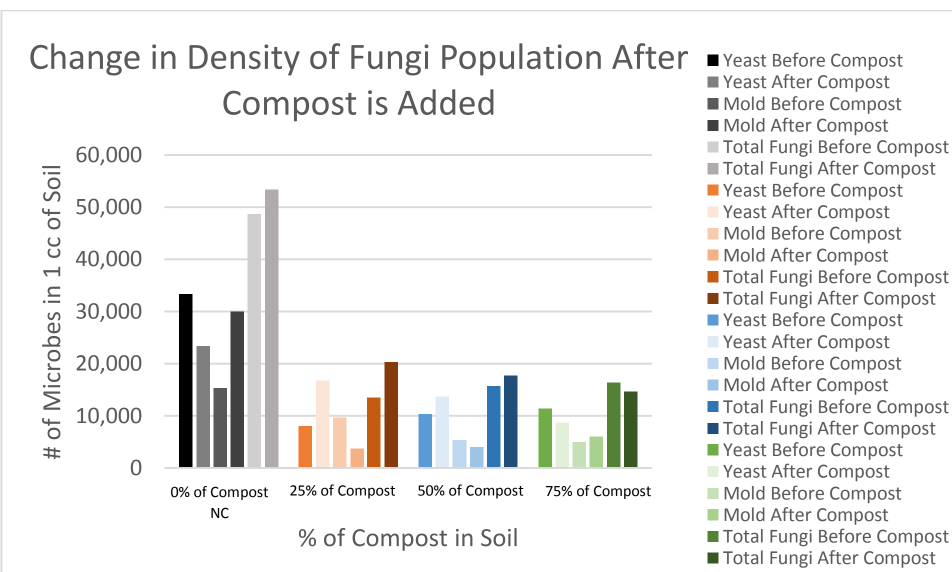
23. Record the results of each bag and compare the density of the fungi in the soil with the compost and the density of the fungi without the compost.

Data Table:

Change in Density of Fungi Population in 1-cc of Soil After Exposure to Compost

Sample	Trial	Total Yeast		Total Mold		Total Fungi		Averages	
		Before Compost (#/cc)	After Compost (#/cc)	Before Compost (#/cc)	After Compost (#/cc)	Before Compost (#/cc)	After Compost (#/cc)	Before compost (#/cc)	After Compost (#/cc)
Soil w/ 0% replaced as compost	**A1**	30,000	20,000	5,000	10,000	35,000	30,000	48,667	53,333
	A2	40,000	10,000	11,000	50,000	51,000	60,000		
	A3	30,000	40,000	30,000	30,000	60,000	70,000		
Soil w/ 25% replaced as compost	**B1**	10,000	10,000	15,000	4,000	25,000	14,000	17,667	20,333
	B2	4,000	20,000	10,000	2,000	14,000	22,000		
	B3	10,000	20,000	4,000	5,000	14,000	25,000		
Soil w/ 50% replaced as compost	**C1**	20,000	30,000	8,000	5,000	28,000	35,000	15,667	17,667
	C2	1,000	10,000	3,000	4,000	4,000	14,000		
	C3	10,000	1,000	5,000	3,000	15,000	4,000		
Soil w/ 75% replaced as compost	**D1**	20,000	10,000	4,000	6,000	24,000	16,000	16,333	14,667
	D2	10,000	6,000	6,000	10,000	16,000	16,000		
	D3	4,000	10,000	5,000	2,000	9,000	12,000		

Graph:



Conclusion:

By performing our experiment, our hypothesis of the density of fungi increasing with a higher percentage of compost was proven to be incorrect. In the negative control, when no compost was added to the soil, comparing the density from the two different times that the soil was tested showed that more fungi changed from its protective yeast state, 33,333 microbes to 23,333 microbes, to its ideal growing form of mold, 15,333 microbes to 30,000 microbes, and increased the overall density of the fungi in the soil, 48,667 microbes to 53,333 microbes. When looking at the soil that had 25% of its soil replaced with compost, the change was the opposite. The yeast numbers went up from 8,000 microbes to 16,667 microbes and the mold numbers went down from 9,667 microbes to 3,667 microbes. Though the total number of fungi in the soil went up, the amount of fungi in its ideal growing form went down, disproving our hypothesis. This trend continued on into the 50% trials, but stopped at the 75% trials. The data collected from the 75% soil-compost mix agreed with our hypothesis up until you compare the overall total number of fungi. The amount of yeast decreased from 11,333 microbes to 8,667 microbes and the amount of mold increased from 5,000 microbes to 6,000 microbes, but unfortunately the final overall amount of fungi found in the soil decreased from 16,333 microbes to 14,667 microbes. The decrease in total amount of fungi and increase in mold count means that something in the soil caused the fungi to spend more energy on transforming into their ideal growing form rather than reproducing. This outcome could have happened because though the compost added nutrients and minerals to the soil, an overabundance could have over whelmed the fungi so much that its natural drive to reproduce became over powered with the need to change into a more acceptable growing form.

Further research and testing that could be performed based on the results of this experiment could include performing this experiment again, but changing the increments of percentage of compost that was added to the soil. For example, we could have bags with 0% compost, 10% compost, 15% compost, and 20% compost. Conducting more research on the nature of the experiment and being more informed on the subject before formed a hypothesis would have significantly affected the nature and perhaps the outcome of the experiment. For example, testing for a change in density of protozoa or bacteria could have been a more logical choice.

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