Ellen Franz, Rebecca Taylor, Caroline Riina
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Soil Aeration Background

Soil is alive, full of living protozoa, bacteria, small animals, plants, and other organisms. These organisms serve purposes in the soil. Some recycle energy by decomposing dead matter that releases carbon dioxide and feeds the plants. Others recycle plant matter by decomposing it into matter that the plants may take up again. Penicillin controls diseases. Some organisms aid neighboring plants in getting water. Burrowing organisms aid in the recycling of clay and minerals by bringing up subsoil through their digging. Many bacteria decompose chemicals, such as pesticides, into water and carbon dioxide. These chemicals are vital to the survival of plants and animals, and if the bacteria are destroyed, plants, humans, and the soil would not be able to survive. Without bacteria, plants will not be able to gain as much water, humans will have a tougher time controlling diseases, and the soil will not be able to get rid of dead matter. (Soil Ecology Background Information, 5/1/05).

Soil aeration is necessary to create a better living environment for these organisms. Aeration improves the properties of the soil, therefore making better living conditions for the necessary organisms. Soil structure can be changed through aeration. Aeration increases the pore sizes of the soil and allows water logged soil, such as a clay based soil, to release some of its water. Aeration also helps the bacteria living in the soil. It increases the size of the pores in the soil, therefore providing the organisms with an easier way to uptake water, sunlight, and oxygen. Since, oxygen is required by plants and organisms to perform respiration, aeration allows oxygen to get down to the organisms at

a deeper depth. (Echochem, 5/3/05). Aeration "reduces runoff and puddling, improves air exchange between the soil and the atmosphere, improves fertilization uptake and use, improves water uptake, and enhances thatch breakdown." (Lawn Aeration, 5/3/05). Aeration is necessary to make better the living conditions of these organisms, so that they will be able to perform their duties, which include hydrolysis.

Hydrolysis is the chemical reaction responsible for the breaking of polymers. In this process water is used to break the bonds between monomers. There are two different types of hydrolysis, acid and enzymes. The chains between the monomers of plants are made of sugar and they are fermented with yeast, which is used to create ethanol. Yeast use this method to decompose polymers and if water is not able to easily reach the yeast, the yeast with not be able to decompose. (Hydrolysis, 5/23/05). Aeration clears thatch, which is build up that prevents water from getting into the soil, therefore the yeast can get the water they need to decompose plants.

With aeration neglect, a negative impact known as turf grass can appear on the upper layer of the grass or lawn. Turf grass appears after a long period of time without soil aeration. When stress is put on the top layer of the lawn without aeration, the section is compacted, leading to other problems. Some of these problems can include maintenance problems and pest problems. These problems begin to appear at a quicker rate and increase as the compacted soil needing aeration continues to exist. Therefore aeration is necessary for the maintenance and health of the soil by making sure that the carbon cycle can be easily performed ("Lawn Aeration", 2005).

The carbon cycle impacts the nourishment of the soil. It begins above ground, where organisms exhale carbon dioxide. Once exhaled, the carbon dioxide is taken in by the plants growing where it is used for nutritional purposes. Plants use the oxygen to complete work, grow, and to provide energy for the organisms which eat the plants. The organisms which eat the plants complete the same tasks as the plants. The organisms then have a very important role in providing nutrients for the soil. A large portion of the soil contains organisms known as decomposers who break down waste. The organisms' excrements are found upon the ground and move into the soil. The excrements of the organism contain the most nutrients from the organism. Therefore the soil breaks down the waste and absorbs some of the nutrients to use for work. The other nutrients are prepared to pass on to the plants through their roots so they are able to use the nutrients as well. The carbon cycle continually repeats after this cycle is complete (SeaFriends-Soil Ecology, 5/23/05). Fungi and organisms benefit from the carbon cycle as well as aeration.

Fungi, organisms that benefit from aeration, serve as one of the main decomposers and maintain the soil's fertility. (Soil Microorganisms, 5/4/05). Fungi are the most active decomposers and can range from a single yeast cell to a mushroom or mold. The reason fungi are great decomposers is because they can tolerate acid in the soil well. (Soil Organisms & Living in the Soil, 5/4/05). Actually, fungi grow best in slightly acidic environments, where the pH is around 5. They are also able to grow in soil that has little moisture, which shows that fungi benefit from aeration. Fungi need aeration because if the soil is water logged, they do not grow as well. (Fungi, 5/4/05). In the soil, fungi feed on organic matter created by the plants. (Soil Organisms & Living in the Soil,

5/4/05). In fact, about 90% of the entire material produced by plants is broken down by decomposers, such as fungi. (The Soil Makers, 5/4/05). Fungi are able to easily contribute to decomposing partially because there are so many fungi in the soil. In four cubic centimeters of topsoil, there are approximately 120,000 fungi living. (Fungi, 5/4/05). Also, there are approximately 1 to 2 kilometers of hyphae per centimeter squared. (The Soil Makers, 5/4/05). Hyphae are "any of the threadlike filaments forming the mycelium of a fungus." (Dictionary.com, 5/8/05). These hyphae are used to secrete enzymes and acids that break down the organic matter around them into simpler molecules, such as water, carbon dioxide, or sugar, for easy absorption. (Soil Organisms & Living in the Soil, 5/4/05). These chemicals are used to create the major biochemicals: nucleic acids, carbohydrates, lipids, proteins, and water. These biochemicals make and break bonds, or chemically react, and the energy produced from this is used to perform the 4 tasks: reproduction, synthesizing proteins, regulating the environment, and cellular respiration. This is the big picture of why fungi are so important. This can also be explained through a major cycle. When a plant dies, fungi decompose debris of the plant. Decomposition creates the basic molecules, as described above. The major molecule that is a result of decomposition is carbon dioxide. That carbon dioxide travels into the plant, where it is used in the process of photosynthesis. When photosynthesis occurs, sugar is produced and oxygen is also produced as a byproduct. This oxygen is then used by animals to breathe and live. Without the fungi decomposing, or if the fungi population suddenly died, the living organisms would become extinct. Knowing what fungi does in soil and approximately how many fungi there are in soil is helpful information when

performing our experiment because we are specifically testing population density and we must understand why the soil is different with different populations of fungi.

Aeration is key for decomposition, and therefore key for fungi to fulfill their role in soil. Because of aeration, the soil receives oxygen, and "oxygen is necessary for organic materials to decompose." (Composting, 5/4/05). Also, biological activity in the soil will decrease because of "poor aeration (high bulk density, particles small, too much moisture)." (BioCycle - Journal of Composting & Recycling, 5/4/05). Also, the opposite of aeration, compaction, is bad for the soil, because it can minimize the amount of soil organisms living. The way to naturally aerate the soil is through various burrowing animals that live in the soil. One of the major soil organisms that naturally aerates is the earthworm. (Soil Ecology and Restoration Group, 5/4/05). Aeration is extremely important to decomposing and fungi populations, so this information will be prevalent when performing our experiment.

In this experiment, we plan to test how aeration can change the density of yeast in the soil. It is necessary to understand the processes that occur in the soil and how they are affected by aeration. From this information we are able to form a hypothesis which states that with an increase in aeration, we will also see an increase in the density of the yeast population. We are also able to create a controlled experiment which involves different amounts of aeration.

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Outline of the Experiment

Problem: Does the density of yeast population change with an increase in soil aeration?

Hypothesis: With an increase in soil aeration, the number of yeast population will increase as well.

Experiment:

Independent Variable: amount of aeration applied to the soil

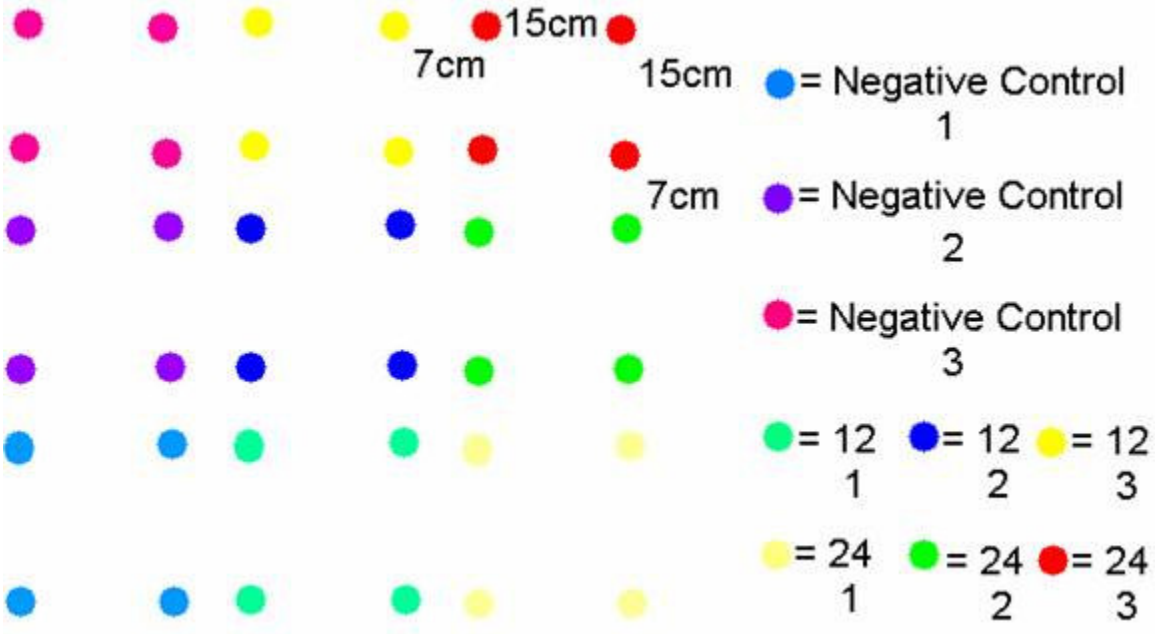
Dependent Variable: density of yeast in the soil

Negative Control: density of the yeast in the soil where no aeration is applied and the density of the yeast in the soil before the aeration is applied

Controlled Variables: the area where the soil samples are taken from, the method of aeration, the size of the land plot, the amount of dilution to the soil, time allowed to grow the yeast colonies, type of food/ plate used, amount of soil taken from the test site, amount of soil dilution sample applied to the plate, time when the soil samples are taken, width of the holes, depth of the holes, the tool used, size of the soil samples, timing of the dilutions

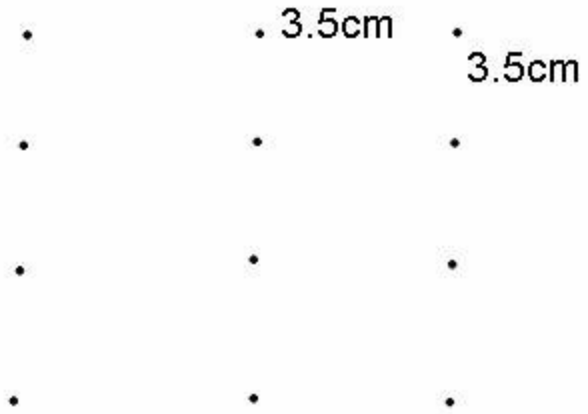
Procedure:

1. Mark a 15 cm by 15 cm plot of land by placing four flags in the four corners.
2. Repeat eight more times placing soil plots seven cm away from one another. Arrange in three rows of three. Label plots accordingly to their amount of aeration.

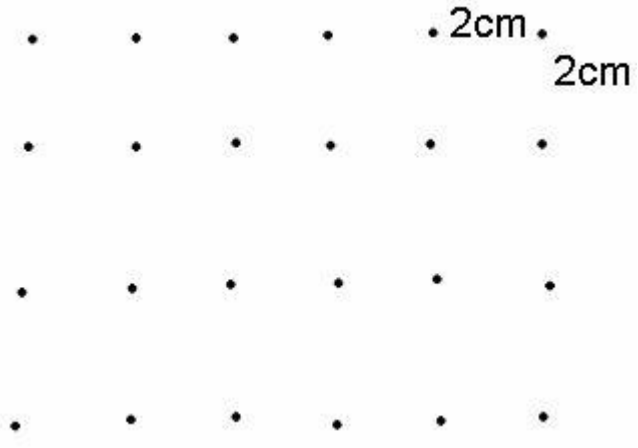


3. Use a two cm diameter soil core sampler to take a 15cm deep sample from the Negative Control 1 plot. Remember to rotate the sampler 360 degrees to isolate the sample.
4. Put the sample in a sealed plastic bag and label it “Negative Control 1 A”.
5. Repeat step three in the same plot, twice, and label the bags “Negative Control 1 B, and Negative Control 1 C”.

6. Use a two cm diameter core sampler to take a 15 cm deep sample from the Twelve 1 plot. Remember to rotate the sampler 360 degrees to isolate the sample. Put the sample in the bag labeled “Negative Control 1 Twelve A”.
7. Repeat step 6 in the same plot, twice, and label the bags, “Negative Control 1 Twelve B, and Negative Control 1 Twelve C”.
8. In this plot, use a screwdriver with .5 cm diameter to punch 12 holes in four rows of three. Each hole should be 3.5 cm apart and 10 cm deep.



9. Use a two cm diameter core sampler to take a 15 cm deep sample from the Twenty Four 1 plot. Remember to rotate the sampler 360 degrees to isolate the sample. Put the sample in a bag labeled “Negative Control 1 Twenty Four A”.
10. Repeat step 9 twice more and label the bags “Negative Control 1 Twenty Four B, and Negative Control 1 Twenty Four C.”
11. In this plot, use the same screwdriver to punch 24 holes in four rows of six. Each hole should be 2 cm apart and 10 cm deep.
12. Repeat steps 3- 11 for the other plots and label the bags accordingly.



13. Let the aerated plots sit for two days.
14. Take three soil samples each 15 cm deep with a diameter of 2 cm from each plot and label their bags accordingly.

15. Repeat all of the following steps for the "before samples" at the same time. Then repeat all of the following steps at the same time for the "after soil samples". Place 1 cc of soil sample "Negative Control 1 A Before" into a culture tube containing 10 mL of sterile water, cap the tube and shake vigorously. Using a serological pipette, remove 1 mL of the soil / water mixture and place into a fresh culture tube.
16. Add 9 mL of fresh sterile water to the second tube, cap and shake vigorously.
17. Take one mL of soil/ water mixture from the second test tube and place it into a third test tube. Add 9 mL of sterile water to the tube, cap and shake vigorously.
18. Plate 100 ul samples from the 2^{nd} and 3^{rd} tubes onto their own separate, individual "Petrifilm Yeast and Mold Count Plate" and allow it to incubate at room temperature for four days.
19. Examine each of the plates for individual yeast colonies and choose the plate with the smallest number of colonies above five, (If both numbers are less then five, then choose the number that is closest to it. If both numbers are equal, use the first dilution.) to make your estimates of the number of yeast in the original 1 cc soil sample (# colonies on plate * 10^2 = # of yeast in dilution tube; # of yeast in dilution tube * $10^{|\text{\# of dilutions}|}$ = # yeast/ cm^3 of soil in original sample tube).

Data

Before Aeration Trial 1		
Amount of Holes per a 15 by 15 cm soil plot	Density of Yeast per 1 cc of soil	Total Density of Yeast per 1 cc of soil
0- A	4000	39000
0- B	30000	
0- C	5000	
12- A	5000	11000
12- B	5000	
12- C	1000	
24- A	2000	11000
24- B	3000	
24- C	6000	

Before Aeration Trial 2		
Amount of Holes per 15 by 15 cm soil plot	Density of Yeast per 1 cc of soil	Total Density of Yeast per 1 cc of soil
0- A	13000	24000
0- B	5000	
0- C	6000	
12- A	2000	8000
12- B	3000	
12- C	3000	
24- A	4000	9000
24- B	2000	
24- C	3000	

Before Aeration Trial 3		
Amount of Holes per 15 by 15 cm soil plot	Density of Yeast per 1 cc of soil	Total Density of Yeast per 1 cc of soil
0- A	3000	61000
0- B	50000	
0- C	8000	
12- A	6000	22000
12- B	4000	
12- C	12000	
24- A	4000	10000
24- B	2000	
24- C	4000	

After Aeration Trial 1		
Amount of Holes per 15 by 15 cm soil plot	Density of Yeast per 1 cc of soil	Total Density of Yeast per 1 cc of soil
0- A	40000	53000
0- B	1000	
0- C	12000	
12- A	3000	14000
12- B	8000	
12- C	3000	
24- A	1000	15000
24- B	8000	
24- C	6000	

After Aeration Trial 2		
Amount of Holes per 15 by 15 cm soil plot	Density of Yeast per 1 cc of soil	Total Density of Yeast per 1 cc of soil
0- A	0	
0- B	3000	5000
0- C	2000	
12- A	8000	
12- B	2000	15000
12- C	5000	
24- A	13000	
24- B	4000	21000
24- C	4000	

After Aeration Trial 3		
Amount of Holes per 15 by 15 cm soil plot	Density of Yeast per 1 cc of soil	Total Density of Yeast per 1 cc of soil
0- A	2000	
0- B	2000	6000
0- C	2000	
12- A	4000	
12- B	1000	7000
12- C	2000	
24- A	1000	
24- B	2000	7000
24- C	4000	

x axis: 1= zero holes
2= twelve holes
3= twenty four holes
Series One= Before Aeration
Series Two= After Aeration

x axis: 1= zero holes
2= twelve holes
3= twenty four holes
Series One= Before Aeration
Series Two= After Aeration

x axis: 1= zero holes
2= twelve holes
3= twenty four holes
Series One= Before Aeration
Series Two= After Aeration

Conclusion

Our hypothesis, which was as aeration increases, the density of the yeast population will increase accordingly; proved to be accurate. Our hypothesis proved true on five out of the nine trials, or 55% of the trials. Therefore we are not able to strongly to support this statement. Our trial one results supported our hypothesis in all aspects. Our negative control had an increase of 14,000 in the density of yeast, our aeration of twelve holes had an increase of 3000 in the density of yeast, and aeration of twenty-four holes had an increase of 4000 in the density of yeast in the soil. All three of these plots suggest that aeration was the cause for this increase, and that data states that our hypothesis was

true. Two out of the three trials supported the hypothesis, however one did not. Our second trial proved controversial. The aeration trial with twelve holes had an increase in yeast density by 7000, and the aeration trial with twenty-four holes had an increase 22,000. On the other hand, our negative control decreased by a large amount. It dropped from a density of 24,000 yeast to a density of 5,000 yeast. This created a difference of 19,000 yeast over a period of two days. Although our trial two somewhat proved our hypothesis, our third trial conveyed opposite results as those that appeared in trial one. All of trial three had a decrease in yeast density over the allotted time for aeration. The negative control dropped by 55,000, our twelve hole aeration dropped by a yeast density of 15,000, and our twenty-four hole aeration dropped by a density of 3,000. Although our results are somewhat skewed, over half convey a result supporting our hypothesis. However in order to thoroughly prove that our hypothesis is true, more trial would have to be completed. There are several factors that may have altered our outcomes.

One key factor that could have altered the outcome of the density of the yeast in the soil could have been the tool we used to aerate the soil with. We chose to use a screwdriver and punch several holes into the ground. However, this had the opposite affect that we desired. Since no soil was being removed, when pushed into the soil, the screwdriver actually compacted the soil. Around the edges, the soil would have had smaller pores which would have affected the yeast and caused their population to decrease instead of increase. This is because yeast are dependant upon the amount of nutrients in the soil, and soil with smaller pores would transfer fewer nutrients. Therefore we may have actually decreased the soil population. Another problem may have been

weather. We took our before aeration samples and after aeration samples at different times. Right before we took our before samples it had rained, which means there was more moisture in the soil. More moisture would lead to more nutrients for the yeast to grow off of. However during the time period between our before aeration and after aeration sample, there was no rain. Therefore there was less moisture in the soil. So it may be plausible that this had some impact upon our results. There was one key mistake we made though when taking our sample. When receiving our results we realized that our negative control yeast densities were very high compared to the before plots with 12 and 24 holes. After recalling what we had done, we realized that previously we had taken samples from the negative control plots which were later deemed invalid because all the plot samples weren't taken at the same time. Therefore our results may have been altered. However we realized that taking samples also works as a form of aeration. By looking at the plot that had previous samples taken, to the plots without precious soil samples taken, we identified that the yeast population probably increased over that period of time. Although we cannot justify this, it is plausible.

There were several things we could do to avoid our mistakes and justify our hypothesis when performing our experiment. Instead of using a screwdriver we and punching 12 and 24 holes into the ground, we could have taken an object with a smaller diameter and punched it several more times into the ground. By doing this, there would have been less compaction. Another alternative would to be to use and object that would "stir" the soil instead of punching holes into it. Another thing we should have done was to take all the samples on the same day the first time. Otherwise we should have set up a

new set of plots and taken new samples. And to deal with the weather a greenhouse could have been used so soil would have been kept in a controlled environment.

Although our experiment had several mistakes and did not strongly support our hypothesis, it can be determined that density of yeast does increase as the amount of aeration in the soil.