Heather Loughran
Janie Outlaw
Rebecca Otto
Biology Project

Microbes in the Soil

Heather Loughran, Janie Outlaw, and Rebecca Otto

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Mr. Brock

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Heather Loughran
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Rebecca Otto
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Background

Before fertilizers were discovered in the 1950's, plants got their nutrients naturally, from animal waste and decomposition. Now, fertilizers can be made from organic or chemically manufactured material, and most contain potassium, nitrogen, and phosphorus, which are all inorganic materials. When fertilizers started being man-made, crop production increased all over the world, and the benefits of chemical now fertilizers include increased crop expansion and production; improved quality of corn, wheat, rice and cotton; and faster crop growth, which allows farmers to grow more in a short amount of time. These seem to be good things, but if fertilizers are used to much they can have negative consequences. People overuse each kind, but an excess of nitrogen is much worse for the plants than an excess of phosphorus. People overuse fertilizer mostly because they do not know what the proper amount for the area they are covering, so they guess and will often just use all. (Bortman and Brimblecombe, 2003). Animal waste, compost, and recycling are an alternative to chemical fertilizers and are less harmful, chemical fertilizers have quicker results, so people use them instead. (Campbell and Reece, 2002).

Using nitrogen fertilizer changes the nitrogen cycle in a negative way. Both the nitrogen and phosphorus cycles are altered when humans use fertilizer, but the way the nitrogen cycle works is first organic residues from animals go into the ground. Fertilizer replaces this when used. The organic matter (animal waste) then turns into ammonium and nitrites. Through nitrification, the nitrite becomes nitrate.

Heather Loughran
Janie Outlaw
Rebecca Otto
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This happens because the bacteria eat the ammonia and nitrite in the soil, and then turns them into nitrate as a waste byproduct. The nitrate is the food/protein for plants, which use it to reproduce, transform energy, synthesize new material, and regulate its environment. (Campbell and Reece, 2002).

Although the phosphorus cycle is similar to the nitrogen cycle, phosphorus plays a different role than nitrogen. Organic matter (plant residue and humus) goes into the soil (which is what the fertilizer replaces) and then through mineralization bacteria in the soil create a phosphorus solution. Plants absorb the solution as their food, and that is where they get their energy. (Mintz and Larin, 2000).

A type of microorganism that is found in both cycles is fungi, or decomposers. The fungi are what turn the decomposing organisms into ammonia for the plants food. If there is not enough fungi in the soil, the plants food is not created as quickly, which means the fewer decomposers in the soil, the weaker/sicker the plant is. These cycles are both altered when fertilizer is substituted. (Campbell and Reece, 2002).

Although all life requires nitrogen, an excess of nitrogen is harmful to plants and the fungi that help it grow. Nitrogen promotes growth and increases the productivity of plants because of its role in protein. This means that plant growth and the amount of fungi in the soil depends on how much nitrogen goes into the soil. If lots of fertilizer is put into the soil, then the fungi will not make anything because they are being burned. They are burned because of the high ammonia levels in the soil, which are added by the fertilizer and their own waste. The fungi then die, and eventually the plants die because there is nothing to make the nitrates which are their food. (Rennenberg and Gesler, 1999)

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This problem can be avoided if there are enough plants to eat all the waste in the area that is being fertilized. If someone stops using fertilizer because they realize they are using to much, this will also kill the plant and the fungi. This happens because if you suddenly take the fertilizer away, the plants don't get enough food because the fertilizer was their only food source because of the burning fungi. If the plant does not get enough food, it dies. When the plant dies, the fungi die because they were getting the sugar to make ATP from the plants. They can no longer make ATP, therefore they have no energy, and therefore they die. Excess nitrogen creates inactivity of the roots, causing plants to grow in different ways then they are supposed to and creating a nutrients imbalance. All of these things occur because the excess nitrates create excess protein, which start and stop too many chemical reactions, so all of the four tasks are trying to happen at the same time. This overloads the plants system and causes it to die. Although more nitrogen is reported to decrease *and* increase frost resistance, in most cases it is found to decrease resistance. (Harrison, 2003).

Even though nitrogen prolongs the growth period of a plant, it lowers its protection from natural and environmental stresses. This happens because the fungi that are helping to feed the plant die (for reasons mentioned above), and so the plant starts to live only off of the fertilizer in the soil. The fertilizer doesn't give any protection to the plant like the fungi did when it was still in the soil. The vitality of the plants starts to wither, and it becomes prone to things like frostbite, drought, and pathogens. Overall, nitrogen is more harmful than helpful to plants, and is one of the main ingredients in common fertilizers. (Bortman and Brimblecombe, 2003).

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Biology Project

Phosphorus is another chemical found in fertilizer. Like nitrogen based fertilizers, there are phosphorus based fertilizers. Unlike nitrogen based fertilizers, phosphorus based fertilizers have almost no negative effects on plants and bacteria. The few negative effects that can occur come from manufactured phosphorus, which makes the soil insoluble by mixing with aluminum and iron. Insoluble soil makes it difficult for the plants roots to reach any phosphate, which makes it hard for them to survive. (Campbell and Reece, 2002). There are many more positive effects of an overabundance of phosphorus. Phosphorus creates phosphate, which is essential for the plant and microorganisms like fungi. Excess phosphate in soil is actually a good thing, because phosphate is basically just ATP, so without the phosphate ATP is not present. This means that there is no energy for the plant or microorganisms. Without the right amount of energy, plant growth becomes stunted and the stems become spindly and weak. Also, if plants do not get enough phosphorus when they are seeds, it is almost for them to ever have enough, which makes most people overuse their fertilizer. Deficiency signs are grayish green leaves and a red looking color at the base of the leaf. All these positive effects of phosphate show that fertilizer with more phosphorus than nitrogen is much better for the soil and microorganisms. (Mintz and Larin, 2000).

Phosphorus is obviously the much better choice for soil. Even if a plant needs more nitrate, it is very risky to use nitrogen fertilizer because of all of its bad affects. The phosphorus fertilizer also has some risks, but it is much safer and more helpful for plants. If any kind of fertilizer is used, the right measures must be taken to ensure the plant and microorganisms health. This is why, for our hypothesis, we said that

Heather Loughran
Janie Outlaw
Rebecca Otto
Biology Project
phosphorus fertilizer would alter the balance of fungi much less than nitrogen

fertilizer would.

References:

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Lab Outline

Problem: Which fertilizer upsets the balance of fungi in the soil, a nitrate fertilizer or phosphate fertilizer?

Hypothesis: If we apply the nitrate fertilizer to a plot of soil and phosphate fertilizer to a plot of soil, then the nitrate plot of soil will be more upset then the balance in the phosphate plot of soil.

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Independent Variable: the different types of fertilizer applied to the soil

Dependent Variable: the nitrate levels of the soil

Dependent Variable²: the phosphate levels of the soil

Dependent Variable³: the amount of fungi in the soil

Negative Control: the soil where only water is added

Controlled Variables:
1. the amount of land tested
2. each plot of the same area tested
3. what is tested
4. the amount of fertilizer applied
5. type of fertilizer
6. the time tested
7. size of soil collected
8. what the fungi is grown on
9. amount of water used in non fertilizer soil
10. type of tests that are performed
11. timing of dilutions
12. how many samples taken
13. type of test solution used to dilute soil
14. size of sample
15. type of pipette
16. type of water
17. temperature which fungi grown
18. amount of H_2O in dilution tubes
19. sterlity of the dilution tubes
20. amount of dilution plotted
21. type of Petri film plate

Procedure
1. Section off 3 plots of land that are each 10 x 10 cm square behind the cafeteria patio 39.35712º N. and 76.63605ºW.

10x10 Nitratre plot	10x10 Water plot	10x10 Phosphate plot

2. Use a metal soil core tester with the diameter of 2cm. and place it in the ground to the first line, which is 15.3cm down, rotate it 360º two times and pull the tester out of the ground to get samples of soil in the section where you will be applying the fertilizer based soil and put the samples in the sterile bag

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3. Perform a Nitrate Nitrogen Test, Phosphorous Test (LaMotte STH 14 kit), and Serial Dilution Test on each soil sample; be sure to complete all three on a given sample at the SAME TIME
4. Record Data
5. Put 11.1 grams of nitrate based fertilizer to one liter of water, shake vigorously
6. Put 11.1 grams of phosphate based fertilizer to another liter of water, shake vigorously
7. Get a liter of regular water
8. Go out and apply the nitrate based fertilizer water to the nitrate plot, the phosphate based fertilizer water to the phosphate plot, and to the water plot, apply just a liter of water
9. Collect new soil samples from each site 2 days later. Put the samples of soils in the sterile plastic bags and label the bag of what plot you got the soil from
10. Repeat Step 3 on new samples.
11. Record Data
12. Repeat experiment 2 more times to have accurate data

Data and Analysis

Number of Fungus per cc of Soil

	Plots with Nitrate Fertilizer Added		Plots with Phosphate Fertilizer Added		Water Only Plots	
Trial	Fungus	Fungus	Fungus	Fungus	Fungus	Fungus
	Before	After	Before	After	Before	After
1	600	210,000	5,000	140,000	1,000	650,000
2	4,000	1,080,000	4,800	3,420,000	6,000	1,130,000
3	500	362,000	1,200	850,000	5,000	16,300,000
Average	1,700	55,066	3,666	1,470,000	4,000	6,026,666

Heather Loughran
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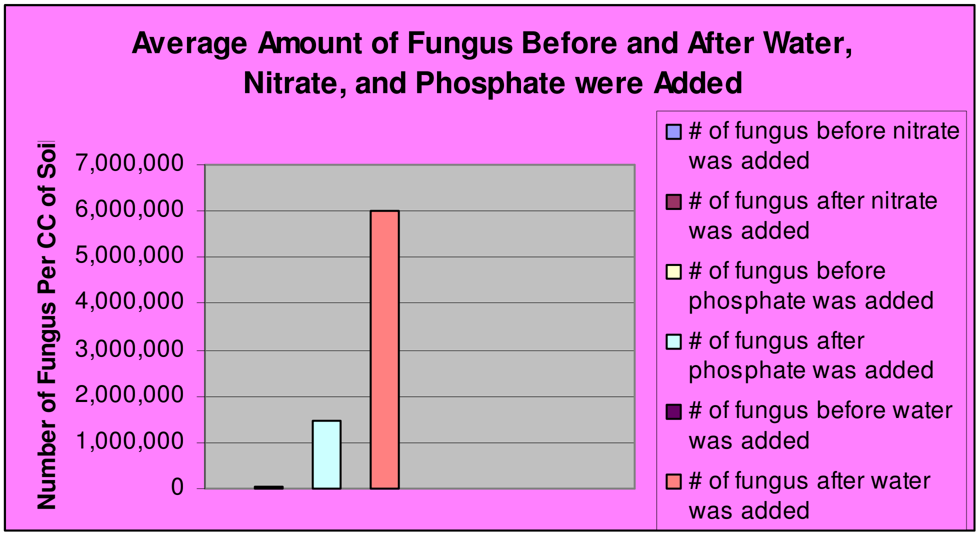
Rebecca Otto
Biology Project



Number of Nitrate (PPM)

Trial	Plots with Nitrate Fertilizer Added		Plots with Phosphate Fertilizer Added		Water Only Plots	
	Nitrate Before	Nitrate After	Nitrate Before	Nitrate After	Nitrate Before	Nitrate After
1	75	80	100	30	40	100
2	10	17.5	50	75	15	40
3	75	75	25	75	15	150
Average	53	57.5	58	60	23	96

Number of Phosphate (PPM)

Trial	Plots with Nitrate Fertilizer Added		Plots with Phosphate Fertilizer Added		Water Only Plots	
	Phosphate Before	Phosphate After	Phosphate Before	Phosphate After	Phosphate Before	Phosphate After
1	75	100	100	100	100	75
2	45	100	50	100	12.5	100
3	50	100	25	100	75	100
Average	56	100	175	100	62.5	91

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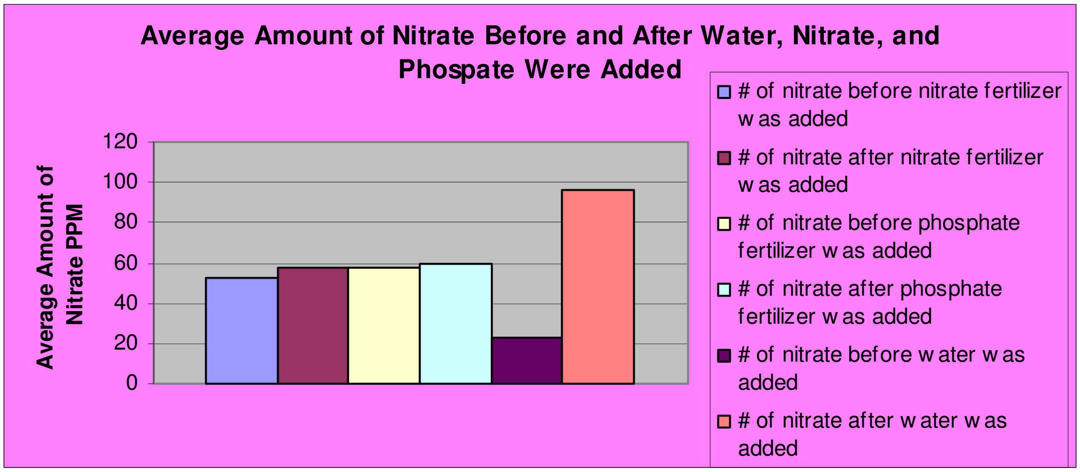

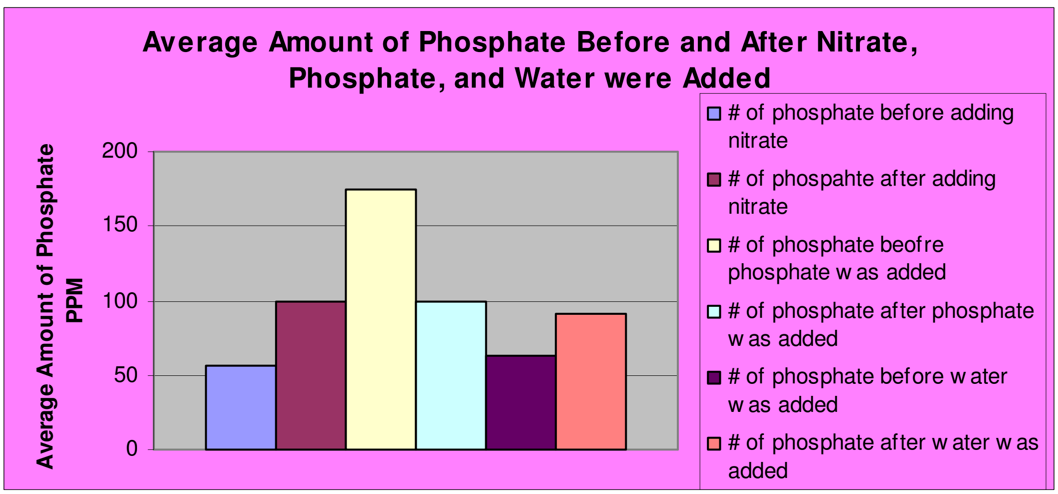

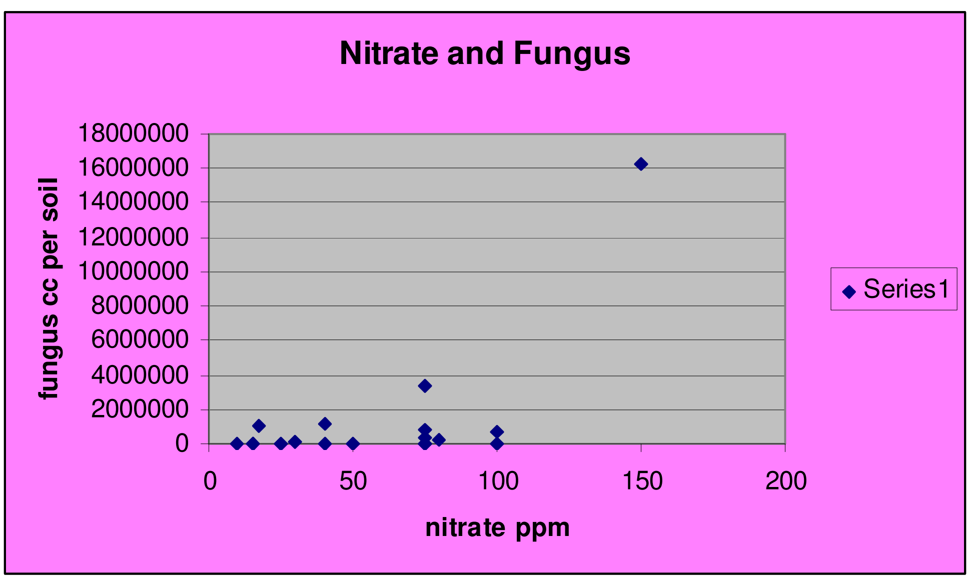

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Conclusion

Our hypothesis, which was if we added phosphate fertilizer to a plot of land, nitrate fertilizer to a plot of land, and just water to a plot of land, that the nitrate fertilizer plot of land would upset the balance more than phosphate based fertilizer, was proven to be correct. The numbers on the fertilizer bag, the 1st number being the nitrate, the 2nd number being the phosphate, and the 3rd number being the potassium, indicates what is in the fertilizer. The phosphate fertilizer amounts were 18-24-6 (24 being the phosphate amount). The nitrate fertilizer amounts were 28-12-28 (28 being the nitrate amount). When we added the nitrate based fertilizer to the soil, the amount of fungi increased. When we added the phosphate, it did not have as dramatic an increase as the nitrate base plot. The nitrate based average before we added the fertilizer were 1,700 fungi, and after we added the fertilizer the average became 55,066 fungi. The phosphate based average for before we added the fertilizer was 3,666 fungi. After we added the fertilizer the average was 1,470,000 fungi. There is clearly a much higher increase in the nitrogen fungi than the phosphorus fungi. The water plots averages were 4,000 before and 6,026,666 after. In our trials, the negative control (the water plot) had the most fungi in the soil. We tested 12 holes two different times – three of the holes were the water plots, three were the phosphate plots, and three were the nitrate plots. Everything was controlled, and so we know

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that the results we found were accurate and true, supporting our hypothesis. To test the soil of such things talked about previously, we used a soil core tester and placed it in the ground to the first line, or 15.3 cm, to get the soil, put the soil in sterile plastic bags and test the nitrate, phosphate, and fungi in the soil. After testing the nitrate and phosphate and diluting the soil to grow the fungi, data proves that our hypothesis is correct.