PHOSPHOROUS APPLICATION COMPARISON BETWEEN ORGANIC FERTILIZERS AND SWINE MANURE IN THE HIGH COUNTRY

By

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Abstract

In the High Country, due to soils being deficient in phosphorus, people predominately lean toward utilizing organic fertilizers to supply additional nutrients to their crops (Boylan, R. personal communication, Oct 16, 2019). As a result, this research seeks to compare two commonly used fertilizers to hog manure in order to find which source supplies the most phosphorus. Hog manure is used as a source of fertilizer due to the high amounts of phosphorus that the waste contains. The reason for this is because swine are unable to break down phytate that is found in phosphorus due to not having an abundance of the phytase enzyme (Joern and Sutton, 2019). Phosphorus being a cheap additive, is also added in hog diets in large quantities, which results in large quantities of phosphorus in their manure (Joern and Sutton, 2019). The three treatments, along with a control group, were randomly assigned to a 10 ft by 10 ft plot, with 16 total plots. Over the course of a six-month timeline after the treatments were applied soil tests were conducted at two periods. The first soil test was taken at the halfway mark at three months and again at the end of the six-month period. The plots that had swine manure (A) applied did increase the phosphorus index of the soil and had the highest index compared to bone meal and rock phosphate. But with an unexpected increase in the phosphorus index in two of the control plots (B1 and B2), other factors such as leaching, and slope could have impacted the uptake of phosphorus. From this research the importance and limitations of on farm research is emphasized, as well as the significance of proper soil and waste management.

Introduction

In the High Country of North Carolina soil tests from the North Carolina Department of Agriculture (NCDA) indicate low levels of phosphorus in the soil, due to younger soils (Boylan, R. personal communication, Oct 16, 2019). Previous research has indicated significant amounts of phosphorus found in swine manure (Labus, Eddy personal communication, Oct 16, 2019). Hogs do not possess the large quantities of the phytase enzyme to digest and break down phytate in phosphorus, which result in high amounts of phosphorus in their manure (Joern and Sutton, 2019). Therefore, this research seeks to test the hypothesis that by using hog manure as a soil amendment and comparing the manure to two other organic soil amendments. The other soil fertilizers are rock phosphate and bone meal, which are two organic fertilizers that farmers practicing organic techniques commonly use to increase the phosphorus content in their soil (Boylan, R. personal communication, Oct 16, 2019).

Background

North Carolina is the 3rd highest state in the United States in hog production, where 40% of those hogs are located in the eastern part of the state (Shahbandeh, 2021). The management system for hog manure is each designed based on the geographic location in the United States. Hog producers that have 250 hogs or more are required to have a waste management system (Facts about North Carolina's Animal Feeding Operations Program, n.d). Each system meets the needs for that specific region for fertilizer application for crops as well as climate and soil type. In North Carolina the waste management system that is used to manage waste are lagoons which utilize anerobic bacteria to break down the waste (*Taking the Mystery Out of Pork Production: Environmental Protection*, n.d). The lagoon system is similar to a septic system where the manure is collected, stored, and then treated (*Taking the Mystery Out of Pork Production:*

Environmental Protection, n.d). Treatment is conducted by microbes which decompose hog waste and nutrients, then fertilizer is collected and sprayed on crop fields that surround the hog houses (*Taking the Mystery Out of Pork Production: Environmental Protection*, n.d). The amount of manure that is applied is limited based on the crop fertility requirements that are being grown as well as laws in North Carolina that only allow manure to be sprayed at specific times during the year (*Taking the Mystery Out of Pork Production: Environmental Protection*, n.d).

The management of waste from hog operations is significant to maintain clean living conditions for hogs, as well as helping to protect the environment. Surface water, groundwater, and other bodies of water can become polluted if the waste is not properly managed. Weather can cause water pollution to occur unintentionally due to hurricanes in eastern North Carolina, such as Hurricane Floyd in September of 1999 (SARE, 2021). In an outdoor hog operation manure management is just as important, but the management looks different. When raising hogs outside on pasture, hogs should be rotated and to encourage their manure to be spread (Barry, Ellsworth, Pietrosemoli, 2015). Hog manure can also be collected and used as an organic fertilizer. Rotating hog throughout multiple paddocks allow grasses and forages to grow back and regenerate by intaking the nutrients from the hog manure (Barry, Ellsworth, Pietrosemoli, 2015). Raw manure from in an outdoor system is equally as environmentally degrading as the manure in the lagoons, therefore managing hog waste correctly and efficiently can help reduce the amount of leaching that can occur (Barry, Ellsworth, Pietrosemoli, 2015).

Organic sources of NPK have lower percentages of nitrogen, phosphorus, and potassium because they are animal by-products that do not contain additional nutrients including ammonium sulfate or ammonium phosphate. Comparatively, inorganic fertilizers that are made up of ammonium sulfate and ammonium phosphate originate from mineral deposits but have higher percentages of NPK (Schiller, 2021). Organic phosphorus, for example, can be applied as bone meal which is generated by breaking down bones that come from slaughterhouses (Schiller, 2021). The NPK percentages of bone meal are estimated to be 2-14-0 for a 50-pound bag, where 14% of bone meal is phosphorus. An example of a non-organic phosphorus fertilizer is diammonium phosphate which has an NPK of 18-46-0. In the High Country organic fertilizers are more commonly used by people to supply nutrients such as nitrogen, phosphorus, and potassium to their crops (Boylan, R. personal communication, Oct 16, 2019).

In addition to supplying fertilizers to increase NPK, the soil acidity or pH affects the availability and or uptake of nutrients such as nitrogen, phosphorus, and potassium. The optimum pH for phosphorus to become more readily available is from 6.5 to 7.5 (see Appendix A). In the High Country the soil pH ranges around 5.5-6.0 which can correlate to lower phosphorus levels and availability (Hardy, Tucker, Stokes, 2014). Farmers and homesteaders in the High Country who grow crops that require an adequate amount of phosphorus can increase the phosphorus uptake by also increasing the pH of the soil. Therefore, reaching the minimum phosphorus index may rely on not only the application of phosphorus in the form of fertilizers, but also obtaining a more basic or alkaline soil pH (Bradley and Osmond, 2019).

If people in the High Country are more inclined to utilize organic fertilizers to supply additional phosphorus to soil, then the concept of applying hog manure as an organic fertilizer could be beneficial. Along with not having the phytase enzyme hogs are given feed that have high amounts of phosphorus to encourage more phosphorus uptake (Joern and Sutton, 2019). Phosphorus being inexpensive to add to feed and the lack of the phytase enzyme correspond to significant amounts of phosphorus in hog waste.

Methods

This study consisted of preliminary soil and hog manure samples to calculate and determine the amount of phosphorous, bone meal, and rock phosphate needed to grow tomatoes at the experimental location in Todd, North Carolina. The collection of hog manure was conducted at Warren Wilson College in Swannanoa. Once the manure was collected the manure, rock phosphate, and bone meal were all applied on top of the soil simultaneously in a completely randomized design to 16 plots. Each plot was 100 ft^2 and between each plot was a 50 ft^2 buffer and was randomly assigned to either bone meal, rock phosphate, manure, or left empty. Plots that were left empty were the controlled variable for the experiment and each variable was assigned 4 times. 50 lbs. of manure for plots assigned with A. Manure was left on top of the soil to replicate real life simulation of pigs depositing waste. 5.8 lbs. of bone meal was added to plots assigned with D and 20 lbs. of rock phosphate was applied to plots assigned with C. Soil samples were taken halfway through the experiment timeline in mid-January and again in mid-April, making the total infiltration period to be six months. During the experiment additional soil sample were collected from hog areas at two farms in the High Country. Soil tests were also analyzed from the North Carolina Department of Agronomics Public Access Laboratory-information-management System, otherwise known as the NCDA PALS. Statistical data was calculated using a T-Test on Microsoft Excel, where a p-value that is less than 0.05 is deemed significant.

Item	Price
Bone Meal (24 lbs.)	$26.98
Rock Phosphate (84 lbs.)	$71.97
Hog Manure (200 lbs.)	$40.00

Gas (Half a Tank)	$20.00
NCDA Waste Test	$12.00
Sales Tax (6.75%)	$6.68
Total	$177.63

Table 1: Costs

Key:

A = Manure

B = Control (Nothing Applied)

C = Rock Phosphate

D = Bone Meal

Figure 1. Completely Randomized Plot Design

A1	Buffer	B4
Buffer	Buffer	Buffer
C1	Buffer	D4
Buffer	Buffer	Buffer
A2	Buffer	D3
Buffer	Buffer	Buffer
B1	Buffer	C4
Buffer	Buffer	Buffer
B2	Buffer	D2
Buffer	Buffer	Buffer
A3	Buffer	C3
Buffer	Buffer	Buffer
A4	Buffer	C2
Buffer	Buffer	Buffer
D1	Buffer	B3

Calculations

Sample ID: RBX2	Recommendations: Crop	Lime (tons/acre)	N	P_2O_5
Lime History:	1 - Tomato	1.8	90-120	30
	2 - Vegetables, other	0.0	80-100	50

Test Results [units - W/V in g/cm^3; CEC and Na in meq/100 cm^3; NO_3-N in mg/dm^3]:

HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%
0.66	0.92	10.1	81	2.0	5.8	83	269	52	16

Figure 2: Initial Soil Test on March 26th 2020

P-I: 83[1] High Phosphorus Index

$$83\ Index \times 2.138\ lbs/acre = 177.454\ P\ avaliable\ in\ lbs/acre$$

Vegetables: 177.454 lbs/acre + 50 lbs/acre (Additional Phosphorus Recommended) = **227.454 Total Phosphorus Needed**

Rock Phosphate: 0-3-0 (NPK)

- 50 lbs. = 1.5 lbs. of Phosphorus
- $\frac{227.454 \text{ lbs/acre}}{0.03} = 7{,}581.8$ lbs of Rock Phosphate per acre needed
- $\frac{7581.8 \text{ lbs of RP}}{1 \text{ acre}} \text{ x } \frac{1 \text{ acre}}{43{,}560 \text{ ft per acre}} \text{ x } \frac{100 \text{ ft}}{1 \text{ acre}}$ = 17.4 lbs. of Rock Phosphate per 100 ft^2
- 17.4 lbs/100ft^2 x 4 = 69.6 => 70 lbs. needed + 10% = 77 lbs. RP

Bone Meal Granular: 2-10-0 (NPK)

- 10 lbs. = 1 lb of Phosphorus
- $\frac{227.454 \text{ lbs/acre}}{0.1} = 2274.54$ lbs of Bone Meal Gradular per acre needed
- $\frac{2274.54 \text{ lbs of BMG}}{1 \text{ acre}} \text{ x } \frac{1 \text{ acre}}{43{,}560 \text{ ft per acre}} \text{ x } \frac{100 \text{ ft}}{1 \text{ acre}}$ = 5.22 lbs. of Bone Meal Granular per 100 ft^2
- 5.22 lbs/100ft^2 x 4 = 20.8 => 21 lbs. needed + 10% = 23.1 lbs. BMG

Hog Manure:

- $\frac{18 \text{ lbs. of phosphorus}}{1 \text{ ton of waste}} \text{ x } \frac{1 \text{ ton}}{2{,}000 \text{ lbs.}} = \frac{0.009 \text{ lbs of phosphorus}}{1 \text{ lb of waste}} \text{ x } 100\text{ft} =$

  $0.9 \text{ lbs of phosphorus for a } 100 \text{ lb bag of pig waste } (\text{N} - 0.9 - \text{K})$

- $\frac{227.454 \text{ lbs/acre}}{0.009} = 25272.66 \text{ lbs bags of phosphorus per acre needed}$

- $\frac{2274.54 \text{ lbs of P}}{1 \text{ acre}} \text{ x } \frac{1 \text{ acre}}{43{,}560 \text{ ft per acre}} \text{ x } \frac{100 \text{ ft}}{1 \text{ acre}}$ = 58 lbs. of phosphorus per 100 ft^2

- $58.2 \text{ lbs}/100\text{ft}^2$ + 5.8 (10% of 58.2) = 64 lbs. for each plot

- 64 x 4 => 260 lbs. of Hog Manure Needed

Results

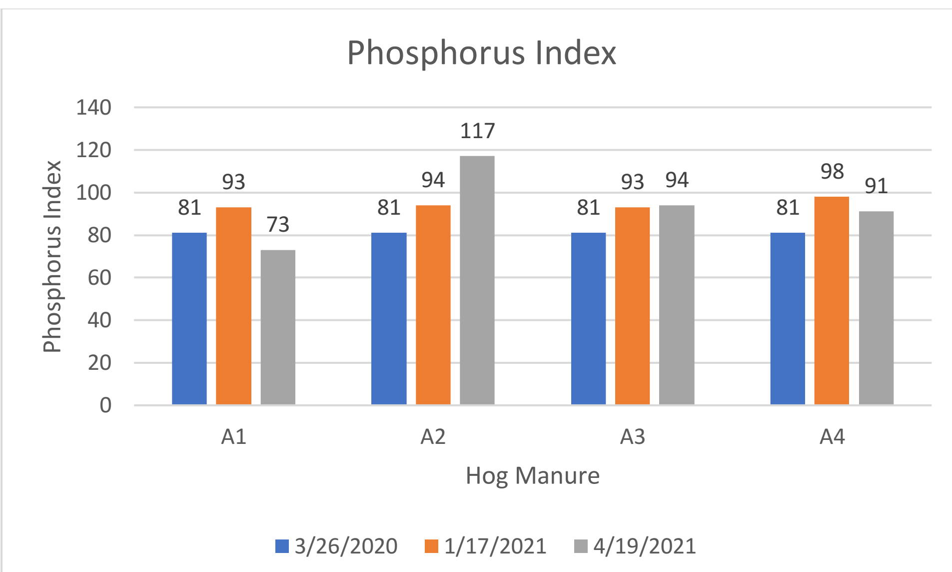

Figure 3: Phosphorus levels of plots where hog manure was applied

At the midpoint of the test period on 1/17/21, the soil phosphorus index of plot A1 increased to an index of 93 from the initial phosphorus index of 81. At the end of the test period the phosphorus index of A1 decreased 20 units to 73. The phosphorus index of plot A2 increased

13 units at the midpoint test period to 94 and continued to increase to a phosphorus index of 117 at the end of the test period. Similarly, the phosphorus index of plot A3 increased 12 units to reach an index of 93 at the midpoint test period. At the end of the test period the phosphorus index of A3 increased to 94. The phosphorus index of plot A4 increased from 81 to 98 at the midpoint test period and decreased 7 units to an index of 91 at the end of the test period. For the first soil test 100% of the plots indicated an increase in phosphorus index. For the second soil test 50% of the plots indicated a decrease in phosphorus index and 50% increased.

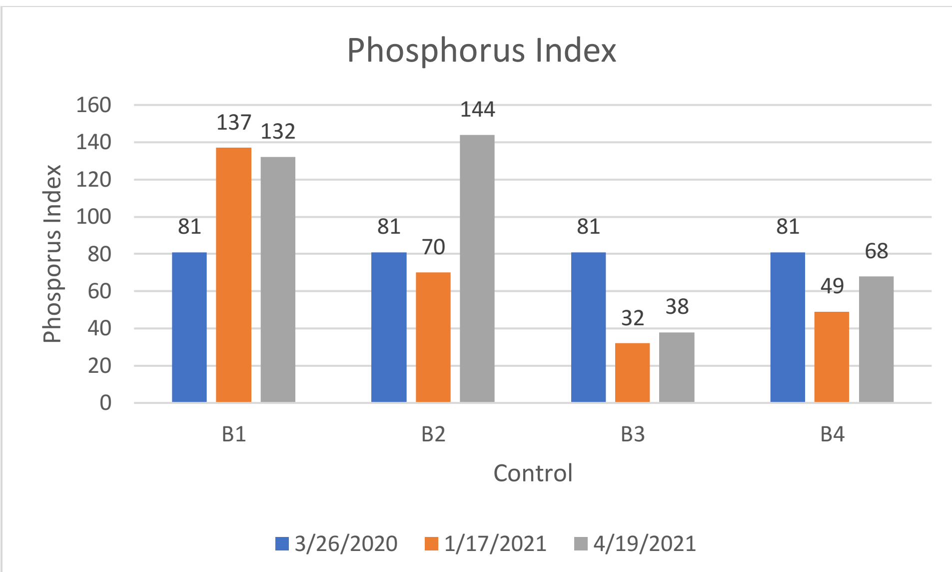

Figure 4: Phosphorus levels of plots where no amendments were applied

At the midpoint of the test period on 1/17/21, the soil phosphorus index of plot B1 increased to an index of 137 from the initial phosphorus index of 81. At the end of the test period the phosphorus index of B1 decreased 5 units to 132. The phosphorus index of plot B2 decreased 9 units at the midpoint test period to 70 but increased to a phosphorus index of 144 at the end of the test period. Similarly, the phosphorus index of plot B3 decreased 49 units to reach an index of 32 at the midpoint test period. At the end of the test period the phosphorus index of B3 increased to 38. The phosphorus index of plot B4 decreased from 81 to 49 at the midpoint test period and increased 19 units to an index of 68 at the end of the test period. For the first soil test 75% of the plots indicated a decrease in phosphorus and 25% increased. For the second soil test 75% of the plots indicated an increase in phosphorous index and 25% decreased.

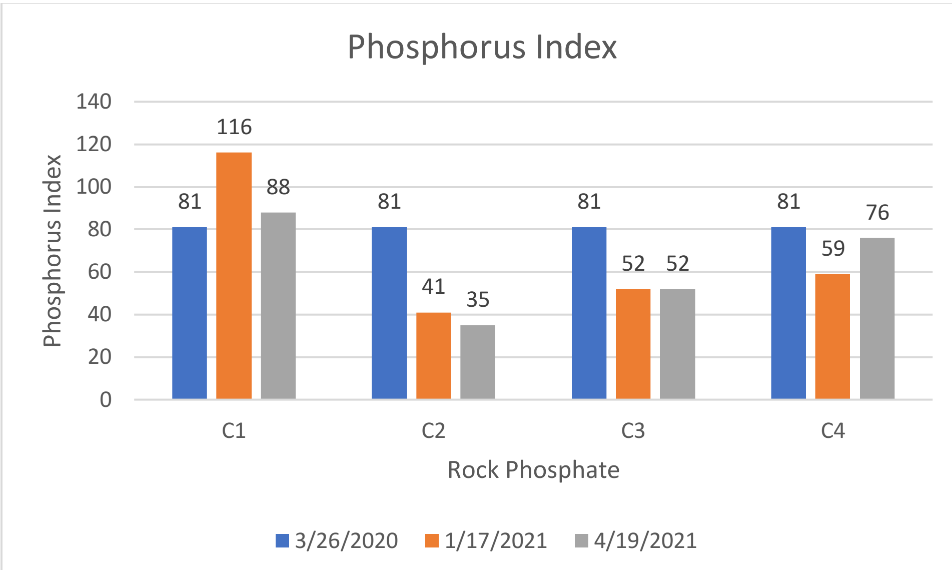

Figure 5: Phosphorus levels of plots where Rock Phosphate was applied

At the midpoint of the test period on 1/17/21, the soil phosphorus index of plot C1 increased to an index of 116 from the initial phosphorus index of 81. At the end of the test period the phosphorus index of C1 decreased 25 units to 88. The phosphorus index of plot C2 decreased 40 units at the midpoint test period to 41 and continued to decrease to a phosphorus index of 35 at the end of the test period. Similarly, the phosphorus index of plot C3 decreased 29 units to reach an index of 52 at the midpoint test period. At the end of the test period the phosphorus index of C3 was maintained at 52. The phosphorus index of plot C4 decreased from 81 to 59 at the midpoint test period and increased 17 units to an index of 76 at the end of the test period. For the first soil test 75% of the plots indicated a decrease in phosphorus index and 25% increased.

For the second soil test 50% of the plots indicated an decrease in phosphorus index, 25% did not change, and the last 25% increased in phosphorus.

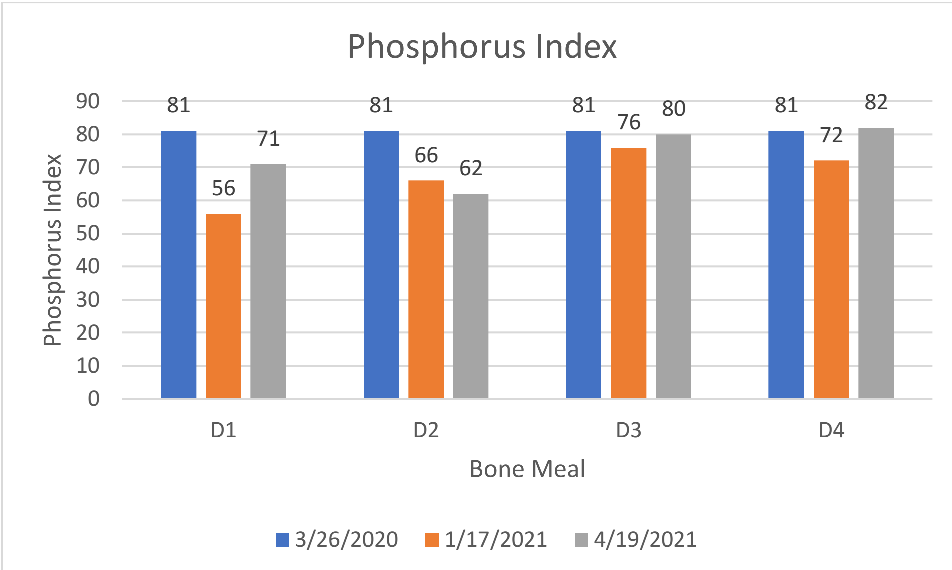

Figure 6: Phosphorus levels of plots where Bone Meal was applied

At the midpoint of the test period on 1/17/21, the soil phosphorus index of plot D1 decreased to an index of 56 from the initial phosphorus index of 81. At the end of the test period the phosphorus index of D1 increased 15 units to 71. The phosphorus index of plot D2 decreased 15 units at the midpoint test period to 66 and continued to decrease to a phosphorus index of 62 at the end of the test period. The phosphorus index of plot D3 decreased 5 units to reach an index of 76 at the midpoint test period. At the end of the test period the phosphorus index of D3 increased to an index of 80. The phosphorus index of plot D4 decreased from 81 to 72 at the midpoint test period and increased 10 units to an index of 82 at the end of the test period. For the first soil test 100% of the plots indicated a decrease in phosphorus index. For the second soil test 25% of the plots indicated an decrease in phosphorus index and 75% increased in phosphorus.

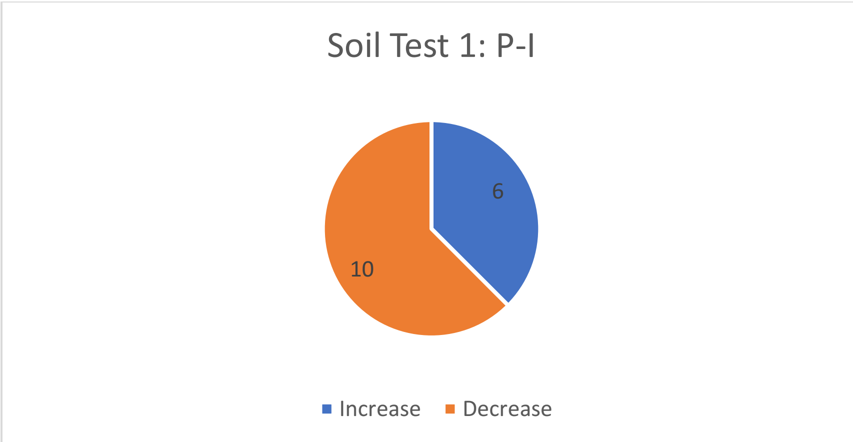

Figure 7: Overall increase/decrease of phosphorus from soil test 1 from all treatments

The first soil test showed that overall, 37.5% of the soil tests increased in the phosphorus index, whereas 62.5% decreased from the initial index of 81.

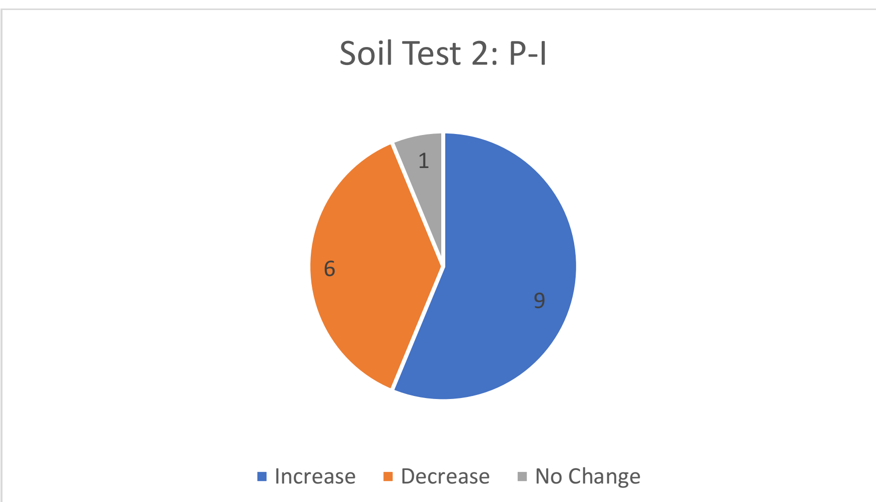

Figure 8: Overall increase/decrease of phosphorus from soil test 2 from all treatments

The second soil test overall showed 37.5.% of the soil tests decreased in the phosphorus index, whereas 56.25% increased and 6.25% did not change from the initial index of 81.

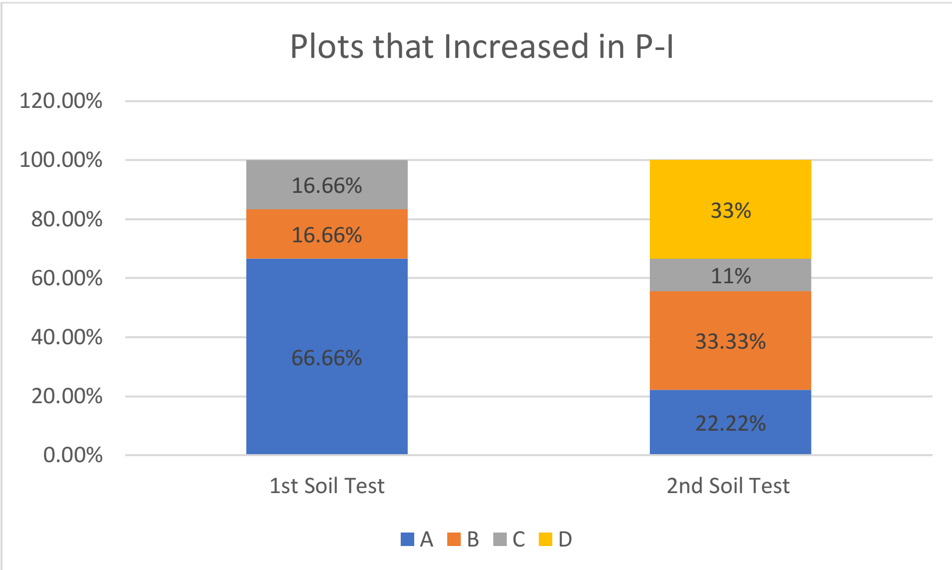

Figure 9: Plots that increased in phosphorus index out of all 16 plots

From the first soil test 6 out of the 16 soil test or 37.25% of the plots increased in the phosphorus index where 66.66% of those 6 plots were A. One B plot and one C plot made up 16.66% each of the 6 plots that increased. In the second soil test 9 out of the 16 soil tests or 56.25% of all 16 plots had an increase in phosphorus index. Three B plots and three D plots or 33.33% out of 10 plots increased in phosphorus index on the second soil test. Two A plots or 22.22% out of 10 plots increased in phosphorus index. One C plot made up 11% out of the 11 plots that increased in phosphorus index.

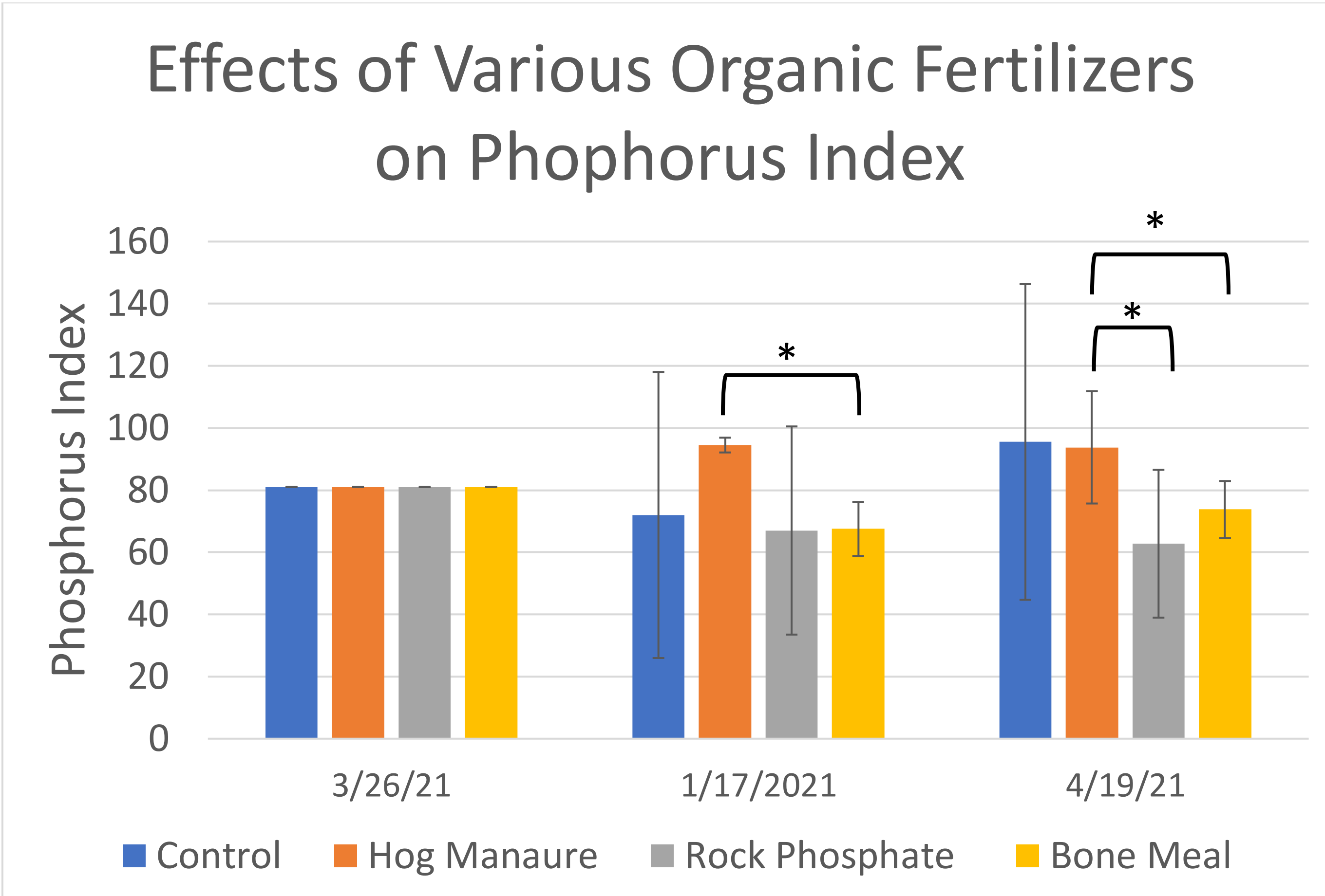

Figure 10. Effects of various organic fertilizers on phosphorus index

Overall, there is a statistical significance between hog manure and bone meal at the first and second soil test throughout the study. There is also a statistical difference between hog manure and rock phosphate after the second soil test was taken on April 19th, 2021. A statistical significance is numerical evident when the P-value is under 0.05. Rock phosphate takes a longer period of time to be released into the soil, which could explain why hog manure and rock phosphate did not have a statistical difference at the first soil test in January.

Discussion

The data collected shows that after the first soil test 37.5% of tests taken from all 16 treatments increased in phosphorus. All the manure plots (labelled A) had an increase in the phosphorus index when soil tests were taken at the halfway mark. After the second or final soil test 56.25% of all the plots increased in phosphorus index, whereas 50% of the plots that had hog manure increased in phosphorus after the second test. The highest phosphorus index out of the 4 plots that had hog manure was A2, with an index of 117 at the second soil test. The plots that hog manure applied to had the highest phosphorus index average of 94.125 across the 8 different phosphorus indexes. Plots that had hog manure had significantly higher phosphorus indexes compared to the bone meal and rock phosphate. The plots with the closest phosphorus index that were consistently close to plot A were plot D, which had bone meal applied.

The highest phosphorus index between all four treatments and both soil tests was from plot B2 at the second soil test, which had a phosphorus index of 144. According to the NCDA Agronomics Division an index of 144 is considered very high (Hardy, Tucker, Stokes, 2014) (see Appendix B). Not only was the phosphorus index extremely high, plot B was the control variable which had no amendments added. This result was not expected because the control plots did not have any organic fertilizers applied to them. Plot B1 also had a high index after the first soil test of 137 and decreased to an index of 132 after the second test.

There appears to be no consistency in the data when comparing the pH to phosphorus index. For example, in control plots B1 and B2 that have the highest phosphorus index out of all 16 plots, but have the lowest pH compared to B3 and B4. Although pH was not the focal point of this experiment, none of the plots tested higher than a pH of 6.1. Phosphorus is most readily available at a pH of 6.5, therefore this result was unexpected because with a high phosphorus index of 144 and 132 the pH decreased for both B1 and B2 to a 5.6. Furthermore, the pH for plot A2 had the highest phosphorus index of 117 out of the other 3 hog manure plots and the pH was tested on 1/17/21 to be 5.9. Although A2 had the highest phosphorus index, the highest pH was tested at the first soil test from plot A1, with a pH of 6.1. Plot A1 had a phosphorus index of 93 after the first soil test, which is categorized as a high index (Hardy, Tucker, Stokes, 2014) (see Appendix B). Overall, 68.75% or 11 out of 16 tests indicate a high phosphorus index. Ultimately the data on pH and high phosphorus indexes indicates additional factors could have derived these unexpected results.

The topography of the testing site had a slope that ran parallel to a road, which sits adjacent to the plots. The row that begins with plot A1 visually had more vegetated growth in March 2020, compared to the other row that starts with B4. The visual identification of more vegetation in one row compared another indicates the presence of more nutrients on that specific row. The slope of the testing site could have played a role in the movement of phosphorus, as well as rainwater that induced leaching. Plots B1, B2, and all of the plots that had hog manure applied were all in the row that visually had more vegetated growth. These two factors of slope and rainfall were not considered in the study.

Further Research and Implications

If this research were replicated, collecting data on rainfall and snow would be beneficial to include, as well as looking at the topography or slope of the land. These two factors are very important in looking at the flow of nutrients and knowing proper soil management. Leaching and runoff become major issues in impacting the environment such as causing an overapplication of nutrients in the soil or pollution to groundwater or other bodies of water. In the High Country there are many microclimates throughout the area, therefore, understanding the weather and topography can help build an effective management plan for applying fertilizers or waste. Replication of this research on different parts of the High Country would be important to not only supply more data, but due to the various microclimates. If replicated testing the phosphorus content of the buffers would be also beneficial to indicate whether leaching is occurring. Overall, the act of taking soil tests is the first step in managing the nutrients that are in the soil, then learning how much fertilizer to apply and how those additional nutrients flow is also significant.

Effective soil management, as well as waste management is important in controlling the flow of phosphorus that occurs. Waste management can include spreading, collecting, or training hogs to deposit their manure in specific locations. Although in the High Country there are not a lot of people who own hogs, the management of two hogs is still important. Tilling the hog manure into the soil could be another treatment to compare to bone meal and rock phosphate. Tilling the waste would also reduce the amount of leaching that could occur during the experimental period. Another method to consider if this research was to be replicated is to control vegetation growth on the plot incase other plants uptake phosphorus throughout the research. Vegetation can be controlled by planting a cover crop or using plastic to restrict the growth of weeds or other plants.

Prior to replication increasing the pH to the optimal 6.5 would be significant to maximize the uptake of phosphorus in the soil. By addressing the pH first more phosphorus could be absorbed by the soil throughout the experiment.

Conclusion

In conclusion the data shows that out of the three treatments; bone meal, rock phosphate, and hog manure, hog manure had the highest increase in phosphorus index. Following the hog manure was bone meal and then rock phosphate, proving that phosphorus was successfully increased in the test area. Overtime the application of hog manure will build and increase a farmer's phosphorus index to their land (See Appendix C). Assuming labor costs are the same, the application of hog waste compared to purchasing organic fertilizers such as bone meal and rock phosphate, hog waste is free and less expensive to apply as an organic fertilizer. The control plots revealed that another factor such as topography or weather could have affected the infiltration of phosphorus. The control plots were not expected to increase in phosphorus to such a high index of 144 in B2 or 137 in B1.

Furthermore, this research was designed to replicate real life application of organic fertilizers and hog waste in the form of on farm research. Through this research the limitations of small on farm research were revealed, such as trying to find available land, finding consistent flat land (topography), labor, and hog manure. On farm research is more realistic but can be more difficult to find good resources such as an effective testing area. Compared to station research, on farm research has many limitations, but the application aspect is real. Ultimately, this research has shown that hog manure did increase the phosphorus more than bone meal or rock phosphate, but also emphasized the importance of waste and soil management.

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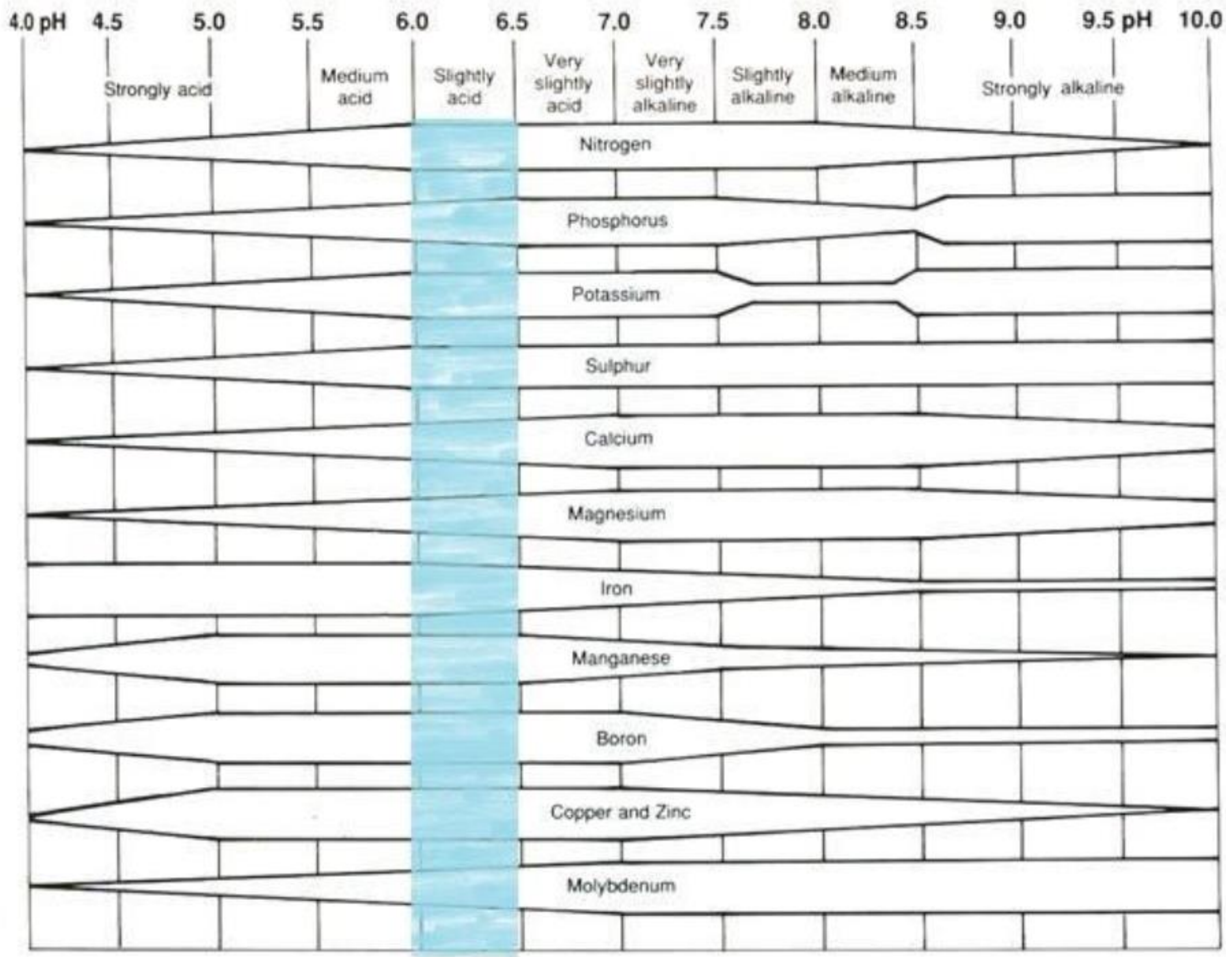
Appendix A. Nutrient availability compared to pH

Figure 1. Nutrient availability as affected by soil pH. The wider areas represent greater availability.



Appendix B. Understanding index ranges

Agronomic Services

Crop Fertilization Based on North Carolina Soil Tests

Table 1.1 Relationship between soil test index and yield

Soil Test Index		Crop Response to Nutrient Application *				
Range	Rating	P	K	Mn	Zn	Cu
0–10	very low	high	high	high	high	high
11–25	low	high	high	high	high	high
26–50	medium	medium	medium	none	none	none
51–100	high	none	low/none	none	none	none
100+	very high	none	none	none	none	none

* Crop response to phosphate (P_2O_5) and potash (K_2O) decreases as the soil test index approaches 50.

Appendix C. Wesley Looper soil sample, hog farmer for more than 30 years

NCDA&CS Agronomic Division Phone: (919) 733-2655 Website: www.ncagr.gov/agronomi/ Report No. FY20-SL032032

Predictive
Soil Report Mehlich-3 Extraction

Links to Helpful Information

Client: Wesley Looper
4695 Petra Mill Road
Granite Falls, NC 28630
Sampled County : Caldwell
Client ID: 81798

Advisor: Dwayne Tate
22 Driftwood Ct
Asheville, NC 28805
Advisor ID: 401875

Sampled: 06/05/2020 Received: 06/11/2020 Completed: 06/17/2020 Farm:

Sample ID: corn
Lime History:

Recommendations: Crop	Lime (tons/acre)	Nutrients (lb/acre) N	P_2O_5	K_2O	Mg	S	Mn	Zn	Cu	B	More Information
1 - Corn, grain	0.0	120 - 160	0	0	0	0	0	0	0	0	Note: 3
2 - Soybean	0.0	0	0	0	0	0	0	0	0	0	Note: 3

Test Results [units - W/V in g/cm^3; CEC and Na in meq/100 cm^3; NO_3-N in mg/dm^3]: Soil Class: Mineral

HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	S-I	Mn-I	Mn-AI1	Mn-AI2	Zn-I	Zn-AI	Cu-I	Na	ESP	SS-I	NO_3-N
0.36	1.08	7.5	88	0.9	6.2	260	98	62	19	42	126	90	83	1102	1102	372	0.1	1		