Not just for Chips and Giggles

Soil Environmental Response to Bison Feces on Tall Grass Restored Prairie

CHICAGO BOTANIC GARDEN

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Intro:

Bovine fertilizer has been a part of human history for thousands of years, as ancient farms of Europe and Egypt discovered the unique properties of manure that help them grow healthier crops [1]. Today we know that these unique properties are chemical compounds such as Nitrate, Phosphate, and Ammonium that are added from the manure to the soil and are then taken up by microbes and plants and used as nutrients for growth. The American Bison (*Bison bison*) is a member of the bovine family but unlike their domesticated counterparts, are widely understudied. In part, this is because they were nearly hunted to extinction before any meaningful scientific inquiry could be conducted [2]. This goal of this project is to answer questions about the impact of bison feces (affectionately named buffalo chips) on restored tall grass prairie soils. We ask: what are the levels of soil nutrients associated with bison chips? How does a bison chips impact soil moisture and do bison chips effect microbial biomass?

Hypothesis: Bison feces improve soil health by adding essential plant nutrients, improving the soil's ability to retain moisture at varying depths, and encouraging microbial activity.

Methods:

Sixteen sampling locations were identified within a single plot in Kankakee Sands, IL. Sub-samples were collected from each, one from the feces and three from the soil.

For Soil:

Soil cores were collected in the field under bison feces and from one meter away, each core was divided into three 10 cm intervals.

For Chips:

Both fresh and old feces were collected from the field, eight samples of each. Freshness was determined by three criteria: color, texture, and presence of fly larvae.

Analyses run for each sample:

- Gravimetric moisture
- Nutrients by colorimetry and spectrophotometry:
  - NO3
  - NH4
  - PO4
- Microbial Biomass
  - Substrate-induced respiration
- Statistics Run (using R studio 4.1) :
  - Wilcox t. test
  - Pearson correlations

What going down in the *dirt*?

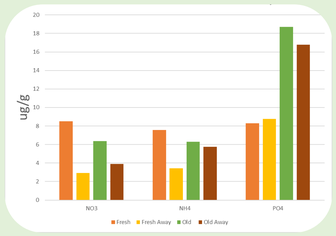

Fig. 1. Nutrients in soil under each sample type (fresh feces, away from fresh feces, old, and away from old feces)

Nutrient levels differed significantly in the top 10 cm soil. Nitrate and Ammonium were more abundant under feces samples, and Phosphorus levels appear to depend on the age of the feces, with more Phosphorus under older feces.

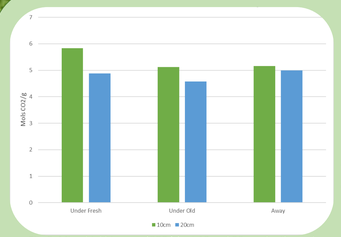

Fig. 2. Microbial biomass (CO_2/g) at 10 and 20 cm depths under each sample type (fresh feces, old feces and away from fresh and old feces).

Microbial biomass did not appear to differ significantly whether under fresh or older bison feces, or between soils under or away from any feces(10 cm soil depth).

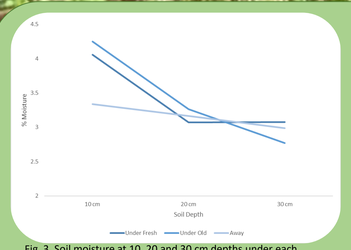

Fig. 3. Soil moisture at 10, 20 and 30 cm depths under each sample type (fresh feces, old feces and the average away samples for fresh and old feces).

Moisture levels under bison feces were slightly higher than areas without feces.

What's the *poop* on poop?

In determine how bison feces impacted the soil immediately below the pie, we needed established a base line of nutrients (nitrogen, phosphorus) present in the feces. We analyzed three key nutrients- ammonium, nitrate, and phosphorus- for each sample and categorized them by age (fresh versus old).

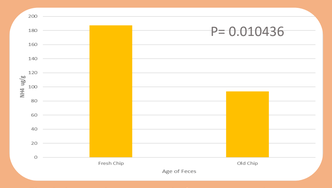

Fig. 4. Ammonium content in fresh and old bison feces.

Ammonium was abundant in both fresh and old samples. However, on average the fresher samples had significantly higher levels of ammonium than older samples ($P<0.05$).

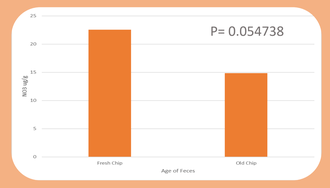

Fig. 5. Nitrate content in fresh and old bison feces.

Nitrate was less abundant than ammonium in both old and fresh samples. There was no significant difference in nitrate levels between the samples of different ages ($P>0.05$).

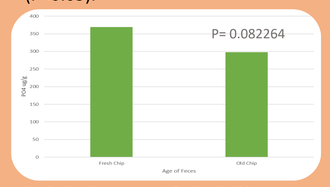

Fig. 6. Phosphate content in fresh and old bison feces.

Of all the nutrients analyzed, phosphorus was the most abundant nutrient, with and average of over 300 ug/g for both fresh and old feces. However, there was no significant difference in phosphorus between the old and young samples ($P>0.05$)

[*Milo collecting Feces samples in the field*]

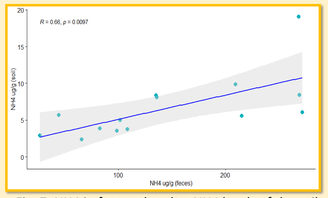

Fig. 7. NH4 in feces related to NH4 levels of the soil.

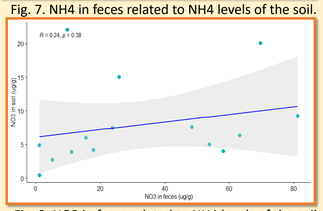

Fig. 8. NO3 in feces related to NH4 levels of the soil.

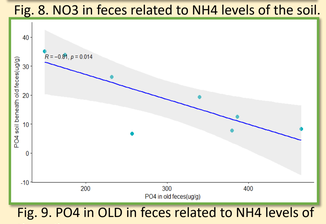

Fig. 9. PO4 in OLD in feces related to NH4 levels of the soil.

Where the *chips* fall…

NH4 (Ammonium)

We detected a positive correlation between the ammonium levels in feces and soil. As a result, higher ammonium levels in feces resulted in higher amounts of ammonium in the soil. This result is largely similar to what has been observed in cattle manure additions to soil.

NO3 (Nitrate)

Unlike the ammonium, there was no significant relationship between nitrate levels in feces and the soil ($P > 0.05$). This is expected based of other studies of bovine feces.

PO4 (Phosphate)

Interestingly, we found an inverse relationship between the phosphate levels of feces and the soil ($p<0.05$). This relationship was only detected under older feces.

Nitrogen: Phosphorus Ratio

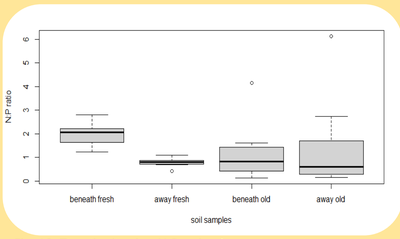

Fig. 10. The distribution N:P ratios for each sample type.

Nitrogen-Phosphorus ratios (N:P) are a measure of the limitations of nutrients for plants and microbes. We detected differences in N:P between soil beneath feces and one meter away for both fresh and old samples.
Soil under fresh samples have a significantly higher ($P>0.05$) ratio compared to samples one meter. In addition, N:P under older feces were largely similar to soil away from the feces.

Conclusion and Discussion

This study was conducted at the Kankakee Sands nature conservancy, in a restored tall grass prairie where bison have been reintroduced. Within the soil context we have found that the presence of bison and their feces has had a significant impact on the soil environment in the plot where this study was conducted.

Firstly, ammonium from bison feces significantly increased ammonium in soil; this form of nitrogen cycling may offer an alternative to the use of artificial fertilizers in restoration projects [3]. Interestingly, the phosphate levels displayed a negative correlation which may be related to the rate of the feces degradation, slow mineralization rate, or plant and microbial use of phosphate that has been observed in other studies [4]. In other systems it has been shown that soil phosphorus retention differs between fresh and composted manure which may explain why we found higher levels of phosphate in the soil collected beneath the older feces [5].

Furthermore, this study did not find any significant difference in microbial biomass under bison feces, which contrasts findings on the effects of other bovine manure on microbial biomass [6]. This is likely due to do with our small sample size and the inconsistencies in feces age. Further testing of additional sites where no bison are found would also be helpful. Additionally, even though moisture was slightly higher when measured under feces there was no significant impacted. Similarly, there was not a significant difference in soil nitrate levels from bison feces, which may be due to nitrate leaching like what has been found in cattle manure[7].

In conclusion, we found that bison feces improves soil health by adding nutrients, much like cattle. However, in the case of bison we find they offer more total nitrogen and phosphorus than common cattle manure. We hope that these findings may lead to more robust methods of conservation and restorative practices in the future.

Acknowledgments

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Sources

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