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*Natural Lands Ecology Papers*

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# The Effects of a Cover Crop Mixture on a Strip-Till Corn Field in Southeastern Minnesota

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2016

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## Abstract
As the negative impacts of conventional agriculture methods are becoming clearer, much research in the field is focused on mitigating these problems now and finding ways to change agriculture for the better. One of the methods to have garnered much attention is the implementation of cover crops. In order to assess the effect of a cover crop, soil samples were taken thrice during a standard growing season with both chemical and physical soil properties examined. Additionally, the data on yield and profit was collected from the field to allow for a monetary assessment. Bulk density, nitrate and ammonia levels, and moisture all varied over time whereas no characteristics varied between the treatments overall. However, characteristics varied between treatments in a given time frame including: nitrate levels during the second sampling round and ammonia levels during the third. The profit and yield analysis show little difference with areas in cover crop averaging more yield (238bu/ha to 227bu/ha). Despite this, the cover crop profit ($567.55/ha) was lower because of high seed costs as compared to the control area ($695.78/ha). The overall soil quality seems to be about even between the two areas in the first growing season a cover crop was implemented; this is expected, as cover crops are known to provide long-term benefits that, if continued in the field, will manifest in a number of ways.

## Introduction

As the harmful practices of conventional mass agriculture have come to light, many farmers are employing a tactic to alleviate some of the stress on their lands – the addition of a cover crop. The implementation of a cover crop regime on agricultural fields has shown many benefits that help both physical and chemical components of those lands. Conventional agricultural methodology includes the use of large amounts of nitrogen fertilizer, yearly tillage of the fields, unchecked use of herbicides and pesticides, and other environmentally harmful practices. Approximately half of the total land of the state of Minnesota is in agriculture this means that it is of paramount importance, for both present and future generations, to ensure the best possible soil so as to allow for continued farming practice (Farmland Information Center, USDA 2015).

With the use of tillage in agriculture, a large problem that has arisen is the erosion of topsoils. As the land is tilled it leaves the soil loose and open to wind or water erosion which removes the fertile topsoil leaving only the barren dirt. This creates a large problem as the topsoil is the soil in which the vast majority of nutrients are held and thus, is the soil in which the crop should be planted in order to provide the most successful growth conditions. Winter cover crops have been shown to help control top soil erosion as well as maintaining levels of N in the soil or, in the case of legume cover crops, increase N in the soil (Sainju 2002, Kramberger 2009, Tonitto 2006, Gabriel 2011).

Nitrogen is a limiting nutrient in the growth of many plants and thus, the amount of usable nitrogen in the soil is of paramount importance when considering the health of the soil of an agricultural field (Teixeira 2016). A low nitrogen level would necessitate additional fertilizer (an extra cost to a farmer) or would mean that the crop grows in conditions that are less than desirable. Additionally, the use of too much fertilizer leads to run off that is a leading cause of eutrophication and thusly, dead zones in the Gulf of Mexico (Diaz 2008).

Additionally, cover crops are known to compete with and expel weeds that were previously in a given field. While one may assume that the implantation of a cover crop would have a negative effect on yield, a meta analysis of the crop yield data shows that the majority do not have any effect on the yield of the field in which the crops are planted (Tonitto 2006).

Given the mass use of till farming and additions of millions of tons of nitrogen via fertilizer in the United States and globally, the implementation of cover crops on a larger scale is incredibly enticing as it could help ameliorate many problems farmers are facing after many years of conventional till farming. On a much smaller scale, a continued proof of the benefits of cover crops on St. Olaf lands could help instill the wish for a change to a combination of no till and cover crop regimes.

In order to show the positive effects of cover crops in the area multiple analyses are needed. A study of chemical characteristics allows for proof that the cover crop is affecting the soil on a deep level and that the cover crop is mitigating problems that all fields experience after a long time in an agricultural rotation. The physical characteristic study also help to prove the same things as the chemical study. Finally, the most accessible information for farmers would be crop yield and profitability. When all is said and done farming is a business and a livelihood and no one wants to see a massive pay cut for themselves so it is necessary to show that one can still eek out a living while acting sustainably. The specific objectives of this study are as follows:

1. Determine the effect of a cover crop mix on the levels of nitrate, ammonia, and phosphorus of an agricultural (corn) field.
2. Determine the effect of a cover crop mix on the bulk density, and percent moisture and organic matter.
3. Determine the effect of a cover crop mix on the yield and profitability of an agricultural field.

## Methods

*Site Selection*

The field in question in this study was a parcel of agricultural land (44°27'58.1"N 93°12'06.0"W) owned by St. Olaf College located to the west of Eaves Avenue in Northfield, MN. The field is in no till and is tile drained via a regulator into a wetland located in the St.

Olaf Natural Lands. Within this field, three strips of 16 rows were planted with cover crops, these rows were separated by at least 16 rows of non cover crop.  Within these three strips per area (for six total study strips) six samples were taken along the strip (Figure 1).

*Soil Sampling*

Soil samples were collected during mid-June, before the planting of cover crops, mid-July, after cover crop planting and a second round of nitrogen fertilization, and a final round was taken in mid-October before harvest. Samples were taken at a depth of 15.2 cm using a corer of known volume. These samples were taken at 6 points in each area of study for a total of 36 cores. Standard methodology was used to measure soil moisture, organic matter and bulk density (Robertson 1999).

*Soil Analysis*

Soil extractions for nitrates and ammonia tests were completed using 2M KCl and extractions for phosphate tests used a Mehlich 3 solution (Robertson 1999, Mehlich 1984). The extracts were analyzed using the WestCo SmartChem 200.

*Cover Crop Density*

Cover crop density was measured twice, once in mid July and once in early October. The density of cover crops was taken every approximately 30meters down each of the three tests strips. At every point (of which there were 11 were taken per strip) a $1m^2$ transect was placed on the ground and the number of each species of cover crop in that area was counted.

*Yield*

Yield data was calculated in 0.5 acre strips across the treatments on the day of harvest, November 10. This means in each of the three cover crop strips a single pass with the harvester was done, totally 0.5 acres, in order to ensure the area was completely in cover crop. This process was repeated for the three areas not in cover crop.

*Profit Analysis*

Using the aforementioned yield data, a profit analysis was done taking into account fertilizer, herbicide, and transportation costs for the entire field. In addition, cost of cover crop was taken into account when calculating the profitability of those areas. The price used for corn was the price in Chicago on the day of harvest (November 10), which was $3.43/bu.

**Results**

*Round 1*

The results of a one-way ANOVA (Table 1) shows no significant differences (p=.333) between the bulk density of samples taken in control and in cover crop areas of the field. The average means of nitrate levels in both the cover crops areas of the Eaves Field and the control areas of the field were found to be not significantly different (p=.803) (Table 2). In addition, the levels of ammonia across the field were not different between the two treatment areas (p=.629) (Table 3).The percent moisture of the field was compared between treatments areas, the results of this ANOVA show that there is not a significant difference between the areas (p=.715) (Table 4). Finally, the percent organic matter of the soil was compared between control areas and cover crop areas, this showed no significant difference between the two (p=.550) (Table 5).

*Round 2*

After a second round of sampling, there was again no difference between bulk density of the soils (p=.321) (Table 6). A significant difference (p=.0488) was found between the levels of nitrate in cover and no cover areas of the field. The areas with cover crops had nearly twice as much nitrate mg/kg soil as control did (Table 7). Unlike the nitrate levels no significant difference (p=.284) was found between the ammonia levels in the areas despite the fact that the cover crop area had almost 20 mg/kg soil more ammonia than non cover crop areas (Table 8). The percent moisture of the soils in the field was compared between treatment types and no significant difference (p=.556) was found (Table 9). The organic matter was compared and while the percent in cover crop areas was slightly higher it was not significantly higher (p=.715) (Table 10).

*Round 3*

The bulk density during the fall sampling time showed no difference between the treatment areas (p=.209) (Table 11). The third round of sampling led to a semi-significant difference (p=.0990) in nitrate levels. This difference was the opposite to the one that was found before with nitrate levels in non cover crop areas being higher now (Table 12). A significant difference was found between ammonia levels in cover crop and control areas with control areas having a significantly higher average ammonia in mg/kg soil (p=.0342) (Table 13). There was no significant difference between the moisture levels of soil in the two areas (p=.203) (Table 14). Much like the moisture, there was no significant difference between organic matter in both areas (p=.304) (Table 15).

*Totals (round, treatment)*

Given a two-way ANOVA test there is a significant difference between the bulk densities and the time of sampling (p=.0442) with the fall date having higher than the two in summer (Table 16, Figure 2). Additionally, there was a semi-significant difference (p=.06197) between the treatments with cover generally having a higher bulk density measure (Table 16, Figure 2). The results show that the nitrate level in the soil varies very significantly over time (p<.001), in addition, the nitrate level in the soil does not vary significantly between the treatment types. This contradicts the results when they are compared solely at each time (Table 17, Figure 3). The two-way ANOVA shows that the ammonia levels of the soil vary over time (p<.001) with the levels very high in mid-July. However, the level does not vary significantly between the treatments (p=.2873) (Table 18, Figure 4). Much like the other variables, the soil moisture varies with time of sampling (p=.04737) but not between the treatments (p=.16823) (Table 19, Figure 5). There was no significant differences between the percent organic matter as time changed (p=.5813), or difference between organic matters level in cover crop or control areas (p=.5843) (Table 20, Figure 6).

*Cost Analysis*

The yield and cost analyses showed two very different results. In areas that were in cover crop the average yield was 10bu/ha higher than in non cover crop areas, the true numbers were 238bu/ha to 226 bu/ha (Figure 7). However, after the cost of seed was added to costs that affected the whole field (herbicide, fertilizer, and transport) the cover crop netted over $100/ha less profit. The profit from cover crop was just $567.55bu/ha to the control profit of $695.78/ha (Figure 8).

*Cover Crop Density*

Density plots showed a high number of radish and clover (on average 1.848, and 1.152 plants per $1m^2$ plot). There were .667 turnip and .424 grass plants per plot (Figure 9).

**Discussion**

*Physical Soil Properties*

The bulk density measures of the field showed a change over time. Over the course of the study (June – November) bulk density showed a net increase. Additionally, there was a slight significance with regards to the treatment type; cover crop areas tended to have higher bulk density measures. According to research done by Hunt and Gilkes (1992), soil is most productive at lower bulk density measurements, this means measures of less than 1.5g/cm$^3$. In the Eaves field both areas had maximum bulk densities lower than 1.5g/cm$^3$ than this meaning the soil is well aerated and prime for full productivity. The changes over time may be due to the sampling methodology in that the same paths were walked over and over to obtain samples. Walking could compact the soils around the specific sites leading to a higher measure. The difference between the treatments could also be attributed to this with the areas in cover crop walked additional times thus compressing the soil to even more. Over time it is likely the bulk density would be lower in the cover crop areas as the roots will break apart the soils slightly more.

The percent moisture of the soil in the field showed a similar trend. There was a change over time with the last sampling round having a very high level of moisture as compared to the second especially. This may be due to the unusually high amount of rain experienced this autumn in the area. There was no change between the treatments in the amount of soil moisture. It is important to note that the field is tile drained and thus, the groundwater is kept at a fairly consistent level throughout all season. Perhaps without this tile pattern we would see some sort of change between the treatments. Past research has shown that cover crops help maintain a higher soil moisture in drought conditions (Teasdale 1993).

Finally, the organic matter of the field showed no changes over time or between treatments. This finding is of no surprise even though a large benefit of cover crops is the fact that it adds organic matter to soils. That being said, this only occurs after the crop dies off which it will not until after the winter. The plants then decompose and add organic matter to the soil via this decomposition. Since the plants here have not died yet there would be no statistical difference between the areas and since the time frame all occurs in one growing season, there would be no change over time.

*Chemical Soil Properties*

The chemical changes of soil in the field are very interesting. With regards to nitrates there is no difference between treatments over the entire time frame but there is a difference over time. This makes sense since there was a large addition of nitrogen via fertilizer approximately two weeks before the second sampling period. At this sampling time there was also a pointed difference between the two treatments with the cover crop areas having significantly more. One could attribute this to the ability of clover (one of the planted crops) to fix nitrogen but since the levels decreased again after it is unlikely, in fact, the levels were lower in cover crop areas during the third area suggesting that the plants were using some of the nitrates at the later stage in the season. One would expect that over time the areas that were planted with cover crops would have higher nitrate levels because of the aforementioned ability of clover to fix nitrogen. The variation in the study seems to be because of fertilizer inputs more than anything to do with the cover crop.

In addition to nitrates, the ammonia levels of the soil did not vary between the treatments but again did over time. This is also likely due to the addition of fertilizer. The very large standard errors may be due to an error in detection by the SmartChem as two samples came back as having no levels of ammonia. Again, there may be a change in the future, as the clover and next year's soybean crop will add nitrogen via fixation.

*Density and Yield*

The density levels of different cover crops show a very interesting trend. In a field approximately 1.5 miles away a similar mix was planted with a large amount of rye grass and no clover (Klenz 2015). In contrast, the Eaves field had high levels of clover and radish. This may be due to the topographical layout in that the other crops were planted on more of a slope, which could make it harder for clover to establish. The reason for the high rates of radish as compared to the turnips that were also planted and are of similar size seed is the seed rate. The rates are as follows: rye 28lbs/ha, turnip .2lbs/ha, radish 2.6lbs/ha, and clover .6lbs/ha. The reason for the high rye rate is that the seed is so light that much blows away, so the more one attempts to seed the higher rate the rate of success should be. In order to determine the mix that works best in this field more repetitions must be done.

With regards to yield an interesting trend showed. The areas that had cover crops had an increased yield. The average difference between the two areas was over 11bu/ha which is not much on a small scale but if that is projected to the entire size of the field (16 acres) that gives an extra 726 bushels which in turn would add another $2500 of revenue. This is consistent with data gathered by Tonitto that showed no difference in yields in cover cropped fields and those that were not (2006).

However, despite this difference in yield there is a smaller profit margin when cover crops are added. The seed mix alone costs an extra $168.24/ha on top of transport, fertilizer, and herbicide costs. The main culprit in the seed cost was one that did not even appear large amounts in the field, the rye seed since it was spread at such a high level ended up costing $100.62/ha. This burgeoning cost is well known and many cost share programs have been put in place by local, state, and the federal government to help subsidize the cost. This means the true profit margin is probably much closer to equal. In this field specifically, the cost could have been heavily reduced had the rye been seeded at a lower rate. Again, determining the perfect mix and seeding rate will take many replicated but should eventually pay massive dividends both environmentally and financially.

*Future Studies*

This study lays the groundwork for myriad future study opportunities. In order to fully assess the effects of cover crops repeated sampling and analysis of those samples for these same variables is necessary. Additionally information regarding phosphorus, which was gathered but not available when because of machine malfunction, could add to this study. As aforementioned studies determining the best mix of cover crops to put on the field would be arguably more beneficial than determining the effects themselves as they are heavily documented. Finding someone or multiple people to continue and expound on this research could lead to a shift in both St. Olaf agricultural policies and in the light cover crops are seen in by local farmers.

*Conclusions*

To conclude this study showed that there was almost no significant difference between soil in a cover cropped and non cover cropped area during the first growing season. The nitrate, ammonia, bulk density, and moisture level of the soil all varied over time but not between treatments and the organic matter levels in the soil remained constant the whole time. This was all expected as cover crops are a long term investment that should, if they are added to the field again, increase the nitrate and ammonia levels, decrease bulk density, and increase percent moisture and percent organic matter in the soils. The most important factor in this study, yield, actually showed an increase in cover crop areas. This means that while the farmer waits for the benefits of cover crops to come to fruition in soils there is no loss of yield in the meantime. In turn, if cost sharing programs are effectively used, the profit of the field should not decrease with the addition of cover crops, in fact it may increase given the yield difference. Farmers now have the opportunity to benefit in both the short and long-term by adding a cover crop mix. The mix itself is somewhat of a problem as given mixes do not replicate their growing status in every field they are planted in. This means more research must be done to a county or even farm specific level to maximize gains from cover crops. It is my firm recommendation that St. Olaf take this data as well as data garnered from past research and make a push to mandate cover crops on agricultural lands owned by the school.

**Acknowledgments**

I would like to thank Dr. Kathy Shea for her advice and help throughout the course of the project and Jason Menard for all his GIS help. Additionally, I would like to thank Dave Legvold for all his help, cooperation, and for letting me drive tractors to complete my liberal arts education.

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**Tables and Figures**

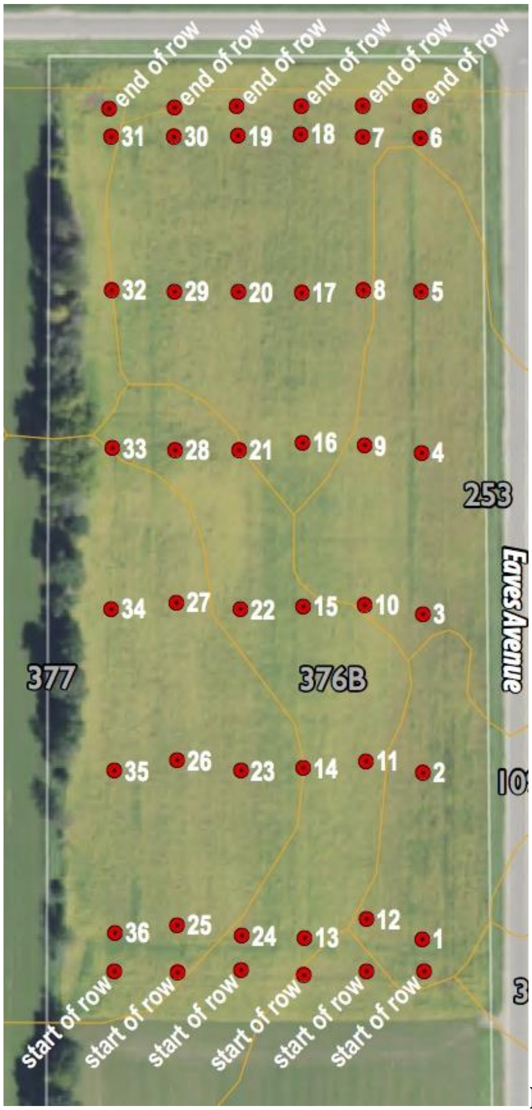


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Figure 1. Shows the sampling sites as well as soil types across the field. Sections 2,4, and 6 were cover crop rows while 1,3, and 5 were not. Sections are separated by units of 6 rows with section 1 being rows 1-6, 2 being rows 7-12, and so on.

Table 1. Showing the ANOVA results of the Bulk Density test during sampling round 1. The results shows no significant differences (p=.333) between the bulk density of samples taken in control and in cover crop areas of the field.

| Area | Mean (g/cm3) | S.D. | n |
|---|---|---|---|
| Control | 1.257 | 0.112 | 18 |
| Cover | 1.295 | 0.117 | 18 |

Table 2. The average means of nitrate levels in both the cover crops areas of the Eaves Field and the control areas of the field were found to be not significantly different (p=.803) as shown by the ANOVA table.

| Area | Mean(mg/kg soil) | S.D. | n |
|---|---|---|---|
| Control | 5.991 | 3.660 | 18 |
| Cover | 5.667 | 4.064 | 18 |

Table 3. An ANOVA table shows the levels of ammonia across the field were not different between the two treatment areas (p=.629).

| Area | Mean(mg/kg soil) | S.D. | n |
|---|---|---|---|
| Control | 3.766 | 2.483 | 18 |
| Cover | 4.170 | 2.484 | 18 |

Table 4. The percent moisture of the field was compared between treatments areas, the results of this ANOVA show that there is not a significant difference between the areas (p=.715).

| Area | Mean | S.D. | n |
|---|---|---|---|
| Control | 12.222 | 2.296 | 18 |
| Cover | 11.969 | 1.784 | 18 |

Table 5. The percent organic matter of the soil was compared between control areas and cover crop areas, this showed no significant difference between the two (p=.550).

| Area | Mean | S.D. | n |
|---|---|---|---|
| Control | 5.098 | 1.515 | 18 |
| Cover | 4.825 | 1.181 | 18 |

Table 6. After a second round of sampling, there was again on difference between bulk density of the soils (p=.321).

| Treatment | Mean (g/cm3) | S.D. | n |
|---|---|---|---|
| Control | 1.249 | 0.105 | 18 |
| Cover | 1.285 | 0.105 | 18 |

Table 7. A significant difference (p=.0488) was found between the levels of nitrate in cover and no cover areas of the field. The areas in cover had almost double the amount of nitrate that non cover areas had.

| Treatment | Mean(mg/kg soil) | S.D. | n |
|---|---|---|---|
| Control | 6.684 | 8.982 | 18 |
| Cover | 12.753 | 8.841 | 18 |

Table 8. Unlike the nitrate levels no significant difference (p=.284) was found between the ammonia levels in the areas despite the fact that the cover crop area had almost 20 mg/kg soil more ammonia than non cover crop areas.

| Treatment | Mean(mg/kg | S.D. | n |
|---|---|---|---|

| | | | |
|---|---|---|---|
| | soil) | | |
| Control | 36.571 | 53.38 | 18 |
| Cover | 53.312 | 38.187 | 18 |

Table 9. The percent moisture of the soils in the field was compared between treatment types and no significant difference (p=.556) was found.

| Treatment | Mean | S.D. | n |
|---|---|---|---|
| Control | 11.454 | 1.961 | 18 |
| Cover | 11.089 | 1.698 | 18 |

Table 10. The organic matter was compared and while the percent in cover crop areas was slightly higher it was not significantly higher (p=.715).

| Treatment | Mean | S.D. | n |
|---|---|---|---|
| Control | 4.979 | 1.403 | 18 |
| Cover | 5.207 | 2.229 | 18 |

Table 11. The bulk density during the fall sampling time showed no difference between the treatment areas (p=.209).

| Treatment | Mean (g/cm3) | S.D. | n |
|---|---|---|---|
| Control | 1.304 | 0.133 | 18 |
| Cover | 1.352 | 0.084 | 18 |

Table 12. The third round of sampling led to a semi-significant difference (p=.0990) in nitrate levels. This difference was the opposite to the one that was found before with nitrate levels in non cover crop areas being higher now.

| Treatment | Mean(mg/kg soil) | S.D. | n |
|---|---|---|---|
| Control | 2.630 | 0.683 | 18 |
| Cover | 2.203 | 0.819 | 18 |

Table 13. A significant difference was found between ammonia levels in cover crop and control areas with control areas having a significantly higher average ammonia in mg/kg soil (p=.0342).

| Treatment | Mean(mg/kg soil) | S.D. | n |
|---|---|---|---|
| Control | 2.491 | 0.904 | 18 |
| Cover | 1.822 | 0.914 | 18 |

Table 14. There was no significant difference between the moisture levels of soil in the two areas (p=.203).

| Treatment | Mean | S.D. | n |
|---|---|---|---|
| Control | 13.158 | 2.465 | 18 |
| Cover | 11.989 | 2.921 | 18 |

Table 15. Much like the moisture, there was no significant difference between organic matter in both areas (p=.304).

| Treatment | Mean | S.D. | n |
|---|---|---|---|
| Control | 4.943 | 1.359 | 18 |
| Cover | 4.508 | 1.126 | 18 |

Table 16. Given a two-way ANOVA test there is a significant difference between the bulk densities and the time of sampling (p=.0442) with the fall date having higher than the two in summer. Additionally, there was a semi-significant difference (p=.06197) between the treatments with cover generally having a higher bulk density measure.

| Time | Control (g/cm3) | Cover (g/cm3) | SD Control | SD Cover | n |
|---|---|---|---|---|---|
| A | 1.257 | 1.295 | 0.112 | 0.117 | 18 |
| B | 1.249 | 1.285 | 0.105 | 0.105 | 18 |
| C | 1.304 | 1.352 | 0.133 | 0.084 | 18 |

Table 17. The results show that the nitrate level in the soil varies very significantly over time (p<.001), in addition, the nitrate level in the soil does not vary significantly between the treatment types. This contradicts the results when they are compared solely at each time.

| Time | Control (mg/kg soil) | Cover (mg/kg soil) | SD Control | SD Cover | n |
|---|---|---|---|---|---|
| A | 5.991 | 5.668 | 3.660 | 4.064 | 18 |
| B | 6.684 | 12.753 | 8.982 | 8.841 | 18 |
| C | 2.631 | 2.203 | 0.683 | 0.819 | 18 |

Table 18. The two-way ANOVA shows that the ammonia levels of the soil vary over time (p<.001) with the levels very high in mid-July. However, the level does not vary significantly between the treatments (p=.2873).

| Time | Control (mg/kg soil) | Cover (mg/kg soil) | SD Control | SD Cover | n |
|---|---|---|---|---|---|
| A | 3.766 | 4.169 | 2.483 | 2.484 | 18 |
| B | 36.571 | 53.412 | 53.380 | 38.187 | 18 |
| C | 2.491 | 1.822 | 0.904 | 0.914 | 18 |

Table 19. Much like the other variables, the soil moisture varies with time of sampling (p=.04737) but not between the treatments (p=.16823).

| Time | Control | Cover | SD Control | SD Cover | n |
|---|---|---|---|---|---|
| A | 12.222 | 11.969 | 2.296 | 1.784 | 18 |
| B | 11.454 | 11.089 | 1.961 | 1.698 | 18 |
| C | 13.158 | 11.988 | 2.465 | 2.921 | 18 |

Table 20. There was no significant differences between the percent organic matter as time changed (p=.5813), or difference between organic matters level in cover crop or control areas (p=.5843).

| Time | Control | Cover | SD Control | SD Cover | n |
|---|---|---|---|---|---|
| A | 5.098 | 4.825 | 1.515 | 1.181 | 18 |
| B | 4.978 | 5.207 | 1.403 | 2.229 | 18 |
| C | 4.943 | 4.508 | 1.359 | 1.126 | 18 |

For all figures below: Control areas are blue and Cover Crop areas are red.

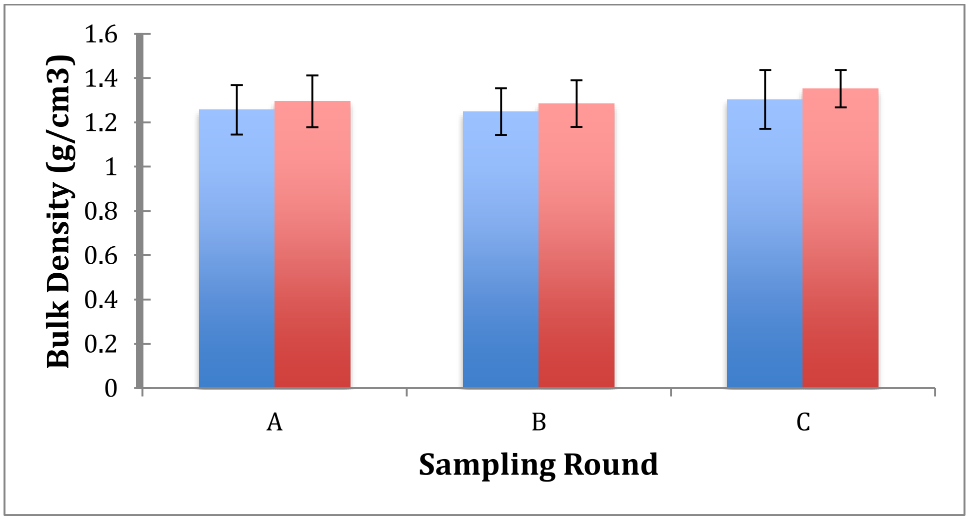


Figure 2. Graph showing the change in bulk density over time. As noted in the table 16 legend there is a significant difference between the bulk densities and the time of sampling (p=.0442) with the fall date having higher than the two in summer. Additionally, there was a semi-significant difference (p=.06197) between the treatments with cover generally having a higher bulk density measure.

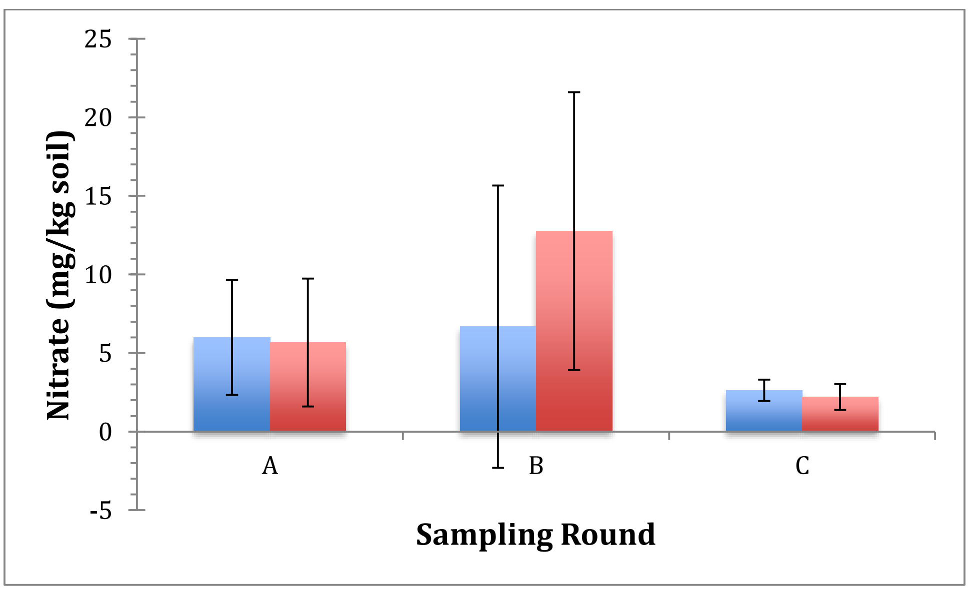


Figure 3. Graph showing the change in nitrate levels over time and between treatments. As noted in table legend 17, the results show that the nitrate level in the soil varies very

significantly over time (p<.001), in addition, the nitrate level in the soil does not vary significantly between the treatment types.

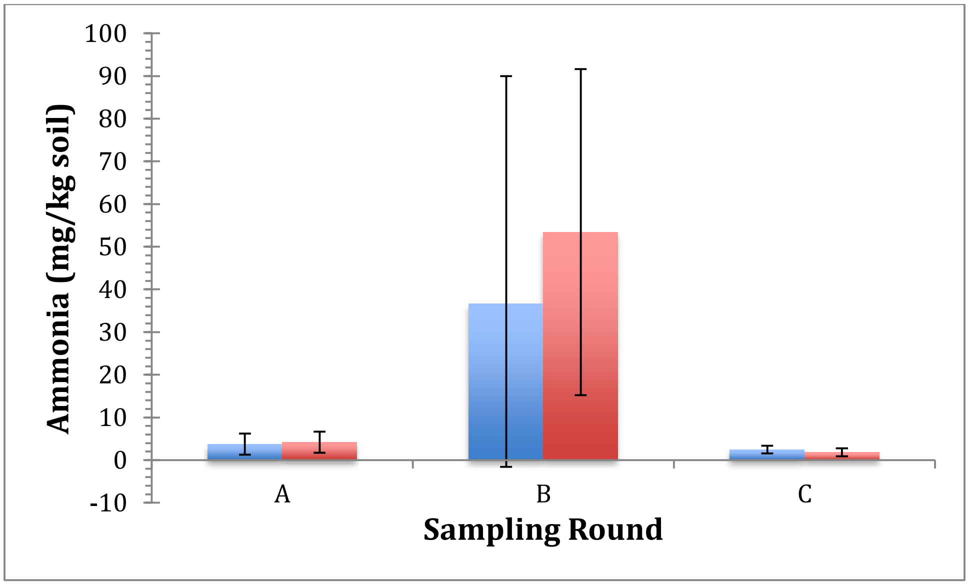


Figure 4. Showing the change in ammonia levels over time. The ammonia levels of the soil vary over time (p<.001) with the levels very high in mid-July. However, the level does not vary significantly between the treatments (p=.2873).

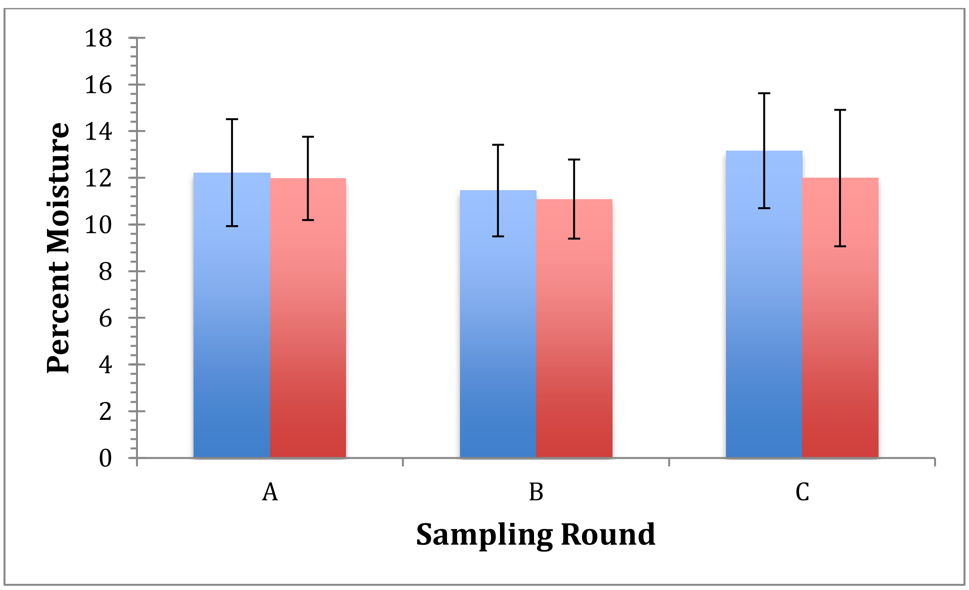


Figure 5. Graph documenting the change in percent moisture over time and between treatments. Much like the other variables, the soil moisture varies with time of sampling (p=.04737) but not between the treatments (p=.16823).

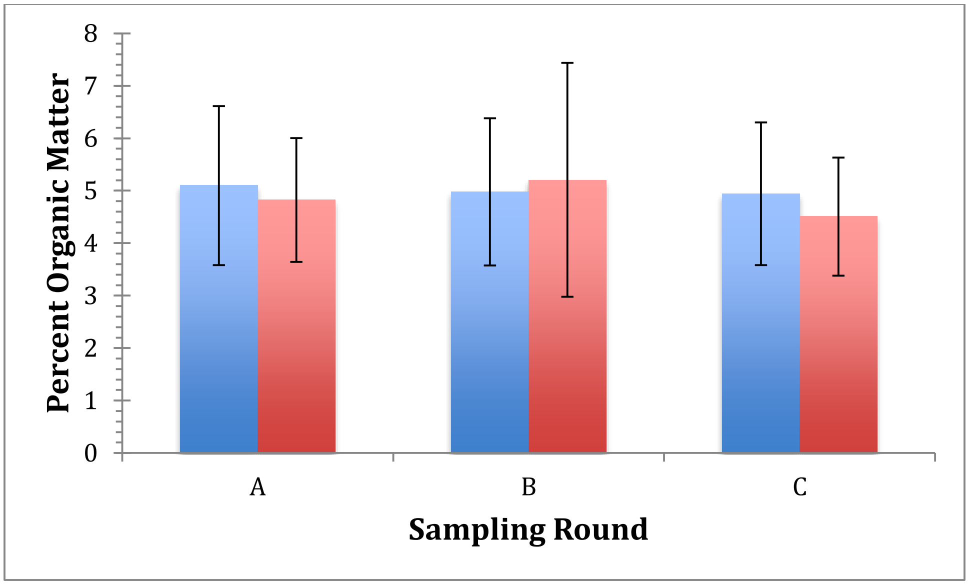


Figure 6. The change in percent organic matter over time and between treatments. There was no significant differences between the percent organic matter as time changed (p=.5813), or difference between organic matters level in cover crop or control areas (p=.5843).

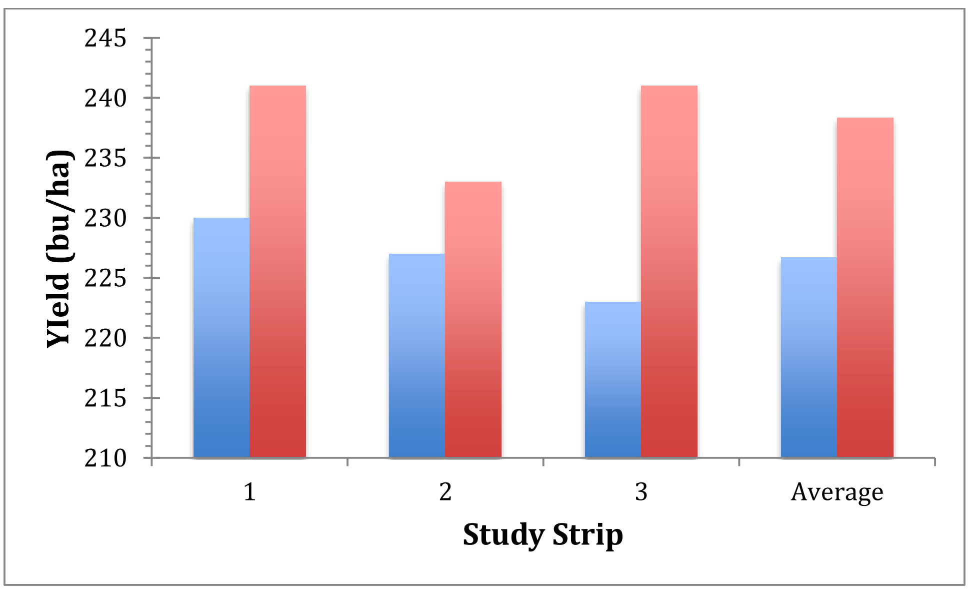


Figure 7. Shows the differences in yield between the two different treatments on each pass. The cover area is higher by about 10 bu/ha across the board.

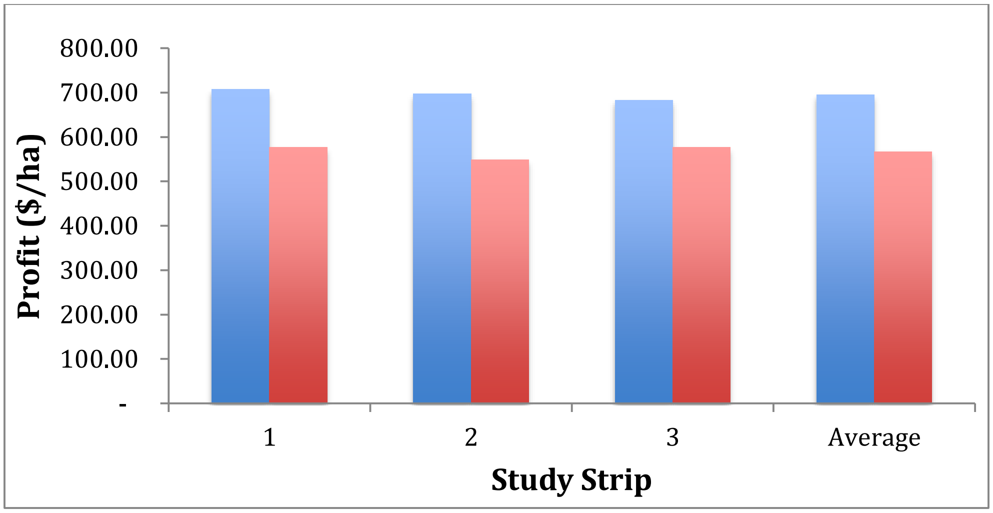


Figure 8. Shows the difference in profit. While the area in cover crop had higher yields, the seed costs led to lower overall profits.

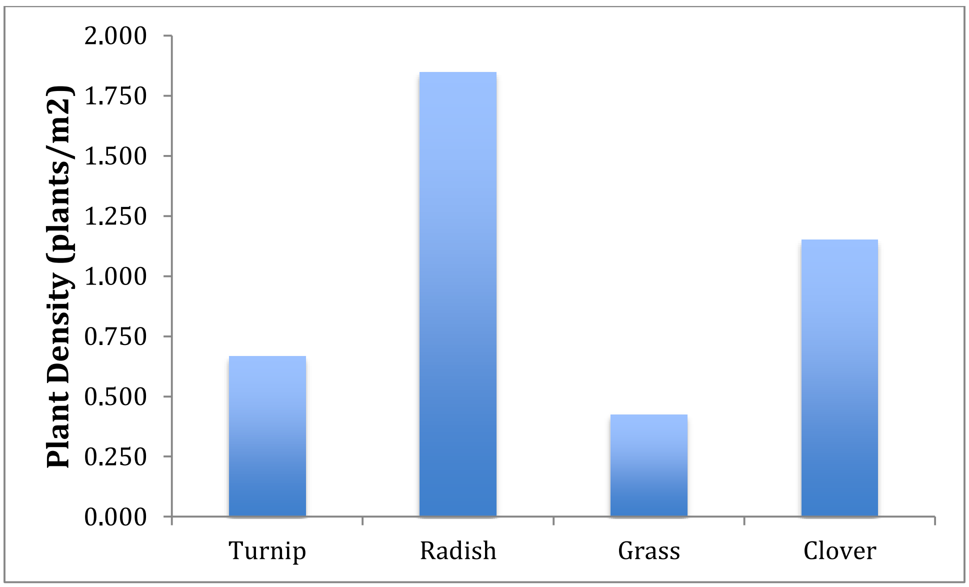


Figure 9. Shows the differences in cover crop density. Contrary to past studies in the area clover did well while rye grass did poorly. Radish (seeded at a higher rate than turnip) was very prevalent across the plots.