Benefits of Cover Crops Following Spring Wheat

Purpose:

Like winter wheat, spring wheat is harvested in mid summer, leaving a significant portion of the growing season when a living crop is not present. A study was initiated to determine what if any benefit could be generated from planting cover crops following the wheat harvest. Does this provide an opportunity to reduce weed growth, sequester residual nitrogen and other nutrients in plant biomass, reduce soil erosion and other benefits?

Producers often target wheat stubble as a location to spread livestock manure. This allows manure application during a convenient time of year, when soil conditions are optimal for handling the weight of equipment associated with manure application, thus reducing the potential for compaction, tracking and other negative effects. The other factor that often favours wheat stubble as the best system for manure application is that corn often follows wheat in the rotation. The corn crop can make ready use of the applied manure nutrients if these nutrients can be “held” until the next spring.

Methods:

A site was established at Osgoode Ontario to consider these questions. Details of the site are summarized in Table 1. Following the harvest of spring wheat in July of 2006, a number of cover crops were planted. Liquid dairy manure was applied at 9000 USGal/ac to half of the site and the various cover crops were planted into manured and non manured portions of the plot area. The manure was incorporated the day of application with the exception of the red clover plots which were not tilled. The cover crops chosen for the study included red clover (RC), oats (OAT), peas (PEA), oil seed radish (OSR), annual rye grass (ARG), sudan grass (SG), hairy vetch (HV), 50% peas plus 50% oats (P+O) and a no cover treatment (NC). The no cover treatment was the worked stubble ground and consisted of volunteer spring wheat and weed growth stimulated by the tillage operation and rainfall. The study was a two replicate experiment with manures and cover crops as split treatments.

Table 1: Site Details

<table>
<tr><th>Location Detail</th><th>Manure Type</th><th>Cover Crop</th><th>Manure Rate (USGal/ac)</th><th>Manure N Supplied</th><th>Application Date</th><th>Incorp. Details</th><th>Soil Type</th></tr>
<tr><td rowspan="2">Osgoode</td><td rowspan="2">Cattle Dairy Liquid</td><td>Red Clover</td><td rowspan="2">9000</td><td rowspan="2">140 lbs/ac</td><td rowspan="2">22-Aug-06</td><td>Not</td><td rowspan="2">Silt Loam</td></tr>
<tr><td>Others</td><td>Within 1 day</td></tr>
</table>

Results:

Soil samples were taken in late October of 2006 across the various manure and cover treatments. The samples were analyzed for soil both nitrate and ammonium nitrogen. The manure effect was not significant (Table 2). The cover effect was significant for nitrate but not for ammonium and the interaction of manure by cover was significant for both. Ammonium in the fall will not be sequestered or available into the following spring, so only nitrate values are presented in the following tables.

Table 2: Statistical Analysis of Fall Soil N Samples

Treatment	Nitrate	Ammonium
Manure	N	N
Cover	Y	N
Manure*Cover	Y	Y
[1] Y = significant treatment effects, N = no significant difference (P=0.15)		

Due to much higher and more frequent rainfall than normal in the fall of 2006 the soil test values of nitrate and ammonium were very low (Table 3.). Liquid dairy manure as the source of manure contains relatively little ammonium, and nitrate soil levels were very low likely due to leaching or denitrification by high levels of rainfall.

Table 3: Soil Nitrate Levels by Manure Treatment in Fall 2006

Manure Treatment	Nitrate (ppm)
No Manure	3.3
Manure	4.2

Some significant cover crop differences in ability to sequester nitrate were found (Table 4). However, the ppm levels were so low that the differences can be considered negligible.

Analysis of the manure by cover crop interaction indicated significant differences but again the levels of nitrate detected were so small that the differences are inconsequential (Table 5).

Table 4: Soil Nitrate Levels by Cover Treatment in Fall 2006.

Cover Type	Nitrate	Sign.
No Cover	4.2	B[1]
Oat	3.7	BC
Oil Seed Radish	3.0	D
Pea	4.0	B
An. Rye Grass	3.0	D
Red Clover	3.3	CD
Pea+Oat	3.9	B
Sudan	4.2	B
Vetch	4.7	A
[1] Treatments that share the same letter(s) are not significantly different at the P=0.15 level.		

The biomass yield and plant nitrogen content of the cover crop treatments and manure was evaluated (Table 6). These results suggest that there were no significant treatment differences between manure and cover treatments in yield and nitrogen sequestration potential this year.

Table 5: Nitrate Levels Detected in Manure by Cover Interaction

Cover Type	Manure Treatment Nitrate (ppm)	
	No Manure	Manure
No Cover	3.6	4.7
Oat	3.1	4.4
Oil Sed Radish	2.7	3.4
Pea	3.8	4.3
An. Rye Grass	2.6	3.4
Red Clover	3.6	3.1
Pea+Oat	3.6	4.3
Sudan	3.6	4.8
Vetch	3.6	5.9

Although not significant, there appeared to be more plant nitrogen and total biomass yield across cover crops in the manured plots (Table 7). However, the nitrogen levels (percentage) in the biomass were not different.

Table 6: Statistical Analysis of Fall Cover Crop Biomass Data

	Biomass N	Biomass Yield	%N in Biomass
Manure	N	N	N
Cover	N	N	N
Manure*Cover	N	N	N
[1] Y = significant treatment effects, N = no significant difference (P=0.15)			

Table 7: Cover Crop Fall Biomass Assessment Over Manure

Manure	Biomass N (kg/ha)		Biomass Yield (kg/ha)		% N in Biomass	
No Manure	17.13	nsd	843.70	nsd	2.24	nsd
Manure	36.30		1760.00		2.26	
[1] nsd = not significantly different at the P=0.15 level.						

When comparing cover crops over manured and non manured treatments, there are no significant differences between any of the cover crops and the no cover standard treatments (Table 8). Although differences were observed, the experimental error in the trial was large enough to prevent significant differences from being detected. This same effect of wide experimental variability shows in the manure by cover analysis, with no significant differences detected (Table 9).

Table 8: Cover Crop Biomass Yield and Nitrogen Content Fall 2006

Cover	Biomass N (kg/ha)		Biomass Yield (kg/ha)		% N in Biomass	
No Cover	25.36	nsd[1]	1215.20	nsd	2.16	bc[2]
Oat	27.23		1203.80		2.20	abc
Oil Seed Radish	22.40		1244.70		1.80	c
Pea	26.70		1011.00		3.00	abc
Annual Rye Grass	28.80		1786.30		2.00	c
Red Clover	33.70		1939.20		1.80	c
Pea+Oat	22.70		878.80		2.60	abc
Sudan Grass	22.80		1355.60		1.80	c
Hairy Vetch	30.90		1082.00		2.90	abc

[1] nsd = not significantly different at the P=0.15 level.
[2] values followed by the same letter(s) are not signficantly different from each other at the P=0.15 level.

Summary:

Conclusion – Effect of Cover Crops on Fall Nitrogen

Based on the rainfall experienced in the fall of 2006, the cover crops could not be shown to differentially trap nitrate and ammonium nitrogen in significant levels as determined by soil nitrogen and plant biomass assessments. No differences between manured and non manured plots in nitrate levels suggest that the fall rainfall caused any appreciable amounts of nitrate in the top 30cm of the soil profile to be either leached or denitrified.

In assessments on the cover crop biomass, no significant differences in covers could be detected. The clear trend was for increasing biomass nitrogen and yield content in the presence of manure compared to non manured plots.

Cover Crop Impact on Following Crops

Since Ontario farmers do not grow only a single crop, it is important to investigate the impact of including these cover crops on subsequent crops in the rotation. Since corn traditionally follows wheat, the impact of the 2006 planted cover crops and manure treatments was examined by growing corn in the plot area during 2007..

The statistical analysis for the data related to impact on corn is presented in Table 10. Significant effects were detected for manure, cover crop, nitrogen rate and the interactions of manure by nitrogen rate and cover by nitrogen rate.

Despite not being able to detect differences in the soil nitrate rates between manured and non manured plots in the fall of 2006, the application of manure compared across all cover crops showed a significant yield boost over the non manured plot (Table 11).

Table 9: Cover Crop by Manure Impacts on Fall Biomass Yield and Plant Nitrogen

Manure	Cover	Biomass N (kg/ha)		Biomass Yield (kg/ha)		% N in Biomass	
No Manure	No Cover	15.70	nsd	788.80	nsd	2.10	nsd
No Manure	Oat	16.70		880.40		2.00	
No Manure	Oil Seed Radish	12.80		1022.20		1.50	
No Manure	Pea	21.60		629.70		3.50	
No Manure	Ann. Rye Grass	6.60		333.90		2.30	
No Manure	Red Clover	31.80		1524.50		2.10	
No Manure	Pea+Oat	20.50		902.30		2.30	
No Manure	Sudan Grass	16.10		827.10		2.00	
No Manure	Hairy Vetch	12.30		684.50		2.50	
Manure	No Cover	35.00		1641.60		2.20	
Manure	Oat	37.70		1527.20		2.50	
Manure	Oil Seed Radish	31.90		1467.20		2.20	
Manure	Pea	31.70		1392.30		2.40	
Manure	Ann. Rye Grass	51.00		3238.80		1.70	
Manure	Red Clover	35.60		2353.90		1.50	
Manure	Pea+Oat	24.90		855.20		2.90	
Manure	Sudan Grass	29.40		1884.00		1.60	
Manure	Hairy Vetch	49.40		1479.50		3.30	

[1] nsd = not significantly different at the P=0.15 level.

Over all cover crops there was almost a 30 bu/ac benefit in corn yield where manure was applied.

Although significant effects were detected, the results were not what was expected. The planted cover crops and red clover were expected to out yield the no cover treatment. However, the results show that many of the cover crops suppressed corn yield. This was likely caused by the spring 2007 sequestering of available soil nitrogen as soil micro organisms began to breakdown the residue remaining from the cover crops. This action will suppress nitrogen availability where a high C:N ratio of residue requires nitrogen for the micro organisms to multiply and attack the cellulosic residue of the cover crop. The grass species, which have higher C:N ratios, were the ones that suppressed corn yield the greatest.

In the spring of 2007, the manure by cover plots from the fall of 2007 were planted with corn. At side dress time, these plots were each split into two so that a Zero and Full rate nitrogen treatment could be applied. There was a significant increase in corn yield in all manure and cover crop plots that received the full rate of nitrogen (Table 13). Averaged across all manures and covers this benefit was almost 64 bu/ac of corn.

Table 10: Statistical Analysis of the Treatment Effects For Corn Yield

Location	Significant Treatment Differences
Manure	Y
Cover	Y
Manure*Cover	N
N_Rate	Y
Manure*N_Rate	Y
Cover*N_Rate	Y
Manure*Cover*N_Rate	N

[1] Y indicates significant treatment differences within the category, N indicates no significant difference detected at P=0.15

Table 11: Effect of Manure Application Across All Covers on Corn Yield 2007

	Osgoode
No Manure	131.0
Manure	161.5
Significance	Y

The impact of nitrogen rate on corn yield in each cover crop situation is demonstrated in Figure 1. The cereal cover crops and red clover seemed so see the biggest response to addition of full rate nitrogen. The issue with the grass species was previously addressed, but the reason for the impact with red clover is unknown.

Another significant interaction was Manure by Nitrogen Rate over all cover species (Figure 2). The delta yield between zero and fully fertilized in the non manured and manured situations was 76.5 and 18 bu/ac respectively. Based on delta yield calculations, the maximum economic rate of nitrogen for the non manured situation was 142 lbs/ac of nitrogen and only 60 lbs/ac for the manured situation. This would suggest at this site for this year, despite all the rain the previous fall following manure application, that that manure supplied the corn crop with an 82 lb/ac nitrogen fertilizer credit.

Conclusion – Reduction in Fertilizer Nitrogen for Following Corn Crop

At this site in Eastern Ontario based on only a single years experiment with high fall rainfall conditions, a benefit to cover crops could not be detected over wheat stubble only. The costs of establishing any of the cover crops tested could not be recouped in additional corn yield the following year.

Table 12: Impact of Cover Crops Across Manure Treatments on Corn Yield 2007

Cover	Osgoode
NC[1]	167.2
OAT	141.1
OSR	143.4
PEA	148.7
RYE	122.7
RC	133.8
P+O	142.7
SUD	150.2
VET	166.8
Significance[2]	Y

[1] NC = no cover (volunteer wheat and weeds) , OAT = oats, OSP = oilseed radish, PEA = pea, RYE = annual ryegrass, RC = red clover (seeded in spring), P+O = 50% pea + 50% oat mixture, SUD = sudan grass, VET = hariy vetch
[2] Y = significant treatment effects, N = no significant difference (P=0.15)

Table 13: Corn Yield Response to Nitrogen Rate Across Manures and Cover Crops

	Osgoode
Zero N	114.4
Full Rate N	178.2
Significance	Y

Figure 1: Corn Yield Associated with Cover Crop by Nitrogen Rate Interaction

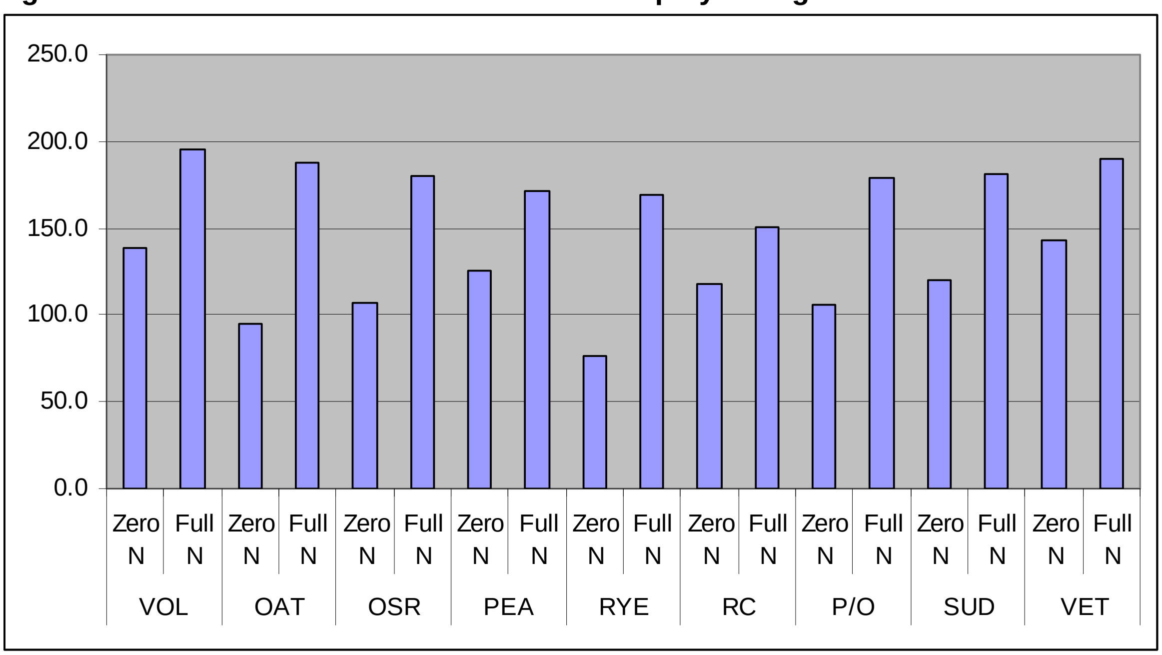
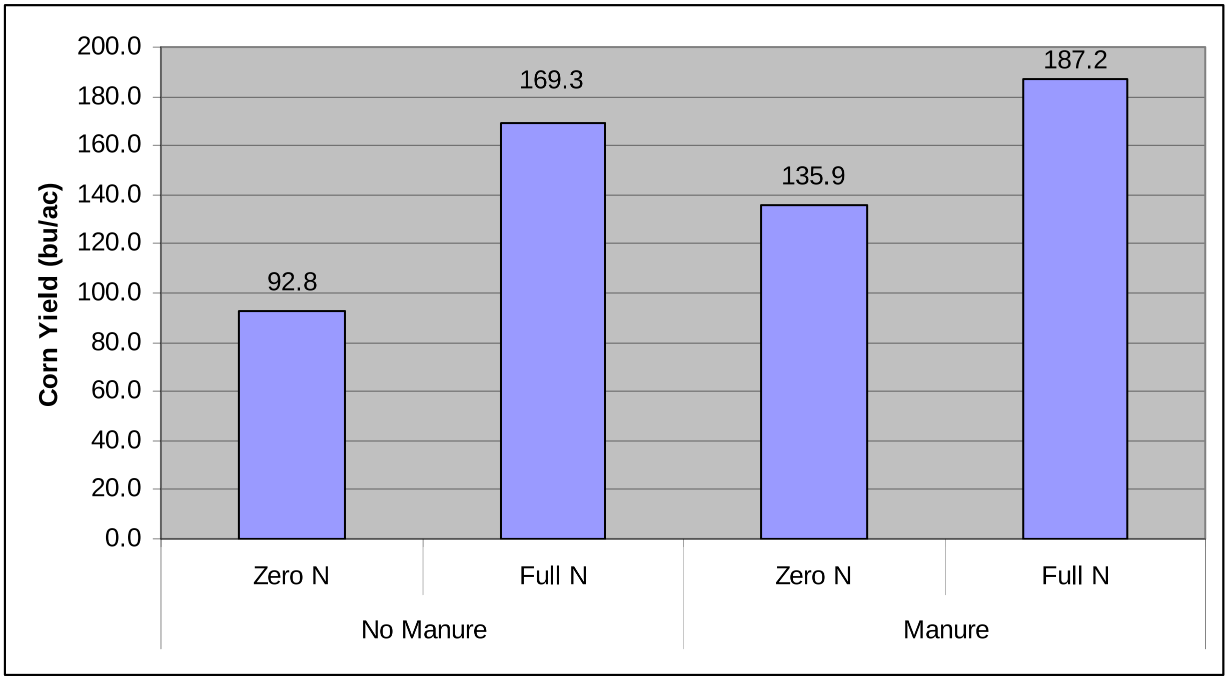


Figure 2: Corn Yield Across Covers for Manure by Nitrogen Rate



Next Steps:

This study was conducted as a single site. More trials on the impacts of cover crops following spring wheat harvest are required to generate enough data to support of refute these initial results.

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