Manure on Forages

Purpose:
This project attempted to put an economic value from yield and quality on the application of liquid manure on forage stands using surface application and partial incorporation.

1. document yield impact of manure on forages
2. determine the impact of partial incorporation
3. determine quality impact of manure on forages
4. determine tire damage and damage from incorporation equipment

Methods:

This project was implemented at 8 forage fields. They ranged from 1st full production year to 3rd production year and most fields had a mix of legumes and grasses. Four of the sites had partial incorporation comparisons – three fields with 4 replicated treatments as shown below. The other sites compared surface application on different varieties and/or used different application rates. One site had manure partially incorporated before 1st cut; 5 sites had manure applied after 1st cut and 3 sites applied manure after 2nd cut.

Soil samples were taken on each treatment to determine field fertility levels. Harvest was done using a 3' diameter hoola-hoop/scissors cut method prior to each cut. The goal was to take three hoola-hoop samples per treatment, but this was modified based on time and weather. Samples were weighed and analyzed for feed value. Some samples had grass-alfalfa separated to determine approximate ratios. The limiting factor came from weather (frequent showers) resulting in short notice for when a field would be cut. A manure analysis, was obtained at time of spreading when possible. Observations and yield comparisons of plant regrowth on wheel tracks and on manured vs. non-manured treatments

Results:

Manure applied to forages after 1st or 2nd cut gave both a yield and quality advantage for the 8 sites involved in this study. The details are provided in the tables below. Table 1 gives some site details around dates of forage harvest(s) and nutrient application. All but one field had a significant mix of grasses with the alfalfa. 1st cut growth was lush and most fields at time of first harvest were lodged. Frequent rain events during late May and throughout June, July and August made strict cutting times for a 4-cut system difficult to accomplish. Overall forage quantity was higher than normal which resulted in most sites only taking 3 cuts.

Table 1: Site Details

Location	Mix	Rate	Applied	1st cut harvest	2nd cut harvest	3rd cut harvest	4th Cut harvest	Total Yield
	Alfalfa-grass	gal/ac	Date	Date	Date	Date	Date	Wet ton/ac
Alymer	100-0	4,000	June 12	June 7	July 9	---	---	---
Innerkip 1	85-15 o-rg-t	3,000	May 25	May 23	Jun 20	Jul 25	---	26.37
Innerkip 2	85-15 0-rg-t	3,000	April	May 19	Jun 20	Jul25	---	22.37
Braemer	85-15	2,500	July 14	~May 31	July 8	Aug 10	---	---
Brooksdale	90-10 rg-rc-b	4,000	July 18	~May 31	July 7	Aug 10	---	---
Holbrook	85-15	4,500	June 14	June 5	July 7	---	---	---
Salford	Pioneer 85-10 t	2,500	June 11	June 6	July 6	Aug 8	Sept 22	26.7
Salford	Pro Rich 90-10 t	2,500	June 11	June 6	July 6	Aug 8	Sept 22	32.0

rg= ryegrass; rc=reed canary; b=brome; o=orchard; t=timothy

Table 2: Soil Analysis Results

Location	pH	OM %	P ppm	K ppm	Mg ppm	CEC
Alymer	7.4	3.1	27	166	323	23.5
Innerkip 1	7.4	4.2	27	60	296	18.4
Innerkip 2	7.1	3.6	16	168	283	16.7
Braemer	7.2	4.8	30	85	344	22.0
Brooksdale	6.5	3.1	7	61	305	15.5
Embro	7.5	4.1	37	122	253	28.0
Holbrook	7.1	3.6	22	99	306	20.0
Salford -Pioneer section	7.4	7.3	24	104	312	32.5
Salford - ProRich section	6.2	4.2	27	110	238	18.0

Table 3: Manure Nutrients Added							
Location	Manure	Rate	Dry Matter	Nitrogen	Phosphorus	Potassium	N-P-K Value
		gal/ac	%	lbs/ac	lbs/ac	lbs/ac	$/ac
Alymer	dairy	4,000	8.0	65	45	60	65.70
Innerkip 1	dairy	3,000	4.8	42	22	65	46.30
Innerkip 2	dairy	3,000	4.8	42	22	65	46.30
Braemer	dairy	2,500	9.4	35	15	60	38.70
Brooksdale	dairy	4,000	3.6	50	37	56	54.10
Embro	dairy	2,500	11.8	88	55	81	86.40
Holbrook	hog	4,500	2.6	83	83	63	91.10
Salford	dairy	~3,000	~3.5	~45	~40	~55	~50.00
Salford	fertilzer	225 lbs/ac		6.5	30	100	41.72

Table 4 gives the summary of yield and quality comparing manured treatments (surface applied and using partial incorporation tools) to non-manured treatments (aeration only and controls) taken from 1st, 2nd 3rd and 4rth cuts over all the project sites. Overall there is an 8 percent yield increase in yield. Wet yield represents samples weighed after scissors cut at about 85% moisture. Quality averages are shown for protein, acid detergent fibre (ADF), neutral detergent fibre (NDF), potassium (K), calcium (Ca) and Weiss total digestible nutrients (WTDN).

Table 4: Yield/Quality Response to Manure				Quality Data (%)						
Treatment (# samples)	Yield/cut (wet tons/ac)	Yield/cut (dry tons/ac)	Advantage %	Protein	ADF	NDF	Lignin	K	Ca	WTDN
With Manure (68)	6.97	1.05	8.0	22.1	35.1	45.9	7.0	3.14	1.49	61.0
Without Manure (60)	6.41	0.96	---	21.8	36.0	47.0	7.5	2.84	1.55	60.1

The calcium values are an indication of grass versus alfalfa content in the sample. In separated samples, there was an average 4% increase in grass content where manure had been applied. Alfalfa has higher calcium content. Any sample over 1.5% calcium is considered high alfalfa content while anything lower indicates significant grass in the sample. A pure grass sample has a calcium level near 0.3%.

Protein content is expected to be higher where manure is applied due to its nitrogen content. Nitrogen will have a greater impact on the grasses in the stand, however can also improve the yield and protein content of alfalfa. The nitrogen added from manure saves the plant energy in obtaining nitrogen from the root nodules which results in higher yield. Similar results have been seen from addition of commercial nitrogen, but would not be economical.

ADF, NDF, Lignin and WTDN are all quality indicators. The ideal protein – ADF – NDF for a pure alfalfa sample would be near 20-30-40% respectively. Grasses, even at ideal maturity are often higher than 30% ADF and 40% NDF. Lignin content greater than 7% decreases digestible nutrient quality.

Surface application of manure had the highest yield in almost every site. In table 5 the yield and quality comparison is broken down by surface application of manure compared to commercial fertilizer or nothing and are also broken down into 2nd, 3rd and 4th cuts.

Table 5: Surface Application vs. Commercial Fertilizer (or nothing) (6 locations)			Quality Data (%) (ave of 32+ samples/treatment)						
Treatment	**Average Yield/Cut** (wet tons/ac)	**% Increase**	**Protein**	**ADF**	**NDF**	**Lignin**	**K**	**Ca**	**WTD N**
No manure (33 treatments)	**5.3**	**---**	**22.0**	**35.8**	**46.3**	**7.40**	**2.56**	**1.61**	**59.8**
Surface Applied (39)	**6.1**	**12.8**	**22.3**	**34.7**	**44.6**	**6.96**	**2.90**	**1.56**	**61.7**
2nd cut no manure (22)	5.57	---	22.2	37.9	48.4	7.70	2.63	1.71	59.5
2nd cut surface manure (22)	7.28	23.4	22.1	36.5	46.8	7.35	3.06	1.66	60.7
3rd cut no manure (13)	5.95	---	21.3	33.7	44.8	6.79	2.44	1.42	60.7
3rd cut surface manure (16)	6.23	4.4	21.9	33.4	43.7	6.36	2.72	1.43	62.3
4rth cut no manure (4)	3.81	---	25.3	31.1	35.9	6.98	2.79	1.92	63.8
4rth cut surface manure (4)	4.13	7.7	25.4	31.0	37.5	7.44	2.88	1.68	63.4

Although this would vary for a year with less rainfall, it demonstrates that the affect of the manure application lasts beyond just the cut after application. This also suggests that manure applied to a forage field during the growing season will have a higher yield advantage than manure applied during the fall after critical harvest period.

Table 6: Grass-Alfalfa Response to Manure		Quality Data (%)									
Treatment – 1st Cut	**Yield (wet tons/ac)**	**CP**	**ADF**	**NDF**	**Lignin**	**P**	**%K**	**Mg**	**Ca**	**RFV**	**WTD N**
No Manure alfalfa	**13.08**	24.0	30.6	38.2	7.48	0.39	3.59	0.30	1.61	158	63.8
No Manure grass		16.2	35.4	61.2	6.47	0.29	3.35	0.15	0.30	93	57.2
Aeration with manure alfalfa	**11.46**	24.6	32.6	36.4	6.77	0.37	3.69	0.30	1.52	162	63.9
Aeration with manure grass		19.5	35.9	58.8	5.95	0.24	4.00	0.16	0.29	97	58.1

Table 6 looks at the comparison of grasses to alfalfa, both in quality as separate species and when manure is applied. From samples where grasses and alfalfa were separated (not shown in table 6), there was a 4% increase in grass content where the manure had been applied. The advantage of the manure to improving the nutrient quality of the grasses is bigger than the advantage of the manure to the alfalfa.

Comparisons were done to assess the affect of partial incorporation to surface application to aeration effect to a control. At one location the slot injection (Kaweco) was compared to surface application and a control. Coulters in 7 inch row spacing's made slots no more than 2 inches into which manure was placed with a shoe-type attachment. The results show a greater than 30% advantage to the manure applied into the slots compared to no manure and surface application (which was done with a tanker). However, with just one location and one harvest this shows a promising trend, but must be repeated for confidence. The comparison was done to a pure alfalfa stand and there was a visual difference between the treatments.

Table 7: Surface Application vs. Partial Incorporation (Aerway) 3 locations			**Quality Data (%)** (ave of 14 samples/treatment)						
Treatment	**Average Yield** (wet tons/ac)	**% Increase**	**Protein**	**ADF**	**NDF**	**Lignin**	**%K**	**Ca**	**WTDN**
No manure – No Aeration	6.11	---	21.7	37.4	49.2	7.40	2.98	1.50	59.61
Aeration only	6.39	4.4	21.3	36.8	49.0	7.49	3.00	1.43	59.25
Surface Applied Manure	7.31	16.4	21.6	37.0	48.5	7.40	3.40	1.43	59.42
Aeration with Manure	6.72	9.1	22.1	36.4	48.2	7.15	3.42	1.48	60.14

In table 7 the implement used for incorporation was an aerway – at two sites manure was applied behind and into the slots of the rotary tines, while at the other site the manure was applied in front of the rotary tines. In each case, there was a yield decrease compared to surface applied manure. Aeration technology was introduced in Ontario as an implement that would aerate pastures and stimulate secondary root function. Compared to the control there is a 4% increase in yield just from aeration. When comparing the aeration to surface application the difference could be most logically explained by plant damage from the rotary tines. Observations such as the picture below, show that although the alfalfa crowns affected by the rotary tines did regrow, the regrowth seems to less vigorous than crowns not affected by the rotary tines. One factor may have been a wetter than normal summer where compaction damage was more prevalent. Repeating this comparison in a drier summer would help determine if this trend is real.

Alfalfa crown affected by airway rotary tine

Slot injection (Kaweco) of manure

If aeration tines do decrease yield compared to surface application then the benefits versus the economics would need to be evaluated. Does the difference in nitrogen saved from partial incorporation by rotary tines save enough nitrogen to pay for the yield difference and cost of equipment and application on forages? An interesting study done near Elora by Greg Stewart, Ian McDonald (OMAFRA) and Neil McLaughlin (AAFC) looked at various tillage tools, incorporation, pre-tillage and ammonia loss from manure applied at the end of August onto wheat stubble. The accumulated ammonia loss was measured using calibrated enclosed ammonia meters. The results show relative differences and suggest very little difference in ammonia N savings with pre-tillage systems. The comparison of N loss when comparing immediate incorporation options showed the lowest N loss with complete incorporation such as cultivation. This is not realistic in a forage stand.

Table 8: Incorporation and Ammonia Loss

Manure Incorporation	**Ammonia Gas Release** (ppm)
No manure	8
Broadcast – incorporated 6 hrs	47
Broadcast – incorporated 24 hrs	75
Injected with Rotary Tine	108
Pre-till with Turbo Till then injected with Aerway	92
Injected with S-Tine	2

Source: Power Demo Day – Wellington SCIA, OMAFRA, AAFC

Table 9: Pre Tillage and Ammonia Release

Pre-tillage Implement	Ammonia release ppm	Tillage Implement Depth, Draft and Power: Depth inches	Draft lbs/ft	Power hp/ft
Sunflower offset disc	233	2.3	220	3.0
Sunflower disc ripper	137	6.5	560	7.5
Tandem Aerway	**185**	4.4	420	5.6
Salford CTS	287	6.4	770	10.3
Salford RTS	285	4.1	570	7.6
Great Plains Turbo Till	**187**	2.2	360	4.8
None (Surface application)	**175**	---	na	na

Source: Power Demo Day – Wellington SCIA, OMAFRA, AAFC

The results of this study as shown in table 8 and 9 indicate that surface application, coulters and rotary tines have similar ammonia release. Manure incorporated using rotary tines did not save nitrogen. Would the results be similar if ammonia loss was measured in an alfalfa stand where plants are actively growing? If ammonia is not saved, then is odour reduction enough reward to pay for equipment costs if yield is not improved over surface application? Another year of study would help answer these questions.

Impact from tire tracks from manure application equipment is significant both for yield and quality. This can be observed in Table 10. In both these examples the manure was applied 11 and 9 days after the field had been cut. Regrowth for both these fields was significant.

Table 10 : Tire Track Impact to Manure Application			**Quality Data (%)**						
Treatment	**Yield/cut** (wet tons/ac)	**Advantage** %	**Protein**	**ADF**	**NDF**	**Lignin**	**K**	**Ca**	**WTDN**
Manure 1	5.80	32	22.7	30.8	42.2	5.01	2.43	1.46	63.4
Tire track 1	3.96		23.7	26.8	33.7	6.12	2.50	1.52	67.2
Manure ave 2	7.73	41	20.7	42.5	52.5	9.12	2.65	1.64	56.0
Tire track 2	4.59		24.5	32.9	38.9	7.32	2.69	1.69	60.8

The key to manure application on forages is to apply the manure as quickly after forage harvest as possible. The forage regrowth is both from the crown and from the apical buds on the stem; so when regrowth is damaged by tire traffic, the regrowth must begin anew from the crowns.

Alfalfa regrowth undamaged by tire tracks

Regrowth after damage from tire tacks

This puts the forage in the wheel track behind in maturity to the rest of the field. This is evident from the quality comparison

In fields where application of manure was within 5 days of cutting, the wheel tracks were difficult to find in the regrowth.

Summary:

Manure application to forage crops is a benefit from an economical perspective. The best option is still to apply manure to corn crops where there is a higher economic return from the nitrogen. However, when a livestock producer is looking to spread out workload, reduce storage requirements, or to prevent compaction damage or is looking for alternative crops or more opportunities in which to apply manure, then manure applied to forages will meet those objectives while providing N-P-K that will save commercial fertilizer inputs. The greatest difficulty is in timely application. Manure applied to haylage crops is usually more timely than dry hay crops, but labour and equipment is required to be able to combine timely forage harvest with timely manure application.

From 8 sites over 4 cuts during one summer, there is a greater than 12% yield advantage to surface application of manure to an alfalfa crop. In addition, forage quality is at least equal and usually slightly higher than non-manured treatments. Aeration incorporation did not show as high a yield advantage probably due to plant damage resulting in less regrowth. Timing of manure to as soon after cutting is critical to regrowth and yield

Next Steps:

The results show a trend to improved yield from manure application. Final stand counts this spring should reveal over wintering differences between manured and non-manured treatments. Aeration incorporation does not show as good a yield improvement as surface application of manure on legumes. The power demo day near Elora tested ammonia losses from various incorporation tools and results indicated that surface application and aeration tools have similar ammonia losses. The ideal next step to this project would be to repeat the project to increase confidence that the trend to yield and quality improvement is real and to repeat the incorporation treatments with ammonia loss meters to determine the economics, including nitrogen savings, from partial incorporation of manure into legumes

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