Effect of Manure Amendments with varying C:N Ratios on N Availability to Canola

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Introduction

As N in solid animal manure is mainly in organic form, the amount of N potentially mineralized from manures is an important variable to be considered when recommending the appropriate rate to apply to meet N needs for optimal crop production.

Manure C:N ratio is an important factor affecting the rate of mineralization and was recently shown to account for 40% of the variation in amount of N mineralized from the manure. A large variance in C:N ratio can be expected in different sources of manures because of differences in animal species, feed, bedding material, age and handling.

For appropriate rate and timing of manure application, it is important to know the N release from manure in soils and its relationship to C:N ratio.

Objectives

- to examine the effect of application of different type of animal manure with different C:N ratios on canola yield and nitrogen uptake;
- to assess N supply in manured soil to determine the pattern of available N release over time;
- to determine the N mineralization in manured soil and its relationship to C:N ratio of the manures.

Materials and Methods

Soils: Haverhill and Blaine Lake (Table 1).

Manure: Thirteen (Table 2). Fertilizer: Urea.

Growth Chamber Study:
- Manure added at rate of 100 mg kg^{-1} of soil with 3 replicates.
- Canola (*AC Excel*) as test crop.
- Yield and N uptake, distribution among seeds and straw measured.

Lab incubation for measuring N supply rate:
- 200 g soil in each vial in triplicate.
- PRS™ anion and cation exchange membrane probes (Western Ag Innovations, Saskatoon).
- Cumulative N supply recorded by inserting probes in the soils for 4 days, 7 days, and 4 successive 2 week intervals in the same slot.

Results and Discussion

Canola Yield and N Uptake as Affected by Addition of Manure (Tables 3 and 4)

Significant ($p < 0.001$) increase in yield and N uptake was observed in both soils amended with DEC and poultry manure. DEC, a pelletized hog manure with mineral fertilizer N added, has 11.5% of total N as mineral N. Poultry manure had low C:N ratio (7.1), and its organic fraction is the most readily mineralizable among the major animal manures.

A lower and sometimes non-significant increase in yield and N uptake was observed in other amendments. This is because the two soils had no history of manure use and the application amount was low (100 mg N g^{-1}).

Solid cattle manure generally has less effect in inducing a yield response in the year of application than liquid slurries as there is less immediately available inorganic N. In this study, inorganic N in the solid manures comprises less than 1% of the total N, except for poultry manure and DEC.

Significantly higher yields were achieved in the Blaine Lake soil than in the Haverhill soil in 6 treatments and in the control due to higher N mineralization in the Blaine Lake soil as a result of its higher organic content (Table 1).

Table 1. Some characteristics of soils used in the experiment

Soil Association	Texture	pH	EC dS m^{-1}	Total C g kg^{-1}	Total N g kg^{-1}	C:N	NH_4-N	NO_3-N
							-- mg kg^{-1} --	
Blaine Lake	Clay Loam	7.9	0.19	23.2	1.77	13.1	0.85	0.72
Haverhill	Sandy Loam	7.6	0.19	11.0	0.84	13.1	0.36	0.66

Table 2. Carbon and N contents of the manure amendments used in the study (fresh weight basis)

Manure	Location	Organic C	N	Inorganic N	Organic C:N
		---------- g kg^{-1} ----------			
Cow-calf penning pack surface (CPS)	Central Butte	172	12	0.04	14.4
Stockpiled 4 yr old manure, surface (S4S)	Central Butte	157	14	0.09	11.3
Stockpiled 4 yr old manure, 10 cm depth (S4P)	Central Butte	163	13	0.13	12.7
Feedlot pen, straw bedding (FB)	Central Butte	411	19	0.09	21.7
Feedlot pen, pack (FP)	Central Butte	374	24	0.08	15.6
Broiler poultry manure (BP)	Saskatoon	243	32	0.92	7.6
Feedlot penning (FYt)	Yorkton	267	17	0.10	15.8
Feedlot penning (FPm)	Poundmaker	215	17	0.08	12.7
Feedlot penning (FA2)	Alberta 2	338	26	0.09	13.0
Pelletized hog manure (fertilized) (DEC)	Alberta 2	273	18	0.03	15.2
Pelletized hog manure (unamended) (LIOR)	Quebec	242	37	4.26	6.6
Compost (from steers bedded on straw) (CP)	Quebec	383	33	0.66	11.5
	Ohio	243	28	0.20	8.7

Table 3. Effect of manure addition on canola yield and N uptake in Haverhill soil.

Treatments	Yield (g)		Uptake (mg pot^{-1})	
	Seed & Straw	StrawS	eed & Straw	Straw
CPS	1.58a	1.46a	14.3a	9.3ab
S4S	1.84ab	1.64a	21.1ab	7.5a
S4P	1.86ab	1.68ab1	9.2ab	10.2b
FB	1.60a	1.48a	11.9a	6.8a
FP	2.22b	1.95b	18.9a	9.4ab
BP	4.58c	4.42c	26.2b	19.3c
FYt	2.11b	1.85b	19.3ab	8.7ab
FPm	2.00b	1.70ab1	8.0a	6.2a
FA1	1.74ab	1.62ab1	6.3a	7.8a
FA2	2.16b	1.91b	19.0ab	7.3a
DEC	4.60c	4.36c	49.1c	39.5d
LIOR	2.24b	2.03b	33.2bc	19.8c
CP	1.57a	1.40a	20.9ab	10.4b
Ctr.	1.43a	1.30a	12.1a	6.4a

Values followed by the same letter in each column are not significantly different ($p = 0.05$) according to Duncan's new multiple range test.

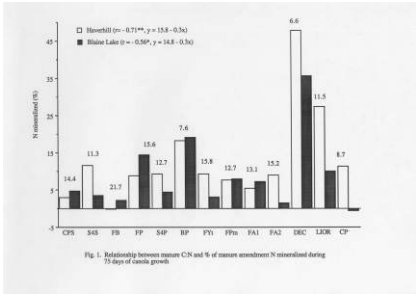

Fig. 1. Relationship between manure C:N and % of manure amendment N mineralized during 75 days of canola growth

Table 4. Effect of manure addition on canola yield and N uptake in Blaine Lake soil.

Treatments	Yield (g)		Uptake (mg pot^{-1})	
	Seed & Straw	StrawS	eed & Straw	Straw
CPS	2.10a	1.69a	22.9a	7.1a
S4S	2.75b	2.35b	21.0a	6.6a
S4P	2.66b	2.39b	21.6a	11.9bc
FB	2.05a	1.75a	20.0a	8.1ab
FP	2.50ab	2.21ab2	9.3b	8.6ab
BP	4.58c	4.18c	33.0c	17.0d
FYt	2.36ab	2.03ab2	0.6a	7.1a
FPm	2.60ab	2.24ab2	4.4ab	6.4a
FA1	2.46ab	2.10ab2	3.8ab	9.8ab
FA2	2.38ab	2.20ab1	9.4a	10.7b
DEC	5.73c	4.78c	45.8d	13.1c
LIOR	2.29ab	2.00ab2	6.0b	8.1a
CP	2.08a	1.81a	17.8a	7.3a
Ctr.	2.14a	1.83a	18.2a	6.6a

Values followed by the same letter in each column are not significantly different ($p = 0.05$) according to Duncan's new multiple range test.

Available Soil N Supply Over Time as Affected by Manure and Urea Application (Fig. 2)

The release of available N (NH_4 and NO_3) over the 67 day period was significantly higher ($p > 0.001$) in poultry manure- and DEC- amended soils than in the controls.

Significantly higher ($p > 0.05$) release of organic N was also observed in soils amended with S4S and S4P (stockpiled, aged manure), which also had relatively lower C:N ratios.

Addition of manure had little impact on N release when the C:N ratio was between 13 and 15, and decreased N supply rate in certain treatments where manure C:N ratio was over 15. It was also observed that soils amended with compost had lower N supply rate than control.

The Blaine Lake soil generally had higher N release than Haverhill, probably due to its higher organic N content.

Relationship between Organic N Mineralization and C:N ratio (Fig. 1)

Manure organic N mineralization = N uptake by canola grown on the different manure amendments N uptake by canola grown on the controls.

Higher C:N ratio in the manure was associated with lower N mineralization. However, the compost had a low C:N ratio (8.7), but low N mineralization. This is because most of the easily mineralizable N has already been converted to inorganic forms and may be lost during composting. The remaining organic N in the compost is in more stable N pools which are more resistant to decomposition.

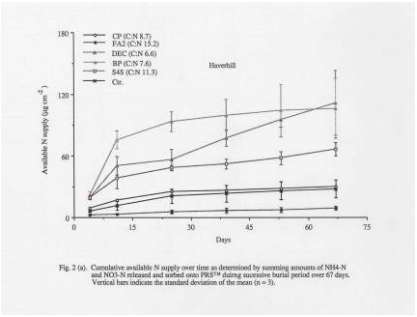

Fig. 2 (a). Cumulative available N supply over time as determined by summing amounts of NH4-N and NO3-N released and sorbed onto PRS™ during successive burial period over 67 days. Vertical bars indicate the standard deviation of the mean (n = 3).

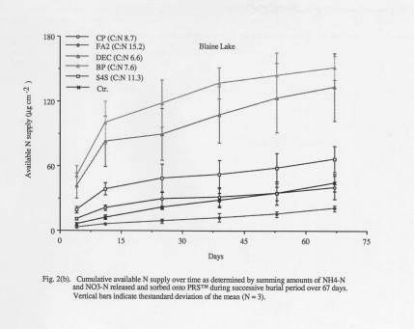

Fig. 2(b). Cumulative available N supply over time as determined by summing amounts of NH4-N and NO3-N released and sorbed onto PRS™ during successive burial period over 67 days. Vertical bars indicate thestandard deviation of the mean (N = 3).

Table 5. Linear regression between N uptake by canola and available N supply over time in two soils used.

Time (days)	Correlation coefficient (r)	
	Haverhill	Blaine Lake
4	0.42	0.68 **
11	0.47	0.78 **
25	0.56 *	0.76 **
39	0.64 *	0.77 **
53	0.69 **	0.80 **
67	0.73 **	0.80 **

Asterisks * and ** following correlation coefficients indicate statistically significant correlations, $P < 0.05$ and $p < 0.01$ respectively.

Relationship between available N supply and total N uptake by canola (Table 5)

A significant relationship was observed between available N supply rate in manure-amended soils and total N uptake by canola with better correlation in Blaine Lake soil.

Correlation coefficient (r) increased by including a longer time span of N supply measured by accumulation on the probe, especially in Haverhill soil, indicating that the continuous contribution of N mineralized is important in influencing plant uptake in manure soils.

Conclusion

Addition of the solid manure amendments in two soils generally did not result in large increases in canola yield and N uptake, with exception of poultry manure and DEC.

Manure C:N ratio plays a significant role as a significant correlation between manure C:N ratio and N mineralization was found for the manure-amended soils. Generally, cattle manures had little impact on short-term release of available N if the organic C:N ratio was in the range of 13-15 and tended to decrease N availability I the short-term if the organic C:N ratio is over 15.

The N supply rate measured by PRS™ probes was quite well correlated with plant N uptake differences obtained among the treatments. Longer periods of supply rate measurement in the soils resulted in better correlation with plant N uptake.

Acknowledgements

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