Canadian Pork Council
Conseil canadien du porc

Agriculture and Agri-food Canada
Agriculture et Agroalimentaire Canada

SYMPOSIUM OF THE HOG ENVIRONMENTAL MANAGEMENT STRATEGY (HEMS)

DECEMBER 10 AND 11 , 1999

NEATBY BUILDING
AGRICULTURE AND AGRI-FOOD CANADA
OTTAWA, ONTARIO

PROCEEDINGS

Posters and Displays ONLY

TABLE OF CONTENTS

Pages 1 - 69 in FILE: hems2_proc.pdf

INTRODUCTION

REDUCING GAS EMISSIONS

MANURE TREATMENT

SOIL AND WATER QUALITY

PUBLIC HEALTH

COMMUNICATIONS

POSTERS & DISPLAYS **IN FILE:** **hems2_posters.pdf**

Infrastructure for hog manure management and utilization systems studies

J. A. MacLeod [1], A. J. Campbell[1], T. VanLunen[1] and D. Hurnik[2]
[1] Crops and Livestock Research Centre, Charlottetown, [2] Atlantic Veterinary College.

PROJECT DESCRIPTION

The study objective is to develop and evaluate manure handling systems for solid and liquid hog manure research. Funds provided were used to purchase a mixer wagon with load cells, a portable sludge pump, a modified a belt conveyor and to construct a small sample mixer and sample splitter. This project is part of a larger program in collaboration with AVC Inc. to conduct studies on various aspects of swine production including manure management. The basic AVC Inc. swine research barn is made up of 20 pens on slats over individual liquid pits and 20 pens designed for deep bedding. Total capacity of the barn is 1000 feeders from a minimum disease facility that operates on a batch system. Research is to include liquid systems and solid systems based on different materials for deep litter. A system for handling and quantifying liquid manure from individual pens was developed in a larger project with other funding but this project helped by providing a pump to move heavy slurry from below pen holding areas to a measuring and transfer pit. Systems for quantifying and handling bedding materials, systems for studying aeration and mixing of the litter pack to facilitate "in barn composting" and facilities to handle and quantify the solid manure were developed. A mixer wagon with load cells was used for mixing and measuring the solid manure and bedding materials. Rubber belt elevators were modified for the system to move bedding from a truck to the mixer wagon and to move manure from the mixer wagon to the truck. Studies (with other funding) were conducted on three fills of the AVC Inc. swine research barn. Manure was quantified from different deep bedding systems and from the liquid system.

REACH

The primary target is the Swine Research Group of The Crops and Livestock Research Centre and The Atlantic Veterinary College (Including the Research Chair of the PEI Hog Board). This will enhance the ability of this group to conduct research on economic and environmentally sound approaches to swine manure management. This will generate useful quantitative data to help develop and refine models for manure management and utilization. The infrastructure provided in this project will facilitate studies to better understand nutrient losses in swine production systems. Results of such research would be a benefit to the swine industry, policy makers and the general public. Results from this research would also be useful for technology transfer in manure handling and utilization.

RESULTS

Preliminary results using the equipment on the first fill of the barn are presented. Start up problems especially with the liquid measuring system introduced some uncertainties into the data but the results are presented to indicate the type of information that can be obtained .

Three deep bedding systems were compared to the liquid manure system for nutrient retention. The bedding materials were:

1. Sawdust
2. Sawdust + straw
3. Sawdust + straw + compost

The incoming feed was the major source of N input (Table 1). The bedding components contributed little to incoming N. The estimated N removal by the pigs (carcass N less N in incoming pigs) accounted for approximately 35 % of the feed N. Nitrogen detected in the manure was also approximately 35 % of the feed N for the bedding systems but only about 20 % for the liquid system.

Table 1. Fate of N in hog production.					
Bedding Type*	**tonnes N/1000 pigs**				
	Source		**Removal**		**Pile at Spreading**
	Feed	**Bedding**	**Market Hog**	**Manure**	
1	6.66	0.08	2.4	2.2	1.11
2	6.83	0.25	2.4	2.69	1.18
3	6.7	0.25	2.4	2.21	1.39
4	6.33	n/a	2.4	1.22	n/a
* types 1-3: various deep bedding systems; type 4: liquid system					

The feed was also the major source of P with only small quantities in the bedding materials (Table 2). Most of the P not accounted for in the marketed pigs was found in the manure. Ratios of various nutrients in the manure at various stages in the handling system were calculated (Table 3). It is proposed that changes in the ratio of N to P indicate the degree of N loss. Systems which minimize N loss will increase N to P ratio thereby decreasing the build up of soil P when manure is applied to supply crops N requirement thereby delaying the requirement limit manure on the basis P build up.

Table 2. Fate of P in hog production.					
Bedding Type*	**tonnes P/1000 pigs**				
	Source		**Removal**		**Pile at Spreading**
	Feed	Bedding	Market Hog	Manure	
1	1.83	< 0.01	0.38	1.27	1.13
2	1.88	< 0.01	0.38	1.22	1.26
3	1.84	< 0.01	0.38	1.18	1.25
* types 1-3: various deep bedding systems					

Table 3. Nutrient ratios in manure				
Sampling Time	**Nutrient ratio**			
	P/Ca	**K/Ca**	**N/Ca**	**N/P**
February (Clean-out)	0.81	1.32	1.83	1.63
Late-March (Pile)	0.8	1.28	1.08	0.81
June (Spreading)	0.8	1.11	0.74	0.5

Mixer wagon with load cells weighing and mixing bedding components. Conveyor for moving bedding into pens.

Bedding material being conveyed into pens.

Removing manure for mixing and weighing.

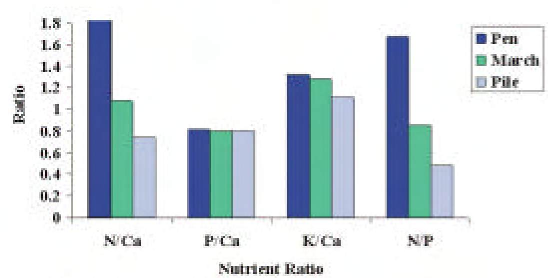
Transferring manure to truck. Lower insert: 1 of 4 of load cells on mixer wagon. Upper insert: Mixer wagon balance display.

Sampling manure from mixer wagon.

Sludge pump for transferring liquid manure.

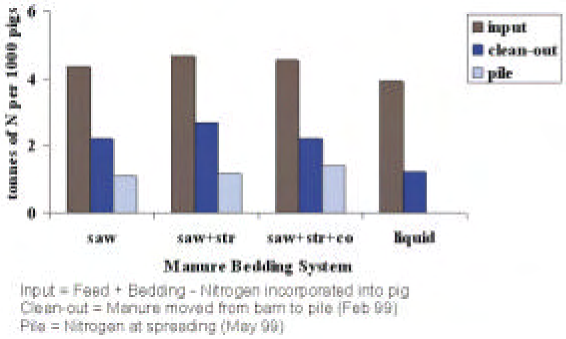
Sample mixer and splitter for subsampling manure.

Changes in Nutrient Ratios in Deep Bedding Manure over Time.



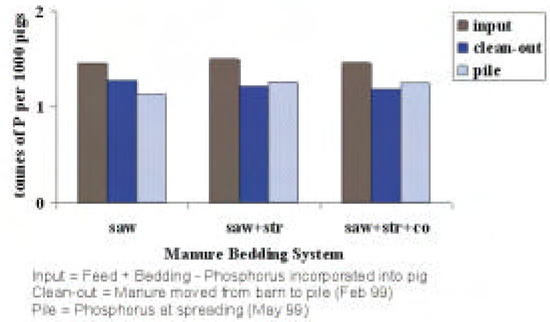
Clean-out = Manure at clean-out (Feb 99)
March = Manure sampled from pile (March 99)
Pile = Manure at spreading (May 99)

Fate of Nitrogen in Hog Manure Systems



Example of results on the fate of N in bedding systems compared to liquid systems.

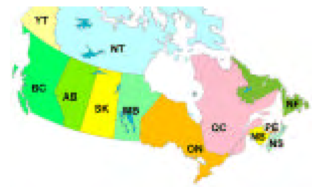
Fate of Phosphorus in Hog Manure Systems



Example of results on the fate of P in bedding systems.

ManureNet - A Canadian Web Site Dedicated to Manure Management Issues

Bruce T. Bowman
Southern Crop Protection &
Food Research Centre
Agriculture & Agri-Food Canada
London, ON



PROFILE

Description: ManureNet is an Internet Web site which is focused on the issues surrounding manure/nutrient management in Canada, with emphasis on documenting research and demonstration projects, expertise in manure management and new technologies for managing various types of livestock manures.

Participants: Leader: Bruce T. Bowman (AAFC, London), David Morris (consultant), Bruce MacDonald (consultant), Trudy Boucher (IT Support, AAFC, Ottawa); Steering Committee: John McLeod (AAFC, PEI), Daniel Massé (AAFC, QC), Katherine Buckley (AAFC, MB), John Paul (Private, BC).

Goals:

1. To develop a National Information Network which would facilitate the identification and transfer of appropriate information to the ManureNet Team for organizing and posting on the ManureNet web site.
2. To establish a Technical Web Site Development Team responsible for the daily operations and content of the Manure Net Web site, including development of a national Oracle data base on manure.
3. To develop a National Internet Web Site, ManureNet, to be hosted on the AAFC Research Branch Server:

REACH

The ManureNet web site provides information and coordination for a wide range of client groups, including:

- Provincial Extension Specialists
- Program Managers - Federal, Provincial, Private
- Livestock Commodity Groups
- Federal Researchers
- Other Coordinating Groups (CARC, Fed./Prov Information Highway Group, provincial information data bases)
- International/foreign agencies (e.g. universities, gov't agencies)

RESULTS

During the first year and a half of operation the following results have been achieved:

- About 230 research projects and 200 "experts" in manure management in Canada have been identified and documented with contact information on the web site.
- Almost 1200 hypertext links (including short descriptions) have been developed on the ManureNet web site, of which 900 are linked to other web sites.
- A prototype design for the Oracle data base has been implemented and tested with more than 600 data records inputted. Following performance evaluation of the data base, its structure has been substantially re-designed to broaden its perspective (scope), and to facilitate integration with other data bases, such as existing Provincial Ag Ministry data bases.
- An advanced Search Engine for locating specific information in the Oracle Data base has been prototyped and

currently is being re-designed and streamlined for easier client use.

- An input interface program has been developed and is currently being tested which will facilitate remote direct entry of new records into the data base, including record editing and validation.
- New selection categories have recently been added to ManureNet to provide a greater range of information. These include: "Feeding Strategies", "Environmental Issues", "Health & Safety", "Community/Social Issues" and "Misc. Facts & Figures".
- Proceedings of the first HEMS Symposium are available on ManureNet, as well as the background and the strategy documents for HEMS.

IMPACTS

The Canadian Agri-Food Council (CARC) was interested in establishing a National "Expert Committee on Manure Management" (ECMM) issues. The development of ManureNet became a logical reason for involving us in that committee, which now has had its first meeting in early October, 1999. A primary function of the ECMM is to act in a support role for ManureNet.

We have been approached by several provincial Ag ministries about the possibility of linking or even integrating the ManureNet data base with their provincial data bases, perhaps as a distributed data base where each group enters and manages its own information while ManureNet would maintain the master national index, including short descriptors of each record.

Feedback on the usefulness of ManureNet has been very positive from a wide range of groups, especially provincial extension specialists. Indications are that ManureNet is performing a very useful national coordinating role for manure management issues. Efforts are being focused on developing information gathering networks for the web site.

The Fed/Prov Information Highway Project which is currently developing a national Pork Information web site asked ManureNet to participate in their efforts, with the possibility of integrating the two projects in the future.

ManureNet has been widely indexed on the World Wide Web by all of the major search engines, including AltaVista, Excite, InfoSeek Ultra, HotBot, Lycos and others. When globally searching for information on manure management issues on any of these major sites, search returns from ManureNet consistently rank high on the results list.

NEXT STEPS

- Implementing the Record Input Interface Program to facilitate data entry and validation from remote locations (in progress).
- Completing the re-design of the Oracle Search Engine feature and implementing the new version (in progress).
- Seeking feedback and suggestions from various commodity groups as to the type of information that they need and would find beneficial to their operations.
- Further developing the Information Gathering Network for ManureNet for the purpose of identifying, collecting and organizing new information.
- Enhancing our working relationships with a variety of Partners, including:
    - Pork Information Network Web site (now in prototyping phase),
    - Provincial Ag Ministry Extension Specialists and their data bases,
    - CARC Natural Resource Committees (Canada Committee, Greenhouse Gas Committee, Expert Committee on Manure Management).

Timing of application: does it impact on soil P transfer ?

R.R. Simard[1], I. Royer[2], G. Barnett[3] and T. Macdonald[4]
[1]Agriculture and Agri-Food Canada, SCRC, Sainte-Foy, Qc, [2]INRS-Eau, Sainte-Foy,
[3]Agriculture and Agri-Food Canada, ARC, Lennoxville and
[4]McGill Univ., Macdonald Campus, Ste-Anne de Bellevue, Qc.

In many areas of Canada, more P is added to agricultural soils than exported as crops or animal products. This is particularly the case in zones where animal operations are concentrated and manure and other agricultural residues are applied to the land (MEFQ, 1997). Soil P accumulation has been observed near the surface and in the subsoils (Simard et al. 1995). Most of this P is in non-labile forms but, when the degree of saturation of the soil P fixation capacity exceeds a certain level (about 20 %), some of this P may be transferred to surface waters (Sims et al. 2000). This P may cause eutrophication, which means excessive growth of algae and aquatic plants, reduced oxygen levels in water and changes in species composition of the aquatic ecosystem (Sharpley et al. 2000).

The risk of water contamination by P is dependent on factors related to site characteristics, the soil P level and to management factors (Bolinder et al. 2000). At the farm level, management factors include P application rate, source of P (mineral fertilizer vs manure), type of manure (solid vs liquid), P application method, timing of application, incorporation of applied P, crop species and others (Bolinder et al. 1998, MEFQ 1998).

It was previously shown that manure N recovery by spring wheat or corn was independent of application period (fall vs spring, Jokela 1992, Garand 1999). Fall application of liquid hog manure is very attractive since it frees a part of the manure storage capacity and it often coincides with manpower availability and adequate soil bearing capacity for machinery. Spring applications are recommended to reduce nutrient losses and increase crop yields (MacKenzie et al. 1989, CPVQ 1996) but are in conflict with seeding operations and wet soil conditions for spreading. Little is known about the effect of timing of manure application on soil P transfer to surface waters. The objective of this work is to document the impact of the timing of manure application as compared with inorganic fertilizer on i) the soil P store ii) the risk of soil P contamination by phosphorus iii) soil P transfer (loss) in runoff, erosion and drainage under continuous grain corn and a timothy-clover meadow.

MATERIALS AND METHODS

This experiment was conducted on a site initiated in 1989 near Lennoxville, Québec, at the Agriculture and Agri-Food Canada Research Centre on a Coaticook silt loam (Humic Gleysol). The soil (0-20 cm) had a pH of 5.8, 5.3 % organic matter and a Mehlich-3 extractable P content of 81 mg kg-1. This soil P level is considered rich for grain corn and hay (CPVQ 1996). The site has a 6 % slope and is equipped to collect surface runoff and drainage waters.

Two crop species were studied, grain corn (Zea mays L.) and a mixture of timothy (Phleum pratense L.), white and red clovers (Trifolium sp.). The experiment included 5 treatments for each species : (C) control; (M) inorganic fertilizers according to soil test and local fertilizer recommendations (180 kg N, 15 kg P , xkg K ha-1); liquid hog (Sus scrofa) manure (LHM) at 360 kg total N ha-1 + inorganic fertilizers applied either all in spring at pre-seeding (S), 50 % in the spring and 50 % in the fall after harvest (SF) and all in the fall after harvest (F). Amounts of 55 kg N and 10 kg P ha-1 were added as inorganic fertilizers in forages and 110 kg total N as LHM. The corn residues were chisel plowed in the fall.

Soils were sampled in the fall of 1997 with a Giddings probe and the 0-5 and 5-20 cm layers analyzed. The amount of labile P was determined by extraction in the Mehlich-3 solution (M3P) and the soil P saturation as evaluated by the ratio of the extractable P to the extractable Al content in the Mehlich-3 solution (Tran and Simard 1993). The risk index of water contamination was calculated according to the procedure of the MEFQ (1998). The surface runoff and sediments were collected from 7 rainfall events in 1999 and the drainage was collected twice. The water was analysed for its molybdate reactive P(MRP, Murphy and Riley 1962). The water and sediment were also analyzed for total P content (Rowland and Haygarth 1997).

RESULTS

Soil store. The amount of M3P in the 0-5 cm layer was significantly affected by the treatments and the crop species. In the 5-20 cm layer, the difference was not significant. In the 0-5 cm layer the M3P was larger under corn than under forages (Fig. 1). Under corn, the F and SF treatments showed the highest M3P contents, which were significantly larger than for the S and M treatments. The M3P content of the mineral fertilizer treatment was only slightly higher than the control. The S treatment showed the highest M3P content under forages. As for corn, all manure treatments were higher than the M treatment. The control showed much lower values.

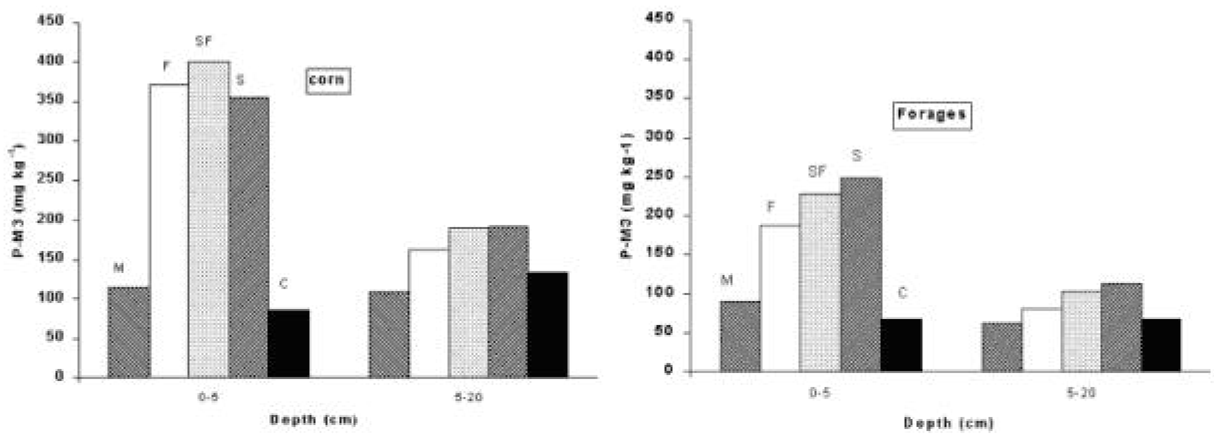


Figure 1. Mehlich-3 extractable P contents from the 0-5 and 5-20 cm layer of a Coaticook silt loam as affected by nutrient source and timing of manure application.

The degree of P saturation of the soil was, as expected, higher under corn than under forages in both layers (Fig. 2), there being less difference between crop species in the 5-20 cm layer. The trend in the M3P/M3Al ratios followed those of the M3P since the Mehlich 3-extractable Al is not a property that varies to as large an extent as M3P in soils (Tran and al. 1996). The manure treatments had the highest values in both crops at both levels, which were over 20 % in corn and between 15 and 20% under forage in the 0-5 cm layer. The 20% level is recognized as excessive in the province (Giroux et al. 1996).

Index of Risk of Water Contamination by soil P. The risk of water contamination was estimated from the real data of the P balance, P soil test, degree of P saturation, type and mode of application of manure. The index under corn is much lower with mineral fertilizer (moderate risk) than for manure (high risk) and is slightly less for the spring than for fall applications (Table1). This difference is related to the type of manure coefficient which is less for spring applications (MEFQ 1998). The values of the index were in general lower for forages than for corn. The differences between the manure treatments were again related to the coefficients allocated to type and mode of manure application. The lower values associated with the inorganic fertilizer treatment are related to lower soil-test P, amount of P added and to the smaller values of the coefficient for mineral P than for manure P.

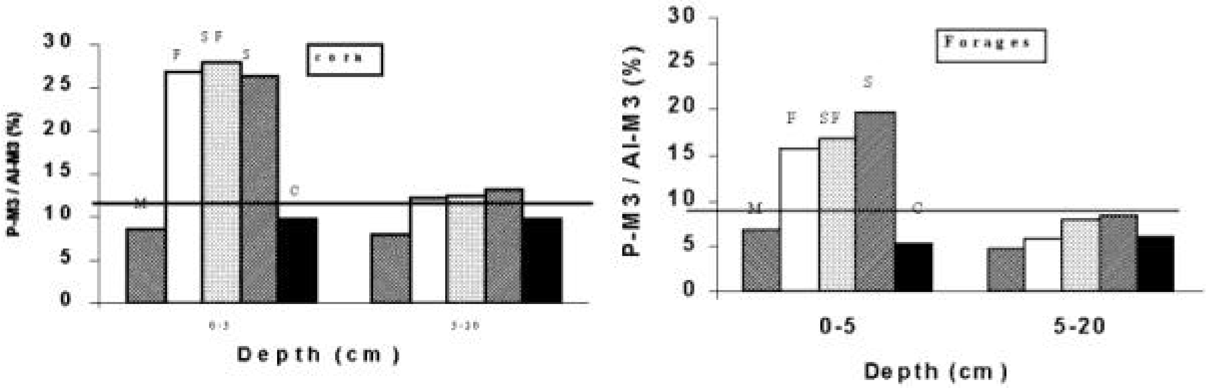


Figure 2. Values of the P saturation index as calculated by the ratio of Mehlich 3 extractable P to the Mehlich 3 extractable Al from the 0-5 and 5-20 cm layers of a Coaticook silt loam as affected by nutrient source and timing of manure application

Table 1. Values of the P index as influenced by crop type and nutrient management

	Corn	Forages
Mineral fertilizers	126	113
LHM-100 % spring	341	295
LHM-50-50	355	275
LHM-100 % fall	355	330

P transfer in surface runoff and drainage. Data for the first years of the study (1989-1992) clearly indicated that transfer of P from these plots was larger for the LHM-F application treatment than for the others and that most of the transfer occurred in the fall and winter (Gangbazo et al. 1997). Summer transfer tended to be lower for manure treatments than for mineral fertilizers.

The P transfer was one order of magnitude smaller under forages (mg) than under corn (kg) (Figures 3a and b). Under forages, the transfer of MRP, the most bio-available form of P, was the highest for the M treatment whereas the total P load was higher for the spring application. The fall application showed the smallest load of MRP and TP amongst manure treatments. The corn TP loads were highest for the F treatment but not significantly different than for the mineral fertilizer or the control. It is very interesting to note that the P transfer for the spring applications to corn are less than for the control. Under forages, the spring application and the mineral fertilizer treatments showed the highest MRP and TP transfer (Figure 3b). It is highly probable that most of the soluble P added in manure the previous fall was already lost when sampling began. Most of the P loss was associated with the fall and winter periods (Gangbazo et al. 1997).

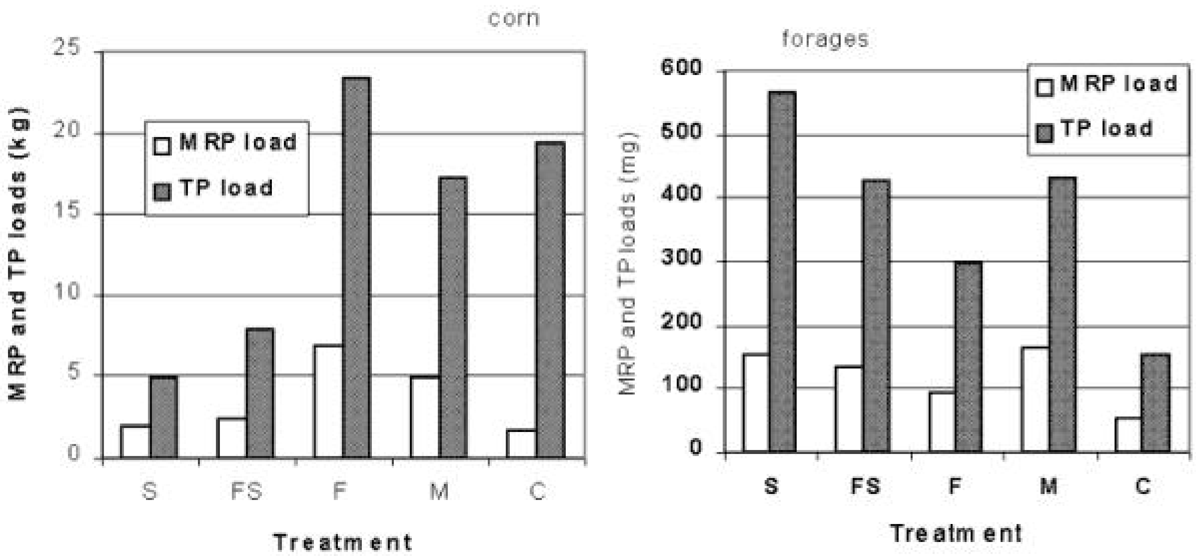


Figure 3. Molybdate Reactive P (MRP) and total P (TP) transfer in surface runoff from corn and forages in seven events in the summer of 1999 as affected by the treatments.

DISCUSSION

This study clearly indicates that under reduced or in the absence of tillage, P accumulates very fast near the surface of soils. This results in a very high degree of saturation of the soil P fixation capacity which suggests a much greater risk of P contamination of surface waters. The predicted risk rankings from the P index for soil-P transfer were generally higher for corn than for forages and were less for spring applications for both crops. A longer period of evaluation would be necessary to make a definitive conclusion. The timing of application had a small but significant impact on the soil P level in most cases. being smaller for fall treatments. The P transfer is influenced much more than soil levels, the data suggesting that fall application of manureto forages is probably not the best possible management practice. Spring application after crop emergence is preferable since it would limit compaction and coincide with rapid growth of the forage crop.

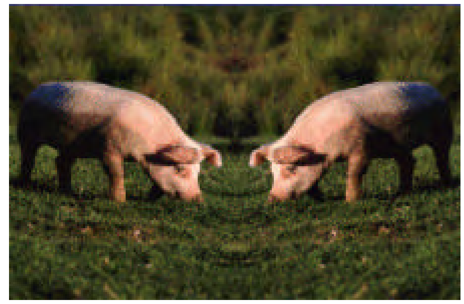
REFERENCES

Bolinder, M.A. et al. 1988. Indicator of Risk of Water Contamination: P component. Report # 24, AAFC, Ottawa, Ont.
Bolinder, M.A. et al. 2000. Can. J. Soil Sci. (in press).
CPVQ. 1996. Grilles de référence en fertilisation. 2nd ed. AGDEX 540.
Gangbazo, G., A.R. Pesant, and G.M. Barnett, 1997. Effet de l'épandage des engrais minéraux et de grandes quantités de lisier de porc sur l'eau, le sol et les cultures. Rapport de Recherches, Direction des Écosystèmes aquatiques, MEFQ, Québec, Qc., Can. 46 pp.
Garand, M.J. 1999. Ph.D. thesis, McGill Univ.
Giroux, M. et al. 1996. Agrosol 9(1): 36-45.
Jokela, W.E. 1992. Soil Sci. Soc. Am. J. 56: 148-154.
MacKenzie, A.F. et al. 1989. Report CORPAQ project 2070.
MEFQ. 1997. Étude d'impact sur le réglement sur la réduction de la pollution d'origine agricole.
MEFQ. 1998. Document technique sur la norme sur le phosphore.
Murphy, J. and J.P. Riley. 1962. Anal. Chem. Acta 27:31-36.
Rowland, A. P. and P.M. Haygarth. 1997. J. Environ. Qual. 26:410-415.
Sharpley, A.N. et al. 2000. J. Environ. Qual. (In press)
Simard, R.R. et al. 1995. J. Environ Qual. 24:1010-1017.
Sims, J.T. et al. 2000. J. Environ. Qual. (In press)
Tran T.S. and R.R. Simard. 1993. Chapter 6 in M.R. Carter ed. Method of Soil Analysis. Lewis Publish.
Tran, T.S. et al. 1996. Agrosol 9(1):21-30.

Deep plowing: a possible solution for meadows amended with Liquid Hog Manure?

R. R. Simard[1], M. A. Bolinder[1], S. Beauchemin[1] and D. Coté[2]
[1]Agriculture and Agri-Food Canada, SCRC, Sainte-Foy, Qc and [2]IRDA, Sainte-Foy, Qc
simardr@em.agr.ca

Long-term application of liquid hog manure (LHM) on meadows often leads to an accumulation of soil P (Simard et al. 1995) and to a potential increase in the risk of P transfer to surface waters. Permanent grasslands, because of the absence of tillage which results in the development of preferential transport pathways through old root channels and earthworm burrows, may be vulnerable to transfer large amounts of P through subsurface pathways (Haygarth et al. 1998). This P transfer, even at low concentration, may cause eutrophication and deleterious effects on surface water quality (Sharpley et al. 2000).



The amount of manure that can be potentially applied on agricultural land is regulated in the province of Québec according to the soil Mehlich-3 P (M3P) content in the 0-18 cm layer (Gouvernement of Quebec 1997). Many studies have linked the soil P load or concentration of P in surface runoff to the top-layer (0-5 cm) P content (Pote et al. 1999). The drainage P concentration has also been related to the water-soluble P content of this layer (Beauchemin et al. 1997). Management methods to reduce the size of the soil P store are embodied in most of the nutrient management plans in North America (Beegle et al. 2000).

The M3P content of meadow soils is often high only near the surface because of the absence of inversion of the soil layers and of the limited mobility of P (Simard et al. 2000). Deeper soil layers have often a larger P sorption capacity because of their comparable sorption capacity (content in Al and Fe amorphous compounds) but relatively small P store. Plowing deeply, to "bury" the large P store accumulated near the surface may appear a potential solution for meadows subjected to long-term inputs of LHM. Since the relationships between surface P transfer and drainage P concentration have been related to soil-test P (STP) (Pote et al. 1999, Beauchemin et al. 1997), decreasing surface STP may decrease the risk of P transfer. The objective of this study is to document the influence of moldboard plowing on the soil P store and P saturation degree of a meadow that had received long-term inputs of LHM.

MATERIALS AND METHODS

This study is conducted at the IRDA (formerly MAPAQ soils unit) experimental farm at St-Lambert de Lévis, Québec, Canada. The soil is a Le Bras silt loam (Humic Gleysol). The experiment was initiated in 1978 and consists of three rates of LHM (0, 50 and 100 m3 year-1) applied to a grass meadow for 18 years on large plots (10 x 65 m) laid out side by side. Half of the plots were kept under meadow whereas the other half were plowed under and re-seeded every five years.

Each treatment was divided into four large blocks to provide within plot replication. Composite soil samples were collected (1998/1999) prior to plowing on September 17, 1998 and in May 19 of 1999 with a Giddings probe mounted on a tractor. The soil cores were divided into 0-2.5, 2.5-7.5, 7.5-15, 15-30, 30-50 and 50-70 soil layers. The samples were extracted with the Mehlich 3 solution (Tran and Simard 1993) to estimate the amount of bioavailable P (M3P). The P saturation degree was calculated from the ratio of the contents of P/Al extracted by this solution. Bulk density measurements were taken from each layer to convert the analysis to a per ha basis. The yield data and the plant and manure P contents were used to calculate the P balance for each plot. The plots are equipped with lysimeters and with surface runoff collectors but the results of this monitoring will not be discussed in the present communication.

RESULTS

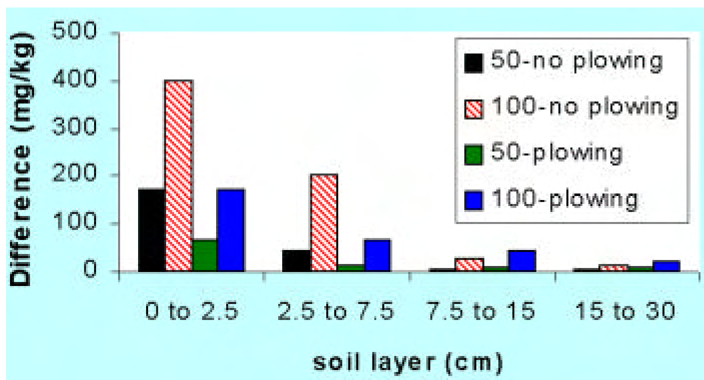
The long-term impact of LHM addition on Mehlich-3 P. The long-term addition of LHM to the meadow in absence of tillage has resulted in a large accumulation of M3P near the surface (Table 1). The P fertility of the unamended soil is very low. The addition of LHM has been beneficial to the P availability of this soil. The difference in M3P content between the amended and unamended treatments is not significant in the 30-70 cm layer suggesting limited downward mobility. The amount of M3P of the LHM-50 treatment in the 0-2.5 cm layers would be rated as excessive according to the local soil-test classification (CPVQ 1996). However its M3P content is not very different from that of the control in the 7.5-15 cm layer.

Table 1. Mehlich-3 P content (mg/kg) of a Le Bras soil profile as influenced by 18 years of LHM applications and an absence of tillage.

Rate (m^3 ha^{-1})	0-2.5 cm	2.5-7.5 cm	7.5-15 cm	15-30 cm	30-50 cm	50-70 cm
0	6 ± 2	3 ± 1	4 ± 1	7 ± 4	16 ± 1	6 ± 3
50	176 ± 56	48 ± 21	10 ± 5	10 ± 5	19 ± 8	7 ± 3
100	403 ± 89	203 ± 105	30 ± 26	19 ± 18	20 ± 8	9 ± 8

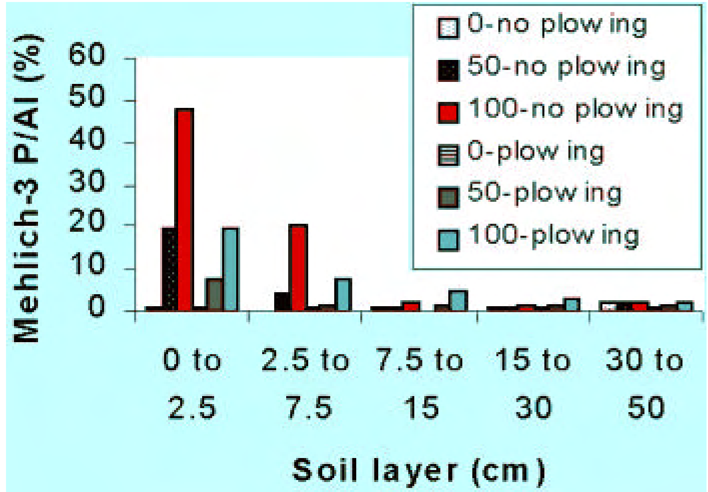
Plowing impacts on Mehlich-3 P. The plowing had no influence on the M3P content of the non-amended plots. The difference in M3P content of 0-2.5 and 2.5-7.5 cm layers of the LHM amended plots compared to that of the control was reduced by more than 50 % by plowing (Figure 1). Plowing slightly increased the M3P content of the 7.5 to 30 cm layers of the 100 Mg LHM plots and tended to increase the content of the 30-50 cm layer (data not shown).

Figure 1. Difference in Mehlich-3 P content between amended and non-amended plots as influenced by plowing.



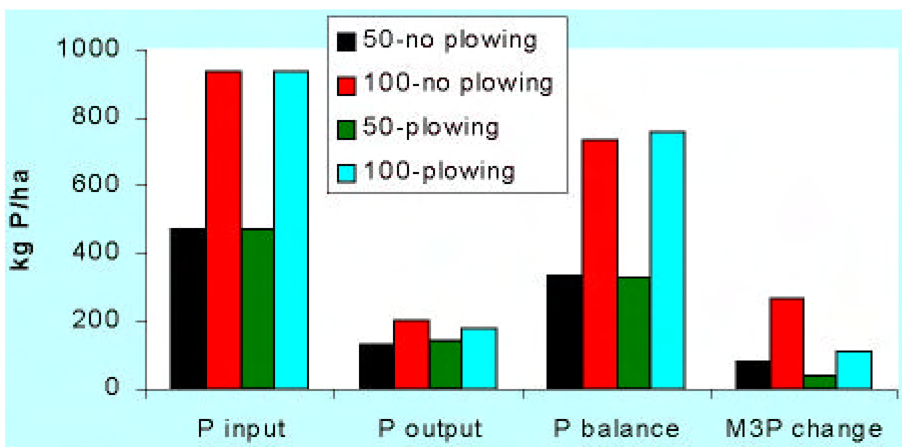
The impact of manure additions and plowing on the soil P saturation degree. The degree of P saturation of the 0-7.5 cm layer was greatly increased by manure additions in both unplowed and plowed plots. The P/Al index was significantly smaller for the plowed treatments than in the unplowed plots (Figure 2). The values associated with the 100 m^3 treatment exceeded the 20 % limit proposed by Giroux et al. (1996) as indicative of excessive soil P availability which may increase the risk of contamination of surface waters. The P saturation degree of the soils below 7.5 cm of the surface was much less and slightly higher for the 100 m^3 LHM plots that were inverted every 5 years than for the unplowed ones.

Figure 2. Mehlich-3 saturation degree (M3P/M3Al, %) of a meadow as affected by HLM rates and plowing.



Amounts of P needed per unit of increase in soil-test P. The nutrient management plans in Québec requires that the evolution in M3P content be predicted so that the farm would comply with the existing regulations (MEFQ 1999). The data on P inputs (LHM) and outputs (harvested hay, P balance (inputs-outputs) and difference in Mehlich-3 P content of the 0-15 cm layer are given in Figure 3. In the 50 m3 LHM- unplowed plots, 4.1 kg total P added were necessary to increase the soil M3P content between 1981 and 1997 by 1 kg/ha whereas only 2.8 kg were necessary for the 100 m3 ones. The corresponding values for the plowed plots are 8.8 and 7.0 kg P/unit change in M3P. The actual guidelines for Québec assumes a single value of 3.5 kg for all soils (MEFQ 1999) regardless of management practices (e.g , no distinction is made between mineral or organic fertilizer and/or tillage frequency).

Figure 3. Total P inputs (HLM) and outputs (harvested hay) and total change in M3P (kg/ha) in the 0-15 cm layer between1981 and 1997.



DISCUSSION

In absence of plowing, the addition of LHM at a moderate (50 m 3 ha $^{-1}$ yr^{-1}) or at a very large rate (100 m3 ha $^{-1}$ yr^{-1}) has increased, to excessive levels, the STP and the degree of P saturation of the soil layers immediately in contact with rainfall. If this soil is vulnerable to surface runoff or to subsurface drainage, there is a high risk of P contamination of surface waters (Simard et al. 2000). The plowing has decreased tremendously these two indices of the soil P status. The amount of LHM- P needed to increase the STP by 1 kg is much higher when meadows are inverted every five years. The data also indicated that the 3.5 kg P/ unit of M3P increase proposed in the present guidelines (MEFQ 1999) may not be appropriate for the studied soil. In that regard plowing meadows will definitively help to reduce the risk of P transfer to surface waters. The P added has not disappeared, some of it was included in soil in forms that cannot be extracted by the Mehlich 3 solution (data not shown). Little of the difference was related to the P exports which were relatively comparable between plowed and unplowed plots.

However, on sloping land, plowing may result in significant erosion during the period when soils are bare. Alternating plowed and unplowed bands in the direction perpendicular to the slope could certainly help to reduce the P load delivered to surface waters since the eroded soil particles may be intercepted by the bands that would be kept in grass. Going to a shorter rotation cycle would also help since the buildup of STP near the surface that would undoubtly occur if plots receive manure on the surface for five years would be limited. Meadows are important potential manure-receiving crops in areas of intensive hog production. It is important to identify best management practices that limit the transfer of P from meadow soils to surface waters. This study shows that tillage frequency (in this case plowing) should definively be considered.

ACKNOWLEDGEMENTS

We wish to thank "La Fédération Québécoise des Producteurs de Porcs" for their financial support in this study.

REFERENCES

Beauchemin, S. et al. 1997. Trans. ASAE 97-2016 pp 61-64.
Beegle, D.G. et al. 2000. J. Environ. Qual. (In press)
CPVQ. 1996. Grilles de référence en fertilisation.2nd ed. AGDEX 540.
Giroux, M. et al. 1996. Agrosol 9 (1) 36-45.
Gouvernement du Québec. 1997. Loi sur la réduction de la pollution d’origine agricole. Gazette officielle 129:2607-2632.
Haygarth, P.M. et al. 1998. Europ. J. Soil Sci. 49:65-72.
MEFQ. 1999. Guide Agroenvironnemental de Fertilisation. EN9901175, Québec, Qc. 28pp.
Pote , D.H. et al. 1999. Soil Sci. Soc. Am. J. 63:1006-1012.
Sharpley, A.N. et al. 2000. J. Environ. Qual. (In press)
Simard, R.R. et al. 1995. J. Environ Qual. 24:1010-1017.
Simard R.R. et al. 2000. J. Environ. Qual. (In press)
Tran T.S. and R.R. Simard. 1993. Chapter 6 in M.R. Carter ed. Method of Soil Analysis. Lewis Publish.

Best Management Practices for application of Swine Manure to Forage Crops in the Eastern Prairies

Byron Irvine, Katherine Buckley, Robert Eilers
Brandon Research Centre (Manitoba), AAFC, Brandon, MB

PROFILE:

Goal: To develop a forage based swine manure management system with will lower the application costs of liquid manure by increasing nutrient uptake per unit area and thus reducing the hauling distance.

Objectives:

1. To determine the value of adding nitrification inhibitors to manure as a means to conserve nitrogen and enhance yields of perennial grasses harvested for hay.
2. To determine the impact of split applications and application timing on forage crop yields and nitrogen use efficiency.
3. To enhance the information base used to develop provincial guidelines and recommendations for manure application on diverse prairie soils.

REACH

The primary target of this research are hog and cattle producers in Manitoba and Eastern Saskatchewan. The information will be used to refine manure application recommendations to perennial forage crops. High yields of high quality forage will reduce the cost of manure application and provide cattle producers with a consistent supply of low cost feed which will fuel increased economic activity in the cattle industry. While cattle feeding also concentrates nutrients, the solid manure handling system used in most of the prairies allows cattle manure to be moved up to 5 times further than swine manure.

Custom manure applicators will find this information useful in determining application rates to ensure optimal yields of crops while limiting the potential for nitrogen buildup. The demonstration of the effectiveness of below canopy application of manure to forage stands provides operators with a low odour, nutrient efficient manure management system. Provincial government departments which are charged with the task of ensuring the environmental sustainability of the industry will use this information, along with other data, to refine guidelines for application rates and to produce information packages for the producers. Data will be made available to directly to the larger hog producing companies, including Maple Leaf, for direct implementation by barns with whom they have contracts. This data will be used to ground truth the GIS map of soil capability developed by Eilers et al.

RESULTS

Manure applicator construction and use

A liquid manure applicator constructed for this project uses a variable rate pump and a load cell to accurately determine the mass of manure applied to a given area. This unit was equipped with a coulter system which was used to "inject" liquid hog manure into forage grass stands at varying times on a variety of soil types across the eastern Prairies. The coulters penetrate to a depth of 12-14 cm and open a slot approximately 2 cm wide. This slot is not wide enough to contain the high rates of manure which must be applied to obtain 200 kg/ha N when the nitrogen concentration of some manures is less than 10 ppm. The result of these high application rates are that some manure was discharged on the surface. The coulters left the soil surface relatively smooth and caused limited crop damage. Crop damage was due mainly to the wheels of the tractor and application and ranged from no visual damage to over a 50% reduction in growth depending on soil moisture, soil type and crop growth stage.

This unit is being used in trials by Manitoba Agriculture, Manitoba Zero Tillage Research Association and AAFC manure researchers in Brandon.

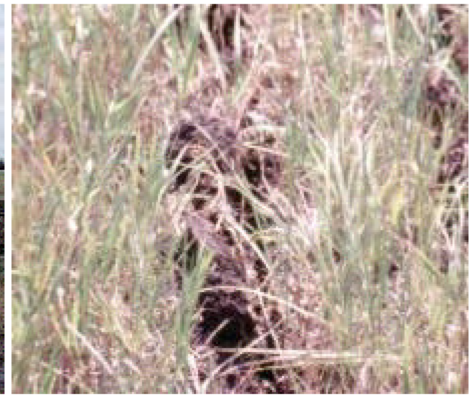
 

Figure 1. Manure application equipment **Degree of soil disturbance.**

Swine manure application to perennial forages

Fall 1998

There was little benefit to the addition of the nitrification inhibitor to hog manure applied to an orchard grass stand in late September of 1998 (Table 1). Soil nitrate levels were 40 kg/ha prior to application. Ammonium levels 4 weeks after application where not increased relative to the untreated plots and the nitrate levels were in the soil were similar. There was rapid transformation of ammonium to nitrate and that this nitrification inhibitor was not effective when used with this form of "injection" to grass. Grass yield were not increased beyond the 50 kg/ha and were not enhanced by the use of the nitrification inhibitor.

Table 1. Yield and nitrogen uptake from fall applied manure on Pelan fine sandy loam

	Nitrate (0-60 cm) 28 DPA	Cut 1		Cut 2	
		Forage yield (kg/ha)	Nitrogen uptake(kg/ha)	Forage yield (kg/ha)	Nitrogen uptake(kg/ha)
Control	51	2403	44.4	1174	24
50N		3933	69.6	1232	31.2
50N & Inhibitor[1]		3429	62.4	1462	32.4
100N		3628	70.2	1407	38.8
100N & Inhibitor		3189	62.4	1079	22
200N	116	3504	74.2	1356	30
200N & Inhibitor	130	3428	89	1634	44
Root MSE		541	15	509	16.6

[1] Nserve (nitrification inhibitor)
Pre-application (Sept 27) Nitrate levels in the top 60 cm were 40 kg/ha

Spring and summer 1999

Application of manure in the spring was delayed at all sites due to very wet weather (200 mm in May) and was responsible for lower than expected forage yields since the crop was nitrogen deficient during a period when growth potential is high. The exception to this was the Oxbow clay loam soil had a history of swine manure application and although soil nitrate levels were only 30 kg/ha had high first cut yields. (Tables 2-5) Crop yields on the lighter textured soils were low and nitrogen removal was just slightly over 100 kg/ha. In contrast nitrogen removal from the heavy texture soils as approximately 200 kg/ha. On sites where significant yield differences were identified nitrification inhibitors did not improve crop yields. There will potentially toxic levels of nitrates accumulating in the forage of the bromegrass on the Oxbow clay loam soil.

Table 2. Forage yield and nitrogen removal of bromegrass on a Stockton loamy sand 1999

Spring		Post Cut 1		Cut 1		Cut 2	
N (kg/ha)	Inhibitor	N (kg/ha)	Inhibitor	Forage (kg/ha)	N uptake (kg/ha)	Forage (kg/ha)	N uptake (kg/ha)
0	-	0	-	1586	30	849	21.5
0	-	200	-	1838	34	1412	51.5
100	-	0	-	2153	53	1277	32
100	-	100	-	1830	51	1375	45.3
100	+	0	-	1931	53	1472	36.8
100	+	100	+	1980	56	1543	53.5
150	-	0	-	2027	53	1310	35
150	-	150	-	2003	51	1599	54.5
150	+	0	-	2037	57	1324	32
150	+	150	+	2036	53	1317	48.3
200	-	0	-	2089	61	1350	38
50	-	0	-	1857	44	1307	29.8
50	-	50	-	1572	37	1023	29
50	+	0		1858	46	1430	37.3
50	+	50	+	1998	53	1072	35
Root MSE				NS	9.9	NS	9.3

Inhibitor was Conserv-N soil (dicyandiamide)

Table 3. Forage yield and nitrogen removal of orchard grass on a Pelan fine sandy loam 1999							
Spring		**Post Cut 1**		**Cut 1**		**Cut 2**	
N (kg/ha)	Inhibitor	N (kg/ha)	Inhibitor	Forage (kg/ha)	N uptake (kg/ha)	Forage (kg/ha)	N uptake (kg/ha)
0	-	0	-	1398	29.5	1394	25.3
0	-	200	-	1119	37.7	1538	30
100	-	0	-	1585	37	1544	31.5
100	-	100	-	1275	35.9	1599	38.8
100	+	0	-	1476	37.6	1344	28.8
100	+	100	+	1358	37.7	1505	34.3
150	-	0	-	1465	40.5	1610	33.8
150	-	150	-	1401	45.7	1445	31
150	+	0	-	1473	38.4	1679	36.8
150	+	150	+	1266	37.8	1620	46.5
200	-	0	-	1521	40.1	1614	38.5
50	-	0	-	1315	34.4	1570	34.3
50	-	50	-	1392	39.5	1471	32.8
50	+	0		1474	36	1392	29.8
50	+	50	+	1452	38.5	1456	31
Root MSE				NS	NS	NS	NS
Inhibitor was Conserv-N soil (dicyandiamide)							

Table 4. Forage yield and nitrogen removal on an imperfectly drain Pipestone clay							
Spring		**Post Cut 1**		**Cut 1**		**Cut 2**	
N (kg/ha)	Inhibitor	N (kg/ha)	Inhibitor	Forage (kg/ha)	N uptake (kg/ha)	Forage (kg/ha)	N uptake (kg/ha)
0	-	0	-	1886	24.5	404	
0	-	200	-	1699	22.5	4632	
100	-	0	-	3672	80.5	1003	
100	-	100	-	2813	60.5	4587	
100	+	0	-	3487	72	1328	
100	+	100	+	3263	63.5	4578	
150	-	0	-	3241	68.5	1141	
150	-	150	-	3622	83	7158	
150	+	0	-	3435	67	1210	
150	+	150	+	3201	75.5	6276	
200	-	0	-	3321	74	1395	
50	-	0	-	3756	65.5	801	
50	-	50	-	3117	60	2723	
50	+	0		3161	57.5	663	
50	+	50	+	4409	79.5	1346	
Root MSE				NS	15.5	541	not availble yet
Inhibitor was Conserv-N soil (dicyandiamide)							

Table 5. Forage yield and nitrogen removal of bromegrass on an Oxbow Clay loam

Spring		Post Cut 1		Cut 1		Cut 2	
N (kg/ha)	Inhibitor	N (kg/ha)	Inhibitor	Forage (kg/ha)	N uptake (kg/ha)	Forage (kg/ha)	N uptake (kg/ha)
0	-	0	-	4215	114.7	3081	85.8
0	-	200	-	4064	112.5	4098	146
100	-	0	-	3745	120.3	3800	86.8
100	-	100	-	3764	120.6	3432	111.8
100	+	0	-			3849	109.3
100	+	100	+			3631	127.3
150	-	0	-	4288	141.3	4138	108.3
150	-	150	-	4194	138.6	3550	117
150	+	0	-			4056	102.5
150	+	150	+			4114	132.7
200	-	0	-	3638	120.8	4012	104.8
50	-	0	-	4287	124.8	3212	79
50	-	50	-	3717	109.3	3480	96.5
50	+	0				3544	93.3
50	+	50	+			3081	97.5
Root MSE				NS	NS	NS	NS

Table 6. Forage yield, nitrogen removal and feed quality of annual forages							
Crop	**Cultivar**	**Brandon**			**Canora**		
		Yield (kg/ha)	Nitrogen uptake (kg/ha)	Relative Feed Value	Yield (kg/ha)	Nitrogen uptake (kg/ha)	Relative Feed Value
Barley	AC Hawkeye	8731	132	86	7188	129	95
Corn	Amazinggraze	10989	147	98	7805	160	93
Corn	Canamaize	11823	169	140	5425	100	113
Corn	Hyland	16811	209	128	10326	165	101
Sorghum sudan	Honeybee	12393	168	86	2043	41	94
Foxtail Millet	Golden German	8354	153	79	3862	88	90
Fababean	Aladin	6805	202	139	5767	131	180
Soybean	Donegal	6862	118	121	2553	54	137
Kale	Premiere	4313	158	365	2478	75	387
Root MSE		1548	28.5	14.7	962	27.7	14.6
Brandon is significantly warmer than Canora							

Annual Forage Crops

The Hyland corn hybrid produced the highest yields are removed the most nitrogen. Nitrogen uptake by corn appears to equal that of forage grasses Nitrogen removal of barley was 130 kg/ha at both sites. Fababean was also high nitrogen removal crop but the performance of the other crops was inferior to the traditional cereal grain crops.

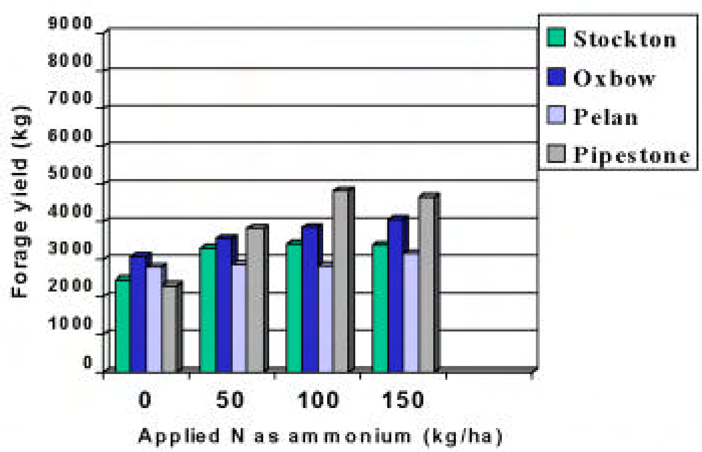


Fig 3. Total forage yield from 2 cuts of bromegrass on the Stockton (loamy sand), Pipestone (clay) soils and from orchard grass on Pelan (sandy loam) soil. Only the second cut was obtained for the Oxbow (clay loam). N-serve was added to manure at a rate of 70 mL per 1000 kg.

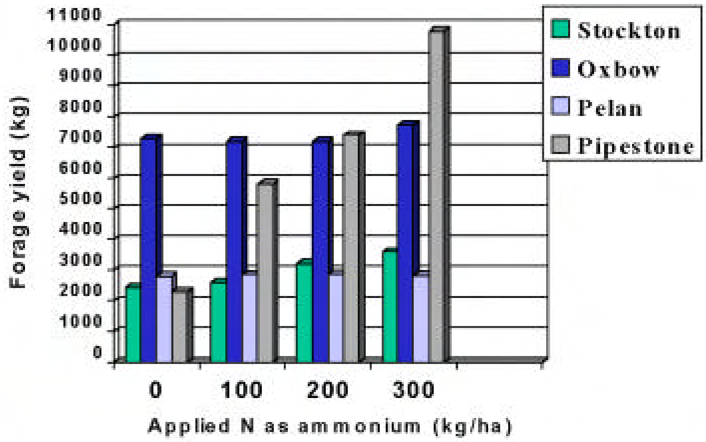


Fig. 4. Total forage yield from 2 cuts of bromegrass on the Stockton (loamy sand), Oxbow (clay loam) and Pipestone (clay) soils; orchard grass on Pelan (fine sandy loam) soil when manure was applied in a split application (50% in spring and 50% in summer).

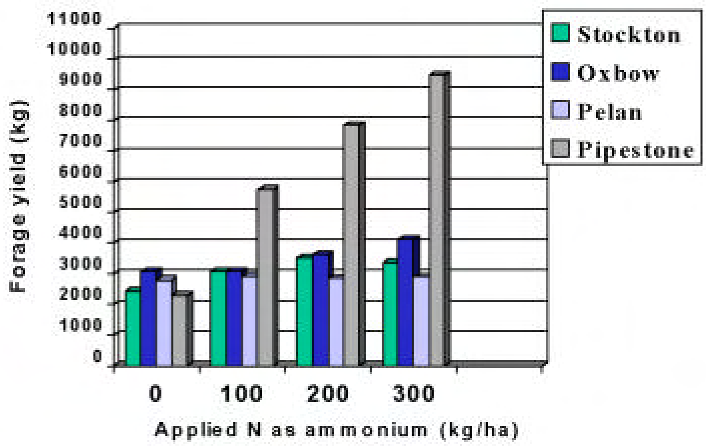


Fig. 5. Total forage yield from 2 cuts of bromegrass on the Stockton (loamy sand), Pipestone (clay) soils and orchard grass on Pelan (fine sandy loam) soil when manure was applied in a split application (50% in spring and 50% in summer). Only the second cut was obtained for the Oxbow (clay loam). N-serve was added to manure at a rate of 70 mL per 1000 kg.

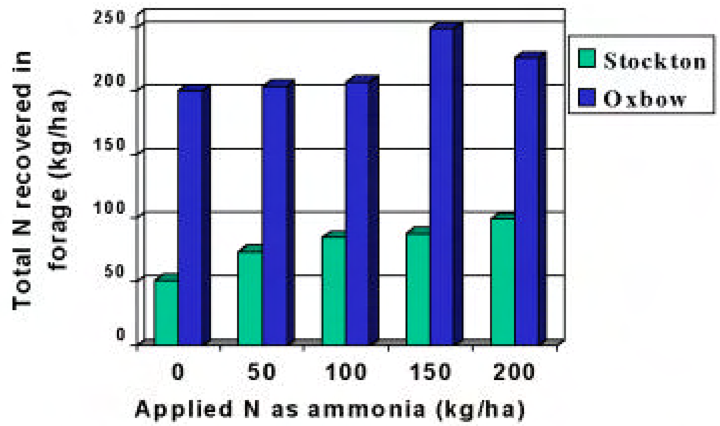


Fig. 6. Total nitrogen recovered in forage harvested from plots on Stockton (loamy sand) and Oxbow (clay loam) soils after a single spring application of manure.

INFLUENCING FACTORS

Soils in the research area were extremely wet during the month of May and June delaying application of manure to sites and causing one site of annual forages to be abandoned. The high moisture levels should have increased the effectiveness of the nitrification inhibitors (the impact was still small). The high soil moisture contents made soil sampling in the spring impossible and caused greater damage to perennial grass stands by the wheels of the application equipment. High soil moisture levels reduced the infiltration rate of manure after application using a coulter based system. The wet spring delayed seeding of annual forage crops which may have resulted in the under estimation of yields. Cooler than average temperatures limited the growth of warm season crop species such as corn, sorghum and soybeans. The manure used in these trials represents the type of manure from a secondary lagoon and was high in ammonium and low in solids.

DISCUSSION AND CONCLUSIONS

The lack of response of nitrification inhibitors is disappointing and may be due in part to this coulter application system with often leaves manure on the soil surface. While this manure infiltrated quickly under moderate soil moisture conditions ammonia loss is possible due to incomplete soil sealing. All of the forage sites where mature grass stands in good condition and represent a reasonable response to nutrient application. The low yields and low nitrogen removal from the light texture soils were predictable and indicate that even with grass production, nutrient application rates should be carefully managed. Manure application can be done at any time in the year when the grass is not likely to be physically damaged by wheel traffic (<12 cm). However, our data does not provide adequate information on yield impacts of mid season applications on the following season’s crop. The potential for high nitrate accumulation in forage grasses was demonstrated at one site. While nitrate tests may be useful in determining the potential for ground water contamination, they do not appear to predict grass response on fields with a history of manure application. This has been demonstrated in other research and is a real research gap which could be addressed through mineralization type tests.

Corn used the most nitrogen of any of the annual forage crops and combined with its high feed value is an excellent choice for removal nutrients on highly productive clay and clay loam soils or lighter textured soils where moisture is high. High seed costs limit the use of corn and fababean to highly productive sites. Another disadvantage of corn, fababean, forage soybean and kale is that they are full season crops which must be planted early to ensure high yields. Early planting means that all manure must be applied in the fall when the potential for nitrous oxide emissions is the greatest Crops such a forage rapeseed, pearl millet and small seeded legumes must be evaluated to improve the economics of annual forage crops in nutrient usage.

Strategy for assessing suitability of soils for application of hog manure.

R.G. Eilers (RB) and K.W. Thompson (PFRA)

Participants: K.E. Buckley (RB); W.R. Fraser (LRU - MB), W. Eilers (LRU - SK), A. Brierley (LRU - AB); R. Woodvine, B. Jones, B. Harron, L. Lenton (PRFA - Regina); D. Kiely (PFRA - Edmonton); K. Bolton (SAF), B MacMillan (AAFRD), K. McGill (MDA); H. Wagner (Producer - CPC rep.); J.D. Hughes (NRCan)

PROFILE

Goals/Purpose: Development of a Decision-Support Methodology

Description:

Brandon Research Centre's Land Resource Unit has partnered with the Prairie Farm Rehabilitation Administration (PFRA) and the Land Resource Units in Saskatchewan and Alberta, to develop a standard methodology for assessing the suitability of soils in the prairie landscape for the application of hog manure. The methodology utilizes and integrates available expertise and existing resource databases to define soils in terms of unique management groups. Physical, chemical, and environmental information on soils, land use, and climate is integrated with other information on geology and hydro-geology. This information is then used to derive a groundwater factor, a surface water factor and a soil nitrogen factor, which are combined in a matrix to determine uniquely different Soil Management Groups (SMG). Specific management considerations are then developed for each of the SMG's with a view to sustaining or improving soil productivity and at the same time, minimizing any potential for adverse impact to the environment. This methodology will provide information to assist provincial specialists and other client groups and planners in identifying suitable areas for livestock expansion and in developing recommendations for rates of swine manure application to various soil landscapes.

This project will deliver a standardized methodology for broad scale evaluation of soils for application of hog manure, a standardized digital data base for soils and geology, and an example generalized map showing the distribution of the various Soil Management Groups. The methodology is being developed and tested for each of three pilot study areas, the Red Deer area in Alberta, the Shaunavon Area in Saskatchewan, and the South Norfolk area in Manitoba. Resource information, soils and geology, will be standardized for each test area at a scale of 1:100,000. The development of the respective management considerations for each SMG is being carried out in collaboration with provincial specialists.

RESULTS

This project will facilitate systematic land suitability assessment at broad scale for large area planning on the prairies. A standardized methodology will facilitate decision making by utilizing available information, concepts and data bases to assist in the orderly development of sustainable agricultural practices related to the hog industry. It will NOT replace site specific evaluations for individual project proposals, but will provide a basic background for planners and developers to work with.

Long Term:

Initially the project is being developed using three pilot study areas. It is anticipated that the end result will be widely promoted to provincial departments of agriculture and natural resources, and depending on the feed back, it is anticipated that there maybe considerable opportunity to expand the process to many other areas of the prairies as needed or required.

INFLUENCING FACTORS

One of the significant influencing factors of this project is the multi-disciplined team approach to method development. It involves RB researchers, provincial soil specialists, engineers, hydrologists, and private sector participants (manure applicators). It will integrate the information based on input of expertise and data from all sectors.

Composition variation in stored swine manure slurry

N. K. Patni, S. Bittman and T. Kannangara
Pacific Agri-Food Research Centre
P.O. Box 1000, 6947 Highway # 7, Agassiz, BC, V0M 1A0
Tel. 604-796-2221, X 220; Fax 604-796-0359

PROFILE

Project Description including purpose and goals:

The most desirable utilization of hog manure is in a land recycling system for feed crop production. The major benefit that occurs is from the supply of crop nutrients by the manure. This increases production efficiency by reducing the need for chemical fertilizers, while at the same time benefits soil quality in terms of improved soil tilth and water-holding capacity, and reduced erosion potential. Indirect benefits also accrue due to conservation of energy required for chemical fertilizer production and reduction in associated greenhouse gas release.

The major constraint in utilization of manure for crop production is the inability to determine the nutrient content of manure in a reasonably short period of time to fit into farmers' time-limiting requirements. Laboratory determination of manure nutrient content often takes too long for practical use as it generally requires initial mixing of slurry in the storage facility, sample collection and shipment to the laboratory, transmission of laboratory results back to the farm, and mixing again prior to land application for uniform application on land at a controlled rate and within crop management time constraints.

The purpose of this study is:

1. To characterize the physical and chemical composition changes in stored swine manure slurry and its liquid fraction, and
2. To determine if these changes can be related to one or more properties which can be relatively rapidly determined, in order to quickly estimate the manure nutrient content with reasonable accuracy.

REACH

The results from this study will be of benefit to hog producers who want to optimize the use of manure slurry for feed crop production by using quick tests to estimate the nutrient content of the slurry with reasonable accuracy. During the last few years there has been a trend towards larger-size production operations at fewer sites. These large operations tend to buy feed rather than produce it. This creates a need to find 'markets' or sites willing to accept large quantities of manure for land application. This is sometimes done with the assistance of custom haulers and farm consultants, who then have to know the product quality in terms of manure composition. The results from this study would therefore also be useful for this latter group who could do the quick tests and make recommendations to the slurry user, and also get a good return for the manure producer. The above would, of course, be feasible only if a reasonably good correlation is found between one or more quick test values and the actual composition of manure. The information on nutrient composition changes with time and space within slurry storage tanks will be useful for estimating the nutrient content of slurry in different depth sections of storage tanks when slurry needs to be removed from storages without prior mixing. Information will also become available on the partitioning of the nutrients between the liquid and solid fractions as mineralization occurs in the stored slurry. The results would be applicable for slurry stored under cool climatic conditions.

Quick-test Determinations Used	Laboratory Composition Determinations in Raw Slurry and its Liquid Fraction
Temperature Specific gravity Electrical conductivity pH Oxidation-reduction potential Ammonia-nitrogen content using the Swedish Agros or Nova nitrogen meter Dry matter % by volume, using a centrifuge to separate the liquid and solid fractions	Dry matter by drying in an oven Ash by burning in a furnace Volatile matter (from ash) Total nitrogen Ammonia nitrogen Total phosphorus Total potassium

STUDY PROCEDURE

- Three concrete tanks (9 ft x 7.3 ft x 9 ft deep each) were filled to a depth of 8 ft with well-mixed 'fresh' slurry from a growing-finishing hog barn.
- The slurry in each tank is sampled at two locations and three depths at about monthly intervals using a custom-built sampler.
- Slurry characteristics (listed below) are determined using both quick tests at the time of sampling and time-consuming laboratory tests later. A centrifuged supernatant is also analyzed in the laboratory.
- Release of nitrous oxide greenhouse gas is determined about weekly in each tank.

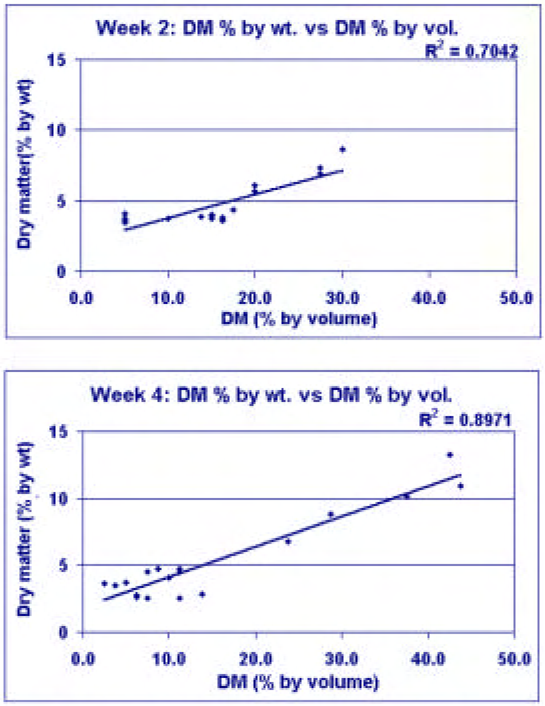
RESULTS

Three replicate concrete manure storage tanks (9' x 7.3' x 9' deep) were filled to 8' depth with pre-mixed slurry from a single source which was a grower-finisher barn. The slurry in each tank is periodically sampled at two locations at three depths. A specially-built sampler, which does not cause disturbance in the slurry during sampling, is used. The open-top tanks are located in a roofed area to prevent the confounding effect of precipitation entering the storage tanks.

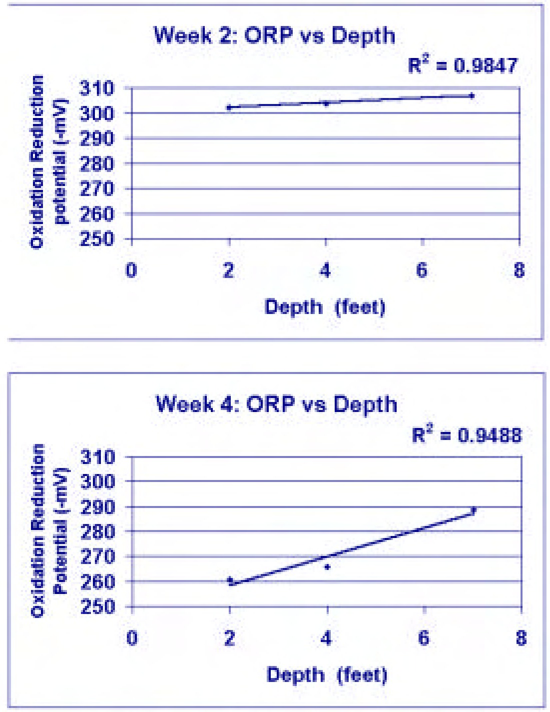
Quick tests on the slurry include determinations of temperature, specific gravity, pH, electrical conductivity, oxidation-reduction potential, ammonia nitrogen using the "Argos"nitrogen meter, and volume per cent solids using a centrifuge. The commercially available nitrogen meter works on the principle of pressure increase in an enclosed container due to release of ammonia in the slurry when its pH is increased by alkali addition.

Composition determinations in the laboratory include dry matter, ash, total and ammonia nitrogen, total phosphorus, and potassium on both the raw slurry and its centrifuged supernatant. The extent of nitrous oxide greenhouse gas release from the stored slurry is also being determined to obtain quantitative estimates. It is has been reported that stored swine manure is contributing to greenhouse gas emissions.

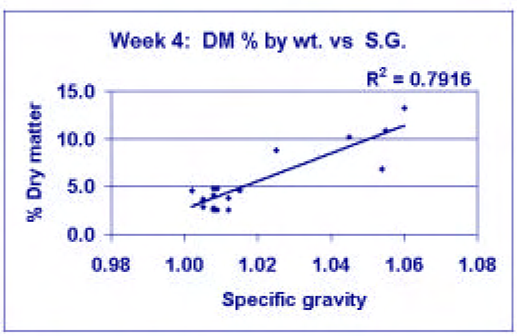
To simulate the regional farm situation which typically requires that slurry should be stored rather than spread on land from November to January (or later), the tanks for this study were filled on November 2 with recently collected (about one week collection) slurry from a grower-finisher barn. At this time (December 1999), data are being collected for the study and it is planned to leave the slurry in storage for data collection until February/March 2000. Results on correlations between quick tests and manure composition values will be reported when data become available.



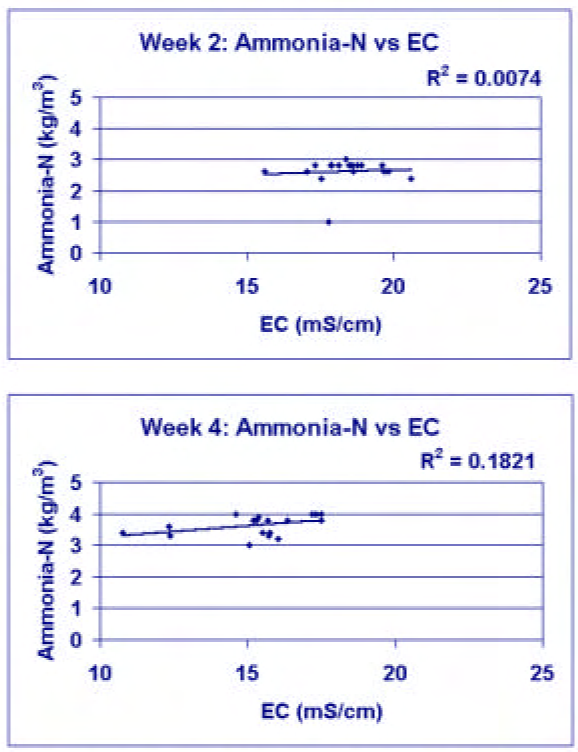
Variation of slurry dry matter by weight with dry matter by volume after 2 and 4 weeks of storage



Slurry oxidation-reduction potential variation with depth after 2 and 4 weeks of storage



Slurry dry matter variation with specific gravity after 4 week storage



Slurry ammonia - nitrogen variation with electrical conductivity after 2 and 4 weeks of storage

DISCUSSION / CONCLUSIONS

The manure slurry being used for this study is from grower-finisher hogs, which is the largest source of slurry in hog production. Farm storage conditions are being closely followed under controlled conditions. This study is using a batch filling system for slurry whereas in many farm situations manure is periodically added to previously stored slurry. Also, precipitation may not always be diverted away from the stored slurry. We have purposely avoided these latter situations in our study to eliminate the confounding effect of periodic addition of variable nutrient amounts to stored slurry. The intent is to first study and understand composition changes that occur in batch filled storages before attempting to understand more complicated situations. It is anticipated that the results from this study will help improve manure utilization and production efficiency.

Initial results from this study indicate:

- a good relationship between: slurry dry matter by weight and dry matter (solids) by volume; slurry oxidation-reduction potential and depth of slurry in the storage tank; and slurry dry matter by weight and slurry specific gravity
- a poor relationship of slurry ammonia nitrogen content and slurry electrical conductivity
- insignificant emission of nitrous oxide gas

Additional results will be used to confirm the above relationships and derive additional ones.

Improving Crop Health With Swine Manure

G. Lazarovits, K. Conn, M. Tenuta, and E. Topp
AAFC, Southern Crop Protection & Food Res. Centre,
1391 Sandford St., London, Ont., N5V 4T3. Tel 519-663-3099, Lazarovitsg@em.agr.ca
Research partners: Ontario Pork, Canadapt, Ontario Potato Mkt Brd, AAFC MII, and Nuhn Industries

We have shown in previous studies that swine manure (SM) applied to two potato soils reduced soilborne diseases in the potato crop for up to three years after a single application (CJPP 21:81-92, 1999). However, reduced disease severity was found at only one of the two sites tested (site B). The reason as to why the same SM applied at a second location did not work is unknown. We are investigating the mode of action of SM for plant disease reduction and the basis for soil specific activity. A laboratory assay has been developed to determine what parameters in soil effect the efficacy of SM for reducing populations of soilborne plant pathogens. We use V. dahliae, a fungus that causes wilt, and Streptomyces scabies, a bacterium that incites potato scab, as indicator organisms. Kill of the overwintering structures of V. dahliae, microsclerotia (MS), introduced into soil or suspended in the airspace above, is measured after periods of incubation.

Results have revealed that the concentration of SM added to soil is directly related to its effectiveness for killing of MS. This provides a recommended rate for disease control, at least for soil B. We also showed that soil moisture can dilute the bioactive ingredient and thus plays a critical role in efficacy. In dry soil, at the highest concentration of SM tested, V. dahliae was eradicated within one day after application. This compares in efficacy to fumigants currently used for this purpose. One of the toxic components is a gas. We tested swine manures in several soils from various locations using soil B and a known SM as a positive control. SM killed V. dahliae in some soils and the control matched disease reductions seen in field trials. We are now developing SM to be more universally effective for disease control in all types of soils. Other parameters being tested include efficacies of various sources of SM, soil temperatures, single vs. multiple applications of SM, and the impacts of SM against other soilborne pathogens.

Three field trials with SM were carried out in 1999 at farms where high disease incidence of scab and wilt were present. One site was near Alliston and two others were in PEI. The SM was surface applied and immediately incorporated with cultivators. The health and productivity of the potato crop was followed over the season. SM reduced the severity of potato scab by 20-50 % at the two PEI sites, but had no impact on disease at the Alliston plots. These plots will be treated next spring with SM in a manner that should significantly enhance their efficacy for disease control.

PLANT DISEASE CONTROL

SUCCESSES

Potato diseases such as Verticillium wilt (Fig. 1) and common scab (Fig. 2) can be controlled for up to three years after a single application of swine manure (Figs. 3, 4).

Figure 1. Verticillium wilt of potato caused by Verticillium dahliae.

Figure 2. Common scab caused by Streptomyces scabies.

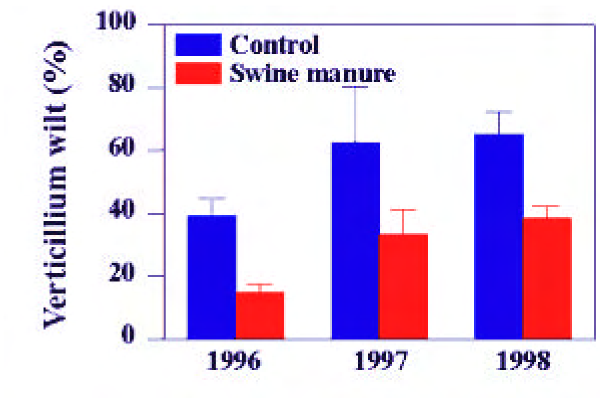


Figure 3. Reduction of Verticillium wilt in a commercial potato field for three years after a single application of swine manure (4600 gal/a). (Means ± S.E.)

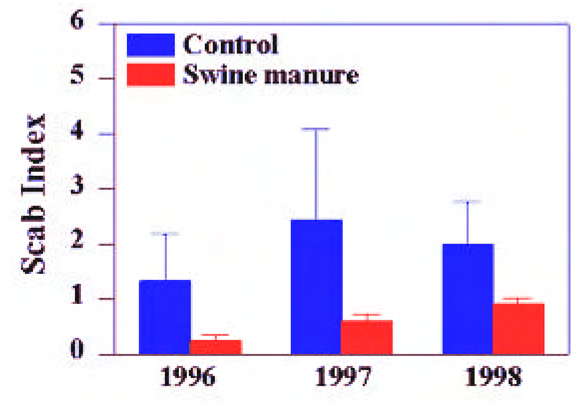


Figure 4. Reduction of common scab in a commercial potato field for three years after a single application of swine manure (4600 gal/a). Index based on % surface scab: 0 (0), 1 (trace-5), 2 (6-15), 3 (16-25), 4 (26-35), 5 (36-60), and 6 (61-100). (Means ± S.E.)

RESEARCH TARGETS

- Determine why disease control with swine manure varies depending upon:
  - Soil type
  - Manure type
  - Manure application rate
  - Climatic factors
- Determine if swine manure can control other soilborne pathogens of potatoes and other crops.
- Determine how swine manure reduces disease.

ENHANCED SOIL MICROBIOLOGY

SUCCESSES

- Swine manure can kill soilborne pathogens such as Verticillium dahliae (Fig. 5).
- It can kill plant parasitic nematodes (Fig. 6).
- It increases certain soil bacterial and fungal populations that may displace some plant pathogens.

Swine manure application rate (gal/a)

Figure 5. Killing of Verticillium dahliae microsclerotia (MS) by adding swine manure to soil from a commercial potato field. The MS were removed from the soil after one week and plated onto an artificial medium to determine if the MS were alive. Alive MS produce black colonies on the plates. Note that as more swine manure is used the fewer MS that are alive.

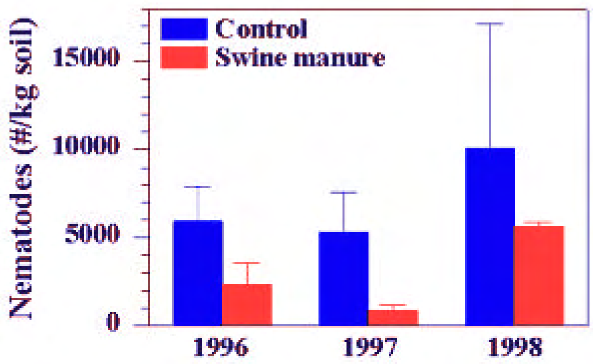


Figure 6. Reduction of plant parasitic nematodes in a commercial potato field for three years after a single application of swine manure (4600 gal/a). (Means ± S.E.)

RESEARCH TARGETS

- Determine how to screen and identify microorganisms that are important to crop health.
- Formulate swine manure by addition of beneficial microorganisms.
- Investigate if addition of swine manure creates disease suppressive soils.

EFFECTIVE MANURE MANAGEMENT

SUCCESSES

- Uniform dispersal of swine manure (Fig. 7) and immediate incorporation enhances disease control, reduces odour, and optimizes capture of nutrient energy.
- A "Manure Research Unit" built by Nuhn Industries (Fig. 8) is being used to test application technology.

Figure 7. Application of swine manure. Field was cultivated immediately after application.

Figure 8. A "Manure Research Unit" built by Nuhn Industries to test direct injection techniques for swine manure.

RESEARCH TARGETS

- Determine optimal application methods to minimize negative environmental impacts.
- Optimize the nutrient balance of swine manure to improve nutrient uptake and limit pollution.
- Test additives to reduce odours.

REFERENCES

Conn, K.L. and Lazarovits, G. 1999. Impact of animal manures on verticillium wilt, potato scab, and soil microbial populations. Can. J. Plant Pathol. 21:81-92.

Lazarovits, G. and Conn, K.L. 1997. Assessment of the influence of manures for the control of soilborne pests including fungi, bacteria, and nematodes. Canada-Ontario Agriculture Green Plan, COESA Report No.: RES/MAN-010/97.

Identification, environmental fate, and mitigation of biological and chemical contaminants including antibiotics, hormones, enteric bacteria, and genes encoding bacterial pathogenicity and antibiotic resistance.

Ed Topp, Kam Leung, Bonnie Ball-Coelho, and George Lazarovits. AAFC
Southern Crop Protection & Food Research Centre
1391 Sandford St., London, Ont., N5V 4T3. Tel 519-457-1470 x235
toppe@em.agr.ca

The total area in Ontario (1997) cropped to corn +soybeans + wheat + hay is 7.1 million acres, and the total value of these crops is $2.25 billion. The land application of manure from livestock operations comes with both opportunities and risks. On coarse-textured soils, poor in organic matter and deficient in the ability to hold and maintain moisture, the benefits of manure incorporation to soil quality and crop yield are significant. At the same time animal manures contain several classes of chemicals (hormones, antibiotics, nutrients) and bacteria which are potentially significant environmental problems. The objectives of this study are to identify, and develop mitigation measures for off-site movement of contaminants, particularly novel bioactive compounds including hormones and antibiotics which are of significant public and regulatory concern, and whose environmental behaviour has not been well characterized. A second focus is to establish the environmental significance of excreted veterinary antibiotics, antibiotic-resistance determining genes, and pathogenic bacteria

We are measuring the persistence of coliform bacteria, nutrients, hormones, and antibiotics in stored swine manure and in manured soils.Various on-farm and laboratory experiments to determine the soil persistence of excreted hormones and impacts on fish in streams adjacent to manured fields are in progress. Soil from farms are being sampled periodically to estimate persistence of hormones, antibiotics, enteric bacteria and antibiotic resistant bacteria. Experiments to develop a method to identify enteric bacteria shed by swine have been initiated. *Escherichia coli* isolates of human, cattle, and swine origin have been obtained and are being subjected to DNA fingerprinting analyses in search of a host-specific marker. Experiments analyzing the impact of injected swine manure on crop yield and subsurface quality are being undertaken on-farm and at the Delhi research station.

The impact of manure storage parameters (initially aeration) on persistence of antibiotics, hormones, composition of microbial community, populations of *E. coli* and *Enterococcus* sp., and genes encoding antibiotic resistance and pathogenicity of *E. coli* is being investigated in laboratory microcosms

Development of tools for studying the fate of enteric bacteria, and genes determining pathogenicity and antibiotic resistance

Source-Specfic Typing - Industry and public health officials would benefit from a method which could determine if fecal pollution comes from a swine operation or from other sources. DNA fingerprinting methods (REP PCR, AFLP) are being tested for swine host-specific patterns or sequences.

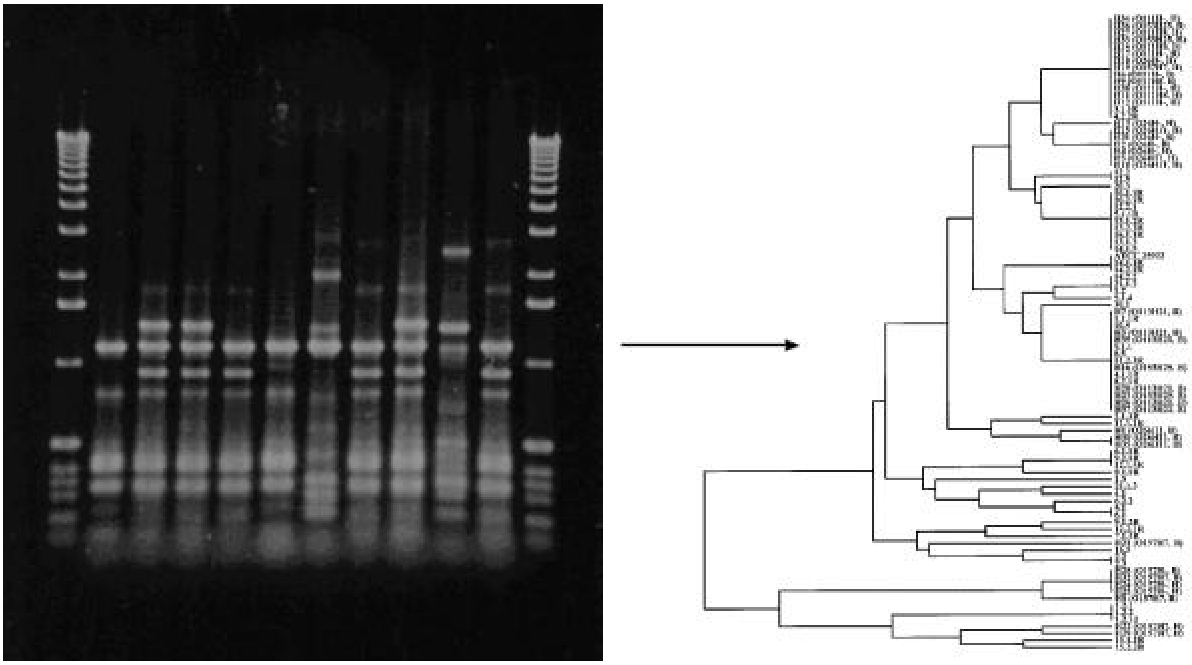


Fig. 1. Fingerprinting of E. coli isolates using the ERIC PCR primers. A comparison of the number and distribution of bands from each isolate is used to determine how closely related they are. The tree shows the relationships of E. coli isolates of human (H) bovine (B) and swine (all others) origin. Swine host-specific patterns or conserved bands that could be used to identify environmental isolates are being sought.

Marked E. coli strain for measuring rate of antibiotic resistance transfer.

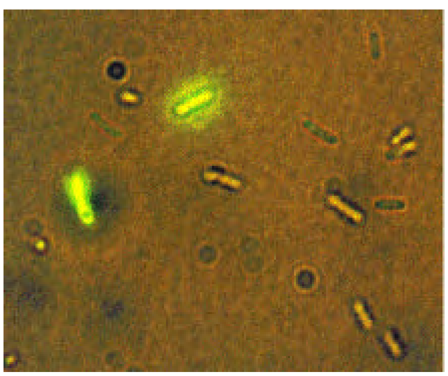


Fig. 2 - A photomicrograph taken with both visible and blue incident light showing cells which do (fluoresce green) and do not (non-fluorescing) contain GFP.

A method is being developed to measure the frequency of movement of antibiotic resistance genes into E. coli. An antibiotic-sensitive strain of E. coli is being engineered to express the Green Fluorescent Protein (GFP). This protein confers the ability to fluoresce under blue light. Following inoculation into manures and soils the rate of "capture" of antibiotic resistance genes by the fluorescent E. coli can be determined.

Detection of antibiotic resistance in enteric and environmental bacteria.

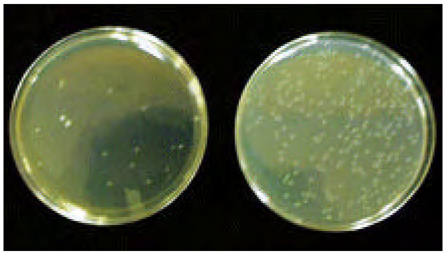


Fig. 3 - Colonies of E. coli growing on plates in the presence (left) and absence (right) of antibiotics.

The relative frequency of antibiotic resistance in bacterial populations in manure and in soils and crop surfaces treated with manure is an important element of this program. Antibiotic resistance is being assessed by plating samples onto agar media containing the antibiotics of interest and comparing the number and diversity of colonies formed. The medium used can be chosen to select specific types of bacteria. We are monitoring "total" populations, E. coli, and Enterococcus sp.

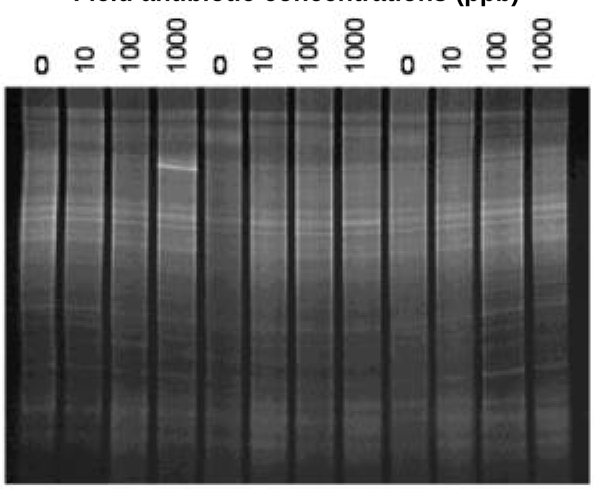
Environmental persistence, movement, and impacts of contaminants associated with swine manure

Antibiotic Resistance and Impacts - The antibiotic resistance of bacteria in soils and on crop surfaces of manured fields is being evaluated using plating methods. Two types of on-farm experiments are currently being undertaken. 1. Monitoring soils periodically following manure application to establish 'die off' of antibiotic resistance and 2. Comparing antibiotic resistance in soils from swine farms that use antibiotics both therapeutically and for growth promotion, therapeutically only, or not at all (organic production).

Transfer of antibiotic resistance from enteric bacteria to environmental bacteria will be evaluated by comparing the DNA sequences of the resistance genes. Environmental bacteria which contain antibiotic resistance genes identical to those in enteric bacteria have acquired the genes by 'horizontal transfer'.

The possible impacts of antibiotic addition to the soil microflora is being evaluated in microplot experiments. Denaturant Gradient Gel Electrophoresis (DGGE) is used to develop a microbial community profile for antibiotic-treated and control soils. The impact of antibiotics on various microbial functions are being evaluated.

Field antibiotic concentrations (ppb)



Examples of genes monitored in our studies.	
Gene	**Function**
E. coli pathogenicity	
STI	Heat-stable enterotoxin
LT	Heat-labile enterotoxin
SLT-I/II	Shiga-like toxin
Antibiotic resistance	
TET1/2	Tetracycline resistance
SUL	Sulfonamide resistance
VAN	Vancomycin resistance

Fig. 4 - DGGE profiles of DNA isolated from untreated plots or plots receiving 1000ppb, 100ppb or 10ppb chlortetracycline + tylosin + sulfamethiazine. Each band corresponds to a bacterium. There are no detectable treatment effects.

Genes Associated with E. coli pathogenicity and anitbiotic resistance. The persistence of pathogenicity genes in environmental samples will be evaluated by PCR detection on isolated DNA.

Hormones - Data from the UK indicates that male freshwater fish exposed to mammalian estrogenic hormones at low concentrations can become feminized. We are evaluating the possibility that fish adjacent to farms are exposed to ‘endocrine disrupting chemicals’.

On-farm The fate and impacts of estrogenic hormones in field soils receiving swine manure is being evaluated on 3 farms in SW Ontario. Chemical analyses of soil and water in adjacent streams is being used to estimate pestistence and movement. Native fish and caged rainbow trout up and downstream of the farms are being evaluated for feminization (blood levels of vitellogenin, testicular egg development).

Laboratory

The persistence, pathways, and rate-controlling parameters of estradiol breakdown are being determined in agricultural soils

Fig. 5 - Field Injection of Liquid Swine Manure

Effect of storage conditions on bacterial and chemical contaminants in manure

Storage conditions could be controlled to decrease the persistence of contaminants. The effect of storage conditions (aeration) on the persistence of bacteria and chemicals is being evaluated. Initial experiments are being undertaken in laboratory experiments, subsequent experiments will be undertaken at a mesocosm scale.

Parameters measured include:

Total bacterial numbers and diversity.

Escherichia coli
Enterococcus
Antibiotic resistance activity and genes.
E. coli pathogenicity genes

Antibiotic concentration
Hormone concentration.

pH, Redox and temperature.

Fig. 6 - Manure is being incubated with (left) and without (right) aeration.

Nutrient Management Plan

Robert Chambers, OMAFRA

This display shows a Nutrient Management Plan for a typical Ontario Swine operation using Nman 2000, a computer software developed to assist farmers in proper environmental and economical management of their nutrient inputs and outputs. Also included in the display are the paper workbook version and the related Nutrient Management from Best Management Practices series.

If you have any other questions please feel free to contact me.

Robert Chambers
Engineer, Swine and Poultry Structures and Equipment
Ontario Ministry of Agriculture Food and Rural Affairs
Wellington Place, RR #1
Fergus (Ont) N1M 2W3
tel. (519) 846-3406
fax. (519) 846-8178

An Overview of the Canadian Pork Council's CQA ™ (Canadian Quality Assurance) Program

Canadian pork is a wholesome product, subject to the rigorous Canadian meat inspection and residue analysis programs. Canadian pork producers are aware, however, of the need to give our customers more formal assurances of our commitment to meeting the highest production standards.

For that reason, the Canadian Pork Council, in close collaboration with government officials, has been dedicated to the development of a national quality assurance program.

The development of the program began in the fall of 1995 with a team of technical experts from industry and government. Its purpose was to find solutions to potential problem areas on-farm that could affect the quality of the final product.

We defined quality as including several components - food safety, product quality and production integrity. Food safety refers to the linkage between the farm and the safety of the pork. This component is a recognition that producers have a responsibility to ensure that their production practices contribute to safe food. Product quality refers to those elements that may affect the quality of the product such as tenderness, texture, and other sensory characteristics. The objective from the national standpoint is to identify where quality could be affected on the farm. Production integrity refers to what producers are doing to ensure that they are good stewards of the animals and land.

The quality assurance program was developed using the internationally recognized concept known as **HACCP** - an acronym - standing for **Hazard Analysis Critical Control Point**. The creation of our HACCP-based program followed three main steps.

1. First, potential problem areas on-farm that could affect food safety, quality and integrity were identified.
2. Second, ways to minimize or eliminate these risks were determined.
3. Third, a plan for producers to follow to ensure the risks are minimized or eliminated was developed.

This program was formally launched in Canada on April 8 of 1998.

In this initial phase, the program standards will focus on food safety. Later phases will focus on quality and integrity standards. The full plan is presented in a producer manual.

Basically, producers following the program must meet a set of national standards. These standards range from writing and following protocols for barn sanitation, feed mixing, medication use and injection techniques to keeping specific records on feeds and medications used on-farm. It calls for standard protocols on addressing physical hazards such as broken needles. It covers chemical hazards such as heavy metals, pesticides and veterinary products. And, it includes measure that should help reduce biological hazards from parasites and bacteria on the farm.

To ensure that producers are indeed following the program and meeting the standards, a program validator will visit the farm, ensure the documentation is in order and verify that protocols are being followed in practice. A certain percentage of validators will be audited by a credible third party to ensure accuracy and consistency.

The entire program will be under review by the Canadian Food Inspection Agency, when they establish a framework to recognize on-farm quality assurance programs.

By following the plan, producers can assure customers that they are following the highest standards for hog production. This program dovetails with what Canadian processors are doing in their operations. As they implement HACCP systems, our program, based on HACCP principles, addresses concerns at the farm-level.

Canadian hog farmers want to do their part in verifying for our customers that we recognize their concerns and are taking formal steps to satisfy their needs. We believe we are taking important steps to maintain Canadian pork as the most wholesome, and of the highest quality in the world.

For more information about this program, contact the provincial hog producer organization in your province or the Canadian Pork Council.