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Manure Impacts on Interrill Erosion

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Abstract

This study was conducted to measure runoff and erosion from interrill areas as affected by the long-term application of manure and fertilizer to a Tripp sandy loam soil located near Mitchell, Nebraska. Soil that had been removed from the top 0.1 m of the soil profile was placed in a 1 m^2 soil pan. Rainfall was then applied to the soil pan during initial and wet simulation events. Total runoff was similar on the manure and no-manure treatments. The long-term application of manure (55 years) at a rate of 27 Mg ha^{-1} (wet basis) per year did not significantly influence interrill erosion on this sandy loam soil. Interrill erosion was also unaffected by the addition of manure immediately before rainfall simulation tests to soils on which manure had been applied in previous years. No significant differences in runoff and erosion were found among plots receiving varying amounts of fertilizer. Selected soil properties were generally unaffected by the varying manure and fertilizer treatments.

Keywords. Interrill erodibility, Manure application, Runoff, Soil loss.

Introduction

Manure is an excellent source of nutrients that can serve as a substitute for synthetic fertilizers. Organic matter contained in manure can improve the chemical and physical properties of soils low in organic matter. Manure can be utilized to achieve an optimum level of agronomic production while conserving natural resources.

A rainfall simulator was used by Giddens and Barnett (1980) to investigate runoff and soil loss as affected by the application of poultry litter. Litter application on fallow soil substantially reduced runoff and soil loss. Westerman et al. (1983) measured erosion from laboratory test plots on which poultry manure had been added. Manure characteristics, loading rates, incorporation, and the time between application and the first rainfall were all found to influence erosion rates. The objectives of this study were to:

- Determine the effects of the long-term application of manure and fertilizer on runoff and erosion.
- Measure runoff and erosion as affected by the timing of the most recent manure application.
- Identify the effects of the long-term application of manure and fertilizer on soil properties used to estimate soil erodibility factors.

Materials and Methods

This study was conducted on a Tripp (coarse, mixed mesic *Typic Haplustolls*) sandy loam soil located near Mitchell, Nebraska that was part of a rotation study since 1912. The sand, silt, and clay content of this soil is 71, 26, and 3%, respectively. A continuous corn cropping system has been used from 1953 to the present. Several tillage operations occur on this site each year. Fertilizer and manure were broadcast and disked each year in the spring before planting. The area has been furrow irrigated, usually five to seven times each year, depending on crop water needs. The manure used in this study was obtained from the same feedlot near Mitchell, Nebraska, used for the long-term field study. The manure was kept in a cooler at 5°C until it was added to the soil samples. Manure and/or fertilizer were mixed with the topsoil increment at the time of testing for those experimental treatments involving addition of manure and/or fertilizer.

The principal experimental variables used in this study included manure or no-manure application, varying fertilizer application rates, and timing of manure and fertilizer applications. This study included 16 treatment combinations in a randomized complete block design. The sequence of each treatment was performed randomly and independently for each block. There were two blocks totaling 32 experimental units which included two replications of the following treatments:

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- Manure applications – 0 and 27 Mg ha^{-1} (w.b.)
- Fertilizer applications – 0; 90; 180 kg N ha^{-1}; and 135 kg N ha^{-1} + 80 kg P ha^{-1}
- Timing of manure and fertilizer applications – Long-term; and immediately before the rainfall simulation tests

For the long-term manure and fertilizer applications, rainfall simulation tests were run on 16 soil samples obtained on 13 April 1998. It had been approximately one year since manure and fertilizer were placed on the field plots from which the soil samples were collected. Manure and fertilizer were also added immediately before the rainfall simulation tests to 16 additional soil samples obtained on 13 April 1998. These soil samples represented conditions occurring in the spring immediately after the annual application of manure and fertilizer.

A 1-m, square, stainless steel soil pan which was maintained at a 9% slope was used in this study. Three outlets were located on the floor of the 10.2-cm deep soil pan to provide drainage. To facilitate water movement to the outlets, two wire screens of 6 and 3 mm mesh, and a cotton fabric were placed on the pan floor before filling with soil. The soil was then placed in the soil pan in three successive uniform layers. A fourth layer was applied on the top and leveled without compressing, resulting in a soil sample depth of approximately 7.6 cm.

A rainfall simulator based on a design by Meyer and Harmon (1979) applied rainfall to the soil pan between May and July 1998. An initial 1-h rainfall application at an intensity of approximately 64 mm h^{-1} occurred at existing soil water conditions. A second 1-h application (wet run) was conducted approximately 24 h later.

Duncan's multiple range test was used to determine the effects of the long-term application of manure and fertilizer on runoff and erosion, soil properties, and soil erodibility factors (SAS, 1990). The effects of timing of the most recent manure application on runoff and erosion were also identified. Tests were run at the 10% probability level. Additional details concerning this experimental study are provided by Gilley et al. (1999).

Results and Discussion

Effects of the Long-term Application of Manure and Fertilizer on Runoff and Erosion

No significant differences in total runoff were found between the manure and no-manure treatments during either the initial or wet rainfall simulation runs (Table 1). Likewise, total runoff for the various fertilizer treatments was similar during both simulation events. Due to the relatively shallow soil depth and high rainfall intensity, total runoff during the initial and wet rainfall simulation runs was similar (47 or 48 mm) for the various manure and fertilizer treatments.

Table 1. Runoff and erosion as affected by the long-term application of manure and fertilizer*

	Initial Run		Wet Run	
	Runoff†	Erosion	Runoff	Erosion
Experimental Variable	(mm)	(Mg ha^{-1})	(mm)	(Mg ha^{-1})
Manure application				
0	48 a	18.6 a	48 a	20.5 a
27 Mg ha^{-1} (w.b.)	47 a	16.4 a	48 a	18.1 a
Fertilizer application (kg N ha^{-1})				
0	48 a	16.9 a	48 a	19.7 a
90	48 a	17.8 a	48 a	19.5 a
135 + 80 kg P ha^{-1}	48 a	17.3 a	48 a	18.6 a
180	47 a	17.8 a	47 a	19.5 a

*Runoff and erosion data are reported for 1 m^{-2} plots where the most recent application of manure and fertilizer was the previous year. Rainfall simulation runs lasted for a 60-min duration at an average intensity of 64 mm h$^{-1.}$

† Separate statistical analyses were performed for the manure and fertilizer applications, and the initial and wet rainfall simulation runs. For a given manure or fertilizer application and rainfall simulation run, differences in runoff and erosion are significant at the 10% level (Duncan's multiple range test) if followed by a different letter.

During the initial and wet rainfall simulation runs, no significant differences in erosion were found between the manure and no-manure treatments even though there was a trend for less erosion when manure was added. Erosion rates were also similar during the initial or wet rainfall simulation runs for the various fertilizer treatments. Even on those plots where small amounts of fertilizer were used, enough plant material appears to have been produced and added to the soil to cause relatively stable interrill erosion conditions.

For a given manure or fertilizer application rate, consistently greater amounts of erosion were measured during the wet run. A breakdown of soil aggregates may have occurred during the initial run causing larger erosion rates during the subsequent runs. The long-term application of manure to soils with greater amounts of silt and clay may also enhance the quantity and stability of soil aggregates. As a result, greater differences in interrill soil erodibility may be evident between manure and no-manure treatments. Manure-induced reductions in soil erodibility may also be more pronounced when greater quantities of manure are applied. Additional testing will be required to determine the effects of varying manure application rates on runoff and erosion from other soils.

Runoff and Erosion as Affected by the Timing of the Most Recent Manure Application

The addition of manure immediately before a rainfall simulation test to plots on which manure had been applied in previous years did not affect total runoff during the initial rainfall simulation run (Table 2). However, slightly more runoff was measured during the second rainfall simulation event (49 vs 48 mm) on those plots where manure was applied immediately before the tests. A difference in total runoff of 1 mm from a total application of 64 mm is minimal. Thus, it appears that the long-term application of manure had little influence on total runoff.

Similarly, the addition of manure immediately before the rainfall simulation tests to plots on which manure had been applied in previous years did not affect interrill erosion during either the initial or wet rainfall simulation runs. In a previous study, runoff and erosion from simulated rainfall were also unaffected by a single application of manure on plots containing sorghum or wheat residue under either no-till or tillage conditions (Gilley and Eghball, 1998).

Table 2. Runoff and erosion as affected by the timing of the most recent manure application*

	Initial Run		Wet Run	
Most Recent Manure Application	Runoff† (mm)	Erosion (Mg ha^{-1})	Runoff (mm)	Erosion (Mg ha^{-1})
Previous year	47 a	16.4 a	48 b	18.1 a
Immediately before test	47 a	16.2 a	49 a	18.6 a

*Runoff and erosion data are reported for 1 m^2 plots. Rainfall simulation runs lasted for a 60-min duration at an average intensity of 64 mm h^{-1}.

†Separate statistical analyses were performed for the initial and wet rainfall simulation runs. For a given rainfall simulation run, differences in runoff and erosion are significant at the 10% level (Duncan's multiple range test) if followed by a different letter.

Effects of the Long-term Application of Manure and Fertilizer on Selected Soil Properties

Soil organic matter (an ion exchange material, chelating agent, and buffering material important in soil aggregation) is contained in manure (Eghball and Power, 1994). The addition of beef cattle manure has been found to substantially increase the organic matter content of some soils (Fraser et al., 1988). In this study, organic matter content was greater on those plots where manure was applied (Table 3). However, the increase in organic matter was not found to be statistically significant. Organic matter measurements were also similar between fertilizer treatments. Since manure was applied annually at the approximate rate required to meet plant N requirements, there does not appear to have been a large accumulation of organic matter within the Tripp sandy loam soil.

Some soil material from the feedlot is usually mixed with manure during the manure removal process. Over an extended period of time, soil textural characteristics at the land application site may be affected if sufficient quantities of soil with different textural characteristics are transported from the feedlot along with the manure. Consequently, particle size distribution of soils from the individual plots was measured in this study.

No significant differences in the fractions of very fine sand, silt or clay was found between the manure and no-manure treatments. Thus, the long-term application of manure and associated soil did not appear to affect surface textural characteristics. Primary particle size distribution of soil material on the fertilizer treatments also appeared to be similar, indicating relative uniformity in surface textural characteristics between experimental treatments.

Table 3. Soil properties resulting from manure and fertilizer applications*

Experimental Variable	Organic Matter (%)	Very Fine Sand (%)	Silt (%)	Clay (%)
Manure application				
0	1.3 a*	10 a	25 a	4 a
27 Mg ha^{-1} (w.b.)	1.8 a	8 a	26 a	2 a
Fertilizer application (kg N ha^{-1})				
0	1.5 a	10 a	25 a	3 a
90	1.5 a	9 ab	25 a	2 a
135 + 80 k P ha^{-1}	1.5 a	8 b	26 a	3 a
180	1.6 a	8 b	26 a	3 a

*Separate statistical analyses were performed for the manure and fertilizer applications. For a given manure or fertilizer application, differences in soil properties are significant at the 10% level (Duncan's multiple range test) if followed by a different letter.

References

Eghball, B. and J.F. Power. 1994. Beef cattle manure management. *J. Soil Water Conserv*. 49(2):113-122.

Fraser, D.G., J.W. Doran, W.W. Sahs, and G.W. Lesoing. 1988. Soil microbial populations and activities under conventional and organic management. *J. Environ. Qual.* 17(4):585-590.

Giddens, J. and A.P. Barnett. 1980. Soil loss and microbiological quality of runoff from land treated with poultry litter. *J. Environ. Qual.* 9(3):518-520.

Gilley, J.E. and B. Eghball. 1998. Runoff and erosion following field application of beef cattle manure and compost. *Transactions of the ASAE* 41(5):1289-1294.

Gilley, J.E., B. Eghball, J.M. Blumenthal, and D.D. Baltensperger. 1999. Runoff and erosion from interrill areas as affected by the application of manure. *Transactions of the ASAE* 42(4): 975-980.

Meyer, L.D. and W.C. Harmon. 1979. Multi-intensity rainfall simulator for erosion research on row side slopes. *Transactions of the ASAE* 22(1):100-102.

SAS Institute. 1990. 4th Ed. *SAS/STAT User's Guide.* Ver. 6.0, Vol. 2. Cary, N.C.: SAS Inst.

Westerman, P.W., T.L. Donnelly, and M.R. Overcash. 1983. Erosion of soil and poultry manure – A laboratory study. *Transactions of the ASAE* 26(4): 1070-1078, 1084.