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UTILIZING MANURE ON ERODED SOIL FOR IMPROVED CROPPING

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INTRODUCTION

Driving across the Great Plains one can see hilltops and side-slopes that are lighter in color than the surrounding soils. The light colored soils are signs these areas have lost topsoil and organic matter through wind or water erosion. Much of the erosion is the result of a combination of both multiple years of tillage and exposure of the unprotected land to erosive forces of the region's winds. Corn, proso millet, and sorghum will typically show zinc and iron deficiency symptoms when planted in these eroded soils. The production on these eroded areas is significantly less than the rest of the field. The lower yields are likely a result of the crop growing in soil that has lost all of its topsoil to erosion. The crop is essentially growing in subsoil instead of normal topsoil. And this subsoil is usually high in pH which causes the zinc and iron deficiency problems. Also these eroded soils are low in organic matter which imparts other nutrient limitations.

MATERIALS & METHODS

An on-farm study site was selected that showed signs of extensive top soil loss (erosion). Proso millet planted on the field in 2005 showed obvious signs of micronutrient deficiencies. The crops that have been planted since we initiated the study are Proso Millet (2007) – Forage Winter Triticale (2008) – Winter Wheat (2009) – Proso Millet (2010)—Corn (2011)—Fallow (2012)—Wheat (2013)—Corn (2014)—Proso Millet (2015)—Corn (2016). These crops are planted across the entire experimental area including alleys, except for eight grass and grass/legume plots. For the grass and grass/legume plots forage sorghum was planted in June 2007 as a cover crop. The grass and grass/legume seed was planted in November 2007.

Manure is applied in the fall, if possible, to allow for winter precipitation to restore moisture lost during tillage operations. Depending on the treatment, manure was applied either annually, biannually or once at the beginning of the study. For the annual treatments, incorporation methods included no-till and sweep till. The plots that received manure biannually (Dp-2yr) and once at the beginning (Dp-6yr), were incorporated using a moldboard plow to a depth of 14 inches followed by a chisel to mix the soil.

Along with the incorporation methods two rates of manure was also applied. A low rate was determined by estimating the amount of nitrogen (N) required to meet crop needs over the next six years which was determined to be approximately 30 lb/ac. Based on past studies, we assumed that 25% of the organic N would be available to the crop the first year. The high rate is simply three times the low rate. The high rate, we hope, is excessive enough to significantly increase soil organic matter content and change soil physical properties within the next six year cycle of the experiment. Chemical N fertilizer rates were 30 and 60 lb/ac. The chemical N fertilizer treatments are broadcast (as urea) on the surface annually to the un-manured plots including the deep tillage plots, just prior to planting.

Starting in 2014, the plots that had manure applications were split in half. Half of the plot continues to receive manure and the other half of the plot receives no manure or fertilizer. This allows us to compare yields and N removal from plots that have continued manure application to plots that are depending on prior manure application for nutrients. For the deep tilled plots, the soil conditions had deteriorated causing yield reductions. Grain yields from plots that were moldboard plowed were at best equal to the control (no manure or fertilizer) and often less than the control. Thus, we decided to cease using deep tillage with the moldboard plow to incorporate manure. The plots that were moldboard plowed to incorporate manure are now (starting 2014) managed exclusively with no-till practices.

RESULTS & DISCUSSION

Statistical Analysis

Considering that there is a large number of treatments in this study we will first look at the statistical analysis of the main effects and their interactions. One main effect is “nutrient type” (M or F); was statistically significant at the 0.10 alpha level every year (Table 1). One other main effect (Incorporation Method) and one interaction (Nutrient type*Tillage) was also significant nearly every year and the average across all years for this interaction was significant. Neither rate nor any other interactions were consistently significant. Our focus now will be on nutrient type (M or F), tillage, and the interaction of those effects.

Table 1. Statistical Analysis by Year for All Main Effects and Their Interactions.									
Source	2007 Millet	2009 Wheat	2010 Millet	2011 Corn	2013 Wheat	2014 Corn	2015 Millet	2016 Corn	Mean
					p-value				
Nutrient type(M or F)	0.005	0.052	<0.001	0.002	0.007	<0.001	<0.001	<0.001	<0.001
Rate	NS*	NS	NS	0.001	NS	NS	NS	<0.001	NS
Tillage	NS	<0.001	NS	<0.001	<0.001	<0.001	0.077	0.001	<0.001
Block	0.003	NS	<0.001	<0.001	0.053	NS	0.001	NS	NS
MorF*Rate	NS	0.037	NS	0.073	NS	NS	0.080	0.043	NS
MorF*Tillage	<0.001	<0.001	NS	<0.001	0.018	0.001	NS	0.006	0.074
Rate*Tillage	NS	0.042	NS	NS	NS	NS	NS	NS	NS
MorF*Rate* Tillage	0.071	NS	NS	NS	NS	NS	NS	NS	NS
*NS = Not significant at the 0.10 alpha level.									

Grain Yields by Incorporation Method (Tillage)

Grain yields have varied with the variability of precipitation. The year 2012 was the driest year on record for Washington County and due to the dry weather millet was not planted. Instead we fallowed the plots and planted wheat in the fall. With very limited subsoil moisture and continued below average precipitation for the 2013 growing season wheat yields were low that season. Most of the years prior to 2012 had precipitation amounts near the long term average for the area of 16.4 inches per year. The years following 2013 were mostly above average. The grain yields reflect these precipitation levels with near average grain yields the first four crops, below average for 2013 and above average the last four crops (Figure 1).

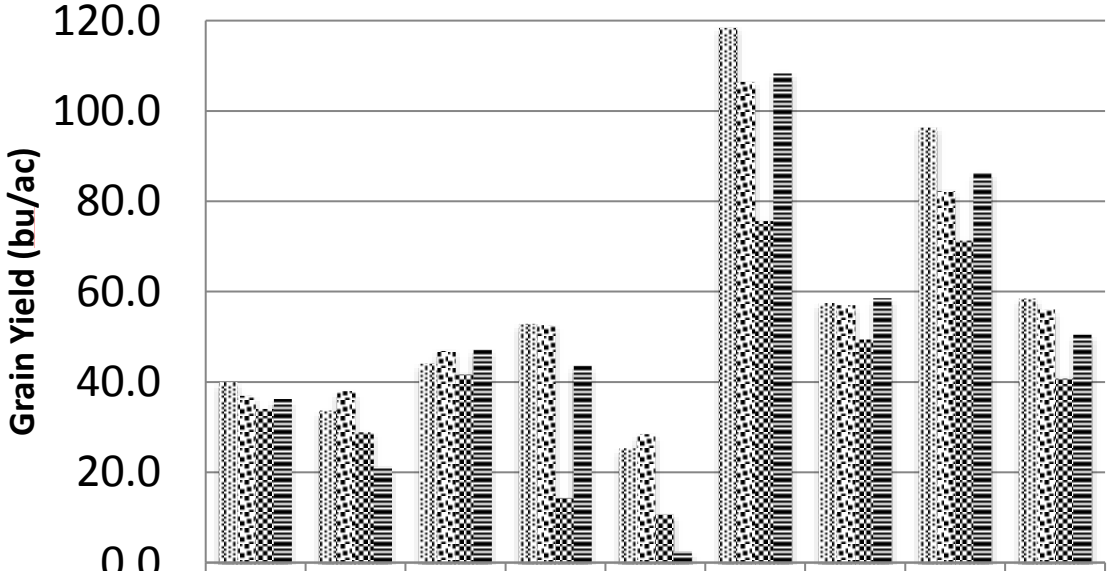
There were treatment differences with respect to incorporation method. The two plow treatments yields were less than the no-till or sweep treatments most years. The no-till and sweep treatment yields were essentially the same. The two plow treatments were detrimental to the soil having a negative impact on soil structure which resulted in poor emergence. In time the Dp-6yr treatment did recover and stands improved to the point that those yields were not significantly different from the no-till and sweep treatment. However, in 2013, when precipitation was very low and there was low subsoil water, the wheat 'burned up' due to the excess nitrogen in the soil. Since manure application rates are based on the assumption that 25% of the organic N will be available the first year and not accounting for the other 75% there is excess N in the soil profile of the plow treatments since the manure us buried and all of the N is captured in the soil. Whereas for the no-till and sweep treatments either all or most of the manure is left on the surface so a percentage of the nitrogen in the manure can volatilize and be lost to the atmosphere.

The Dp-2yr treatment, which has manure applied and incorporated with a moldboard plow bi-annually, continued to have poor emergence and yields due to the continued destruction of the soil structure by the plowing operation. The mean yields for the Dp-2yr treatment for the first six crops was 36.4 bu/ac compared to 52.4 and 51.5 bu/ac for the no-till and sweep treatments, respectively.

Due to the poor soil conditions which resulted in poor yields following the plow treatments the plowing treatments were no longer performed after the sixth crop. Changes were made following the sixth crop in 2014 to eliminate the plow treatments learn more about the residual effect of the

manure we had been applying. The incorporation method for the original deep plow treatments was no incorporation (no-till) with the Dp-6yr treatment receiving manure annually and the Dp-2yr treatment receiving manure biannually. Also, all of the plots that had manure application, regardless of tillage, were split in half where half of the plot no longer received any manure relying only on the residual fertility.

Figure 1. Grain Yields from 2007 Through 2016 by Incorporation Method (averaged across rate & source)



	2007 (Millet)	2009 (Wheat)	2010 (Millet)	2011 (Corn)	2013 (Wheat)	2014 (Corn)	2015 (Millet)	2016 (Corn)	Mean
No-Till	40.0	33.6	44.0	52.8	25.3	118.4	57.5	96.3	58.5
Sweep	36.9	38.0	46.8	52.6	28.4	106.4	57.0	82.2	56.0
Dp-2yr	34.0	28.9	41.6	14.3	10.7	75.6	49.4	71.3	40.7
Dp-6yr	36.2	21.2	47.1	43.6	2.5	108.3	58.5	86.4	50.5

Grain Yields by Fertilizer Source

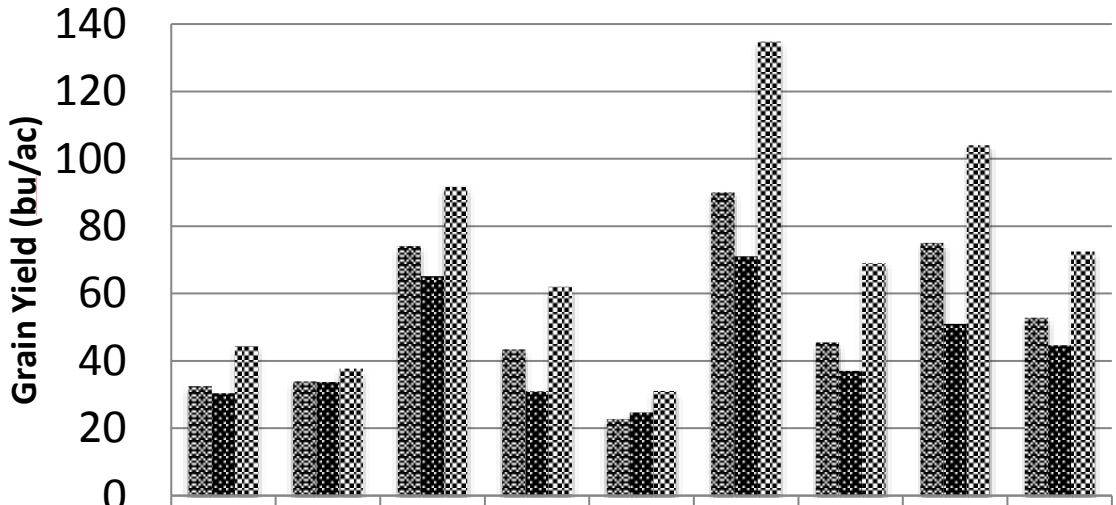
Since there is only two years of data since the plots were split we will not examine the effect of residual fertility verses continued manure application on yields. We will, however look more closely at the impact of manure verses chemical fertilizer on yields using the data from the plots that continued to receive manure applications.

Grain yields where manure was used as the source of fertility averaged 36% more than with chemical N (Fig 2). The yields were 73 bu/ac versus the 53 bu/ac for manure and chemical N, respectively. What is the cause of the increased yield with manure? Is it nutrition, the impact of added carbon, or a combination of the two? This is a question we are still considering.t. Nutrition is certainly improved with manure application since the original source of the manure was plant material we are applying all of the same nutrients required for plant growth back to the soil. This

would include not only the macronutrients but also all micronutrients. A manuscript currently being written analyzes the plant nutrient content with respect to these treatments.

There does appear to be some effect on soil water dynamics as well. Infiltration measurements were taken in 2012 after four crops and the results were mixed. The variability was high making it difficult to interpret the data. Further measurements need to be taken including infiltration, possibly by another method, and canopy temperatures to further understand why manure applications have had such a large impact on grain yields.

Figure 2. Grain Yields by Fertilizer Source (Averaged Across No-Till and Sweep Treatments)



	2007 (Millet)	2009 (Wheat)	2010 (Millet)	2011 (Corn)	2013 (Wheat)	2014 (Corn)	2015 (Millet)	2016 (Corn)	Mean
Fertilizer	32	34	74	43	23	90	45	75	53
No F or M	30	34	65	31	25	71	37	51	45
Manure	44	38	92	62	31	135	69	104	73

CONCLUSIONS

Manure application to eroded soils in this study significantly improved crop yields. . The site used was a highly eroded side slope field typical to many in the western Great Plains region. This study has shown an increase in grain yields of nearly 36% with manure application compared to chemical N fertilizer. With regard to the method of incorporation, no incorporation (no-till) and sweep incorporation provided the best results and produced similar yields. Using a moldboard plow/chisel to incorporate the manure negatively affected yields. Yields with moldboard plow incorporation were 30% lower than yields with no manure incorporation. This was primarily due to the destructive nature of moldboard/chisel tillage on soil structure resulting in poor emergence and likely poor infiltration.