Manure remediates eroded hilltop soils

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During the Dust Bowl, millions of farm acres were damaged by a combination of excessive tillage and wind erosion. Those damaged soils can still be observed while traveling through the region. They are most obvious on hilltops and side slopes of tilled farmland.

Just look for the lighter colored soils in a field. The light color indicates that all, or most, of the original (dark-colored) top soil has been eroded away. The exposed subsoil is low in organic matter and high in pH. Often free limestone or white chert can be found at the soil surface. The limestone causes the high pH and the high pH makes nutrients like zinc (Zn) and iron (Fe) crop-unavailable.

For these reasons, “pH sensitive” crops like corn, proso millet and sorghum typically show classic zinc and iron deficiency symptoms (interveinal chlorosis) when planted in these eroded soils. From a distance, the crop just looks bleached yellow when compared to other areas of the field where there is less erosion.

We know that organic amendments, like beef manure, are good sources of plant nutrients (high in nitrogen [N], phosphorus [P], potassium [K], Zn, Fe, sulfur [S] and others). Also, because manure is high in carbon-rich organic matter, manure is a good amendment for mitigating organic matter depletion of an eroded soil.

The question is, how do we best use manure as an amendment to fix these soils? Specifically, at what rate should manure be applied? Should the manure be incorporated (tilled in)? How deep should we incorporate it? Can we just apply the manure on the surface and manage the field with no-till practices? These are the practical questions we wanted to answer.

Our experimental approach for answers

In 2006, we initiated an on-farm field study near Akron, Colorado to evaluate best management practices for

remediating eroded hilltop soils with beef manure as the amendment. We selected a site that showed extensive top soil loss (erosion). Proso millet planted on the field in 2005 showed classic micronutrient deficiencies including interveinal chlorosis.

We employed two rates of manure, a low rate (2 to 3 tons per acre per year) and a high rate (6 to 8 tons per acre per year). Some plots had the manure plowed under, some were shallowly incorporated with V-blade sweeps, and others the manure was applied on the surface and managed with no-till practices.

For comparison, we included two check treatments: (1) an unfertilized check, (2) plots that were fertilized with just fertilizer N at either 30 pounds per acre or 60 pounds per acre. Urea was used as the N source.

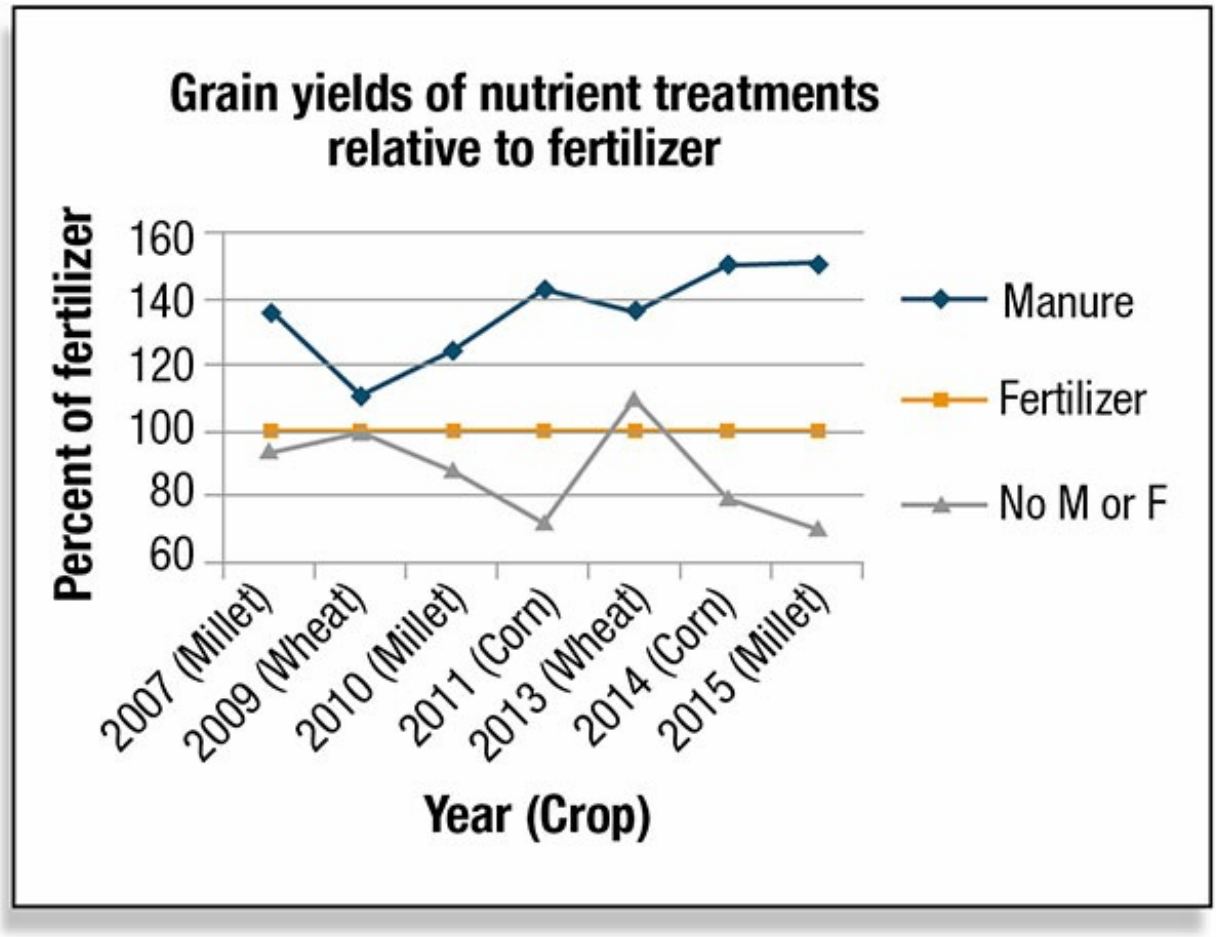
All treatments were replicated across a slope four times. The first rep was on the most eroded soil and the other reps moved down the slope and showed less erosion. The crops raised at the site were corn (2006), proso millet (2007), forage winter triticale (2008), winter wheat (2009), proso millet (2010), corn (2011), fallow (2012), wheat (2013), corn (2014), and proso millet (2015).

Manure was applied in the fall to allow for winter precipitation to restore moisture lost during tillage operations. Every year we measured grain and biomass yield, as well as changes in soil properties and nutrient uptake in the grain and biomass.

What did we learn?

The key result from the trial was the value manure provided as an organic amendment (**Figure 1**). In all years, the grain and forage yields from the manured plots were statistically greater than the fertilizer plots.

Figure 1 Manure vs. fertilizer comparison



In **Table 1**, we show the yield response of millet in 2015, which provides the typical trend for the crops in the other years of the study. We expected that manure, as an amendment, would be better than just chemical N fertilizer because with manure you are adding more than just nitrogen and phosphorous.

Table 1 Millet yields ranked from highest to lowest in 2015

Manure or fertilizer	Rate tons/acre	Manure incorporation tillage method	*** Yield bushels/acre
M	6	Sweep	75 a
M	6	Deep6*	75 a
M	6	No-till	73 a
M	3	Deep6*	70 a
M	3	Deep2**	65 ab
M	3	No-till	65 ab
M	3	Sweep	62 abc
M	6	Deep2**	57 abcd
	Lbs/acre		
F	30	Deep6*	49 bcde
F	30	No-till	48 bcde
F	30	Sweep	45 cde
F	60	Sweep	45 cde
F	60	No-till	44 cde
F	60	Deep6*	43 cde
F	30	Deep2**	40 de
F	60	Deep2**	35 e
0	0	Sweep	32 e
0	0	No-till	31 e

* Deep6 tillage at 12 to 14 inches with manure application and incorporated with moldboard plow in 2006 only.

** Deep2 tillage with manure application and incorporated at 12 to 14 inches with moldboard plow every two years: 2006, 2008, and 2010.

*** Yields followed by the same letter are not significantly different at the 5% probability level.

With the manure, you are applying a cocktail of nutrients and you are adding a source of organic matter that changes soil physical properties. However, we were surprised that the yields on the manured plots were as much as 55 percent greater than the chemically fertilized plots.

Another surprise was the lack of a need for incorporation of the manure. Overall, the most cost-effective practice was manure applied on the surface and not incorporated.

If a person has it in mind that manure has to be incorporated, we suggest shallow tillage with sweeps; many times the sweep treatment gave similar results as the no-till-managed manure. Incorporating the manure with deep tillage, with a moldboard plow, was a waste of effort and money.

A final key result was that most of the time, the low rate of manure (2 to 3 tons per acre) gave similar yields as the high rate of manure (6 to 8 tons per acre).

The impact manure has had on these soils is encouraging. If one examines the data closely, one can see that there has been a trend of increasing yields over time for the manure treatments. The yields in the manured plots during the first three years was 24 percent greater than the N fertilizer plots.

The average increase in yield with manure the last two years was 51 percent. We don't know if this trend for increasing yields with annual manure application will continue or not. Perhaps the yields will reach a plateau with additional years of manure application.

Based on what we found so far, the most cost-effective practice is a low rate of manure of between 2 and 3 tons per acre per year applied on the surface and not tilled in. This practice gave similar yields as the high rate and is the least expensive method of management.

Our current thoughts are, why spend the time and energy to incorporate manure? What is gained if a similar yield result can be achieved by simply applying manure on the soil surface and leaving it undisturbed until planting the next spring?

These results were obtained under semi-arid, dryland conditions in a 16-inch annual precipitation zone and should be carefully interpreted with that in mind. ***FG***

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