What Is The Impact Of Manure On Soil Organic Matter?

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Regular manure applications combined with forage-based rotations are the envy of crop producers when soil organic matter (SOM) levels and soil resilience are considered. What is the actual organic matter benefit from manure to the soil, and how does that vary with different types of manure and organic amendments?

Livestock manure is an excellent source of nutrients and organic matter for the soil. However manure composition, soil characteristics and application management will impact the nutrient and organic matter value.

Factors Impacting Nutrient & Organic Matter Benefits

Manure composition varies with animal type, age, feed ration and the environment.

- **Ruminants** usually have forage based diets, while **monogastrics** (i.e. hogs) are fed grain-based rations. Beef and dairy manure contain undigested forages and often contains bedding materials. These materials are high in cellulose and lignin and take longer to decompose in soil when compared to the less complex sugars from undigested corn.
- **Animal stage / age** will influence the amount of feed consumed, but also dictate the protein and mineral content.
- **Ration** formulations vary. High production phases require more concentrated diets, including phosphorus, potassium and trace elements such as calcium. Regular and high application rates of manure will build up phosphorus and potassium levels, pH (in acidic soils). Micro-nutrients deficiencies, including zinc and sulphur, are rare with regular applications.
- The animal **environment** (housing) determines the amount and type of bedding. The **storage method** and additional materials or wastewater determine the manure dry matter content. The carbon-to-nitrogen (C:N) ratio of wood chips (200+) will be much higher than straw (50 – 80).
- The **C:N ratio** is the proportion of organic carbon to total nitrogen of manure or organic material. The nitrogen is a food source for the soil micro-organisms while they break down the carbon material. When that process is complete, the soil microbes die and decompose. The microbial nitrogen is then returned to the soil and becomes available to the plants. This is considered the "organic nitrogen" component. How long this process takes depends on the ratio of carbon to nitrogen in the material.
- Manure or organic material with C:N ratio under 20:1 is considered ideal for crop production. When there is not enough nitrogen in the organic material to break down the carbon, the micro-organisms utilize nitrogen from the soil. When C:N ratios are higher than 25 to 30:1, it could result in a nitrogen deficiency of a crop that relies on soil nitrogen, such as corn.

Manure will add organic matter but also adds nutrients. Over-application of nutrients could lead to crop damage or nutrient losses into the environment. In addition, any benefits from soil organic matter are easily negated if soil compaction results from application on unfit soils.

Building Soil Organic Matter With Manure

Applying manure to the soil will provide other benefits, such as a greater diversity and activity of organisms and better soil structure. Table 1, *Effects of 11 Years of Manure Additions on Organic Matter Levels*, shows the increase in soil organic matter (SOM) over time. This suggests that at an application

rate of 20 tons / acre / year, the SOM level was maintained, while at lower rates and without other additions such as residue or cover crops, the organic matter level gradually decreased.

Table 1. **Effects of 11 Years of Manure Additions on Organic Matter Levels**				
	Application Rate (tons/acre/year)			
	None	**10 Tons**	**20 Tons**	**30 Tons**
Organic Matter (%)	4.3	4.8	5.2	5.5
pH	6.0	6.2	6.3	6.4
P (% increase)*	---	3.2	57	65
K (ppm)	121	159	191	232
Total pore space (%)	44	45	47	50
Source: *Building Soils for Better Crops,* (Magdoff) SARE Outreach, www.sare.org				
Note: The original organic matter level was 5.2%. The study was conducted on continuous corn silage on a clay soil adding dairy manure. The manure application also improved soil aggregation and the amount of pore space. * P ppm (Bray) was converted to % change				

Maintaining Soil Organic Matter Example

The question often comes up, "How much organic matter am I adding to the soil with manure application?" In order to just maintain SOM levels it could take over 20,000 gal/ac per year of liquid hog manure (adding nearly 500 lbs each of available N-P-K), or just under 10,000 gal/ac for dairy manure or 6 tons of solid broiler manure. The answer is complicated, depending on soil texture, existing SOM, cropping practices such as rotation and use of cover crops, tillage, and residue management. Figure 1 illustrates how to estimate application rates required to maintain current soil organic matter levels. Assumptions include:

- the weight of 6 inches of soil in an acre is 2 million lbs;
- on average 3 % of the organic matter decomposes each year, and
- only 20% of the manure solids (mostly organic carbon) provide stable carbon to the soil, while the 80% provides food for soil micro-organisms.

The chart shows the required application rate to match the annual soil decomposition for 2.7% organic matter using typical livestock analysis data. The application rate required to match annual SOM decomposition should consider nutrients added. Solid and liquid cattle manure applied at SOM decomposition rates align nicely with nutrient additions, while liquid hog and broiler manure to meet SOM decomposition rates would apply up to 6 times the nutrients removed from a crop of grain corn.

Figure 1 - Example of Application rates required to maintain SOM levels

Maintaining Soil Organic Matter - Example

soil organic matter (2.7 %)
2,000,000 lbs in surface 6 inches x 0.027=
54,000 lbs organic matter/acre

X 0.03
(3% SOM decomposes each year)

Lost by decomposition = 1,620 lbs OM

Manure Application to Maintain Soil Organic Matter - Example

1 ton solid dairy manure
(26% dry matter)
= 520 lbs solids

X 0.20 stable carbon
(~80% decomposes in 1st year)

Gain from manure = 104 lbs

1,620 ÷ 104 = 15.5 tons solid dairy manure (provides 81 lbs available N, 114 lbs P_2O_5; 204 lbs K_2O)

Adapted from: Magdoff – Building Better Soils for Better Crops

Approximate Application Rates of Various Organic Amendments Required to Maintain Soil Organic Matter

Material (as applied basis)	Solid Dairy	Liquid Dairy	Liquid Hog	Solid Broiler	Leaf/yard compost
Dry Matter %	26	8.5	3.5	66	50
Total N %	0.72	0.40	0.40	3.12	0.9
NH4-N ppm	1500	1600	2645	6550	15
C:N ratio	31 : 1	14 : 1	3.7 : 1	8 : 1	17 : 1
P %	0.20	0.09	0.12	1.4	0.24
K %	0.61	0.25	0.19	1.8	0.46
Stable solids added	104 lbs/ton	172 lbs/1000 gal	70 lbs/1000 gal	264 lbs/ton	200 lbs/ton
Stable carbon added	90 lbs/ton	112 lbs/1000 gal	30 lbs/1000 gal	100 lbs/ton	61 lbs/ton
Rate to maintain SOM decomposition	15.5 tons/ac	9,400 gal/ac	23,000 gal/ac	6.1 tons/ac	8.1 tons/ac
Available N-P-K applied/ac (SOM maintenance rate)	80 -115 - 205	120 – 155 - 255	470 – 505 - 470	230 – 315 - 235	15 – 70 - 80

Note: 1 gallon of liquid manure weighs approximately 10 lbs. Assuption: 1000 gallons is equivalent to 5 tons