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News and Information on natural resource management in western North Dakota

Active Soil Carbon

by Jon Stika

Back in the June 2002 issue of this newsletter, I published some preliminary information regarding a labile (active) carbon study in Golden Valley County, ND. I decided it was time to take a closer look at that study by comparing the sample data with the crop management history on each field.

Using the crop and tillage history supplied to me by now retired District Conservationist, Dale Ferebee, I calculated a crop rotation diversity index for each scenario that was sampled for analysis. All of the sites were on the same type of soil; Chama silt loam.

What I noticed from the data (see Table 1) was that crop rotation diversity was a key factor in increasing carbon in the soil. Both the Cropland 1 and Cropland 4 sites were in no-till crop production for 22 years, but the Cropland 1 site had three times the carbon stored as the Cropland 4 site. The Cropland 1 site correspondingly had a crop rotation diversity index that was three times greater than the Cropland 4 site crop rotation diversity index. This suggests that a cropping system of no-tillage will not gain significant soil carbon without being paired with crop rotation diversity.

The other conclusion that can be drawn from this data supports the rule of thumb that a diversity index of at least 2 is needed in order to restore the soil food web to the point of adequate nutrient cycling and carbon building.

Table 1

Site	Tons/ac. Active Organic Matter 0-10 cm	Crop Rotation Diversity Index	Number of different species of crops / different crop types in rotation	Number of legume crops since 1980	Years of no soil disturbance from tillage	Water Infiltration rate in cm/hr first inch	Water Infiltration rate in cm/hr second inch
Cropland 1	3.07	2.71	9/4	3	22	23	8
Native Prairie	1.52	-	-	-	-	-	-
CRP	1.35	-	-	0	20	-	-
Cropland 2	1.23	1.49	6/2	2	13	299	10
Cropland 3	1.15	0.50	2/2	0	3	3	-
Cropland 4	0.97	1.08	4/2	1	22	7	3
Cropland 5	0.91	0.80	3/3	1	19	69	15
Cropland 6	0.74	0.5	1/1	0	0	-	-

The Cropland 4 site had a “mattress” of wheat residue. This residue did an excellent job of eliminating erosion and conserving moisture, but nutrient cycling was very slow and thus the system was still dependent upon nitrogen fertilizer to produce crops. On the other hand, the Cropland 1 site crop rotation had to be adjusted in order to maintain cover on the field because the residue decomposed too quickly to maintain adequate soil cover.

This data strongly suggests that a system to build soil health must combine low disturbance, high diversity, living roots as much as possible and soil covered with plant residues at all times in order for the soil food web to restore all the functions we need the soil to perform for agricultural production and profitability.

The beauty of such a system is that it can pay its’ own way in fuel savings and increased nutrient cycling without significant outside influence. Farming in Natures’ image is the most efficient way to produce crops and thus the most sustainable for the land (restored soil health) and sustainable for the farmer (profitable).

Cover Crops and Soil Moisture

By Jon Stika

With the advent of late season multi-species cover crops has come concerns about soil moisture deficits for a cash crop that follows. So, I dug into the archives and unearthed my copy of "Soil Water Storage and Use" by Al Black of the USDA-ARS Northern Great Plains Research Lab in Mandan, ND presented at the Manitoba-North Dakota Zero Tillage Farmers Association annual workshop in Brandon, Manitoba January 1993.

In this landmark paper, Mr. Black made several important observations.

- "A dense population of volunteer grain can remove 1.5 to 3.0 inches of soil water from mid-August to soil freeze-up time."
- "Total snow fall in the northern Great Plains averages 30 to 36 inches and comprises 20 to 30% of the annual precipitation received."
- "… the quantity of crop residue available to suppress evaporation rates must be greater than 2500 lbs/ac (60 to 75% cover)."
- "… soils freeze during this period [over winter] and fallowed soils frozen at a high water content in the upper two feet virtually prevents infiltration of snowmelt or rain while in the frozen state."

Let's see how this applies to our current scenarios of cover crops in a no-till system. Assume a cover crop planted after an early-harvested crop (such as winter wheat, barley, spring wheat, or pea) will use up to 3 inches of water from mid-August to freeze-up. Assume that the soil will be fairly dry at freeze-up and have at least 75% soil cover with much of the cover crop residues still standing at least 13" tall. Assume average winter precipitation will provide 3 inches of water (16" annual precipitation x .2 = 3.2"). Since the soil is dry, it does not freeze and therefore allows the snow to melt into liquid water that infiltrates the soil.

Therefore, the 3 inches of water a cover crop may use from late summer into fall will typically be replaced in a situation with adequate soil cover. If the soil has appreciable moisture in the upper two feet of soil at freeze-up, any water from snow melt will most likely pond on the surface and evaporate, or not infiltrate until the soil thaws, or run off if on sloping land.

The choice of using fall and winter precipitation to grow a cover crop to increase soil health instead of allowing the water to pond or runoff will pay dividends in both the short and long term productivity of the soil.

A multi-species cover crop in Dunn County, ND

Increasing soil health includes increasing; water holding capacity, water infiltration, water permeability, nitrogen fixation and nutrient supplying capacity of the soil. A cover crop must be combined with an approach that minimizes soil disturbance and maximizes plant diversity and soil cover in order for the benefits of the cover crop to be fully realized. The most limiting element in most agricultural soils is carbon, not water or nitrogen. A crop production system that increases soil health also increases soil carbon.

Notes from the Burleigh County Soil Conservation District Soil Health Workshop 2012 "It's Not Just Dirt Anymore"

Following is a compilation of notes taken by me at the workshop. As such, they are my interpretation of what was presented - Jon Stika

Joshua Dukart, Burleigh County Soil Conservation District - Introduction. "It is a good day for the resource and for the people." Soil is a biologically active and alive. Natural laws and universal principles govern soil function. Understand the processes and

don't focus on the tools. We as humans break things down into parts to be able to understand and control things. We must look at nature in wholes and deal with it in wholes and work to allow nature to function rather than be restricted. Look for the "why" in managing for soil health as it is more important than the "how" and "what".

Rolf Derpsch, No Till Consultant, Paraguay – No Tillage Effects on Soil Quality & The Ecosystem, Part 1. No till on 24% of cropland in the U.S. in 2008. 56% of cropland in U.S. still tilled annually. South America cropland is 75% no till. "We cannot conserve soil as long as we are doing tillage." "Conservation tillage is an oxymoron." The objectives of tillage (seedbed preparation, weed control, etc.) are obsolete and incorrect. Soil loss of T is acceptable according to U.S. scientists but is actually not sustainable. Recommended the book: Dirt- The Erosion of Civilization. USDA estimates that 50% of fertilizer used in the U.S. is to replace productivity lost due to soil erosion. Three basic principles to improve soil health: absence of tillage, permanent organic soil cover and adequate plant diversity through crop rotation and cover crops. Corrupting these principles means you will not gain the benefits of improving soil health. Benefits of applying these principles accrue after at least five years of continuous no tillage.

"We cannot conserve soil as long as we are doing tillage." -Rolf Derpsch

All soil chemical properties for plant growth are improved with no tillage. Soil does not need to be tilled to mix Phosphorous or lime into soil. Lime is transported deeper into the soil by organic acids produced by plants. Soil bulk density increases slightly under no till and helps provide better traffic ability. The percentage of soil covered by plant residue is the overriding factor that controls water infiltration into the soil. Raindrops impact disintegrates soil aggregates into soil separates that seal the soil surface pores in as little as ten minutes. Roughly 80% soil cover results in 20% water runoff, 60% soil cover results in 40% water runoff , 20% soil cover results in 80% runoff, 100% soil cover results in 0% runoff. Soil organisms go dormant when soil temperature rises above 40°C (104°F) which can readily occur at 1" depth of bare soil on a clear day. Cover crops can be used to till soil biologically to address compaction. No tillage has a positive influence on soil biology, including earthworms, mycorrhiza and higher cellulose degradation by insects and saprophytic fungi. We know more about the dark side of the moon than about living creatures in the soil. 6x earthworm population in no till compared to chisel plow tillage systems. More rhizobia nodulation on legume roots in no till than tilled soil.

Gail Fuller, Farmer from Emporia, KS – What Does Soil Health Mean to You in Dollars and Sense? Crop diversity is the key to improving soil health. Improving soil health is a journey. Fuller Farms managing for soil health "we feed trillions daily". Soil health harbors predatory insects that totally control corn pests. Build soil rather than degrade it. Started no till in 1995. Quote of Henry Ford; "Don't find fault, find a remedy". All cover crops are grass-broadleaf mixtures and are cutting fertilizer inputs. Maximum sunlight harvest should occur. Paul Jasa experimental farm in Nebraska had good water infiltration into the soil. The University installed runoff collectors on the experimental farm, but after 3 years they took them out as no runoff occurred. Use 100% of moisture for crop growth; not crop cooling, leaching nitrates, runoff into surface water or evaporation from the soil. The answer to improving soil health is to imitate nature. Crop rotation went from corn-soybean to 12 cash crops in rotation with cover crops in between as much as possible. Experimenting with letting cover crops live after a cash crop is planted, then killing cover crop with herbicide. Attract as many different insects as possible so insecticides to control insect pests are not needed. Need to practice crop rotation intensity and diversity above ground to produce intensity and diversity below ground, thus mimicking nature. Stopped mechanically harvesting cover crops and instead harvests them with cattle. Most cash crops are grown as polycultures instead of monocultures. Beginning to do biological soil testing for micro organism species and populations.

Jay Fuhrer, District Conservationist, NRCS Bismarck, ND & Ken Miller, Burleigh County Soil Conservation District Technician , Bismarck, ND and Morton County rancher – The Menoken Farm, Where Are We & Where Are We Going? A report on the Burleigh County Soil Conservation District's Menoken Farm soil health demonstration. Farm of 150 acres was purchased in 2009. Jay Fuhrer said "We have mistakenly accepted a degraded soil as normal." Exploring methods of measuring carbon in the soil with spectral analysis. Biologic analysis can be conducted by assessing phospholipids, which are fatty acids unique to soil organism cell membranes. Recent

crop yields produced on the Menoken Farm without commercial fertilizer were: 27 bu/ac wheat, 100 bu/ac corn, 27 bu/ac pea and 755 lb/ac canola. For the 2012 crop year they are planning to polycrop: canola+pea, flax+lentil and wheat+pea. No till garden grew potatoes without tillage. Potato seed pieces where laid on compost on top of soil then covered with grass mulch and netting. Some cover crops on the crop fields were grazed by sheep in 2011. Used 4' tall netting to control sheep movement. 417 grazing days/ac for sheep or 23 grazing days/ac for cattle or 10,000 lbs/ac. Dry matter. Compost made onsite at Menoken Farm. The greater diversity of starting materials for compost results in the greater diversity of organisms in the finished compost. Compost tea was made and applied to allow beneficial organisms in the compost tea to occupy the surfaces of plant leaves so plant leaf disease organisms could not proliferate, thus eliminating the need for fungicides.

Doug Peterson, State Grassland Conservationist, NRCS, Gallatin, MO – Building Soil with High Density Grazing. People in the city are far removed from where their food comes from. Farmers are several generations removed from what was healthy soil and think that degraded soil is normal. The principles of building soil are the same regardless of location. The canary-in-the-coal-mine of the soil is organic matter. 58% of soil organic matter is carbon. Alan Savory was quoted as saying "The only known tool to heal the land is animal impact". This includes the animals above and below the surface of the soil… the macro herd (of livestock) and micro herd (of organisms living on plant surfaces) above the soil and the micro herd (of soil organisms) in the soil.

"We need to feed the soil livestock purposefully, just as the above ground livestock are fed purposefully." –Doug Peterson

Stock density is the most powerful tool to manage grazing land and soil health. Healthy soil has functioning water and nutrient cycles. Need to have plants that fully recover between grazing. Fully recovered [between grazing events] plants provide more food to the soil microorganisms than unrecovered plants or plants not grazed at all. We need to feed the soil livestock purposefully, just as the above ground livestock are fed purposefully. Soil surface must be covered at all times to protect soil aggregates and increase water infiltration and reduce soil temperature. Trampling of plants by livestock speeds up biogeochemical nutrient cycling. Lower quality forage should be trampled to feed the underground herd. Parts of plant that don't meet livestock nutritional requirements should be trampled to feed the soil. Haying is damaging to the soil because it removes food and cover and starves soil organisms and allows the soil to get too hot and soil organisms suffer. Be observant to note what cattle are eating and what insects are living in your pastures.

Rolf Derpsch – No Tillage Effects on Soil Quality & The Ecosystem, Part 2. There are a greater number of weeds in tilled systems. Cover crops reduce weed pressure during and after the cover crop is grown. No tillage results in less fuel consumption, less labor and longer tractor life. Modern technology allows you to sit too comfortably too far from the soil and disconnects farmers from the soil. No till results in increased yields with fewer inputs. No till reduces carbon dioxide emissions and requires 20% less herbicide if quality no till is practiced. Continuous quality no till improves soil health. Water use efficiency increases with higher cropping intensity. How to achieve quality no tillage: stop using rotational tillage, retain residues on the soil surface, use low-disturbance seeding equipment and use diverse crop rotations and cover crops. Livestock can help increase diversity of crops grown as more crops can be harvested more easily with livestock. More benefits come from permanent cover than from not tilling the soil. Conflicting no till research conclusions are the results of dissimilar seeding equipment used in studies of no till systems. One pass seeding equipment has very different degrees of soil disturbance. Only 12% of no till in U.S. is continuous quality no till.

Question and Answer Session – Plant cover crop seed into heavy crop residue cover and if humidity is not high enough for seed to germinate, humidity will be high enough after even a minimal rain event.

Feed the Soil, Not a Seep

by Jon Stika

In many places of western North Dakota saline seeps remain a concern on cropland. A saline seep results when excess water in the soil profile makes its way to a position low enough on the landscape to result in soil saturation at or near the soil surface. Excess water! In western North Dakota! How can this be… in an area that receives between 12 and 18 inches of annual precipitation?

In areas where seeps occur, the soils are obviously allowing water to pass through the soil profile unused. If there is a living root in the soil drawing water for

only 80 days (in the case of wheat), then 285 days remain when the soil can recharge moisture up to the extent of what it can hold. This means that 78% of the year the soil is accumulating water that it may not be capable of storing. In western North Dakota, approximately 8" of precipitation occurs from April through July when most crops (like wheat) are using water from the soil. The remaining seven or more inches of precipitation occurs outside of the time when a short-season crop is using water from the soil.

A multi-species cover crop in Slope County, ND during 2011

A soil with ideal water holding capacity in western North Dakota can hold 2" of water per foot of soil. In the 3.5' rooting depth of wheat, all 7" of the water that occurs outside of the growth period of wheat would have to be stored in the soil. As we all know, precipitation does not always occur according to the averages and each acre of cropland in western North Dakota is not prime water-holding soil. Given these parameters and the ability of no-till cropping systems to infiltrate water from precipitation, soils and weather conditions would have to be near perfect to prevent water in excess of soil capacity will occur.

It is for this reason that we need to use more water from the soil outside of the growth period of crops like wheat if we are to prevent saline seeps. This can be accomplished by growing crops that root deeper and grow longer than wheat, such as; sunflower, corn, or alfalfa. Alfalfa has been proven to be an excellent seep fighter by using water from deep in the soil all through the growing season. It is not realistic for the whole seep-prone region of western North Dakota to convert all cropland to alfalfa production to address seep prevention.

However, we can use some additional water from various depths in the soil by growing late-season multi-species cover crops to accomplish the same objective. Cover crops can feed and cover the soil to improve soil health while using excess water late in the growing season. A soil that is dried of excess water (particularly near the surface) in the fall does not freeze solid. Frozen soil prevents water from infiltrating the soil during the early spring. Dry soil allows the precipitation that occurs during the winter as snow that is trapped by a cover crop to infiltrate the soil instead of running off.

This would help match the timing of the presence of water in the soil with crop or cover crop growth so excess water does not pass through the soil and produce a seep. Cover crops can only use soil water at the time they are actively growing and cannot use soil water that is not present in the soil or has not fallen to earth yet. Cover crops will cease growth when the soil has been depleted of excess water or a killing frost occurs.

Studies conducted at Dickinson (Ashley and Messer 2007 http://bit.ly/AxQmCS) have shown that crop failure of a crop followed by a cover crop would occur less than 18 times in 100 year period. This means we would have an 82% success rate growing cover crops after short-season cash crops while simultaneously addressing excess water that could contribute to saline seeps.

Cover crops can be used effectively in western North Dakota to build soil and reduce seeps in no till cropping systems. As we work to improve soil health by eliminating tillage we must also adjust to be sure we use water to feed the soil, not a seep.