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Ray Ward is president and co-owner of Ward Laboratories, Inc. since 1983. He is an ARCPACS Certified Professional Soil Scientist with a Ph.D. Soil Fertility, South Dakota State University (SDSU) 1972; MS Soil Fertility, University of Nebraska, 1961; and BS Soil Conservation, University of Nebraska, 1959. He has served as lab division manager for Servi-Tech, Inc. in Dodge City, KS, from 1977-1983; associate professor at Oklahoma State University (OSU), Stillwater, OK, from 1974-1977; assistant professor SDSU and Manager, James Valley Research and Extension Center, Redfield, SD, 1972-1974; and instructor at SDSU from 1961 to 1972. He holds numerous memberships in scientific and honorary academic societies and organizations. Ray received the Soil Science Industry Award from the Soil Science Society of America at their annual meeting in November 2005 at Salt Lake City. The University of Nebraska Alumni Service Award was presented in May 2007. Additionally, he was awarded the Soil Science Professional Service Award sponsored by the Soil Science Society of America at the American Society of Agronomy annual meeting in November 2007. He received the J. Benton Jones, Jr. award “In Appreciation for Dedicated Service to the Development of Soil Testing and Plant Analysis Procedures” at Chania, Greece, June 2011. In September 2012 he received the “Service to Agriculture Award” from Nebraska AgRelations Council. His goals for agriculture and agronomy are to help production agriculture use its resources as efficiently as possible, to provide information and data for developing the best use of soil and water resources while maintaining environmental quality, to be involved in “value-added” agriculture, and to provide accurate laboratory data for managing production enterprises.

What Makes a Productive Soil

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I often hear the comment that this field was very fertile because the yield was very good. Then soil samples are taken for fertility evaluation and the producer finds that the high yield areas have the poorest soil test values. When I am asked about the discrepancy I make the comment that the high yield area removed more nutrients so it should have lower soil test values. Lower producing areas do not remove as many nutrients so the soil tests are higher. This is the reason I am talking about soil productivity. How do we recognize the soil attributes that make a productive soil and what do we do to capture more yield from the more productive soils. I have been called to look at nutrient deficiencies problems. For example, I have found poor plant growth and determined the poor growth was caused by a very shallow root zone. The poor crop growth was caused by a root zone problem not a nutrient deficiency problem.

We look for physical, chemical and biological properties that make our soils productive. When we recognize a productive soil we can enhance inputs to capture increased yield. The need for more food production means we have to produce more from our current land because only marginal/fragile land is remains and may be not suitable for food production. Therefore we need to learn to produce more yields off of our very best land. The other challenge is make our less productive soils more productive by analyzing the physical, chemical and biological properties that are needed to increase yield. It cannot be done by just applying more plant nutrients.

Many of our soils have been damaged by water and wind erosion over the 100 plus years of crop production by conventional tillage. Now we are trying to improve our soil and stop soil erosion. On our farm in Saline County Nebraska I have estimated 15 to 18 inches of top soil loss from our sloping silt loam and silty clay loam soils by past tillage. Yields are much lower on these soils than on the bottom land soils that did not experience erosion. So we are fertilizing our more productive soils differently than the lower productive soils. But how do you identify your productive soils.

First, look at the physical properties. We want the topsoil or A horizon to have granular structure that crumbles in your fingers with light hand pressure. We do not want to see a crust at the soil surface. If the soil is covered with crop residue, cover crop or the intended crop there will not be a crust. The A horizon should be 12 inches deep or more. Soil structure that looks platy 4 to 8 inches deep in the soil indicates soil compaction caused by previous tillage. If the platy structure does not allow root penetration then some kind of tillage will have to be done to break up the platy structure. Usually the platy structure will allow root growth to penetrate it. If this happens then the structure will heal itself in a few years so no tillage needs to be done. The deeper the topsoil the more productive the soil will be.

Next evaluate the subsoil or B horizon. It should have blocky or prismatic structure. The blocky structure is irregular blocks that we call sub-angular blocky structure. Some soils have small prisms while others will have larger prisms. Blocky structure cubes that are dense and difficult to break apart indicate soil compaction. Most times it is best to let the soil heal itself. Tillage breaks up the good structure in addition to the bad structure. So it is best to avoid abusing the soil when it is wet to prevent potential soil compaction. With time structure develops enough strength to hold heavy loads. Soil structure gives the soil strength and is the reason you can drive on a grass strip after a rain.

To evaluate the physical properties of the soil I encourage you to use a tile spade. The spade allows you to dig in the soil easily and to go to depth easily to observe soil structure. The evaluation should determine how well crop roots are exploring the soil. Any physical structure that restricts root growth will tend to reduce yield. If the structure is restricting root growth it is probably restricting water movement and water storage. Normal root zone growth is 4 to 6 feet. The deep root growth is needed for water and nutrient uptake. Compacted soil will not hold as much water. I shallow root zone will not hold as much water. A clayey subsoil will not hold as much water and does not allow water permeability. Sandy soils will not hold as much water unless there is a clay layer deeper in the root zone that will hold water. There are many different examples that restrict or allow root development deep in the soil. A productive soil has no root zone restrictions.

Next I would look at the chemical properties of the soil. Soil pH should range from 5.8 to 7.2 for the most productive soil. Productivity is decrease slightly on either side of the range but the further away the less productive the soil will be. For acid soils with a soil pH less than 5.7 Ag lime should be applied. Alkaline soils that have soil pH above 7.6 may have production problems because of the free lime that interferes with uptake of some nutrients.

Organic matter is very important for nutrient and water storage. Our native soils had organic matter levels about twice as high as most of our soils are today. Some producers had made great strides in improving the soil organic matter but the majority of the soils need much improvement. It is difficult to say what the organic matter level should be. You need to strive to increase organic matter level from where they are today. Crop rotation diversity, cover crop mix, manure application, needed fertilizer nutrients, and returning crop residue are needed to increase organic matter. If a nutrient is taken out of the soil organic matter then organic matter will be lost. Organic matter was lost from our soils because we used the nutrients out of the organic matter to feed our crops. Eventually we had to start using fertilizer. Nutrients in the crop harvest were hauled off the land and no attempt was made to replace lost nutrients. As we try to increase soil organic matter we have to have a diversity of crops to encourage microbial activity to incorporate organic matter into the soil. Remember that organic matter will not increase unless plant nutrients are incorporated into the organic matter.

A productive soil has to be supplied more nutrients depending on the soil test levels in the soil. Usually the productive soil will have good nutrient levels in the soil. However, high soil tests are not a surety that you will have high yields. Soil testing and plant analysis can be used to be sure nutrients are not lacking.

The third soil property is biological. This area is pretty new to me and I am trying to learn how to encourage soil biology. I am finding that a diversity of plants (crops) is necessary to improve the biological life in the soil. Root systems leak plant “juices”. Different plants have different exudates that encourage different microbes. Each plant produces slightly different chemical compounds. Microbes are necessary to develop soil structure and build organic matter. Microbes produce sticky substances and glomalin that binds sand, silt and clay particles together to form aggregates or granules.

Microbes make nutrients more available to plants. More microbial activity improves the nutrient supply to the crop when the nutrients are present in the soil. If a nutrient is in short supply in the soil then a source of nutrient has to be added. If there is enough in the soil but not available then the microbes can increase the availability of the nutrient. We know that Mycorrhizae fungi are needed to supply phosphorus, zinc and copper to corn and a few other crops.

These soil organism, both micro and macro and necessary for crop residue decomposition. Rapid crop residue decomposition means the soil has very diverse biological activity. A diverse population of soil organisms will improve nutrient cycling, organic matter improvement, soil structure development, and perhaps plant pest suppression.

We are just getting started measuring microbial populations in our soils. We like to get comparison soil samples for different management systems to determine if the systems are affecting the microbial population. As we get more comparisons we think more producers will be interested to looking at their microbe populations.

Here are a few interpretations of microbial populations in the soil.

(1) Community Composition Ratios.
   a. Fungi:Bacteria. A value around to 0.3 indicates a steady supply of carbon and nitrogen for both groups. A low value indicates soil stress like excess N or tillage.
   b. Predator:Prey. This is an estimate of protozoa to bacteria. Protozoa eat bacteria and release nutrients especially N.
   c. Gram+:Gram-. A value close to 1 indicates a well-balanced bacterial community.

The best time to take sample is during active root growth. A soil sample should be taken near the plant to get more of the root tissue in the sample. The microbes are attracted to the roots so it is best to take samples where root growth is the most active. Be sure to sample different cropping systems. Sample 0-8 inches deep at least ten spots to combine into a composite sample. Package the soil in plastic zip lock bags or our plastic lined paper soil sample bags. Ask for the Bio Test.

Productive soils are high producing soils. Fertile soils have high soil tests for nutrients. By evaluating the physical, chemical and biological properties in your soils you will be able to identify your most productive soils and add more inputs to produce higher yields.