TURF **TIPS**

Understanding Soil Health - Turf

A Soil Health Assessment provides a reference point to use in gauging the current quality of a soil and the impact of any management steps taken to improve that quality.

Soil health testing combines the chemical and physical analyses of traditional soil testing with biological assessments of microbial activity to provide a measure of the quality of the soil. The microorganisms present in soil benefit turfgrass through decomposition of grass residues and nutrient cycling, but they also compete with plants for available nutrients. Knowing how actively soil microorganisms react to the availability of nutrients helps to understand plant requirements.

AgSource Laboratories' Soil Health Assessment includes a standard soil analysis. This focuses on the chemical characteristics of soil fertility. The parameters measured include pH, nutrients extracted using traditional methods and cation exchange capacity (CEC). The bulk density of the sample is also determined, along with the organic matter percentage, and can be used to infer the soil's ability to provide water to plants over the growing season (see Figure 1).

The results from these tests are used to provide fertilizer guidelines and management practices for the desired turfgrass type. For more information on a standard soil test, refer to the Understanding a Soil Analysis technical bulletin, available at agsource.com.

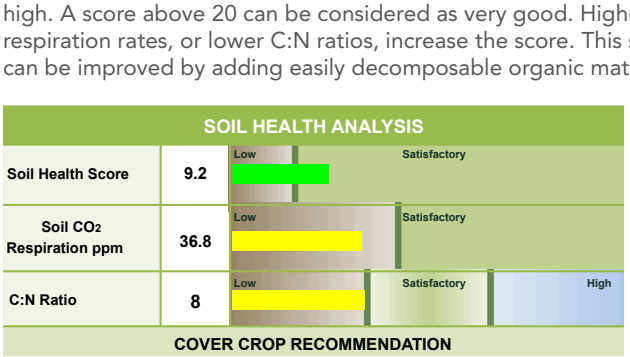
Three Soil Health Options: Basic, Routine and Complete.

All of the assessments include a measure of the biological activity in the soil, done by rehydrating a dry soil and measuring the carbon dioxide generated from microbial respiration. A water extraction is also used to determine the soluble forms of carbon and nitrogen. These two nutrients, in this form, most directly influence bacterial growth in the soil.

The Basic Assessment package includes the following:

Soil Health Score

The **Soil Health Score** is calculated from measurements of the rate of microbial respiration and the availability of soluble carbon and nitrogen. Combining these into a simple number that ranges from a low of zero up to 50 gives a quick evaluation of health. Increasing this score indicates an improvement in soil health. Scores below 10 are low, 10 to 29 are moderate and above 29 are classified as high. A score above 20 can be considered as very good. Higher respiration rates, or lower C:N ratios, increase the score. This score can be improved by adding easily decomposable organic material.

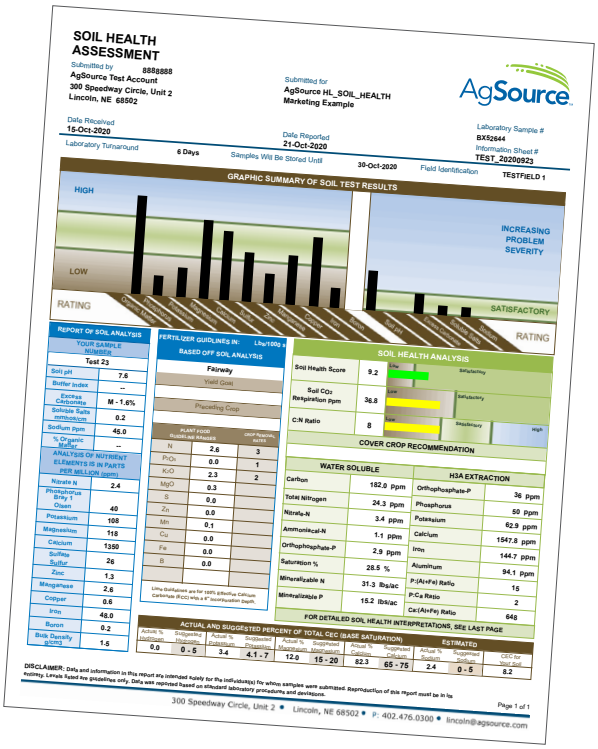


CO_2 Respiration

CO_2 Respiration measures the respiration rate of the soil microorganisms. A dry sample is allowed to slowly absorb water and is kept in a sealed chamber to capture all the carbon dioxide evolved in a 24-hour period. The microorganism activity is briefly enhanced with this technique because the water stimulates their growth after the dry soil conditions. This one-day measurement reliably predicts the respiration rate in the soil under normal conditions. Respiration rates vary depending on the density and diversity of the population, as well as on the nutrient supply. An adequate rate of microbial respiration would yield CO_2 values from 60 to 300 ppm. Increasing respiration values are a sign of vigorous microbial growth. Respiration could be improved by stimulating microbes with the addition of organic matter, readily available nutrients, or biological products.

C:N Ratio

C:N Ratio is a measurement of the availability of two of the most important nutrients for microorganisms in the soil. Carbon is used as an energy source and nitrogen is a requirement for building proteins and enzymes. A desired C:N ratio for a soil with three to five percent organic matter would be around 10 or 12. The right balance of carbon and nitrogen is important. A high number is not better in this case! If the C:N ratio is too high (above 17), nitrogen limits the growth of the organisms and they will compete with plants for any available source of N.



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If the ratio is too low (below eight), the carbon is restricting the growth of microorganisms and their beneficial activities of nutrient cycling are limited. Other benefits from a healthy soil also depend on a balanced C:N ratio. These benefits include factors such as higher organic matter content and improved soil structural stability, both of which increase the soil's water holding capacity. Low ratios can be improved with the addition of decomposable carbon. High ratios can be improved with the addition of nitrogen.

The Routine Assessment includes the basic assessment plus …

Water Soluble Extractions

Water Soluble Extractions evaluate the forms of nutrients that are utilized most easily by the organisms and by plants. Carbon and total nitrogen, used in determining the C:N ratio, are two nutrients that are in high concentration and regulate the soil biologic life. The soluble phosphorus content is very low, but is also an essential nutrient for microbial growth.

Table 1. Interpretation of Water Soluble nutrient results in Soil Health samples.

Parameter	Low	Adequate	High
Carbon, ppm	<150	150 – 300	>300
Total Nitrogen, ppm	<25.0	25.0 – 60.0	>60.0
Nitrate-N (NO_3-N), ppm	<10.0	10.0 – 30.0	>30.0
Ammoniacal-N (NH_4-N), ppm	<10.0	10.0 – 30.0	>30.0
Orthophosphate-P, ppm	<1.5	1.5 – 3.0	>3.0
Water Saturation, %	<35	35 – 60	>60

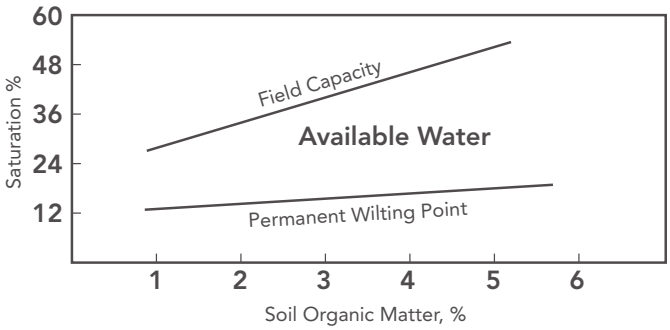
Total Carbon is used in determining the C:N ratio. Soluble carbon is the energy source that stimulates biological activity in the soil. These sugars and carbohydrates that are secreted from plant roots are readily used by microorganisms for growth. When these populations die, the larger carbon compounds remain as part of the organic matter.

Total Nitrogen is also used in determining the C:N ratio. This water extraction includes organic forms of nitrogen, such as soluble organic matter, proteins, and other by-products of decomposition, as well as inorganic nitrate and ammonium nitrogen. This soluble nitrate-nitrogen is easily leached from the soil with water movement, or it can be converted to gas if the soil is saturated with water. The ammonium form is retained in the soil by adsorption on clay particles where it can be utilized by plants and micro-organisms or converted to nitrate. Organic forms of nitrogen are also converted to inorganic forms as by-products of the biologic processes naturally occurring in the soils.

Orthophosphate-P is the form of phosphorus soluble in water and easily absorbed by plants and organisms in the soil. The solubility of phosphate is very low and is controlled by pH, as well as the concentrations of calcium, iron and aluminum in the soil solution. Therefore, the water extracted values for orthophosphate are very low, typically in the range from one to five ppm.

Water Saturation percent indicates the amount of water held in the soil when it is allowed to freely absorb water upwards by capillary action. Values range from 40 to 70 percent, and higher values indicate greater water availability to plants. Increasing amounts of organic matter will increase the saturation percentage and provide a greater supply of water for turf growing on this soil. Increasing the soil's organic matter content by one percent increases the retention of available water by one acre inch, or up to ten percent of the soil's water holding capacity.

Figure 1. Water holding capacity as influenced by organic matter



Mineralizable Nitrogen and Phosphorus estimate the potential release from organic sources of these elements. Mineralizable N comes from the easily decomposable organic material in the soil, such as the microbial biomass or plant residues. If the CO2 Respiration value rises above 50, and the C:N ratio is in the range of 8:1 to 15:1, this organic matter will release increasing amounts of N for plant uptake. Mineralizable P increases in the same way as the mineralizable N, because the source of this available P is the same easily decomposed organic matter in the soil. Fertilizer recommendations can be adjusted to account for this release by subtracting from the amounts indicated in the fertilizer guidelines (for mineralizable P, multiply by 2.3 to convert to P_2O_5).

Table 2. Interpretation of H3A Extraction nutrient results in Soil Health samples.

Parameter	Low	Adequate	High
Orthophosphate-P, ppm	<10	10 – 20	>20
Phosphorus, ppm	<15	15 – 25	>25
Potassium, ppm	<40	40 – 60	>60
P:(Al+Fe) Ratio, %		>5	
P:Ca Ratio, %		>3	
Ca:(Al+Fe) Ratio, %		>200	

The Complete Soil Health Assessment also includes …

H3A Extration

H3A Extraction is the third assessment. This is an extraction of the soil sample with a weak combination of citric, malic and oxalic acids. This combination is used to mimic the acids secreted from plant roots during growth. This H3A extraction, often called the 'Haney Extract' evaluates the concentration of plant nutrients in the form and concentrations present at the root surfaces. Results from this test help to identify low nutrient availability and imbalances in the soil.

The orthophosphate-P value in the H3A extract will be higher than the water soluble amount. This is because of the acidic nature of the extract, and is an indication of the amount of P readily available to the root for uptake. The value reported as phosphorus measures all of the P extracted by the H3A solution, both the orthophosphate-P and forms bound to organic compounds. The organic portion of the extracted P is a form that can be utilized after it is made plant-available by activity of microorganisms, through a process called mineralization. This is the source of phosphorus expressed as mineralizable P in the paragraph above. Comparison of the water soluble and H3A extracted P with the P reported in the soil analysis will give a good indication of the P status of the soil. Phosphorus fertilizer guidelines are based on the standard soil test P results.

Extracted amounts of K and Ca are lower than those reported in the standard soil test because of the weaker extracting characteristics of the H3A solution. Calibrations of this H3A extract for making fertilizer recommendations are not available, therefore fertilizer recommendations are based on the standard soil test results. Concentrations of iron (Fe) and aluminum (Al) are used in determining the ratios of these elements to P and Ca to reveal the potential for P fixation, as discussed below. No ranges are given for calcium or these elements because the data has not been related to plant requirements.

Phosphorus fertilizer guidelines take into consideration the efficiency of fertilizer applications caused by the tendency of soil minerals to remove P from soil solution. The P:(Al+Fe) ratio evaluates this ability of the soil to remove, or 'fix', applied phosphorus in forms insoluble and unavailable to plants. A value below five percent indicates a greater tendency for this to take place, and is associated with acidic soil. The P:Ca ratio is a similar evaluation of the tendency of the soil to remove P as calcium phosphate. The risk of this increases in high pH soil and when the ratio is below three percent. The Ca:Al+Fe comparison shows the potential for improving the availability of P through lime application. If the value is below 200, there is a greater possibility that liming will enhance phosphorus uptake.

Conclusion

Soil health includes the chemical, physical and biological characteristics of the soil. A Soil Health Assessment provides a measure of these characteristics so they can be managed and improved. Anything that builds organic matter and maintains a readily decomposable nutrient source for an active microbial population in the soil will improve soil health. This, in turn, will enhance the overall quality of the soil.