

Understanding a Soil Health Assessment

The Soil Health Assessment combines the chemical and physical tests of traditional soil testing with biological assessments of microbial activity to provide a measure of the quality of the soil. The micro-organisms present in soil benefit the crops through decomposition of crop residues and nutrient cycling, but they also compete with plants for available nutrients. Knowing how actively soil micro-organisms react to the availability of nutrients helps to understand crop requirements for the growing season.

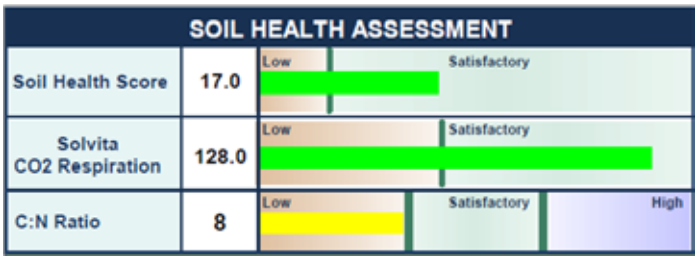
A Soil Health Assessment provides a reference point to use in gauging the current quality of a soil and the impact of any management steps taken to improve that quality.

The AgSource Soil Health Assessment includes a standard soil analysis. This focuses on the chemical characteristics of soil fertility. The parameters measured include pH, plant 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 crops over the growing season (see Figure 1). The results from these tests are used to provide fertilizer guidelines and management practices for the desired crop and yield goal. For more information on a standard soil test, refer to the *Understanding a Soil Analysis* technical bulletin, available at *www.agsource.com/agronomy.*

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 0 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. This score can be improved by adding easily decomposable organic material or encouraging microbial activity in the soil by reducing tillage operations.

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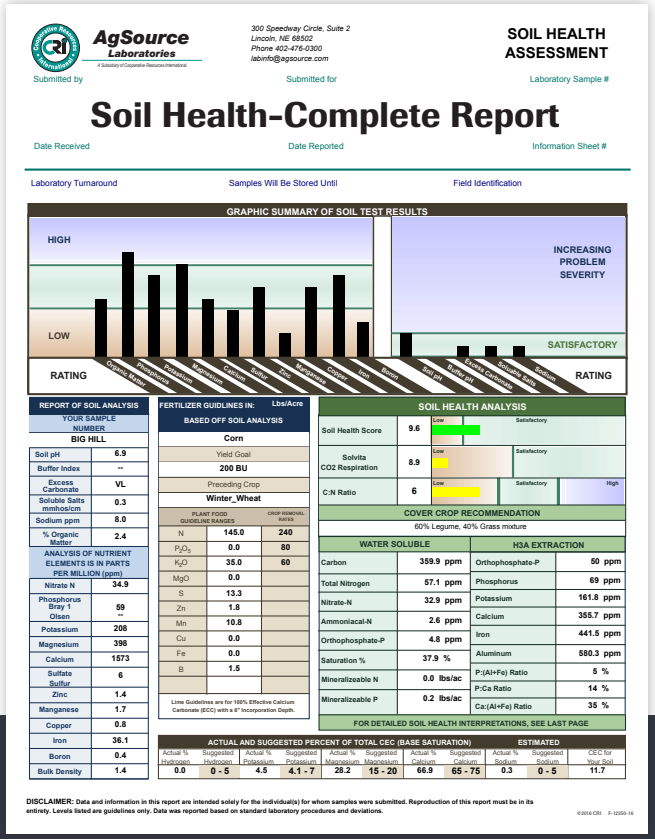
Solvita CO_2 Respiration

Solvita CO_2 measures the respiration rate of the soil micro-organisms. 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 micro-organism activity is briefly enhanced with this technique allowing this one-day Solvita measurement to predict the respiration rate in the soil under normal field 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 CO2 values from 60 to 300 ppm with values below 60 classified as low and values above 150 considered to be high.

C:N Ratio

The **C:N Ratio** is a measurement of the availability of two of the most important nutrients for micro-organisms 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 productive soil with 3 to 5 % organic matter would be between 10 and 15. If the C:N ratio is too high (above 17) then nitrogen limits the growth of the organisms and they will compete with plants for any available source of N. If the ratio is too low (below 8) then the carbon is restricting the growth of micro-organisms and their beneficial activities of nutrient cycling and release 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.



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SOIL HEALTH ASSESSMENT

Submitted by | Submitted for | Laboratory Sample #

Soil Health-Complete Report

Date Received | Date Reported | Information Sheet #

Laboratory Turnaround | Samples Will Be Stored Until | Field Identification

GRAPHIC SUMMARY OF SOIL TEST RESULTS

HIGH
LOW
INCREASING PROBLEM SEVERITY
SATISFACTORY
RATING
Organic Matter | Phosphorus | Potassium | Magnesium | Calcium | Sulfur | Zinc | Manganese | Copper | Iron | Boron | Soil pH | Buffer pH | Excess Carbonates | Soluble Salts | Sodium
RATING

REPORT OF SOIL ANALYSIS

YOUR SAMPLE NUMBER	BIG HILL
Soil pH	6.9
Buffer Index	--
Excess Carbonate	VL
Soluble Salts mmhos/cm	0.3
Sodium ppm	8.0
% Organic Matter	2.4
ANALYSIS OF NUTRIENT ELEMENTS IS IN PARTS PER MILLION (ppm)	
Nitrate N	34.9
Phosphorus Bray 1 Olsen	59 --
Potassium	208
Magnesium	398
Calcium	1573
Sulfate Sulfur	6
Zinc	1.4
Manganese	1.7
Copper	0.8
Iron	36.1
Boron	0.4
Bulk Density	1.4

FERTILIZER GUIDLINES IN: Lbs/Acre
BASED OFF SOIL ANALYSIS
Corn
Yield Goal
200 BU
Preceding Crop
Winter_Wheat

	PLANT FOOD GUIDELINE RANGES	CROP REMOVAL RATES
N	145.0	240
P_2O_5	0.0	80
K_2O	35.0	60
MgO	0.0	
S	13.3	
Zn	1.8	
Mn	10.8	
Cu	0.0	
Fe	0.0	
B	1.5	

Lime Guidelines are for 100% Effective Calcium Carbonate (ECC) with a 6" Incorporation Depth.

SOIL HEALTH ANALYSIS

		Low	Satisfactory	High
Soil Health Score	9.6		Satisfactory	
Solvita CO2 Respiration	8.9	Low	Satisfactory	
C:N Ratio	6	Low	Satisfactory	High

COVER CROP RECOMMENDATION
60% Legume, 40% Grass mixture

WATER SOLUBLE		H3A EXTRACTION	
Carbon	359.9 ppm	Orthophosphate-P	50 ppm
Total Nitrogen	57.1 ppm	Phosphorus	69 ppm
Nitrate-N	32.9 ppm	Potassium	161.8 ppm
Ammoniacal-N	2.6 ppm	Calcium	355.7 ppm
Orthophosphate-P	4.8 ppm	Iron	441.5 ppm
Saturation %	37.9 %	Aluminum	580.3 ppm
Mineralizeable N	0.0 lbs/ac	P:(Al+Fe) Ratio	5 %
Mineralizeable P	0.2 lbs/ac	P:Ca Ratio	14 %
		Ca:(Al+Fe) Ratio	35 %

FOR DETAILED SOIL HEALTH INTERPRETATIONS, SEE LAST PAGE

ACTUAL AND SUGGESTED PERCENT OF TOTAL CEC (BASE SATURATION) | ESTIMATED

Actual % Hydrogen	Suggested Hydrogen	Actual % Potassium	Suggested Potassium	Actual % Magnesium	Suggested Magnesium	Actual % Calcium	Suggested Calcium	Actual % Sodium	Suggested Sodium	CEC for Your Soil
0.0	0 - 5	4.6	4.1 - 7	28.2	15 - 20	66.9	65 - 75	0.3	0 - 5	11.7

DISCLAIMER: Data and information in this report are intended solely for the individual(s) for whom samples were submitted. Reproduction of this report must be in its entirety. Levels listed are guidelines only. Data was reported based on standard laboratory procedures and deviations.

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Recommendations

Cover Crop Recommendations are formulated to meet two objectives: to provide the soil with easily decomposable plant biomass for better health and to retain the nutrients that are still present in the soil after crop harvest. These recommendations are expressed as various mixtures of grass and legume cover crops. Soils with a low Soil Health Score are improved by establishing more legumes, plants that will biologically fix nitrogen in the soil, thus adding N for a better C:N ratio. Along with the legumes, it may be beneficial to add a variety of plants such as radishes, turnips or other Brassica species to the proportion designated for grasses as a way to increase the diversity and vigor of the soil microbial life. Soils with a higher Soil Health Score receive a recommendation with fewer legumes and more grass, reflecting the objective to retain the nutrients already in the soil in the biomass of the roots and shoots of the grass.

Cover Crop Recommendations	
If 0 <= SHS < 5.0 then	70% Legume, 30% Grass mixture
If 5.0 <= SHS < 10.0 then	60% Legume, 40% Grass mixture
If 10.0 <= SHS < 15.0 then	50% Legume, 50% Grass mixture
If 15.0 <= SHS < 20.0 then	40% Legume, 60% Grass mixture
If 20.0 <= SHS < 25.0 then	30% Legume, 70% Grass mixture
If SHS > 25.0 then	20% Legume, 80% Grass mixture

The Routine Assessment includes the basic assessment plus...

Water Soluble Extractions

The **Water Soluble** extraction evaluates 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 water extraction of Total Nitrogen includes both the organic and inorganic forms. Organic forms of nitrogen include soluble organic matter, proteins and other by-products of decomposition. Inorganic nitrate nitrogen is easily leached from the soil with water movement and can be converted to gas if the soil is saturated with water. Ammonium is another inorganic form of nitrogen but it is retained in the soil by adsorption on the clay particles where it can be utilized by plants and micro-organisms or converted to

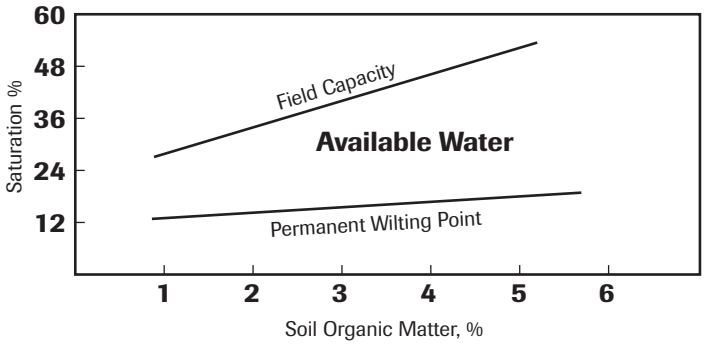
nitrate. Organic forms of nitrogen are converted to inorganic forms as by-products of the biological processes naturally occurring in the soil.

Parameter	Low	Adequate	High
Carbon, ppm	<150	150 - 300	>300
Total Nitrogen, ppm	<25.0	25.0 - 60.0	>60.0
Nitrate-N (NO3-N), ppm	<10.0	10.0 - 30.0	>30.0
Ammoniacal-N (NH4-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
Water Saturation, %	<35	35 - 60	>60

Orthophosphate-P is the form of phosphorus that is 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 and 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 1 to 5 ppm.

Water Saturation % 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% 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 crops growing on this soil. Increasing the soil's organic matter content by 1% increases the retention of available water by one acre inch, or up to 10% of the soil's water holding capacity.

Figure 1. Water holding capacity as influenced by organic matter



Mineralizeable N and P are determined from the concentration of water extractable quantities of carbon and organic nitrogen and the observed rate of microbial respiration as measured by the Solvita test. These values are an estimate of the potential release of N and P from the organic matter present in the soil. The AgSource nitrogen fertilizer guidelines that are provided for crops receiving a standard soil test are adjusted to take into account the nitrogen that becomes available from the soil during the growing season. Those sources of nitrogen include the organic matter content of the soil (10 to 30 lbs N per 1 OM%), legume crop residue (up to 40 lbs N) and any nitrate available at the time of testing. The Mineralizeable N expressed in the Soil Health test will be an equivalent estimate of the amount of N potentially available from the organic matter and crop residue present in the sample.

The Mineralizeable P is an estimate of the phosphorus that will be released when these same organic matter sources are decomposed during the growing season. Fertilizer guidelines for phosphorus provided with the standard soil test also take into account both the effect of P fixation by the soil (losses) and releases of P from crop residues (gains). This estimate in the Soil Health analysis indicates the potential release of P from crop residues. But bear in mind that a portion of the released P will also be fixed by soil minerals. Therefore the value reported will tend to over-estimate the potential P availability. AgSource suggests that only half the value will become available over the growing season. To convert the value from P to P2O5 multiply by 2.29.

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	

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The Complete Soil Health Assessment also includes...

H3A Extration

The 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 micro-organisms through a process called mineralization. This is the source of phosphorus expressed as Mineralizeable P in 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 crop fertilizer recommendations are not available, therefore 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 crop 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 ratio of P to aluminum plus iron evaluates this ability of the soil to remove or 'fix' applied phosphorus in forms that are insoluble and unavailable to plants. A value below 5% 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 a calcium phosphate. The risk of this increases in high pH soil and when the ratio is below 3%. 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 that they can be managed and improved. A typical first-step recommendation to improve soil health is to grow a cover crop. This will help to retain nutrients, enable vigorous soil microbial growth throughout the year and will build soil organic matter content. Other beneficial practices include reducing tillage or converting to no-till operations, adding a hay crop or pasture into an extended cropping rotation and applying manure in ways that maximize the nutrient and organic benefit to the soil.

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, maximizing the productive capacity of the land.