

Appendix A - Soil Health Test Comparisons

This appendix provides information on the specific tests that can be utilized for soil health measurements and a comparison of the three tests. Whichever lab an organization chooses, it is important to work with them consistently, as results from different tests are not comparable. These tests were reviewed over the course of this project, but this is not an exhaustive list of tests or labs. If choosing a different soil health testing package, review the parameters being tested to check that the test is looking at more than just chemical properties.

Comprehensive Assessment of Soil Health (CASH)

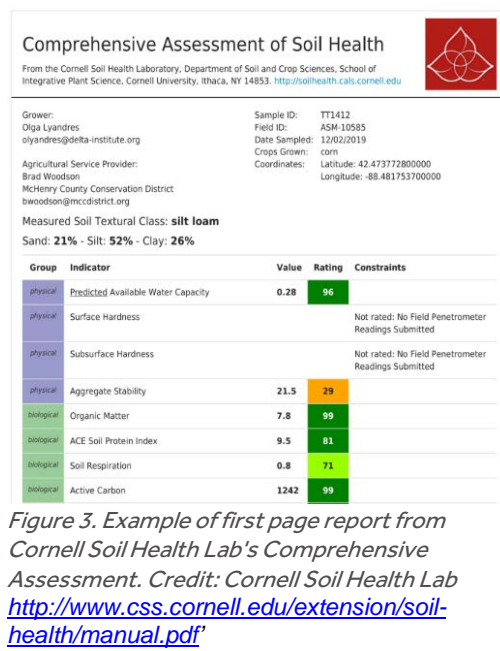
The Comprehensive Assessment of Soil Health (CASH) test is a soil health test designed and conducted by the Cornell University Soil Lab. This test evaluates twelve metrics that capture biological, physical, and chemical indicators. Metrics were chosen due to their sensitivity to changes in soil management practices and ability to represent agronomically and environmentally important soil processes, among other factors. The CASH test offers Basic and Standard packages for testing, with add-on tests available.

More information is available via [Cornell's College of Agricultural and Life Sciences' website](http://www.cornell.edu/college-of-agriculture-and-life-sciences/).²⁰

Output

The CASH test provides a ten-page report outlining the soil health test results. Figure 3 shows an example of the first page of the report. Results are provided as absolute values and converted to ratings. Ratings are indexed to a 0 to 100 scale, based on curves that take into consideration geography and soil texture. Figure 4 shows examples of these curves for a property where a higher absolute value is better. Other metrics will be rated on downwards curves when it is better to have a lower absolute value, or on a bell curve when there is an optimum value between two extremes.²¹

Along with the individual metrics, the CASH test provides an overall rating score out of 100 points, which is an average of the 12 individual ratings. It also identifies



²⁰ <http://soilhealth.cals.cornell.edu/>

²¹ Cornell University College of Agriculture and Life Sciences, "Comprehensive Assessment of Soil Health."

soil constraints, properties that are limiting the soil health of a parcel that was tested and provides recommendations to address these constraints.²²

Tested Properties

Below are the properties that CASH reports. **Bolded metrics are available in both the Basic and Standard packages**, and unbolded metrics are only available in the Standard package. **Biological properties appear in green, physical in blue, and chemical in yellow.**

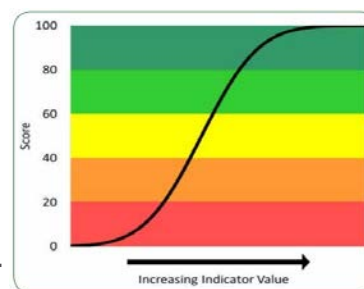


Figure 4. Example of soil health index scores and increasing indicator values. Credit: Cornell Soil Health Lab
<http://www.css.cornell.edu/extension/soil-health/manual.pdf>

Properties	Definition	Soil Processes
Organic Matter	Measure of the carbonaceous material in the soil that is biomass or biomass-derived	Indicates soil aggregate stabilization, water retention, nutrient cycling, and ion exchange capacity; Indicates need for inputs and resiliency to drought and extreme rainfall
Soil Proteins	Fraction of the soil organic matter that are present as proteins or protein-like substances	Indicates the ability of the soil to make N available by mineralization, and has been associated with soil aggregation and water movement
Soil Respiration	Measure of the metabolic activity of the soil microbial community	Indicates the biological status of the soil community, integrating abundance and activity of microbial life
Active Carbon	Measure of the small portion of the organic matter that can serve as an easily available food source for soil microbes	Indicates the ability to support a healthy and diverse microbial community, which is essential to maintain disease resistance, nutrient cycling, and aggregation
Texture	Measure of how acidic the soil is, which controls how available nutrients are to crops	Not a true soil health indicator, but helpful in interpreting other metrics

²² Ibid.

Available Water Capacity	Measure of the porosity of the soil, within a pore size range important for water retention	The amount of plant-available water the soil can store, and therefore how crops will fare in drought conditions.
Surface Hardness	Measure of compaction that develops when large pores are lost in the surface soil	Indicates ability of roots and fungal hyphae to grow through soil and may be severely restricted by excessively hard soil; Indicates water movement through soil.
Subsurface Hardness	Measure of compaction that develops when large pores are lost in the subsurface	Subsurface hardness prevents deep rooting and thus deep water and nutrient uptake by plants and can increase disease pressure by stressing plants. It also causes poor drainage and poor deep-water storage
Aggregate Stability	Measure of how well soil aggregates or crumbs hold together under rainfall	Good aggregate stability helps prevent crusting, runoff, and erosion, and facilitates aeration, infiltration, and water storage, along with improving seed germination and root and microbial health.
Soil pH	Measure of how acidic the soil is	Indicates controls how available nutrients are to crops
Extractable Phosphorus	Measure of phosphorus (P) availability to a crop	Low P values indicate poor P availability to plants, and excessively high P values indicates a risk of adverse environmental impact through runoff and contamination of surface waters.
Extractable Potassium	Measure of potassium (K) availability to the crop	Indicates tolerance to extreme conditions, with good potassium levels extending season
Minor and Micro-Nutrients	Measure of essential plant nutrients taken up by plants in smaller quantities	Deficient nutrients will decrease yield and crop quality, while excess may cause toxicities ²³

²³ Ibid.

Solvita Test

The Solvita test is a suite of tests that look at the biological, physical, and chemical properties of soil health. The test was developed in collaboration with Woods End Lab and the University of Nebraska and is conducted at multiple labs across the country. Testing procedure and guidelines are similar across labs, though reporting and customer interface can vary.²⁴ For this project, the Midwest Biotech lab was used on the recommendation of Woods End Lab staff.

More information is available via the [Solvita Test website](https://www.solvita.com/soil/)²⁵ and the [Midwest Biotech website](https://www.midwestbioman.com/soil-health-lab/).²⁶

Output

Reporting materials vary based on the testing lab. Figure 5 shows an example report from Midwest Biotech. Metrics are given as absolute values, with Solvita metrics converted to a rating. Figure 6 shows the color-coded rating system used by Midwest Biotech. An overall soil health index out of 100 points is calculated as an average of the three Solvita metric ratings.



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Field ID: ASM
Sample ID: 10585
2017 crop: SOY
2018 crop: SOY
2019 crop: COG

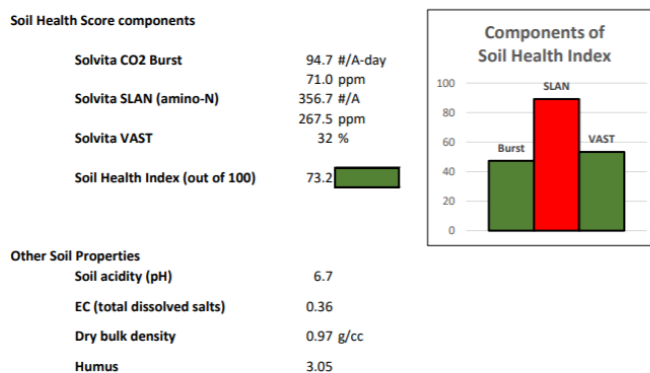


Figure 5. An example report from Midwest Biotech. Credit: Midwest Biotech, Sample Test Report. <https://www.midwestbioman.com/wp-content/uploads/2019/11/Sample-soil-test-report-092019b.pdf>

Color scale and qualitative ratings used to report the Solvita test results





Burst	SLAN	VAST	Color scale	Rating
135+	250+	45+		High
90-135	150-250	30-45		Medium high
45-90	50-150	15-30		Medium low
0-45	0-50	0-15		Low

Figure 6. The color-coded rating system used by Midwest Biotech. Credit: Midwest Biotech, Sample Test Report <https://www.midwestbioman.com/wp-content/uploads/2019/11/Sample-soil-test-report-092019b.pdf>

²⁴ Solvita, "Solvita Soil Health Suite," Accessed September 23, 2020, [solvita.com/soillabtest/](https://www.solvita.com/soillabtest/).

²⁵ <https://www.solvita.com/soil/>

²⁶ <https://www.midwestbioman.com/soil-health-lab/>

Metrics

Below are the metrics that the Solvita test through Midwest Biotech reports. Metrics may differ when using a different lab to perform the Solvita test. **Bolded metrics are part of the Solvita suite of tests** and should be included in any Solvita test, while unbolded metrics were included based on the discretion of Midwest Biotech. **Biological metrics appear in green, physical in blue, and chemical in yellow.**

Metric	Definition	Soil Health Indicators
Solvita CO2 Burst	Measures the pounds of carbon from CO2 released	Indicates microbial activity in soil
Soil Organic Matter	Measure of the carbonaceous material in the soil that is biomass or biomass-derived	Indicates soil aggregate stabilization, water retention, nutrient cycling, and ion exchange capacity; Indicates need for inputs and resiliency to drought and extreme rainfall
Humus	Measures the fraction of soil organic matter that does not have cellular structure	Indicates soil aggregate stabilization, water retention, nutrient cycling, and ion exchange capacity
Solvita VAST	Measures the percent stable micro-aggregates	Indicates the presence of air space between the aggregates for root penetration and water infiltration and storage
Dry Bulk Density	Measures the mass of soil by volume	Healthy soils have adequate air space for root penetration and water infiltration and storage
Solvita SLAN	Measures the amount of amino-N available for future crops	Microbial activity generates amino nitrogen in the soil, which is distinct from the nitrate and ammonium forms of nitrogen commonly reported on traditional soil tests
Soil pH	Measure of how acidic the soil is	Indicates controls how available nutrients are to crops
Electrical Conductivity	Measures the total dissolved salts in the soil	Indicates soil fertility, water absorption ability, and burn risks for plants ²⁷

²⁷ Midwest Bio-Tech, "Sample Soil Test Result," Accessed September 23, 2020. www.midwestbioman.com/wp-content/uploads/2019/11/Sample-soil-test-report-092019b.pdf.

Haney Test

The Haney test integrates biological and chemical attributes of soil. It was developed by the US Department of Agriculture and is conducted at multiple labs across the country.²⁸ For this protocol, Agricultural Soils Management (ASM) was used.

More information is available via the [Ward Laboratories' website](#).²⁹

Output

Reporting materials vary based on the testing lab. Figure 7 shows an example report from Midwest Labs, another local provider of the Haney test. An overall soil health index out of 50 points is calculated using soil respiration, water extractable organic carbon (WEOC), and water extractable organic nitrogen. Though scored out of 50, most soils do not score higher than 30.³⁰

Metrics

On the next page are the metrics from the Haney test through ASM reports. Metrics may differ when using a different lab to perform the Haney test. **Biological metrics appear in green, and chemical metrics appear in yellow.**

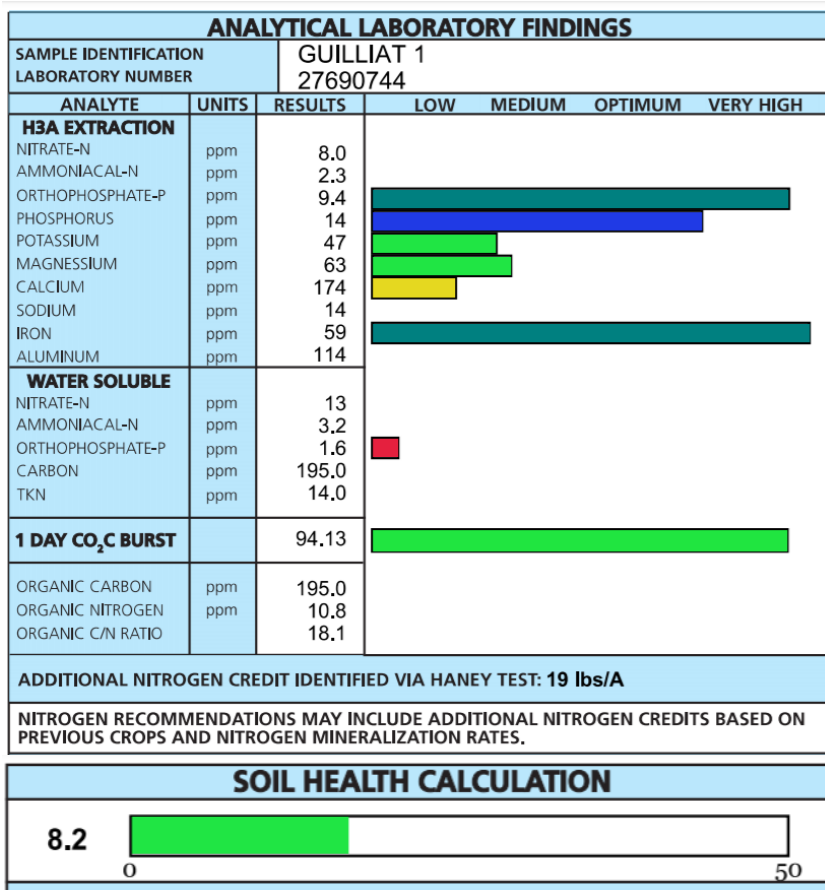


Figure 7. Example report from Midwest Labs. Credit: Midwest Labs.

²⁸ Midwest Labs, "Haney Test Explanation," accessed September 23, 2020, midwestlabs.com/wp-content/uploads/2016/12/190-Haney-Test-Explanation.pdf.

²⁹ <https://www.wardlab.com/haney-test/>

³⁰ Ward Laboratories, Inc., "Haney Report Definitions," accessed September 23, 2020, www.wardlab.com/wp-content/uploads/2019/09/Haney-Definitions-New-Report.pdf.

Metric	Definition	Soil Health Indicators
Soil Respiration	Measures the amount of CO ₂ -C a soil can produce over a 24hr incubation period	Indicates the level of microbial activity in the soil and is tied to soil health functions like nutrient cycling, soil aggregate and organic matter formation, disease suppression and stimulation of plant growth
Organic Matter	Measure of the carbonaceous material in the soil that is biomass or biomass-derived	Indicates soil aggregate stabilization, water retention, nutrient cycling, and ion exchange capacity; Indicates need for inputs and resiliency to drought and extreme rainfall
Water Extractable Organic Carbon	Measures the organic carbon or food that is most readily available to the microbes	Indicates the quality of the organic matter present in a soil system
Microbial Active Carbon (%MAC)	Measures how much of the WEOC pool was acted upon by the microbes measured as soil respiration	Indicates whether the availability of carbon is the limiting factor for soil respiration
Water Extractable Organic Nitrogen	Measures the pool of organic N that is available to the microbes	Indicates the protein available to microbes, where protein rich diets allow plants to better carry out functions
Organic C to Organic N Ratio	Measures the balance between WEOC and WEON	Indicates the quality and energy value of available food
Organic N to Inorganic N Ratio	Measures the balance between organic and inorganic nitrogen	Indicates the dependency of soil on added nitrogen through fertilizer
Organic N Release	Measures the overall nitrogen credit based on the other soil health parameters	Measures the potential for nitrogen mineralization
Organic N Reserve	Measures how much of the measured WEON pool is left	Indicates how much of the available nitrogen is not being released

	following the credit given for organic N release	
Soil pH	Measure of how acidic the soil is	Indicates controls how available nutrients are to crops
H3A Extractant	Measures the level of macronutrients in the soil like potassium and phosphorus	Indicates the availability of nutrients necessary for plant health ³¹

³¹ Ibid.

Test Comparison

The following provides a comparison of the CASH, Solvita, and Haney test metrics and reporting. Information for the Solvita and Haney tests are based on results from Midwest Biotech and ASM respectively.

Property	CASH	Solvita Test	Haney Test
Microbial Activity and Health	Soil Respiration	CO2 Burst	Soil Respiration Microbial Active Carbon
Organic Matter	Organic Matter	Soil Organic Matter Humus	Organic Matter
Soil Stability	Aggregate Stability	VAST	
Water and Air Filtration	Available Water Capacity Surface Hardness Subsurface Hardness	Dry Bulk Density	
Soil Nutrients	Soil Proteins Active Carbon Extractable Phosphorus Extractable Potassium Minor and Micro-Nutrients	SLAN Electrical Conductivity	Water Extractable Organic Carbon Water Extractable Organic Nitrogen Organic Carbon to Organic Nitrogen Ratio Organic Nitrogen to Inorganic Nitrogen Ratio Organic Nitrogen Release Organic Nitrogen Reserve
Soil Acidity	Soil pH	Soil pH	Soil pH
Reporting*	Ten-page report with recommendations Compiled spreadsheet	Two-page report Compiled spreadsheet	Compiled spreadsheet

*Reporting may vary. Most labs will be accommodating to the format and file type needs.

The following provides an overview of logistics and other considerations for the three tests.

Characteristic	CASH	Solvita Test	Haney Test
Cost*	\$110 per sample for Standard, \$60 for Basic	\$60 per sample	\$95 per sample
Lab Availability	Only available through Cornell University	Available at labs nationwide	Available at labs nationwide
Geographic Considerations	Tests originally designed for NE soils, though have been updated	Test conducted nationwide. Developed in collaboration with University of Nebraska	Test conducted nationwide

*Some labs will provide bulk discounts when testing multiple sites.

Soil health testing tools continue to evolve, providing accurate and concise information to land managers. By thoughtfully considering the appropriate test prior early in the process, land managers can begin collecting data that will inform decisions now and continue to support land management goals in years to come.