Soil Health Tool (SHT) ver 4.6

An Integrated approach to soil testing

Soil Testing in Nature's image

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The soil health tool is an integrated approach to soil testing using chemical and biological soil test data; it is designed to mimic nature's approach to soil nutrient availability as best we can in the lab. This tool is the culmination of nearly 20 years of research in soil fertility and I believe it represents the next step in soil testing for the 21st century.

This tool is designed to answer some simple questions:

1. What is your soil's condition?

2. Is your soil in balance?

3. What can you do to help your soil?

The Soil Health Tool is designed to work with any soil under any management scenario because the program asks simple, universally applicable questions. The methods use nature's biology and chemistry by using a soil microbial activity indicator, a soil water extract (nature's solvent), and the H3A extractant, which mimics the production of organic acids by living plant roots to temporarily change the soil pH thereby increasing nutrient availability. These organic acids are then broken down by soil microbes since they are an excellent carbon source, which returns the soil pH to its natural, ambient level. The tool uses an integrated approach to soil testing, reflecting the complex ecosystem of the soil, instead of depending upon the narrow measurement of inorganic N, P, and K. The integrated approach is naturally controlled so that N or P will not exceed what is available from the organic N and organic P pools.

Procedure for soil analysis:

Each soil sample received in the lab is dried at 50^{o} C for 24 hr. and ground to pass a 2 mm sieve (Do not grind finer than 2 mm). The dried and ground samples are scooped with the weight recorded using a Sartorius Practum 2102-1S into two 50 ml centrifuge tubes (4 g each) and one 50 ml plastic beaker (40 g) that is perforated and has a Whatman GF/D glass microfiber filters to allow water infiltration. The two 4 g samples are extracted with 40 ml of DI water and 40 ml of H3A for a 10:1 dilution factor. The samples are shaken for 10 minutes, centrifuged for 5 minutes, and filtered through Whatman 2V filter paper. The water and H3A extracts are analyzed on a Seal Analytical rapid flow analyzer for NO_3-N, NH_4-N, and PO_4-P. The water extract is also analyzed on an Elementar TOC select C: N analyzer for water-extractable organic C and total N. The H3A extract is also analyzed on an Agilent MP-4200 microwave plasma for Al, Fe, P, Ca, and K.

It is critical to use a C: N analyzer designed for water samples, theses instruments determine concentrations in ppm whereas C: N analyzers designed for soil are not sensitive enough since they measure C and N in the % range.

The 40 g soil sample is analyzed with a 24 hour incubation test at 25^o C., the sample is wetted through capillary action by adding 18 ml of DI water to an 8 oz. glass jar (ball jar with a convex bottom) and placed in the jar and then capped. Solvita paddles can be placed in the jar at this time and analyzed after 24 hrs with a Solvita digital reader. Alternatively, at the end of 24 hour incubation, the CO_2 in the jar can be pulled through a LiCor 840A IRGA, which is a non-dispersive infrared (NDIR) gas analyzer based upon a single path, dual wavelength infrared detection system. The peak height is recorded via the Licor software and saved in an Excel file. We then use an Excel file with a “peak hunter” macro to find the highest peak for each sample at a constant pressure, the macro then corrects for the ideal gas law (thanks to Will Brinton) and converts the result to CO_2-C ppm.

Following lab analysis, the raw data are placed in an Excel file (rawraw) that uses macros for correction by sample weight for each extract as well as various calculations and checks to ensure analytical performance. Once the results pass the checks, they are copied and pasted into the Master Excel file to perform the various calculations that yield available NPK, chemical analysis, and soil health results. The final results are copied and pasted into the “results” file for delivery to the user. In the Excel “results” file you will find the following:

NPK TAB

Fertilizer Recommendations

N, P_2O_5, and K_2O (lbs/acre):

These numbers represent the amount these nutrients presently in your soil in lbs/ac.

Nitrogen: From the water extractable NH_4-N + 70% of NO_3-N + MAC * WEON *4 where; MAC = microbially active C and WEON = water extractable organic N. The number 4 represent a conservative estimate of the number of significant rainfall events (>1 in.) over the course of a growing season.

Phosphate: From the H3A extractable ortho-phosphate and organic P based on microbial respiration and a sliding scale C: N ratio.

Potassium: H3A extractable K.

Nutrient value per acre: Current fertilizer prices are multiplied by the nutrients present in your soil. This is the value in dollars per acre of nutrients currently in your soil.

N, P2O5, and K2O needed calculator (Run button):

In the crop column, type in your crop type. In the yield goal column, type in your yield goal. Click on the Run button and the next three columns will calculate your N, P2O5, and K2O needed in lbs per acre to produce your stated yield goal. You must put a crop and yield goal for each sample or you will get an error.

The method used to calculate fertilizer requirements is based on a simple concept: NPK needed for your yield goal minus NPK you have in the soil. However, it is your money; if you think these numbers are too high or too low adjust them accordingly. We are giving you the best numbers we can based on our current understanding of soil and the limits of technology.

NO3-N Only (traditional testing) lbs per acre: National 4 year average is 24 lbs per acre

This column represents testing for nitrate-nitrogen in lbs/acre. This is the only form of nitrogen that most soil test labs measure. We only credit 70% of this measurement due to leaching and denitrification over the growing season.

Additional N (SHT) lbs per acre: National 4 year average is 35 lbs. per acre

This column represents the amount of nitrogen present in your soil in addition to the nitrate described above. This number is attained by incorporating contributions from the biological component in the soil plus NH4-N from the water extract. In other words, this value is the biologically available N value and NH4-N as compared to the inorganic N measured by most commercial or university labs.

$ Nitrogen saved per acre: National 4 year average is $21 per acre

This column represents the amount of nitrogen saved in dollars per acre by accounting for the biologically available N and ammonium as compared to the nitrate only approach.

Soil Health

We have included the national average for some of the measurements based on the mean of 20,000 soil samples from across the country over a four year period (2012-2015).

1-day CO_2-C:

National 4 year average is 52 ppm

This result is one of the most important numbers in the soil test procedure. This value is the amount of CO_2-C (ppm) released in 24 hr. from soil microbes after your soil has been dried and rewetted (as occurs naturally in the field). This is a measurement of the microbial activity in the soil and is highly related to soil fertility. In most cases, the higher the number, the more fertile the soil.

Microbes exist in soil in great abundance. They are highly adaptable to their environment. Their composition, adaptability, and structure are a result of the environment they inhabit. They have adapted to the temperature, moisture levels, soil texture, crop and management inputs, as well as soil nutrient content. In short, they are a product of their environment. If this were not true they most likely would have died out long ago, but they didn't. Since soil microbes are highly adaptive and are driven by their need to reproduce and by their need for acquiring C, N, and P in a ratio of roughly 100: 10: 1 (C: N: P), it is safe to assume that soil microbes are a dependable indicator of soil health. It is clear that C is the driver of the soil nutrient-microbial recycling system. This consistent need sets the stage for a standardized, universal measurement of soil microbial activity. Since soil microbes take in oxygen and release CO_2, we can couple this mechanism to their activity. It follows that soil microbial activity is a response to the level of soil quality/fertility in which they find themselves.

Water extractable organic C (WEOC):

National 4 year average is 225 ppm

This number (in ppm) is the amount of organic C extracted from your soil with water. This C pool is roughly 80 times smaller than the total soil organic C pool (% Organic Matter) and reflects the energy source fueling soil microbes.

A soil with 3 % soil organic matter (SOM) when measured with the combustion method at a 0-3 inch sampling depth produces a 20,000 ppm C concentration. When we analyze the water extract from the same soil, that number typically ranges from 100-300 ppm C. The organic C in the soil water extract reflects the quantity of the C in your soil that is readily available to the microbial population; whereas % SOM is reflective of the entire organic C pool that may become available over the lifetime of the soil. The amount of WEOC reflects the quality of the soil. In other words, % SOM is the house that microbes live in, but what we are measuring is the food they eat (WEOC and WEON).

Water extractable organic N (WEON):

National 4 year average is 20 ppm

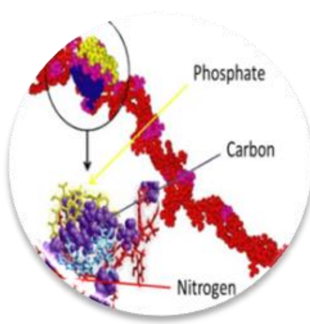
This number is the amount of the total water extractable N minus the inorganic N (NH_4-N + NO_3-N). The WEON pool is highly related to the water extractable organic C pool and will be easily broken down by soil microbes and released to the soil in readily plant available inorganic N.

Organic C: Organic N:

National 4 year average is 12.8

This number is the ratio of organic C from the water extract to the amount of organic N in the water extract (WEOC: WEON). This C: N ratio is a critical driving factor in the nutrient cycle. Soil organic C and N are highly related to each other as well as the water extractable organic C and N. We assess the organic C: N ratio of the water extract since this relationship reflects the portion of C and N that are readily available to soil microbes and is a more sensitive indicator of soil health than the total soil C: N ratio. A soil C: N ratio above 20:1 generally indicates that no net N and P mineralization will occur, meaning the N and P are "tied up" within the microbial cell until the ratio drops below 20:1, as the ratio decreases the more N and P are released to the soil solution which can be taken up by growing plants.

Note: water extractable organic C and N are **not** separate entities in the soil, the C and N are actually from the same molecule, although we separate C and N in analysis because of the nature of the instruments we use to analyze them.



Soil Health Calculation:

National 4 year average is 9.3

This number is calculated as 1-day CO_2-C / 10 + WEOC/100 + WEON/10 to include a weighted contribution of microbial activity, water extractable organic C and N. It represents the overall health of your soil system. It combines 5 independent measurements of your soil's biological and chemical properties. The calculation looks at the balance of soil C and N and their relationship to microbial activity. This soil health calculation number can vary from 0 to more than 50. We like to see this number increase over time. This number indicates the current soil health and helps us identify what it needs to reach its highest sustainable state. Keeping track of this Soil Health number will allow you to gauge the effects of your management practices over the years.

Cover Crop Mix:

This is a suggested cover crop planting mix based on your soil test data. This is a recommendation of what you can do to increase your Soil Health number; it is not what you have to do. It is designed to provide your soil with a multi-species cover crop to help you improve soil health and thus improve the fertility of your soil.

Nitrogen

Total N: National 4 year average is 77 lbs. per acre

This number is the total N from the water extract from your soil (in lb/ac). It contains both inorganic N and organic N, which are shown in the next two columns.

Inorganic N: National 4 year average is 38 lbs. per acre

This is the combined amount of plant available forms of inorganic N (NO_3-N (nitrate N) plus NH_4-H (ammonium N)). NO_3-N is the form of N that is easily lost from soil through surface runoff, subsurface leaching, erosion, and in water logged conditions, it can revert back to a gas. NH_4-H is usually quickly converted to NO_3-N by soil microbes but is less susceptible to leaching.

Organic N: National 4 year average is 39 lbs. per acre

Organic N is the total water extractable N minus the total water extractable inorganic N in lbs. per acre. This form of N should be easily broken down by soil microbes and released to the growing plant providing minimal chance of loss since the N is bound in large organic molecules. This pool represents the amount of potentially mineralizable N in your soil.

Phosphate

This lists the same type of results as nitrogen but for inorganic P and organic P.

Total P: National 4 year average is 97 lbs. P_2O_5 per acre

Inorganic P: National 4 year average is 75 lbs. P_2O_5 per acre

Organic P: National 4 year average is 22 lbs. P_2O_5 per acre

Potassium

National 4 year average is 140 lbs. K_2O per acre

Remaining columns

Columns to the right of the phosphate column on the **NPK TAB** are used for the **GRAPH IT TAB** where you can click on a sample, click the **Graph it button** and see the results from that sample in pie charts and bar graphs.

Al H3A: the amount of H3A extractable aluminum in ppm. National 4 year average is 230

Fe H3A: the amount of H3A extractable iron in ppm. National 4 year average is 126

Ca H3A: the amount of H3A extractable calcium in ppm. National 4 year average is 1231

Organic N release: This is the portion of the water extractable organic N that we credit as plant available based on the microbial activity, WEOC, WEON and the balance of the two (C: N).

Organic N reserve: This is the amount of organic N that is not credited as plant available usually due to lower microbial activity relative to the WEOC and WEON pools. If this number is 0 then the entire WEON pool is considered plant available.

Organic P release and organic P reserve: the same as described above for nitrogen except phosphate uses the H3A extractant.

%P saturation: The amount of H3A extractable P/the amount of H3A extractable Al and Fe expressed as a percentage. This is an index of the P associated with Al and Fe in your soil, a number below 5 usually indicates a need for P fertilizer and a number above 20 usually indicates excess P in soil. These numbers can be misleading if you have high P and low AlFe but high Ca, these numbers are just indicators of some of the chemical properties of the soil but can reflect P fertilizer additions.

Ca/AlFe: the H3A extractable calcium/H3A extractable Al and Fe, this ratio is used to indicate the balance of some of the drivers of soil pH. A number less than 1 may indicate a need to add lime, numbers greater than 20 usually indicate a high pH soil (>7.7).

SHC is the soil health calculation and $ saved per acre is nitrogen.

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