ALTA

AGRICULTURAL LABORATORY TESTING ASSOCIATION

Overview:

- Illinois Soil Testing Association (ISTA) was founded in 1981 address Illinois growers' needs for quality soil test information. ISTA rebranded as the Agriculture Laboratory Testing Association (ALTA).
- ALTA's mission is to promote the interests of the Ag testing industry and advance high-quality soil & plant-tissue analysis data for farm profitability, and sustainability in the US.
- ALTA is committed to ensuring the quality of data to agricultural communities by encouraging the development, use, and acceptance of proven agricultural testing methods.

Soil Scooping Assumptions and Issues

Robert O. Miller, PhD
ALP Technical Director
Fort Collins, CO

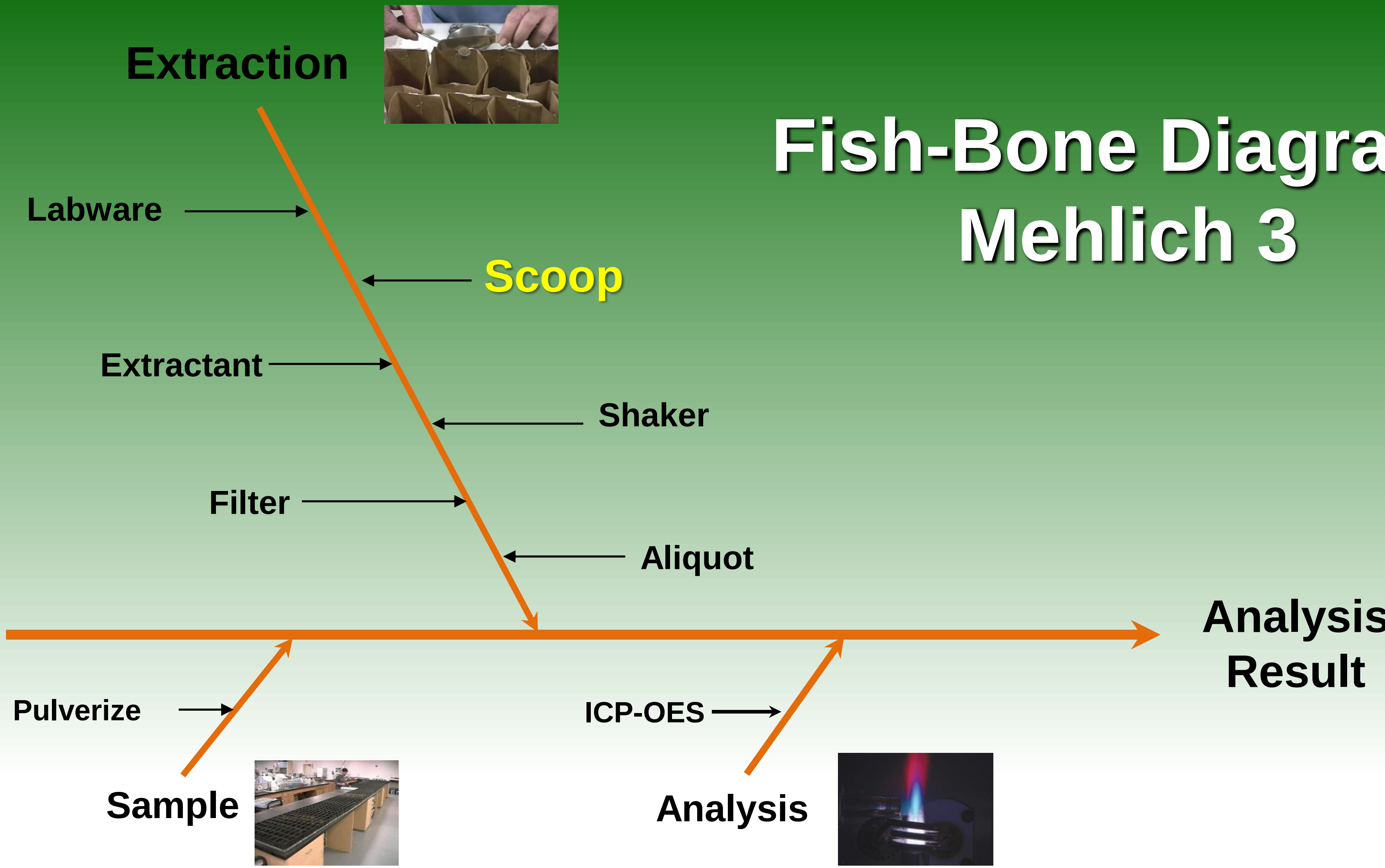
Rmiller@soiltesting.us

ALTA AGRICULTURAL LABORATORY TESTING ASSOCIATION

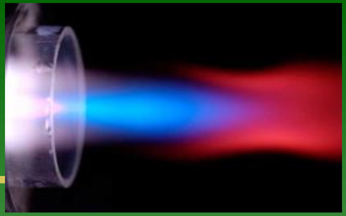
Worldwide Interlaboratory Testing
Collaborative Testing Services

ALTA-SPAC Webinar
August 24, 2021

Fish-Bone Diagram: Mehlich 3



History

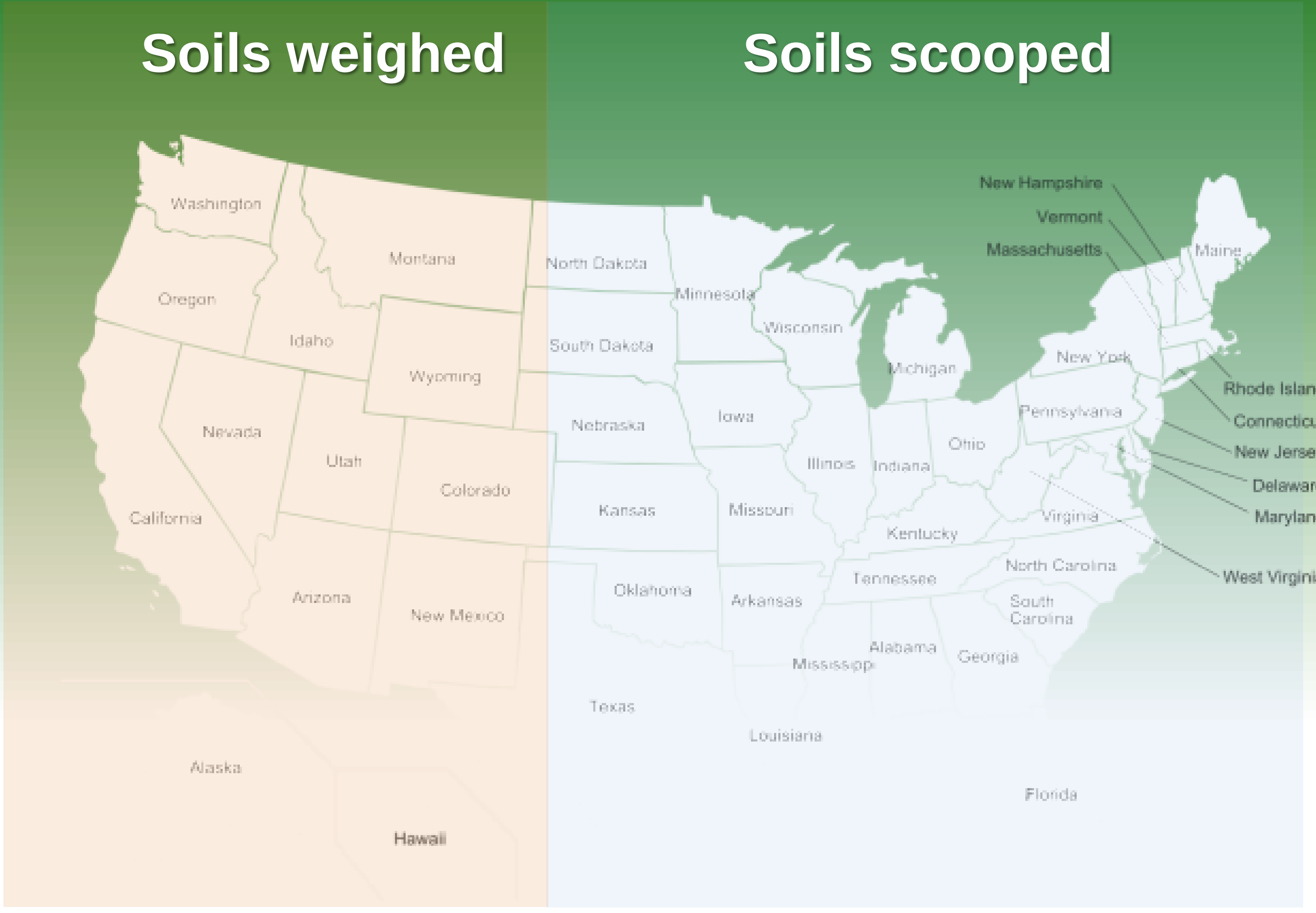


The North Carolina Dept of Agriculture Services laboratory was an early adopter of soil scooping. Subsequently was implemented by the University of Illinois and across the NERA-13 Region in 1967. Developed to facilitate processing.

Soils are scooped by volume by North Carolina Department of Agriculture, Agronomic Division.

Three scooping procedures are practiced today: (1 soils scooped based on a volume basis (cm^3); (2 on a mass basis (g) and 3) weighed. Procedure is regionally specific.

Regional differences

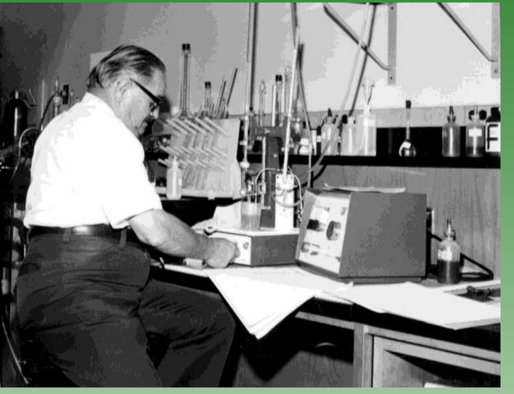


Basis of scooping

Soil scooping on a volume basis was reported by Adolph Mehlich (1953 and 1973) and is based on the premise plant roots grow in volume, results expressed as g dm^{-3}.

Soil scooping, on a mass basis, was reported by Bray (1946), Jackson (1958) and Melsted and Peck (1967) and is based on chemistry expression for concentration mg kg^{-1}, and reported in the Midwest as lbs ac^{-1}.

The mass basis assumes a defined soil density, with literature values reported of 1.18 – 1.32 g cm^{-3} (Peck, 1967; Page 1965; and Christenson, 1971).



Adolph Mehlich, NCDA Agronomic Division - 1970.

Soil density values vary across University testing laboratories ranging from 1.10 to 1.30 g cm^{-3} with 1.18 g cm^{-3} the most common.

John Spargo, Penn State Univ.

Soil scoops

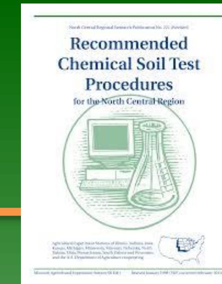
A soil scoop, as defined by the NCERA-13 Workgroup, is based on an assumed soil density of 1.18 g cm^{-3}. Thus a mass of 2.0 g requires a scoop volume of 1.70 cm^{-3}. A range of scoop sizes are available ranging from 0.5 – 15.0 g, dependent on the method.

Standard soil scoops, based on NCERA-13 scooped mass and volume basis, are available from the Soil and Plant Analysis Council (SPAC).

Soil Scoop	Volume (cm^{-3})
0.5 g	0.425
1.0 g	0.85
1.5 g	1.28
2.0 g	1.70
5.0 g	4.25
10.0 g	8.50

Soil scoops based on volume are also available : 1.0, 2.0, 4.0 5.0 and 10.0 cm^{-3} sizes.

Soil scooping procedure



1. **Stir crushed soil with spatula to loosen prior to measuring.**
2. **Dip into the center of the soil with scoop, heaping it full without pushing against the side of container.**
3. **Hold scoop firmly, tap the handle three times with a spatula from a distance of 2-3 inches.**
4. **Hold spatula blade perpendicular to the top of the scoop and strike off excess soil.**
5. **Empty scoop into extraction vessel.**

Peck, T.R. 1998. Recommended chemical soil test procedures for the North Central Region, page 7-9. Missouri Agricultural Experiment Station SB 1001.

Soil scooping

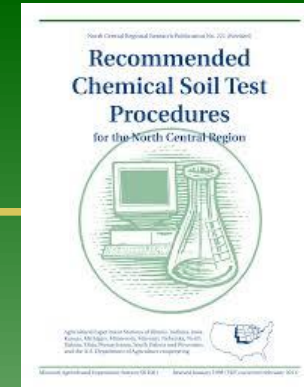
Procedural assumptions

Soil measurement and extraction presumptions

Operational Issues

Scooping technique, consistency and quality

Procedural assumptions



"The typical soil is defined as a medial silt-loam texture with 2.5 percent organic matter crushed to pass a 10-mesh screen. Bulk density of crushed, typical soil approximates 1.18 g cm^{-3} ".

Peck, T.R. 1998. Recommended chemical soil test procedures for the North Central Region, page 7-9. Missouri Agricultural Experiment Station SB 1001.

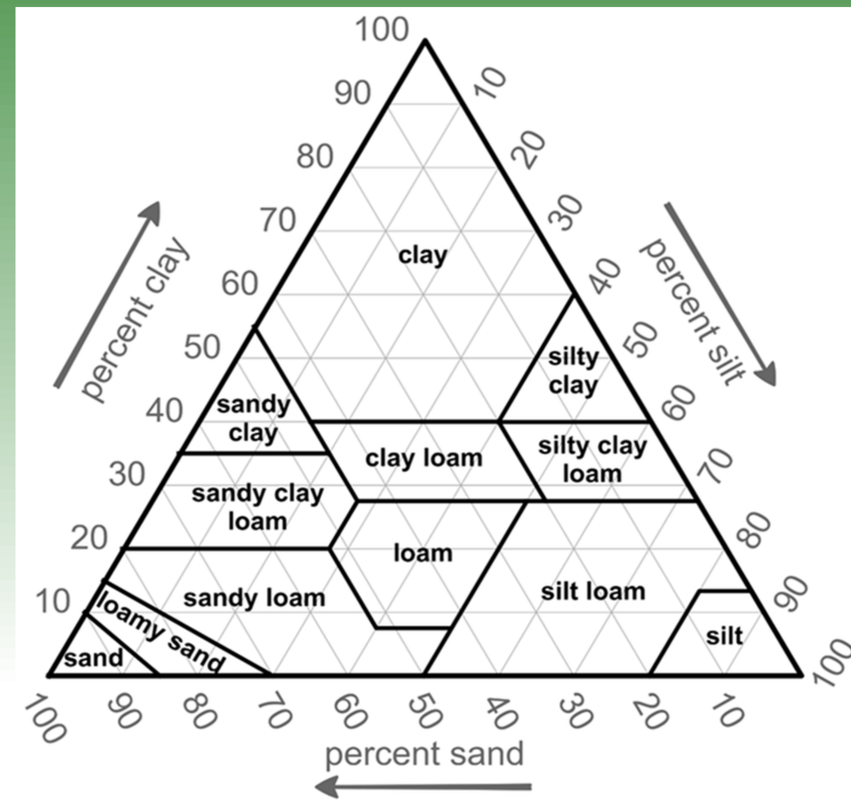
Procedural assumptions

The "typical" soil

Texture	Density (g cm $^{-3}$)	2g Scoop (g)
Sand	1.62	2.75
Loamy sand	1.54	2.62
Sandy loam	1.46	2.48
Loam	1.33	2.26
Silt loam	1.21	2.06
Silty clay L	1.19	2.02

Source: ALP Database, density based on 2.0 g scoop, Values represent means within each USDA texture, SOM < 4%.

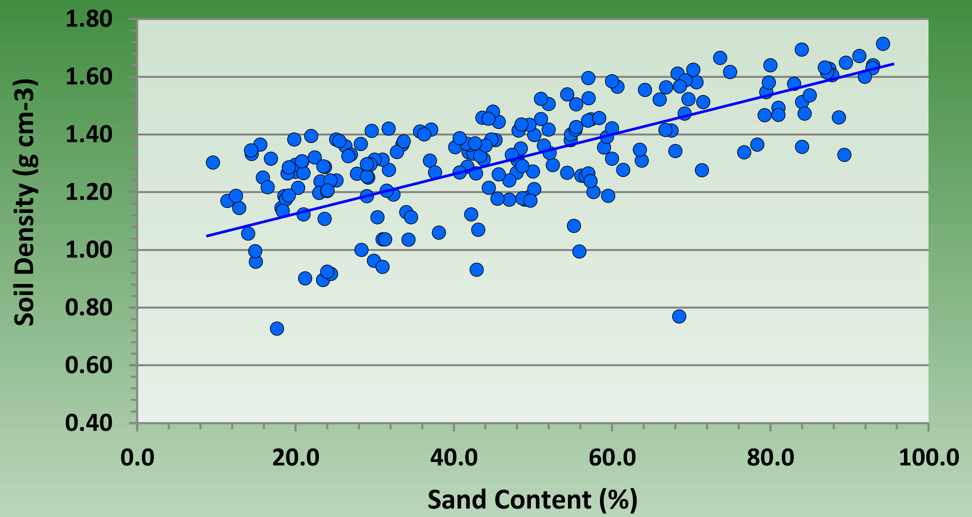
Texture triangle



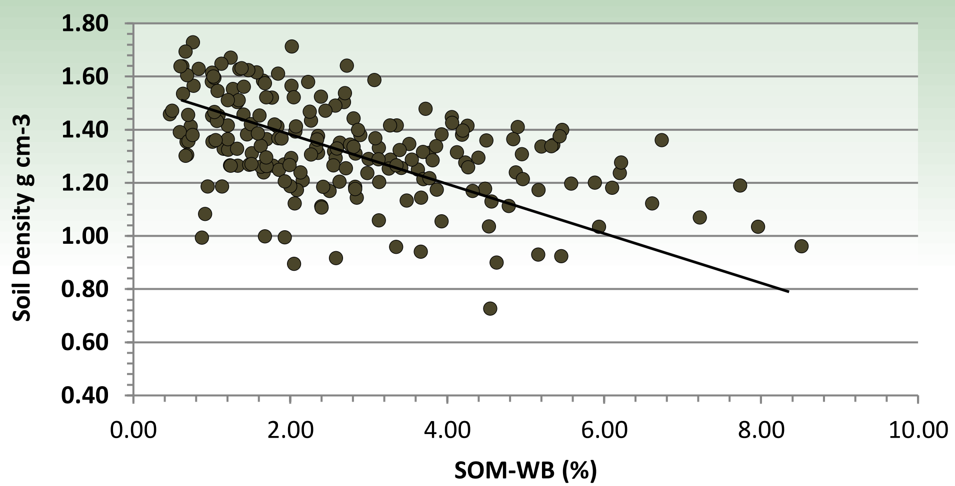
Procedural assumptions

The "typical" soil

Soil scoop density increases with increasing sand content (R^2 0.41) and decreases with increasing SOM content (R^2 0.22).



Texture and SOM impacts soil density, and therefore the mass of soil extracted across scooped based test methods.



Source: ALP database, 215 soils.

Assumptions: density

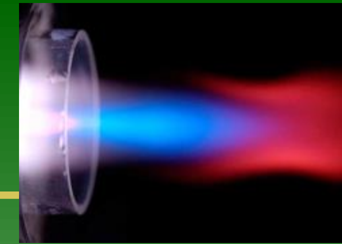
A soil density study of scoop mass was conducted using five reference soils ranging in density from 1.04 to 1.56 g cm^{-3} and M3-P from 11 – 50 mg kg^{-1}.

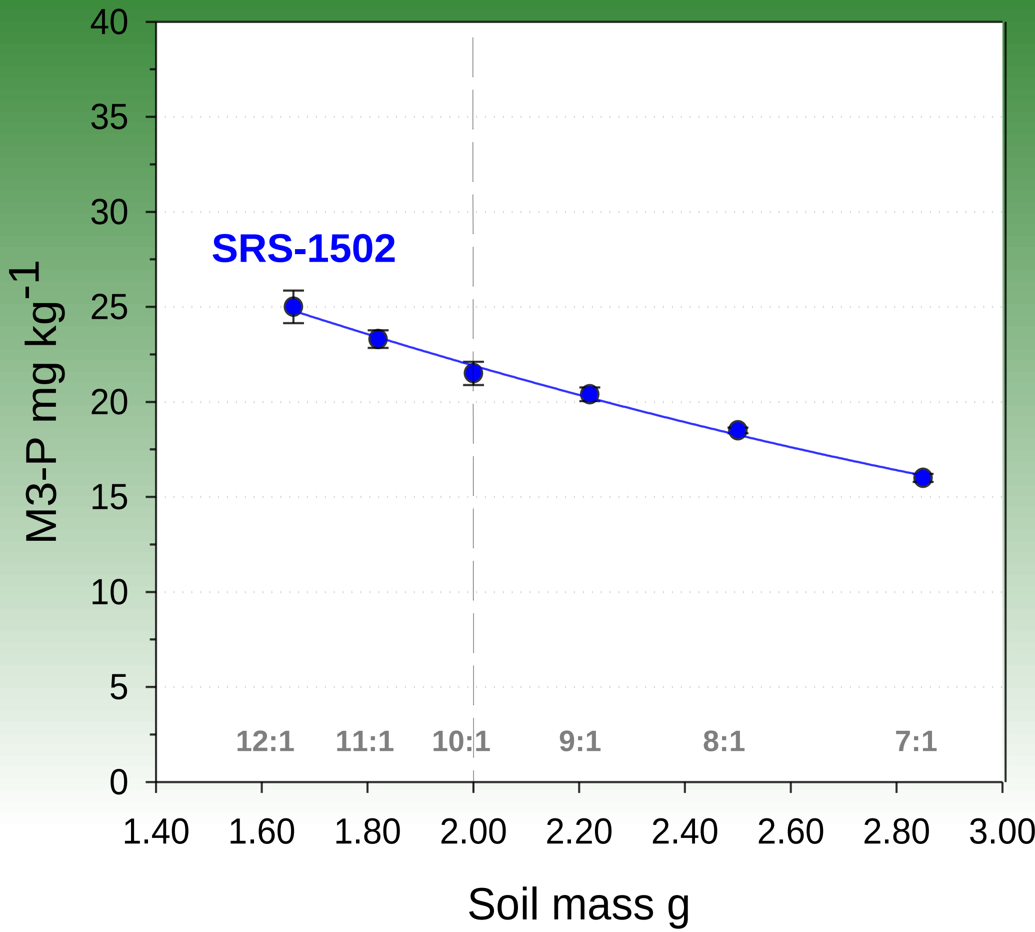
Soils were weighed based on extraction ratios (extractant:soil) of: 7:1, 8:1, 9:1, 10:1, 11:1, and 12:1, extracted with 20 mL Mehlich 3, and analysis by ICP-OES for P, K, Ca, Mg, S and Zn, four replications.

Soil ID	M3-P	Density	Sand
	mg kg^{-1}	g cm^{-3}	%
SRS-0812	33.5	1.56	64.2
SRS-1502	14.8	1.15	12.9
SRS-1914	21.3	1.37	28.2
SRS-2011	50.4	1.45	40.7
SRS-2105	11.2	1.04	30.4

Source: ALP Database, 2008 - 2021.

Assumptions: scoop mass M3-P



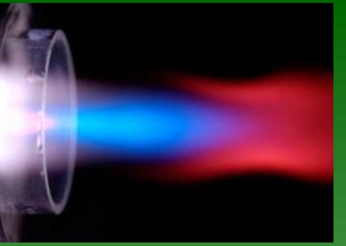


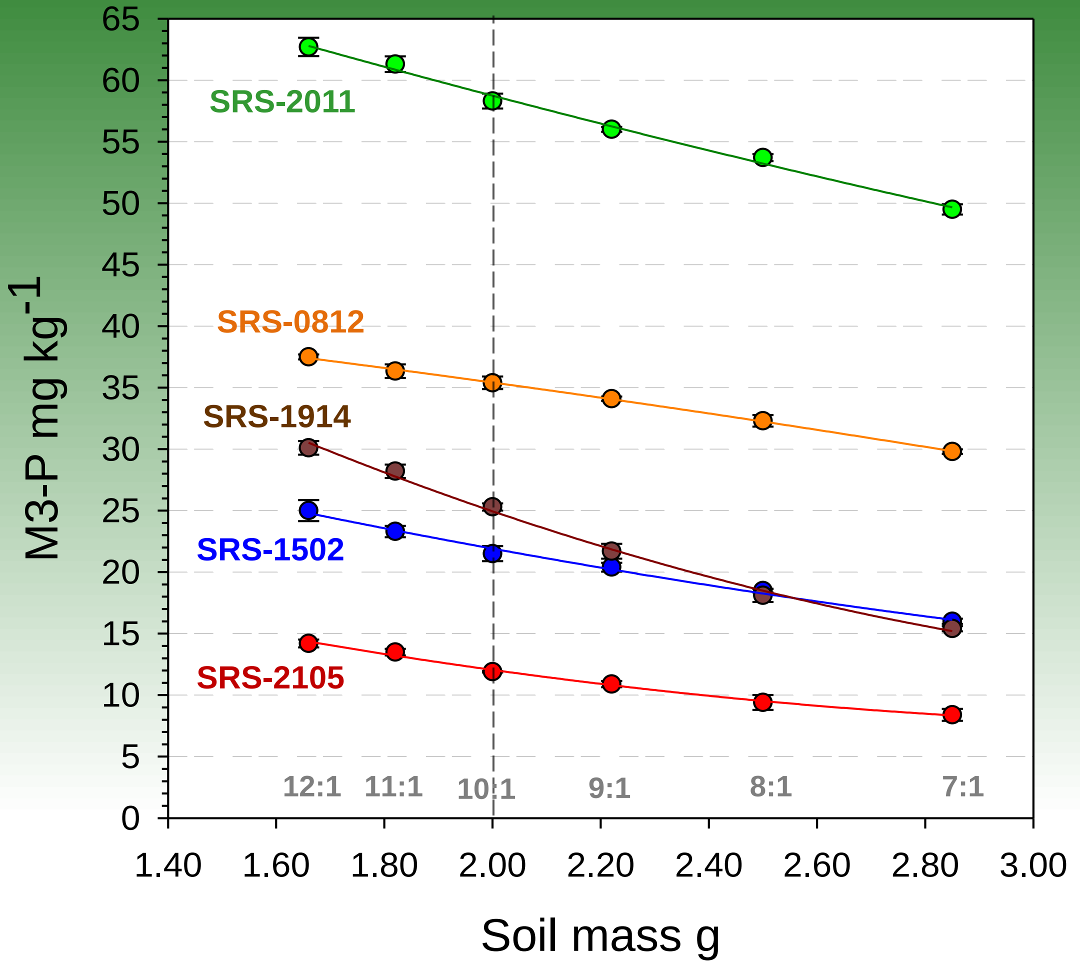
M3 extraction of ALP SRS-1502, soil weighted based on extraction ratios ranging from 7:1 to 12:1 with 20 mL of extractant, analysis by ICP-OES.

Results: M3-P concentration declines with decreasing extraction ratio. Actual 10:1 mass ratio denoted by dashed vertical line.

Data supplied by Steven Piercy, ICP Technician A&L Great Lakes Laboratory.

Assumptions: scoop mass M3-P



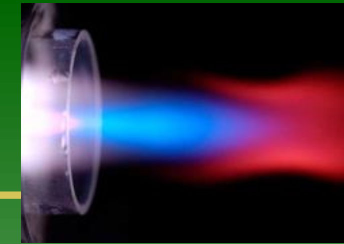


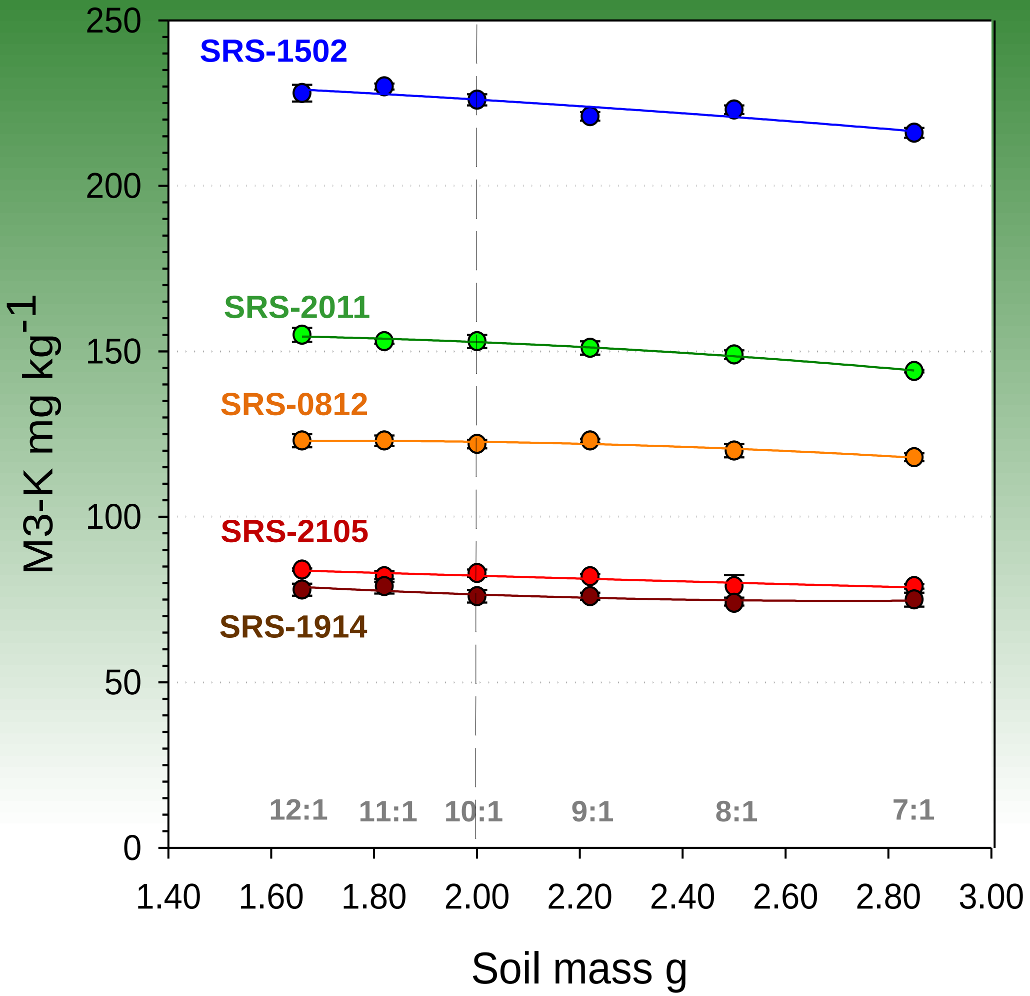
M3 extraction of five reference soils showed consistent M3-P declines with decreasing extraction ratio, independent of soil concentration.

Soil SRS-1914 had a steeper slope than the other four soils.

Data supplied by Steven Piercy, ICP Technician A&L Great Lakes Laboratory.

Assumptions: scoop mass M3-K



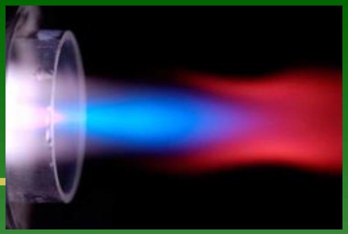


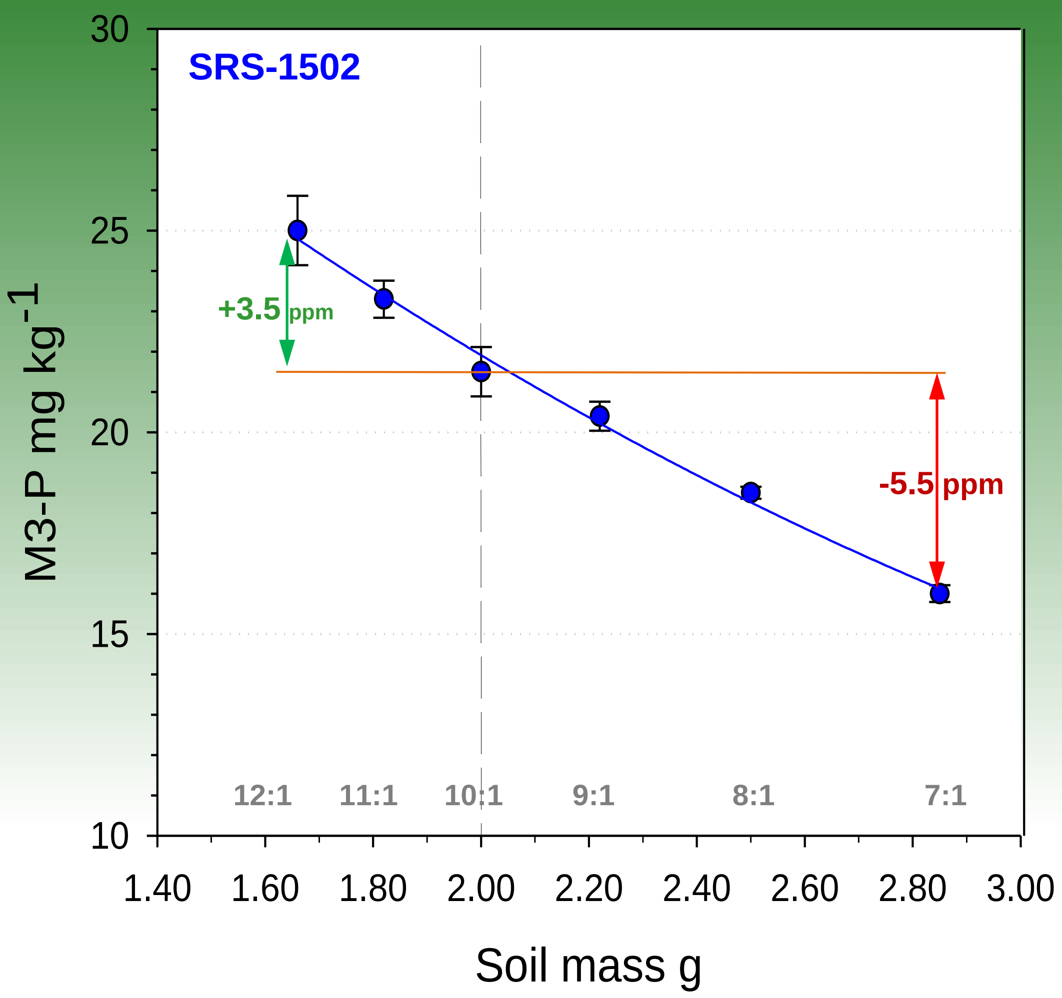
M3 extraction of reference soils, showed little or no changes in M3-K with decreasing extraction ratio, independent of soil concentration.

Similar results were found for M3-Ca and M3-Mg. M3-S and M3-Zn showed minor decreases with increasing mass, and was soil dependent.

Data supplied by Steven Piercy, ICP Technician A&L Great Lakes Laboratory.

Assumptions: scoop mass M3-P





A high scoop soil density results in a lower M3-P value of 5.5 ppm lower than a ratio of 10:1, whereas a low soil density results in a value 3.5 ppm higher.

Ramification, SRS-1502 with a high density has 25% lower soil test P. This may resulted in an increase in the fertilizer recommendation. Opposite for soils of low density.

Data supplied by Steven Piercy, ICP Technician A&L Great Lakes Laboratory.

Assumptions: M3-P content

Soil ID	M3-P 10:1	M3-P 2g scoop[1]	Delta M3-P
	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
SRS-0812	35.9	32.4	- 3.5
SRS-1502	21.5	25.6	+ 3.4
SRS-1914	25.3	22.8	- 2.5
SRS-2011	58.3	54.5	- 3.7
SRS-2105	11.9	9.8	- 2.1

[1] *2g scoop mass used to calculate M3-P content.*

Across the five soils, those with a scoop mass > 2.30 g resulted in a M3-P low bias of 2.1 - 3.7 mg kg^{-1}. Soils with a mass < 1.8 g resulted in a M3-P high bias of 3.4 mg kg^{-1}.

Midwest LGU soil correlation / calibration is based on a mass/mass extraction, thus a "heavy" or "light" scoop impacts M3-P rec.

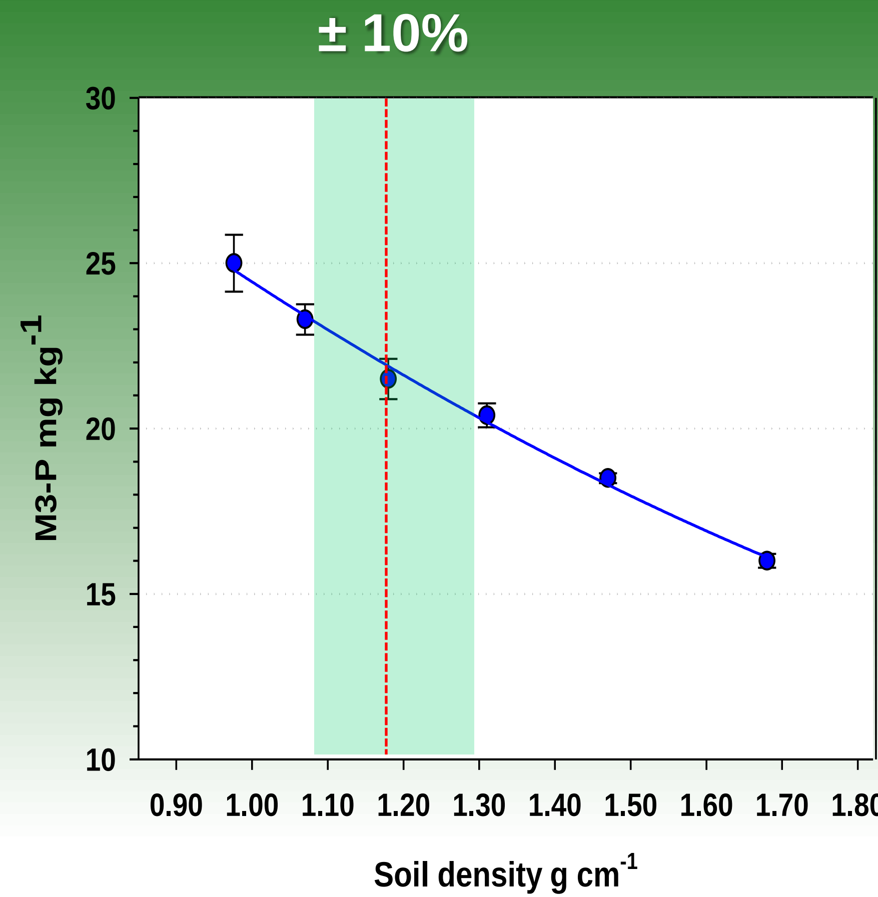
Data supplied by Steven Piercy, ICP Technician A&L Great Lakes Laboratory.

Impact of scoop mass

We have to be mindful that soil densities between 1.05 and 1.30 g cm^{-3} are within M3-P uncertainty. However, densities outside this range likely result in soil M3-P bias and may impact fertilizer management.

Greatest impact, coarse textured soils with M3-P 12-25 mg kg^{-1} .

Soil density has almost no affect on M3 K, Ca, Mg concentrations and none therefore on fertilizer management.



Operational issues

Soil variables:

- Texture: sand content and particle distribution
- SOM content
- Soil moisture
- Soil pulverizing, screen size and particle distribution

Scooping issues:

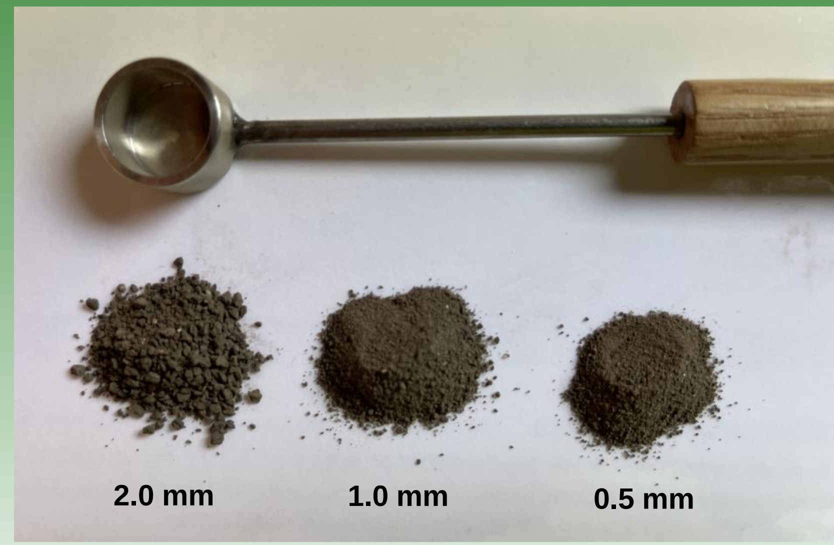
- Scoop technique
- Tapping: tool, tap force, number of taps,
- Technique of striking excess
- Worn scoops

Operational issues: technique

Impact of sieve size on soil mass

Sieve size	2 g scoop mass (g)	
Minus Size (mm)	Mean	Stdev
2.00	**1.756**	**0.035**
1.00	**1.791**	**0.008**
0.50	**1.782**	**0.004**

Soil, silty clay loam, air dried, pulverized using stone rolling pin, and sieved to pass each sieve. 2.0 g scoop, metal spatula tap, four replicates.



Soil pulverized sieve size has minimal impact on 2 g scoop weight, but does improve precision.

Operational issues: technique

Impact of tapping on soil mass

Soil ID	Taps	Scoop mass (g)	
		Mean	Stdev
SRS-1503	0	2.48	0.03
	3	2.59*	0.01
	5	2.62*	0.01
SRS-2105	0	1.36	0.02
	3	1.42*	0.03
	5	1.46*	0.01

ALP soil, 2.0 g scoop, metal spatula tap, four replicates.
*Values denoted by * are statistically different from Tap 0.*

No tapping, scoop and level, resulted in the lowest scooped soil mass. Increasing the number of scoop taps, increased soil mass, independent of soil texture.

Increasing the number of taps improved soil mass precision.

Operational issues: technique

Impact of operator on scoop mass

Soil ID	Tech	Scoop mass (g)	
		Mean	Stdev
SRS-0812	1	2.45	0.05
	2	2.69*	0.04
	3	2.54	0.06
SRS-2011	1	1.47	0.02
	2	1.59*	0.05
	3	1.56*	0.05

ALP soil, 2.0 g scoop, three technicians, four replicates.
*Values denoted by * are statistically different from Tech 1.*

Scoop mass varies by technician. Two soils at right indicates Tech 2 tends to scoop heavy independent of soil.

Scoop variance results are similar across operators and soils averaging 2.5% – 3.4% of the mean, independent of technician.

A heavy scooper can be an issue.

Operational issues

Worn soil scoop

Soil scoop wear over time.

Calibration should be periodically checked and scoop mass verified using reference soil or sand.

The method SOP should define the frequency of verification, and tolerance limits.

Operational issues: SOP

The soil scoop SOP

The SOP should define:

1) **The scoop size, calibration verification and frequency checked.**
   - **Scoop mass exceeding mass specifications by > 5%, replace.**
2) **Define scoop technique, tapping and leveling procedure.**
3) **Training protocol of staff / technician, and performance standard.**
4) **Procedure for addressing and resolving scoop issues.**

[1] Reference calibration verification based on 100 mesh washed silica sand, 7 reps.

Summary

The soil scoop is fundamental to soil testing in 70% of the US. Soil scoops are based on mass and volume basis.

Procedure assumptions of scooped mass impact M3 soil test P, but negligible impact on K, Ca and Mg analyses. Coarse texture soils result in low P bias, and fine texture soils + SOM > 4% result in high P bias.

Operation issues, soil variables and scoop technique, impact method extraction bias and precision. Scoop technique is critical to consistency and minimizing scooped mass bias.

Special thanks

Special thanks to Steven Piercy, ICP Technician and Greg Neyman of A&L Great Lakes Laboratory, Fort Wayne, IN

Byron Vaughan, of Lawns by Dr. Vaughan and former lab Director Harris Laboratory, Lincoln, NE

Mike Lindaman, ALTA-SAC assessor, Boone, IA

Jodi Jaynes, Sure-Tech, Indianapolis, IN

John Spargo, Penn State University

ALTA-SPAC Webinar - January 2022

A webinar is planned for January 11th 2022

- Topic soil: Basics of Quality Control

Thank you for your time and attention

E-mail:
RMiller@soiltesting.us
Txt: 970-217-2572

ALTA
AGRICULTURAL LABORATORY TESTING ASSOCIATION

ALP
Agricultural Laboratory Proficiency Program