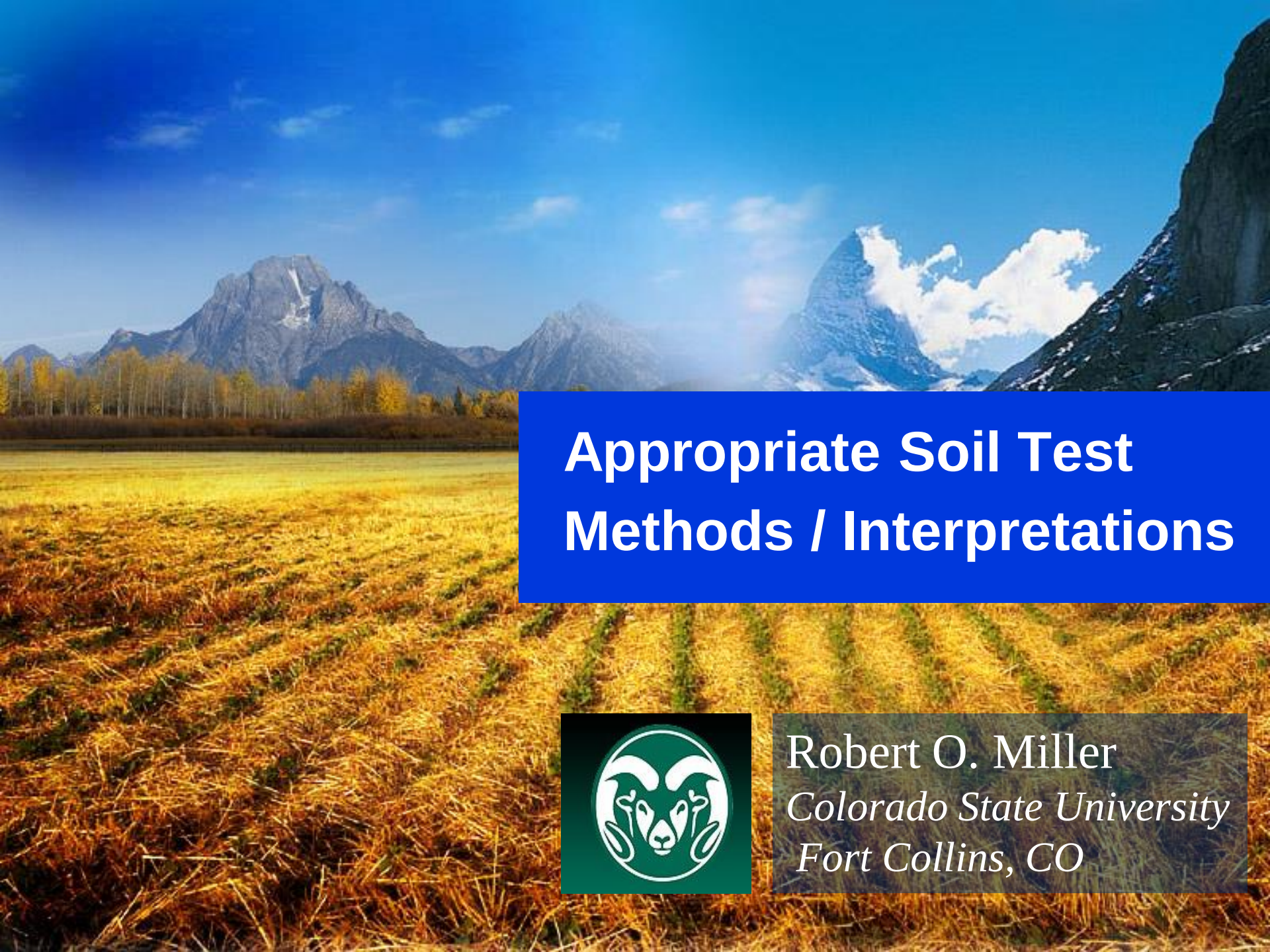


# Appropriate Soil Test Methods / Interpretations

Robert O. Miller
*Colorado State University*
*Fort Collins, CO*

# Background

**Affiliate Professor Colorado State University**
**Extension Soil Specialist UC Davis 1988 - 1997**
**Ph.D. Montana State University**

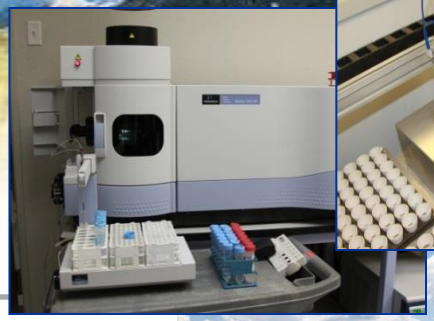
**Coordinate the Agricultural Laboratory Proficiency (ALP) Program; three other lab proficiency programs.**

**Conduct Regional Research in: Soil sampling, Soil fertility, Lab analysis and Soil test calibration.**

Photographed at the William Lefler farm in Sarpy County, Nebraska in the mid-1930s.

Millard Lefler, Craig Hubbard, Harry Lefler, William Lefler

# The ALP Program



**ALP Program provides analytical proficiency services to 93 laboratories for evaluating soil, plant, water and environmental analyses.**

**37 Years experience and the only accredited Proficiency Testing provider in North America.**

ALP
Agricultural Laboratory Proficiency Program

CTS

# Program Basics

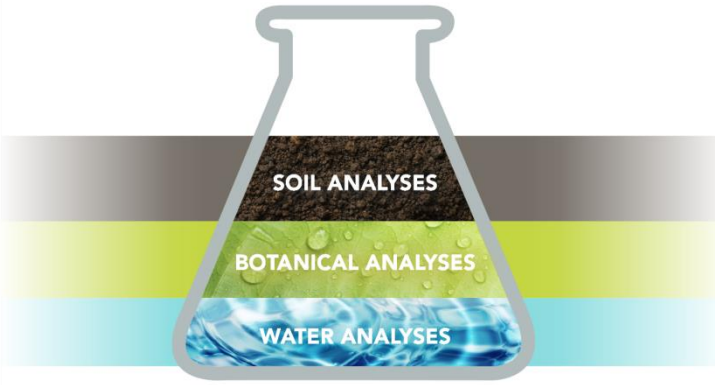
**ALP submits five proficiency soils samples tri-annually, to each testing laboratory. Labs may choose from 132 analysis methods (i.e. SP, EC, P, etc) with each soil analyzed in triplicate. Plants and waters three samples per cycle.**

**Lab performance across the five soils is evaluated for both accuracy and precision.**

ALP
Agricultural Laboratory Proficiency Program

CTS

# ALP Participants




## California Laboratories Enrolled 2014

Ag Laboratory & Consulting
A & L Western Agricultural Labs
Bolthouse Farms
Betteravia Farms
D & D Agricultural Laboratory
Deerpoint Group
Denelle Laboratory
Dirty Business Soil Consulting
J G Boswell Farms
JM Lord Inc.
Morgan Consulting
Precision Agri-Lab
Soil Control Laboratory
Stanworth Crop Consultants, Inc
Valley Tech Agricultural Laboratory
VPN Laboratory
UC Davis Analytical Lab

**AClass Accredited ISO 17043**

# Overview

Basis of Soil Testing

Lab Measurement Uncertainty

Appropriate Use Measurements

Interpretation and Pitfalls

New Methods

# Soil Testing: A Chain

Soil Sample

Test Method

Calibration Database

Soil Testing is based on three components, each required to make an accurate recommendation.

Miller, 2014

Miller, 2014

# Types of Soil Tests

## *Quantitative*

Electrical Conductivity

$NO_3$-N

Total Nitrogen

Clay Content

## *Semi-Quantitative*

Phosphorus (Bray, Olsen)

K, Ca, Mg, Na

Micronutrients (Zn, B, Cu)

SOM

Generally soil fertility methods are semi-quantitative, an index of plant nutrient availability.

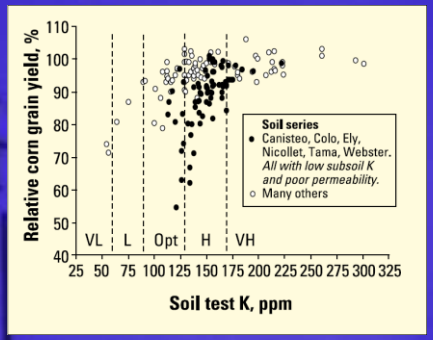


Miller, 2014

# Example: Soil Test P
## An Index of Fertility

Soil Test P (STP) is an *index* of P supply and is not related directly to a quantity.

- *It's based on a* probability of crop response. It is not an intrinsic quantity of P in the soil.
- Two STP methods are used in the Western US: Bray for soils pH < 7.0 Olsen for soils pH > 6.0.
- Phosphorus is measured as ppm, not calculated as pounds per acre.




Mallarino et al., 2003 Better Crops

Miller, 2014

# Standard Soil Analysis Methods

Standard methods for California are published in: *Soil, Plant and Water and Water Reference Methods for the Western Region*, 3rd edition.

Soil methods include:

Saturated paste moisture, pH, EC and soluble ions
pH 1:1 and Buffer pH
$NO_3$-N and $NH_4$-N
Phosphorus, (Bray and Olsen)
K (and extractable Ca, Mg, and Na) by $NH_4$oAC, 1:10 pH 7.0
Zn, Cu, Fe, Mn (DTPA), $SO_4$-S
SOM, TKN, CEC by displacement and $CaCO_3$

Methods not recognized include Mehlich 3 (P, K, Ca, Mg, Na, Zn, Cu, Mn, B) Mehlich 1, CEC by sum of cations,

*Miller, 2014*

# Soil Analysis
## Measurement Uncertainty


**Every measurement has associated with it, an uncertainty limit**


**± 0.5 volts**

**This is true for any measurement**

pH, EC, P, K, yield monitor, speedometer, sprayer output, temperature, etc.

http://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&docid=eZzWiyD7KfWnGM&tbnid=YjSBDFuTqFsR8M:&ved=0CAUQjRw&url=http%3A%2F%2Fwww.bluesea.com%2Fproducts%2F1025B%2FVoltmeter%252010-16%2520Volts&ei=_IAyUe6HKZCFyQG_7IHgAQ&bvm=bv.43148975,d.aWc&psig=AFQjCNH373nb9BVk_iCv0O-4UKVlvMjkjw&ust=1362338131819570

# Soil Testing

**pH** : Measurement of acidity or alkalinity

| | | |
|---|---|---|
| Lab A | 7 | ± 0.5 |
| Lab B | 7.1 | ± 0.05 |
| Lab C | 7.08 | ± 0.05 |

**Which Lab is more accurate?**

**Issue of significant digits**

**Default interpretation is ½ interval of the reported value**

# Uncertainty and Management

**With agricultural management we must always assess the measurement uncertainty in the decision.**

**Example soil EC dS/m**

| Field 1 | Field 2 |
|---|---|
| 2.5 ± 1.0 | 3.5 ± 0.3 |

Example, there is no difference in soil EC for the two fields

Miller, 2014

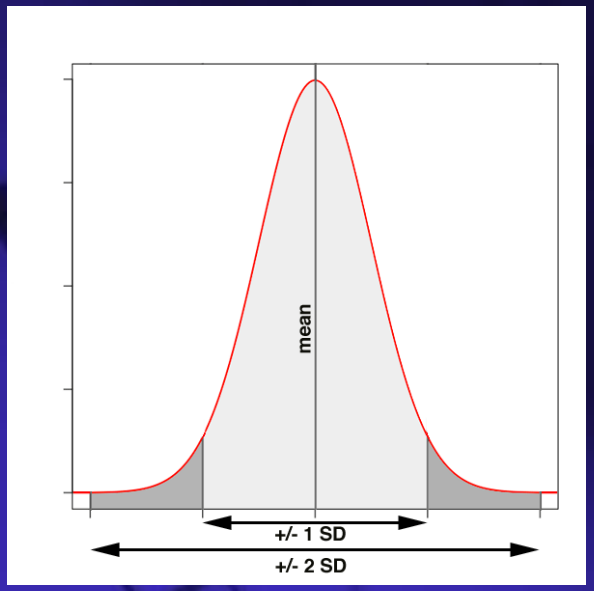
# Uncertainty Calculation

## Equation

$$x \pm t\ s / \sqrt{n}$$

where:

*t(n-1)* is a Student-t distribution with (*n*-1) degrees of freedom, *x* is the sample mean and *S* the unbiased estimate of the true standard deviation. Note often known as the t-test.




http://www.microbiologybytes.com/statsbytes/graphics/normal.png

*Values of Student's t*

| DF | 90 % CL | 95% CL | 99% CL |
|---|---|---|---|
| 2 | 2.92 | 4.30 | 9.93 |
| 3 | 2.35 | 3.18 | 5.84 |
| 4 | 2.13 | 2.78 | 4.60 |
| 5 | 2.02 | 2.57 | 4.03 |

# pH and Salinity

## Method Uncertainty

99% of agronomists and consultants samples are analyzed in a single laboratory.

**pH ± 0.2 across the pH range**

**EC (saturated paste)**

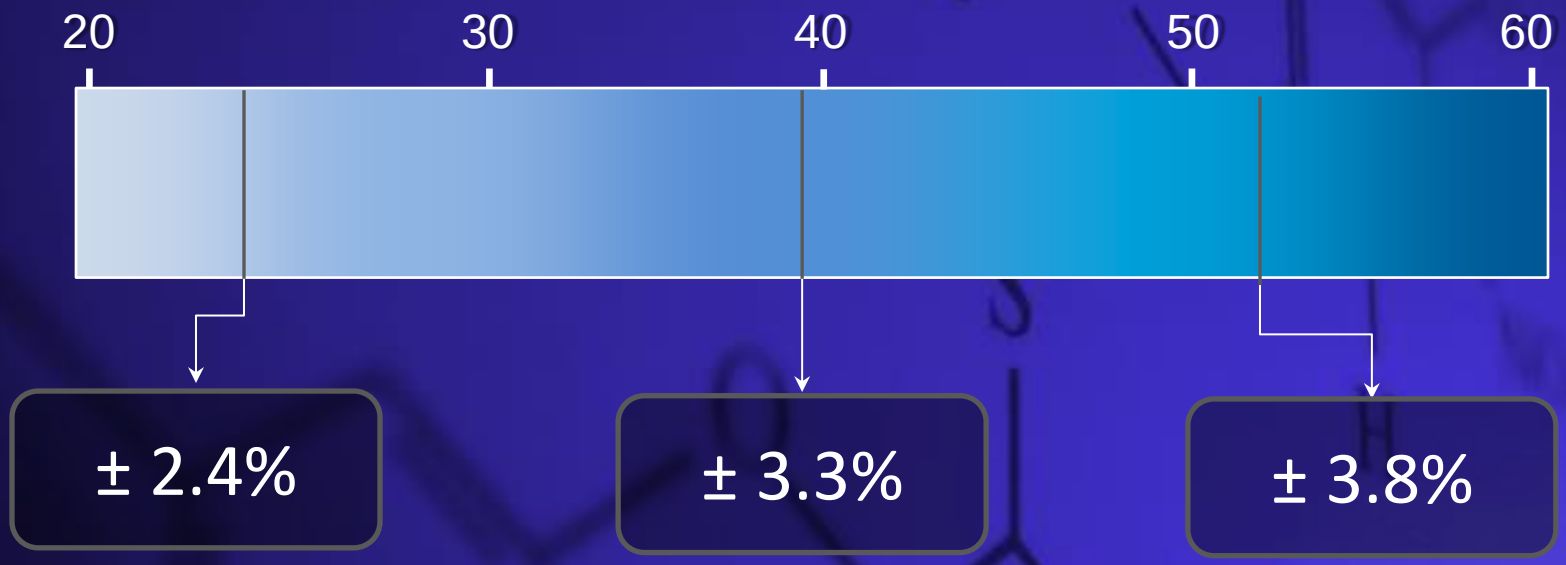
| EC dS/m | Uncertainty |
|---|---|
| 0.5 | ± 0.05 |
| 1.8 | ± 0.09 |
| 3.7 | ± 0.29 |

Miller 2014, within lab uncertainty,
Data from ALP Program

# Saturated Paste Moisture

## Within Lab Uncertainty

Soil saturated paste moisture percentage (%)




Uncertainty changes with analysis range

Miller 2013, within lab uncertainty,
data from ALP Program

# Soil Nitrate

## Within Lab Uncertainty

Uncertainty increases with $NO_3$-N concentration.

Uncertainty of $NO_3$-N analysis is soil method specific with Cd reduction the least and ISE the greatest.

| Soil ID | Median (ppm) | *Uncert* (ppm) |
|---|---|---|
| SRS-0804 | 4.8 | ± *1.2* |
| SRS-0907 | 13.6 | ± *2.7* |
| SRS-1101 | 27.4 | ± *3.2* |
| SRS-1115 | 54.1 | ± *4.6* |
| SRS-1210 | 84.5 | ± *6.8* |

Data based on within lab stdev, average of 30 Labs, uncertainty 95% confidence limits.

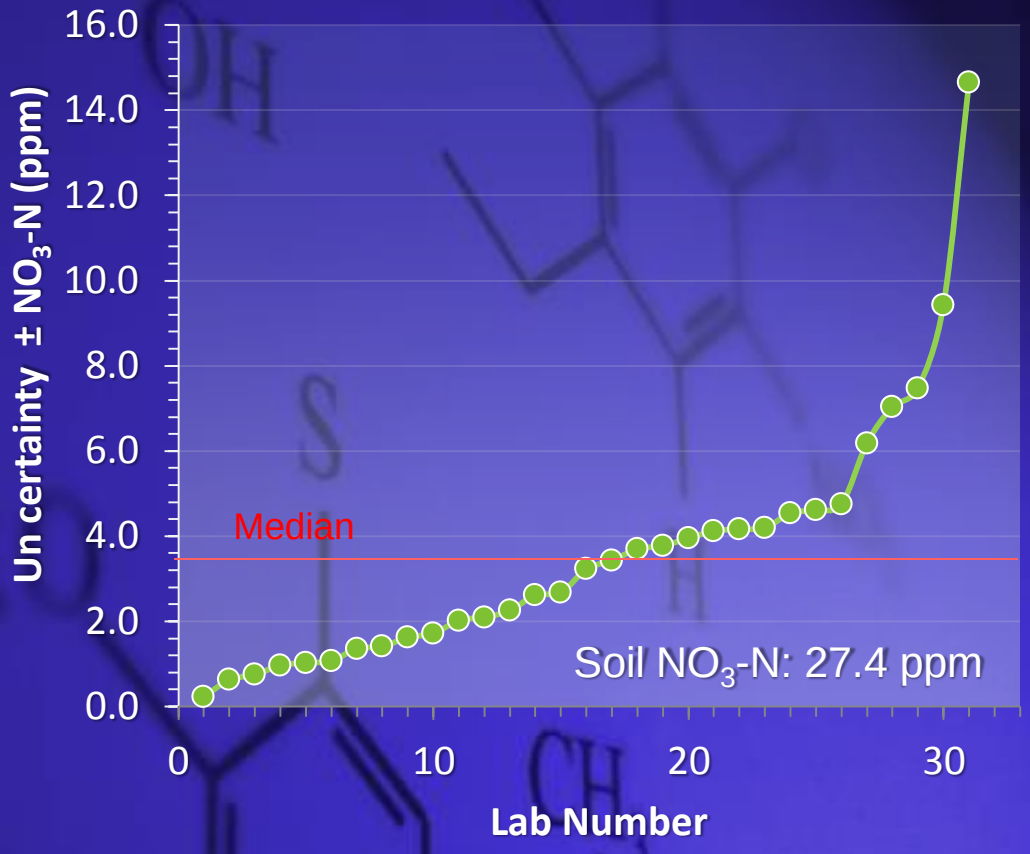
Miller 2013, within lab uncertainty, data from ALP Program

# Lab $NO_3$-N Uncertainty

$NO_3$-N uncertainty across labs

Across labs $NO_3$-N uncertainty ranges from ± 0.2 to ± 14.7 ppm, with a median of ± 3.2 ppm, for soil SRS-1101 [1].

84% of labs provided results for uncertainty < ± 4.0 ppm. Five labs had uncertainties much higher than the median of ALP participants.

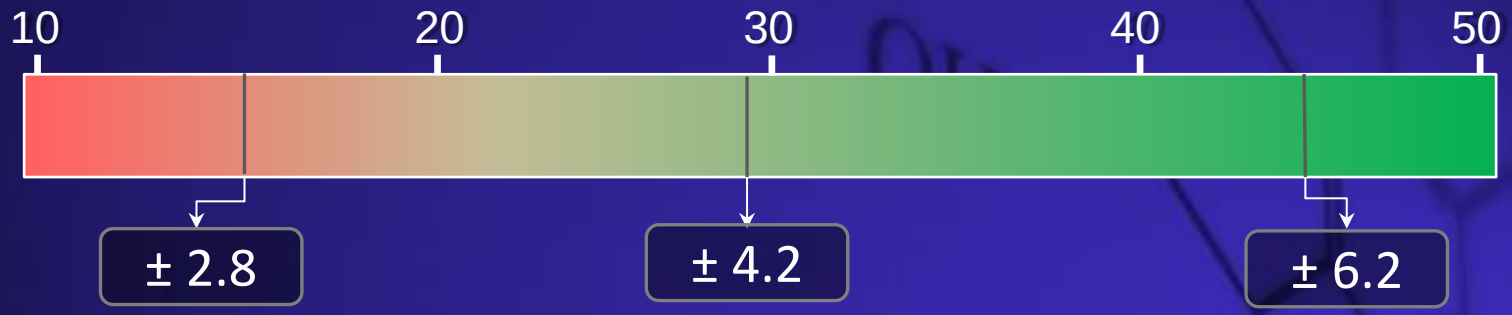



[1] ALP data based on within lab stdev, 31 Labs, uncertainty 95% level.

Miller 2013, within lab uncertainty, data from ALP Program

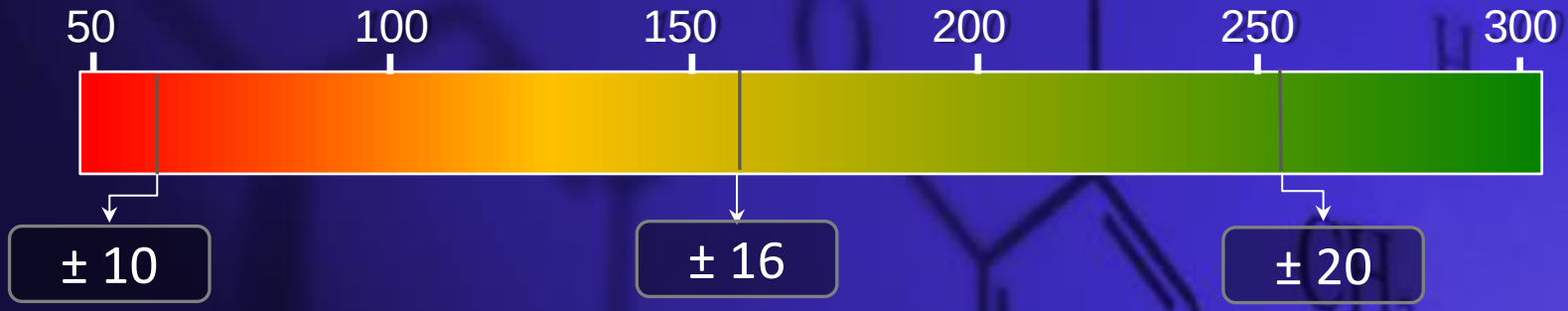
# Soil Test P and K

## Olsen Phosphorus (ppm)




± 15%

## Soil Potassium (ppm)




± 12%

[1] Data based on within lab stdev, 45 Labs, uncertainty 95% level.

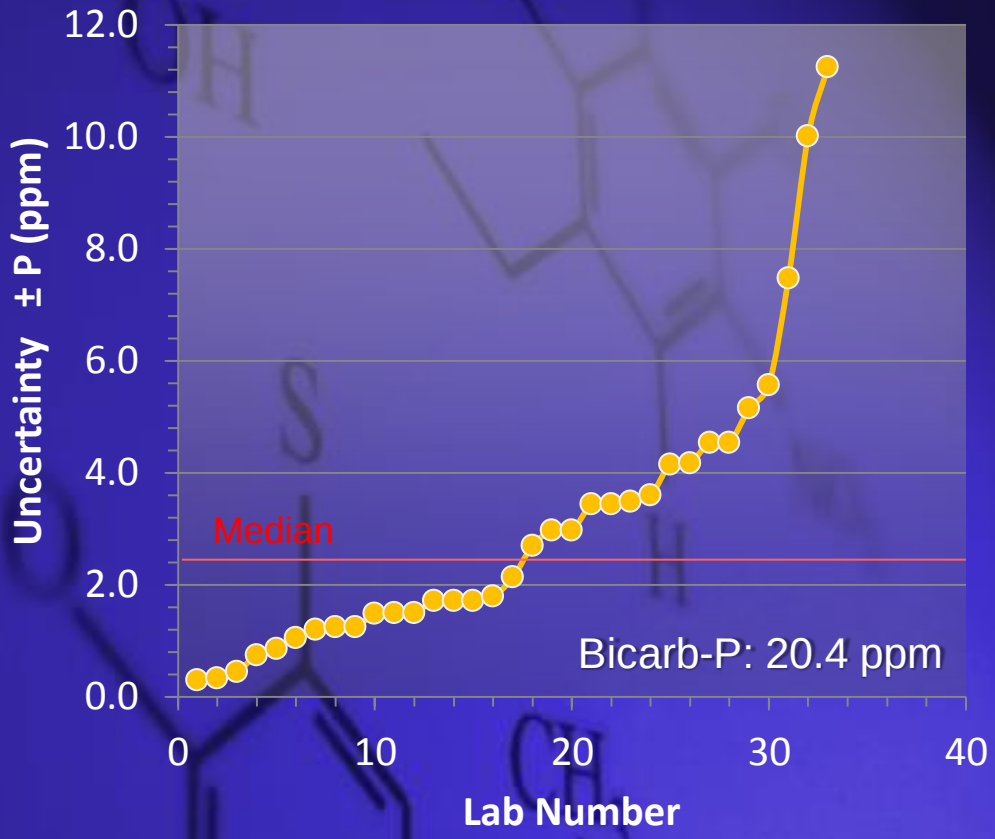
Miller 2013, within lab uncertainty, data from ALP Program

# Lab Olsen-P Uncertainty

## Lab Olsen-P Uncertainty Across Labs

Across labs Olsen-P uncertainty ranges from ± 0.3 to ± 11.2 ppm, with a median of ± 2.2 ppm, for soil SRS-1201 [1].

72% of labs provided results for uncertainty < ± 4.0 ppm.
Seven labs had uncertainties much higher than the median of ALP participants.




Miller 2013, within lab uncertainty, data from ALP Program

[1] ALP data based on within lab stdev, 33 Labs.

# Plant Analysis Uncertainty

ALP SRB-1106, Tissue Leaf

| Analysis Median | | Intra - Lab Uncertainty | |
|---|---|---|---|
| N % | 3.10 | ± 0.119 | ± 3.8% |
| P % | 0.302 | ± 0.024 | ± 8.0% |
| K % | 2.40 | ± 0.107 | ± 4.6% |
| S % | 0.24 | ± 0.023 | ± 9.5% |
| Ca % | 0.78 | ± 0.065 | ± 8.3% |
| Mg % | 0.24 | ± 0.033 | ± 14% |

ALP 30 laboratories providing results. N Results based on Dumas N
Within lab uncertainty based on 95% confidence level, 3 replications.

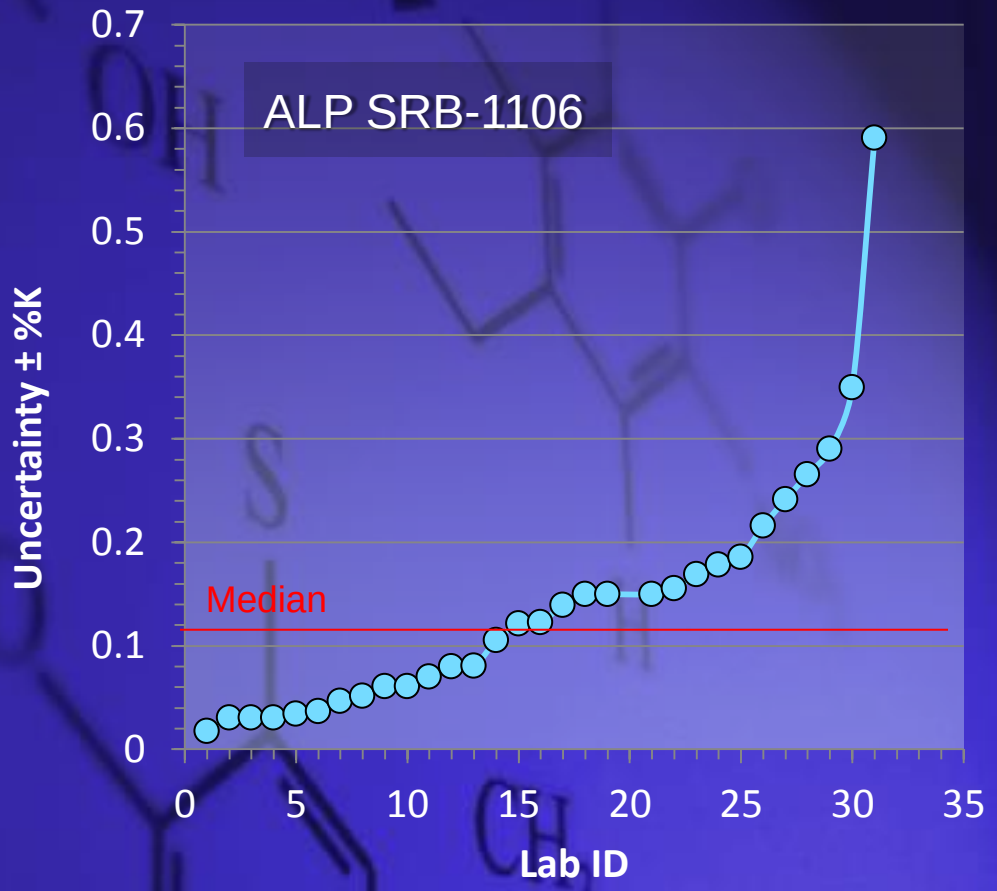
*Miller, 2014*

# Plant Tissue K

Within lab K Uncertainty

Across labs Plant K uncertainty ranges from ± 0.02 to ± 0.6 %K, with a median of ± 0.11 %, for sample SRB-1106 [1].

80% of labs provided results for uncertainty < ± 0.2 %K. Six labs had uncertainties much higher than the median of ALP participants.




[1] ALP data based on within lab stdev, 31 Labs, uncertainty 95% level.

Miller 2013, within lab uncertainty, data from ALP Program

# Plant Analysis Performance - Micros

www.hear.org/starr/images/image?q=080914-9918&o=plants

## ALP SRB-1106, Tissue Leaf

| Analysis Median | | Intra - Lab Uncertainty |
|---|---|---|
| Zn (ppm) | 40.9 | ± 5.8 |
| Cu (ppm) | 11.6 | ± 1.6 |
| Fe (ppm) | 194 | ± 44 |
| Mn (ppm) | 61.1 | ± 4.4 |
| B (ppm) | 15.0 | ± 2.9 |

ALP 30 laboratories providing results. Within lab uncertainty based on 95% confidence level, 3 replications.

*Miller, 2014*

# Soil Analysis

## Right Sample …Wrong Analysis

*The Labs primary responsibility is for the accurate analysis of the sample…. Need to select the most appropriate test.*

**Examples:**

Soil > pH 7.0, Olsen (bicarbonate) is the recommended method for phosphorus, not the Bray P method. Recommend Olsen P pH > 5.8

Calcareous soils, exchangeable calcium is typically over reported, by $NH_4$oAC extraction due to the dissolution of $CaCO_3$.

Estimated CEC for acid soils is under estimated and for alkaline soils CEC over reported. Estimated CEC cannot be calculated from sum of cations.

*Miller, 2014*

# Soil Phosphorus

## Bray vs Olsen Methods ppm

| Soil ID | pH Sat Paste | Bray P | Olsen P | Ratio |
|---|---|---|---|---|
| SRS-1408 | 6.26 | 39.8 | 17.0 | 0.42 |
| SRS-1106 | 6.37 | 26.9 | 10.1 | 0.37 |
| SRS-1209 | 6.51 | 7.3 | 4.6 | 0.63 |
| SRS-0604 | 7.50 | 3.0 | 15.9 | 5.3 |
| SRS-1002 | 8.74 | 2.9 | 19.3 | 6.6 |

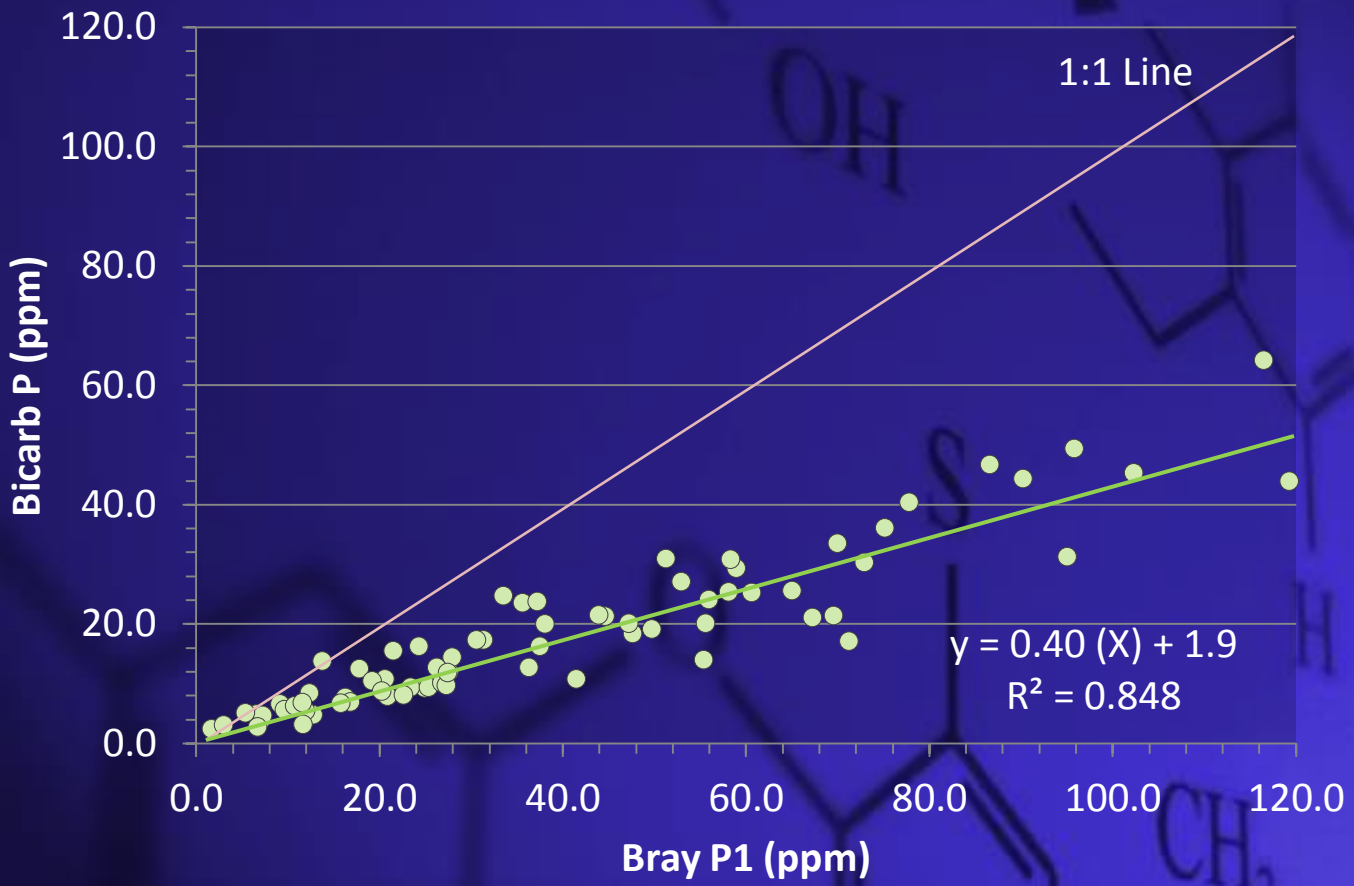
ALP data based on average of 30 Labs, each soil analyzed in triplicate.

**Generally Olsen P is 40% of Bray P for soil pH < 7.3**

Miller, 2014

# Soil Phosphorus

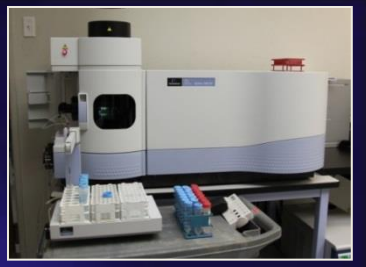
## Bray vs Olsen P




ALP data, 81 soils, pH < 7.3, Bray P1 < 120 ppm.

Miller, 2014

# Exchangeable Ca



## $NH_4OAC$ over estimation

| Soil ID | pH Sat Paste | *$NH_4OAC$ 1.0 N (Ca ppm)* | | $CaCO_3$ % |
|---|---|---|---|---|
| | | pH 7.0 | *pH 8.5* | |
| SRS - 96108 | 7.10 | 1906 | 1389 | 0.5 |
| SRS - 96105 | 7.70 | 4907 | 2841 | 2.0 |
| SRS - 96106 | 7.72 | 3509 | 1703 | 25.0 |
| SRS - 95105 | 7.65 | 4532 | 2367 | 9.0 |
| SRS - 96104 | 6.10 | 1326 | 1381 | 0.1 |

IAS Lab data based on average of triplicate analysis.

**Soil pH > 7.0, $NH_4OAC$ dissolves $CaCO_3$, resulting in over inflated Ca**
**Does not impact K, Mg or Na**

Miller, 2014

# Soil CEC Acid Soils

## Direct vs Estimated Methods cmol $kg^{-1}$

| Soil ID | pH $_{Sat\ Paste}$ | CEC Direct | *CEC Estimated* | Buf pH |
|---|---|---|---|---|
| SRS-0906 | 5.74 | 7.4 | 3.1 | 6.79 |
| SRS-0915 | 4.21 | 5.4 | 2.1 | 6.45 |
| SRS-1008 | 5.59 | 9.2 | 6.6 | 6.87 |
| SRS-1101 | 4.67 | 8.1 | 2.0 | 6.26 |
| SRS-1107 | 5.25 | 20.7 | 8.4 | 6.37 |

ALP data based on average of 30 Labs, each soil analyzed in triplicate.

**Soils with pH < 6.0 results in low bias for CEC estimated**

Miller, 2014

# Soil CEC Alkaline Soils

## Direct vs Estimated Methods: cmol $kg^{-1}$

| Soil ID | pH Sat Paste | CEC Direct | *CEC Estimated* | % $CaCO_3$ |
|---|---|---|---|---|
| SRS-1307 | 5.97 | 4.8 | 5.3 | <0.2 |
| SRS-1308 | 6.70 | 10.9 | 9.4 | 0.7 |
| SRS-1105 | 7.62 | 9.6 | 14.0 | 5.3 |
| SRS-1014 | 7.72 | 37.7 | 43.4 | 51 |
| SRS-1002 | 8.74 | 11.1 | 26.4 | 1.6 |

ALP data based on average of 30 Labs, each soil analyzed in triplicate.

**Soil pH > 7.0 results in high bias for CEC estimated**

Miller, 2014

# Salinity / Sodicity / Boron Toxicity

## Paste Constituents

Saturated Paste is the most important test used to assess soil salinity and sodicity.

Results can be cross checked

10 x EC = □ cations [1]

[1] Results within analysis uncertainty

| Analysis | ALP Soil SRS ID | | |
|---|---|---|---|
| | 0912 | 1014 | 1012 |
| Sat Paste % | 34.6 | 50.5 | 31.0 |
| pH | 7.39 | 7.72 | 7.13 |
| EC dS/m | 1.10 | 3.6 | 0.51 |
| Ca meq/l | 7.6 | 11.6 | 3.4 |
| Mg meq/l | 2.7 | 3.7 | 0.75 |
| Na meq/l | 1.9 | 23.9 | 0.33 |
| SAR | 0.87 | 9.3 | 0.24 |
| □ Cations | 12.1 | 3.9 | 4.5 |

ALP data 41 Labs, each soil analyzed in triplicate.

Miller, 2014

# Saturated Paste Extract

## Paste Anions

Saturated Paste is the most important test used to assess soil salinity and boron.

Results can be cross checked

10 x EC = □ anions [1]

*B values < 0.04 are = '0.0'*

[1] Results within analysis uncertainty

| Analysis | ALP Soil SRS ID | | |
|---|---|---|---|
| | 0912 | 1014 | 1012 |
| Sat Paste % | 34.6 | 50.5 | 31.0 |
| pH | 7.39 | 7.72 | 7.13 |
| EC dS/m | 1.10 | 3.6 | 0.51 |
| B (ppm) | 0.12 | 2.1 | 0.05 |
| $HCO_3$ meq/L | 2.0 | 2.2 | 1.3 |
| Cl meq/L | 0.84 | 11.7 | 0.4 |
| $NO_3$ meq/L | 3.5 | 5.5 | 2.2 |
| $SO_4$ meq/L | 4.9 | 15.7 | 0.7 |
| □ Anions | 11.2 | 35.1 | 4.7 |

ALP data 41 Labs, each soil analyzed in triplicate.

Miller, 2014

# Saturated Paste – Acid Soils

## Paste Constituents

Acid soils typically have $HCO_3$ < 0.5 meq/l and B values < 0.10 ppm.

For acid soils (pH < 6.5) EC is generally high (> 0.4 dS/m) only on soils with high $NO_3$

$HCO_3$ < 0.3 meq/l is near MDL (method detection limit).

| Analysis | ALP Soil ID | |
|---|---|---|
| | 1204 | 1215 |
| Sat Paste % | 30.7 | 41.5 |
| pH | 5.08 | 5.07 |
| EC dS/m | 0.11 | 1.26 |
| $HCO_3$ meq/L | 0.35 | 0.44 |
| Cl meq/L | 0.47 | 0.27 |
| $NO_3$ meq/L | 0.03 | 10.6 |
| $SO_4$ meq/L | 0.26 | 0.07 |
| B (ppm) | 0.04 | 0.03 |

ALP data 41 Labs, each soil analyzed in triplicate.

Miller, 2014

# Saturated Paste Interpretation

- Saturated paste % □ 2 x field capacity
  30.5% □ *15.2% moisture, or 1.3" per* ft soil
- SP pH > 8.0 associated with high $CaCO_3$ contents, pH > 8.5 yield limiting.
- SP EC > 2.0 impact sensitive crops, EC values > 4.0 impact all but very tolerant crops.
- SP Ca:Mg ratios < 2.0 likely to have water infiltration issues, especially on serpentine soils
- SP $HCO_3$ > 40% of anions will result in a higher adjusted SAR value.

Alkaline soils dominated by $HCO_3$ and $NO_3$-N may result in crop Fe deficiencies

Miller, 2014

# Lab Results CSI

## Example 1

A SJV field has been sampled and a new consultant is recommending gypsum for a melon crop which has shown Ca deficiencies in the past.

| SP% | pH | EC | Ca | Mg | Na | SAR | $HCO_3$ | Cl | $NO_3$ | $SO_4$ | B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % | | dS/m | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | ppm |
| 36.0 | 7.56 | 2.3 | 13.2 | 6.1 | 4.8 | 1.6 | 1.6 | 2.8 | 10.9 | 8.9 | 0.2 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| P | X-K | X-Ca | X-Mg | X-Na | SOM | $CaCO_3$ | **CEC** | | | | |
| ppm | ppm | ppm | ppm | ppm | % | % | cmol/kg | | | | |
| 49.3 | 565 | 3450 | 366 | 96 | 1.51 | 5.5 | 12.5 | | | | |

**Is this a good recommendation?**

[1] Real field soil sample, previous crop potato.

# Lab Results CSI

## Example 2

A Sonoma county field under new ownership has been sampled. Field *has had production issues. What' your recommendation for chardonnay* grapes in the 7th year of production.

| SP% | pH | EC | Ca | Mg | Na | SAR | $HCO_3$ | Cl | $NO_3$ | $SO_4$ | B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % | | dS/m | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | ppm |
| 37.9 | 5.46 | 0.41 | 1.1 | 1.3 | 0.8 | 0.73 | 0.36 | 1.23 | 0.6 | 1.39 | 0.08 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| P | X-K | X-Ca | X-Mg | X-Na | SOM | $CaCO_3$ | **CEC** | | | | |
| ppm | ppm | ppm | ppm | ppm | % | % | cmol/kg | | | | |
| 6.9 | 240 | 1174 | 449 | 31 | 2.30 | 0.60 | 10.1 | | | | |

**Why this recommendation?**

[1] Real field soil sample, previous grapes.

# Lab Results CSI

## Example 3

A Turlock almond orchard field has been sampled. Owner not pleased *with production. What' do you see as issues.*

| SP% | pH | EC | Ca | Mg | Na | SAR | $HCO_3$ | Cl | $NO_3$ | $SO_4$ | B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % | | dS/m | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | meq/l | ppm |
| 38.4 | 7.61 | 0.93 | 7.0 | 0.96 | 0.41 | 0.2 | 2.1 | 0.4 | 4.9 | 1.8 | 0.41 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| P | X-K | X-Ca | X-Mg | X-Na | SOM | $CaCO_3$ | **CEC** | | | | |
| ppm | ppm | ppm | ppm | ppm | % | % | cmol/kg | | | | |
| 33.6 | 167 | 3100 | 94 | 12 | 1.70 | 5.50 | 10.6 | | | | |

**What's your recommendation(s)?**

[1] Real field soil sample, almonds.

# New Soil Tests

## Soil Health - Solvita $CO_2$

www.colorbox.com

**Premise:** Rewetting a dry soil with moisture results in a burst of microbial respiration release of $CO_2$. Quantity related to microbial population and soil C & N supply.

**Method:** 50 g of soil is adjusted to field moist, sealed and $CO_2$ content of absorbing gel content measured after 24 hours.

**Interpretation:** low values indicate low microbial population and low potential for N mineralization. Calibration data limited, missing 3rd link of the chain.


http://www.themeterman.com.au/images/solvita-classic-soil-kit.jpg

Developed by Dr. W. Brinton, Woods End Laboratory.

# New Soil Tests

## Solvita $CO_2$


http://www.themeterman.com.au/images/solvita-classic-soil-kit.jpg

ALP results show the Solvita method has inconsistencies in specific labs for some soils.

Lab comments indicate that low values are associated with $CO_2$ leakage, resulting low bias.

Method uncertainty suggests Solvita interpretation ranges: 0-10, 10-20, 20-30, 30-50 and > 50 ppm.

| Soil ID | *Lab A* | *Lab B* | *Lab C* |
|---|---|---|---|
| SRS-1406 | 7.8 | 7.3 | 6.0 |
| SRS-1407 | 9.7 | 7.8 | 2.3 |
| SRS-1408 | 57.1 | 57.2 | 34.9 |
| SRS-1409 | 37.2 | 30.8 | 14.6 |
| SRS-1410 | 31.1 | 27.2 | 24.0 |

ALP data 9 Labs, each soil analyzed in triplicate, June 2014.

Miller, 2014

# New Soil Tests

## Uni-best Test


**Premise:** Based on an ion exchange resin to extract nutrient cations and anions from soil. Developed by Dr. E. Skogley at Montana State, Univ. Marketed as lab and in-field soil test.

**Method:** Resin Capsule is placed in soil for 4 days. Extracted and tested in laboratory. Quantitative for NO3 and soil index for all other nutirents.

**Interpretation:** Little or no calibration data limited. Missing 3rd link of the chain.

Miller, 2014

# New Soil Tests

## Soil Optix Sensor

**Premise:** Based on passive sensor measurement of isotope decay of thorium, potassium 40, uranium and cesium in upper foot of soil. Algorithms are then developed with standard soil tests which include texture.

**Method:** In field scanner, capable of sub acre resolution developed in the Netherlands. Requires standard soil test calibration.

**Interpretation:** Little or no calibration data limited. Needs to be correlated.

http://www.practicalprecision.ca/wp-content/uploads/CG_SoilOptix_COFS_2013.pdf

www.practicalprecision.ca

Miller, 2014

# Conclusions

**All soil analyses testing has associated with it uncertainty, which needs to be considered when reviewing lab results.**

**All lab results have uncertainty. Specific labs have wide uncertainty issues.**

**Low analysis test values near the lab detection limits are problematic. (ie. B saturated paste < 0.5 ppm)**

# Continued

**Specific analysis methods are prone to miss use. Bray is not appropriate for alkaline soils. Estimated CEC (sum of cations) is susceptible to errors. Saturated Paste provides useful information for making salinity / sodicity / nutrients.**

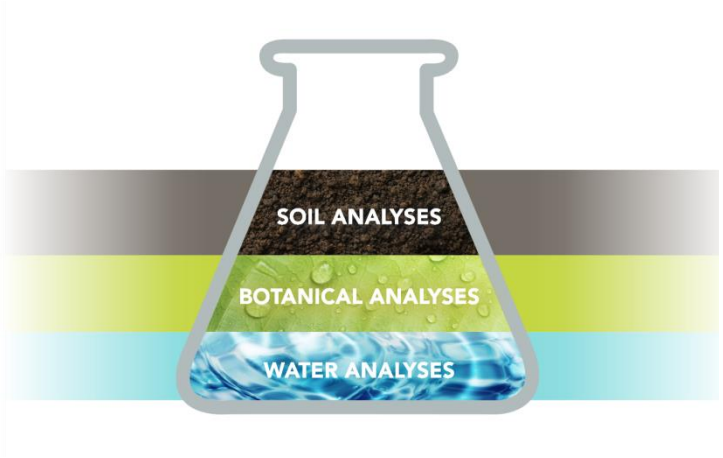
**Evaluate soil results based on multiple analyses, site/crop history.**

**New methods need to have calibration, without which the test is just a number!**

Miller, 2014

# ALP Program

## Laboratory Quality




**Test Method**

When contacting a laboratory verify they are enrolled in a proficiency program – *and that it's a program that* assesses lab performance based on both accuracy and precision!

**AClass Accredited ISO 17043**

Miller, 2014

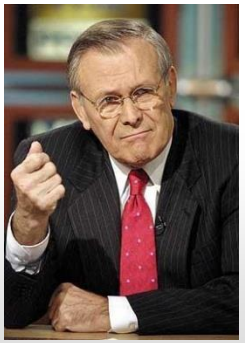

Thank You for Your Time
and Attention

# The Unknown

***There are known knowns.***
***We also know, there are known unknowns.  That is to say***
***We know there are some things***
***We do not know.***

***But there are also unknown unknowns, The ones we don't know we don't know.***

—



*D. Rumsfeld Feb. 12, 2002  Department of Defense news briefing*

# Soil Testing: A Chain

Soil Sample

Test Method

Calibration Database

Soil Testing is based on three components, each required to make an accurate recommendation.

Miller, 2014

# Mapping P Uncertainty

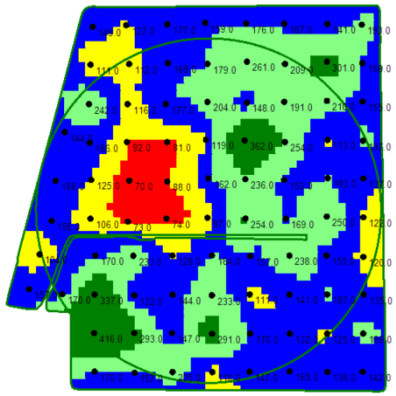
*What is your uncertainty?*

*Olsen P = 16 ppm*

*Method Uncertainty ± 4*

*16 ± 4 ppm*

| | | |
|---|---|---|
| 12 | 15 | 18 |
| 14 | 13 | 17 |
| 19 | 14 | 20 |



# New Soil Tests

## Soil Health – H3A

*Premise: New extractant for NO3-N, P and K based on dilute organic acids developed by Dr. Rich Haney at USDA-ARS. May be used in conjunction with soluble C and N.*

*Method: 5 g of soil extracted with organic acid, analysis by ICP-AES.*

*Interpretation: low values indicate low fertility. Calibration data limited. Little or no field research.*

**SOIL HEALTH ANALYSIS**

| Lab Number | 0048 | 0049 |
|---|---|---|
| Description | FIELD D | FIELD E |
| **Soil Health Results** | | |
| Respiration (Solvita $CO_2$-C) (ppm) | 36.4 | 29.0 |
| Water Extractable Organic Carbon (ppm) | 153 | 191 |
| Water Extractable Organic Nitrogen (ppm) | 9.3 | 16.1 |
| Organic C:N | 16.4 | 11.9 |
| Organic N:P | 0.4 | 1.9 |
| % Microbially Active Carbon | 23.8 | 15.2 |
| Soil Health Calculation | 6.1 | 6.4 |