Assessing the Accuracy and Precision of Soil Chemical Analyses Performed by Eight Agricultural Laboratories

Andre Biscaro,
Irrigation and Water Resources Advisor
University of California Cooperative Extension,
Ventura County

University of California
Agriculture and Natural Resources

Acknowledgments:

- Co-PI:
  Robert Miller, ALP Program Director, former Extension Soil Specialist, UC-Davis

- Project Cooperators:
  Steve Orloff, UCCE Advisor (*in memoriam*)
  Dirk Holstege, UC Davis Analytical Lab (retired)
  Tim Hartz, UC Davis (retired)
  Anthony Luna, SRA, UCCE Ventura
  Eryn Wingate, Tri-Tech Ag Camarillo

University *of* California
Agriculture and Natural Resources

Presentation Outline

- Context of soil chemical analyses
- Material and methods
- Results
- Summary

Context of Soil Chemical Analyses

- An accurate soil chemical analysis is the cornerstone of an efficient nutrient management program
- Without a reliable soil test result, significant mistakes in fertilization programs can occur, resulting in under or over fertilizer recommendations
- This can dramatically affect profitability and can potentially have negative environmental consequences

Context of Soil Chemical Analysis

- Skewed soil analyses can also bias the data and findings of soil fertility and nutrient management research
- In some cases, dozens or hundreds of soil samples are collected from a single site and submitted to a laboratory for fertility assessment
- Deciding which laboratory to send a sample to can be a daunting task

Context of Soil Chemical Analysis

- Unfortunately, there are no public data reporting the accuracy of the analysis performed by agricultural laboratories, and there isn't a true certification program in the United States

- Current proficiency programs, the Agriculture Laboratory Proficiency (ALP) and the North American Proficiency Testing (NAPT) are not mandatory, and <u>they do not guarantee quality control</u>

- Lab users deserve to be able to assess the quality of a laboratory before committing and trusting in its results

Objectives

- ✓ Assess the accuracy and precision of soil chemical analysis performed by the eight agricultural laboratories
- ✓ Provide lab users with science-based information of the quality and reliability of agricultural laboratories

Material and Methods

3 times
(December 2018, April and June 2019)

8 Laboratories

- Soil A: SRS-1809
- Soil B: SRS-1714
- Soil C: SRS-1604
- Soil D: SRS-1610

https://collaborative-testing.com

Basic soil fertility:

NO_3-N, P, X-K, X-Na, X-Ca, X-Mg, SO_4-S, CEC estimated, ECe, pH, SPE Cl, Ca, Mg, Na and B, DTPA Zn, Fe, Mn, Cu

University of California
Agriculture and Natural Resources

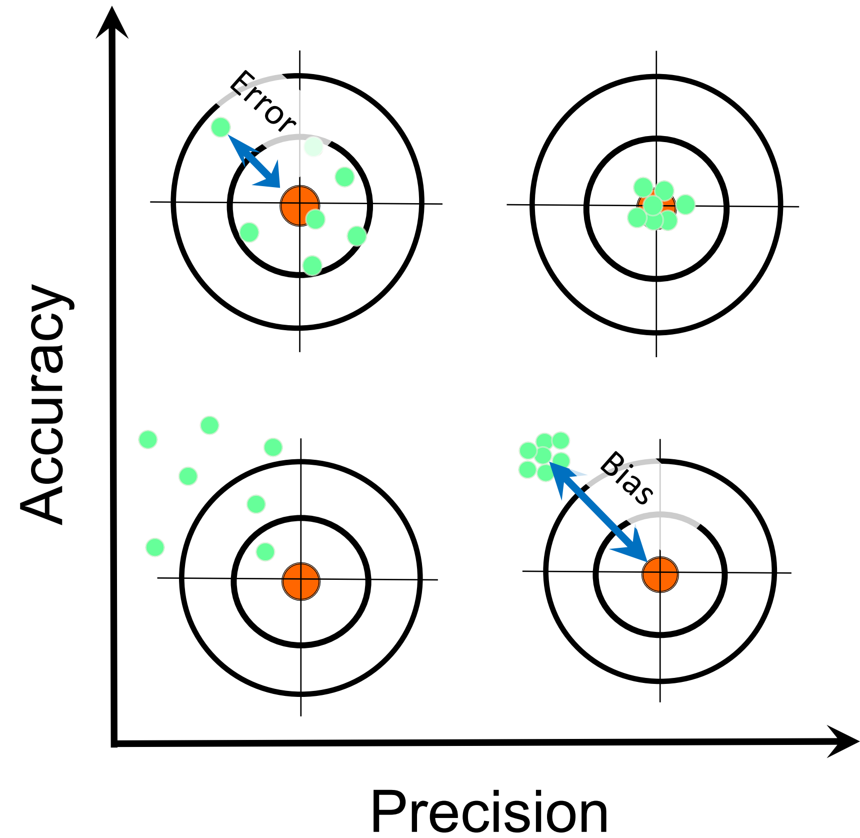
Material and Methods

- Reference soil samples are soils collected by the ALP and analyzed by at least 30 credible laboratories over 90 times total for each sample
- Each of these samples has a nutrient content value determined by the median of those 90+ analyses, and they were used as the reference of nutrient content value

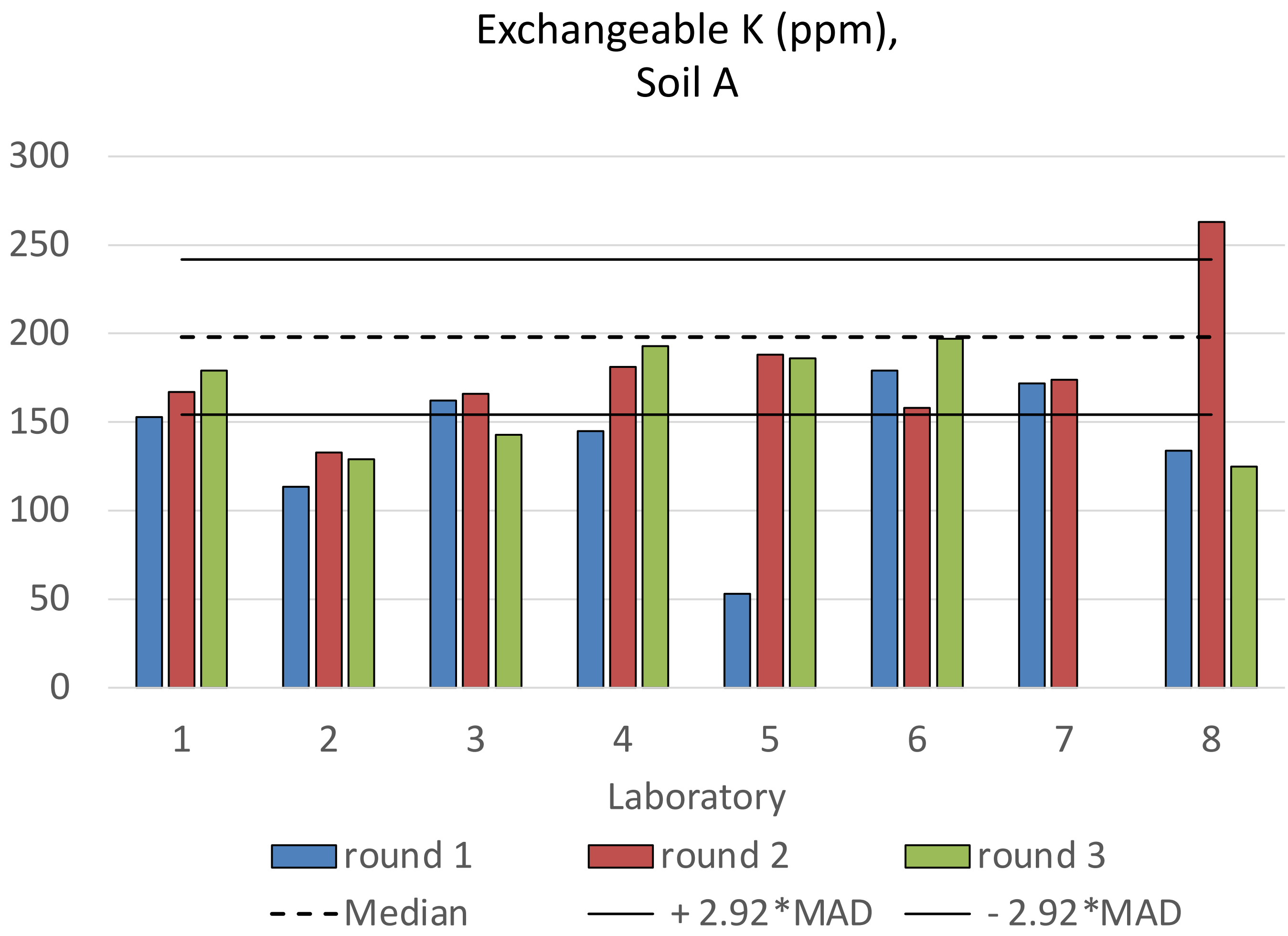
Accuracy vs. Precision

Accuracy: how close the analyses were from the accepted value (ALP's median)

Precision: how variable the analyses of the same soil were across time

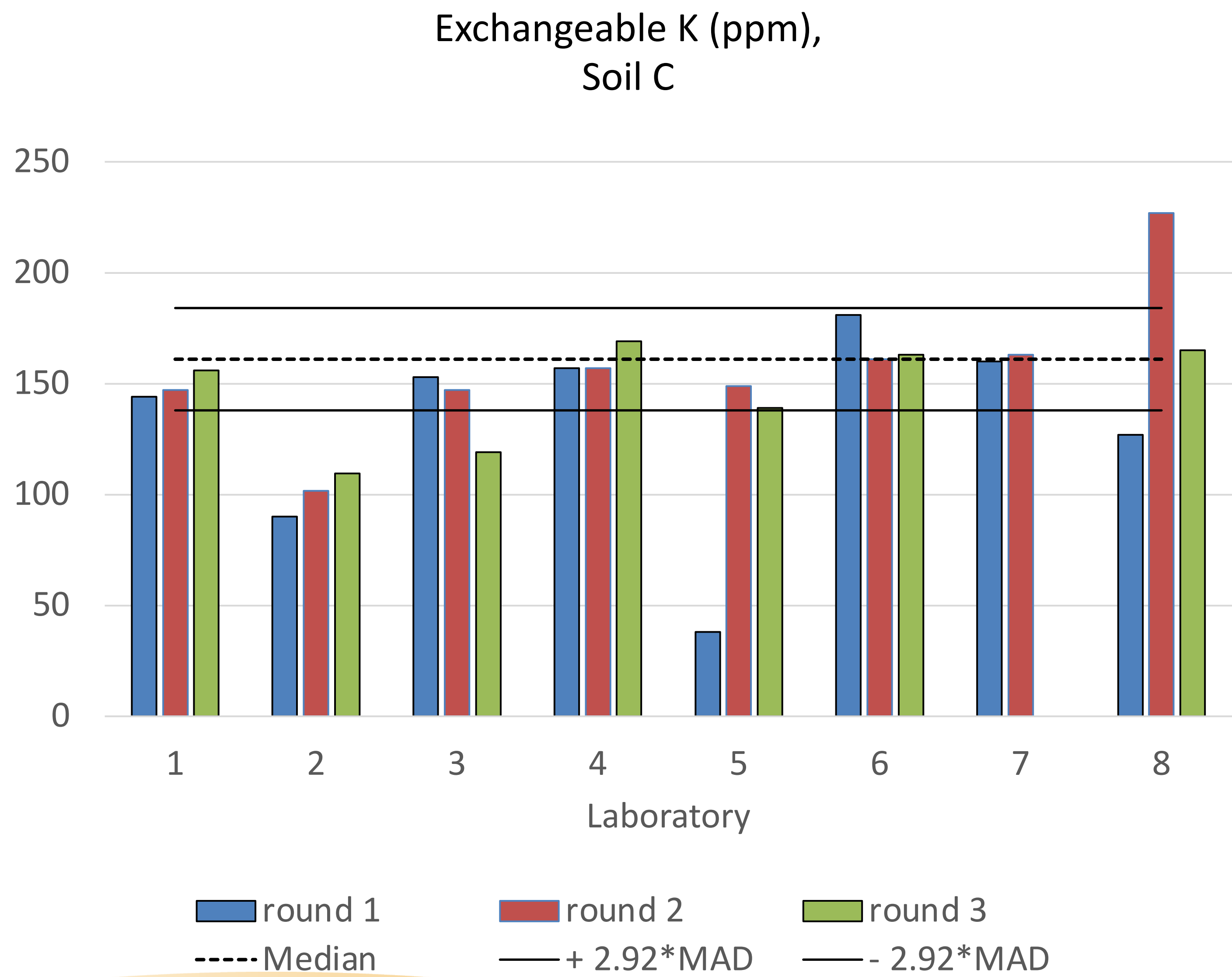


Results

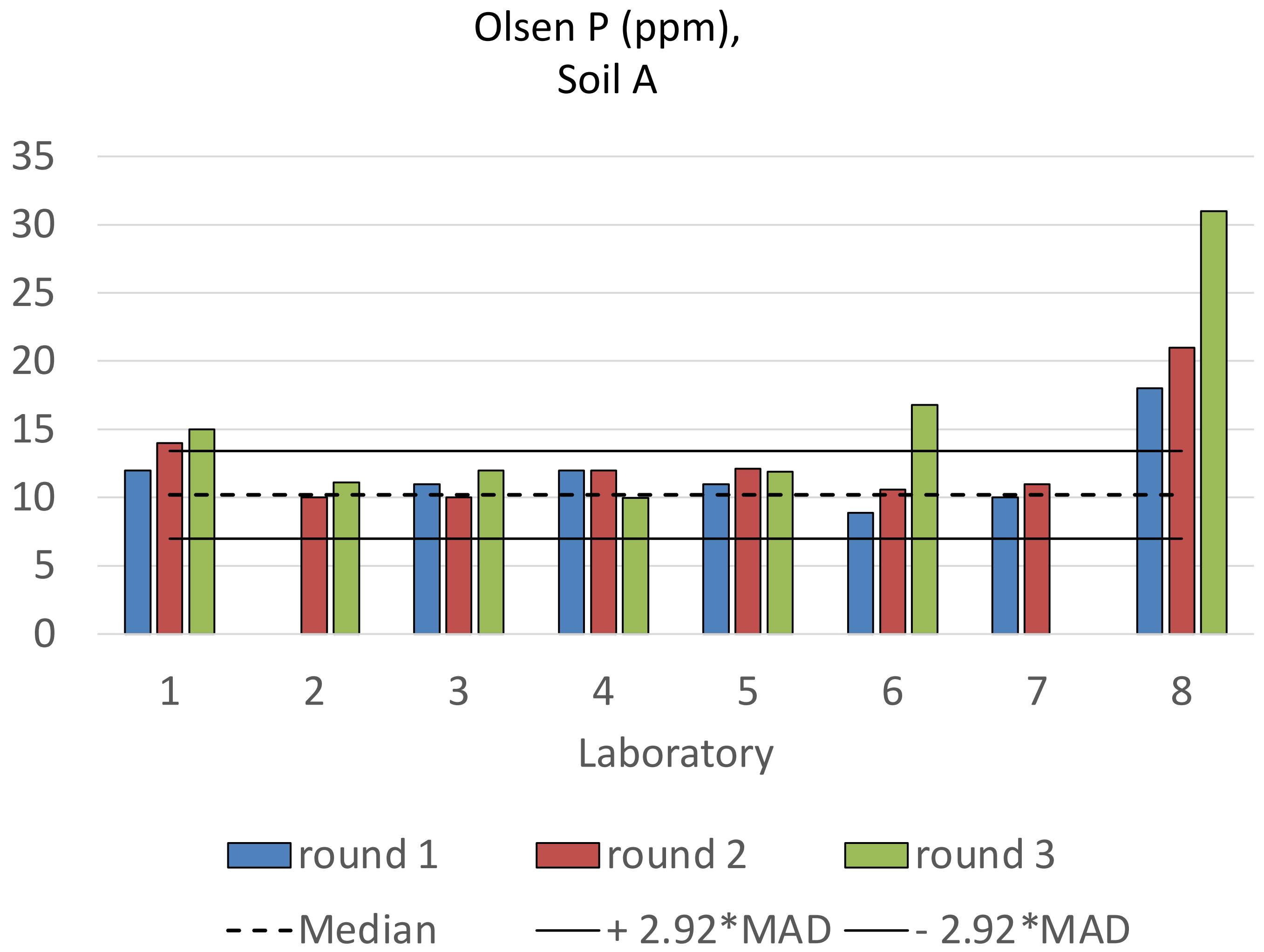


Median Absolute Deviation:
$MAD = Median\ (|X_i - \tilde{X}|)$

University *of* California
Agriculture and Natural Resources

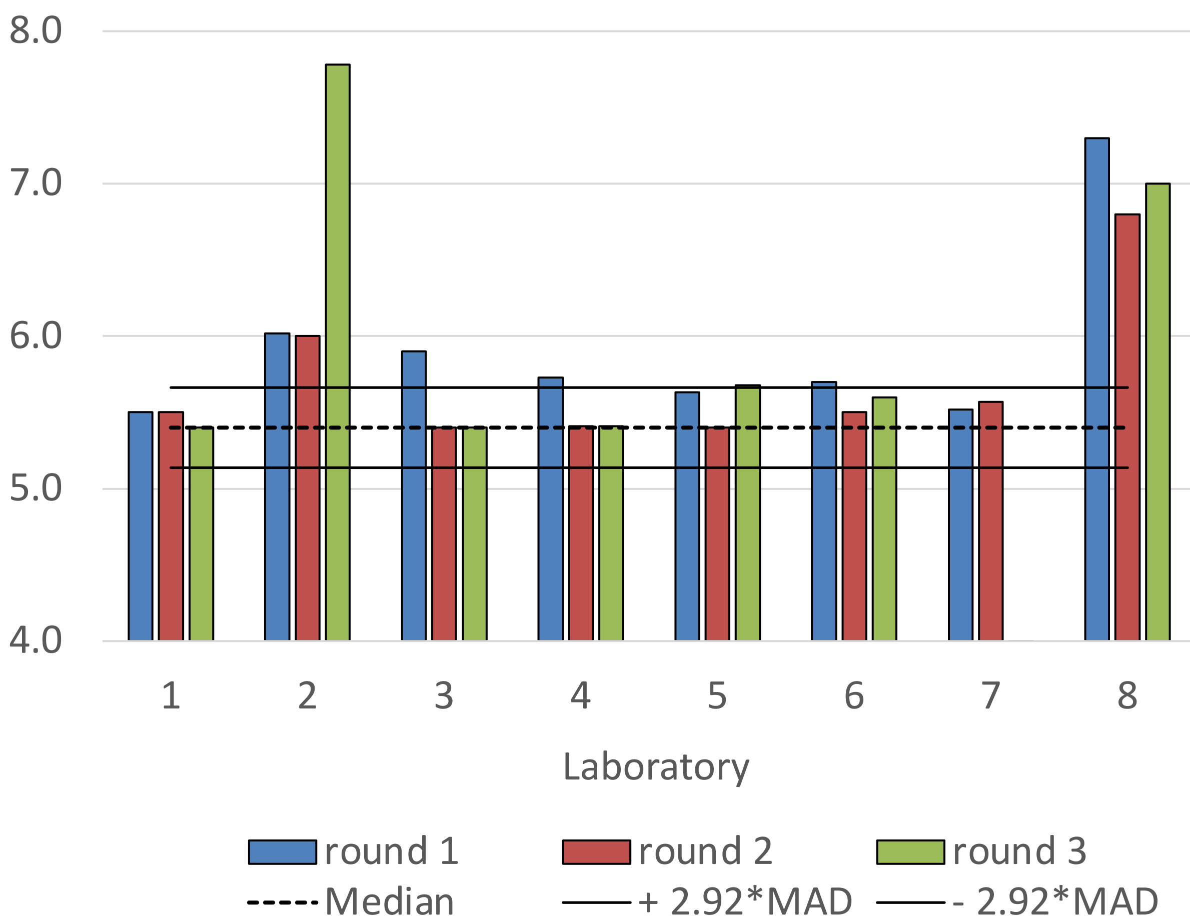


University of California
Agriculture and Natural Resources

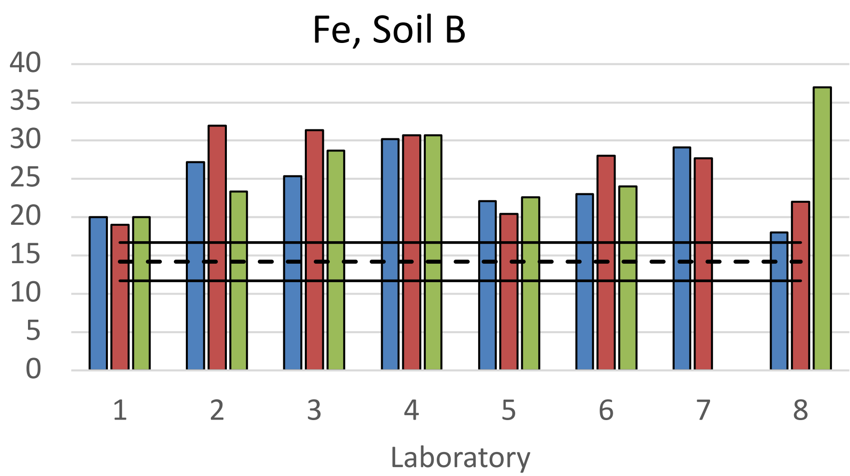


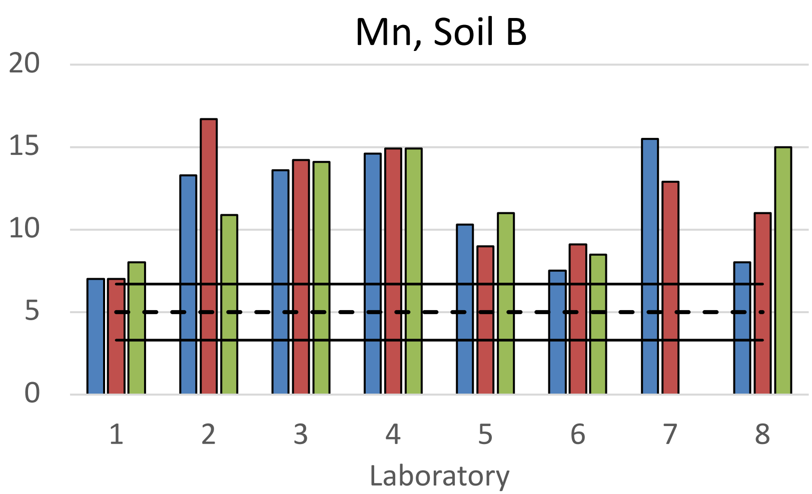
University *of* California
Agriculture and Natural Resources

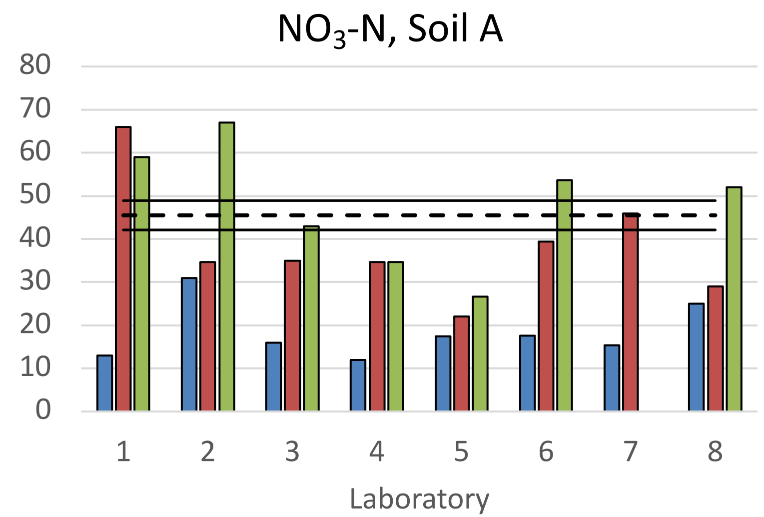
pH, Saturated Paste,
Soil C



Inconsistencies between lab results and reference soils







Soil analyses chosen for the accuracy and precision scores:

- ✓ Olsen P
- ✓ X-K
- ✓ X-Ca
- ✓ X-Mg
- ✓ ECe
- ✓ pH
- ✓ SAR
- ✓ DTPA Zn

Data Analysis

Accuracy Method:

Failure: > ALP's median + (2.9*MAD)
< ALP's median - (2.9*MAD)

Median Absolute Deviation:
MAD = Median ($|X_i - \tilde{X}|$)

✓ The overall precision score was calculated as a proportion of unflagged analyses to the total number of analyses

Data Analysis

Precision Method: ratio of the standard deviation to the mean for each analysis and soil across the three rounds.

Relative Standard Deviation:
RSD% = (SD/Mean)*100

✓ Non-acceptable analyses were 'flagged' as outliers based on ALP's standards

✓ The overall precision score was calculated as a proportion of unflagged analyses to the total number of analyses

Results

Example: Lab #1

Analysis	Soil ID	Media	MAD	±95% CL	1st		2nd		3rd		RSD %	
Olsen P	SRS-1604	**12.5**	1.6	4.7	13.0		13.0		15.0		8	
	SRS-1610	**26.2**	3.7	10.8	34.0		32.0		35.0		5	
	SRS-1714	**24.0**	4.0	11.7	33.0		33.0		37.0	* H	7	
	SRS-1809	**10.2**	1.1	3.2	12.0		14.0	* H	15.0	* H	11	P
X-K	SRS-1604	**160**	7.9	23	144		147		156		4	
	SRS-1610	**95**	11	31	100		118		123		11	P
	SRS-1714	**489**	75	219	438		446		461		3	
	SRS-1809	**199**	15	44	153	* L	167		179		8	
X-Ca	SRS-1604	**6.8**	*0.40*	1.2	6.0		6.2		6.7		6	
	SRS-1610	**3.4**	*0.30*	0.9	3.4		3.6		3.9		7	
	SRS-1714	**9.0**	*0.60*	1.8	8.4		8.2		8.7		3	
	SRS-1809	**8.7**	*0.70*	2.0	6.8		8.2		8.6		12	P
X-Mg	SRS-1604	**2.5**	*0.14*	0.4	2.2		2.6		2.7		9	
	SRS-1610	**0.7**	*0.07*	0.2	0.7		0.8		0.8		7	
	SRS-1714	**2.4**	*0.16*	0.5	2.2		2.3		2.3		4	
	SRS-1809	**1.4**	*0.07*	0.2	1.1	* L	1.3		1.4		12	P
SPE - pH	SRS-1604	**5.40**	0.1	0.26	5.5		5.5		5.4		1	
	SRS-1610	**5.94**	0.1	0.26	6.0		5.9		5.9		1	
	SRS-1714	**6.79**	0.1	0.38	7.2	* H	6.9		7		2	
	SRS-1809	**7.41**	0.1	0.35	8.0	* H	7.8	* H	7.6		3	P
ECe	SRS-1604	**1.95**	0.1	0.41	0.9	* L	1.8		2.6	* H	48	P
	SRS-1610	**1.99**	0.2	0.61	2.0		2.3		1.8		12	
	SRS-1714	**2.32**	0.1	0.18	0.8	* L	2.8	* H	2.3		53	P
	SRS-1809	**1.79**	0.1	0.35	0.5	* L	1.3	* L	1.5		48	P
SAR	SRS-1604	**0.20**	*0.02*	0.06	0.24		0.29	* H	0.28	* H	9	
	SRS-1610	**0.27**	*0.03*	0.08	0.25		0.34		0.29		14	
	SRS-1714	**0.22**	*0.02*	0.06	0.24		0.29	* H	0.29	* H	10	
	SRS-1809	**1.45**	*0.07*	0.19	1.30		1.35		1.39		3	
Zn (DTPA)	SRS-1604	**0.90**	0.1	0.26	1.4	* H	0.8		1.3	* H	28	P
	SRS-1610	**1.01**	0.2	0.44	1.7	* H	1.4		1.6	* H	10	
	SRS-1714	**11.2**	1.4	4.1	13.3		11.8		13.5		7	
	SRS-1809	**0.87**	###	0.26	1.10		1.00		1.10		5	
	Score average per submissio				**71.9**		**81.3**		**78.1**			

Overall Proficiency Score % 77.1

Overall Precision Score % 71.9

Overall Accuracy and Precision Scores

	Laboratory #							
	1	2	3	4	5	6	7*	8
Accuracy %	77	52	62	68	71	77	88	21
Precision %	72	54	63	58	56	69	84	17

*Only participated in rounds 1 and 2

Summary

- ✓ Although all labs presented certain inaccuracy and imprecision, some stood out
- ✓ Laboratories 2 and 8 were consistently inaccurate and imprecise throughout the analyses and soils
- ✓ Laboratories 1 and 7 were the most accurate and precise
- ✓ Laboratories 3, 4, 5 and 6 presented fluctuating accuracy and precision

Other observations

- ✓ Main challenge of the industry is consistency: methods of analyses, reporting of the methods, reporting units, and of the interpretation of the results;
- ✓ Lab users could advocate for lab's adhesion to a proficiency program where there is a standard for expected performance.

Poll questions

Thank you!

Robert Miller
rmiller@soiltesting.us
(970)217-2572

Andre Biscaro
asbiscaro@ucanr.edu
(805)645-1465

University of California
Agriculture and Natural Resources