NEW TOOLS IN SOIL AND MANURE TEST INFORMATION INTERPRETATION IN UTAH

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INTRODUCTION

An effort is underway to update the USU Analytical Laboratory's (USUAL) procedures and data presentation/interpretation capabilities. Modern database management tools and analytical instruments have, in many cases, gone under-exploited in reducing sample turn-around time, in improving data dissemination and interpretation, and in providing research and extension personnel with access to comprehensive historical and current trend data on soil fertility, and manure and plant analysis.

This presentation will outline the efforts being made, and detail the development of procedures and database/educational products designed to meet the stated goals. Specifically, the following examples within this updating effort will be discussed: a) the streamlining of manure analysis procedures for pH and salinity determinations, b) the development of a comprehensive manure test database for Utah, c) the development of a coupled state-wide and county-level database of historical soil test information, and d) the development of an annual newsletter of state-wide and county-level soil test and sample demographic information.

Streamlining Manure Analysis Procedures for pH and Salinity Determination

The number of manure and compost samples submitted to the USUAL has been steadily increasing over the past several years. The state is home to a growing number of dairies, poultry facilities (turkey and egg laying facilities), and swine production operations. Increasingly, growers and homeowners alike are looking to local manure and compost products as a source of fertilizer and for soil conditioning, hence the increase in demand for analysis.

There has, therefore, been a pressing need to streamline the processing of these samples for improvements in efficiency and turn-around time. One of the bottle-necks in the process has been the use of standard saturated-paste extraction methods for obtaining solutions for pH and salinity determination (by electrical conductivity, or EC). In many laboratories around the country, volumetric dilution methods (1:1 or 2:1 water:solid ratio) are employed to reduce the time-intensive process of obtaining these solutions. The USUAL recently undertook an investigation to explore the possibility of changing to one of these volumetric dilution methods.

This is the first time such methods have been tested in Utah, so there was no local calibration database useful in comparing saturation extract data to volumetric dilution determinations. The USUAL put out a request through the network of county Extension agents and livestock specialists in Utah, for participation in this effort by asking for submission of as many different types and sources of manure and composts that could be used in the calibration effort. Samples were requested in triplicate from as many locations as the agents were able to find in their areas. In total, about 200 samples were submitted to the USUAL covering bovine (dairy cow, calf, and feeder cattle), equine, ovine (sheep), caprine (goat), swine, and poultry sources in the state.

One of the desirable features of volumetric dilution methods is the option of measuring pH and EC directly on the slurry, without extraction. So, for complete comparison to the standard saturation extract procedure currently employed, the following analyses were perfomed: a) pH and EC determination on the standard saturation extract solution, b) pH and EC determination directly on the saturation paste, c) pH and EC determination on volumetric dilution (both 1:1 and 2:1) solutions following vacuum filtration, and d) pH and EC determination on volumetric dilution slurries without filtration.

Calibration of EC measurements

The comparison between the standard method (saturation extract) and direct electrode measurement of EC on the saturated paste and volumetric dilution slurries, are shown in Figures 1 through 3. Two important results to note are 1) as the ratio of water to solid increases, errors in direct electrode measurements (on the saturated paste or dilution slurries) decreased as noted by decreasing scatter in the data, and 2) the reduction in error at higher dilution (2:1) results in improved correlation to the standard saturation extract determination.

Calibration of pH measurements

The comparison between the standard method (saturated paste) and direct electrode measurement of pH on the volumetric dilution slurries (both 1:1 and 2:1) is shown in Figure 4. It is important to note from Figure 4 that there is almost no change in pH measurement at the higher dilutions. The slopes of the resulting correlations between direct electrode measurement on dilution slurries and on the saturated paste are nearly equal to 1.0 and the intercepts are nearly equal to zero. Hence, there seems to be no loss of pH information by employing either of the volumetric dilution methods.

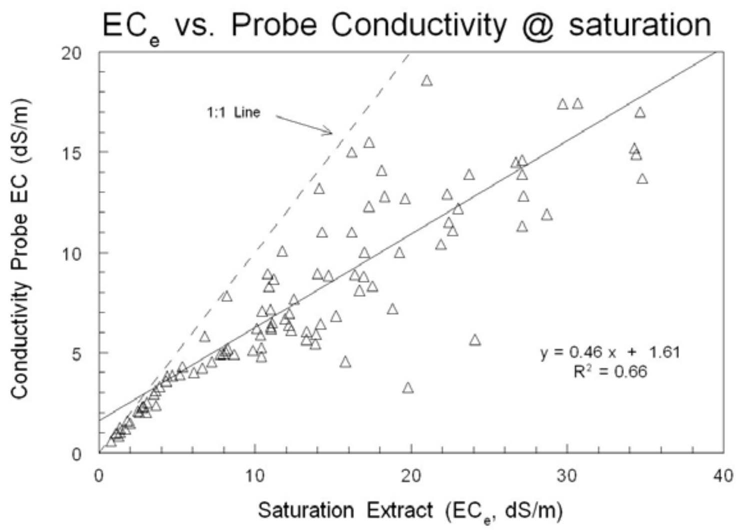

Figure 1. Correlation between saturation extract EC and direct electrode EC measurement on saturated paste

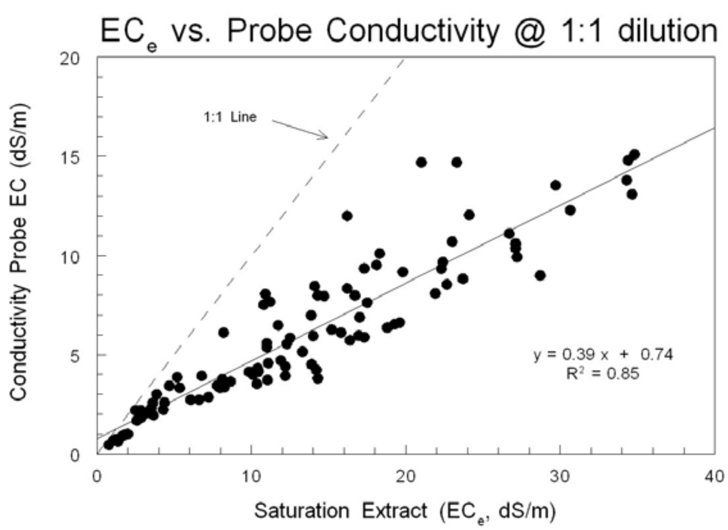

Figure 2. Correlation between saturation extract EC and direct electrode EC measurement on 1:1 dilution slurry

Summary of Streamlining Study

The information shown in Figures 1 through 4 indicate that a change to the 2:1 water-to-solid volumetric dilution method will allow rapid and accurate determination of pH and salinity on manure and compost samples from a wide range of sources. Direct electrode measurement on the dilution slurry is also appropriate and further reduces the time and effort needed to obtain measurements.

In the future, the USUAL will employ the 2:1 volumetric dilution, direct electrode measurement method for the determination of pH and EC on these materials. Further, the USUAL will report the 2:1 test value for these measurements along with a calculation of the saturation extract value determined from the calibrations given in Figures 3 and 4.

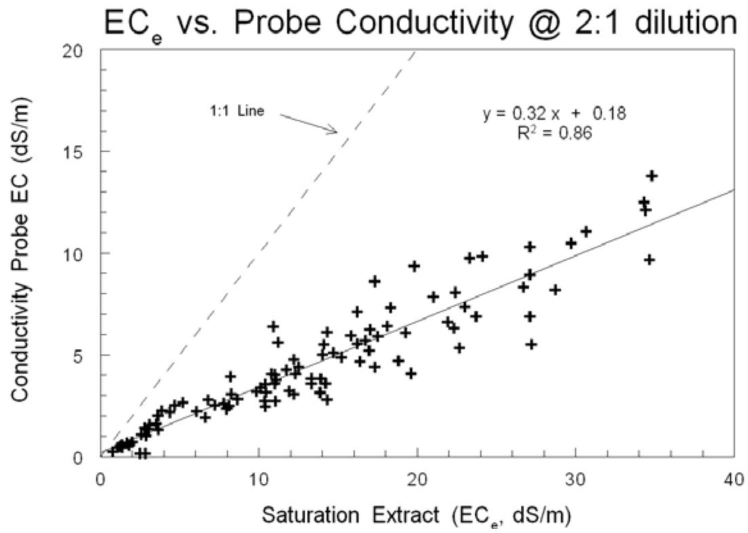

Figure 3. Correlation between saturation extract EC and direct electrode EC measurement on 2:1 dilution slurry.

Comprehensive Survey and Database of Manure Test Levels for Utah

The samples noted in the previous section were also used to build a comprehensive manure and compost test level database for the state. Many inquiries are handled each day by Extension specialists and extension agents regarding "typical" levels of pH, salinity and nutrient content of manures and compost. Information from the literature is available, but is both scattered and often incomparable due to differences in handling and measurement.

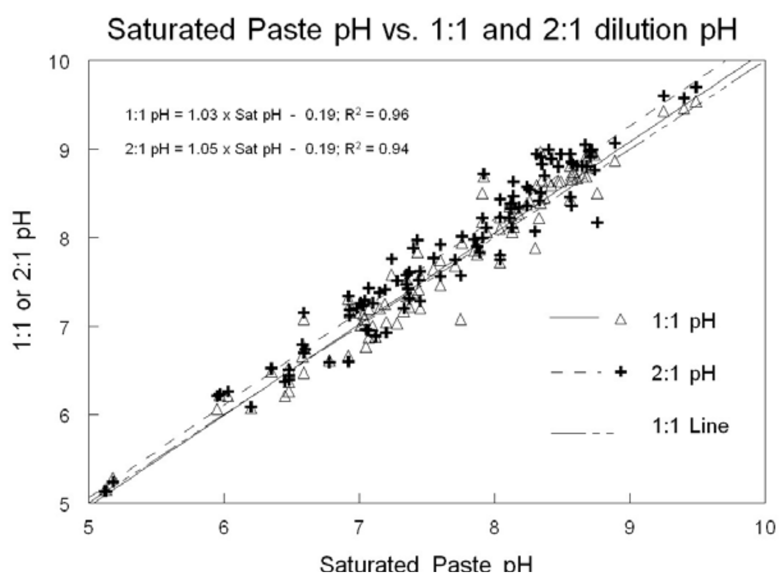

Figure 4. Correlation of saturated paste pH measurement and pH measurements on 1:1 and 2:1 volumetric dilution slurries.

The number of samples and breadth of sample sources described in the previous study, provided an opportunity to create a valuable, comprehensive, uniform database of "typical" values for pH, salinity, and Nitrogen content particularly, and the content of 40 additional elements, secondarily, useful in guiding the utilization of these resources across the state. The discussion of results is limited in this presentation to pH, salinity (as EC) and N content (%, on an as-is basis). However, the comprehensive elemental content of these materials is also available.

The survey results are given in Tables 1 through 3. For each determination, the mean value and range for each type of manure or compost is given. It is no surprise to those working with these materials to note the variability in and among manure sources. The width of the ranges on each source is large enough to motivate individual source testing, and will be used to encourage such. The most interesting finding in this survey is the stand-alone quality of Caprine (goat) manure. This type of manure has a moderate average pH (8.11), low average salinity (ECe = 1.41 dS/m) and relatively high N content (1.43% as is, or 28.6 lbs/ton).

Table 1. Typical Utah manure test level results for pH.

Animal Type	pH Sat mean	pH Sat range	pH 2:1 mean	pH 2:1 range
Bovine				
Feeder	8.59	8.76 - 8.24	8.75	9.05 - 8.17
Dairy Heifer (lactating)	7.51	8.74 - 6.20	7.56	8.99 - 6.09
Dairy Heifer (dry)	7.32	7.89 - 6.78	7.16	7.83 - 6.59
Calf	7.16	7.75 - 6.45	7.19	7.57 - 6.37
Equine	7.83	9.49 - 6.48	8.1	9.70 - 6.51
Swine				
Raw	5.85	7.60 - 5.12	6.02	7.92 - 5.13
Composted	8.26	8.37 - 8.24	8.6	8.70 - 8.54
Ovine	7.84	8.65 - 7.07	8.05	8.85 - 7.38
Caprine	8.11	8.14 - 8.04	8.51	8.63 - 8.43
Poultry				
Layer	6.56	6.60 - 6.48	6.62	6.74 - 6.43
Egg wash water	9.76	---	---	---

Table 2. Typical Utah manure test levels for EC

Animal Type	EC Sat mean	EC Sat range	EC 2:1 mean	EC 2:1 range
Bovine				
Feeder	11.06	27.10 - 4.30	3.8	6.89 - 2.34
Dairy Heifer (lactating)	19.27	34.65 - 2.85	6.36	10.30 - 1.00
Dairy Heifer (dry)	16.46	29.70 - 8.25	6.03	10.49 - 3.07
Calf	19.66	30.65 - 14.20	6.38	11.06 - 3.60
Equine	4.53	11.73 - 0.77	1.85	4.26 - 0.15
Swine				
Raw	23.19	34.80 - 12.30	8.06	13.80 - 4.06
Composted	20.17	23.30 - 16.20	8.23	9.75 - 7.10
Ovine	10.2	17.30 - 1.25	3.13	5.93 - 0.43
Caprine	1.41	1.81 - 1.08	0.52	0.56 - 0.45
Poultry				
Layer	11.05	11.20 - 10.90	6.2	6.61 - 5.60
Egg wash water	3.31	---	---	---

Table 3. Typical Utah manure test level results for N content

Animal Type		N (% as is) mean	range	N lbs/ton	% Moisture (as is)
Bovine					
	Feeder	0.77	1.20 - 0.04	15.4	47.98
	Dairy Heifer (lactating)	0.51	0.86 - 0.36	10.2	78.71
	Dairy Heifer (dry)	0.51	0.69 - 0.27	10.2	83.46
	Calf	0.89	1.28 - 0.63	17.8	76.14
Equine		0.54	1.56 - 0.29	10.8	64.07
Swine					
	Raw	1.58	2.46 - 0.75	31.6	60.61
	Composted	1.79	1.89 - 1.68	35.8	49.3
Ovine		0.69	1.03 - 0.14	13.8	68.45
Caprine		1.43	1.46 -1.38	28.6	32.53
Poultry					
	Layer	6.62	9.20 - 3.64	132.4	20.77
	Egg wash water	0.05	---	---	---

State-Wide and County-Level Soil Test Level Database

In 2001, the USUAL put a computerized data management and reporting system into using Microsoft's Access database programming and manipulation software. As a result, a digital archive of soil test information has been available, but as yet unused, to provide both historical and annual trends in soil test level in the state as a whole, and in individual counties. Moreover, the metadata submitted and recorded for each sample allows for the demographic categorization of information into specific crop and urban landscape origin, geographic location (to the city level), and acreages of coverage represented by the sample.

This database is invaluable in guiding soil fertility trends, possible soil fertility research focus areas, extension education programs for soil fertility management and encouragement of soil testing, and comparison of major issues in urban and agricultural settings individually.

The USUAL is preparing this information for Extension specialists and county agents in two formats. First, a 5-year, historical summary both state wide and county by county is in preparation. This is created from the recorded information from 2002-2006, and will be updated each year on a rolling, 5-year average (over the five most recent years' data). Second, an annual newsletter is prepared showing that year's state-wide summary, and a county-by-county breakdown.

An example of the information that will be provided, tables 4 through 7 have been prepared. The tables cover the breakdown of soil test level information for two rural, agricultural counties (Box Elder and Cache County) and two urban counties (Salt Lake and Washington County). A demographic breakdown of urban and agricultural submissions is provided, along with the means, sample numbers, and percentile distribution of results for a selection of analyses.

Table 4. Box Elder County soil test summary for 2006

			pH	EC	P	K	N	Zn	Fe	Cu	Mn	SO4-S	OM	SAR	Acres
Box Elder County															
		average	7.81	2.87	24.17	449.05	11.93	1.32	7.91	1.18	4.21	3.12	2.14		20.00
		max	9.39	49.60	165.00	1400.00	96.00	2.77	23.20	2.58	7.16	4.60	3.00		150.00
		min	6.40	0.20	1.30	43.00	2.50	0.63	2.62	0.78	2.29	2.20	0.90		1.00
home count	15.00														
ag count	105.00	count	117.00	119.00	118.00	118.00	50.00	15.00	15.00	15.00	15.00	7.00	7.00		30.00
total samples	120.00														
		10th Percentile	7.30	0.48	4.87	155.80	4.48	0.66	3.53	0.86	2.68	2.32	1.32		2.44
		25th Percentile	7.59	0.60	10.00	237.75	5.26	0.79	4.80	0.91	3.57	2.45	1.80		6.25
		50th Percentile	7.73	0.80	17.30	371.00	7.22	1.21	5.86	0.98	4.03	2.90	2.40		20.00
		75th Percentile	7.92	1.00	27.45	565.75	9.67	1.58	8.91	1.26	4.35	3.64	2.55		38.75
		90th Percentile	8.50	2.18	48.30	960.20	24.27	2.25	14.92	1.64	6.28	4.12	2.76		67.40

Table 5. Cache County soil test summary for 2006

			pH	EC	P	K	N	Zn	Fe	Cu	Mn	SO4-S	OM	SAR	Acres
Cache County															
		average	7.72	1.77	37.32	371.22	19.15	2.22	15.12	1.33	9.52	6.35	3.06	10.47	22.50
		max	8.60	16.90	883.80	1569.00	406.00	6.08	112.00	4.29	39.10	51.10	6.60	46.00	50.00
		min	6.43	0.40	0.00	39.00	2.02	0.65	0.72	0.13	0.74	0.00	1.40	0.53	5.00
home count	50.00														
ag count	164.00	count	190.00	184.00	189.00	156.00	101.00	34.00	34.00	34.00	34.00	34.00	42.00	19.00	18.00
total samples	214.00														
		10th Percentile	7.29	0.70	6.50	122.00	3.85	1.20	7.54	0.90	4.44	1.50	2.31	0.85	5.70
		25th Percentile	7.56	0.80	11.00	186.00	4.87	1.75	8.59	0.97	5.69	2.73	2.80	1.15	11.00
		50th Percentile	7.75	1.00	19.60	314.00	10.70	2.17	10.70	1.10	8.21	3.58	2.90	10.50	22.50
		75th Percentile	7.93	1.62	35.00	464.00	23.40	2.56	15.20	1.34	10.48	6.60	3.48	14.65	28.75
		90th Percentile	8.08	3.18	89.08	669.50	35.20	2.85	21.93	2.28	12.64	11.88	3.70	18.94	50.00

Table 6. Salt Lake County soil test summary for 2006

			pH	EC	P	K	N	Zn	Fe	Cu	Mn	SO4-S	OM	SAR	Acres
Salt Lake County															
		average	7.56	1.73	51.15	438.12	19.32	8.78	16.15	5.27	5.98	44.18	3.32	4.24	40.00
		max	8.39	11.19	286.00	1569.00	197.00	32.50	102.00	47.80	21.20	464.00	14.80	13.40	40.00
		min	5.76	0.10	2.30	41.00	0.45	0.44	1.25	0.16	0.37	2.90	0.10	0.49	40.00
home count	197.00														
ag count	12.00	count	202.00	199.00	195.00	195.00	40.00	37.00	37.00	37.00	37.00	33.00	38.00	12.00	1.00
total samples	209.00														
		10th Percentile	7.11	0.50	5.64	123.00	2.96	0.64	3.84	0.36	1.56	4.74	0.70	0.55	40.00
		25th Percentile	7.37	0.70	12.95	198.50	4.82	2.21	6.24	1.65	3.50	8.10	1.23	0.70	40.00
		50th Percentile	7.61	1.00	31.00	331.00	11.90	7.97	11.40	2.57	4.71	12.60	2.70	1.65	40.00
		75th Percentile	7.80	2.09	66.50	575.50	18.40	13.20	18.40	4.75	7.56	32.50	3.60	6.11	40.00
		90th Percentile	8.01	3.93	132.20	939.80	34.78	19.00	32.58	11.76	10.98	61.98	8.58	12.81	40.00

Table 7. Washington County soil test summary for 2006

			pH	EC	P	K	N	Zn	Fe	Cu	Mn	SO4-S	OM	SAR	Acres
Washington County															
		average	7.77	3.20	30.53	310.47	18.22	1.55	11.51	0.88	6.76	160.61	2.11		80.00
		max	8.28	25.00	167.00	1413.00	81.70	4.71	85.80	2.21	33.10	864.00	6.40		80.00
		min	6.89	0.35	0.00	52.00	2.57	0.23	2.00	0.39	1.09	2.80	0.20		3.50
home count	55.00														
ag count	18.00	count	73.00	73.00	73.00	73.00	20.00	21.00	21.00	21.00	21.00	15.00	15.00		5.00
total samples	73.00														
		10th Percentile	7.41	0.63	2.90	99.40	3.05	0.29	2.26	0.45	2.26	3.61	0.74		34.10
		25th Percentile	7.60	0.80	5.80	141.00	7.55	0.57	3.95	0.59	2.60	7.30	1.30		80.00
		50th Percentile	7.80	1.20	13.70	225.00	12.60	1.03	5.94	0.83	4.18	22.50	2.00		80.00
		75th Percentile	7.99	4.70	33.00	353.00	26.00	2.50	10.55	1.02	6.84	240.95	2.35		80.00
		90th Percentile	8.13	7.53	93.00	642.40	35.41	3.18	14.10	1.22	12.50	383.98	3.24		80.00

SUMMARY

This paper details a number of efforts by the Utah Extension Soils program and the USUAL, in improving the efficiency of soil, manure, and plant testing procedures, and providing valuable access to the large databases of analyses now available in digital formats. It is anticipated that additional procedures and database products will be developed over the near future to provide our clientele with accurate, timely analysis, more complete interpretation, and more complete guidance in the soil sampling and soil fertility issues and research across the state.

PROCEEDINGS

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