Soil Health Analysis

Overview

- As we know what makes a healthy soil is more than just organic matter content.
- Microbial populations
- Nutrient levels
- Physical factors, compaction, soil texture
- Drainage
- Water holding capacity

I will briefly comment on microbial soil testing

The rest of the presentation I will go over the most common vineyard soil tests

Soil metagenomics

Soil microbiome

- **The soil microbiome is the complete set of microbes that can live in soil ecosystems.**
- *Soil represents the greatest microbial reservoir of biological diversity*
    - more than 30,000 prokaryotic species
    - presence of soil microbes depends on many environmental factors including geographic location, salinity, temperature, oxygen, nutrients
- *Plant-microbe interactions*
    - microbes are essential for plant growth and health
    - soil serves as a major source of plant-associated bacteria

Rhizosphere microbiome

- **Rhizosphere microbiome consists of all soil microbes that colonize the roots of plants.**
- *Microbes support plant growth and health*
    - microbial colonization of roots is beneficial to plant growth and health
    - microbes help to absorb nutrient absorption and to protect against pathogens
- *Plant-specific microbioms*
    - plants are able to control their rhizosphere microbiom by root secretions
    - different plant species growing on the same soil attract different microbes
- **read more**

Biological Tests For Soil

- A new frontier
- With the advent of DNA sequencing, more affordable equipment, and qualified technicians there are more private laboratories offering analysis.
- DNA sequencing is routine but how do you interpret the analysis?
- Biological indicators are being developed they need to be
- Accurate for the purpose they are developed for
- Easy to measure, Reproducible, Standardized
- Examples of biological indicators are Abundance and diversity of earthworms or nematodes, or specific groups of fungi or bacteria.
- Not always necessary to monitor all biological activity in the soil.

Soil Analysis

- I will discuss the important soil test for a north coast vineyard how and why they are done.
- It is important to know how tests are done depending on the test not all results are comparable between labs or if a lab changes its method.

SOIL ANALYSIS

Grower:
Location:
Date:

Sample ID	Lab #	MILLIEQUIVALENTS/LITER					PPM					MEQ/100 grams			
		Water Extract					Ammonium Acetate				HNO				
		Ca	Mg	Cl	Na	HCO_3	B	Ca	Mg	K	Na	K	Ca	Mg	K	CEC

Lab #	Saturated Soil		PPM									TONS/ACRE	PERCENT				
			Olsen		Brey	DTPA				Ion Electrode	CaHPO	Lime Requirement		Base Saturation			
	S.P.	pH	ECe	P	P	Zn	Mn	Fe	Cu	NO_3-N	SO_4-S		O.M.	Ca	Mg	K	Na

Soil Tests

Water Extracts / Soil Paste

- Water extracts are derived from a saturated soil paste.
- The soil paste is used to measure soil pH estimate soil texture (saturation percentage)
- Boron and salt index is measured from the water extract.
- Some labs especially eastern labs will use hot water extracts for boron, and they may not measure soil pH from a saturated paste. Results will be different.

Organic Matter

- Test results are reported as % OM. The tests are estimated analysis based on a test called loss on ignition. A fancy way of saying they burn off all the carbon in a muffle furnace.
- The healthy soil literature talks about particulate organic matter and total organic carbon.
- Particulate organic matter will not be included because the larger pieces of plant material will be screened off prior to testing.
- Total organic carbon is stored in organic matter.
- 58% of the soil organic matter is organic carbon. Divide OM by .0172 to get TOC

Soil Tests

Lime Requirement

- SMP buffer test
- Not all soils have the same buffering capacity. In other words, a ton of lime will not change the soil pH equally in all soil types or conditions.
- Not perfect but a good guideline.

Gypsum Requirement

- This test is specifically used for calculating the amount of gypsum needed for soils with high sodium.
- Not used for high magnesium soils.

Phosphorous

- One extract used for lower pH soils and one for slightly acidic and above.

Micronutrients

- All standard DTPA analysis

Calcium, Magnesium, Potassium

Most important part of a soil analysis. More money is spent adding Calcium and potassium than most other elements besides nitrogen.

Ammonium Acetate Extract

- Standard test for estimating available levels of Ca, Mg, K, Na
- Estimating cation exchange capacity CEC
- The only way to calculate base saturation
- The only way to calculate Ca:Mg ratios in order to estimate if gypsum is need to alleviate high magnesium levels.
- The only way to calculate out % base saturation of Ca,Mg, K

Base Saturation

- Base saturation was developed in the 50's back east. It has become a widely used guideline for calculating the percent Ca,Mg, K in your soil.
- In order to calculate CEC and % base saturation tests results in ppm or mg/kg need to be converted to Meq /100 g. Some labs break this down on their report's others not.
- General guideline Ca 60 to 70%; Mg 10 to 20%; K 5 to 7%

North Coast Issue

- Magnesium. In soils with elevated magnesium levels, it is very hard to achieve the ideal percentages.
- These ranges can only be effectively modified in the top 12 or 8 inches of soil.
- To incorporate large amounts sometimes 1 to 5 tons / ft of soil is expensive and very hard to do. Can only be attempted preplant.

Example

- Ca % is 50; CEC is 20. I want to increase Ca to 65%. (65-50) = .15 X 20 X 1.7 = 5.1 TAF of gypsum

Continued

- If magnesium levels are over 1:1 Mg to Ca on a Meq/ 100 g basis you can calculate how much calcium it will take to raise the Meq levels in the soil.
- If calcium needs to be amended below 1 foot typically gypsum would be applied vs lime.
- Lime should only be applied when soil pH is below 6.5.
- Over applying lime is negative because it wont break down when soil pH levels are around 7 or above.
- Don’t apply more than 4 tons of pure lime / acre foot of soil. Gypsum around 5 tons / AF

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Some Ideal Nutrient Ranges For Soils.

	Low	Adequate
Phosphorus	< 10 ppm	> 10 ppm
Potassium (extractable)	< 100 ppm	> 100 ppm
HNO_3 (K) Potassium (available)	< 200 ppm	> 250 ppm

Potassium deficiency is probable when extractable potassium is below 100 ppm and available potassium is below 250 ppm. Other factors such as type of clay and Ca/Mg ratios further effect Potassium availability

Ca:Mg ratio in MEQ / 100g : An ideal range is 2:1 to 4:1. Greater than 1:1 Mg can cause growth suppression and decreased potassium uptake.

Manganese deficiencies are common on high magnesium soils.

pH values :

Below 5 - can have acid infertility problems such as manganese and aluminum toxicity. Reduced nitrogen and phosphorus uptake, and poor microbial activity.
5 to 5.5 - generally do not have pH related infertility problems. However, yield reduction has been reported from vines grown on soils with pH values below 5.5. Phosphorus uptake can be reduced in low phosphorus soils, and reduced microbial activity can occur.
6 to 6.5 - Ideal range

Saturation Percentage (SP) :
Grams of water required to saturate 100 grams of soil, related to soil texture

Below 20	Sand or loamy sand
20 - 35	Sandy loam
35 - 50	Loam or silt loam
50 65	Clay loam
65 - 135	Clay

Water soluble Ca:Mg ratios in MEQ/L: Ratios greater than 1:1 Mg can reduce potassium availability even when extractable potassium levels are adequate.

BORON : General guideline for grapevine sensitivity to soil boron in water extract.

PPM Boron	Grapevine Symptoms
0 - 0.5	None
0.5 - 1	Very Slight to None
1 - 1.5	Slight
1.5 - 2.5	Moderate
2.5 4	Severe

Percent Base Saturation :
General guidelines

Ca	60 - 65 %	(Light soil)
	65 - 70 %	(Heavy soil)
Mg	10 - 20 %	
K	5 - 7 %	

	NAPT Methods--->			S1.00	S1.10	S1.20	S1.60	S1.60	S1.60	S1.40	Calc.			S2.50	S1.50	S3.10	S4.10	S4.20	S5.10	S6.10	S6.10	S6.10	S6.10	S9.20	
	Handbook 60--->											60-22d	60-23a											
				Sat.	Sat.	Sat.	Sat.	Sat.	Sat.	Sat.					Sat.	AA	Olsen	Bray	AA	DTPA	DTPA	DTPA	DTPA		
				Paste	Paste	Paste	Paste	Paste	Paste	Paste		Gypsum	Lime	Lime	Paste	Ext	Ext	Ext	Ext	Ext	Ext	Ext	Ext		
No.	Description	Depth		SP	pH	EC	Ca	Mg	Na	Cl	ESP	Req.	Pres.	Req.	B	NO_3-N	PO_4-P	PO_4-P	K	Zn	Mn	Fe	Cu	OM	
				%	units	dS/m	meq/l	meq/l	meq/l	meq/l	%	T/ac-6"		lbs/ac-6"	mg/l	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	
1	#2 Top	18''		53	7.0	0.30	1.4	1.1	0.5		ND		ND		ND	5	32		303	4.0	16.0	87.0	4.4	2.90	
2	#2	36-48''		52	7.0	0.70	1.4	3.7	2.3		0.8		ND		ND	ND	4		78	0.3	7.6	45.0	2.9	2.50	
3	#3 Center Top	18''		54	7.1	0.30	1.4	1.1	0.4		ND		ND		0.1	4	52		362	3.6	19.0	69.0	3.4	2.70	
4	#3 Center	32-48''		56	7.0	1.10	2.5	5.4	3.5		1.3		ND		0.1	4	17		79	0.4	8.7	48.0	2.9	2.50	
5	#5 Top	18''		49	6.2	0.30	1.2	1.1	0.3		ND		ND		ND	5	18		158	3.6	21.0	93.0	3.9	3.40	
6	#5	36-48''		54	6.4	0.80	2.3	4.9	1.3		ND		ND		ND	4	26		83	0.6	15.0	70.0	3.9	2.80	
ND = None Detected																									
Vineyard soils				Texture	pH	salts**	Ca	Mg	Na	Cl	ESP	Tons/Ac	Lime Pr.	Tons/Ac	B*	NO_3-N*	PO_4-P*	PO_4-P*	K*	Zn*	Mn*	Fe*	Cu*	OM	
Low				Sand <20	<6.0	<0.5	<1or<Na	<0.5		-	1				0.1	<2	<10	<10	<150	<1.0	<3.0	<5	<1	<1.0	
Medium				20-50	6.0-7.8	0.5-2.0	1-10	1/2 Ca		<4	1-5				0.2-0.5	2-5	15-30	15-30	150-350	1-2	3-10	5-10	1-2	1-3	
High				Clay >50	7.8+	2.0+	10+	> Ca	>Ca	6+	5+		4		1.0+	10+	30+	30+	350+	2.0+	50+	50+	2+	3+	

Report of Soil Analysis

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No.	Description	Depth	Ca	Mg	Na	Al	H	K	Ca	Mg	Na	Al	H	K	Ca	Mg	Na	Al	H	CEC	Ca/Mg	K/Mg
		NAPT Methods--->	S5.10	S5.10	S5.10	S15.10	S2.50	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.
		Handbook 60--->																				
			AA	AA	AA	1N KCl		AA	AA	AA	AA	1N KCl		of Est	of Est	of Est	of Est	of Est	of Est			
			Ext	Ext	Ext	Ext		Ext	Ext	Ext	Ext	Ext		CEC	CEC	CEC	CEC	CEC	CEC	Estimated	Ca/Mg	K/Mg
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%	%	%	%	%	%	meq/100g	Ratio	Ratio
1	#2 Top	18''	1970	711	28.0			0.8	9.8	4.7	0.1	4.7		4.7	59.3	35.30	0.70			16.6	1.70	0.1
2	#2	36-48''	1340	1990	158			0.2	6.7	16.4	0.7	4.7		0.8	27.9	68.40	2.90			24.0	0.40	ND
3	#3 Center Top	18''	1800	549	22.1			0.9	9.0	4.7	0.1	4.7		6.4	61.8	31.20	0.70			14.5	2.00	0.2
4	#3 Center	32-48''	1700	1870	215			0.2	8.5	15.4	0.9	4.7		0.8	33.9	61.60	3.70			25.0	0.60	ND
5	#5 Top	18''	2230	816	20.2			0.4	11.1	4.7	ND	4.7		2.2	60.7	36.60	0.50			18.3	1.70	ND
6	#5	36-48''	1820	1750	82.8			0.2	9.1	4.7	0.4	4.7		0.9	37.7	59.90	1.50			24.0	0.60	ND