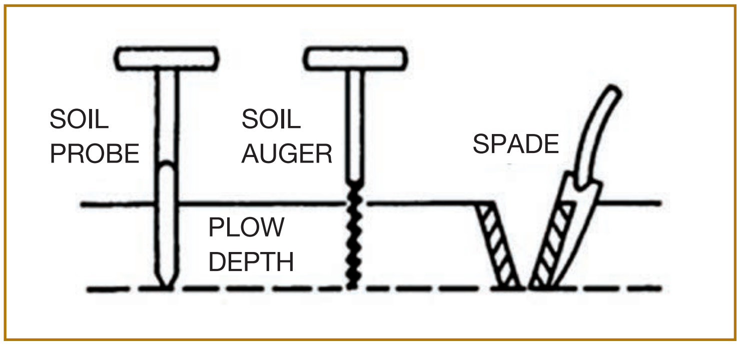
Soil Sampling & Soil Test Interpretation

Collecting Soil Samples

Collecting soil samples is the most important part of a soil testing program. The objective of soil testing is to determine the nutrient status of a field and to provide measurement of nutrient variability. Soil test results can be no better than the sample that has been submitted to the laboratory.

Equipment

Soil sampling can be made easier with tools designed for this purpose. Some type of soil probe, soil auger, spade or trowel is required. Use a clean pail preferably plastic, for carrying and mixing your soil samples. Use clean equipment to avoid contamination. Galvanized, brass, chrome, or other containers may contaminate the sample if it is being tested for heavy metals. Soil sample bags, information sheets, and sampling supplies are available through MVTL.



> **"Providing value to our customers through on-time quality testing with friendly service"**

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When to Sample

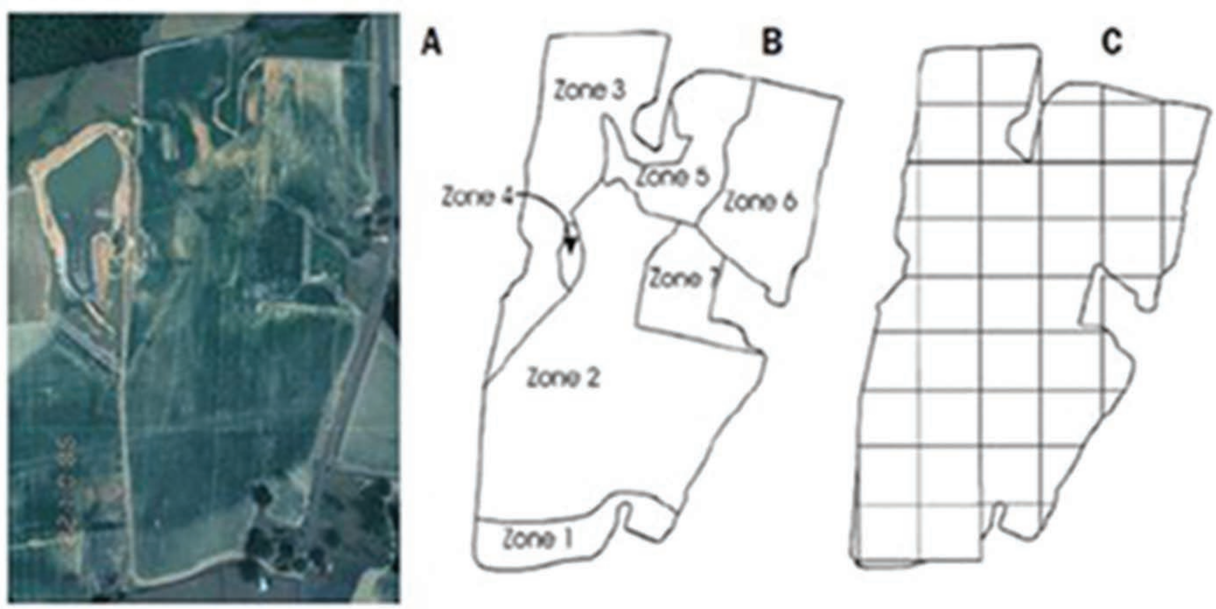
Sampling should be done before any applications of fertilizer, sludge, lime, or manure. Soil sampling can be done at any time of the year. However, it is recommended to sample the field during the same season if possible. Potassium (K) results can be influenced by winter sampling due to the tendency for potassium (K) soil test levels to be overstated as K is released from clay matrices when soils freeze. In a drought year, K also can become fixed between clay layers until water moves through the soil again. Potassium test levels will increase to more normal values if you can wait to sample following a significant fall rain event.

Sampling Gardens or Small Plots

- Need 20 cores (0-4" deep).
- Dump and mix cores using a 1 gallon pail.
- Pour the mixed sample (about 1 pint) into a MVTL soil bag (or other container).
- Label each sample with proper identification, complete information sheet providing necessary contact information.

Field Scale Composite (A)

Uniform fields can be randomly sampled throughout the field to see long-term trends in soil nutrient data. Suggested 1 composite sample per 5-20 acres in complex terrain and 1 composite sample collected for each 20-40 acres in uniform terrain.



Zone Management Sampling (B)

Zone sampling is a soil sampling technique that assumes each field contains different soils with unique soil properties. Determining areas of the field to be sampled separately can be determined by crop yield history, past nutrient applications, variations in slope, texture, or depth of subsoil. Unlike grid sampling, the number of zones and their shape and size will depend on the degree of field variability. Soil survey maps and yield history maps are useful for determining zone management maps.

Grid Management Sampling (C)

Grid sampling can be particularly useful where there is little prior knowledge of within-field variability. Two common types of grid sampling include grid-cell and grid–point. Grid-cell soil sampling randomly collects multiple subsamples throughout the cell for a composite sample. Grid-point soil sampling collects multiple subsamples around a geo-referenced point within a grid. Grid samples are usually 2.5 to 10 acres in size.

Procedure

1. Divide fields into area to be sampled.

2. Avoid sampling areas such as dead or back furrows, manure or straw piles, eroded knolls or low spots, tile lines spoils, terraces, old fence rows, old roads and/or old building sites. Keep set-back away from gravel roads.

3. Scrape off all surface litter and take a core to a depth of 6-9 inches deep.

4. Keep soil core depth consistent and document soil depth on information sheet when submitting to testing lab. Be consistent on depth across all samples, 1/2 inch can make a big difference.

5. Pull adequate number of cores for a representative sample. It is suggested to pull 8-10 soil cores for a representative sample.

6. Do not sample shortly after a lime, fertilizer or manure application

7. Avoid smoking or other contamination.

8. If it is too wet to till it is too wet to sample.

9. Dump and mix cores using a 1 gallon pail.

10. Pour the mixed sample (about 1 pint) into a MVTL soil bag (or other container).

11. Label each sample with proper identification, and provide necessary contact information.

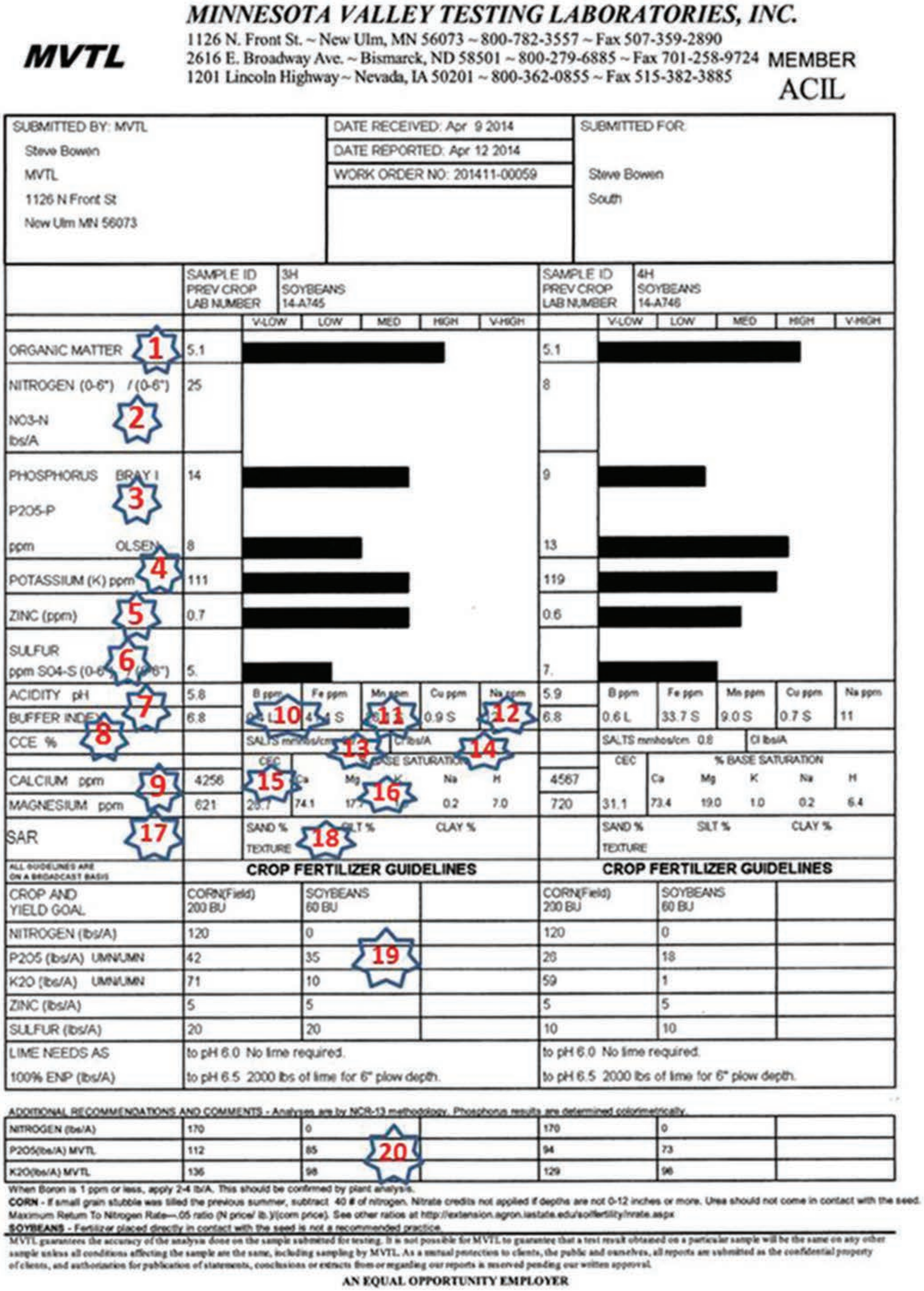
Table 1. The number of subsamples required to provide a composite soil sample of given levels of accuracy and confidence for nitrogen, phosphorus and potassium (Swenson et al., 1984).

Confidence Level	Accuracy Level [a]					
	± 15%			± 25%		
	N	P	K	N	P	K
Percentage	Number of Subsamples					
90	25	34	7	10	12	3
80	18	21	5	6	8	2
70	10	14	3	4	5	2

Soil sample information sheets may be downloaded at: www.mvtl.com.

Web portal access is also available for sample submission and obtaining soil results.

Contact MVTL for more information.



MVTL

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MEMBER
ACIL

SUBMITTED BY: MVTL Steve Bowen MVTL 1126 N Front St New Ulm MN 56073	DATE RECEIVED: Apr 9 2014 DATE REPORTED: Apr 12 2014 WORK ORDER NO: 201411-00059	SUBMITTED FOR: Steve Bowen South

SAMPLE ID PREV CROP LAB NUMBER	3H SOYBEANS 14-A745	4H SOYBEANS 14-A746
	V-LOW / LOW / MED / HIGH / V-HIGH	V-LOW / LOW / MED / HIGH / V-HIGH
ORGANIC MATTER	5.1	5.1
NITROGEN (0-6") / (0-6") NO3-N lbs/A	25	8
PHOSPHORUS BRAY I P2O5-P ppm	14	9
OLSEN	8	13
POTASSIUM (K) ppm	111	119
ZINC (ppm)	0.7	0.6
SULFUR ppm SO4-S (0-6") / (0-6")	5.	7.
ACIDITY pH	5.8	5.9
BUFFER INDEX	6.8	6.8
CCE %		
CALCIUM ppm	4256	4567
MAGNESIUM ppm	621	720
SAR		

	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm
3H	[illegible] L	[illegible] S	[illegible]	0.9 S	[illegible]
4H	0.6 L	33.7 S	9.0 S	0.7 S	11

	SALTS mmhos/cm	Cl lbs/A
3H		
4H	0.8	

	CEC	% BASE SATURATION Ca	Mg	K	Na	H
3H	[illegible]	74.1	[illegible]	[illegible]	0.2	7.0
4H	31.1	73.4	19.0	1.0	0.2	6.4

	SAND %	SILT %	CLAY %	TEXTURE
3H				
4H				

ALL GUIDELINES ARE ON A BROADCAST BASIS	CROP FERTILIZER GUIDELINES			CROP FERTILIZER GUIDELINES		
CROP AND YIELD GOAL	CORN(Field) 200 BU	SOYBEANS 60 BU		CORN(Field) 200 BU	SOYBEANS 60 BU	
NITROGEN (lbs/A)	120	0		120	0	
P2O5 (lbs/A) UMN/UMN	42	35		28	18	
K2O (lbs/A) UMN/UMN	71	10		59	1	
ZINC (lbs/A)	5	5		5	5	
SULFUR (lbs/A)	20	20		10	10	
LIME NEEDS AS 100% ENP (lbs/A)	to pH 6.0 No lime required. to pH 6.5 2000 lbs of lime for 6" plow depth.			to pH 6.0 No lime required. to pH 6.5 2000 lbs of lime for 6" plow depth.		

ADDITIONAL RECOMMENDATIONS AND COMMENTS - Analyses are by NCR-13 methodology. Phosphorus results are determined colorimetrically.

NITROGEN (lbs/A)	170	0		170	0	
P2O5(lbs/A) MVTL	112	85		94	73	
K2O(lbs/A) MVTL	136	98		129	96	

When Boron is 1 ppm or less, apply 2-4 lb/A. This should be confirmed by plant analysis.
CORN - If small grain stubble was tilled the previous summer, subtract 40 # of nitrogen. Nitrate credits not applied if depths are not 0-12 inches or more. Urea should not come in contact with the seed.
Maximum Return To Nitrogen Rate—.05 ratio (N price/ lb.)/(corn price). See other ratios at http://extension.agron.iastate.edu/soilfertility/nrate.aspx
SOYBEANS - Fertilizer placed directly in contact with the seed is not a recommended practice.

MVTL guarantees the accuracy of the analysis done on the sample submitted for testing. It is not possible for MVTL to guarantee that a test result obtained on a particular sample will be the same on any other sample unless all conditions affecting the sample are the same, including sampling by MVTL. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

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Soil Sample Report Terms

Parts per million (ppm)

Major and minor elements are reported in parts per million (ppm) on an elemental basis. An acre of mineral soil 6-7 inches deep weighs approximately 2 million pounds. To convert parts per million to pounds per acre—multiply by 2.

Meq/100g (milliequivalents per 100 grams)

Milliequivalents are useful in understanding charge in soil and quantities of ions (often nutrients) that various soils can hold. The units of cation exchange capacity (CEC) are displayed in milliequivalents per 100 g (meq/100 g).

Millimhos/cm (mmhos/cm)

Electrical conductivity measurements are often used to measure the amount of soluble salts in the soil. Conductivity increases with increasing soluble salts.

Soil Analysis Terms and Applications

1. **Organic Matter (OM):** (Combustion Weight Loss). Percent OM is determined by the dry combustion method. OM content in soil is, especially, important for determining nitrogen and sulfur needs. The OM% along with soil texture can be very important when determining rates of certain soil-applied herbicides.

2. **Nitrate-Nitrogen:** (Cadmium Reduction). Most calibrations for nitrate-nitrogen are based on sampling depth, geographic location, and time of year. Fertilizer nitrogen is just one of the nitrogen sources that plants utilize. Another common source is released by the mineralization of organic matter, therefore, requires proper evaluation. The relative level of nitrate-nitrogen is variable and depends on the season, yield goal, and level of OM. In general, less than 0-30 lbs at a 24" depth is considered low, while 30-60 lbs is medium, and 60+ lbs is high.

3. **Extractable Phosphorus (P):** (Colormetric). There are four different extractions used by MVTL to determine levels of available P. Olsen-Bicarbonate is generally used where soil pH is at or above 7.2. This method has a known reliability in alkaline soils with medium to high CEC levels, as well as, free lime or calcareous soils. Bray I is best adapted to fine-textured soils where the pH levels are below 7.0. Bray I methods typically do not perform well in high lime soils and/or higher CEC's. Bray II uses a stronger acid for the extraction method. The Bray II test measures part of active reserves in the soil. The Mehlich III method is used in much of Iowa. It has proven to be a more stable method versus Bray, because it can adjust to excess (free) lime and a larger pH scale. Mehlich III, like Bray I, use the same fertility scale to differentiate between high and very high testing soils.

4. **Exchangeable Potassium (K):** (ICP). Potassium is extracted from the soil using an ammonium acetate solution. This amount is considered readily available or exchangeable potassium. The potassium supplying power of the soil is determined by the exchangeable (readily available). The amount or percent of exchangeable potassium needs to be higher on sandy soils (lower CEC's), but on clay soils (higher CEC's) it can be lower and still supply the plants with enough potassium.

5. **Zinc (Zn):** (Atomic Absorption). Zinc is extracted using a DPTA solution and reported in ppm. Soil test levels greater than 1.0 ppm are considered adequate for all crops. Levels between 0.5 and 1.0 ppm are marginal, and less than 0.5 ppm is considered low. Corn, edible beans, flax, and potatoes are more responsive to zinc than most crops. Zinc deficiencies are most likely as soil pH increases. Also, soils with low organic matter will increase the chances of crops being sensitive to zinc and other micro deficiencies.

6. **Extractable Sulfur (S):** (ICP). Extractable sulfur is reported in ppm of sulfate-sulfur. The determination is made on a 0-6" or 0-24" sample. Optimum levels of S depend largely on organic matter content, soil texture, drainage and yield goals. Sulfur deficiency has generally been limited to soils low in organic matter, since organic matter is the primary source of sulfur in soils. Soil tests for available sulfur are helpful but in general are not as precise as phosphorous or potassium. Sulfur is in a constant state of change in the soil similar to nitrogen. Lack of sulfur appears as a light green coloring of the while plant.

Micro-nutrient Sensitivity of Major Crops

Nutrient	Sensitive Crops	Soil Conditions Likely
Zinc	Corn	Soil Test < 1.5 ppm
	Edible Beans	High pH, Low O.M.
	Potatoes	Cool and wet soils
Boron	Alfalfa	Soil Test < 1.0 ppm
	Sugar Beets	High pH, Low O.M
Copper	Wheat	Soil Test < 0.3 ppm
	Barley	High O.M.
Iron	Beans	Soil Test < 4.0 ppm
	Millet	High pH
	Sorghum	High carbonates
Manganese	Navy Beans	Soil Test < 2.0 ppm
	Soybeans & Oats	High pH
Molybdenum	Alfalfa	Soil Test < 0.1 ppm
	Peas	High pH
Chloride	Wheat	Soil Test < 7.0 ppm per depth
	Oats	Dryland soils testing
	Barley	high in potassium (K)

7. **Soil pH (Acidity or Alkalinity):** (Electrode). pH is determined on a 1:1 suspension and is a measure of the hydrogen ion concentration in the soil.

   Soil BpH (Buffer Index): (Electrode). The buffer index is determined on a soil to water suspension after a buffer (SMP) has been added. The buffer index measures the soils reserve acidity and is a more accurate index for determining lime requirements on acid soils.

Optimum pH Ranges for Different Crops

Group 1.

- alfalfa
- alsike clover
- apples
- asparagus

Group 2.

- annual canary seed
- birdsfoot trefoil
- buckwheat
- corn
- edible beans
- flax
- grapes
- grass for seed
- grass hay
- mustard
- millet
- peas
- canola
- red clover
- barley
- wheat
- oats
- raspberries
- rye
- sorghum sudan
- soybeans
- strawberry
- sugar beets
- sunflowers
- sweet corn
- vegetable crops

Group 3.

- potatoes
- grass sod
- blueberries
- wild rice

Group 1 Lime should be applied to raise the soil pH to 6.5 for crops such as alfalfa, alsike clover, apples.
Group 2 Lime should be applied to raise the soil pH to 6.0.
Group 3 crops grow best in acid soils and no lime is needed.

8. **Calcium Carbonate Equivalent (CCE):** measures the total calcium (Ca) & magnesium (Mg) in the soil. Levels 0-2% carbonates is low, 2.5-5% is medium, 5-10% high, and >10% is considered very high. Testing your fields for carbonates when the pH is above 7.2 and the soluble salts are above 0.3 mmhos/cm will improve your ability to manage iron chlorosis. Soils with pH below 7.2 can also have considerable free Ca and Mg carbonates.

   In the table below, increase Risk Level when CCE's are over 5%.

   - ➢ Sandy soils with low organic matter (<3.0%) and a high salt level (>1.0) have a higher risk of iron chlorosis than a loam or clay soil with the same level of carbonates and salt.
   - ➢ The risk and severity of iron chlorosis will increase in years with excessive moisture.
   - ➢ When CCE's are high, make sure the potassium (K) levels are in the very high range as well.

CCE	Soluble Salts	Risk Level
1 – 5%	0.3 – 0.4	Moderate
1 – 5%	0.5 – 0.6	High
1 – 5%	0.7 – 0.9	Very High
1 – 5%	.0 – 1.50	Extremely High
1 – 5%	> 1.50	Not Suitable (Soybeans)

9. **Exchangeable Calcium (Ca) and Magnesium (Mg):** (ICP). Calcium and Magnesium are extracted from the soils using ammonium acetate solution and reported in ppm. Knowing the amount of exchangeable Ca and Mg is important for the calculation of the Cation Exchange Capacity (CEC) by summation. Mg and Ca deficiencies are most likely in coarse textured soils with pH less than 6.0.

10. **Extractable Boron (B):** (ICP). Boron levels are determined by using DTPA-Sorbitol extractant to release boron from the soil. Results are reported in ppm. Many factors affect boron availability to plants. These include organic matter, soil texture, and soil pH. Crops like alfalfa, and many vegetable crops, tend to show the most response to added boron on deficient soils. Soils testing less than 1 ppm will likely be deficient, but following up with a plant analysis is recommended. Levels in excess of 4-5.0 ppm may be toxic to some crops.

11. **Extractable Iron (Fe), Manganese (Mn), and Copper (Cu):** (ICP). These levels are determined using DPTA extraction and reported in ppm. Soils with test levels greater than 4.0 ppm (Fe), 1.0 ppm (Mn), and 0.2 ppm (Cu) are unlikely to show a response to nutrient applications.

12. **Exchangeable Sodium:** (ICP). Sodium is extracted using ammonium acetate and is reported in ppm. Sodium is not a plant essential nutrient, but these levels are important for determining the CEC by summation. These levels also help establish excess amounts of sodium and whether they will have the potential to cause problems with soil structure.

13. **Soluble Salts (Electrical Conductivity):** Soluble salts in the soil are measured on a 1:1 soil:water suspension or using a saturated paste method (SPM). The amount of electrical current this suspension conducts is an indicator of the total salt content of the soil. A soil with a high soluble salt content will conduct more electricity than a soil with a low salt content. The relative amount of soluble salt in a soil is reported as millimhos per centimeter (mmhos/cm). High soluble salt levels can decrease water uptake of growing plants, therefore, affecting the growth and germination of many crops. Soluble salts are mobile. EC exceeding 0.50 mmhos/cm are damaging. See below:

mmhos/cm		Description	Effect on Crop
1:1	SPM		
0 – .25	0 – 2	Non-Saline	None
.25 – 50	2 – 4	Slightly Saline Sensitive	Crop Restrictions
.50 – 1.0	4 – 8	Moderately Saline	Many Crop Restrictions
1.0 – 1.5	8 – 16	Strongly Saline	Most Crops are Restricted
>1.50	>16	Extremely Saline	Few Tolerant Crops

Crop Tolerance		
Poor Tolerance	Average Tolerance	Good Tolerance
Soybeans, Red Clover, Green Beans	Wheat, Oats, Rye, Corn, Sorghum, Alfalfa, Sunfulower, Flax, many grasses	Barley, Sugar Beets, Rape, Western Wheatgrass

14. **Chloride (Cl):** Like nitrate, Chloride acts as a counter-ion for the transport and uptake of essential cations such as calcium, potassium, and magnesium and ammonium. Chloride also is important in enzyme activation and osmotic regulation. Visual deficiency symptoms appear as leaf spotting. Chloride present in the soil can come from rainfall, volcanic emissions, irrigation water, and fertilizers. Commonly used potassium fertilizers contain levels of chloride. As with nitrate and sulfate soil tests, chloride should be taken in 0-24" profile sample. Chloride is recommended for crops at soil test levels below 6 ppm or 45 lb. Cl in the 24 inch sample depth.

15. **Cation Exchange Capacity (CEC):** CEC is routinely determined by the summation method. This method is more accurate for soils that do not contain free calcium and magnesium, generally, associated with soils with a pH of 7.0 or greater. When high levels of free calcium and magnesium are present, the CEC's will appear higher and may provide inaccurate information for herbicide recommendations and other management decisions.

16. **Percent (%) Base Saturation:** Percent base saturation is calculated from exchangeable potassium (K) 2-7%, calcium (Ca) 65-75%, magnesium (Mg) 10-17%, and sodium (Na) 1-5% when the CEC is reported by the summation method. Sodium can be damaging when it exceeds 2.5% (and/or is higher than the %K).

17. **SAR (Sodium Adsorption Ratio):** (Atomic Absorption). The SAR reflects the Na:Ca + Mg relationship and is calculated using meq/L units. As sodium levels increase, the calcium and magnesium cations are replaced. This reduces soil structure and is often observed by crusting and low water permeability. An SAR ratio of 1-5 is considered low and non-damaging, 6-10 is moderate and potentially damaging, and >11 is damaging.

Equation for Sodium Absorption Ration (SAR)

$$SAR = \sqrt{\frac{Na^{+}}{\frac{[Ca^{++} + Mg^{++}]}{2}}}$$

Other notes: High levels of sodium in the soil tend to flocculate (disperse soil particles), resulting in poor soil structure and low water infiltration. Since Sodium is mobile, added calcium (gypsum) will displace sodium and allow it to leach out of the soil profile by way of irrigation water and/or rainfall. Soils high in calcium have better structure than those high in sodium. Use of gypsum on soils where sodium is not high has generally not been shown to be effective in improving soil structure.

18. **Texture:** Estimated texture is grouped into categories of coarse or medium/fine based on organic matter content. Peat is indicated if the organic matter level is greater than 20%. Precise texture determination can be made by measuring the percent sand, silt, and clay in the sample using the hydrometer method. Texture, along with organic matter content, is vital when determining rates for soil-applied herbicides.

19. **Recommendations:** The recommendations on the soil test report can be made for a three-year sequence of crops. These recommendations are based on the soil test results and on the information you provided such as crop to be grown, expected yield, crop rotation and plow depth. Nutrient recommendations are based on Land Grant University where the sample was taken along with MVTL Laboratories recommendations as options.

20. **MVTL Nutrient Recommendations:** Additional recommendations and comments; include MVTL Laboratories recommendations. MVTL nutrient recommendations maintain soil nutrient balances by allowing for crop nutrient removal considerations along with a more aggressive build program to optimize crop yields.