Fertilizer and Soil Amendment Selection and Use in Utah Soils

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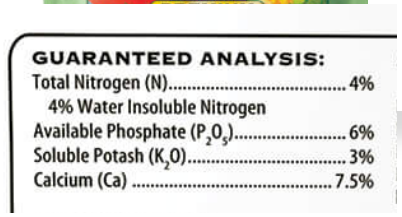
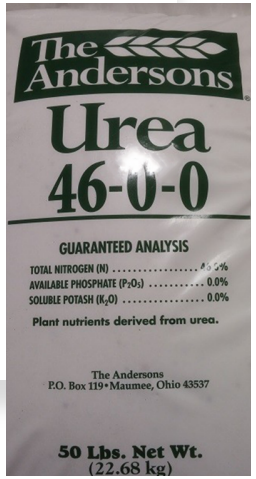
Today's Topics

- Core concepts of soil fertility
- Understanding and selecting fertilizers and amendments
- Determining nutrient application rates to maintain sustainable soils

Let's start with definitions

- Products intended to supply plant nutrients always have 3 numbers: N-P-K, the percent nitrogen, phosphorus (as P_2O_5), and potassium (as K_2O)
- The product is a **fertilizer** when the three numbers **add up to <u>more</u> than 24.**
- The product is an **amendment** when they **add up to <u>less</u> than 24**.





Last definition: “Organic”

1. **Organic matter** – the remains of decomposed plants/animals in soil.
2. **Certified Organic** – USDA program ensures product meets certain farming practice standards *e.g.* seed source, fertilizer, pesticides, etc. Official labels.
3. **Organic** (chemistry) – any compound with carbon in it, typically from something that was once alive. For example, the nitrogen inside a decomposing clover plant is considered “organically bound”.

Nutrients in the Soil

17 Essential Nutrients

Macronutrients (large quantities, % in tissue):

oxygen	hydrogen	carbon
nitrogen	**phosphorus**	**potassium**
sulfur	magnesium	calcium

Micronutrients (small quantities, ppm or ppb)

zinc	**iron**	copper
boron	manganese	chlorine
cobalt	molybdenum	

Element	Role in Plant
Nitrogen (N)	Important part of proteins, chlorophyll, and nucleic acids
Phosphorus (P)	Important for energy transfer and building proteins, coenzymes, nucleic acids, and metabolic substrates.
Potassium (K)	Used in photosynthesis, carbohydrate translocation, protein synthesis, and more
Calcium (Ca)	Used in cell walls and plays a role in structure/permeability of membranes
Magnesium (Mg)	Used in chlorophyll, and is an enzyme activator
Sulfur (S)	Important part of plant proteins
Boron (B)	Helps move sugars and metabolize carbohydrates
Chlorine (Cl)	Involved with oxygen production in photosynthesis
Copper (Cu)	Catalyst for respiration, and used in enzymes
Iron (Fe)	Helps make chlorophyll and in enzymes for electron transfer
Manganese (Mn)	Controls oxidation/reduction systems and photosynthesis
Molybdenum (Mo)	Involved in nitrogen fixation and transforming nitrate to ammonium
Nickel (Ni)	Necessary for germination and the function of urease, an enzyme
Zinc (Zn)	Helps regulate metabolic activity

Adapted from: Brady and Weil (2005)

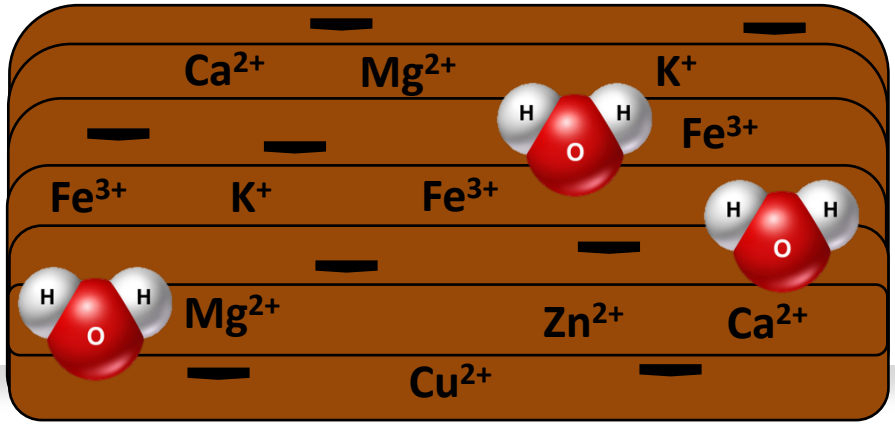
Plant available nutrient forms (key nutrients)

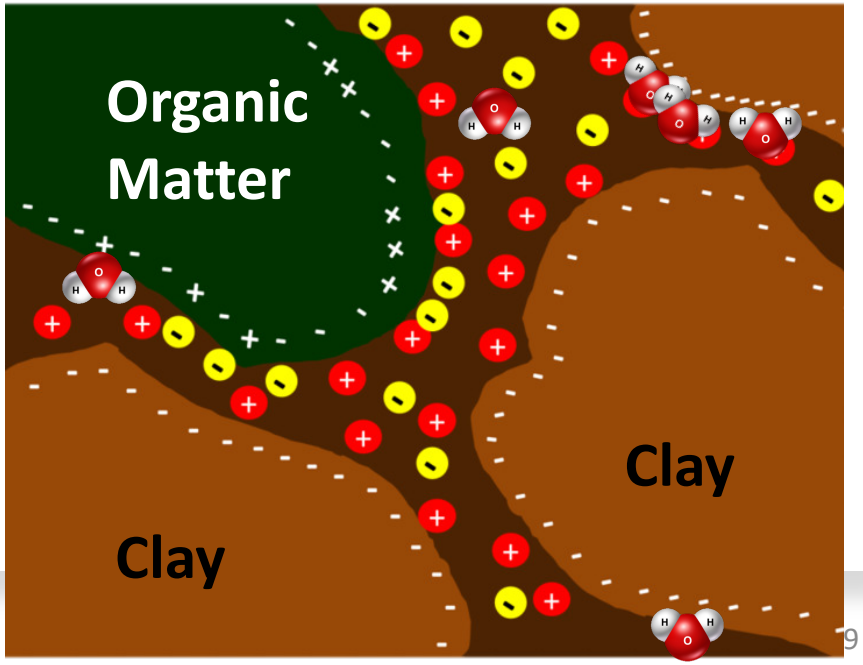
Nutrient Type	Nutrient name	Plant Available form(s)	
Macronutrients	Nitrogen (N)	NO_3^- and NH_4^+	"nitrate and ammonium"
	Phosphorus (P)	$H_2PO_4^-$ and HPO_4^{2-}	"orthophosphates or phosphate"
	Potassium (K)	K^+	"potassium"
	Sulfur (S)	SO_4^{2-}	"sulfate"
	Calcium (Ca)	Ca^{2+}	"calcium"
Micronutrients	Zinc (Zn)	Zn^{2+}	"zinc or chelated zinc"
	Iron (Fe)	Fe^{2+} and Fe^{3+}	"iron; ferrous, ferric, chelated iron"

What do these plant available forms have in common?

General nutrient retention in the soil

- Sand and silt have no charge, no attraction.
- Clay has a negative charge. It attracts water and nutrients with a positive charge. It repels nutrients with a negative charge (magnet analogy)
- Organic matter attracts water and nutrients with positive and negative charges





General nutrient retention in the soil

It depends where and how the nutrients are stored in the soil

- "Soluble" nutrients in the soil water can be accessed immediately by plants, like a free checking account
- "Insoluble" nutrients in the soil cannot be accessed by plants, like a custodial account. The soil makes them available when the checking account gets low, often with the help of microbes
  - Nutrients without a charge are often "organically-bound" or "insoluble" – aka not plant available. They must first decompose ("mineralize")
- Nutrients embedded into the soil's crystalline structure will not be available to the plant in its lifetime, like a very protected trust account

Nutrient release from fertilizers/amendments – same concept

- "Available" or "soluble" nutrients are available right away
- "Insoluble", "organically-bound nutrients", or "slow release" are NOT available right away. They must be broken down first. Pluses and minuses - important considerations.

Total Nitrogen (N) 12.0%
12.0% Water Insoluble Nitrogen*
**12.0% Slow Release Nitrogen from Feather Meal*

Total Nitrogen (N).....5.0%
0.50% Ammoniacal Nitrogen
3.75% Other Water Soluble Nitrogen
0.75% Water Insoluble Nitrogen*
Available Phosphate.....1.0%
Soluble Potash.....1.0%

General nutrient release timing

- Soluble nutrients are available right away and last weeks to months
  - Consider split applications (early and mid-season)
  - Depending on concentration, may want to mix into soil to avoid burn.
- Insoluble nutrients take several weeks to years to be available
  - Example: Blood meal (13-2-1) – several weeks. Greensand (0-0-1) – years or more
- Composts – has soluble and insoluble nutrients
  - Year 1: ~5-10% of N, ~75% P, and most K released
- Manure – has soluble and insoluble nutrients
  - Year 1: ~75% of N, P, K available. Weeks – months.
  - Years 2 & 3: ~10% of nutrients available

Sustainable application rates

Soil Testing Tips: Start with Routine Test

Why?

- Monitor nutrients (P & K) to only add what's needed and avoid excessive levels
- Monitor salinity and pH – critical for plant growth
- Know your texture
- Diagnose problem – many problems look the same by eye

When?

- Best done prior to planting, especially in new landscapes
- Resample every 2-3 years to monitor soil environment

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General Nitrogen (N) needs by crop intensity

- **Low** intensity vegetables (pea, bean). 1-2 lb N/1000 sq. ft (1.5-3 oz/100 sq. ft):
- **Medium** intensity vegetables (most vegetables). 2-4 lb N/1000 sq. ft (3-6 oz/100 sq. ft)
- **High** intensity vegetables (corn, potato, onion). 4-6 lb N/1000 sq. feet (6-9 oz/100 sq. ft)

Selecting a fertilizer or amendment

- Base on soil test. What nutrients do you need? Nitrogen alone or a “complete” fertilizer?
- Do you need the extras?
- The cost factor
  - The extras in fertilizers increase the cost
  - You pay for TLC in manufacturing and marketing

Sources of nutrients

- Store bought fertilizers and amendments
  - Many options, e.g. 16-16-16 (“all purpose”), 14-14-14 (“balanced”), 5-1-1 to 46-0-0, and everything in between. Also N-only (e.g. 46-0-0), P-only (e.g. 0-46-0), and K-only (e.g. 0-0-62) fertilizers to make your own mix.
  - Inorganic fertilizers (mineral salts of nutrient elements): concentrated. Need less.
  - Organic fertilizers (manures, composts, and other organic materials): dilute – need more. Careful.
- Green manures: legumes and other plants grown and used in place that fix atmospheric N.

Organic Nutrient Sources

- Lower nutrient concentration; can add OM.
- Some options: fresh/composted manure, mulches, food wastes, bone/blood meals.
  Typical N contents:
  - **Very Low**: Kelp products (1-2%); Fish Emulsion (2-5%)
  - **Low**: Alfalfa meal (5%), Cotton Seed Meal (6%), Soybean Meal (7%)
  - **Medium**: Blood Meal (12%), Fish Meal (10-14%), Feather Meal (14-16%)

Ideal manure = more N, pH ~7, lower salinity

Solid Manure Type	N	P_2O_5	K_2O	pH	Salinity [dS/m]
	-------- % --------				
Alpaca*	0.4	0.3	0.6	8.3	11
Beef	0.9	0.6	1.1	8.3	8
Biosolids	2.6	2.0	0.2	7.1	6
Chicken	2.0	2.7	1.4	8.0	16
Dairy	0.8	0.5	1.2	8.0	10
Deer*	1.3	0.6	0.0	7.5	1
Goat	0.4	0.5	0.1	8.3	1
Horse	0.7	0.4	1.1	8.7	3
Llama*	0.5	0.4	0.7	8.6	6
Mink	1.7	4.8	0.5	7.6	6
Rabbit*	2.3	1.1	0.4	7.6	1
Sheep	1.0	0.5	1.0	8.3	7
Turkey	3.1	2.9	1.7	7.7	10

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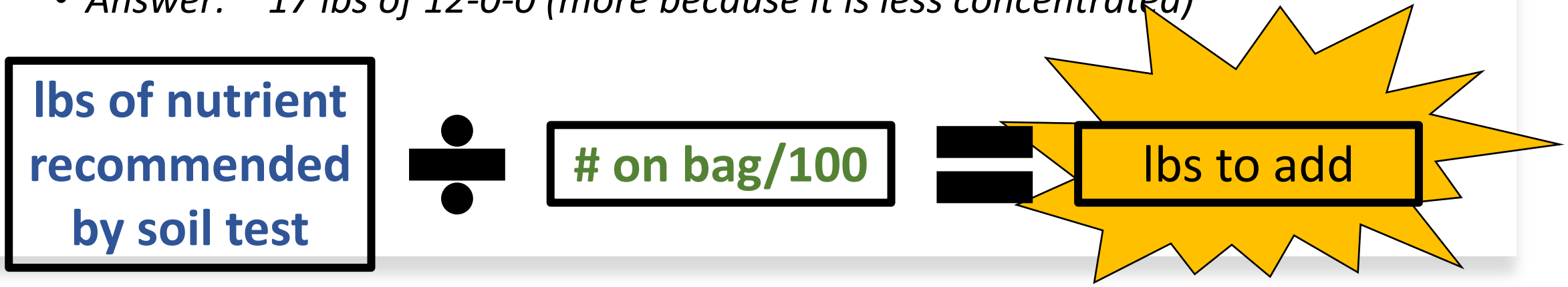
Potential limitations on organic fertilizer sources

- N content – determine “agronomic rates”. Soluble N?
- Harder to find sources with low P and K (especially for erosion-prone soils, sensitive watersheds).
- Salt content – some sources “hotter” than others
- Weed seeds – generally only un-composted sources
- Woody/fibrous – potential N immobilization, needs N supplement
- Increase soil organic matter, but be mindful of salt content and excessive buildup of some nutrients

Calculating the fertilizer rate

- The soil test says you need **2 lbs** nitrogen/1000 square feet for a garden
- How much **46**-0-0 fertilizer is that?
  - *Answer: ~4 lbs of 46-0-0/1000 sq ft.*
- How much 12-0-0 fertilizer would you need if used instead?
  - *Answer: ~17 lbs of 12-0-0 (more because it is less concentrated)*



Equation:

From Soil Test: lbs of nutrient to add	÷	*From fertilizer:* # on bag divided by 100	×	Your garden area (ft²) divided by 1000	=	lbs of fertilizer to *add* to your garden

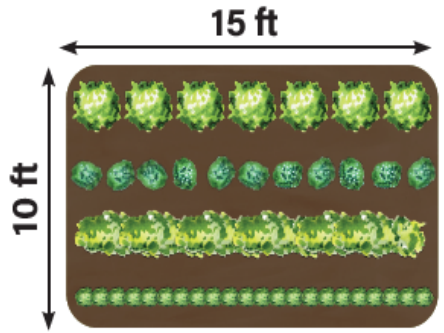
Example:

Soil Test Results

		Recommendations
P	72.1	0 lbs P2O5/1000 sq ft
K	680	0 lbs K2O/1000 sq ft
Nitrate-N		2-4 lbs N/1000 sq ft*

2-4 lbs Nitrogen

(12 % ÷ 100)



15 × 10 = 150

150 ÷ 1000 = 0.15

3 lbs	÷	0.12	×	0.15 ft²	=	3.75 lbs of fertilizer

Worksheet:

____ lbs	÷	____ % ÷ 100	×	____ ft² ÷ 1000	=	_____ lbs of fertilizer to add

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Summary

- The soil is a plant nutrient BANK. Primary macronutrients need to be replenished.
- Soil test to get a baseline - find out what you need. If you only need N, choose options with low/no P & K.
- Read the back on the fertilizer/ amendment label. Don't overapply - happens a lot in urban soils with "natural" or organic management.

Thank you!

(please fill out my eval)

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Soil nutrients of special concern in UT

- Usually Nitrogen needs to be added *each year*, but not always P or K.
- Potassium and Calcium (K and Ca) tend to be naturally high in UT soil.
- Iron (Fe) is abundant in soil, but plants can be deficient when soil pH is high: use chelated Iron (EDTA < DTPA < EDDHA)