SOIL NUTRIENT GUIDE

There are many factors of an environment which contribute to the success of plants. Sunlight, water, air, and soil have significant influence on plants' survivability. While it's fairly easy to determine if plants are receiving the right amounts of sunlight, water and air, determining soil health gets quite a bit more complicated.

This guide is designed to give a general overview of:

- What nutrients found in soils are needed by plants and how they are utilized
- How pH can indicate what nutrients are available in soil
- Identifying nutrient issues in plants and how to remedy them
- Fertilizer comparisons

Feel free to text us at **(585)-488-4170** if you have any questions, or reach out to your local Cooperative Extension for further guidance.

The Fundamentals: Plant Nutrients

Plants require 17 essential nutrients for survival, 14 of which are found in soil. The three nutrients that are not found in soil are **carbon**, **hydrogen** and **oxygen**, which are found in the air and water. These are also referred to as **structural** nutrients, because the contribute to strengthening the physical components of the plant, in addition to providing sources of energy.

The remaining 14 nutrients can be broken down into **primary macronutrients**, **secondary macronutrients** and **micronutrients**.

Primary macronutrients include **nitrogen**, **phosphorus**, and **potassium**. Plants need these in *much* larger amounts compared to the secondary macronutrients and micronutrients.

The **secondary macronutrients** are **calcium**, **magnesium** and **sulfur**.

Lastly, the **micronutrients** consist of iron, boron, copper, manganese, molybdenum, zinc, cobalt and nickel.

Below is a table of the nutrients, the form which plants use, their sources, and some, but not all of, the functions of each nutrient. Occasionally, fertilizers found in garden stores will refer to a nutrient by its **form**, which is why they are listed here.

Nutrient	Form	Source	General Function
Carbon	Carbon dioxide, Carbonic acid	Air	Sugar production for energy
Hydrogen	Hydrogen, Hydroxide, Water	Water	
Oxygen	Oxygen	Air and Water	
Nitrogen	**Ammonium or Nitrate**	**Soil**	**Protein synthesis**
Phosphorus	**Hydrogen phosphate or Dihydrogen phosphate**	**Soil**	**DNA/RNA component**
Potassium	**Potash**	**Soil**	**Metabolism component**
Calcium	Calcium	Soil	Structural integrity
Magnesium	Magnesium	Soil	Moves phosphate
Sulfur	Sulfate	Soil	Chlorophyll production
Boron	Boric acid	Soil	Fruit and seed development
Copper	Copper	Soil	Pollen formation
Iron	Iron	Soil	Chlorophyll production
Manganese	Manganese	Soil	Drought and cold resistance
Molybdenum	Molybdenum	Soil	Processes phosphorus
Zinc	Zinc	Soil	Plant defenses
Cobalt	Cobalt	Soil	Nitrogen fixation
Nickel	Nickel	Soil	Nitrogen conversion

Nitrogen, **phosphorus**, and **potassium** are bolded, because, as previously stated, plants need the most of these nutrients to survive compared to all others. They are also the nutrients that "disappear" from soils the fastest. Because of this, the majority (nearly all) of fertilizer packages will present **NPK** numbers. The letters represent **nitrogen (N)**, **phosphorus (P)**, and **potassium (K)**. *This will be discussed in more detail in the **fertilizers** section.*

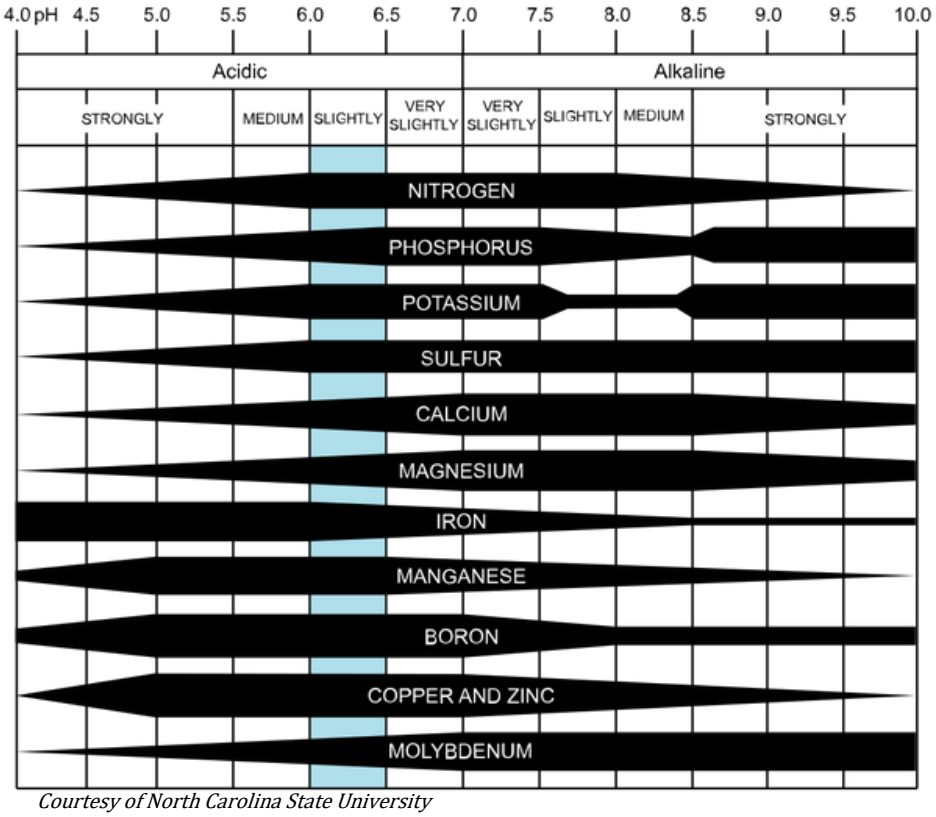
Further Understanding: Soil pH

Soil pH (power or potential of hydrogen), in short, is how acidic or alkaline soils are. The pH scale goes from 0 to 14, with 7 being truly neutral, everything below 7 being more acidic, and everything above 7 being more alkaline. Many factors affect the pH of soil including: soil texture, rainfall, and temperature.

When it comes to soil texture, the denser the soil is (clay), the least likely it is for its pH to shift. This is attributed to the electrical charge of the soil, and its ability to retain to specific kinds of nutrients. Coarser soils, like sand, do not have the same electrical charge, and are more prone to losing nutrients. This makes the soil pH more likely to shift in usually an acidic direction. Organic compost has a similar chemical charge as clay, and can hold nutrients just as well, if not better. It's one of the reasons we at Bristol's Garden Center use it when we install new plants – we blend compost with the native soil to create a pH stable, nutrient rich environment.

Soil minerals are prone to leaching during rain events. Leaching is the loss of nutrients from soil. Rain events, in conjunction with warm temperatures, can accelerate leaching by both washing away nutrients and increasing decomposition rates of organic matter. As decomposition rates increase, available nutrients can be diverted from plants. Freezing events can also increase leaching. When soil freezes, it opens pores in the soil that, when the ground thaws, allow nutrients to easily leach from root zones of plants. These nutrients also become prone to entering waterways, creating toxic environments that are harmful to aquatic life and animals (including humans!)

These nutrient fluctuations influence soil pH, which can serve as an indicator for what the soil needs to be healthy. Below is an infographic showing the relationship of 11 essential nutrients for plants and where they are most prevalent across the pH scale.



Courtesy of North Carolina State University

The **tallest** regions of each nutrient indicate where nutrients are most abundant at the relative pH number. The region between 6.0 and 6.5 show the most overlap where nutrients have the most abundance possible. This is also the pH region where the majority of plants thrive.

It is important to note that some plants thrive in nutrient deficient soils when others can't. This is because these plants can utilize the available nutrients more efficiently than others.

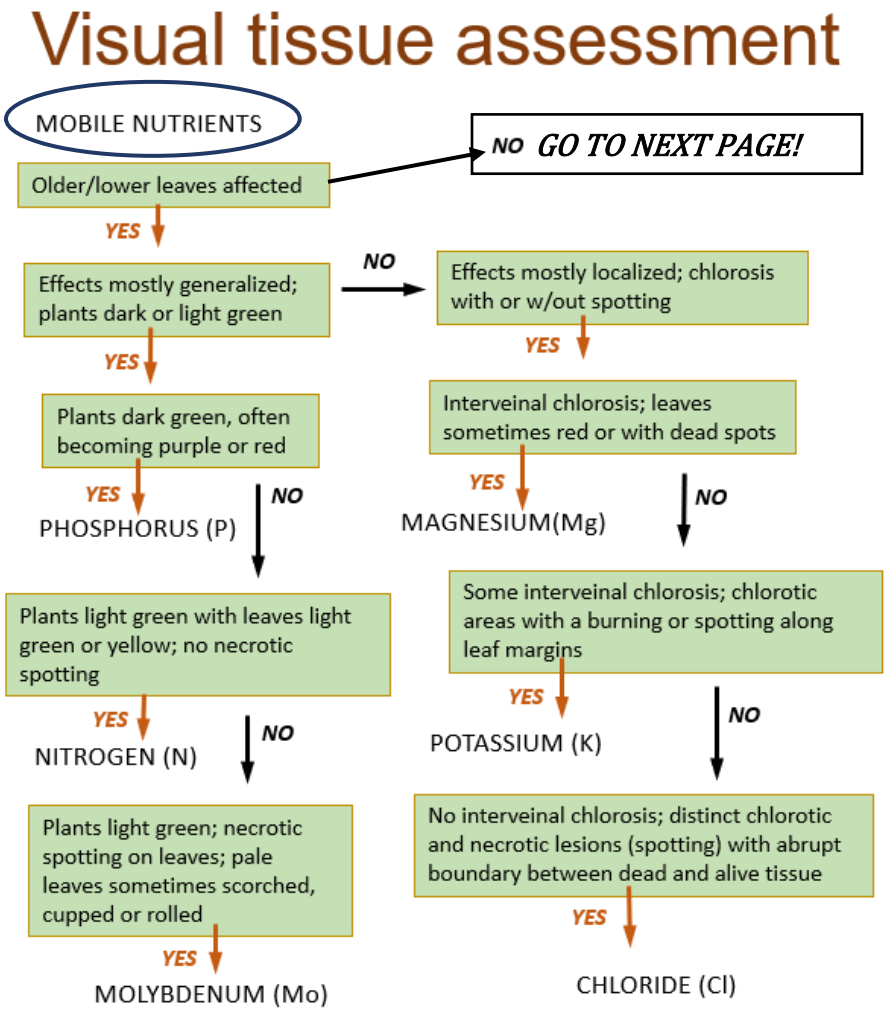
When testing your soil's pH, you can refer to this infographic to begin to estimate what soil nutrients may be present.

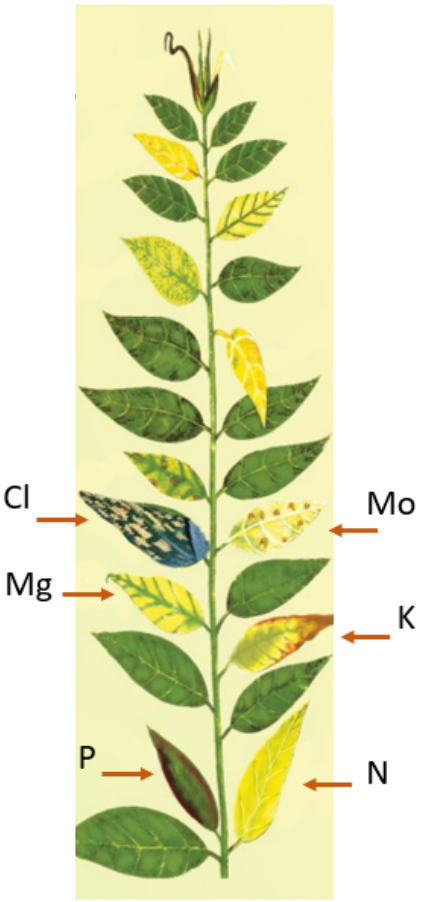
If Plants Could Speak: What are my plants trying to tell me?

We now have an idea on what nutrients plants need, how they use them, and how pH can indicate what nutrients are available in the soil. Without submitting a soil sample to a laboratory, there was a guide created by **Montana State University** that provides an excellent flow chart to identify what nutrients may be deficient in a plant just by looking at it.

Before diving into it, there are a few disclaimers:

- Nutrient deficiency symptoms can *sometimes* overlap with symptoms caused by pathogens, improper sunlight, and over/under watering. Refer to an expert on the subject matter if you are unsure how to identify the differences between these.
- The flow chart is divided into two images: one containing **mobile** nutrients and **immobile** nutrients.
    - **Mobile nutrients** go to where they are needed most, typically where a plant is growing.
    - **Immobile nutrients** are locked in place once the plant sends them where they need to go.
    - Therefore, **older** leaves/plant material are prone to **mobile nutrient** deficiencies, and **newer** leaves/plant material are prone to **immobile nutrient** deficiencies.
- **Chloride** is included as a **macronutrient** in this diagram. In very small amounts, it assists with water transport.
- See **DEFINITIONS** page for clarification of vocabulary





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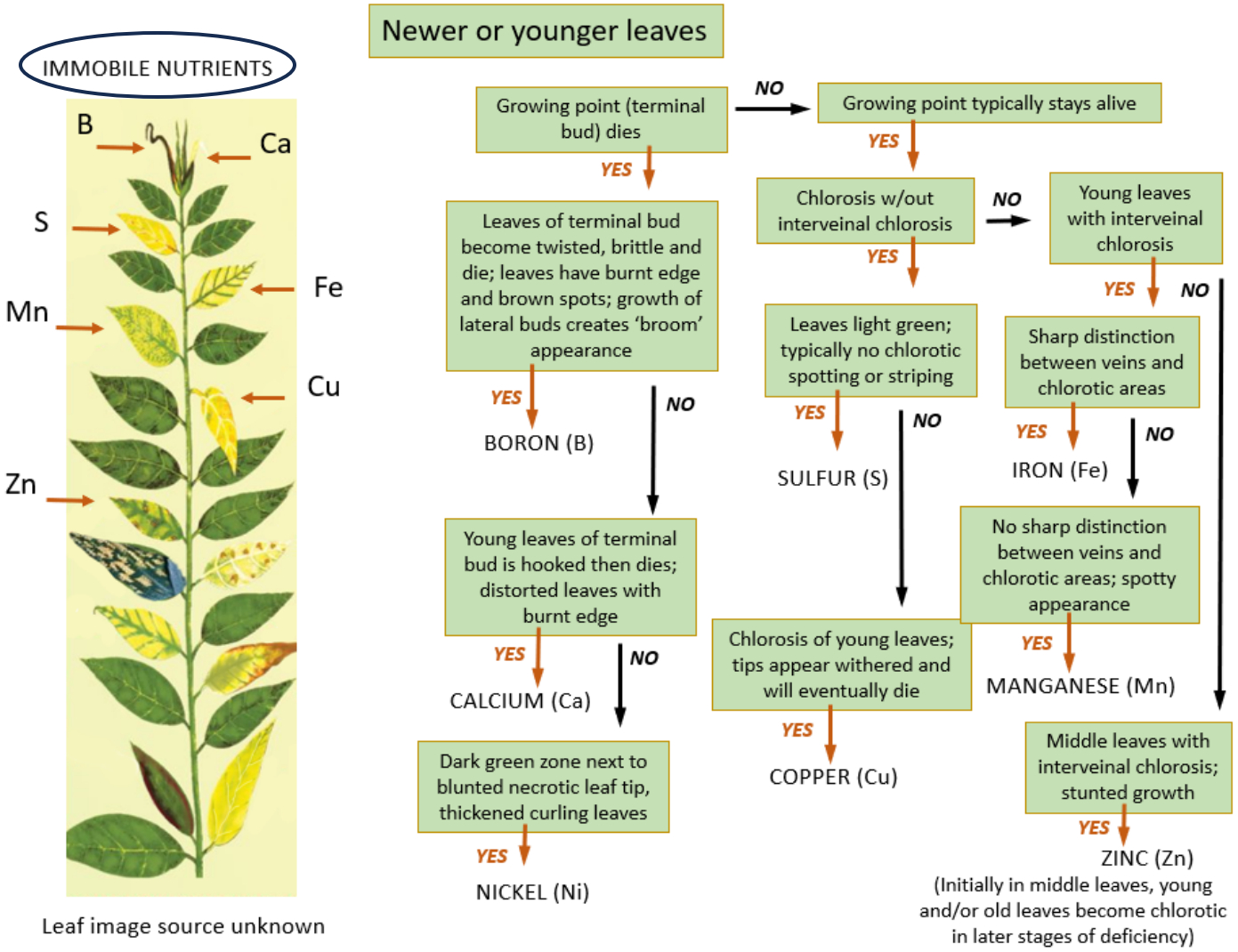

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More information can be found here. If you're still unsure what could be causing these symptoms, text us at **(585)-488-4170** and we will help with identification. If we deem the issue to be outside of our scope of services, contact your local Cooperative Extension office, and submit a sample for laboratory testing.

Definitions

Chlorotic/Chlorosis: Discolored
Generalized: Widespread
Interveinal: Veins are not discolored, while the plant tissue around it is
Lateral Bud: A bud on a branch that is not at the tip
Necrotic/Necrosis: Dead plant tissue
Terminal Bud: Bud at the tip of a branch

Solving Nutrient Issues: Fertilizers

All of the sections leading to this point have provided a solid understanding as to how the nutrients in soils interact with plants. **Fertilizers** are used to supplement soils which have lost nutrients, or stimulate plant growth with excess nutrients. But there are so many different fertilizers available for purchase, it can become daunting to figure out which one is the most helpful for your plant. Here, we will go more in-depth on selecting the right fertilizer for your needs.

We briefly mentioned **NPK** in **The Fundamentals: Plant Nutrients** section. Since **NPK** nutrients are easily leached from soils, they are the most common nutrient supplements needed, which is why they are in nearly all fertilizers. The numbers associated with **NPK**, which are usually presented as **# - # - #**, indicate how much of each nutrient is present as a ratio. For example, if a fertilizer has **NPK** numbers of **12-8-17**, it means for every **10 pounds** of fertilizer, there are **1.2 pounds of nitrogen**, **0.8 pounds of phosphorus oxide**, and **1.7 pounds of potash**. The remainder of fertilizer mass includes other nutrients and physical matter.

Fertilizer manufacturers have taken great care to find optimal balances of **NPK** depending on what the target plants' needs are. They have also provided timing of when to fertilize to reduce chances of **over fertilization**. When this occurs, plants cannot uptake water easily, growth can stunt and wilt, and pathogens can infiltrate root systems, leading to death. **Always follow the manufacturer's guidelines!**

You may come across some fertilizers that have the same **NPK** ratios, but different **secondary macronutrient** or **micronutrient** percentages. In these cases, they have been optimized for specific plants or use cases.

Organic fertilizers contain **carbon** and were derived from once-living animal or plant material. Most of the time, **organic** fertilizers contain beneficial microbes promoting soil health. These can sometimes contain harmful bacteria or fungi, so precautions should be taken when handling them.

The modes of which fertilizers can be added to soil can vary. There are **granular**, **liquid**, and **spikes**, to name a few different varieties.

Type	Granular	Liquid	Spikes
Organic?	Usually	Rarely	Usually
Use	Slow-release of nutrients Seasonal applications	Corrects nutrient deficiencies quickly Covers larger areas easily	Nutrients go directly to roots Seasonal applications
Note	Material should not touch the plant	Tend to have high nutrient concentrations	Not suited for large trees

Sources

This guide was compiled from the sources stated below. These subjects go much further in depth than what was covered here. Feel free to read more details from the sources provided.

Cornell Cooperative Extension Nutrient Management
Montana State University Nutrient Deficiency and Toxicity
Oregon State Extension Guide to Understanding Fertilizers
Oregon State Extension Soil Test Results Interpretation
Purdue Calculating pH
University of Minnesota Extension Quick Fertilizing Guide
USDA pH Soil Health

The remaining section of this guide is a table of most of the fertilizers we carry, how they compare to one another, and their general use purposes.

Brand	Fertilizer	Organic	N	P	K	Other Nutrients	Purpose	Trees and Shrub Timing	Flower and Vegetable Timing
Bonide	Plant Starter	No	3	10	3	*Insignificant*	Transplants	Once at time of transplant	
Bonide	Root & Grow	No	4	10	3	IBA Growth Hormone	Transplants	Every 4-6 Weeks starting in spring	Every 6-8 Weeks starting in spring
Espoma	Azalea / Berry / Evergreen / Holly Tone	Yes	4	3	4	Calcium, Magnesium, Sulfur, Bacillus spp.	Continual growth stimulation	Early spring and Late Spring	Not recommended
Espoma	Bio Tone	Yes	4	3	3	Calcium, Magnesium, Sulfur, Bacillus spp. & Mycorrhizae	New planting	Once at time of planting	
Espoma	Blood Meal	Yes	12	0	0	*Insignificant*	Nitrogen boost	Once in spring, once in fall	
Espoma	Bone Meal	Yes	4	12	0	Calcium	New planting and continual growth	Not recommended	Once at time of planting and once every spring and fall
Espoma	Chicken Manure	Yes	5	3	2	Calcium	Continual growth stimulation	Once in spring, once in fall	Monthly from spring through fall
Espoma	Citrus Tone	Yes	5	2	6	Calcium, Magnesium, Sulfur, Bacillus spp.	Continual growth stimulation	Late winter, later spring, late fall	Not recommended
Espoma	Cottonseed Meal	Yes	6	2	1	*Insignificant*	Nitrogen boost	Once in spring, once in fall	Not recommended
Espoma	Flower Tone	Yes	3	4	5	Calcium, Magnesium, Sulfur	Bloom stimulation	Not recommended	Once per month during growing season
Espoma	Garden Food	Yes	10	10	10	*Insignificant*	Continual growth stimulation	Once during the growing season, spring is preferable	
Espoma	Garden Gypsum	Yes	0	0	0	Calcium, Sulfur	Soil conditioner	Any time when the ground is not frozen	
Espoma	Garden Lime	Yes	0	0	0	Calcium, Magnesium	Raises soil pH	Every 20 weeks starting in spring	
Espoma	Garden Tone	Yes	3	4	4	Calcium, Magnesium, Sulfur, Bacillus spp.	New planting	Not recommended	Once - mixed into soil prior to planting
Espoma	Greenrock	Yes	0	0	0	Calcium, Magnesium, Iron	Continual growth stimulation	Once in spring, once in fall	
Espoma	Iron Tone	Yes	3	3	5	Calcium, Magnesium, Sulfur, Iron, Bacillus spp.	Treats iron deficiency	Early spring or any time iron deficiency is observed	
Espoma	Kelp Meal	Yes	1	2	0	*Insignificant*	Minor nutrient supplement	Sparsely throughout the growing season	
Espoma	Plant Tone	Yes	5	3	3	Calcium, Magnesium, Sulfur, Bacillus spp.	Continual growth stimulation	Once in spring, once in fall	Once every month during the growing season
Espoma	Potash	No	0	0	60	*Insignificant*	Treats potassium deficiency	Once as needed	
Espoma	Rock Phosphate	Yes	0	3	0	Iron	Bloom stimulation	Not recommended	Once - mixed into soil prior to planting
Espoma	Rose Tone	Yes	4	3	2	Calcium, Magnesium, Sulfur, Bacillus spp.	Bloom stimulation	Once every month during the growing season	
Espoma	Soil Acidifier	Yes	0	0	0	Sulfur	Lowers soil pH	Early spring and/or until desired pH is reached	
Espoma	Tomato Tone	Yes	3	4	6	Calcium, Magnesium, Sulfur, Bacillus spp.	New plantings for increased yields	Not recommended	Once - mixed into soil prior to planting
Espoma	Tree Tone	Yes	6	3	2	Calcium, Magnesium, Sulfur, Bacillus spp.	Continual growth stimulation	Once in spring, once in fall	Not recommended
Espoma	Triple Phosphate	No	0	45	0	*Insignificant*	Treats phosphate deficiency	Once as needed	
Espoma	Urea	No	45	0	0	*Insignificant*	Treats nitrogen deficiency	Once as needed	
Jack's	African Violet	No	12	36	14	Boron, Copper, Iron, Manganese, Zinc	Bloom stimulation	Every 7-14 days	
Jack's	All Purpose	No	20	20	20	Boron, Copper, Iron, Manganese, Zinc	Balanced nutrient boost	Every 7-14 days	

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Brand	Fertilizer	Organic	N	P	K	Other Nutrients	Purpose	Trees and Shrub Timing	Flower and Vegetable Timing
Jack's	Blossom Booster	No	10	30	20	Magnesium, Boron, Copper, Iron, Manganese, Zinc	Bloom stimulation	Every 7-14 days	
Jack's	Houseplant Special	No	15	30	15	Boron, Copper, Iron, Manganese, Zinc	Continual growth stimulation	Every 14 days	
Jack's	Orchid Special	No	30	10	10	Boron, Copper, Iron, Manganese, Zinc	Bloom stimulation	Every 14 days	
Jack's	Palm Food	No	16	5	25	Sulfur, Boron, Copper, Iron, Manganese, Zinc	Continual growth stimulation	Every 7-14 days	
Jack's	Petunia FeED	No	20	6	22	Magnesium, Boron, Copper, Iron, Manganese, Zinc	Bloom stimulation	Every 7-10 days	
Jack's	Root Boost	No	5	5	13	Calcium, Sulfur, Magnesium, Boron, Copper, Iron, Manganese, Zinc, Bacillus spp.	New planting	Once at time of planting	
Jack's	Tomato FeED	No	12	15	30	Calcium, Magnesium, Boron, Copper, Iron, Manganese, Zinc	Continual growth stimulation	Every 7-14 days	
Jobe's	Citrus Spike	Yes	4	6	6	Calcium, Sulfur, Mycorrhizae	Continual growth stimulation	Once in spring, once in fall	Not recommended
Jobe's	Evergreen Spike	Yes	11	3	4	Calcium, Sulfur, Mycorrhizae	Continual growth stimulation	Once in spring, once in fall	Not recommended
Jobe's	Fruit Fertilizer Spike	Yes	8	11	11	Calcium, Sulfur, Mycorrhizae	Continual growth stimulation	Once in spring, once in fall	Not recommended
Jobe's	Tree & Shrub Spike	Yes	8	2	2	Calcium, Sulfur, Mycorrhizae	Continual growth stimulation	Once in spring, once in fall	Not recommended
Ross	Root Feeder Tree and Shrub	No	25	10	10	*Insignificant*	Continual growth stimulation	Once in spring, once in fall	Not recommended

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