# Fertilizer Management

***Soil Fertility and Plant Nutrition***

***Fertilization of Garden Soil***

***(Grades 9-12)***

UCCE Master Gardener Program of
Riverside County

# Master Gardeners

The University of California Cooperative Extension (UCCE) Master Gardener Program (MGP) is an educational program designed to teach and effectively extend information to address home gardening and non-commercial horticulture needs in California.

UCCE is the outreach arm of UC's division of Agriculture and Natural Resources (ANR). Master Gardener volunteers (MG volunteers) promote the application of basic environmentally appropriate horticultural practices through UCCE-organized educational programs that transfer research-based knowledge and information.

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program

# Why is This Important?

Fertile soil contains nutrient elements in amounts favorable for optimal growth of crop plants and in a plant available form that crop roots can absorb.

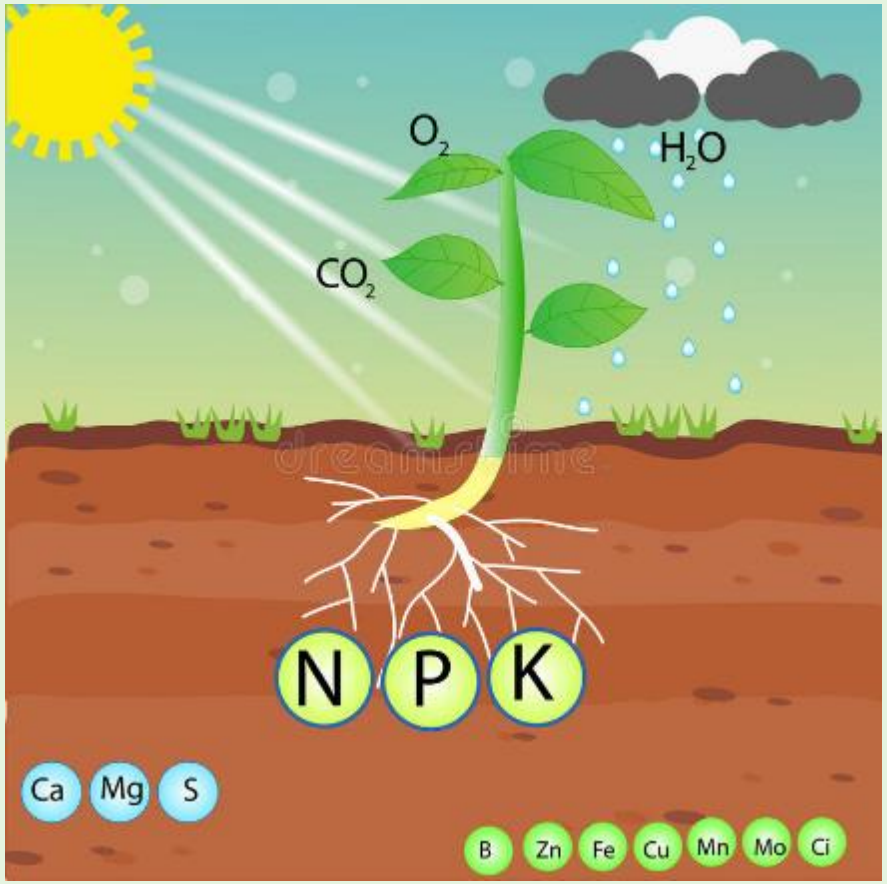
**Learning Goal:** Students will learn that plant nutrition is a plant's need for and use of 17 chemical elements for growth and development, and that factors can enhance plant use of these nutrients.

# Part 1

## Soil Fertility and Plant Nutrition

# Plant Nutrients

- Plant nutrients are chemical elements and compounds necessary for plant growth and reproduction.
- Healthy soil contains the 17 elements plants need
  - 3 from air and water
    - Oxygen (O), Hydrogen (H), and Carbon (C)
  - 14 from minerals in soil
- Gardeners can add nutrients to plants ***if needed***



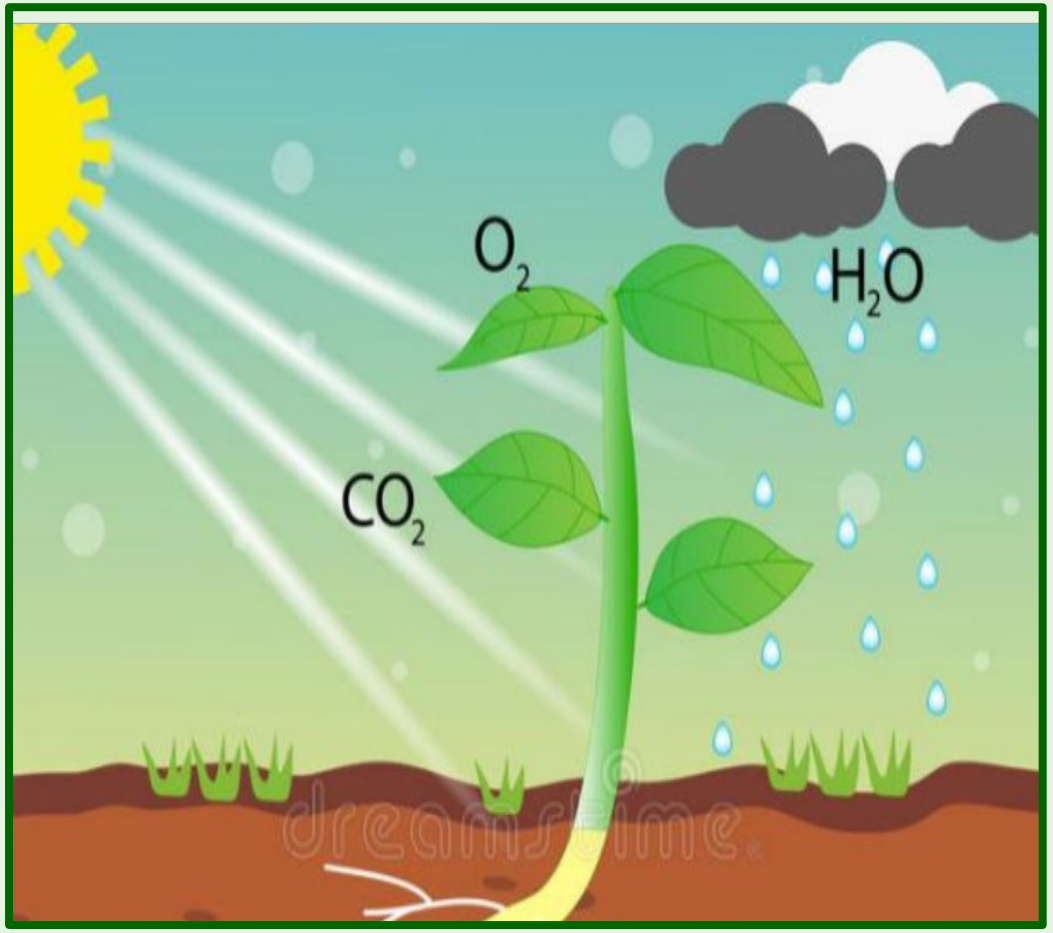
# 17 Essential Plant Elements

**The 17 plant nutrients are divided into mineral and non-mineral elements.**

- *Mineral* nutrients enter plants primarily through the soil.
- *Non-mineral* nutrients may enter either through the soil or atmosphere.

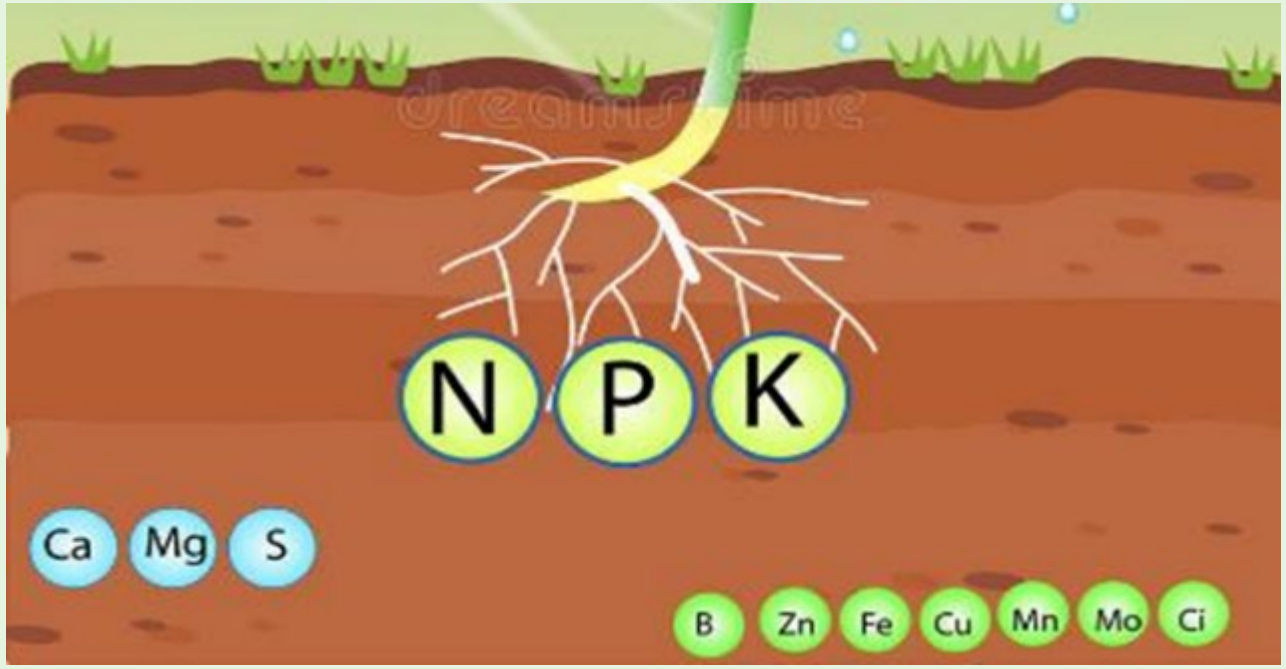
# Non-Mineral Nutrients

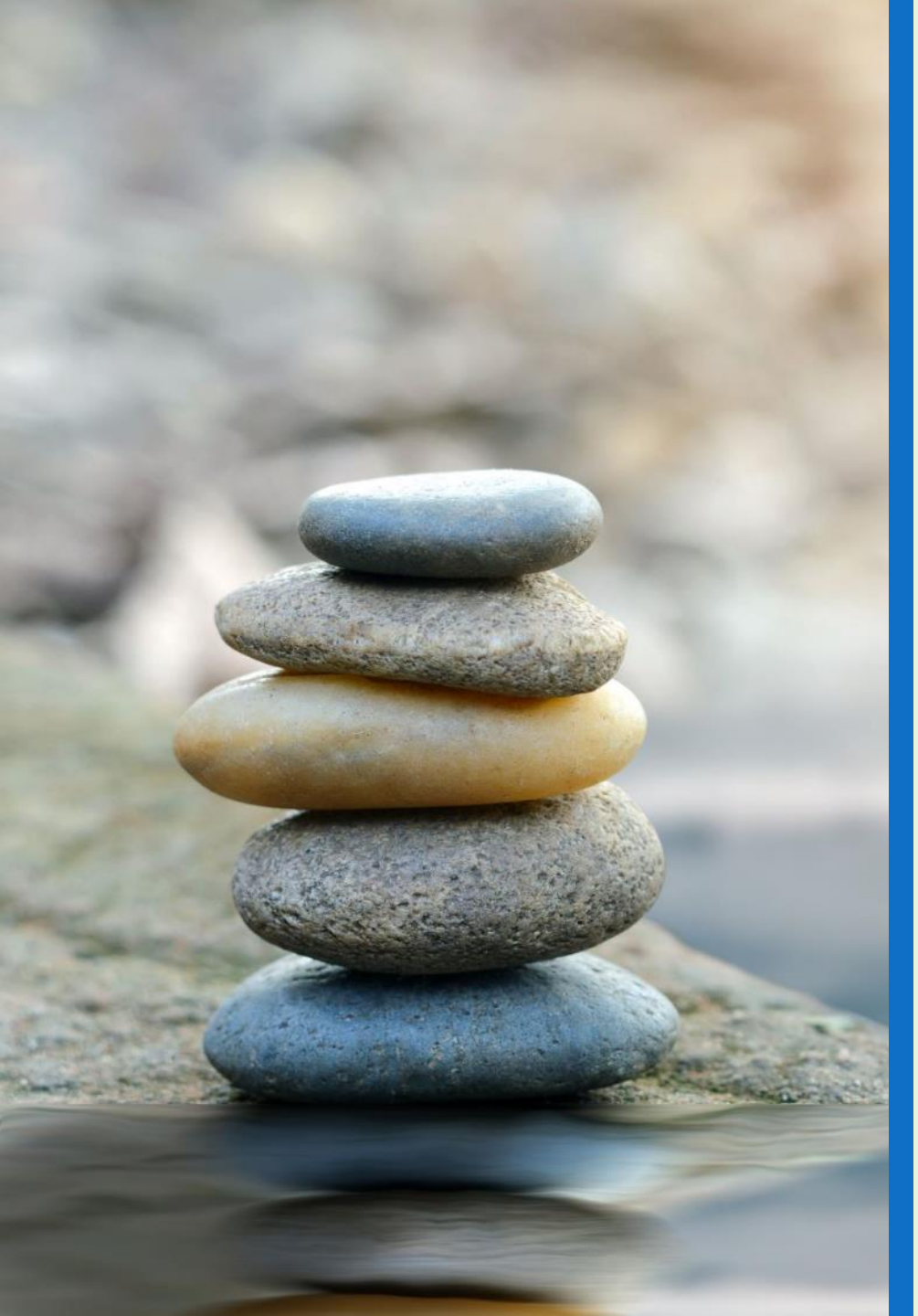
Non-mineral nutrients are in the ***compounds*** required for photosynthesis. Water, supplied via irrigation or rainfall provides the hydrogen required to convert solar energy (light) into chemical energy (sugars.)



# Mineral Nutrients

All other essential elements are mineral nutrients. These are dissolved in water and most commonly enter the plant when absorbed by plant roots.





# What You Need to Know

## Mineral Nutrients

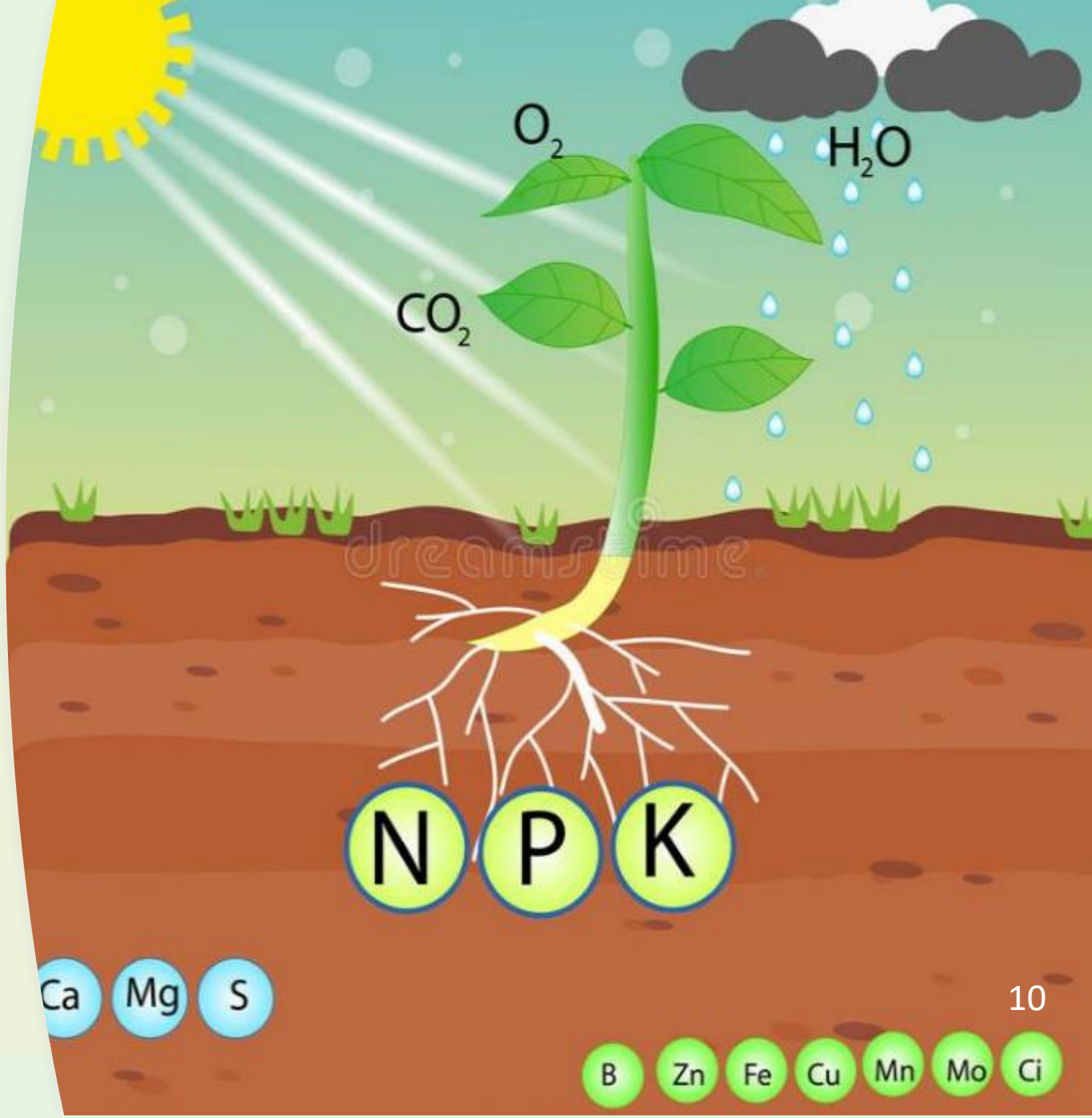
**There are 14 mineral elements that are needed by plants, but the required amount varies.**

- **Macronutrient**
  - Plant-essential elements required in relatively large amounts by plants.
- **Micronutrient**
  - Plant-essential element required by plants in very small amounts.

# NPK

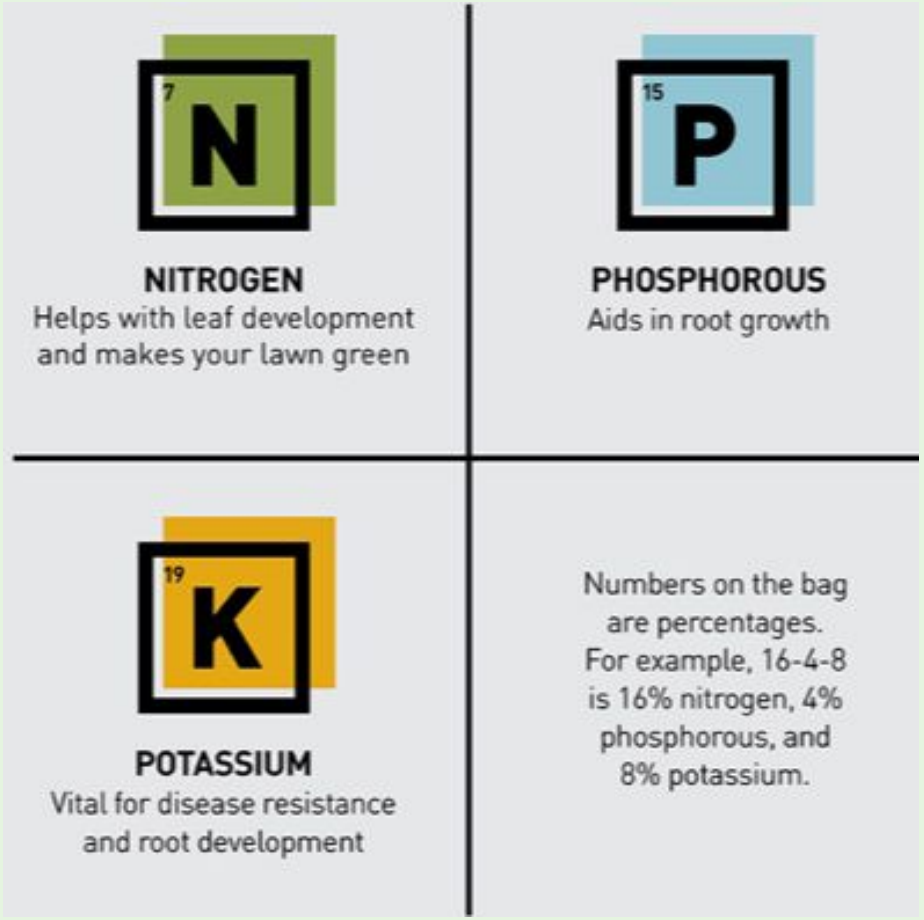
Three **primary** mineral macronutrients for plants:

- **N** Nitrogen
  - Greening of plant
- **P** Phosphorus
  - Health and vigor
- **K** Potassium
  - Movement of water and nutrients



# Plants' Need for NPK Varies

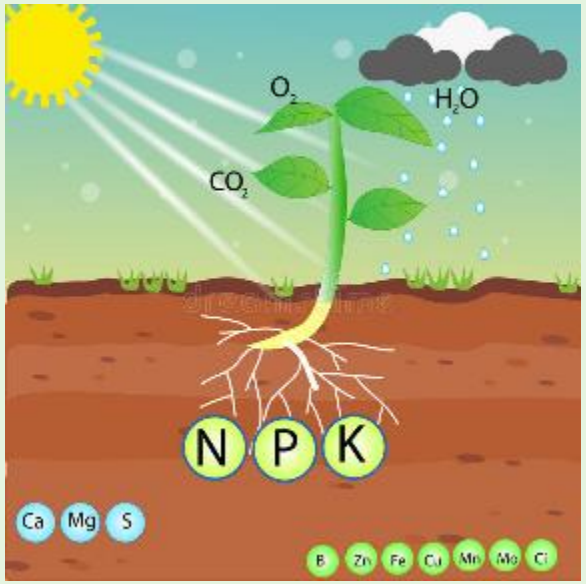
- Some plants need different levels of the three primary macronutrients, so fertilizers, or plant food products, list three values (percentages) for nitrogen, phosphorus and potassium.
- Numbers on fertilizer products provide the % for each chemical element.



# Additional Mineral Nutrients

**In addition to Nitrogen, Phosphorous and Potassium, plants need other minerals from the soil**

- Other *secondary macronutrients*
  - Calcium
  - Magnesium
  - Sulfur




- Eight *micronutrients*
  - Boron
  - Chlorine
  - Copper
  - Iron
  - Manganese
  - Molybdenum
  - Nickel (not included in this diagram)
  - Zinc

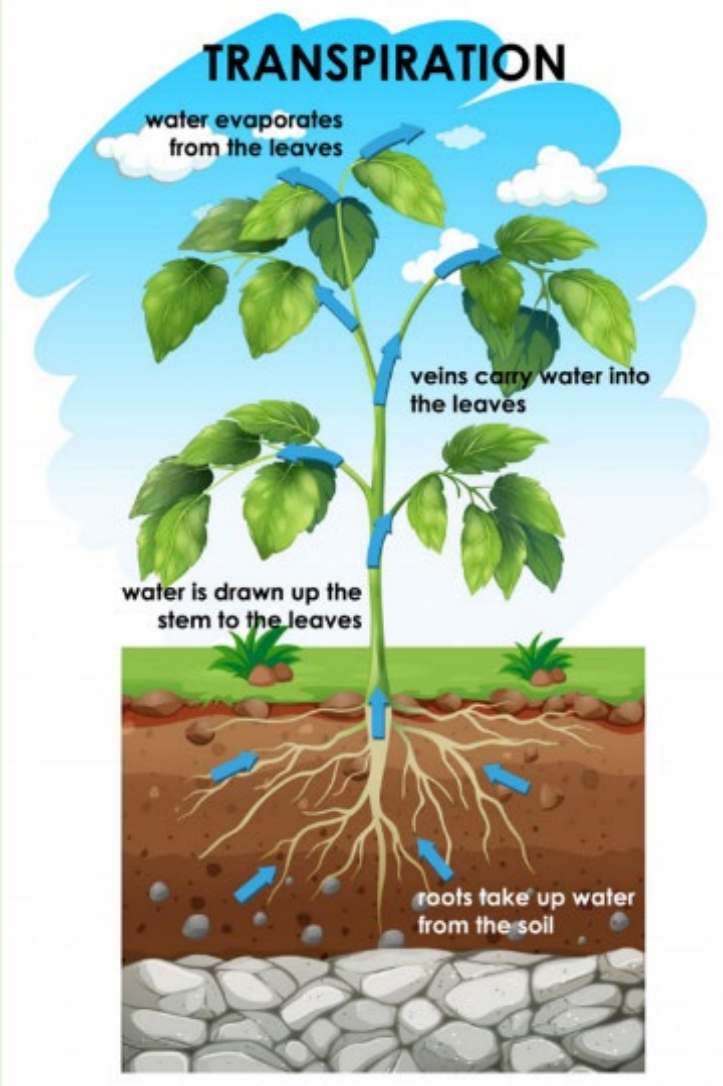
# Nutrient Balance

- Although plants need much higher amounts of macronutrients  than micronutrients, all 17 essential elements must be present for a plant to be healthy.
- A common problem in California is related to a plant's need for nitrogen, phosphorus, potassium, zinc and iron, as well as symptoms caused by excesses in boron, chloride and sodium.

Source:  California Master Gardener Handbook Second Edition, Pettinger, 2015

# Uptake of Nutrients

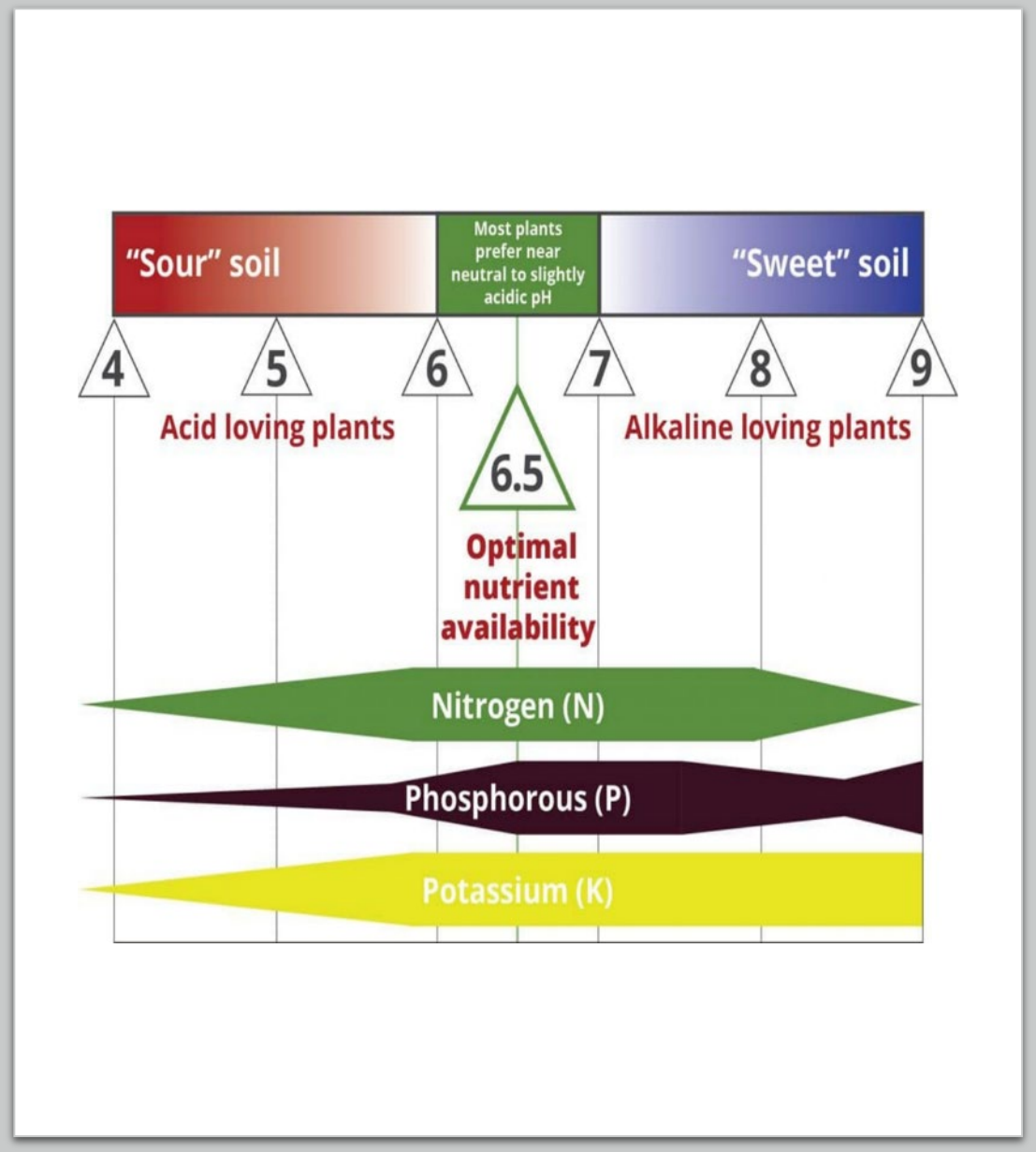
- Before a nutrient can be used by plants it must be dissolved in a soil and water solution.
- Nutrients are carried up through the plant with water absorbed through the roots.
- Most minerals and nutrients are *more available in acid soils* than in neutral or slightly alkaline soils.



# Know the pH Level in Your Garden's Soil

The pH level measures the acidity and alkalinity of soil.

- The scale ranges from 4.0 to 9.0
- pH Level affects the availability of nutrients to support plants
  - Nutrients can be absorbed at a pH level from 5.5 to 7.5
  - Many plants do well at a pH range of about 6 to 7



# Determining Hunger Signs in Your Plants

It is hard to tell whether the soil has a nutrient problem just by looking at the plants. Symptoms vary by nutrient and plant species. Common symptoms include:

- Little or no growth
- Dead tissue at the leaf tips, on the leaf edges, or within the leaves
- Yellow or dead leaves on one part of the plant only
- Overall leaf yellowing, yellow streaks, or white between the leaf veins

Source: Texas A&M AgriLife Extension Service, Tony L. Provin and Mark L. McFarland, 4/14

# Rule Out Other Possible Causes

Before adding any fertilizer check for other possible causes of the problem. Similar symptoms can be caused by:

- Diseases
- Insects
- Herbicides
- Compacted soil
- Wide changes in soil moisture levels

Source: Texas A&M AgriLife Extension Service, Tony L. Provin and Mark L. McFarland, 4/14

# Video: Determining Nutrient Level in The Soil

To learn whether you need to add nutrients, have your garden soil tested. You can begin by using a soil testing kit sold at most garden centers and nurseries.

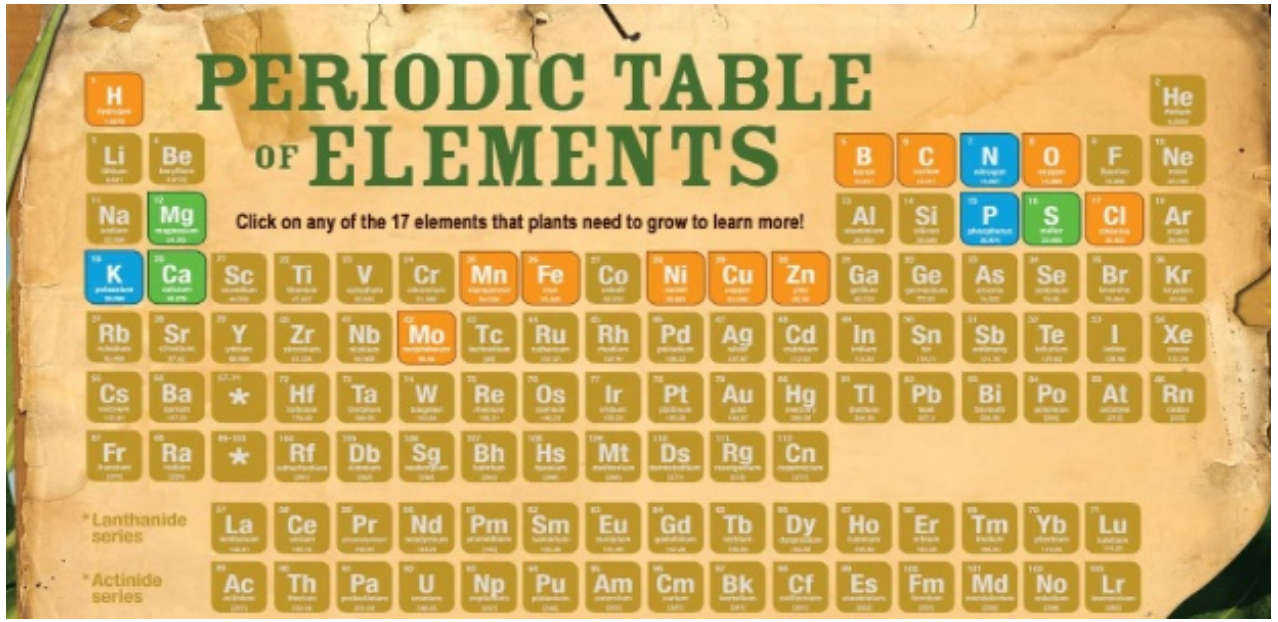

Note: Ideally, **distilled** water should be used when administering a soil test.

# Check For Understanding

- What is essential nutrition for plants?
- Name the three primary mineral elements for plant nutrition.
- How does pH level affect a plant's use of nutrients?
- What are three common plant hunger signs?

# Extend Your Understanding

Explore the interactive periodic table to learn more about how each chemical element is important to plant nutrition.



# Part 2

## Fertilization of Garden Soil

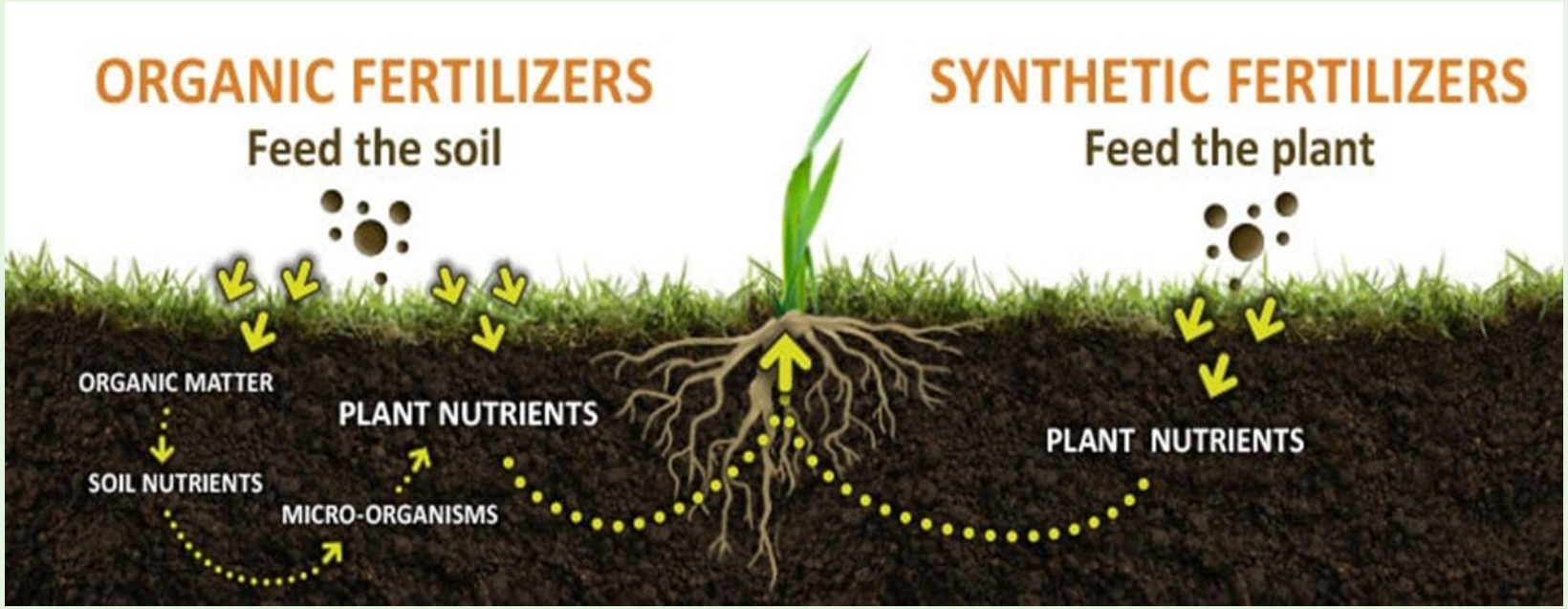
*Become familiar with fertilizer options and follow the 4 R's of plant nutrient stewardship!*

# Correcting Nutrition Deficiencies: Amount of Fertilizer

- Too *little* fertilization can result in poor plant growth and appearance.
- Too *much* fertilization, regardless of the source, is unnecessarily expensive, may cause plant injury, and may pollute groundwater or surface water.

# Correcting Nutrition Deficiencies
# Types of Fertilizer

Nutrient deficiencies can be corrected by the addition of inorganic or organic fertilizer, along with soil and water management.



# Types of Fertilizers

- **Inorganic (chemical)**
- Generally contains 3 primary nutrients:
  - NPK
- Fast acting
  - Reduces deficiencies in NPK
  - Promotes plant growth

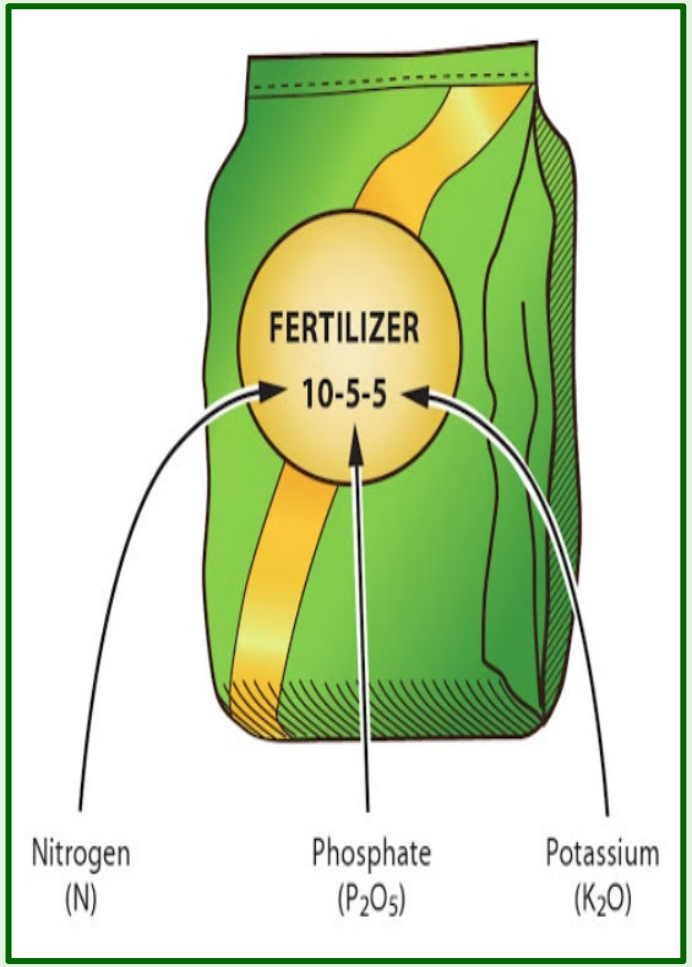
- **Organic (from plants and animals)**
  - Animal excrement (manure)
  - Plant remains (compost)
- Slow acting
- Improves plant health
- Enriches soil with organic matter to improve the health of the soil

**Many successful gardeners use a combination  of inorganic and organic fertilizers.**

# A Closer Look at Inorganic Fertilizers

## Commercial Fertilizers

- Commercially available inorganic fertilizers vary in their plant nutrient content. By California law, the guaranteed content of the fertilizer is expressed as a percentage and must be stated on the bag.
  - For example, a 100 pound bag of complete fertilizer may be labeled 12-12-12. That means it contains 12 pounds each of nitrogen, phosphorous, and phosphate. The remaining 64 pounds is filler which helps facilitate even spreading of the fertilizer.
- *Complete* inorganic fertilizers are mixes containing the three primary nutrients: Nitrogen, phosphorus and potassium.




Source: CA Master Gardener Handbook, Pettinger, 2015

# A Closer Look at Inorganic Fertilizers
# Commercial Fertilizers: Other Factors

Other factors to consider:

- The advantage of inorganic fertilizers is that they are fast-acting, dissolving and releasing nutrients readily.
- Key disadvantages are their potential to contaminate the environment through run-off or leaching, and to "burn" crops if overused or mismanaged.
- Slow-release inorganic nitrogen fertilizers are available at a higher cost. Their release rates are governed by environmental factors such as soil moisture content and temperature. Using these slow-release products reduces the chance of environmental contamination and crop injury.

Source: CA Master Gardener Handbook, Pettinger, 2015

# A Closer Look at an Organic Fertilizer Manure

When used correctly, manure can be a good organic fertilizer.

- For its organic nutrient sources to be beneficial to plants, the nutrients must be changed into chemical forms. *This means any type of manure used must be mixed into the soil at least one month before planting*.
- Because manure may contain weeds and salt, it should be applied cautiously where these could be a problem.

Source: CA Master Gardener Handbook, Pettinger, 2015,

# A Closer Look at an Organic Fertilizer
# Manure

Other factors to consider:

- Manure can vary greatly in nutrient content.
- However, typically manures are more complete than most inorganic plant nutrients because they contain most or all of the essential nutrients required for plant growth.
- Dry chicken manure is  the most concentrated with primary plant nutrients.
- Steer manure from animals fattened on concentrated feeds is richer in nutrients than dairy manure.

Source: CA Master Gardener Handbook, Pettinger, 2015

# When Using Fertilizer Apply the 4R's

# Right Place

**Right place refers to two different aspects of fertilizer placement:**

- Within Soil Profile: Placement of fertilizers within the soil profile means to place the nutrients *close to the rooting zone*. This is especially important for less mobile nutrients, like phosphorus and potassium, but less so for nitrogen.
- Within a Field/Planting Beds: Within a growing field or planting beds there may be variability in soil texture, soil type, or organic matter content. Depending on where, this will change the "right rate". *Use of a single, uniform rate of fertilizer across a field or several planting beds is likely to under-fertilize in some areas and over-fertilize in others*.

# Right Source

**Assess soil nutrient supply (including from organic sources and existing soil levels), assess plant demand, and predict fertilizer-use efficiency.**

- When applying fertilizer, it is important to ensure the correct form of fertilizer is being added for your *specific* garden conditions.
  - Ammonium-based fertilizers can *have a strong acidifying effect on soil.*
  - Nitrate-based fertilizers  can *have an alkalinizing effect on soil*.
  - These changes in pH can alter nutrient availability to plants!

# Right Rate/ Amount

**It is important to administer your fertilizers in the correct proportions. Be sure to read the fertilizer product labels!**

- Also, be aware that additional Nitrogen (N) fertilizer will not produce increases in crop yield if P, K, or other micronutrients are deficient
- One of the most difficult decisions around N fertilizer management is the correct rate. This is due to the many factors that affect fertilizer availability:
  - soil texture
  - soil mineralogy
  - organic matter content
  - season
  - crop

# Right Time

**Assess the timing of a crop's growing period, the soil's current nutrient supply, and weather factors.**

- To increase the effectiveness of fertilizer applications, it is necessary to match fertilizer release with plant demand. This can be achieved by either splitting fertilizer applications throughout the season and/or the use of stabilized fertilizers.
  - **Split Application:** Applying smaller amounts of fertilizers at shorter intervals reduces salt stress and losses by leaching. Split application of Nitrogen (N) fertilizer is effective for a wide variety of California field crops and tree crops.
  - **Stabilized Fertilizers:** These are slow and controlled release fertilizers. In addition to increased efficiency and productivity, the use of stabilized fertilizers has led to increased air and water quality.

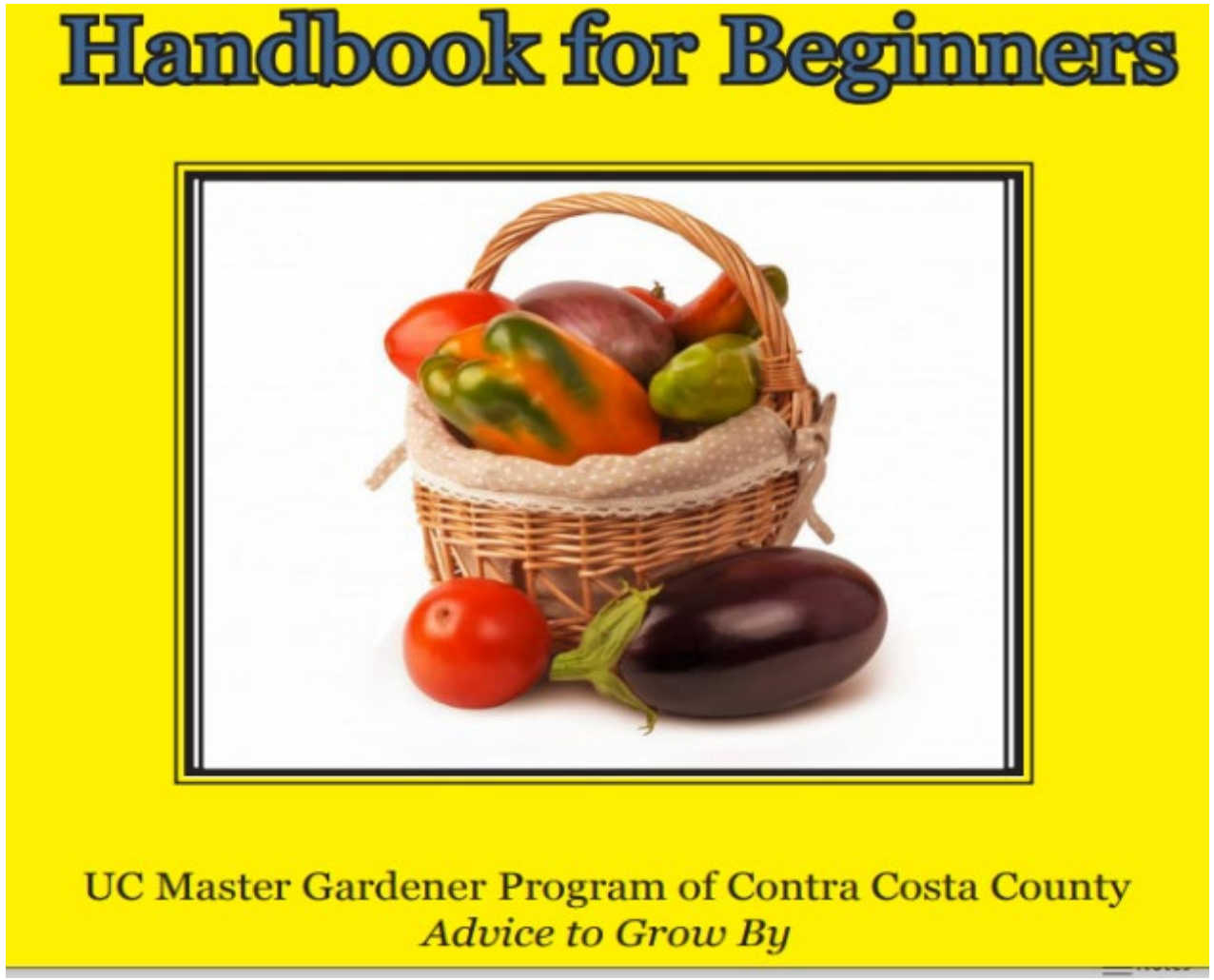
# Video: The 4 R's of Plant Nutrient Stewardship

# Check For Understanding

- What are the advantages to using an inorganic fertilizer?
- What are the advantages to using an organic fertilizer?
- What does California law require to be labeled on a bag of commercial fertilizer?
- What are the 4 R's of  plant nutrient stewardship?
- How will the 4 R's affect your gardening practices?

# Apply Your Understanding

Research the best options for fertilizing your vegetable garden with inorganic and/or organic plant nutrients. Refer to pages 14-15 in the Vegetable Gardening Handbook for Beginners .



# Extend Your Understanding

## Plant Nutrients and the Environment

The 4 R's of Plant Nutrient Stewardship were developed to minimize possible adverse effects some fertilizers can have on the environment.

To learn more watch this the short video.

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# Next Generation Science Standards

**LS1.C: Organization for Matter and Energy Flow in Organisms**

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)

**S2.B: Cycles of Matter and Energy Transfer in Ecosystems**

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
- The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

# Next Generation Science Standards
## *Continued*

**ESS3.C: Human Impacts on Earth Systems**

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)

# Career Technical Education

## Agriscience Pathway Standards

**C2.0 Examine the interrelationship between agriculture and the environment.**

- C2.1 Identify important agricultural environmental impacts on soil, water, and air. C2.2 Explain current environmental challenges related to agriculture.

**C10.0 Explain soil science principles.**

- C10.2 Summarize how soil texture, structure, pH, and salinity affect plant growth.
- C10.4 Differentiate among the types, uses, and applications of amendments and fertilizers.

**C11.0 Analyze plant growth and development.**

- C11.2 Identify plant growth requirements.

# Resources

- California Master Gardener Handbook, Second Edition, Dennis R. Pittenger, Editor, 2015
- Solution Center for Nutrient Management
- Suny College of Environmental Science and Forestry
- Essential Plant Nutrients - November 27, 2002, Jeff Schalau, County Director, Agent, Agriculture & Natural Resources, Arizona Cooperative Extension, Yavapai  County
- Nutrients For Life Foundation

# Resources
## *Continued*

- Images www.kiddle.co www.Britannica.com www.lowes.com www.cepolina.com www.dreamstime.com www.worldatlas.com www.extension.imn.edu
- Images https://www.fertilizer.org/Public/Media/Change_Makers_Drivers/2019_01_29_Plant_Nutrition_Pioneers.aspx

https://www.fertilizer.org/Public/Stewardship/Nutrient_Stewardship/Public/Stewardship/Nutrient/Nutrient_Stewardship.aspx#4Rs

- Image www.ucanr.edu
- Image www.milorganite.com
- Creative Commons
- Getty Images

# Gardening Questions?

- Email the UCCE Master Gardeners of Riverside County
- Email Helpline
  - anrmgriverside@ucanr.edu
- Riverside Master Gardeners Website

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