Plant Nutrition

Introduction

We know that humans have nutrient requirements, and that in the United States, most food products must have nutritional information on their labels, This information helps us make appropriate nutritional choices. We also know that if we fail to make good nutritional choices we may have health problems and nutritional deficiencies. Plants, too, have nutrient requirements. Although plants can manufacture the bulk nutrients (carbohydrates, proteins and lipids) from inorganic materials, and do not require these substances as a part of their "diets", they do require the minerals and other molecules needed to synthesize their cells' needs. In fact, many of the substances plants do need are used to make carbohydrates, proteins and lipids. (Good thing, too, since we need those bulk nutrients made for us, and only plants can do it). If plants do not get their needed nutrients, they will have growth problems just like we do.

In addition to carbon, hydrogen, and oxygen, which comprise about 98% of the fresh weight of the plant, at least 13 other chemical elements, called the **essential inorganic nutrients**, are needed for plant growth. Six of these: nitrogen, potassium, calcium, phosphorus, magnesium, and sulfur, are required in relatively large amounts and are known as **macronutrients**. The remaining essential inorganic nutrients: iron, chlorine, copper, manganese, zinc, molybdenum, and boron, are required in very small, or trace amounts (as little as a few parts per million), and are known as **micronutrients**.

Deficiencies of one or more of the essential nutrients result in abnormal plant growth and development. Plants suffering from the deficiencies exhibit deficiency symptoms, such as

- A pale green or yellow color, which is known as chlorosis
- Localized death of tissues, called necrosis
- Abnormal anthocyanin formation
- Stunting of growth.

In order to determine which inorganic nutrients or combination of inorganic nutrients a plant needs for growth, plants can be grown in solution cultures, a technique known as hydroponics. When we want to know how one mineral affects plant growth, that element is omitted from the culture solution and a nonessential mineral is substituted so that the relative amounts of the other elements are not altered.

Exercise

Today you will observe the effects of some nutrient deficiencies on plant growth. Tomato (*Lycopersicon esculentum*) seeds were germinated in washed sand and watered with distilled water until established. They were transferred to the following solution cultures two to four weeks ago:

1. Solution containing all essential inorganic nutrients, or elements (This is our experimental control).
2. Solution lacking nitrogen
3. Solution lacking phosphorus
4. Solution lacking magnesium
5. Solution lacking potassium
6. Solution lacking calcium
7. Solution lacking sulfur
8. Solution lacking iron
9. Distilled water

Examine the experimental (nutrient-deficient) plants and compare them with the control plant. Many of the plants undoubtedly will look abnormal in comparison with the control. Record the deficiency symptoms shown by the treated plants on the chart provided. Use the Key to Plant-Nutrient Deficiency Symptoms, which follows, to help describe the symptoms. As you look at and describe the deficiency symptoms shown by the respective plants, think about and record what functions the missing nutrient normally has in plant growth.

Plant Deficiency Symptoms

Cultures	**Observations**
Control	
Lacking Nitrogen	
Lacking Phosphorus	
Lacking Magnesium	
Lacking Potassium	
Lacking Calcium	
Lacking Sulfur	
Lacking Iron	
Distilled Water	

Key to Plant Nutrient-Deficiency Symptoms

I. Effects general on whole plant or localized on older, lower leaves 2

2. Leaves light green. Uniform chlorosis of older leaves, which may die and turn brown. Abnormal production of anthocyanins in stems and leaves. Stems with greatly reduced terminal growth ....Nitrogen

2 Leaves dark green. Stunted growth. Abnormal production of anthocyanins resulting in red and purple colors. Death of older leaves. Stems weak and spindly...Phosphorus

II. Effects mostly localized on older, lower leaves 3

3. Older leaves chlorotic, initially interveinal, beginning at tips of leaves. Margins and tips of leaves may turn or cup upward. If severe, all leaves become yellow or white. Older leaves may drop off ....Magnesium

3. Older leaves mottled, with necrosis of leaf tips and margins. Leaves may curl and crinkle. Internodes abnormally short and stems weak, sometimes with brown streaks ....Potassium

III. Effects localized on new leaves 4

4. Terminal bud dies. Tips and margins of youngest leaves necrotic and then buds. Initially young leaves pale green with hooked tips, as well as being deformed ....Calcium

4. Terminal bud remains alive 5

5. Leaves light green (never yellow or white), beginning with younger ones. Veins lighter than interveinal areas. Necrotic spots may appear but not common ....Sulfur

5. Leaves chlorotlc, beginning with younger ones. Veins remain green, except in case of prolonged, extreme deficiency . ...Iron

Nutrient Role(s) in Plants

Essential Nutrient	**Plant Function(s)**
Nitrogen	
Phosphorus	
Magnesium	
Potassium	
Calcium	
Sulfur	
Iron	
Chlorine	
Copper	
Manganese	
Zinc	
Molybdenum	
Boron	

Plant Nutrient Functions

Macronutrients

Element	Form	Source	Function
Carbon	CO_2	Air	Major element in organic molecules; photosynthesis
Oxygen	O_2	Air	Major element in organic molecules; cellular respiration
Hydrogen	H_2O	Soil	Major element in organic molecules
Nitrogen	NO_3^- or NH_3^+	Soil	Major element in proteins, nucleic acids, and chlorophyll
Potassium	K^+	Soil	Principal positive ion inside cells; control of stomatal opening and closing; enzyme activation
Phosphorus	H_2PO_4 or $HPO_4^=$	Soil	Major element in nucleic acids, phospholipids, and electron carriers in chloroplasts and mitochondria
Calcium	Ca^{++}	Soil	Component of adhesive compounds in cell walls; important in control of membrane permeability; enzyme activation
Magnesium	Mg^{++}	Soil	Component of chlorophyll; enzyme activation; ribosome stability
Sulfur	$SO_4^=$	Soil	Component of proteins and many coenzymes

Micronutrients

Element	Form	Source	Function
Iron	Fe^{++} or Fe^{+++}	Soil	Needed for synthesis of chlorophyll; component of many electron carriers
Chlorine	Cl^-	Soil	Required for photosynthesis
Manganese	Mn^{++}	Soil	Required for photosynthesis; enzyme activation
Molybdenum	$MoO_4^=$	Soil	Required for nitrogen metabolism
Copper	Cu^{++}	Soil	Enzyme activation; component of electron carriers in chloroplasts
Boron	Bo^{---}	Soil	Involved in sugar transport
Zinc	Zn^{++}	Soil	Enzyme activation; protein synthesis; hormone synthesis