ANIMAL, PLANT & SOIL SCIENCE

D3-6
CHARACTERISTICS AND SOURCES OF PHOSPHORUS AND POTASSIUM

INTEREST APPROACH

- Show images of plants suffering from phosphorus and potassium deficiencies. Ask students if they can diagnose the causes of the plants' diseases. List their answers on the writing surface.

OBJECTIVES

- 1 Identify the forms of phosphorus in soil and examine factors that affect phosphorus availability.
- 2 Identify and describe symptoms of phosphorus deficiency and phosphorus toxicity.
- 3 Identify and describe fertilizer sources of phosphorus.
- 4 Describe the availability of potassium to plants.
- 5 Identify and describe symptoms of potassium deficiency and potassium toxicity.
- 6 Identify and describe the fertilizer sources of potassium.

TERMS

- banding
- cation
- chlorosis
- interveinal chlorosis
- langbeinite
- leach
- necrosis
- stomata
- sylvinite
- sylvite

WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- I. Phosphorus is an unstable element and bursts into flames when exposed to air. Therefore, phosphorus is always bonded to other elements in soils or in fertilizers.

- A. Although phosphorus may be present in organic and inorganic forms, plants absorb most phosphorus when it is in the inorganic forms $H_2PO_4^-$ and HPO_4^{2-}.

WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- 1. Organic forms of phosphorus are found in plant residues, manure, and microbial tissues.
- 2. Inorganic forms of phosphorus come from parent materials. Unlike nitrogen, phosphorus does not have a gaseous state. It is not part of the atmosphere. Phosphorus cycles from land to sediments in the oceans. Eventually, geologic forces form new rock from the sediments and lift the rock to form land. The cycle is extremely slow. As the rocks weather, phosphorus is released.

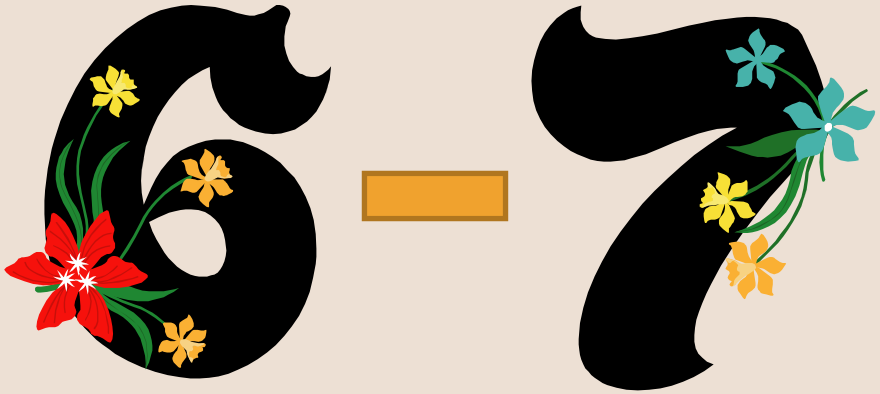
WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- a. Water carries inorganic phosphorus molecules (P04 3-) to soils. Also, when organisms die and decompose, phosphorus is returned to the soil.
- b. The phosphorus content of some soils is naturally low because of low phosphorus content in the parent material.
- c. Phosphorus does not ***leach***, or pass through, soil as readily as nitrogen because its solubility is extremely low. However, it often needs to be added as a fertilizer to obtain optimal levels for plant growth.

WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- B. A number of factors influence the availability of phosphorus.

- 1. Soil pH affects phosphorus availability in a number of ways. Phosphorus is most available to plants when the pH of the soil is in the 6.0 to 7.0 range. That pH range is more conducive to H2P04 -, which is more readily absorbed than HP04 2-.



WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- a. The rate of phosphorus absorption is reduced in soils with high pH due to competition with OH- ions.
- b. Calcareous soils with a pH near 8.0 cause phosphorus to bond with calcium.
- c. In strongly acid soils, phosphorus bonds with iron and aluminum.

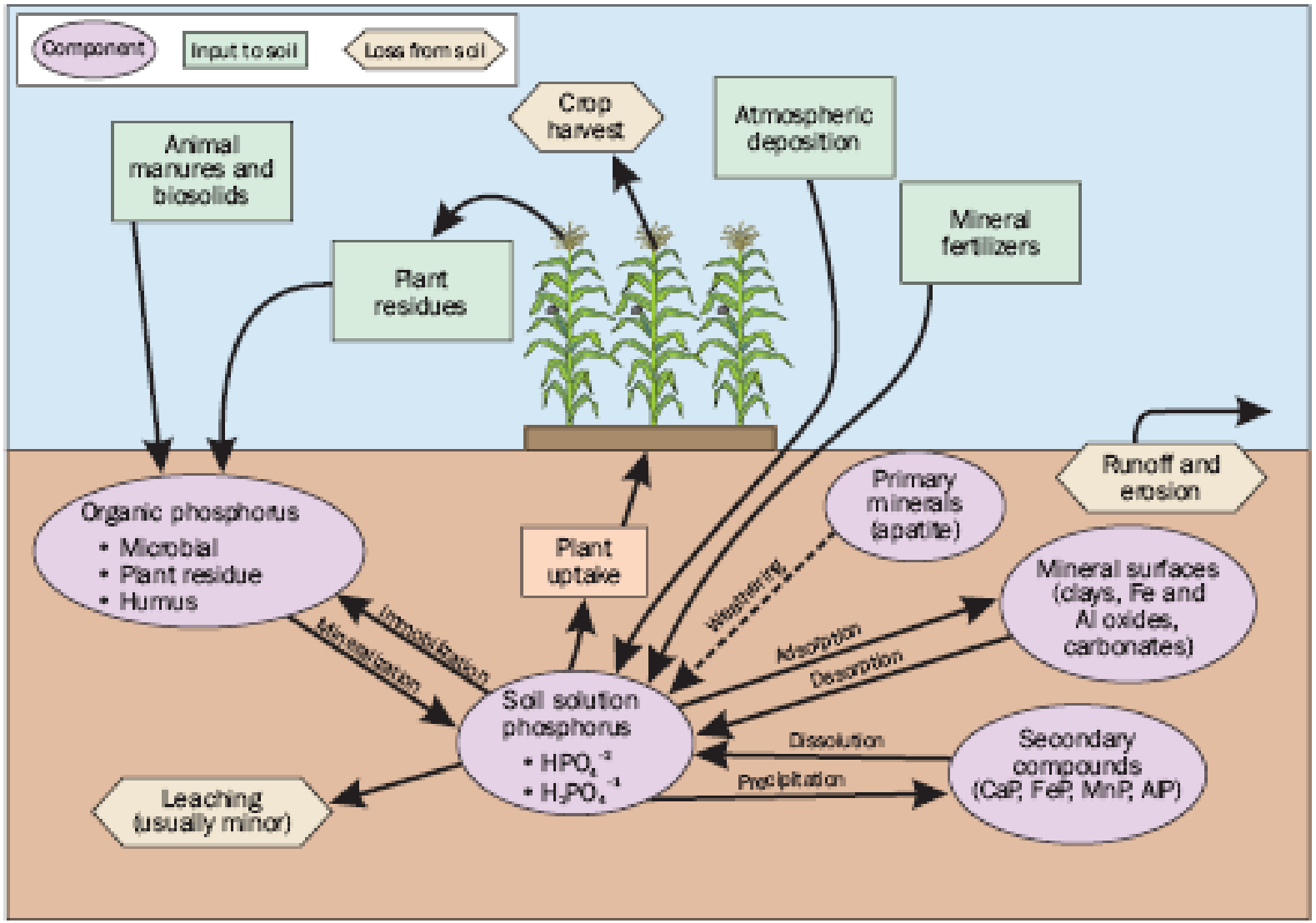
WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- 2. An abundance of other plant nutrients in the soil tends to improve the rate of absorption of phosphorus.
- 3. High organic matter content improves the availability of phosphorus.
- 4. Soils with 1:1 type clay (e.g., kaolinite) fix, or retain, phosphorus for plant use better than soils with 2:1 clay (e.g., montmorilonite, illite, vermiculite).

WHAT ARE THE FORMS OF PHOSPHORUS IN SOIL, AND WHAT AFFECTS PHOSPHORUS AVAILABILITY?

- 5. The timing of fertilizer applications is important. In general, the application of phosphorus fertilizers shortly before planting is effective. Applications can be made several months prior to planting in soils with low phosphorus-fixing capabilities. ***Banding*** (placing a band of fertilizer below and to the side of seeds) is effective with soils of high phosphorus-fixing capacity.
- 6. Phosphorus absorption is best in warm soils with good soil aeration.

THE PHOSPHORUS CYCLE



WHAT ARE THE SYMPTOMS OF PHOSPHORUS DEFICIENCY AND PHOSPHORUS TOXICITY?

- II. Phosphorus is put to many uses in plants. It is found in phospholipids, which are an essential component of cell membranes. Phosphorus is important for seed formation and is found in abundance in seeds. Phosphorus is a component of adenosine triphosphate (ATP), an important energy-carrying molecule found in cells. It is a component of proteins, nucleic acids, DNA, and RNA. It is essential for photosynthesis and cellular respiration. Phosphorus affects cell division, root development, maturation, flowering and fruiting, and overall crop quality. A lack or an excess of phosphorus can be detrimental to the health of a plant.

WHAT ARE THE SYMPTOMS OF PHOSPHORUS DEFICIENCY AND PHOSPHORUS TOXICITY?

- A. The first signs of phosphorus deficiency are stunted plant growth and darker green leaves. Then, lower leaves and stems may develop red or purple coloration. In worst cases, lower-leaf ***chlorosis*** (a yellowing of the leaves) and necrosis (the death of tissue) occur. Symptoms may include stunted growth and maturity, reduced yields due to decreased seed and fruit formation, and a poorly developed root system.

WHAT ARE THE SYMPTOMS OF PHOSPHORUS DEFICIENCY AND PHOSPHORUS TOXICITY?

- 1. In most cases, phosphorus deficiency is not common.
- 2. A slight phosphorus deficiency is sometimes intentional, as in the case of plug production for horticultural purposes. A shortage of phosphorus results in compact plugs with dark leaves.

PHOSPHORUS DEFICIENCY

WHAT ARE THE SYMPTOMS OF PHOSPHORUS DEFICIENCY AND PHOSPHORUS TOXICITY?

- B. Excess levels of phosphorus may contribute to deficiency of micronutrients.

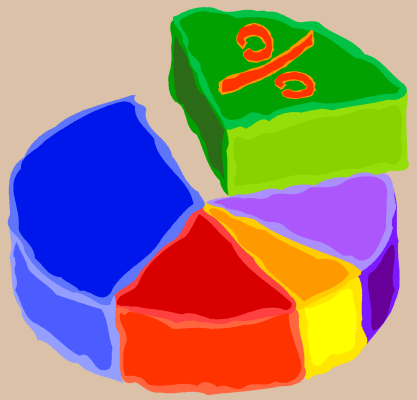
WHAT ARE FERTILIZER SOURCES OF PHOSPHORUS?

- III. Phosphorus fertilizers are obtained almost exclusively from phosphate rock of sedimentary origin. There are a number of fertilizer sources of phosphorus.

WHAT ARE FERTILIZER SOURCES OF PHOSPHORUS?

- A. Normal superphosphate consists of monocalcium phosphate (Ca (H2PO4)2) and gypsum (CaSO4 2H2O). Phosphorus availability is high, and calcium and sulfur are also supplied. It can be used with ammonia solutions. However, because of a low (20%) analysis of P2O5, it is not used with high-analysis fertilizers.

WHAT ARE FERTILIZER SOURCES OF PHOSPHORUS?



- B. Triple superphosphate consists of 46 to 48 percent P205. The phosphorus is highly available, and it can be ammoniated.

WHAT ARE FERTILIZER SOURCES OF PHOSPHORUS?

- C. Ammonium phosphates are made by neutralizing phosphoric acid with ammonia. Two types are monoammonium phosphate (MAP) and diammonium phosphate (DAP). The common analyses for MAP are 10-50-0 and 11-52-0. DAP typically has an analysis of 18-46-0.

WHAT FACTORS INFLUENCE THE AVAILABILITY OF POTASSIUM TO PLANTS?

- IV. Potassium is a very abundant element, making up 2.4 percent of the earth's crust. All naturally occurring potassium in soils originated from rocks. Although it is found in abundance, potassium is often a limiting factor in plant growth. Some potassium is more available than others.

WHAT FACTORS INFLUENCE THE AVAILABILITY OF POTASSIUM TO PLANTS?

- A. Ninety to 98 percent of potassium in soil is relatively unavailable potassium. It is a component of insoluble minerals, such as feldspar and mica. These minerals release potassium very slowly.

WHAT FACTORS INFLUENCE THE AVAILABILITY OF POTASSIUM TO PLANTS?

- B. A slowly available form of potassium makes up 1 to 10 percent of the total potassium supply in soil. Some potassium firmly bonds between the layers of clay particles and is released very slowly. The amount of potassium available for plants depends largely on the type and amount of clay.

WHAT FACTORS INFLUENCE THE AVAILABILITY OF POTASSIUM TO PLANTS?

- C. A third category of potassium in soil is readily available for plant use. This form makes up between 0.1 and 2 percent of the total potassium in the soil. The potassium is in the soil solution and is held on clay and organic matter particles. It is exchangeable in that it can be replaced with other cations. A ***cation*** is an ion with a positive charge.

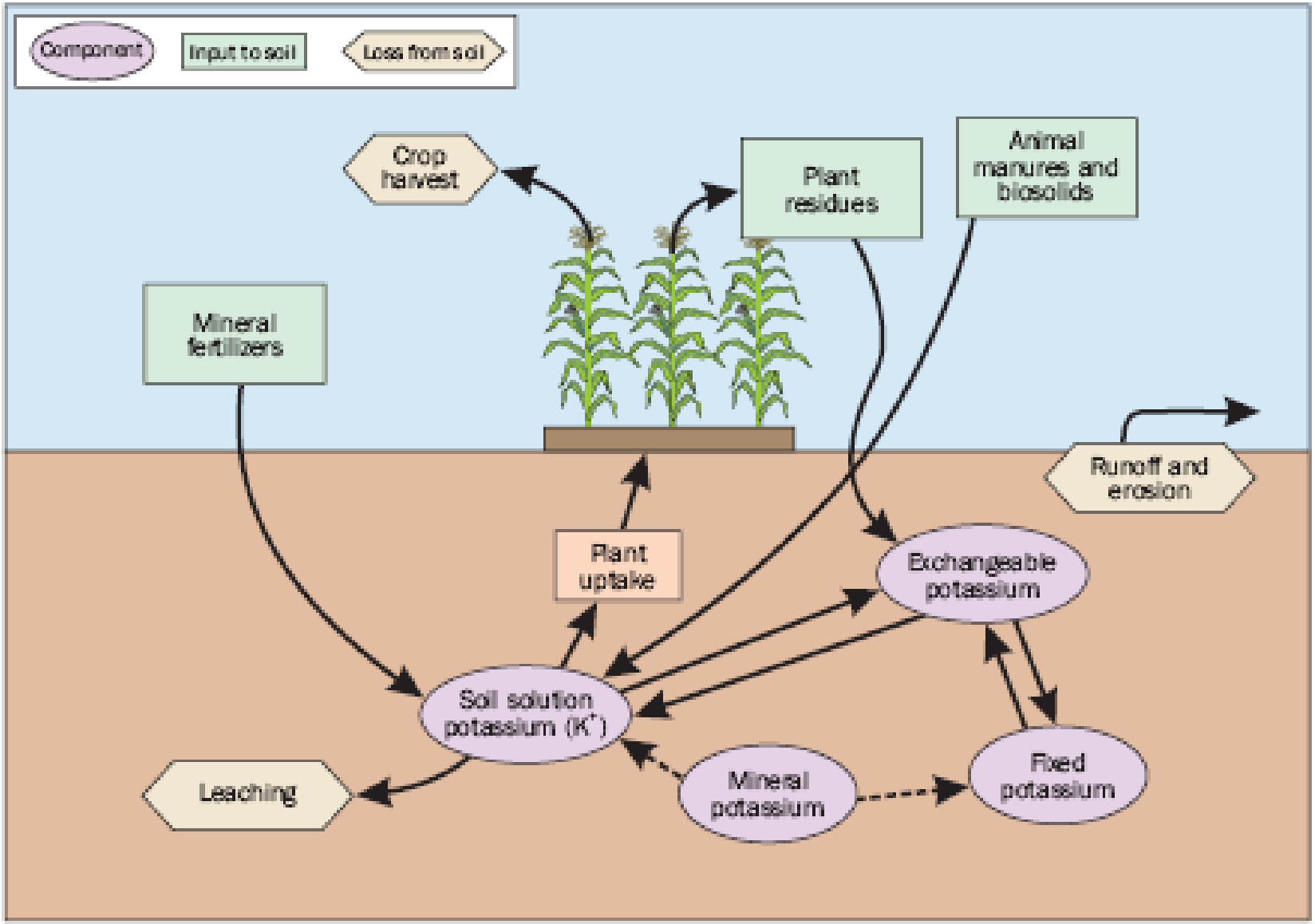
WHAT FACTORS INFLUENCE THE AVAILABILITY OF POTASSIUM TO PLANTS?

- D. Potassium interacts with other nutrients in the soil. In fact, adequate levels of other nutrients are necessary for the optimal response from potassium fertilizers. Magnesium deficiency may occur when high levels of potassium fertilizer are applied. Also, high rates of lime used on soils low in potassium can result in potassium deficiency.

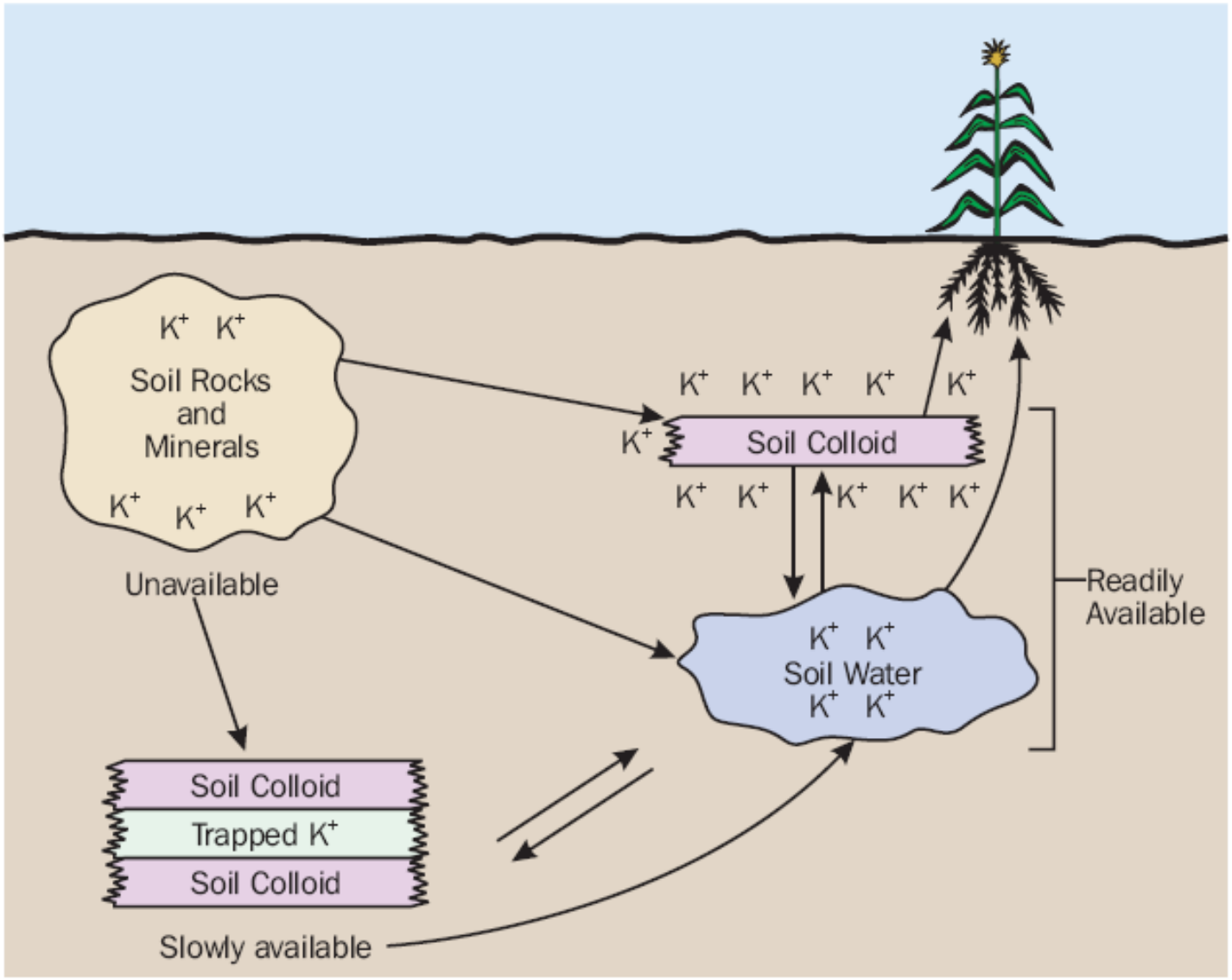
WHAT FACTORS INFLUENCE THE AVAILABILITY OF POTASSIUM TO PLANTS?

- E. The timing of potassium absorption by plants varies. For instance, most plants absorb a large amount of potassium during the early stages of growth.

THE POTASSIUM CYCLE



AVAILABILITY OF POTASSIUM



WHAT ARE THE SYMPTOMS OF POTASSIUM DEFICIENCY AND POTASSIUM TOXICITY?

- V. Potassium is a contributor to many plant processes. It activates enzymes, regulates the opening and closing of ***stomata*** (minute pores in the epidermis of leaves and stems), and regulates water uptake by root cells. Potassium is essential for photosynthesis, starch formulation, and the translocation of sugars. It aids in nitrogen metabolism and promotes growth of meristem tissue.

WHAT ARE THE SYMPTOMS OF POTASSIUM DEFICIENCY AND POTASSIUM TOXICITY?

- A. In the majority of crops, potassium deficiency starts with marginal chlorosis and advances rapidly to necrosis. In some crops, the marginal chlorosis will advance inward and become ***interveinal chlorosis*** (yellowing between the structural vessels or veins) with marginal necrosis. Potassium deficiency often results in lodging, decreased yields, lack of disease resistance, and decreased crop quality.

POTASSIUM DEFICIENCY IN POTATO

WHAT ARE THE SYMPTOMS OF POTASSIUM DEFICIENCY AND POTASSIUM TOXICITY?

- B. Excessive potassium contributes to deficiencies of nitrogen, calcium, and magnesium.

WHAT ARE THE FERTILIZER SOURCES OF POTASSIUM?

- VI. Potassium is mined from beds of solid salts beneath the earth's surface and from brine in dying lakes or seas. The most important minerals from which potassium is obtained are sylvinite, sylvite, and langbeinite. ***Sylvinite*** is composed primarily of potassium chloride (KCl) and contains 20 to 30 percent K20. ***Sylvite*** is mostly KCl and contains around 63 percent K20. ***Langbeinite*** contains about 23 percent K20. A number of fertilizers are produced from these materials.

WHAT ARE THE FERTILIZER SOURCES OF POTASSIUM?

- A. Potassium chloride, or muriate of potash, contains 60 to 62 percent K20 and is water soluble. It makes up about 90 percent of all the potassium sold in the United States.

WHAT ARE THE FERTILIZER SOURCES OF POTASSIUM?

- B. Potassium sulfate, or sulfate of potash, contains about 50 percent K20 and 18 percent sulfur. It contains low levels of chlorine. It is the fertilizer of choice when chloride buildup is a problem.

WHAT ARE THE FERTILIZER SOURCES OF POTASSIUM?

- C. Potassium nitrate (KNO_3) supplies crops with both nitrogen and potassium. It contains 44 percent K_2O, 13 percent nitrogen, and little (if any) chlorine or sulfur. Therefore, it is useful for chlorine-sensitive crops.

REVIEW

- 1. What are the forms of phosphorus in soil, and what affects phosphorus availability?
- 2. What are the symptoms of phosphorus deficiency and phosphorus toxicity?
- 3. What are fertilizer sources of phosphorus?
- 4. What factors influence the availability of potassium to plants?
- 5. What are the symptoms of potassium deficiency and potassium toxicity?
- 6. What are the fertilizer sources of potassium?