## The Need for Mineral Elements

NAME ________________________________________DATE __________________

Nutrient uptake in the soil is achieved by root hairs in the soil. The mineral ions are taken up from the soil, along with the water that enters by osmosis. However, only water can move by osmosis. Mineral ions have to enter the root cells by active transport. These minerals are critical for plant growth and development.

Nutrients are moved inside a plant to where they are most needed. For example, a plant will try to supply more nutrients to its younger leaves than its older ones. So when nutrients are mobile, the lack of nutrients is first visible on older leaves. However, not all nutrients are equally mobile. When a less mobile nutrient is lacking, the younger leaves suffer because the nutrient does not move up to them but stays lower in the older leaves.

Sixteen elements have been determined to be essential to plant growth and reproduction. An element is considered essential if in the absence of one or more of these elements, plant growth and reproduction is significantly hindered.

The following elements are considered essential plant nutrients: carbon(C), hydrogen(H), oxygen(O), nitrogen(N), phosphorus(P), potassium(K), calcium(Ca), magnesium(Mg), Sulphur(S), iron(Fe), manganese(Mn), boron(B), molybdenum(Mo), copper(Cu), zinc(Zn) and chlorine(Cl). C, H, O, N, P, K, Ca, Mg and S are needed in large amounts and are referred to as the macronutrients. Fe, Mn, B, Mo, Cu, Zn and Cl are needed in small amounts compared to the macronutrients and are referred to as the minor nutrients. They are called minor nutrients because they are needed in smaller amounts; this in no way diminishes their importance. A shortage of any particular mineral results in particular symptoms in the plant, called a mineral deficiency disease.

**Nitrogen**

Though nitrogen is plentiful in the Earth's atmosphere, relatively few plants engage in nitrogen fixation (conversion of atmospheric nitrogen to a biologically useful form). Most plants therefore require nitrogen compounds to be present in the soil in which they grow. These can either be supplied by decaying matter, nitrogen fixing bacteria, animal waste, or through the agricultural application of purpose made fertilizers. Nitrogen is an essential component of all proteins. Nitrogen deficiency most often results in stunted growth and yellowing of older leaves.

**Phosphorus**

Phosphorus is important in plant bioenergetics. As a component of ATP, phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis. Phosphorus can also be used to modify the activity of various enzymes by phosphorylation, and can be used for cell signalling. Since ATP can be used for the biosynthesis of many plant biomolecules, phosphorus is important for plant growth and flower/seed formation. Phosphorus deficiency most often results in poor root growth and younger leaves turning purple

**Potassium**

Potassium regulates the opening and closing of the stomata by a potassium ion pump. Since stomata are important in water regulation, potassium reduces water loss from the leaves and increases drought tolerance. Potassium deficiency may cause yellowing of leaves between the veins

**Fertilisers**

Fertilisers are known for providing certain vital nutrients to plants, to ensure their fast growth and better yield. The main ingredients of almost all fertilizers are nitrogen, potassium and phosphorus. However, along with them, fertilizers also contain a small amount of other nutrients.

**Materials**

- test-tube rack - 4 test-tubes - wash bottle of distilled water
- spirit marker - graph paper - 1 can to hold 4 tubes
- 4 strips cotton wool about 20 x 100 mm
- labelled receptacle for collecting seedlings from each solution for determining dry weight
- water culture, full culture, lacking calcium, lacking nitrogen

**Procedure**

1. Label four test-tubes as follows: +, Ca, N, --.
2. Fill each tube to within about 20 mm of the top, with the appropriate water culture.

(+) Solution containing all mineral elements thought to be needed for healthy growth
(Ca) Solution containing all mineral elements as in + except for calcium
(N) Solution as in + but lacking nitrate
(--) Distilled water, i.e. no mineral elements at all

3. Select four seedlings which appear to be at the same stage of development. If there is a wide difference between the development of the root systems, reduce all systems to the same number and approximate length of root as in the least developed.
4. Measure and record the root and shoot length.
5. Leaving the shoot and roots free, roll a strip of cotton wool round the grain to hold the seedling lightly but firmly in place in the mouth of the: test-tube (Fig. 1).
6. Place a seedling in each test-tube so that the root is well covered by the culture solution.

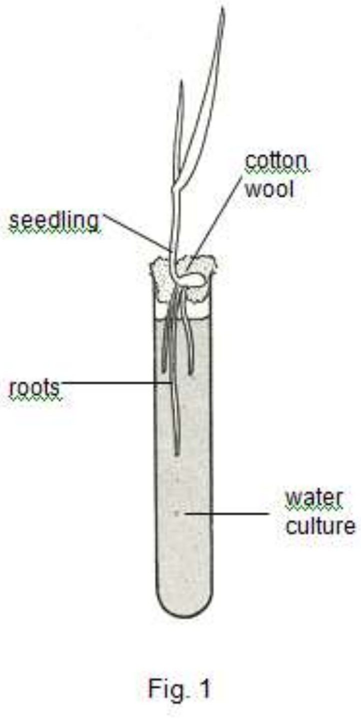


Fig. 1

7. Mark your initials and the date on the rack or container provided and place the four tubes in a position where they can receive daylight or artificial illumination. Leave the seedlings to grow for two weeks.
8. During this period of time the levels of the solutions will fall in the test-tubes. They need to be inspected every two days and the level restored if necessary. Carefully remove the cotton wool and top up the test-tubes with DISTILLED WATER from a wash-bottle.
9. After two weeks transfer the tubes to a rack so that the seedlings can be compared side by side.
10. Use the table below to record your observations
11. Study the whole group of seedlings and note in your table any which show abnormalities of leaf colour or shape, e.g. dead areas, discoloured patches, pale green colour.
12. Remove the seedling from the full culture (+), unwind and discard the cotton wool and cut off the leaves as shown in Fig. 2. By placing the leaves end to end along a ruler, measure and record their total length.
13. Cut the root system just below the grain (Fig. 2) and use forceps to separate the main roots, working from the top. Place these end to end along a ruler to measure their total length. Ignore the lateral roots for this purpose (unless you have plenty of time and patience).
14. When you have made the measurements, place the roots and leaves in the container labelled '+' so that their dry weight can be found later.
15. Repeat the measurements for each of the seedlings in turn, placing the leaves and roots in the appropriate container afterwards.
16. Plot histograms (bar graph) of the root and shoot lengths for each seedling.

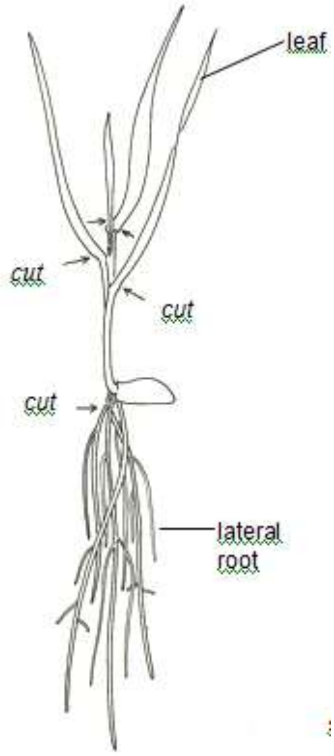

Fig. 2

| Culture solution | + | Ca | N | -- |
|---|---|---|---|---|
| Leaf colour | | | | |
| Total leaf length | | | | |
| Total root length | | | | |
| Dry weight* | | | | |

* Whole class

## Discussion

1. Which solution of mineral salts provided (a) the best and (b) the worst medium for the growth of the seedlings as judged by leaf length?

2. From your knowledge of plant nutrition, explain why nitrates (source of nitrogen) and calcium should be so important to a green plant.

3. Why would it be difficult to judge whether the lack of a particular element did more harm to the root growth than the shoot growth or vice versa?

4. Why do you think a small-seeded plant, rather than a runner bean, was used for this experiment?

**5.** Why do you think the solutions were topped up with distilled water rather than with the appropriate culture solution?

**6.** In what ways is this experiment unrepresentative of natural conditions?

**7.** Why was a culture solution lacking carbon not included, bearing in mind that plants need carbon for making their carbohydrates?