Mineral Nutrition

Plants require mineral elements for survival. Not all species require the same complement of minerals in the same amounts, but the differences between species are much less variable than the differences between the amounts of specific minerals within a single species. Each plant requires minerals in various proportions. Large amounts of some minerals (CHOPKiNS CaFe Mg), called **macronutrients**, are essential. Other elements (Mo Cu Zn Mn Fe B Cl) are needed in much lower quantities and are therefore called **micronutrients**. Micronutrients may be just as important to survival as macronutrients, the amount needed is simply less. In addition to those elements listed above, certain plants need special nutrients (Si, Co, Na, V) for proper growth and survival.

Your textbook lists typical endogenous levels of the macronutrients and micronutrients in Table 5.1 (page 68). That table was derived by measuring the levels of nutrients found in living plants. While this might be an interesting approach to a study of mineral requirements, it requires an atomic absorption spectrometer and is relatively tedious to carry out. More importantly, the results only indicate the levels actually accumulated. This does not indicate how important these accumulations may be to a plant, and certainly has no bearing on the relative necessity of each nutrient.

An inexpensive and empirical demonstration of the essential need for a particular nutrient is to observe growth of plants grown hydroponically in various solutions of mineral-containing waters lacking certain individual elements. This approach was carried out long ago (1850-1930), before the advent of analytical techniques, to establish the list of macro- and micro-nutrients.

We will use this empirical method. We will prepare solutions of minerals lacking in a single nutrient. Plants will be suspended with their roots immersed in the solutions. Their growth and characteristics will be observed over several weeks. The consequences of deficiency will be demonstrated by comparison with plants held in a solution containing a complete set of nutrients. What is an experiment? Do we have one here?

1. You will prepare a hydroponic medium using the table below. The instructor will provide a duty chart to be sure all the media have been made. You might want to circle or highlight the column in the chart for your medium.

2. You will use two 16 oz (473 mL) opaque Solo™ cups to prepare two 250 mL batches of your medium. These cups are brand new so you don't have to worry about cleaning them.

3. Label both cups with the name of the medium, your name, and the date.

4. Put 250 mL of distilled water in each cup.

5. Add the medium components you circled or highlighted in the table below. Be sure not to cross-contaminate the pipettes or the component stock solutions! Leave the pipettes standing in the stock solution bottles.

Table 1: Composition of hydroponic solutions to be made. Each stock solution is 1 Molar unless indicated by an *. Volumes to be used are shown as mL stock solution per 250 mL total volume of medium.

HYDROPONIC MEDIA

STOCK SOLUTION	Com	-N	-K	-P	-Ca	-Mg	-S	-Fe	-μs	-B	-Mn	-Zn	-Cu	-Mo
$Ca(NO_3)_2$	1.25	-	1.25	1.25	-	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
KNO_3	1.25	-	-	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
$MgSO_4$	0.5	0.5	0.5	0.5	0.5	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5
KH_2PO_4	0.25	0.25	-	-	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Fe-EDTA*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	-	0.25	0.25	0.25	0.25	0.25	0.25
Micros**	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	-	-	-	-	-	-
$NaNO_3$	-	-	1.25	-	2.5	-	-	-	-	-	-	-	-	-
$MgCl_2$	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-
Na_2SO_4	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
NaH_2PO_4	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-
$CaCl_2$	-	1.25	-	-	-	-	-	-	-	-	-	-	-	-
KCl	-	1.25	-	0.25	-	-	-	-	-	-	-	-	-	-
NH_4NO_3	-	-	-	-	1.25	-	-	-	-	-	-	-	-	-
H_3BO_3**	-	-	-	-	-	-	-	-	-	-	0.25	0.25	0.25	0.25
$MnCl_2$**	-	-	-	-	-	-	-	-	-	0.25	-	0.25	0.25	0.25
$ZnCl_2$**	-	-	-	-	-	-	-	-	-	0.25	0.25	-	0.25	0.25
$CuCl_2$**	-	-	-	-	-	-	-	-	-	0.25	0.25	0.25	-	0.25
Na_2MoO_4**	-	-	-	-	-	-	-	-	-	0.25	0.25	0.25	0.25	-

* = 42 mg Sequestrene/ml stock solution (=5 mg/ml Fe)

** = 2.86g H_3BO_3, 1.81g $MnCl_2 \cdot 4H_2O$, 0.11g $ZnCl_2$, 0.05g $CuCl_2 \cdot 2H_2O$, and 0.025g $Na_2MoO_4 \cdot 2H_2O$ per liter.

6. Add perlite to within 1 cm of the rim of each cup. It is good to add this slowly and roll the cup between your hands to settle the perlite into the medium in the cup. Be careful not to crack the plastic cup!

7. Carefully plant eight sunflower (*Helianthus*) seeds 1 cm deep in the perlite.

8. Observe all of the plants in all of the containers each week. Replenish the volume of solution by adding distilled water. Your observations should be sufficient to distinguish the deficiency symptoms described and shown in your textbook (pg 68-75).

9. When instructed to terminate the trials, make your final observations. Measure the length of the shoot of each plant. Measure the length of the root system as gently as possible. Record the fresh weight of the ***three typical*** plants from each container. Wrap the plants loosely in a weighed piece of foil and place them in the drying oven for one day. Be sure to mark the foil with the treatment! After a day or two, record the dry weight of the plants from each container.

Hand in one week from today: Recreate Table 5.3 on page 71 of your textbook as closely as possible for the recipe for the **complete medium** shown above.