HONORABLE MENTION

Sleuthing the Nutrients That Make Your Houseplant Grow

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Using houseplant fertilizers, a teacher can design consumer chemistry projects for the classroom that can be used with children of various ages. At the most elementary level, students can learn to read fertilizer labels—an accomplishment that may well be beyond the ability of their parents. If they want to become knowledgeable consumers, they can go on to figure the cost of one fertilizer as compared with another. Or, they can figure out exactly how much fertilizer they are applying when they use different brands. While undertaking these projects, the students are linking chemistry, biology, math, and even a bit of physics.

Among the advantages of using houseplant fertilizers in teaching are their low cost; their small packages, which make them easy to carry and store; their familiarity to students because of their wide use; and their ready availability in supermarkets, garden centers, drugstores, and department stores.

Understanding Fertilizers

Houseplant fertilizers capture the interest of students because of their slick packaging, catchy names, and miraculous claims. Novel brand names include Miracle-Gro, Granny's Bloomers, Jungle Juice, Cow Power, and Dr. Sher's Hydroponic Plant Nutrient Elixir. Printed claims on houseplant fertilizer labels include such statements as "works like magic," "the gourmet food for plants," and "grow plants beyond your wildest dreams."

A basic scientific knowledge of fertilizers indicates that the above claims are not valid. Although fertilizers are often called "plant foods," they are not really analogous to the foods animals eat. Foods for animals are composed mainly of complex organic molecules, such as carbohydrates, fats, and proteins. Green plants cannot ingest complex molecules. Instead, they synthesize such molecules, using water, carbon dioxide from the air, and thirteen nutrient elements, which are absorbed primarily by their roots. Thus, plant fertilizers are not really food.

The Fertilizer Elements

There are currently sixteen elements considered essential for higher green plants. These are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), zinc (Zn), molybdenum (Mo), boron (B), copper (Cu), manganese (Mn), and chlorine (Cl). The chemical symbols of these elements can be remembered with the mnemonic: C HOPKNS CaFe ClZn; MoB CuMn Mg. In prose form the mnemonic reads "C. Hopkins cafe closing; mob coming with machine guns."

All except C, H, and O are considered nutrients. The macronutrients, those required in relatively large amounts, are N, P, K, Ca, Mg, and S. The micronutrients, those required in relatively small amounts, are Fe, Zn, Mo, B, Cu, Mn, and Cl. Because Cl is so ubiquitous in nature, sufficient Cl is always present, and Cl is not considered a fertilizer nutrient. That leaves twelve essential elements that may be supplied by fertilizers. A complete fertilizer must contain at least N, P, and K, which are called the primary nutrients. Secondary nutrients that are sometimes supplied are Ca, Mg, and S.

Labeling Fertilizers

Laws governing fertilizers are in some ways more strict than laws governing food. Each fertilizer must

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have a label indicating its nutrient content and source of nutrients (see figure 1).

The percentage by weight of N, P, and K in a fertilizer is expressed as a series of three numbers—for example, 5-10-5. The numbers are called the analysis and represent the chemical substances N, P_2O_5, and K_2O. N, of course, stands for the nitrogen that is available in the fertilizer. However, P_2O_5, which is called phosphorous pentoxide or available phosphoric acid, and K_2O, called soluble potash, are compounds that do not actually exist in the fertilizer.

These expressions are a continuation of long-used but now scientifically obsolete terminology. Scientists express a fertilizer analysis on an elemental basis. To do this, they use the conversion factors $P_2O_5 \times 0.43 = P$ and $K_2O \times 0.83 = K$. If other elements are claimed on a fertilizer label, they are typically expressed on an elemental basis.

Houseplant fertilizers come in a variety of forms. Many are mixtures of soluble salts that must be dissolved in water. Others are concentrated liquids that must be diluted prior to application. Natural organic types can be either dry solids, like gelatin, or liquids, like fish emulsion, both of which are generally combined with water before use.

Different Kinds of Fertilizers

A special category of fertilizers, called controlled-release fertilizers, release their nutrients over a period of many months, making infrequent applications possible. A common type of controlled-release fertilizer consists of a small granule of soluble fertilizer salts coated with a membrane—the trade name is Osmocote. When wetted, the fertilizer dissolves and slowly diffuses (a physical process) from the granule through small holes in the membrane. A less common type of controlled-release fertilizer is the ion-exchange fertilizer. In ion-exchange fertilizers, all the fertilizer nutrients are bound electrostatically as ions on plastic beads with negative or positive charges.

Activity One: Teaching Students to Read Fertilizer Labels

Background

To teach your students to read a fertilizer label, begin by explaining that plants make their own food,

How to Read a Fertilizer Label

Label

(1) DR. JOE'S SUPER PLANT FOOD

(2) 10 - 10 - 10

(3) GUARANTEED ANALYSIS:

(4) Total Nitrogen (N) 10%

(5)
3.0% Ammoniacal Nitrogen
3.0% Urea Nitrogen
1.0% Nitrate Nitrogen
3.0% Water Insoluble Nitrogen

(6) Available Phosphoric Acid (P_2O_5) 10%

(7) Soluble Potash (K_2O) 10%

(8) Primary nutrients from Sulfate of ammonia, Urea, Sulfate of potash, Potassium nitrate, Ureaform, Ammonium phosphate

(9)
Calcium (Ca) 2.0%
Magnesium (Mg) 1.0%
Sulfur (S) 7.0%
Iron (Fe) 0.5%
Manganese (Mn) 0.1%
Zinc (Zn) 0.1%
Boron (B) 0.1%

(10) Secondary and Trace Elements from Dolomite, Sulfate of potash, Manganese sulfate, Zinc sulfate, Iron sulfate, Borax

(11) Potential Acidity 500 lbs. Calcium carbonate Equivalent per ton

Key

(1) The brand name

(2) The analysis, grade, or formula. The 3 numbers are the percentages (by weight) of nitrogen, available phosphoric acid, and soluble potash, respectively.

(3) Manufacturer's guarantee of the minimum analysis

(4) The amount of nitrogen from all sources

(5) The sources of nitrogen

(6) The amount of available phosphoric acid claimed

(7) The amount of soluble potash claimed

(8) Sources of the 3 primary plant nutrients

(9) Guaranteed percentages of other plant nutrients. Other nutrients are not always listed even though they may be present.

(10) Sources of secondary and micronutrients

(11) The acidity (or alkalinity) of the fertilizer given in pounds of pure limestone (calcium carbonate) required to neutralize one ton of fertilizer. Most fertilizers containing urea or ammonium are acidic.

Figure 1. Student handout

using light energy to combine carbon, hydrogen, and oxygen. These basic compounds are then converted to more complex substances by incorporating some of the essential elements, most of which are absorbed through their roots. List the sixteen essential elements on the board and explain which twelve are considered fertilizer nutrients.

Procedure

Hand out copies of figure 1 to the students. Using the key beside the figure, discuss what each part of the label means.

Follow-up

Ask students to collect or record fertilizer labels that they find in their homes, in the homes of friends that garden, or in a hardware or garden store. Discuss the labels to be sure they can read them and make a bulletin board display of them.

Comparing Costs of Fertilizers

Nitrogen is by far the most important element in houseplant fertilizers. This is because nitrogen is the element that the plant requires in the greatest amount —by dry weight, from 1 percent to 4 percent of the plant is composed of nitrogen. In spite of this, even good quality houseplant potting soils have relatively small amounts of nitrogen, while containing, relative to the needs of the plant, large amounts of the other eleven fertilizer elements.

Because the amount of nitrogen in a fertilizer is the major consideration, the cost to the consumer of different brands of fertilizers can be compared by calculating the cost per unit of nitrogen in each. The nitrogen cost in dollars ($) per kilogram (kg) is calculated with the formula: N cost in $/kg = package price in $ ÷ percentage N expressed as a decimal × package mass in kg.

For example, you would calculate the nitrogen cost of Bandini Houseplant fertilizer, given in table 1, as follows:

The package price is $2.99; percentage of nitrogen is 21%; package mass, or weight, is 0.454 kg.

$$2.99 \div (0.21 \times 0.454) = \$31/\text{kg of N}$$

Thus the cost of Bandini Houseplant fertilizer would be $31 per kilogram.

People are generally astounded by the wide range in nitrogen cost; from $31 to $4,700 per kilogram in a group of twenty brands for which I calculated the cost for comparison (see table 1).

Activity Two: Calculating the Cost of a Variety of Fertilizers

Background

Explain to the students why nitrogen is the most important component of any houseplant fertilizer.

Procedure

1. Explain the math that they will need to use to calculate the cost per unit of nitrogen. Decide what figures they need to collect for each fertilizer to make the calculations: i.e., package price, package weight (or mass), and percentage of nitrogen.
2. Ask the students to bring in the information needed for any fertilizers they can find.
3. Calculate the cost of the nitrogen in each fertilizer, using the formula above.
4. Make a chart showing the fertilizer costs, arranged from best value to poorest.
5. Discuss the range of costs shown in table 1.

Follow-up

Ask the students to write a short report explaining why a careful consumer should know the cost of the nitrogen in their houseplant fertilizer.

Comparing Solutions

An important aspect of adding fertilizers to houseplants is the concentration of nutrients provided in the irrigation solution. A typical irrigation solution used by commercial houseplant growers will contain about 100 to 200 mg/liter of N. The N concentration provided by individual houseplant fertilizers is fairly easy to calculate.

Liquid Fertilizers

A typical dilution rate recommended for liquid fertilizers is 1 teaspoon per quart. This is about a 200-fold dilution—1 teaspoon is 4.93 ml; a quart is 946 ml; and 946 ÷ 4.93 is about 200. The nutrient concentration of a liquid fertilizer after dilution is calculated as follows: percentage of nutrient × 10,000 ÷ dilution factor. The figure 10,000 is introduced to convert parts per hundred to the parts per million needed to keep the calculation in whole numbers.

For example, for Marsh's VF-11 brand, the dilution rate is 200, and the percentage of N is 0.15.

$$(0.15 \times 10{,}000) \div 200 = 7.5 \text{ mg/liter N}$$

So the solution used to irrigate the plant has about 8 mg/liter N. This is an extremely low rate, suggesting that the fertilizer is not likely to be effective. The legal limit for nitrate-N in drinking water is 10 mg/liter; thus you could even drink this diluted fertilizer solution without harm.

Soluble Fertilizers

To calculate the N concentration provided by soluble fertilizers, determine the mass of fertilizer added per volume of water.

As an example, Miracle-Gro is diluted by adding 1 teaspoon of the dry fertilizer to 1 gallon of water. The mass of 1 teaspoon of Miracle-Gro is 2800 mg, 1 gallon is 3.78 liter, and Miracle-Gro has 15% N.

Table 1. Retail Cost of Nitrogen Supplied by 20 Brands of Houseplant Fertilizers

Brand of houseplant fertilizer	Type[1]	N-P-K (%)	Package price ($)	Package weight (kg)	Nitrogen cost[2] ($/kg)
Bandini Houseplant	S	21-3.4-6.6	2.99	0.454	31
RaPidGro	S	23-8.2-14.1	1.99	0.227	38
Spoonit Orchid	S	30-4.3-8.3	2.19	0.170	43
Osmocote, 3–4 month	C	14-6.0-11.6	4.95	0.553	64
Stern's Miracle-Gro	S	15-12.9-12.5	2.19	0.227	64
Schultz-Instant	L	10-6.5-8.3	1.39	0.156	89
Liquid Miracle-gro	L	8-3.0-5.0	2.19	0.278	98
Ortho African Violet	L	6-3.9-4.2	1.79	0.278	107
Peter's Houseplant	S	15-12.9-6.5	1.19	0.071	112
Knox Gelatin	O	15-0-0	0.59	0.028	140
Hyponex African Violet	L	10-4.3-8.3	1.99	0.142	140
Ortho Houseplant	L	5-4.3-4.2	1.29	0.176	147
Ortho Fish Emulsion	O	5-0.43-0.83	3.49	0.454	154
Clarel Labs Orchid	L	5-2.2-2.5	2.69	0.170	316
Restore	O	3-1.7-3.3	4.49	0.397	377
Jobe's Houseplant Spikes	C	10-1.7-4.2	0.89	0.015	593
Clarel Jungle Juice	L	2-2.2-3.3	2.69	0.170	791
Hyponex Hypostyx	C	4-4.3-4.2	0.98	0.025	980
Clarel Cactus Juice	L	1-3.0-5.0	2.69	0.170	1582
Marsh's VF-11	L	0.15-0.37-0.46	3.49	0.499	4663

[1]S = soluble; L = liquid; C = controlled-release; O = organic; G = granular.
[2]Nitrogen cost ($/kg) = package price ÷ %N × package weight in kg.

$$(2800 \times 0.15) \div 3.78 = 111 \text{ mg/liter of N}$$

The N concentration in the diluted fertilizer is 111 mg/liter, a very reasonable value.

Activity Three: Calculating the Amount of Nitrogen in a Solution

Background

Explain that houseplant fertilizers are diluted or dissolved according to the directions on the package before application.

Procedure

1. Have the students dilute or dissolve different fertilizers according to the strengths indicated on the package.
2. Ask them if they think each solution has the same amount of nitrogen in it.
3. Explain how to calculate the amount of nitrogen in each solution.
4. Compare the amounts of nitrogen being applied in each case.

Follow-up

Ask the students how they could give the plants the same amount of nitrogen using different fertilizers. (They could adjust the strengths of the solutions so that the percentage of nitrogen in each was the same, or they could use the suggested dilution but calculate the different quantities of solution that would be needed to supply the same amount of nitrogen.)

REFERENCES

California Fertilizer Association. 1985. *Western fertilizer handbook*, 7th ed. Danville, Il.: Interstate.

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