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PB1616-Plant Nutrition and Fertilizers for Greenhouse Production

The University of Tennessee Agricultural Extension Service

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Plant Nutrition & Fertilizers For Greenhouse Production

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Plant Nutrition & Fertilizers For Greenhouse Production

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This publication is one of three in a series that covers the basics of developing a nutritional program for producing container-grown plants in greenhouses. A complete nutrition program encompasses the fertilizers, media and water used. The first section in **Plant Nutrition and Fertilizers for Greenhouse Production** develops background information about plant nutrition that growers need to understand before discussing which fertilizers to use. The second section covers the range of fertilizers that growers can choose from.

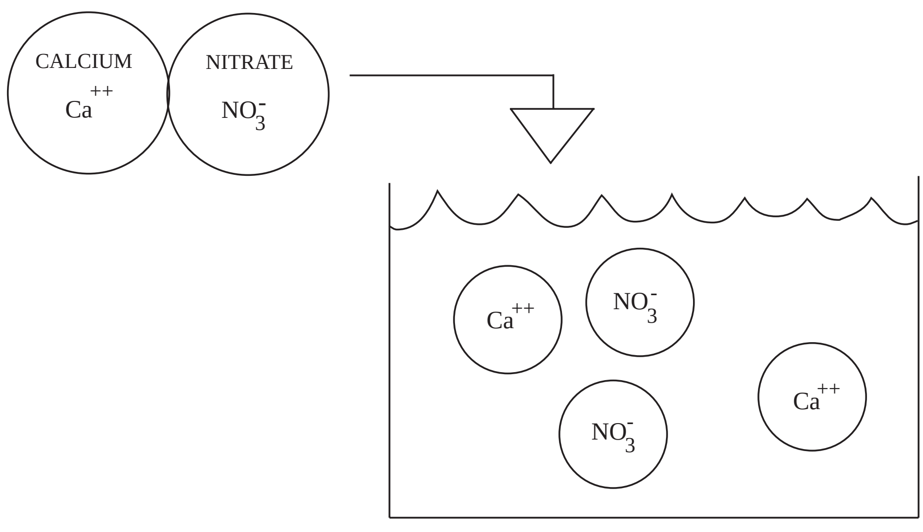
The second publication in the series, **Irrigation Water Quality for Greenhouse Production** (PB 1617), examines the effect of water quality on a greenhouse nutritional program. The third publication, **Growing Media for Greenhouse Production** (PB 1618), describes the important physical and chemical properties of growing media, media testing procedures and interpretation of test results. The objective of this series of publications is to provide basic information that will allow greenhouse operators to develop a nutritional program for their specific business.

Plant Nutrition: The Basics

Fertilizer Salts

Fertilizers are salts. Salts are chemical compounds that contain one positively charged ion (cation) bonded to one negatively charged ion (anion). When a salt is placed into water, the two ions separate and dissolve. An example of a fertilizer salt is calcium nitrate, which contains one calcium cation and a nitrate anion. Other examples include: ammonium phosphate, magnesium sulfate, potassium nitrate and ammonium nitrate.

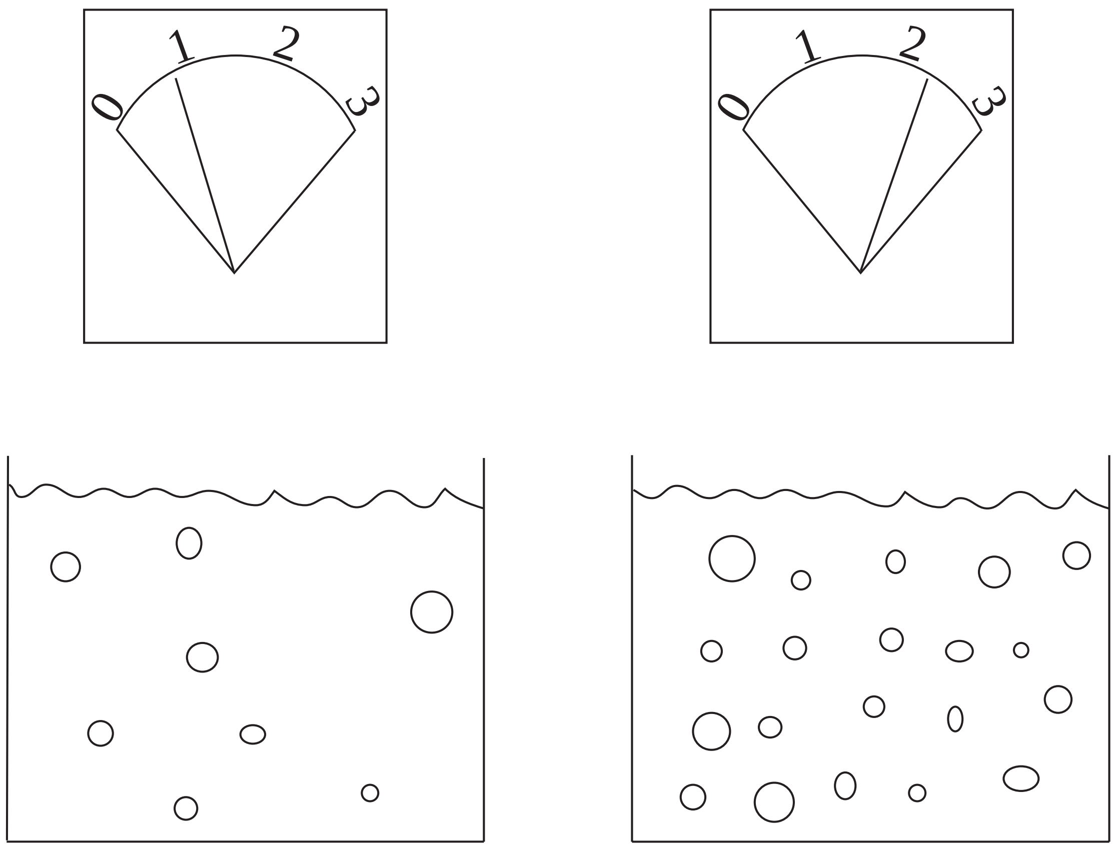
Fertilizer concentration (or saltiness) of a solution can be determined by measuring the ability of a solution to conduct an electrical signal (electrical conductivity). Electrical conductivity meters, often called soluble



salts meters, measure the concentration of salts/ions in solution; therefore, a grower can always measure the amount of fertilizer being applied to a crop. However, electrical conductivity meters do not specifically measure which specific salts are in solution. For example, an electrical conductivity meter can not tell the difference between table salt (sodium chloride), which is dangerous to plants, and potassium nitrate, which is useful for plants.

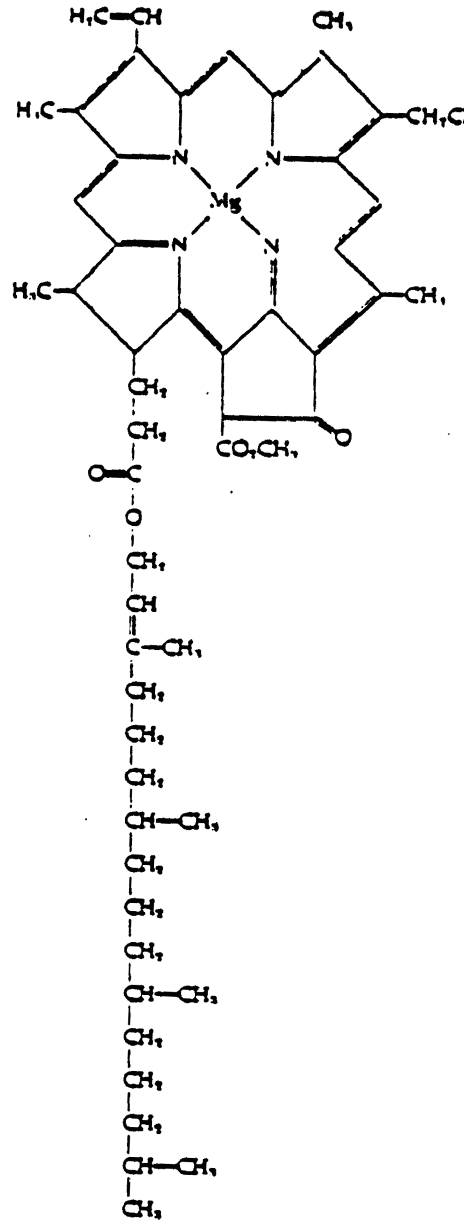
Ions dissolved in water are taken up through the roots and distributed within the plant. Plants actually expend energy to take up most ions, however, calcium is thought to only come along for the ride, i.e., plants don't actively take up calcium, it just comes into the root with the water.

Once inside the plant, ions are recombined into compounds useful for plant growth. The most common example of plant metabolism involves photosynthesis, during which water (hydrogen and oxygen) is combined with carbon dioxide (carbon and oxygen) to form starch or sugars (carbon, hydrogen and oxygen). Another example is the chlorophyll molecule shown below that contains:



55 carbon atoms
60 hydrogen atoms
5 oxygen atoms
4 nitrogen atoms
1 magnesium atom

Therefore, for the plant to build one chlorophyll molecule, the leaves must take in carbon dioxide, for the carbon and oxygen; the roots must take in water, for the hydrogen and oxygen; and the roots must take up nitrogen and magnesium provided from the fertilizer applied.



Once inside the plant, some nutrients can be mobilized to support new growing tissues, while other nutrients are fixed in older plant tissues. This fact helps us to diagnose some plant nutrient deficiencies. For example, if a plant is deficient in an immobile nutrient, then deficiency symptoms (yellowing/chlorosis) occur in the new growth, since the older tissues "hold" on to the immobile nutrients. In contrast, deficiencies of mobile nutrients typically occur in the older leaves, since the mobile nutrients move from the old leaves to the new leaves.

Plants require different amounts of each nutrient. Carbon, hydrogen and oxygen are required in the greatest amounts; however, these are taken up by the plant in the form of water and carbon dioxide. Nitrogen, phosphorus, potassium, calcium, magnesium and sulfur are required in large amounts, thus are called macronutrients. Iron, manganese, copper, zinc, boron, chloride, molybdenum are required in relatively small amounts, thus are called micronutrients, or minors.

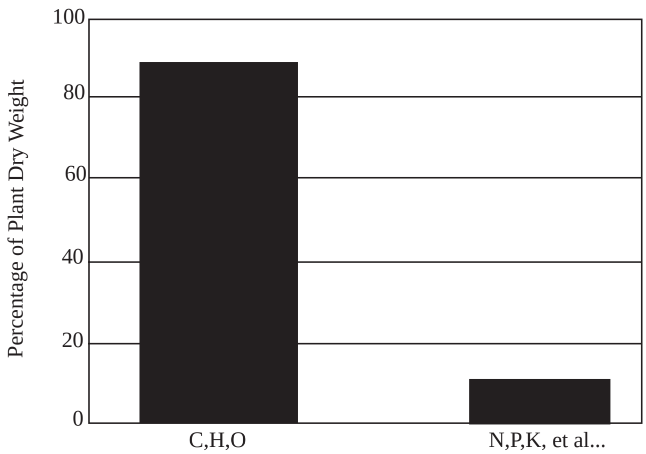
Table 1. Mobility of individual nutrients within plants.

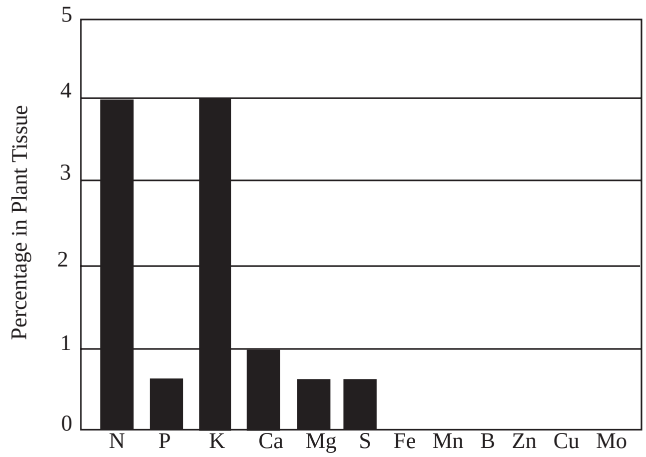
Mobile	**Immobile**
Nitrogen	Calcium
Phosphorus	Iron
Potassium	Manganese
Magnesium	Zinc
Sulfur	Copper
	Boron
	Molybdenum

pH

pH is a measure of the concentration of hydrogen (H+) ions, sometimes called protons. The greater the H+ ion concentration, the more acid the solution, hence a lower pH.

pH controls the uptake of nutrients. If the pH is not in the desired range, individual nutrients can not be taken up, creat-





ing a nutrient deficiency, or the nutrient can be taken up too readily, resulting in a nutrient toxicity. These nutrient imbalances will occur even when proper amounts of nutrients are applied to the media, if the pH is too high or too low. The figure below demonstrates the availability of nutrients to plants at different media pH. Nitrogen and potassium are readily available at a wide pH range. Although phosphorus is more readily available at a low pH, phosphorus problems are not commonly observed in greenhouse crops. Calcium and magnesium are more readily available at a higher pH. At a low pH, the minor nutrients (iron, manganese, boron, zinc and copper) are readily available. Minor nutrient toxicities are relatively common at a low pH (<5.8), while deficiencies frequently occur at a high pH (>6.5)

Factors affecting media solution pH:

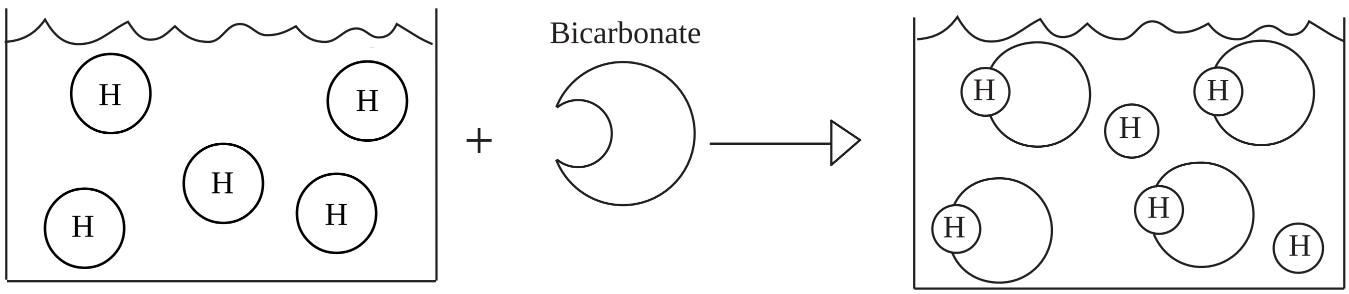
1. Water Quality/Alkalinity: Alkalinity is one measure of the quality of water used for irrigation. Alkalinity is the measure of the concentration of bicarbonates and carbonates in water which determine the water's capacity to neutralize acids. In other words, irrigating with bicarbonates in water is equivalent to applying lime with each irrigation. The bicarbonates react with hydrogen ions and remove them from solution. This process effectively decreases the H+ ion concentration in the media and thus increases the media solution pH.

The reverse situation can also occur. Very pure water (low bicarbonates) can cause media solution pH to decrease over time. The pH drops, because there may not be enough bicarbonates to absorb excess hydrogen ions. Thus, the H+ concentration in the media increases.

The most common solution for pure water sources is to increase the amount of pulverized dolomitic limestone incorporated into the media prior to transplanting plants into the media. Another solution is to top-dress containers with the limestone. Finally, bicarbonate can be added to irrigation water in the form of potassium bicarbonate to improve the buffering capacity of the media solution (i.e., reduce pH fluctuation).

Water quality issues are covered in more depth in *Irrigation Water Quality for Greenhouse Production* (PB 1617).

2. Media Components. Peat tends to be acidic. Pulverized dolomitic limestone ($CaMg(CO_3)_2$) is incorporated into most amended media to adjust the starting pH to ~6.0. Coarser grades of dolomitic



limestone change the media pH more slowly, and thus are not often used in peat-based media. A relatively new, but popular media component, coconut coir, is less acidic than peat, so less limestone needs to be used.

The role of media in a greenhouse nutritional program is covered in more depth in Growing Media Quality for Greenhouse Production (PB 1618).

3. **Fertilizers Applied.** Fertilizers are categorized into one of two groups: acid-residue or alkaline-residue. The fertilizers themselves are not acidic or alkaline, but they react with microorganisms in the media and plant roots to affect media solution pH. Fertilizers with ample ammonium or urea tend to acidify the media, i.e., lower the pH. Fertilizers with ample nitrates tend to raise the pH of the media solution slowly over time.

Fertilizers and Fertilization

Water-Soluble Fertilizers

Most greenhouse fertilization programs rely on water-soluble fertilizers to provide most of the nutrients required for plant growth. Water-soluble fertilizers are often applied at each irrigation. This is referred to as a constant liquid fertilizer (CLF) program. A specific fertilizer program must be developed around the irrigation water, media and crops grown. Following is a typical CLF program:

200 ppm N from 20-10-20 Peat-Lite Special applied each irrigation for one week.

200 ppm N from 15-0-15 applied each irrigation the following week.

100 ppm Mg from Epsom salts (magnesium sulfate) applied once.

Repeat.

The 20-10-20 Peat-Lite Special supplies nitrogen, phosphorus, potassium and minor nutrients. The 15-0-15 fertilizer supplies nitrogen, potassium, calcium and minor nutrients. The epsom salts supply magnesium and sulfur. Rotating these three products provides all essential nutrients required for plant growth. Recently available are water-soluble fertilizers that supply all essential nutrients in one fertilizer. Examples include 15-5-15 Cal-Mag Special and 13-2-13 Plug Special.

Slow-Release Fertilizers

Slow-release, or controlled-release, fertilizers are usually used when crops are grown outdoors. Slow-release fertilizers are beneficial because they create less environmental pollution, e.g., fertilizer run-off, when sprinkler irrigation is used, and they continue to supply nutrients during rainy weather. Slow-release fertilizers are marketed based on the time of release, for example, 3- to 4-month longevity. The actual fertilizer release rate is determined by the temperature and water content of the media. Therefore, the actual effective release time of the fertilizer may vary from the labeled time.

Slow-release fertilizers can be incorporated into the media prior to filling the containers or top-dressed after planting. Slow-release fertilizers are often incorporated into the media for garden mum production as an insurance policy against rainy weather.

Fertilizer Labels

This section will discuss information that is critical to understand as you develop a nutritional program for containerized greenhouse crops. A useful place to start when discussing fertilizers is the fertilizer label itself. These labels contain several very useful pieces of important information for all growers.

Nutrient Analysis. The fertilizer analysis indicates the percentage of a particular nutrient contained within the fertilizer (on a percent weight basis). The fertilizer analysis typically refers to the percentage of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) contained in a given fertilizer. A balanced fertilizer should provide nutrients in amounts relative to plant requirements. Since nitrogen and potassium are used in relatively similar amounts (on a weight basis), a fertilizer should have a nitrogen to potassium ratio of approximately 1:1. Phosphorus is required to a lesser degree, so the nitrogen-to-phosphorus ratio should be approximately 2:1 to 4:1. Therefore, a 2:1:2 (N-P_2O_5-K_2O) is suitable for most greenhouse crops. An example of this type of fertilizer is 20-10-20. While 20-20-20 is still commonly used, 20-10-20 is preferred, since the N-P_2O_5-K_2O ratio is closer to that required by plants. The extra phosphorus provided by 20-20-20 is usually wasted, thus creating potential environmental concerns.

Nitrogen Form. Nitrogen is provided in three different forms: nitrate-nitrogen (NO_3), ammoniacal-nitrogen (NH_4) and urea-nitrogen. The nitrogen form affects plant growth and media solution pH. Ammoniacal nitrogen, sometimes called ammonium, tends to contribute to "lush" plant growth, for example, greater leaf expansion and stem elongation, whereas nitrate nitrogen produces a "hard" or well-toned and compact plant. High ammonium can be toxic to plants during cold, cloudy growing conditions. Therefore, ammonium and urea should make up <40 percent of the nitrogen during winter months. "Dark-Weather" or "Finisher" fertilizers tend to have high nitrate and low ammonium nitrogen.

The following equation demonstrates how to calculate the percentage of the total nitrogen that is in the ammoniacal form. Note: When calculating the percentage nitrate versus ammonium, assume urea will break down to ammonium.

% N in ammonium form = (% Ammonium + % Urea) ÷ % Total N x 100

For example, a 15-5-15 label indicates the following nitrogen breakdown:

Total Nitrogen (N)......15%
1.20 % Ammoniacal Nitrogen
11.75 % Nitrate Nitrogen
2.05 % Urea Nitrogen

(2.05% Urea + 1.20% Ammonium) ÷ 15% Total N x 100 = 21.7% N in ammonium form

Potential Acidity or Basicity. The potential acidity or basicity indicates how the fertilizer will affect media solution pH. A fertilizer label will indicate that the fertilizer has either a potential acidity or a potential basicity. The potential acidity refers to the fertilizer's tendency to cause the media pH to decrease, while the potential basicity refers to the fertilizer's tendency to cause a media pH increase. The larger the number, the greater the tendency for the media pH to be affected by the fertilizer (Table 2). Fertilizers high in ammonium cause the pH to decrease (become more acidic), while fertilizers high in nitrate cause the pH to increase (become more basic or alkaline).

Several trends are apparent in Table 2. Fertilizers with a considerable percentage of the nitrogen in the ammonium form tend to leave an acid residue in the media, indicated by the potential acidity. Fertilizers that have low ammonium, and thus high nitrate form of nitrogen, tend to leave an alkaline, residue indicated by the potential basicity. The high-ammonium fertilizers tend to have very little or no calcium or magnesium, while the low-ammonium, alkaline-residue fertilizers contain higher levels of calcium or magnesium.

Proper Dilution Rate. The proper dilution rate is indicated on the fertilizer label and can be tested with a soluble salts meter. The soluble salts concentration of the fertilizer solution increases as the amount of fertilizer increases. For example, 20-10-20 Peat Lite Special will have an electrical conductivity (EC) of 0.33 mmhos/cm for every 50 ppm of nitrogen. Therefore, a fertilizer mixed to provide 250 ppm nitrogen will have an EC of 1.65 mmhos/cm [(250 ÷ 50) ¥ 0.33]. Note: Each fertilizer has a different soluble salts to nitrogen relationship, so the specific fertilizer label must be examined.

Fertilizer Injectors

Injectors mix precise volumes of concentrated fertilizer solution and water together. Injectors or proportioners are commonly available in a mixing range of 1:16 to 1:200. For example, 1:100 injection ratio indicates that one gallon of concentrated fertilizer will produce 100 gallons of final fertilizer solution. Injectors allow growers to have a smaller stock tank and mix their fertilizer stock solutions less frequently. However, not all fertilizers can be mixed together. Calcium and magnesium fertilizers typically can not be mixed with phosphate and sulfate fertilizers while concentrated. A solid precipitate will form in the bottom of the stock tank if the fertilizers are not compatible. Once the individual fertilizers are diluted to their final concentration, then all fertilizers are compatible and thus can be mixed together.

Multiple Injectors. Multiple injectors or multiple-headed injectors can be used to inject incompatible stock solutions. If separate injectors are plumbed serially, i.e., one after the other, then fertilizer stock solutions can be mixed at the same concentration as if one injector is being used. For example, one head can inject calcium nitrate, while the other head injects magnesium sulfate. However, if two injector heads are placed into one stock solution, then the final concentration delivered to the plants will be twice the desired concentration, unless proper dilution occurs, e.g., mix the stock solution for 100 ppm N if 200 ppm is desired.

Injector Accuracy and Calibration. It is very common for injectors to lose calibration accuracy over time. Growers should test the calibration accuracy with a soluble salts meter every time a new batch of fertilizer is mixed. If a soluble salts meter is not available, then Calibration Method #2 can be performed.

Calibration Method 1. Use a soluble salts/electrical conductivity (EC) meter to determine concentration of fertilizer coming from the end of the hose. The EC of the water must be subtracted from the EC of fertilizer solution. The correct EC for a given concentration is usually found on the fertilizer label.

Calibration Method 2. Place the siphon into a known volume of solution, e.g., a quart or a gallon. Turn the water on through the injector and fill up a large container, such as a 20- or 40-gallon garbage can. When the siphon has removed all of the solution from the small container, turn off the water. If using a Hozon Injector (1:16), then one gallon of stock solution should empty into 16 gallons final solution. If a 1:100 injector is used, then one quart of stock solution should fill 25 gallons of final solution.

Table 2. The fertilizer analysis for the percentage (weight basis) of Ca, Mg, S and ammonium (NH4) provided in several commercially-blended fertilizers. Also, the potential acidity or basicity are listed for each fertilizer.

Fertilizer (N-P2O5-K2O)	Ca (%)	Mg (%)	S (%)	NH4 (%)	Potential Acidity (lbs. Calcium carbonate equivalent per ton)	Potential Basicity (lbs. Calcium carbonate equivalent per ton)
21-7-7 acid	0	0	0	90	1700	-
24-9-9	0	0	10	50	822	-
20-2-20	0	0	0	69	800	-
20-18-18	0	0	1	73	710	-
24-7-15	0	1	1	58	612	-
20-18-20	0	0	1	69	610	-
20-20-20	0	0	0	69	583	-
20-9-20	0	0	1	42	510	-
20-20-20	0	0	0	69	474	-
16-17-17	0	1	1	44	440	-
20-10-20	0	0	0	40	422	-
21-5-20	0	0	0	40	418	-
20-10-20	0	0	0	38	393	-
20-8-70	0	1	1	39	379	-
15-15-15	0	0	0	52	261	-
17-17-17	0	0	0	51	218	-
15-16-17	0	0	0	47	215	-
15-16-17	0	0	0	30	165	-
20-5-30	0	0	0	56	153	-
17-5-24	0	2	3	31	125	-
20-5-30	0	1	0	54	118	-
17-4-28	0	1	2	31	105	-
20-5-30	0	0	0	54	100	-
15-11-29	0	0	0	43	91	-
15-5-25	0	1	0	28	76	-
15-10-30	0	0	0	39	76	-
20-0-20	5	0	0	25	40	-
21-0-20	6	0	0	48	15	-
20-0-20	7	0	0	69	0	-
16-4-12	0	0	0	38	-	73
17-0-17	4	2	0	20	-	75
15-5-15	5	2	0	28	-	135
13-2-13	6	3	0	11	-	200
14-0-14	6	3	0	8	-	220
15-0-15	11	0	0	13	-	319
15-0-15	11	0	0	13	-	420

Table 3 provides assistance in calculating the amount of fertilizer to mix to make different stock solutions using different injection ratios.

To use this chart:

•Select your injector's ratio setting across the top of the columns.
•Select percentage of nitrogen (N) formula used in left column.
•Read across and down to find ounce required per gallon of concentrate.
•Multiply this amount by the number of gallons of concentrate used in your fertilizer stock tank.

The table is based on 100 ppm N. For 150 ppm, multiply amounts to be used by 1.5; for 200 ppm, multiply amounts to be used by 2, etc.

Starting a Fertilization Program

Nutrients can be placed into the media prior to planting, i.e., a pre-plant nutrition program, and during plant growth, i.e., a post-plant nutrition program. Do not forget that irrigation water can also be a significant source of plant nutrients, especially calcium and magnesium.

Despite considerable gardening advice to the contrary, specific nutrients do not promote rooting or flowering! Specifically, phosphorus does not promote rooting and potassium does not promote flowering. Excess nitrogen can potentially reduce flowering and produce excessive vegetative growth.

Pre-Plant Nutrition Programs

Nutrients can be supplied in limited quantities, while the media components are being mixed. Calcium and magnesium are provided when dolomitic limestone is used to adjust the starting pH. Phosphorus and sulfur are provided with superphosphate plus gypsum (calcium and sulfur). (Single phosphate is 50 percent gypsum by weight). Iron, manganese, zinc, copper, boron and molybdenum are provided with micronutrient formulations (e.g., Micromax or Esmigram). Nitrogen and potassium are provided with potassium nitrate.

Typical pre-plant recipe for 1 cubic yard of soilless media:

Dolomitic limestone	10 lbs.
Treble Superphosphate	2.25 lbs.
Gypsum	1.5 lbs.
Micromax	1.25 lbs.
Potassium Nitrate	1 lb.

(The additional nitrogen and potassium will last ~1 to 2 weeks.)

Table 3. A quick chart to determine the number of ounces of fertilizer required per gallon of stock tank solution based on the percentage of nitrogen in the fertilizer and the injection ratio. See Appendix A for more specific calculations.

% N	Ounces of fertilizer to make 100 ppm nitrogen at an injector ratio of: 1:16	1:50	1:100	1:200
10	2:16	6.75	13.5	27.0
15	1:44	4.5	9.0	18.0
20	1:08	3.38	6.75	13.5
25	0.86	2.7	5.4	10.8
30	0.72	2.25	4.5	9.0

Note: Acid injection is discussed in *Irrigation Water Quality for Greenhouse Production*.

Post-Plant Nutrition Programs

Most small to medium-sized commercial greenhouses use commercially blended fertilizers for convenience and dependability; however, for some growers it is economical to buy individual fertilizers and mix them together. Table 4 shows some of the common ingredients in a variety of different commercial fertilizers.

Following are some important notes about each of the essential plant nutrients:

Nitrogen (N)

Sources: ammonium nitrate, urea, calcium nitrate, potassium nitrate, magnesium nitrate.

The concentration applied is determined by the amount of leaching. For example, in a constant liquid feed program using a sub-irrigation system (0 percent leaching) 100 ppm N may produce adequate growth, while 300 ppm N may be needed if overhead irrigation results in 25 percent leaching.

Crop requirements:

Bedding Plants	Light
New Guinea Impatiens	Light
Geranium	Moderate
Poinsettias	Moderate to heavy
Chrysanthemums	Heavy

Table 4. Some common ingredients found in a variety of commercially blended fertilizers. Note: Each fertilizer may contain several other ingredients not listed below.

Commercial Sources	Urea	Ammonium Nitrate	Calcium Nitrate	Potassium Nitrate	Magnesium Nitrate	Ammonium Phosphate
Plug Special 13-2-13		X	X	X	X	
Cal-Mag Special 14-0-14		X	X	X	X	
High Calcium Spec. 15-0-15		X	X	X		
Pansy Special 15-2-20		X	X	X	X	X
Poinsettia Spec. 22-8-20		X		X		X
Poinsettia Finish. 15-11-29	X			X		X
Pot Mum Special 1 5-11-29	X			X		X
Geranium Spec. 15-15-15	X			X		X
Plant Starter 15-50-5				X		X
Fern Special 18-24-18	X			X		X
General Purpose 20-10-20		X		X		X
All Purpose 20-20-20	X			X		X

Phosphorus (P)

Sources: Ammonium phosphate, urea phosphate

A nitrogen-to-phosphate (P2O5) ratio of 2:1 is acceptable for most crops. Fertilizers with high concentrations of ammonium phosphate, such as 9-45-15, appear to promote stem stretching.

Potassium (K)

Sources: Potassium nitrate, potassium sulfate

A nitrogen-to-potash (K2O) ratio of 1:1 is acceptable for most crops.

Calcium (Ca) and Magnesium (Mg)

Sources: Dolomitic limestone, irrigation water, calcium nitrate, magnesium sulfate (Epsom salts), magnesium nitrate.

Calcium and magnesium provided by dolomitic limestone are released slowly over several months. These two nutrients can have an antagonistic relationship (i.e., they compete within the plant), thus a Ca:Mg ratio of 3:1 to 5:1 is desirable. Calcium and magnesium are commonly found in irrigation water, especially high alkalinity water. Calcium and magnesium deficiencies are most common when the pH is low (less than 5.8). Calcium and magnesium fertilizers can not be mixed in the concentrated form with phosphate or sulfate fertilizers, thus calcium and magnesium are frequently omitted from commercial fertilizers. A few relatively new fertilizers contain calcium and magnesium along with the nitrogen, phosphorus and potassium. These fertilizers often list five numbers in the analysis. These numbers represent N, P2O5, K2O, Ca and Mg, respectively. For example, (15-5-15-5-2, 14-0-14-6-3, 13-2-13-6-3). Note: Epsom salts are 10 percent magnesium by weight.

Micronutrients

Micronutrients are sold in different formulations; for example, Micromax, Esmigran and Soluble Trace Element Mix contain only inorganic sources, while Compound 111 contains chelated sources. Chelated forms are superior in that the micronutrients are more soluble, therefore more readily available to the plant. Consequently, chelated micronutrients are applied at lower rates. Compound 111 and STEM are labeled for use in constant liquid feed programs. The rates are based on adding a certain amount of micronutrient mix per 100 ppm of N used in the fertilization program.

Micronutrient deficiencies are closely related to media pH. High pH (greater than 6.5) can produce deficiencies, while low pH (less than 5.8) can cause toxicities. Adjusting the media pH is the best solution to avoid micronutrient toxicities or deficiencies.

Table 5. The micronutrient concentration (ppm) to be applied with each 100 ppm nitrogen.

	Micronutrient ppm at 100 ppm N liquid feed					
Fertilizer	**Iron (Fe)**	**Manganese (Mn)**	**Zinc (Zn)**	**Copper (Cu)**	**Boron (B)**	**Molybdenum (Mo)**
Soluble Trace Element Mix (STEM)	0.25	0.27	0.15	0.11	0.05	0.001
Compound 111	0.25	0.13	0.012	0.019	0.04	0.004

Appendices:

A. Fertilizer calculations

1. Calculating the parts per million for a fertilizer solution:

Actual ppm = pounds fertilizer x %N x Z ÷ gallons stock ÷ proportioner ratio

For N, Ca, Mg, Fe,	**Z=1200**
For Phosphorus (P),	**Z= 528**
For Potassium (K),	**Z= 996**

Example 1: Calculate the concentration (ppm) of nitrogen applied when 1 pound of 15-0-15 is mixed into a 5 gallonstock tank and a 1:16 proportioner is used.

1 lb. Fert. x 15%N x 1200 ÷ 5 gal. stock ÷ 16 proportioner = 225 ppm nitrogen.

Example 2: Calculate the concentration (ppm) of potassium applied when 1 pound of 15-0-15 is mixed into a 5 gallon stock tank and a 1:16 proportioner is used.

1 lb. Fert x 15%K ¥ 996 ÷ 5 gal. stock ÷ 16 proportioner = 187 ppm potassium

Example 3: Calculate the concentration (ppm) of calcium applied when 1 pound of 15-0-15 is mixed into a 5 gallon stock tank and a 1:16 proportioner is used. (Note from Table 2, 15-0-15 contains 11% calcium). Also note that the irrigation water has 15 ppm calcium.

1 x 11 x 1200 ÷ 5 ÷ 16 = 165 ppm calcium from fertilizer plus and additional 15 ppm calcium from the irrigation water = 180 ppm calcium applied

2. Calculating the amount of fertilizer to add to a stock tank:

lbs. of fert. = desired ppm x gal. stock soln. x proportioner ratio ÷ %N ÷ Z

Example 1: How many pounds of 21-5-20 fertilizer should one add to a 20 gallon stock tank in order to irrigate with 200 ppm N using a 1:100 injector?

200 ppm N x 20 gal. x 100 (injector ratio) ÷ 21%N ÷ 1200 = 15.9 pounds of fertilizer (21-5-20) added to a 20-gallon stock tank will produce 200 ppm N when injected at a 1:100 ratio.

B: Conversion of Units

Liquid

1 ounces = 29.6 milliliters = 2 table spoons
8 ounces = 1 cup
2 cups = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
10 liters = 2.64 gallons
1 gallon= 128 ounces = 3.785 liters = 8.34 pounds of water
1 gallon concentrate per 100 gallons of spray = 2.5 tablespoons per gallon

Dry Weight

1 ounce = 28.35 grams
1 pound = 454 grams = 16 ounces
1 tablespoon = 3 teaspoons
1 ppm = 1 milligram per 1 kilogram or 1 milliliter per liter or 1 milligram per liter

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