A Mechanism for Designing and Implementing an Interiorscape Fertilization Program

1. Start with a base fertilizer that you will use for all plants. Either a slow release granular or water soluble fertilizer can be used. This discussion will focus on water soluble fertilizers only. Typical recommendations for foliage plants are fertilizers with a 3-1-2 or 2-1-2 ratio of Nitrogen(N) – Phosphorous(P) – Potassium(K). Both are good fertilizers for foliage plants but the3-1-2 will emphasize the Nitrogen which is typically not desirable in interiorscapes. The 3-1-2 would be an acceptable choice for higher light environments where plants are actively growing.

   Most fertilizers deliver the total percentage of Nitrogen in different forms. The two most common in higher end fertilizers are ammoniacal Nitrogen and Nitrate Nitrogen. Ammoniacal Nitrogen is used when lush growth and greater internode elongation are desired. Nitrate Nitrogen is used when more compact plants are desired. Also, Ammoniacal Nitrogen can build up to toxic levels in plants where Nitrate Nitrogen does not. The catch is, Nitrate Nitrogen is the more expensive of the two. Many quality fertilizers deliver half of the total nitrogen as ammoniacal and half as nitrate. The obvious choice for interiorscapes is nitrate nitrogen so pick a fertilizer that supplies the majority, if not all, of the Nitrogen in the nitrate form.

   Use the nitrogen form and the recommended ratio of N, P, and K as your deciding criteria for picking a fertilizer. The phosphorous and potassium source should be suitable without much consideration.

2. The next major consideration for your fertilizer program is where all of the other nutrients that plants need will come from. The complete list of recognized essential nutrients for plants are Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Sulfur, Iron, Manganese, Zinc, Molybdenum, Copper and Boron. All are essential, but some are more important than others for foliage plants and palms. Most complete fertilizers contain adequate amounts of sulfur, manganese, zinc, copper, boron, and molybdenum. For foliage plants additional iron, magnesium and calcium are usually required unless the base fertilizer emphasizes one or more of these. In addition to these, extra Potassium and Magnesium will help palms maintain full canopies with nice looking older leaves.

   Of course, there are other factors to consider. The type of soil in the pot may change the need to supply other nutrients. For example, a palm, grown in a marl field in South Florida, will contain a large portion of the soil that is very high in calcium. This makes additional calcium less important than additional magnesium. Especially since disproportionately high levels of Calcium over magnesium will suppress the uptake of magnesium usually causing a magnesium deficiency. Compare this situation to a palm that has been grown in a 100% soil-less media where all the required nutrients must be supplied by the fertilizer program. The point is, the nutrient content and properties of the soil, when interior acclimated plants have been grown in the ground, can vary substantially. The water source can also contain some of these essential plant elements as well as other contaminants. If you are going through the effort to design a fertilizer program to the degree outlined here, it makes sense to have some water samples tested for nutrient content. This can be helpful in many ways. An element missing from a fertilizer, that otherwise would be perfect for your situation, might be supplied by the water. Also, water sources, that are high in some elements, may be a cause of plant nutrition problems.

If it sounds complicated it's because it is. However, don't despair. Instead remember two basic points: 1) You don't need to “know it all” to get started. Do a water test to find out what you have there, and assume that no nutrients are being supplied by the soil. Design your program to supply all needed elements in the desired quantities, and refine your program over time as you gain insight from observations, study and information from your suppliers. 2) You will never know it all, but it is interesting and rewarding to learn how to feed these living things.

3. The next major consideration is how much to apply and how often. For a constant (every day) liquid feed program in a nursery environment a rate of 200 to 250 ppm (parts per million) Nitrogen is a typical recommendation for foliage plants. That rate can go to 300 – 400 ppm N for periodic feeding schedules. There are lots of variables to play with here. As the time between fertilizer applications grows longer the ppm N applied should be increased. Of course too much at one time can be a problem and it is better to deliver a steady supply of fertilizer during the life of the plant.

One possible solution would be to apply fertilizer every other watering or every third watering adjusting the ppm N to fit the schedule you choose. If 200 ppm N is recommended for nurseries on an every day feed schedule then somewhere in the range of 100 to 300 ppm N may be a good starting point for an every other week feeding schedule in an interiorscape. Remember 2 things, one, this is the base program only and plants in higher light or with special needs will need additional nutrients, and, two, the plants should be observed and the rate adjusted depending on the results.

The idea is to deliver all the nutrients the plant will need for the period between fertilizer applications, no more or no less. At this optimal rate there is no salt buildup, no matter what type of container the plants are in. Salt buildup should be a concern, but it should not prevent the proper feeding of plants. An early symptom of high salts would be a plant that appears wilted due to water stress yet has adequate water in the soil. If this is observed, skip the fertilizer, add some clear water and adjust your fertilizer schedule or Nitrogen rate. If you want to take a more scientific approach, buy an EC meter and test the soluble salts on a periodic basis. The 2:1 extraction method is the best approach and can be done on a subsample of the plants being maintained. The method is easy to perform, but takes some time. First a sample of soil is removed from the pot being tested and placed in a container. Then an amount of distilled water equal to 2 times the volume of soil is added to the container and the mixture stirred. The mixture should be tested with a calibrated EC meter from 20 minutes to 1 hour after adding the water. If you have a pH meter you can test the pH at the same time. For example, if you collect 1 cup of soil you would mix it with 2 cups of distilled water. Distilled water is used because it has a soluble salt content of zero therefore the water does not contribute to the EC reading. It is possible to use tap water, just measure the EC of the water first and subtract this from the final reading. Remember with this fertilization method if the plants look healthy and the EC reading is very low you are doing well. You only want to apply exactly what the plants need between fertilization and no more. As a guideline, an EC value of 1.0 or more would be approaching the high side, unless the plant looked perfect with no signs of water stress or salt stress.

As an example of the thought processes involved in designing a fertilizer program, consider the label of Scott's Champion brand water soluble fertilizer 13-2-13:

N 13%	P 2%	K 13%					
Ca 6%	Mg 3%	B .0068%	Cu .0036%	Fe .05%	Mn .025%	Mo.0009%	Zn .0025%

This label can be found at the Scotts Champion brand fertilizer webpage. This fertilizer has 12.1% of its 13% nitrogen as nitrate nitrogen, plus small amounts of all minor nutrients, plus larger amounts of additional calcium and magnesium. All by itself it satisfies the nitrate nitrogen requirement, the NPK ratio requirement and the additional Calcium and Magnesium requirement. However, this particular fertilizer lacks sulfur. Sulfur is necessary, and a deficiency shows up as yellowing of newer growth with dark green veins. This condition can be corrected in a short time with the addition of a sulfur source. Therefore, one solution would be to not add additional sulfur and watch for a sulfur deficiency symptom and correct it with one or a few applications of ammonium sulfate, calcium sulfate(gypsum) or elemental sulfur. Another solution would be to add some small amount of gypsum to plants as they go out on the job. Both calcium and sulfur are beneficial and the gypsum can supply the sulfur.

The only thing to add now is additional Iron. The iron in the 13-2-13 is only .05%. As a starting point, add additional iron to bring the final concentration of iron up to .5% then watch plants for iron deficiency symptoms. The additional iron can be increased or decreased from this starting point depending on results.

With this program, all nutrients are supplied or there is a plan for addressing deficiencies if they occur. There are myriad choices of water soluble fertilizers to use as a base and many products that will supply anything missing. Another idea could be to use a water soluble 2-1-2 fertilizer, without the extra calcium and magnesium, in conjunction with a liquid minor nutrient formulation that emphasizes iron and magnesium and enhances the minors package supplied by the base fertilizer. A top dress of dolomite, as the plants go onto the job, would supply additional calcium and magnesium for 6 months to a year depending on the plant's environment. The main idea is to design a program that supplies all of the nutrients plants need in the right forms(Nitrate nitrogen) and the desired concentrations(additional calcium, iron, magnesium, potassium) at the right frequency so as not to cause problems.

Some important concepts to keep in mind.

- Remember 13-2-13 means 13% Nitrogen, 2% Phosphorous and 13% Potassium
- Using the value 75 in example 1 - section 1 below means you are working with a dry fertilizer and the oz are a weight measurement (16 oz = 1 pound). Use the value 78 in place of the 75 if your starting fertilizer is a liquid. Then the oz are fluid oz and they are a volume measurement(128 fl oz = 1 gallon)

- Parts Per Million or ppm can be stated as:

$$\frac{mg}{L} \quad \text{or} \quad \frac{\mu l}{L}$$

These are units for expressing a rate. This fact is hidden by the values 75 and 78 used in the calculations below. The value 75 is **1oz/100 gal** expressed as **mg/L**, as shown below. For any dry material X, 1oz of X mixed in 100 gallons of water results in a solution containing 75 ppm X. Similarly, 78 is **1 fl oz/100 gal** expressed as **1 microliter/L**. Again, for any liquid material Y, 1 fl oz of Y mixed in 100 gallons of water results in a solution containing 78 ppm Y.

$$\frac{1\,oz}{100\,Gal} = \frac{28349\,mg}{378\,L} = 75\ ppm$$

$$\frac{1\ fl\,oz}{100\,Gal} = \frac{29573\,\mu l}{378\,L} = 78\ ppm$$

Example 1. Mixing fertilizers for a desired concentration

Lets make the desired concentration **200 ppm N** using Scott's Champion 13-2-13

1. **Use this formula to determine the ppm N achieved with 1oz of this fertilizer in 100 gal. Water**

$$ppm\ N\ \left(\frac{1\,oz\ fert.}{100\,gal}\right) = \%\,N\ in\ fertilizer \ * \ 75$$

$$ppm\ N\ \left(\frac{1\,oz\ fert.}{100\,gal}\right) = .13 \ * \ 75 = 9.75\ ppm\,N$$

9.75 ppm N when 1oz of 13-2-13 is dissolved in 100 gallons of water. You know that 75 is 75 **ppm 13-2-13** when 1 oz is mixed in 100 gallons of water. Multiplying 75 by the percentage Nitrogen in the 13-2-13 converts it to **ppm Nitrogen** when 1 oz is mixed in 100 gallons of water.

Check your understanding of this step by finding the ppm N of 1 oz of the following fertilizers in 100 gallons water:

Fertilizer	/	Answer
20 – 10 – 20	/	15 ppm N when 1 oz is dissolved in 100 gallons
15 – 5 - 15	/	11.25 ppm N when 1 oz is dissolved in 100 gallons
24 – 8 – 14	/	18 ppm N when 1 oz is dissolved in 100 gallons

2. **Find the number of oz to dissolve in 100 gals of water to achieve 200 ppm N**

   Desired ppm N / ppm N from 1 oz in 100 gals = multiplier to get desired ppm N in 100 gallons

$$\frac{Desired\ ppm\, N}{ppm\, N\ \ (\frac{1\, oz\ fert.}{100\, gal})} = \boldsymbol{X}$$

   Where $\boldsymbol{X}$ is the factor by which to increase the 1 oz / 100 gal rate to achieve 200 ppm N in 100 gallons of water

   In this case:

$$\frac{200\ \ ppm\, N}{9.75\ \ ppm\, N} = 20.5$$

   The result tells us to multiply the 1 oz / 100 gal rate by 20.5 to achieve 200 ppm N in the 100 gallon solution.

$$20.5\ * \ \frac{1\ \ \ oz}{100\ \ gal} = \frac{20.5\ \ oz}{100\ \ gals}$$

   Therefore, 20.5 oz of 13-2-13 dissolved in 100 gallons water will give you 100 gallons of a 200 ppm N mixture.

3. **Find the number of oz per gallon to make the 200 ppm solution so that any quantity of fertilizer solution can be made**

   Just do the division:

$$\frac{20.5\ \ oz}{100\ \ gal} = \frac{.205\ \ oz}{1\ \ \ gal}$$

   Therefore to make a 200 ppm N solution in 1 gallon of water mix .205 oz of 13-2-13 in 1 gallon.

   If you need 30 gallons of fertilizer multiply the rate by 30 gallons:

$$30\, gal\ water\ * \ \frac{.205\ \ oz\ fert.}{1\ \ \ gal\ water} = 6.15\ \ oz$$

   So the result is mix 6.15 oz of 13-2-13 in 30 gallons of water to make a 200 ppm N solution.

Here are all three steps again for this scenario using different values:

> Using a water soluble fertilizer with the label 12-4-12 make a 350 ppm N solution in 45 gallons of water.

1. ppm N of 1 oz in 100 gallons

$.12 * 75 = 9 \quad ppm\,N$ when 1 oz is disolved in 100 gallons water

2. Find # of oz to dissolve in 100 gallon for a 350 ppm N solution

$$\frac{350 \quad ppm\,N}{9 \quad ppm\,N} = 38.9$$

$$38.9 * \frac{1 \; oz}{100 \; gals} = \frac{38.9\,oz}{100\;gals}$$

3. Find # of oz to dissolve in 45 gallons of water for a 350 ppm N solution

$$\frac{38.9 \quad oz}{100 \quad gals} = \frac{.389 \; oz}{1 \quad gal}$$

$$45\,gallons * \frac{.389 \; oz}{1 \quad gal} = 17.5 \quad oz$$

So, 17.5 oz 12-4-12 in 45 gallons of water will give you 350 ppm N solution.

For clarity this can be stated another way:

The number of oz of your desired fertilizer to mix into the quantity of water you will use to achieve the desired ppm is:

$A * 75 = X$ (for dry fertilizers) OR $A * 78 = X$ (for liquid fertilizers)

$$\frac{B}{X} = Y$$

$C * \frac{Y}{100} =$ oz of fertilizer to use in desired quantity of water

Where:

A is percent N in the fertilizer
B is Desired ppm N
C is quantity of water you want to make.
And

X is ppm N when 1 oz of fertilizer is mixed in 100 gallons water

Y is the factor by which to increase the 1 oz / 100 gal rate to achieve B ppm N

Example 2. Adding additional nutrients

1. From the discussion above, it was decided to add an additional source of iron to boost the .05% iron delivered by the fertilizer. You can figure out the ppm Iron using the same technique that we used for Nitrogen, then increase the Iron, or any other element, with an additional fertilizer product. Lets assume that the chelated iron product you will use is a dry product that contains 7% iron, as specified on the label. Here are the steps to figure out how much of this product to add to the fertilizer mixture to achieve the desired amount of Iron.

1. Find the ppm of Fe you are delivering with the base fertilizer(.05%). Use the same method used above to find the ppm Nitrogen

$$.0005 \; * \; 75 \; = \; .0375 \, ppm \, Fe \quad \frac{1 \, oz \; 13-2-13}{100 \, gal}$$

Mixing 1oz of 13-2-13 in 100 gallons the concentration of Fe is .0375 ppm. The rate you are going to apply this fertilizer at is 20.5 times this rate (See #2 in each of the scenarios above). So after mixing you will have a concentration of iron that is:

$$.0375 \, ppm \, Fe \; * \; 20.5 \; = \; .768 \, ppm \, Fe \quad \left(\frac{20.5 \, oz \; 13-2-13}{100 \, gal}\right)$$

2. Using the same technique, find the ppm of the Fe you would be delivering <u>if the base fertilizer contained your desired percentage of Fe (.5%)</u>

$$.005 \; * \; 75 \; = \; .375 \, ppm \, Fe \quad \frac{1 \, oz \; 13-2-13}{100 \, gal}$$

$$.375 \, ppm \, Fe \; * \; 20.5 \; = \; 7.68 \, ppm \, Fe \left(\frac{20.5 \, oz \; 13-2-13 \quad (.5 \, Fe)}{100 \, gal}\right)$$

3. Figure out the number of oz/100 gallons needed to make up the difference between 1 and 2

From the results of 1 and 2 the difference in the rates is

$$7.68 \, ppm \, Fe \; - \; .768 \, ppm \, Fe \; = \; 6.912 \, ppm \, Fe$$

We need to add the right amount of additional iron to increase the concentration of iron, in the final fertilizer mix, by 6.912 ppm.

4. **Find the number of oz of the 7% iron product to add to the fertilizer mix to get a 7.86 ppm Fe rate. This is the same problem as finding how much 13-2-13 to mix to achieve 200 ppm N**

Find the ppm of Fe delivered in 1oz/100gal water by the chelated Fe product.

$$.07 \; * \; 75 \; = \; 5.25 \; ppm \; Fe \quad \frac{1 \; oz \; Chelated \; Iron \; Product}{100 \; gal}$$

Find the number of oz/100 gallons needed for the desired ppm Fe

$$\frac{6.912 \; ppm \; Fe}{5.25 \; ppm \; Fe} \; = \; 1.32$$

So, 1.32 oz of the 7% iron product in 100 gallons will give you a rate of 6.912 ppm Fe. This, plus the iron delivered by the base fertilizer, will make the rate of iron 7.68 ppm, which is what we desired. Since the 1.32 oz is for making 100 gallons of mix we need to adjust this rate for the 30 gallons actually being made.

$$\frac{1.32 \; oz \; 7 \; Fe \; product}{100 \; gal} \; = \; \frac{.0132 \; oz}{1 \; gal}$$

$$\frac{.0132 \; oz}{1 \; gal} \; * \; 30 \; gallons \; = \; .396 \; oz \text{ of 7\% Fe product}$$

Finally, all quantities are known. To make 30 gallons of a 200 ppm N fertilizer solution with .5% Iron using 13-2-13 and a 7% chelated iron product you must mix 6.15 oz 13-2-13 and about .4 oz of 7% iron in 30 gallons of water.

This may look complex because it is spelled out in great detail, hopefully for clarity, but the reality is that the math is not very involved. If you spend some time becoming familiar with ppm and these calculations you will discover the simplicity.

