Fertilization with Open Hydroponics Systems

Nutrient Solution Management

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A. What's the difference between fertilization with regular hydroponics or Open Field Hydroponics?

True hydroponics is growing plants without soil in a nutrient solution, usually in a greenhouse. In true hydroponics, the chemistry of the nutrient solution must be maintained within a narrow range of salts (from the fertilizer materials) and pH concentrations, so controllers that manage the water and fertilizer are set up to monitor EC (Electrical Conductivity – a way of measuring the amount of salinity), pH, and then create a solution within the desired ranges.

Open Field Hydroponics uses hydroponic techniques for plants growing in the field. The roots are in the soil, so the system is affected and buffered by the soil chemistry. Since the soil is involved, it's not as necessary to maintain the chemistry of the solution in such tight tolerances.

However, the goal is still to grow the trees with the nutrient solutions rather than relying on soil storage of water and nutrients. The drip system allows the roots to form dense clusters under the emitters, and the applied water bathes the roots in the nutrient solution throughout the daylight hours when the trees are transpiring water so the roots can take up the solution directly with minimal interaction with the soil.

Microsprinklers apply water over a larger area than drip emitters, so the root clustering does not occur to the same extent. Trees can be grown with fertigation with microsprinklers, but the water and nutrients must be stored in the soil rather than applied directly to the root clusters.

Since the drip emitters feed the roots directly with the nutrient solution, it's similar to a hydroponic approach. Also, the mental image of hydroponics helps people understand the effect they're trying to achieve – achieving direct uptake by the roots rather than storing water and nutrients in the soil to supply tree demands.

B. How do you decide how much fertilizer the tree needs?

With normal fertilization in Florida, growers apply fertilizer as dry granular, or liquid solution through the irrigation system. The program is based on the total annual needs of the tree, and the annual ratio of nutrients. The timing of applications is adjusted only to reflect periods of peak demand.

With OHS, the program is built around supplying the needs of the tree each day in the balance of nutrients the trees need that day. The program is broken down into monthly increments. The goal each month is to apply all of the necessary nutrients in the solution, including microelements such as molybdenum, boron, and iron. Since the trees take up the solution directly, these can be simple and inexpensive compounds.

The amount of each nutrient required each month is based on studies that determine the nutrient levels in the tissue of fruit and trees during that month. It is a demand-based system, unlike the system we use in Florida which is based on studies that relate the total amount of each nutrient applied to fruit production.

Since research in Florida has not determined the monthly demand of each nutrient by trees of different size, variety, and rootstock, we contract with South African and Australian consultants to provide this information for us. The programs are updated once per year using a form called the "Orchard Information Master".

C. What are the components of the fertilizer program?

Two factors must be calculated for fertilizer each month – the balance of nutrients, and the volume of solution required.

Balance -- The balance of nutrients required is different each month based on the growth events of the trees. For example, nitrogen levels are higher relative to the other nutrients in the spring, while potassium is higher in the summer. Unlike Florida fertilizer programs, calcium, magnesium, and sulfur are also calculated and adjusted based on tree demand.

The nutrient balance is adjusted in the fertilizer mixture in the tanks. Each month's mixture is different. Since every nutrient is supplied, there can be interaction if they are all dissolved together in the same tank, so two tanks are used – the "A" and "B" tank. Since Calcium is a key ingredient, but interacts with other nutrient compounds, it is usually isolated in the B tank, often with one or more other nutrients that would be stable with calcium.

Simple A and B tank configuration. Fertilizer materials must be separated to avoid chemical interactions in the tanks.

The OHS fertilizer program is created by calculating the demand of each nutrient necessary for tree growth and fruit production. Then, a fertilizer blend is created that contains all the nutrients in the proper balance for that month.

To maintain stability, we limit the total concentration of all nutrients in each tank to a 10% maximum. Maintaining a diluted mix reduces the interactions of the various nutrient compounds in the tanks, and allows for cold mixing the solutions on site to save money if so desired.

Volume -- The volume of fertilizer required is based on the tree size. Research in South Africa has shown how much fertilizer that trees need each month after it has reached maturity and grown to fill the space allotted. The demand is differs for each variety and rootstock combination.

If trees are smaller, the volume required is less. The factor used to adjust the volume is called the **"percent canopy cover". T**he volume calculation starts with the amount needed for a full sized tree, and is then adjusted by a factor based on tree size to provide the amount of the mixture that will be necessary for the month. The volume of fertilizer necessary for that month determines the finished gallons in each tank at the beginning of the month. The fertilizer is then injected on a daily basis to drain the tanks in preparation for the following month's blend.

D. How is volume actually calculated, and what is "% Canopy Coverage"?

Trees that have grown to fill the space allotted to them have "100% Canopy Coverage". This is not the same as ground coverage – the drive middles between the tree rows are not included. It's only the space that can be occupied by the trees themselves. The canopy coverage variable is used to determine the schedule for both water and fertilizer each month.

The % canopy coverage is the width of the trees in relation to the tree row spacing. The drive middle is not included.

When a new grove is first planted, we use an arbitrary value of 10% canopy coverage, meaning they will receive only 10% of the fertilizer and water calculated for a full size tree. As the trees grow, the % canopy coverage is adjusted at the beginning of each program year by estimating the size of the trees. Full sized trees that are being hedged and topped always have 100% canopy coverage. For smaller trees, the % canopy coverage must be estimated at the beginning of each program year.

The % canopy coverage determination is made from the area under the canopy on the ground – not on the height of the trees. So, it's necessary to visualize the ground footprint of the tree. An easy way to do that is to take the tree row width and subtract the desired drive middle. For example:

Tree row width = ***25 feet***
Drive middle hedged = ***8 feet***
Allowed tree canopy width = ***17 feet***

Then, measure the actual width of the trees if they are not full sized. For example:

Width of a 3 year-old tree = ***10 feet***

The % canopy coverage for that grove would be the ratio of the actual tree width to the allowable width. For example:

Actual tree width = 10 feet, divided by Allowed tree width = 17 feet, results in 59% canopy coverage.

E. Can you buy OHS fertilizer blends from suppliers?

Since each month's blend is different, and the blend for each grove, and sometimes each block, vary depending on the tree characteristics, the blend of fertilizer in the A and B tanks are always customized. Also, the total amount of fertilizer in the tanks is limited to no more than 10% to avoid chemical interactions, so the finished blend is 90% water.

The low concentration allows cold-mixing. Higher analysis blends, such as a 10-0-10, which is 20% fertilizer, must be hot-mixed to make the fertilizer dissolve in the water. A 10-0-10 only has two nutrients in it, whereas the OHS blends have many, so hot-mixing is not normally an advantage due to the likelihood of chemical interaction.

Sophisticated facility for mixing fertilizer materials on the farm. This grower makes up stock tanks and injects each nutrient separately.

There are a number of ways to obtain the blends. For smaller groves, it's generally easier to must mix the solutions on site. The programs will provide every material needed in the form it is purchased – for example the number of pounds of calcium nitrate to mix rather than just the calcium or nitrogen requirements themselves.

For larger groves, the blends can be ordered from a fertilizer company to make and deliver. The delivery cost creates a break point in feasibility – if there isn't much material required, the delivery cost can be higher than the value of the source materials. Or, fertilizer mixing facilities can be designed according to the needs of the grower.

Large, sophisticated OHS systems allow the grower to mix multiple stock tanks of nutrients and then blend the fertilizer on the fly by injecting the material in each tank simultaneously, or by creating an injectable blend in a dedicated tank using materials stored in stock tanks. Stock tanks allow mixing to a higher percentage since there's only one or just a couple of fertilizer materials in the tank, so there's less chance of salting out. This approach requires control systems that are capable of injecting multiple sources of fertilizer, and an appropriate facility for handling the source materials and stock tanks.

Simple A and B tank configuration using totes.

For smaller growers, mixing their own fertilizer is easy and much less expensive than buying the finished product from a fertilizer company due to the savings in delivery costs.

Arapaho programs provide an easy-to-follow recipe for mixing the A and B tanks each month.

F. Is agitation of the materials in the tanks required?

Agitation is highly recommended. Since there are many materials in the same tanks, periodic agitation (mixing) is helpful to avoid salting out of the fertilizer. If the materials in the tank are not agitated periodically, the fertilizer will settle in the solution, resulting in increased concentrations at the bottom that can reach sufficient strength to cause precipitation of the materials. Since the total concentration is 10% or less, agitation avoids this situation. Agitation is also required if the fertilizer solutions are mixed on-site.

There are numerous options for agitation. Electric motors with mixers can be mounted directly on larger tanks, but the cost is high for smaller tanks. Pumps that circulate the materials in the tank by pulling from the bottom and pumping back into the top or a spurge system (pvc pipe with holes drilled in it work great). These can be permanently mounted or portable. For small systems with smaller tanks, a paddle would do the job. The actual method isn't important as long as the material can be agitated in the tank.

G. Summary:

The nutrient requirements of the tree each month determine the balance of nutrients in the monthly mix. This is used to formulate the blend of nutrients in the A and B tanks. The volume of this mixture required is based on the % canopy coverage of the tree.

The programs provided will include the blend of fertilizer materials in each tank, the number of gallons to mix in each tank, and the amount to apply per day from each tank to supply the needs of the trees without stress or deficiency.