Soil Fertility Management

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Introduction

Fertilization is one of several cultural practices that is needed for rapid development and maintenance of a healthy and productive orchard. Young trees usually grow more rapidly following fertilization and more quickly attain optimum size. However, mature trees require a program that encourages fruiting with less emphasis on tree vigor. Too much vigor in the mature tree leads to unnecessary canopy growth which causes interior shading, loss of fruiting area, and more pruning work in the late spring.

Nitrogen and to a lesser extent potassium and iron are the only common nutrient deficiencies in California cherimoyas. Most plants respond to the addition of nitrogen which is available in various organic and inorganic forms. Iron is usually present in soils in adequate amounts; however, plants cannot absorb iron if soils are either alkaline or poorly drained.

Fertilization with other nutrients is not needed unless a specific deficiency exists. This deficiency can be identified by tissue analysis or plant symptoms. Improper or excessive fertilization damages plants, can cause pest problems, lead to more pruning, induce other nutrient deficiencies, and may pollute water. Fertilization does not replace improper irrigation or other cultural practices.

Soil-Nutrient-Plant Relationships

Physical Properties of Soil

Physical as well as chemical properties of soil influence the amount of nutrients held by a soil and, to a certain extent, the availability of the nutrients to plants.

Soil texture, the size distribution of soil particles, directly influences the amount of nutrients adsorbed or held by the soil. The finer the soil texture, the more nutrients (and water) will be held. For example, to apply the same yearly amount of nitrogen and have it stay in the root zone, a sandy soil would require more frequent applications at smaller rates than would a clay soil.

Soil depth can determine the total nutrient and water-holding reservoir available to the plant. The deeper and wider a plant is able to root in a soil, the more water and nutrients will be available.

Soil structure, the arrangement of soil particles, influences root exploration and the plant's nutrient and water absorption ability. A compacted soil, or one lacking an open, granular structure, may restrict root growth and activity by limiting water and air movement, and by physically impeding growth. A compacted soil layer several inches below the surface may improve moisture conditions above the layer for certain shallow rooted plants like weeds, but such a layer would be detrimental for the cherimoya tree.

Chemical Properties of Soil

Sixteen elements have been found essential for plant growth (Table 1). A seventeenth one, nickel, was identified in 1987, but is required in such small amounts that dust probably supplies that total requirement. These elements are essential because:

- In the absence of any one of the elements the plant fails to complete its life cycle;
- Each element is specific, it cannot be replaced or substituted for by another element;
- Each element has a direct effect on the plant (not an indirect effect, such as repelling insects, which might prevent completion of the plant's life cycle).

Table 1. Elements Essential for Plants

Source		
Air and water	Soil	
	macronutrients	micronutrients
carbon	nitrogen	manganese
hydrogen	phosphorus	iron
oxygen	potassium	zinc
	sulfur	copper
	calcium	boron
	magnesium	molybdenum
		chlorine

Carbon, oxygen and hydrogen are supplied from air and water while the other thirteen plant nutrients come from the soil. The micronutrients, although required in much smaller amounts than the macronutrients, are equally essential for plant production.

Soils are rarely fertile enough to supply all the nutrients needed for optimum growth and production. However, it is equally rare for a soil to be deficient in several of the mineral nutrients that plants need. In California, soils contain most of the elements known to be essential to plants, so it is only necessary to add the ones deficient in the area of concern (Table 2).

These same nutrients in excess can become toxic. Many growers are aware of the leaf burn associated with chlorides. Boron in some areas can also be at toxic levels that cause defoliation. In many coastal areas reliant on well water for irrigation, general water salinity can be at high enough levels to cause salt burn. Any overapplication of highly soluble fertilizer, such as calcium nitrate, can give salt burn effects as well.

Table 2. Possible Areas of Nutrient Deficiency or Toxicity for Cherimoya in California.

Element	Where Deficient	Where Toxic
Nitrogen	Almost all soils.	
Potassium	Some fine-textured soils of coastal valleys.	
Boron		Coastal Calif. from Santa Clara to Los Angeles.
Iron & Manganese	Alkaline soils. Increasingly deficient above pH 7. Wet & cold soils in winter & spring.	
Zinc	Santa Barbara south along coast.	
Copper	Corral & Indian mound areas. Central Coast to Orange Co.	
Sodium & Chloride		These are not initially associated with soil in cherimoya growing areas, but stem from irrigation practices.

A chemical property of soil that can have tremendous effects on plant nutrients is soil pH. The soil's acidity or alkalinity influences the availability of many nutrients to plants. Most nutrients are most available at a soil pH of 7 which is neutral. A pH smaller than 7 is termed acid, and greater than 7 is alkaline. Many nutrients becoming less available at pH's less then 6 and greater than 8.

Micronutrient availability, especially that for iron, zinc, and manganese, is adversely affected by high pH soils. In the soils where many cherimoyas are grown, the high pH soils are more common. While iron and manganese deficiencies can be corrected by fertilizers, the best long term solution is to correct the soil pH. Iron is one of the major constituents of most soils and merely needs to be made available for plant use.

In areas of alkaline soils, acidification (reducing soil pH) can be accomplished with sulfur, acidifying fertilizers, or through a routine program of mulch additions. The equivalent acidity of various materials is given in Table 3. These are relative numbers that show how acidifying the materials are relative to potassium sulfate which is neutral, having no effect on soil pH. For example, while urea is 71 times more acidifying than potassium sulfate, calcium nitrate actually causes an increase in pH.

Table 3. The Relative Acidity-Alkalinity Rating of Certain Fertilizer Materials. Values are Given in Equivalent Acidity (Alkaline).

Material	Equivalent Acidity relative to potassium sulfate	Equivalent Acidity per lb. nitrogen
Sulfur	312	
Sulfuric acid	104	
Ammonium sulfate	110	5.3
Urea	71	1.6
Ammonium nitrate	62	1.8
Most potassium salts	0	
Calcium nitrate	(20)*	(1.3)
Potassium nitrate	(23)	(1.8)

*Alkaline reaction. Data adapted from Western Fertilizer Handbook.

Soil salinity is a common problem in western soils where annual rainfall is less than 20 in. and irrigation waters contain moderate to high amounts of salts. Minimizing salinity is primarily a matter of irrigation and drainage practices. In fertilizing, high analysis fertilizers cause the least increase in soil salinity, because less fertilizer is required. Being more concentrated, high analysis fertilizers require more careful application to avoid "fertilizer burn," which is actually a salt burn.

Determining Nutrient Deficiencies and Toxicities

Nutrient deficiencies and toxic conditions can be diagnosed by soil analysis, plant analysis and nutritional trials. Of the three methods, plant analysis is the quickest and surest way of identifying nutritional needs of the tree (Chapman, 1966).

Generally soil analysis for trees, such as cherimoya, is best used for determining toxic levels of substances, such as boron, chloride, sodium and total salt. Minerals in water can contribute toxic levels of these elements and should be tested, as well. There is no published experimental evidence showing a good relation between phosphorus and potassium soil levels to tree growth. The amounts of other nutrients present in the soil can also be determined, but these values are also of limited value for determining fertilizer needs of tree species.

Plant analysis, either by visual symptoms or tissue analysis, can be extremely helpful in assessing fertilizer requirements. Visual symptoms can be extremely helpful in guiding a nutritional program. The more typical symptoms for deficiencies and toxicities are given in Table 4. Age of leaves affected and their position in the plant provide additional clues. Since there may be multiple symptoms and symptoms reflecting disease or irrigation practices, the tree needs to be evaluated in the context of the whole farming practice.

Table 4. Visual symptoms associated with most common deficiencies and toxicities in California cherimoya areas.

NUTRIENT	DEFICIENCY SYMPTOMS
Nitrogen N	Leaf: General yellowing of older leaves; small leaves. Shoot: Short, small diameter. Flower & Fruit: heavy bloom.
Potassium K	Leaf: crinkling and upward roll of older leaves; chlorosis followed marginal burn.
Iron Fe	Leaf: yellow with narrow green veins on young leaves first; most severe in cold, wet years.
Zinc Zn	Leaf: yellow, small young leaves. Shoot: short internodes between leaves causing a rosette. Fruit: light fruit set.
Manganese Mn	Leaf: young leaves yellow with wide green bands along veins followed by necrotic spots.
ELEMENT	**TOXICITY SYMPTOMS**
Boron B	Leaf: marginal & tip burn; interveinal chlorosis and dead spots.
Sodium, Chloride Na Cl	Leaf: marginal and tip burn.

Tissue analysis can be extremely helpful in confirming a visual diagnosis and anticipating fertilizer needs. The best method is to do yearly leaf analysis to adjust the fertilizer program as the tree's needs vary with weather and fruit load. In the case of major crops, good standards have been developed that relate tissue analysis to plant performance.

This is not the case with cherimoya. We do have general guidelines from citrus and avocado, but there may be nutritional requirements that are different for each cherimoya cultivar. With time, more precise values will be developed. A recent survey of 30 grower samples gives an idea of the average leaf tissue values for six different varieties of cherimoya. These values generally fall within the range tentatively recommended for atemoya in Australia (Table 5; Sanewski, 1991) and for the ‘Bronceada’ and ‘Concha Lisa’ varieties in Chile (Gardiazabali, 1991). Until more detailed values are developed, the Chilean cherimoya and Australian atemoya ranges seem appropriate in light of their similarity to avocado and citrus values.

Table 5. Leaf tissue values for California cherimoya

NUTRIENT	CALIFORNIA AVERAGE	CHILEAN RANGE	AUSTRALIAN RANGE
Nitrogen	3.07	2.4 - 2.8	2.5 - 3.0 %
Phosphorus	0.18	0.15 - 0.18	0.16 - 0.2 %
Potassium	1.14	1.2 - 1.9	1.0 - 1.5 %
Calcium	1.93	>1.2	0.6 - 1.0 %
Magnesium	0.50	>0.3	0.35 - 0.5 %
Zinc	24.9	>25	15 - 30 ppm
Manganese	71.5	>32	30 - 90 ppm
Iron	77.7	NA	50 - 70 ppm
Copper	10.5	>12	10 - 20 ppm
Boron	129.4	NA	15 - 40 ppm
Sodium	0.02	NA	<0.02 %
Chloride	NA	NA	<0.3 %

Sampling leaves for analysis should occur in November or December. To be as uniform as possible, choose the tenth leaf from the base (not the tip) of this season's growth; avoid fruiting branches. The leaves chosen should be well dispersed over the block and from all sides of the trees. Twenty leaves of each variety should be collected. Keep different varieties separate to avoid the possibility misrepresenting the individual varieties nutritional requirements.

Nutritional experiments can provide valuable guidelines for fertilizing. However, few careful field experiments have been conducted on the nutrition of cherimoya. Nutritional studies on tree crops are long term and need to consider numerous effects, such as fruit yield and quality, tree growth, and nutrient interactions.

A rule to keep in mind when planning a fertility program is that it is important to know why a given fertilizer is being used. It is true that the plant needs 17 essential elements, but the bulk of these are present in most soils. Some of these may be at a marginal level and by adding some other nutrient, it might be possible to induce a deficiency of the marginal nutrient that would not otherwise be present. This is called a nutrient interaction.

Common nutrient interactions are zinc and copper deficiency induced by high rates of phosphorus fertilization, reduced magnesium with high applications of potassium, and lower boron tissue levels with high nitrogen application rates. In changing from one form of fertilizer to another or switching from broadcasting to injection through the irrigation system, it may be necessary to alter other fertilizer practices because of changes in plant uptake efficiencies.

Correcting Deficiencies of Specific Nutrients

Nitrogen

Nitrogen is the most commonly deficient element. Plant response to nitrogen fertilizer is almost universal. Uniform yellowing of entire, older leaves is usually the first symptom of nitrogen deficiency.
The decay of soil organic matter is the major source of plant nitrogen in nature. This matter can be a major source if mulches, manures or leguminous cover crops are used in a commercial orchard.

Another major source of nitrogen can be nitrate contamination in irrigation water. Some coastal areas have groundwaters which exceed 10 parts per million (ppm) nitrate-N, and irrigating trees with two feet of this water would contribute 55 pounds of nitrogen per acre. The legal limit for municipal water systems is 10 ppm. Soil bacteria and algae that naturally fix nitrogen from the air can contribute 10 - 20 pounds of nitrogen per acre. Plant available nitrogen, in turn, can be lost to competition with weeds, leaching loss from the root zone, denitrification by soil organisms, and erosion. Nitrogen fertilizers come in different chemical forms. Nitrate and ammonium ions are the most common inorganic forms. Nitrate ions are attracted by soil colloids and move with soil water. This nitrogen form can cause a rapid growth response in the tree, but it is extremely subject to leaching with excess water from irrigation and rainfall. Ammonium ions are attracted to soil colloids and do not readily move with soil water. Although ammonium can be absorbed by plant roots, it is often converted to the nitrate form by soil microorganisms before tree uptake. Depending on soil temperature and moisture, the conversion can take several weeks or months. Soil retention of ammonium results in a slower plant response than with nitrate, but this ion is also less subject to leaching loss.

Urea, an organic form of nitrogen that moves with soil moisture, can be taken up by the plant as urea or after it is converted to ammonium or nitrate. Virtually all other organic forms of nitrogen need to be converted to less complex forms by microorganisms before plant uptake. The rate of decomposition or transformation is controlled by environmental factors, such as soil temperature and moisture, degree of soil aeration, and type of material. In many climates, organics are considered to be slow release nitrogen forms (Chaney, 1992).

However, because of the favorable weather in cherimoya growing areas, the residual value of many organics may be good for as little as a few weeks to a few months, depending on the material.
Materials, such as blood, fish meal, and cottonseed will decompose fairly rapidly, while some composts and manures will have a longer residual. The longer residual is because they often contain a larger fraction of materials, such as lignin or cellusose, which are more resistant to decay.

Manures can be a good source of fertilizer, although they are typically low in nitrogen. Manures help improve soil structure and supply trees with many other nutrients beside nitrogen. However, they may also contain undesirable weed seeds and relatively high amounts of salts. They, along with composts and mulches, also require considerable amounts of energy to apply the materials because of their bulk. Often their application can be contracted.

Manures also vary greatly in their nutrient content, depending on the type of manure and how it has been handled (Table 6). Chicken manure is by far the most concentrate and can serve as the sole source of nitrogen. Dairy manure is much less concentrated. Steer manure from animals fattened on concentrated feeds is richer in nutrients than dairy manure.

Table 6. Nutrient contents of various manures versus urea.

Type of manure or fertilizer	Percentage			Suggested amount of material per acre
	Nitrogen (N)	Phosphorus[1] (P_2O_5)	Potassium[1] (K_2O)	
chicken manure, dry	2 - 4.5	4.6 - 6	1.2 - 2.4	3 - 5 tons
steer manure, dry	1 - 2.5	0.9 - 1.6	2.4 - 3.6	10 - 15 tons
dairy manure, dry	0.6 - 2.1	0.7 - 1.1	2.4 - 3.6	15 - 30 tons
urea, dry	46	0	0	100 - 400 pounds

[1] P_2O_5 actually contains 44 percent phosphorus and K_2O contains only 83 percent potassium. The percentages given for the oxide may be converted to percentages of the element by multiplication: P_2O_5 X 0.44= P; K_2O X 0.83 = K. The conversion is important because soil and tissue analyses are given in the elemental form and fertilizer labels give the oxide form.

Commercially formulated slow-release fertilizers are also available. They provide the ease of handling of synthetic fertilizers and the slow release characteristics of organics. However, these materials tend to be relatively expensive as compared to fast-release forms of synthetic fertilizers, such as urea and ammonium nitrate.

In light of the fact that most of the synthetics can be injected through the irrigation system and with frequent, small applications, slow-release can be imitated. Irrigation injection also saves labor and material, because it placed right where the roots are growing Price is an issue with most of the organic forms of fertilizer.

Selection of nitrogen source is often guided by price, but application technique, leachability, acidifying effect, and soil physical effects should also be considered. Soil organic matter can be a limiting factor in crop production. Organic matter can improve the chemical and physical properties of a soil and thereby improve crop production and tree health. Besides adding various sources of organic nutrients, a cover crop or mulches of yardwaste might be considered to improve soil organic matter. These practices are generally more expensive in the short run than using synthetic fertilizers.

Phosphorus

Phosphorus occurs in adequate amounts for cherimoyas in most agricultural soils, even in those where phosphorus fertilization is required for vegetable or flower crops. The best way to assess phosphorus deficiency is by leaf tissue analysis. If the current season's tissue analysis is below 0.15 %, there may be a need for phosphorus.

Potassium

Potassium deficiency causes sparse leaf growth on shoots. Older leaves turn yellow and develop brown tips and margins or spots near the leaf edge. This can be easily confused with salt burn from poor water quality or irrigation practices. Check the water first before jumping into a potassium fertilizer program. A potassium deficiency does occur in some coastal valleys, but generally the deficiency is found on soil texture extremes of very sandy or heavy clay, and not on loams.

Application of potassium to trees must be in rather large amounts and properly applied to be effective if broadcast. Anywhere from 200 to 500 pounds per acre are required depending on the soil type. Plant uptake is improved with banding the material along the tree row or making holes at the compass points of the tree and burying the fertilizer. It has been applied successfully through irrigation systems and foliarly. These application methods do not require as high rates as broadcasting. Foliar potassium as potassium nitrate is effective, but requires yearly applications.

Potassium sulfate is a satisfactory potassium source. Potassium chloride, also called muriate of potash, should not be used in most of our soils because of its chloride content. Potassium nitrate when used on the soil for deficiency correction will often result in an excess of nitrogen. Soil application rates for potassium should be sufficient for five to ten years after application.

Nitrogen, Phosphorus, and Potassium

So-called complete fertilizers contain nitrogen, phosphorus, and potassium, listed by percent in that order. They are not complete in the sense that the formulation supplies all the nutrients a plant requires. Orchard soils are rarely deficient in all three elements, and adding sufficient fertilizer to correct the deficient element can lead to an excess of the other nutrients. This procedure can also lead to salinity problems or even induce other nutritional problems. Plants should be fertilized in response to specific needs and complete fertilizers are generally not recommended for cherimoyas or other orchard crops.

Iron

Iron deficiency symptoms appear first on new leaves. The leaves are undersized with green veins standing out against yellow midveins. This may be a transient condition that appears during cold winters and disappears with the spring. However, in alkaline soils dominated by calcium carbonate, the condition will not go away.

Iron is present in most soils, but in waterlogged conditions or high pH soils it is less available. Before trying to correct the deficiency with iron fertilizers, look at irrigation and drainage practices first. Improved soil aeration can dramatically reduce iron deficiency symptoms.

If pH is the problem, addition of 2 to 4 tons per acre of elemental sulfur along with a regular mulching program can significantly correct the problem. Regularly applying organic matter as a mulch will eventually remedy the problem as soil then becomes more acidic with organic matter decomposition. The mulch will provide many other nutrients.

Applications of iron sulfate to the soil in holes in the compass directions of the tree at the rate of 5 pounds per tree will eventually resolve the problem. A single application may be good for several years. Iron chelate (Sequestrene 138®) applied as a soil drench will also give a good response. Foliar sprays of chelates will often green up the tree within a couple of weeks, but frequent respraying is required in order to treat new leaves.

Before embarking on an iron fertilization program, check to see if iron is the problem. Soil correction is the long term solution, but to determine if iron fertilization is the answer, a quick check can be made by giving a foliar treatment to a few trees. Spray trees with a 1% solution of iron chelate. Greening of the leaves should occur within two weeks.

Zinc

Zinc deficiency, sometimes called little leaf or corral sickness is common in most fruit trees. It is most common on sandy soils and the sites of old barnyards. A mild deficiency resembles iron deficiency, although the veins are more distinctly green with lack of iron. The most common symptom is a flush of small yellow leaves at the end of shoots. These shoot tips often will die back. Often flower and bud break is delayed.

Zinc has been corrected by foliar spray, trunk injection with glazier points or galvanized nails, soil application and irrigation injection. As with iron, when applied to the soil, it should be in a concentrated band or hole around the base of the tree. Soil application at 5 pounds zinc sulfate per tree can often bring correction for several years. Injection through the irrigation system on a quarterly basis at an annual rate of 5 pounds per tree is also effective. Foliar zinc sulfate and chelates are short term corrections of the problem and new applications must be made with each leaf flush. Zinc-coated glazier points or galvanized nails driven into the tree trunk two inches apart in a spiral pattern around the trunk have given long term correction of zinc deficiency in numerous tree species.

Manganes

Manganese deficiency produces pale, yellow leaves similar to iron deficiency. Manganese often has broader bands of green along the veins. It appears primarily on alkaline soils. As with iron, correcting soil pH with sulfur is the best long term cure for the problem. Manganese sulfate (2 - 4 pounds per tree) can be placed in holes at the compass points around the tree or applied as a foliar (3% solution buffered with soda ash). As with other foliar sprays, annual applications are necessary.

Other Deficiencies and Toxicities

Copper deficiency is rare, but it can show up in small areas of a grove where animal corrals or Native American camps have been located. Soils where this deficiency may develop are usually sandy or alkaline. Deficiency symptoms consist of terminal dieback and a brushy appearance as with zinc.

Annual spraying of Bordeaux fungicides, fixed copper fungicides or copper chelates has eliminated symptoms and corrected this deficiency. As a soil application, from 5 to 25 pounds of copper sulfate per acre is sufficient to correct the problem.

The most common nutrient toxicities are boron, sodium, and chloride. They exhibit similar appearances with marginal tip burn to the leaves. Sodium and chloride appear first on older leaves and move progressively to younger ones. Boron can start with both young and older leaves. Boron will often commence as a twig die back. The solution to all three is similar - proper irrigation with good quality water. Insure that adequate leaching is performed to push salts accumulated from irrigation water below the root zone.

Application Methods

Fertilizers can be applied in a variety of ways, including:

- Broadcast to the soil surface,
- Placed in holes in the soil or in a trench around the drip line of the tree, Sprayed on the foliage,
- Injected through the irrigation system.

The particular method selected depends on the nutrient(s) applied, equipment available, and accessibility of the site.

Surface application

This is the old stand-by labor intensive method of fertilizer application. It is relatively inefficient since labor determines the frequency of application. As a consequence, growers will often put a lot on at once. This practice may be fine for something like potassium which is not so prone to losses, but in the case of nitrogen there can be substantial losses. These losses are due to the increased leaching below the root zone and the greater likelihood of volatilization loss due to the conversion of ammonium to ammonia. The cherimoya needs nutrients on a regular basis, and applying materials on a the grower's schedule is not in the best interests of the tree.

Surface applications should be limited to those nutrients which are mobile in the soil, such as nitrogen. As soon as nitrogen is broadcast it should be watered into the soil as soon as possible to
reduce the possibility of its loss as a gas. In sandy soils, potassium can be broadcast; in heavier soils, incorporation as bands or holes is recommended. When broadcasting materials, increased uptake efficiency is obtained by applying within the wetted pattern of the sprinkler.

Soil incorporation

Soil incorporation should be practiced for less mobile nutrients, i.e., those that tend to stay near the point of application and not move with soil water.. These are the zinc and iron fertilizers and potassium. These can be deposited in holes at the compass points of the tree or in a trench around the tree trunk.

Foliar application

Foliar application is effective primarily with micronutrients. Plant requirements for "micros" is small relative to the amount that can be taken up by leaves. Macronutrients like potassium and nitrogen can be taken up by leaves; however, the amount required is high making frequent applications necessary. In the case of lemons, using a combination of four tons of manure and one or two sprays of urea have been successfully employed to supply nitrogen. The urea used should be one with a low content of the contaminant biuret that will burn the leaves. One of the advantages of foliar sprays is that the complicated interactions with soil are avoided, and most of the material goes into the tree.

There are numerous exotic spray materials, but the rule of thumb is "don't spray what you don't need." A regular leaf analysis program will dictate what materials are used.

Irrigation injection

Applying materials through an irrigation system (fertigation) can improve the efficiency of uptake, since the material is put into the wetted root zone. It also saves in energy and labor and provides flexibility of timing, regardless of growth stage or tree or machinery accessibility (Rolston, 1979).

Plant nutrient or chemicals applied through the irrigation system must not clog or corrode the system. It is important that the selected fertilizer or chemical materials selected be entirely soluble in water and do not react with salts or chemicals contained in the irrigation water. Most sources of nitrogen should cause little if any clogging, but that matter should be resolved with the supplier before applying a new product. There are even some forms of organic nitrogen that can be injected, such as fish emulsion and liquid chicken manure (Schwankl, 1992).

Application of phosphorus fertilizers through a system can potentially result in extensive clogging, although phosphoric acid with appropriate precautions can be successfully used. The common potassium fertilizers are readily soluble in water and should cause few clogging problems. Micro- nutrients, especially in their chelated form, can be applied with little threat of clogging.

Precipitation of applied chemicals is a critical problem and must be controlled carefully to prevent complete clogging of the system. If in doubt about the compatibility of chemicals, lines should be flushed completely before applying a different chemical through the system.

Another clogging problem in fertigation is associated with algal and bacterial populations in the form of slimes. These slimes are produced as a result of the increased nutrients in the water. Such clogging is one of the major problems confronted in drip irrigation. Various acids, e.g. sulfuric and N- phuric®, and algaecides, such as bleach, have been successfully used to control this type of clogging.

Most modern irrigation systems are constructed entirely of plastic and applied chemicals will not corrode pipes or emitters. Filters are desirable in any closed irrigation system, and especially so when applying fertilizers. All fertilizers should be introduced into the system at a point well ahead of the filters. The filter should therefore be corrosion resistant.

A Fertilizer Program

We are still learning about the nutritional needs of cherimoya, but there are basic horticultural practices we know from other subtropical tree species that can guide a fertility program. Fertilization of young, nonbearing trees differs from mature, bearing trees because nutrients are not harvested with the fruit and the trees are much smaller. The objective in a young orchard is to produce a bearing tree as soon as possible, while a mature orchard is fertilized to sustain yields.

The primary nutrient required by young and old trees is nitrogen. Other macronutrients, such as potassium, are often added to the fertilizer mix, but they have less impact on tree growth than nitrogen. In fact, trees coming from the nursery often have leaf macronutrient levels in the high to excess range. Leaf micronutrients levels in nursery trees are also high, and supplemental sprays are not needed unless deficiency symptoms appear. If potassium deficiency is known in the area, then beginning in March apply 4 ounces per tree of a mixed fertilizer, such as 15-15-15, every 8 weeks until October. Fertilize young trees cautiously so as not to harm them, yet sufficiently ensure maximum growth.

Table 7 gives suggested amounts of nitrogen to inject into an irrigation system on a yearly and monthly basis. Organic fertilizers can be used in a similar fashion, adjusted for their nitrogen content. Get into the habit of applying materials on a monthly basis during the eight months of irrigation from March to October. Dry fertilizer should be applied evenly within the irrigation pattern for each tree irrigated by a low-flow system. For young trees, dry fertilizer application should occur four to six times in the year, while older trees with their larger root systems only require two to three applications per year.

Table 7. Suggested Amounts of Nitrogen to Inject into an Irrigation System.

	Annual Amount	Amount per	tree per	month
	pounds	pounds	pounds	pounds
Orchard Age		Urea	Ammonium nitrate	Calcium nitrate
1st year	0.10	0.03	0.04	0.09
2nd year	0.20	0.06	0.08	0.17
3rd year	0.33	0.09	0.13	0.29
4th year	0.50	0.14	0.19	0.43
5th year*	1.0	.28	.38	.90

*Adjust rates based on leaf analysis.

The suggested amounts in Table 7 may require adjustments determined by leaf analysis after coming into commercial bearing. Adjust fertilizer rates each year depending on the crop load. If a tree is groaning under a load of fruit, give it a little extra, while trees that are not bearing heavily can have their rates reduced. As stated previously, fertilization of mature trees is necessary to replenish nutrients lost during harvest and leaching, to maintain tree vigor, and to obtain optimum yields.

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