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Bulletin

Nutrients and Nutrient Management of Containerized Nursery Crops

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Introduction

Nursery growers use soilless media to grow nursery crops in containers. The formulated media vary not only with the individual component make-up (e.g. bark, peat, compost, sand, or vermiculite) but also with the ratios used. Most soilless media used in container nursery operations have low cation exchange capacities (except vermiculite) and provide very few, if any, nutrients. The limited container volumes and excellent drainage of containers require frequent watering during the growing season, which often leads to leaching of applied fertilizers. Hence, nutrient management is a challenge for producers of container-grown nursery crops. Maintaining an adequate level of macronutrients and micronutrients in the soilless media solution is the key objective of the fertilization program. A combination of fertilization programs can ensure nutrient availability to containerized nursery crops.

Fertilization Programs

A. Pre-Plant Fertilization

Pre-plant fertilization allows a successful start through the incorporation of nutrients at rates sufficient for plant growth. Macronutrients and micronutrients must be available in forms which the plant can use. Adjusting the pH of the growing media before planting will ensure nutrients are available for uptake by the plants' roots.

Proper management of macro, as well as micronutrients, is essential for the successful production of vigorous woody plants. The primary macro-elements nitrogen (N), phosphorus (P) and potassium (K) are required in the highest amounts, and thus, of greatest importance in a fertilization program. In woody ornamentals, the elemental ranges of these primary nutrients can be used as a guideline: 2.0–2.5% N, 0.2–0.4% P and 1.5–2.0% K in uppermost mature leaves (using dry leaves tissue test).

Nitrogen (N) is often used as the benchmark or starting point for determining the fertilizer requirement. Incorporate a controlled-release fertilizer at or soon after the time of planting. Nitrogen supplements may be necessary during the growing season through application of liquid fertilizers or by top-dressing granular or controlled-release fertilizers. This is particularly true later in the growing season when controlled-release fertilizers may lose their nutrient supplying power. If pre-plant controlled-release fertilizers cannot be incorporated into the media, some formulations may be uniformly applied to the surface of the media. However, fertilizer materials applied to the surface may be lost through heavy rains, spillage, and/or volatilization.

Nitrogen is required in the highest amount of all of the mineral elements. Plants may take up N either as nitrate (NO_3^-) or ammonium (NH_4^+). Although NH_4^+ may be taken up directly by the plant, it is also converted to NO_3^- in the substrate container media.

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$2(NH_4^+) + 3(O_2) \Rightarrow 2(NO_2^-) + 2(H_2O) + 4(H^+)$

$(NO_2^-) + (O_2) \Rightarrow 2(NO_3^-)$

The production of protons (H^+) in the first step of this conversion is one reason why NH_4^+-based fertilizers are acidic and tend to cause the pH of the substrate container media to go down over time. Ammonium-based nitrogen (NH_4-N) fertilizer is preferred where it can be used because it is relatively inexpensive. However, high levels of ammonium can be toxic to plants. Levels can build up over time due to over application of ammonium or due to low substrate container media temperatures in winter months, since conversion of ammonium to nitrate is slowed under low temperatures. Conversion of ammonium to nitrate is rapid in the temperature range 68–86°F (20–30°C) and at pH values above 5.6. This means that ammonium is likely to accumulate in media that are waterlogged (low oxygen content), at temperatures below 68°F and above 104°F (40 °C). For this reason many growers use ammonium-based nitrogen during warm months but cut back and shift to nitrate-based nitrogen during winter months. High levels of ammonium can be toxic to plants. The main effects are on root growth by restricting root development; however, leaf chlorosis is another symptom of ammonia toxicity. Below 55ºF (12.8ºC), ammonium should be monitored. Water extracts (1:1.5 by volume) of media for sensitive plants should contain less than 30 mg/L (ppm) ammonium-N. Zeolites, and silicate minerals with high cation exchange capacities, incorporated at 2–5% by volume in container media could eliminate the possibility of ammonium toxicity and improve efficiency of fertilizer nitrogen use. On the other hand, numerous studies showed that when nitrogen fertilizer is applied in the form of ammonium to a container crop, ammonium when nitrified can leach from the container during the growing season. Other studies showed that rapid decreases in ammonium N concentrations were observed when ammonium based fertilizer was applied to a pine bark media (due to adsorption to media) and to increases in nitrate nitrogen concentrations.

Incorporate **phosphorus (P)** into the media before planting and supplement, when necessary, with liquid, controlled-release, or granular fertilizers containing this nutrient. Since most adopted container media for nursery crops include bark and peatmoss that no longer have mineral soil (adsorbs P), it is recommended to use controlled-release fertilizer (to avoid using phosphorus from superphosphate-based fertilizers, which readily leaches from the soilless mix immediately after potting). Incorporate a complete fertilizer that supplies adequate amounts of available phosphorus. Plants require lesser concentrations of P than those of nitrogen and potassium.

Potassium (K) is required at a higher concentration than phosphorus but a lower concentration than nitrogen for the growth of healthy nursery crops. Supply potassium before planting through a controlled-release fertilizer or complete granular fertilizer.

Particular ratios of nitrogen, phosphorus, and potassium (N-P_2O_5-K_2O) have been shown to promote optimum growth of numerous container-grown plants. To encourage vegetative growth, use fertilizers with ratio of 5-1-3 to 8-1-4 (i.e. higher N number). Researchers observed that genera including *Berberis*, *Betula*, *Cotoneaster*, and *Acer* grow well when supplied with an N-P-K ratio of 6-1-5. Although these ratios have been observed to promote good growth, they are not exclusive of other fertilizer ratios. Many different N-P-K ratios may be used with favorable results. On the other hand, to favor flowering, root, and underground storage organ growth, use fertilizers with low N and high P and/or K ratio (for example, use a 1-2-2 or 1-3-2 ratio fertilizer).

Calcium (Ca) and Magnesium (Mg) are also macro-nutrients and are often supplied to soilless media, particularly those that contain hardwood bark. Calcium and magnesium sulfates also have the ability to supply adequate levels of these elements. To supply calcium or magnesium without altering the media pH, incorporate calcium sulfate (gypsum) or magnesium sulfate (Epsom salts), respectively. The finer the liming material is, the faster rate of pH change. Little or no change in pH occurs through the addition of calcium sulfate, particularly if the media pH is between 5.5 and 7.5. On the other hand, incorporating dolomitic limestone (contains Ca and Mg) prior to planting nursery crops supplies the media with calcium and magnesium. If a soilless media contains pine bark, ammonium-nitrogen availability decreases as a result of adsorption to pine

bark. Additionally, as limestone is incorporated into the media, ammonium is readily transformed to nitrate (increasing soilless medium's pH). Consequently, nitrate-nitrogen becomes the predominant form of available nitrogen. Hence, leaching of nitrate nitrogen to the environment happens with frequent prolonged irrigation rates.

Incorporation of **micronutrients** (trace elements), including iron, manganese, boron, copper, zinc, and molybdenum, into the media, if micronutrients are too low, should be included in the pre-plant fertilization programs. Types of media, used for growing plants, may influence the need for supplemental micronutrients fertilization. Media formulated from organic components do not require the same level of micronutrient application as sand-based media. By maintaining organic media solution within a pH range of 4.4–5.6, macronutrients are maintained in the available forms and concentrations; supplemental micronutrients may not be as critical as in other types of media with inorganic components. It is recommended that micronutrient levels are monitored to avoid any toxicities, especially when composted sludge is a component of the media. Boron toxicity may occur when irrigation waters contain boron in high concentrations. Micronutrients can be applied by pre-plant incorporation, top-dressing, or injection through irrigation. Micronutrient availability depends on the form of the element, media pH, and the element's propensity for precipitation or leaching. Micronutrients are most available when the media pH is between 5.0 and 6.5. Media pH greater than 7.0 results in micronutrient unavailability except for molybdenum, while media pH less than 4.5 leads to micronutrient toxicity. Table 1 lists fertilizers that can be applied to supply micronutrients to nursery crops grown in containers. Most manufacturers of soluble trace elements make specific recommendations, which should be followed. However, researchers have shown that the following concentrations are beneficial for container-grown forest species: 4.0 ppm iron, 0.5 ppm manganese, 0.5 ppm boron, 0.02 ppm copper, 0.05 ppm zinc, and 0.01 ppm molybdenum. Others reported that many woody ornamental species fertilized with similar nutrient concentrations injected through the irrigation system responded favorably.

B. Post-Plant Fertilization

Post-plant fertilization is an integral part of any nutrient management program. Post-plant fertilization programs can be implemented by using **dry** or **liquid fertilizers**. Dry fertilizers include both **granular** (e.g. 10-10-10 and 15-15-15) and **controlled-release** fertilizers. The grade or analysis of the fertilizer represents its composition of the three primary macro plant nutrients. Nitrogen is expressed on an elemental basis as percent N, whereas P, and K are expressed on an oxide basis as percent P_2O_5 (phosphate), and percent K_2O (potash), respectively. To convert from the elemental form to the oxide form, use the following formulas:

$$\%P_2O_5 = \%P \times 2.29$$

$$\%K_2O = \%K \times 1.2$$

However, to convert from the oxide form to the elemental form, use the following formulas:

$$\%P = \%P_2O_5 \times 0.44$$

$$\%K = \%K_2O \times 0.83$$

A wide variety of dry fertilizers are available for container nursery crop fertilization. Application of dry fertilizers do not require a substantial equipment investment but sometimes labor costs may be significant when multiple applications are necessary during the growing season. Granular nitrogen sources can be either incorporated into the media before planting or top-dressed after planting. If nitrogen (N), phosphorus (P), and potassium (K) were not incorporated in the media before planting, they should be applied using complete granular fertilizers after planting. **Complete granular fertilizer** (contains nitrogen, phosphorus and potassium) may be applied at frequent intervals due to potential loss of these elements, mainly through leaching, during the growing season. Also, granular fertilizers can be used to supplement a liquid feeding or a controlled-release system, which may fail to deliver these nutrients when needed by plants. Always apply fertilizer materials according to media analysis results and recommendations for producing healthy plants.

Fertilizers and Mode of Release

Fertilizers can be classified into: a) organic slow-release, b) low-solubility slow-release (SRF), c) controlled-release (CRF), and d) quick-release water soluble (liquid feeding).

Organic slow-release fertilizer includes **natural** (plant wastes, sewage sludge, and animal by-products) organic fertilizers and **synthetic** ones such as urea formaldehyde (e.g. Ureaform® and Nitroform®). Organic fertilizers have low water solubility, prolonged nutrient release rate, extended residual, and reduced likelihood of causing fertilizer injury. However, **such fertilizers are mostly affected by microbial (bacterial) activity and substrate water content.** Care should be taken when growers use the animal by-product organic fertilizer because water content can speed breakdown and give rise to ammonium toxicity at low temperatures. However, ammonium is transformed into nitrate (NO_3^-) at pH level > 5.5, and as weather warms up. Bacteria are more prevalent at pH greater than 5.5, whereas fungi are active at pH less than 5.5. The rate at which these transformations occur meters the release of nitrogen for plant uptake. Examples of organic fertilizers, of natural sources, with their particular ratios of nitrogen, phosphorus, and potassium are listed in Table 2. Ureaformaldehyde (UF) is a chemically modified urea with 38% N, 70 percent of which is water-insoluble. This percentage is often listed as the Percent W.I.N., or the percent of water-insoluble nitrogen. This form of nitrogen is released gradually by microbial action. Its release is mainly affected by temperature and amount of organic matter. Ureaformaldehyde can also be used when nursery stock is overwintered. It does not rupture when frozen as controlled-release fertilizers do, releasing total content of soluble material at one time, causing high soluble salt levels in the root zone and subjecting the roots to fertilizer injury.

S**low-release fertilizer** (SRF) includes **magnesium ammonium phosphate** (e.g. MagAmp) and **isobutylidenediurea (IBDU)**, a combination of urea and isobutyraldehyde. MagAmp consists of relatively insoluble nutrients in pelletized form. As the pellet size is increased, the time it takes for the fertilizer to breakdown by microbial action is also increased. MagAmp is used commercially for container plants. **IBDU does not depend on soil microorganisms for release but is broken down by water into urea**. Nitrogen release from this fertilizer increases with moisture and temperature. However, the rate of urea release from IBDU varies with particle size, and media pH. The smaller the particle, and the lower the media pH, the faster the rate of released nutrients. Woodace ® (20-4-11) is 0.80% ammoniacal N, 1.35% nitrate N, 15.15% urea N, and 2.7% water insoluble N. Sulfur-coated ammonium phosphate is the P source in Woodace. The SRF have low burn potential and are particularly useful when leaching of N is a concern. The main disadvantages of SRF are the high cost relative to quick-release fertilizer and the release rate can be too slow for fast growing nursery crops.

Controlled-release fertilizer (CRF) is a type of soluble fertilizer such as urea coated or encapsulated by either sulfur [sulfur-coated urea (SCU), e.g. SCU, Scotts® 17-3-6)], or resin- and polymer-coated materials [polymer resin coated urea (PCU), e.g. Osmocote® 18-6-12, and Nutricote® 18-6-8]. The SCU is made by spraying molten sulfur onto urea granules. Release of N from the sulfur-coated urea granule depends on the time it takes water and microorganisms to break down the sulfur coating. The thicker the coating is, the slower the release rate. Release will be faster in warm, wet soil—conditions that favor microbial activity. The PCU products have fast become a major part of the controlled-release N market. These products work by allowing urea to gradually diffuse through the polymer membrane at a rate that, depending on the exact technology, may vary according to temperature, moisture, or coating thickness. These products provide a precise N-release rate, and some can even deliver N for an entire growing season. They are, however, relatively expensive. CRFs are available in several formulations to meet the nutrient requirements of different plants, and also are available with different coatings to provide nutrient release over different time frames (e.g. 4-month vs. 12-month formulations). These products generally provide more consistent nutrient availability to plants over time than traditional granular fertilizers. Controlled-release fertilizer is usually mixed with substrate media at time of planting.

Additional applications can be made when the CRF becomes exhausted. As the salinity of the substrate container medium approaches that of the irrigation water (0.3–0.5 mmhos/cm), supplemental fertilization is needed. On the other hand, salt readings (> 3 mmhos/cm) approaching those harmful to the indicator species should signal the need to implement leaching practices. Salt sensitive plants (azaleas) and salt-tolerant plants (*Hydrangea*, *Magnolia grandifolia*) can be used as indicators. Some fertilizer blends contain a mixture of water-soluble and polymer-coated products to reduce cost. It is noted that some of the coated products on the market are manufactured with a portion of urea that is not protected with coating and will have a quick-release characteristic after application. Again, a quick look at the label will give the percent composition of each in the product.

Quick-release water soluble fertilizers are formulated for maximum solubility in water, designed for injector systems and foliar spraying. Water-soluble sources are useful to encourage short-lived growth and have minimal temperature dependence. They are cheaper in cost per unit of N. Sources of water-soluble N include ammonium nitrate [34-0-0; NH_4NO_3], urea [46-0-0; $CO(NH_2)_2$], potassium nitrate [13-0-44; KNO_3] and ammonium sulfate [21-0-0; $(NH_4)_2SO_4$). These are all inorganic compounds except urea (although synthetically made, it acts like organic). However, unlike most other organic types, urea is soluble enough to be considered a quick-release product. If injection of soluble fertilizer is used with overhead irrigation systems, runoff must be collected or steps need to be taken to address nutrient loading of water leaving nursery property. Environmental concerns are hightened from the continuous use of soluble fertilizers without proper management of containing the runoffs.

Fertilizer Application

Apply fertilizer rates following the manufacturers' recommendations. The method of application affects nutrient release. Top-dressing typically results in reduced nutrient losses from the medium and extends the nutrient release period compared to incorporation. In case of resin- and polymer-coated materials (CRF), the intermittent drying of top-dressed fertilizer between irrigation events may be slowing down the movement of nutrients through the fertilizer coating. Physically marring or disrupting the resinous fertilizer coating before or after incorporating into the media hastens the release of nutrients from the coated granules. Mix CRF (Nutricote ® 18-6-8 or Osmocote ® 18-6-12) with growth substrate prior to potting rather than applying fertilizer to substrate surface if containers are subject to blow-over. Nutrients in the substrate can be leached regardless of the type of fertilizer applied, making irrigation management important. Fertilization through irrigation water is appropriate for low-volume irrigation systems in which irrigation water is delivered to the container. Care should be taken to minimize leaching from the container to prevent nutrient runoff from entering surface and ground water.

Fertilizer Nutrient Management

For an efficient fertilizer management fertilizer supply such as nitrogen should be synchronized with the plant demand for that nutrient. The general concept of balancing supply and demand implies maintaining low levels of mineral N in media when there is little or no plant growth, and providing sufficient N to meet plant requirements during periods of rapid growth. It is important to identify nursery beds with severe leaching or surface runoff potential and employ all appropriate management practices on these sites to reduce nutrient movement to water bodies around the nurseries. The following are general guidelines in fertilizer management and can be practiced in containerized nursery operations:

Group plants with similar water and nutrient needs. Plants vary in both water and nutrient needs. Placing plants of similar water and nutrient needs improves irrigation and nutrient efficiency. For example, Japanese boxwood and gardenia require medium water amounts and nutrient needs. Heavy water- and nutrient-requiring plants (e.g. hibiscus) should be placed farthest from collection ponds, lakes, and rivers.

Group plants according to different water and nutrient needs. Some plants differ in their water and nutrient needs. For example, Euonymus plants

require low water and high nutrient needs (Table 3). Such plants should not be grouped under the same growing structure, fed, or watered as hydrangea and rhododendron spp. that have high water and low nutrient requirements. To learn more about irrigation management options and grouping of nursery plants according to their water requirements, refer to RCRE bulletin E302.

Adopt controlled-release fertilizers. Use controlled-release fertilizers (CRF) over soluble fertilizer (SF) except when special circumstances warrant the occasional use of soluble fertilizer formulations. Spread CRF over the growing season (split applications). Choose a product with a 3–4 month release period to avoid salt problems during overwintering.

Optimize fertilizer use. Plants vary in nutrient demands. Rate of nutrient demand varies with plant growth stage, light intensity, temperature, and growth habits. Many nursery crops have not been well studied or characterized in terms of their specific rates of nutrient demand. Nevertheless, it is possible to categorize plants according to their general nutrient needs (Table 3). Follow manufacturers' fertilizer recommendations and label directions. Keep records of fertilizer formulations, rates, and time of application. Properly apply and time application of N fertilizer to coincide as closely as possible to the period of maximum crop up-take during the growing season. Monitor growing medium fertility and avoid excessive fertility levels. Regardless of the fertilizer source and formulation, regular analysis of the nutrient status of the production substrate is recommended to make adjustments before plant problems develop. An easy method to use, which was developed at Virginia Tech, is the Pour-Through (PT) method. In brief, an amount of water is poured through the substrate media to collect about 50 ml. (2 fl. oz.) of leachate from both the center and side holes of the container media into a vessel. Details of the Pour-Thru method of monitoring nutrients in containers can be accessed through the web at *www.ces.ncsu.edu/depts/hort/hil/pdf/hil-450.pdf*, and reading the Rutgers Cooperative Research & Extension fact sheet, FS848. The fact sheet can be accessed at website *www.rcre.rutgers.edu/pubs/pdfs/fs848.pdf*. Desirable nutritional levels to be maintained in soilless media for plants with medium to high nutritional requirements are listed in Table 4. Note that, while nutritional levels should not drop below the desired levels during the active growing period, plants with low nutritional requirements may grow adequately with lower nutrient levels cited in Table 4. Soluble salts level in collected leachates above 3mmhos/cm is problematic. Frequent watering reduces the build up of salts in the medium. If recycled water is used for irrigation, make sure to monitor recycled water for salt levels. Phosphorus is commonly over-used and application should be based on media tests. Eliminate superphosphate from the growing medium. Phosphorus washing into surface water bodies leads to excessive algae growth in water.

Improve cultural practices. Avoid heavy pruning during late spring and summer, which stimulates vigorous new growth and additions of nutrients and water. Grade the nursery to efficiently direct runoff water to collection ponds. Construct collection ponds to hold all irrigation runoff plus storm water runoff. Such systems conserve water and reduce water with nitrates to reach water bodies. In sandy soils, install lined drainage channels and collection basins to prevent nitrogen movement, from runoff, into shallow ground water.

Re-use irrigation water. Monitor recycled water for pH, salts, pesticides content, and diseases before applications to nursery plants at least three times a year. To avoid over fertilization, test recycled water for nitrogen and phosphorus content in irrigation water before fertilizer application. Runoffs contain these nutrients and accumulate in available forms in recycled water. An ideal irrigation water soluble salt (expressed as electrical conductivity, EC) value is less than 0.5 mmhos/cm. Blend recycled water with fresh water to reduce salt concentrations. Refer to RCRE Fact Sheet, FS893 at the website address *www.rcre.rutgers.edu/pubs/pdfs/fs893.pdf* for more details on chemical properties and constituents of irrigation water for ornamental production. The nitrogen concentration in recycled water should be monitored constantly and fertilizer programs should be adjusted accordingly, otherwise plants will show lush, soft growth that is prone to disease and intolerant of other stresses. Using

recycled waters with phosphorus concentrations above 1ppm, over time, will supply more phosphorus than plants need.

Construct grass-lined waterways to filter sediment and runoff. Rout runoff into pre-designed wetland plant production areas to mitigate nutrients before recycling irrigation. Install vegetative filter strips adjacent to beds and containment basins for reducing contaminants in effluent before water enters recycle irrigation supplies. Use vegetated filter strips along edges of the nursery, particularly where lakes and streams border the nursery. For references on filter strips, contact the local office of the Natural Resources Conservation Service (NRCS).

Summary

A carefully planned and properly implemented nutrient management program can improve container nursery crop production and produce healthy woody plant materials. Sound nutrient management practices supplemented by regular nutrient analysis, pH testing, and soluble salts monitoring yield vigorous woody ornamental plants.

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Table 1. Fertilizers that can be applied to supply micronutrients to container nursery crops.[†]

Micronutrient Fertilizer	Element (%) Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)	Boron (B)	Molybdenum (Mo)
Esmigran®[z]	2.0	0.5	1.0	0.3	0.02	0.0006
Micromax®[y]	16.0	2.5	1.0	1.0	0.1	0.05
Peters STEM®[x]	7.5	8.0	4.5	2.3	1.35	0.046
STEP® Hi Mag[w]	8.0	3.0	1.0	0.5	------	------
Lesco-Fe Plus®[v]	5.0	0.5	1.0	0.5	0.05	------

[†] Adopted from Gilliam, C. H. and E. M. Smith. 1980. *Fertilization of Container-Grown Nursery Stock.* Ext. Bul. 658. Ohio State University.
[z] Esmigran® is a micronutrient mixture adsorbed on clay particles; Scotts Co.®
[y] Micromax® is a sulfate-based micronutrient fertilizer with a release period greater than 18 months; Scotts Co.®
[x] Peters STEM® is designed to be mixed with water and only applied as a drench or spray; Scotts Co.®
[w] STEP® Hi Mag also contains 12% magnesium in the form of magnesium oxide and magnesium sulfate; Scotts Co.®
[v] Lesco-Fe Plus® is a chelated iron; Lesco Co.®

Table 2. General nitrogen, phosphorus, and potassium ratios of selected organic slow release fertilizers.[†]

Fertilizer	Analysis N	P	K
Chicken manure	0.5	0.3	0.5
Cotton seed meal	6	2.5	2
Dairy manure	1	0.5	0.8
Dried blood	12	1.5	0.5
Hoof and horn meal	14	0	0
Horse manure	0.6	0.3	0.6
Sewage sludge	2	1.0	0.5
Sheep manure	0.9	0.5	0.8
Spent mushroom	1	1	1
Swine manure	0.6	0.5	1

[†] Adopted from Halbrooks, M. C. 1990. *Nutrition of Container and Field-Grown Nursery Crops.* Ext. Bul. 138. Cooperative Extension Service, Clemson University.

Table 3. List of nursery plants (scientific name, common name) categorized in terms of general nutrient needs.†

Low nutrient requirement	Medium nutrient requirement	High nutrient requirement
Camellia japonica, Camellia	*Acer rubrum*, Red Maple	*Cuphae hyssopifolia*, False Heather
Hydrangea macrophylla, Hydrangea	*Buxus microphylla*, Japanese Boxwood	*Euonymus* spp., Euonymus
Nerium oleander, Oleander	*Gardenia jasminoides*, Gardenia	*Hibiscus rosa-sinensis*, Hibiscus
Pennisetum setaceum, Red Fountain Grass	*Hemerocallis* spp., Daylily	*Ilex crenata*, Japanese Holly
Pinus spp., Pine	*Juniperus chinensis* 'Torulosa'	*Ligustrum japonicum*, Wax-Leaf Ligustrum
Rhododendron spp., Azalea, Rhododendron	*Lagerstroemia indica*, Crape Myrtle	*Spiraea spp.*, Spiraea

† Adopted from Yeager, T.R., C.H. Gilliam, T.E. Bilderback, D.C. Fare, A.X. Niemiera, and K.M. Tilt. 1997. *Best Management Practices Guide for Producing Container-Grown Plants*. Southern Nurserymen's Association.

Table 4. Desirable nutritional levels in soilless media using Pour-Through method when fertilizing with solution or liquid fertilizer alone or in combination with CRF.†

Analysis	Solution only or CRF plus solution	CRF only
pH	5.0 – 6.0	5.0 – 6.0
Electrical conductivity- soluble salts (mmhos/cm)	0.5 – 1.0	0.2 – 0.5
Nitrate-N, NO3-N mg/L (ppm)	50 – 100	15 – 25
Phosphorus, P mg/L	10 – 15	5 – 10
Potassium, K mg/L	30 – 50	10 – 20
Calcium, Ca mg/L	20 – 40	20 – 40
Magnesium, Mg mg/L	15 – 20	15 – 20
Manganese, Mn mg/L	0.3	0.3
Iron, Fe mg/L	0.5	0.5
Zinc, Zn mg/L	0.2	0.2
Copper, Cu mg/L	0.02	0.02
Boron, B mg/L	0.05	0.05

† Adopted from Yeager, T.R., C.H. Gilliam, T.E. Bilderback, D.C. Fare, A.X. Niemiera, and K.M. Tilt. 1997. *Best Management Practices Guide for Producing Container-Grown Plants*. Southern Nurserymen's Association.

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