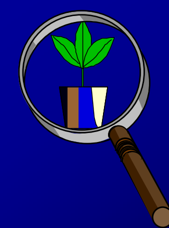
Getting the Most Plant Response for Your Fertilizer $



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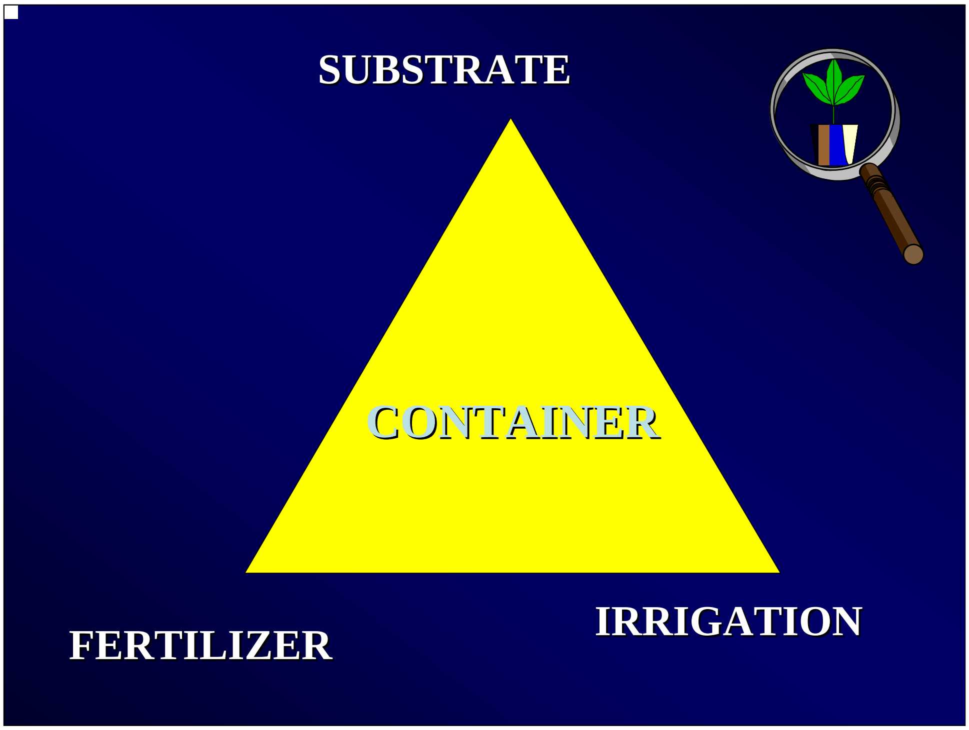
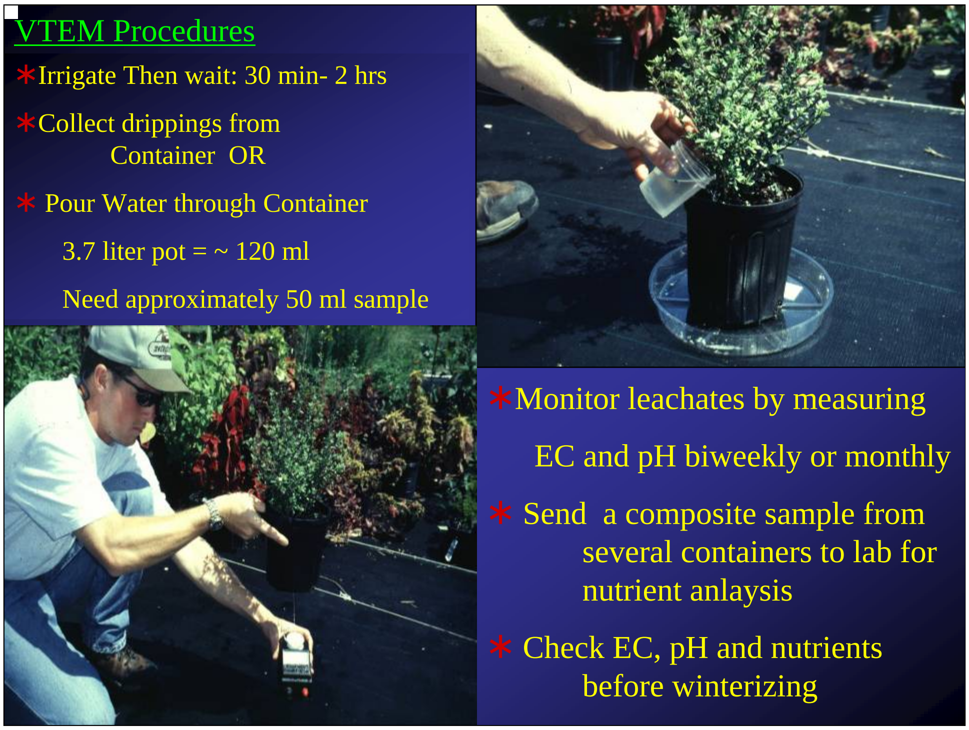
This presentation is not a complete and comprehensive handling of nursery plant nutrition. The purpose of this presentation is to provide general guidelines on container solution sampling and expected nutrient ranges and to introduce studies conducted related to fertilizer application and nutrient considerations related to nursery crop production.



Cultural practices related to fertilizer, irrigation and container substrates are inter-related and un-separable. As an example, if a nursery chooses to change the rate of fertilizer applied to a crop, the solution concentrations will be altered in the container substrate. However, if irrigation is applied sparingly, limiting leaching; nutrient concentrations may increase in the substrate solution.

Planning a nutrient program at a nursery begins with testing the irrigation supplies; this is particularly essential if re-cycled irrigation supplies are utilized, since residual nutrients will be contained in re-cycled irrigation. The need for application of dolomitic limestone may be influenced by the irrigation supplies. Irrigation supplies that contain significant levels of Ca, Na or bicarbonates may dictate that dolomitic limestone not be applied by the nursery since pH may already be high due to bicarbonate concentrations. If the irrigation supply contains high Na bicarbonates or NaCl, alternative calcium and magnesium sources may need to be identified such as $CaSO^4$ (gysum) and $MgSO_4$ (Epsom Salts) or CropMag which do not have any major effect on elevation pH as dolomite limestone does. If the irrigation pH is high then the grower may need to supplement Fe nutrition with Fe chelates either incorporated into the potting substrate or as sprays and/or drenches during the growing season. High levels of boron or other nutrients, minerals or compounds may require further adjustment of fertilizer programs to avoid excessive levels of some elements and deficient levels of other elements. Currently 17 elements are considered essential for plant production of nursery crops.



The PourThru extraction procedure is the recommended method for sampling conductivity, pH and nutrient levels of nursery container crops. An alternative is to collect leachate that drains from containers 30 minutes to 2 hours after irrigation. The waiting period is required for equilibration of nutrients in the container solution.

There are many pH and conductivity meters and pens available.
They may read different units so be prepared to make conversions.

Solubridges in the upper left hand corner generally read units in mhos / cm x 10^{-5}. The orange colored Hanna meter and the Myron meter (black box with a cup on top) read units in mmhos/cm x 10^{-3} (same as mS/cm x 10^{-3}) . The Blue Hanna meter reads in uS/cm x 10^{-6}

Conversions would be Solubridges read 40 mhos x 10^{-5} = 0.40 mmhos x 10^{-3} for the Myron and Orange Hanna = 400 umhos x 10^{-6} for the Blue Hanna meter.

The Myron meter is the most convenient to use since the sample can be tested for EC and pH by collecting the sample in the cup on the top of the meter, but the Myron retails for approximately $400. The Hanna meters have a probes on a cable and the sensors are at the end of the probe requiring the solution to be in a cup or vessel, however, Hanna meters may sell for less than $200. The pens also require a vessel to contain the solution. Pens read in a variety of units but some may cost less than $50. Some meters and pens read total dissolved salts. An approximation of EC from total dissolved salts is

EC x 700, therefore a high EC reading of 2.0 mmhos x 10^{-3} x 700 would be 1400 TDS which also is toward the upper limit for nursery crops.

Chemical Properties

Desirable nutritional levels for VTEM interpretation of the solution, liquid or CRF fertilizers.

Nutrient parameters	Desirable levels: Solution only or CRF and Solution	Desirable levels: CRF only
pH	5.0 to 6.0	5.0 to 6.0
EC, dS/m (mmhos/cm)	0.5 to 1.0	0.2 to 0.5
Nitrate-N mgL (ppm)	50 to 100	15 to 25
Phosphorus, mg/L	10 to 15	5 to 10
Potassium, mg/L	30 to 50	10 to 20
Calcium, mg/L	20 to 40	20 to 40
Magnesium mg/L	15 to 20	15 to 20
Manganese, mg/L	0.3	0.3
Iron, mg/L	0.5	0.5
Zinc, mg/L	0.2	0.2
Copper. mg/L	0.02	0.02
Boron, mg/L	0.05	0.05

Desirable levels in this table are those suggested in the Southern Nursery Association's Best Management Practices manual. These levels may not include back ground irrigation water levels.

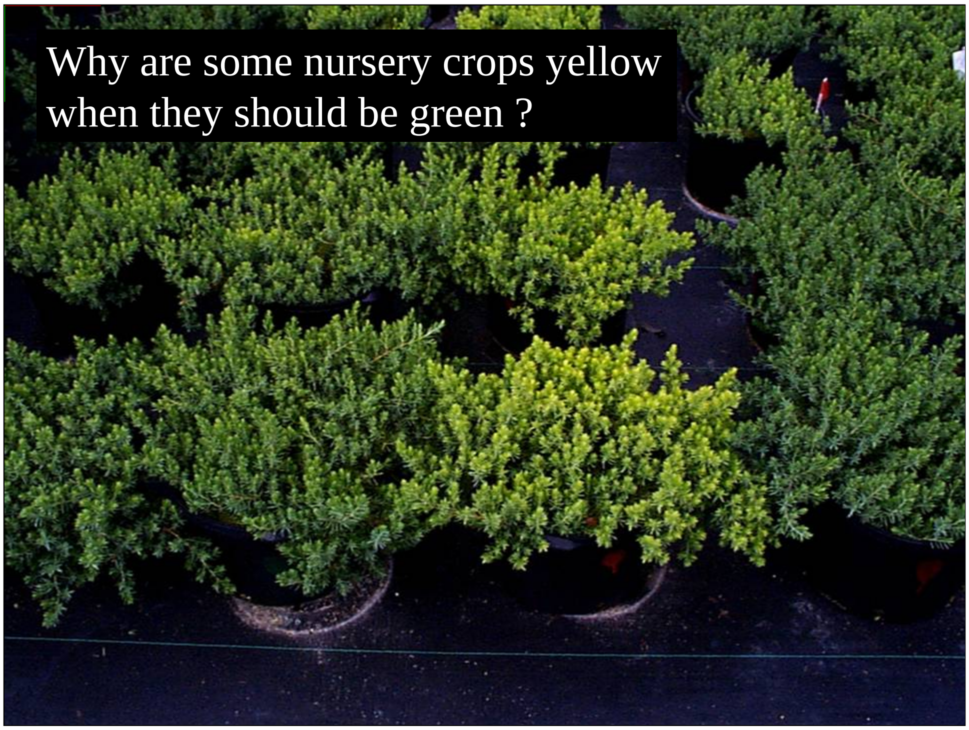
Chemical Properties

Desirable nutrient levels for VTEM interpretation of the fertilizers.

Nutrient parameters	Desirable levels: Irrigation Water	Desirable levels: Leachate
pH	5.4 to 7.0	5.2 to 6.3
EC, dS/m (mmhos/cm)	0.2 to 2.0	0.5 to 2.0
Nitrate-N mgL (ppm)	10.0	50.0
NH_4NO_3 (ppm)	2.0-10.0	50.0
Phosphorus, mg/L	< 1.0	3 to 10
Potassium, mg/L	< 10.0	< 100
Calcium, mg/L	< 60.0	< 200
Sulfur, mg/L	<24.0	75.0 to 125
Magnesium mg/L	6.0 to 24	10 to 50
Manganese, mg/L	<0.5 to 2.0	0.2 to 3.0
Iron, mg/L	0.2 to 4.0	0.3 to 3.0
Zinc, mg/L	< 0.3	0.3 to 3.0
Copper. mg/L	< 0.2	0.01 to 0.5
Boron, mg/L	< 0.5	0.5 to 3.0
Sodium	<3.0 meq or 50.0 ppm	<50.0 ppm
Chlorides ppm	<70.0	<70.0
SAR meq	< 10.0	
Alkalinity ppm	<100.0	
Bicarbonate	<100 ppm or 2.0 meq/L	
Total Dissolve Salts ppm	1400	

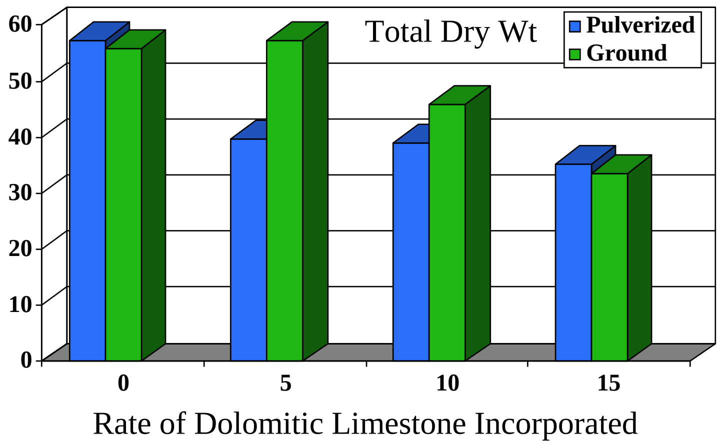
Ranges shown in this table represent appropriate nutrient capacity levels that generally provide good plant growth. If samples have levels above or below these ranges, some adjustments may be required for best results.

Mid-summer frequently brings high temperatures and elevated root zone temperatures in container grown nursery crops. Heat stress, moisture stress, elevated soluble salts, non-optimal pH levels or root diseases may result in foliar chlorosis in many nursery crops (crop in the picture is abelia). The cause of the foliar discoloration is frequently due poor root growth or unhealthy root systems. Any or all of the stress conditions can cause dieback of fibrous adsorbing roots in the container substrate. Poor color of foliage is frequently due to an iron deficiency. Active root growth and healthy white root tips are required for uptake of iron. Cultural practices to help plants recover may include application of fungicides and an iron chelate, both applied as a spray or drench. Monitoring for excessive EC and pH help to diagnose problems early. Low pH may indicate low Ca and Mg levels. Healthy roots are also required for uptake of calcium. Application of dolomitic limestone may be necessary to correct low pH problems. High pH due to bicarbonates in irrigation supplies may cause iron to be unavailable from the substrate solution, therefore application of an iron chelate may be appropriate. Foliar analysis of leaves sent to a lab is useful in diagnosis of foliar deficiencies.

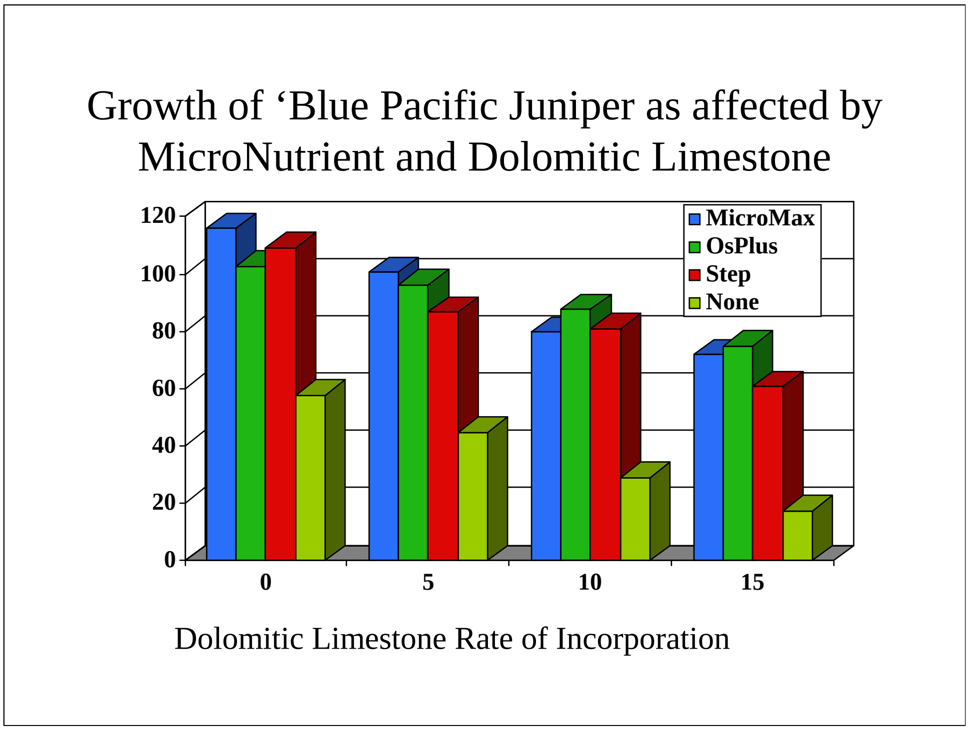


A 2 year study was conducted by Warren and Bilderack to investigate dolomitic limestone and minor element products effects on foliar chlorosis of ‘Blue Pacific’ juniper. Numerous short term studies had been conducted at other universities, most concluding that no lime was required for production of container grown nursery crops.

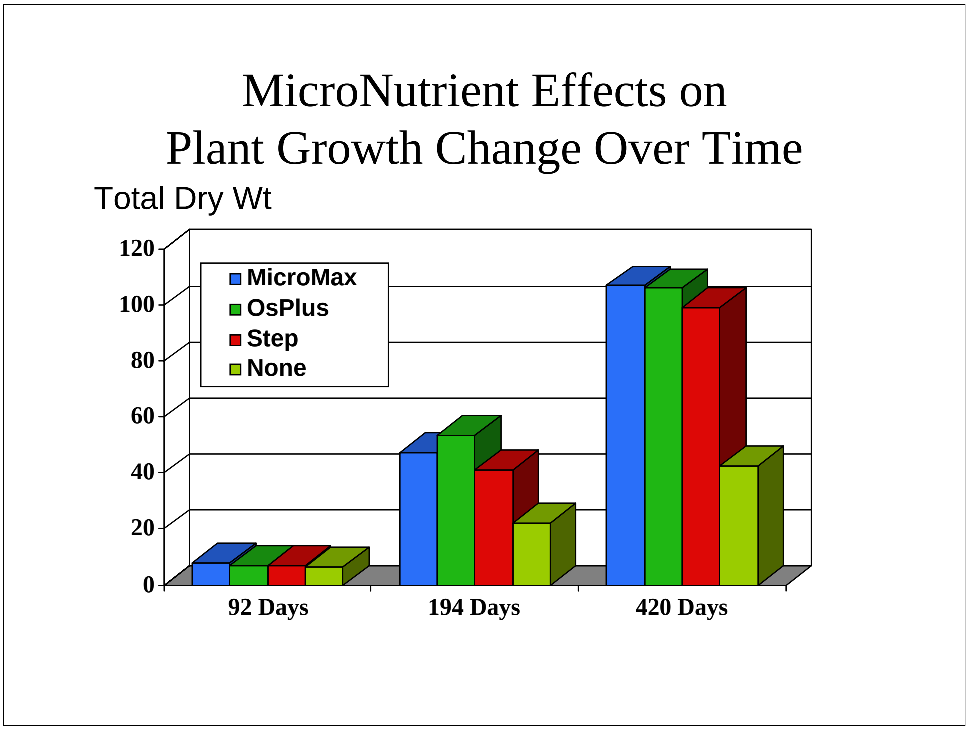
Growth of ‘Blue Pacific Juniper as affected by Dolomitic Limestone Rate



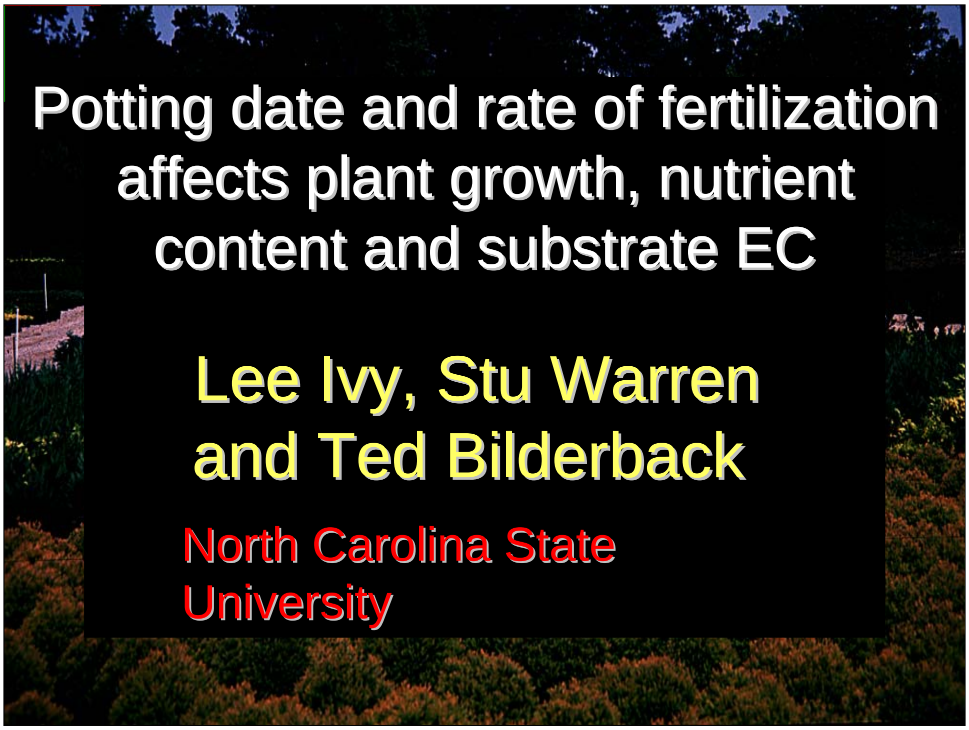
Warren and Bilderback compared two dolomitic limestone products incorporated into a pine bark substrate. The products were a fine particle pulverized dolomitic limestone and a coarse ground dolomitic limestone. Results indicated that less growth was achieved with pulverized dolomitic limestone compared to no lime addition. The coarse dolomitic limestone increased growth of ‘Blue Pacific’ juniper at the 5 lb per cubic yard rate. The irrigation supply contained 16 ppm Ca and 3 ppm Mg.



Three minor element products were compared at four dolomitic limestone rates. Results indicated that minor element products were necessary for best growth. Results also indicated that if dolomitic limestone was applied, a minor element product was very important for best plant growth. Increasing rates of dolomitic limestone decreased growth.



Three harvest dates provided further conclusive data. At 92 days, minor element products would not have appeared to be necessary, however production cycles for nursery crops are usually longer than 3 months. At 194 and 420 days, best growth was provided by addition of minor element products. The minor element products MicroMax and Step were incorporated at potting, the OsPlus product was contained in a topdressed NPK Osmocote product applied once each season of growth. Results indicated either minor element application technique was adequate for best growth and that all minor element products provided adequate nutrient levels for the 420 day study.



Traditionally, university research studies are initiated in spring and harvested and analyzed at the end of the growing season. This study included five potting dates throughout a calendar year.

Materials and Methods

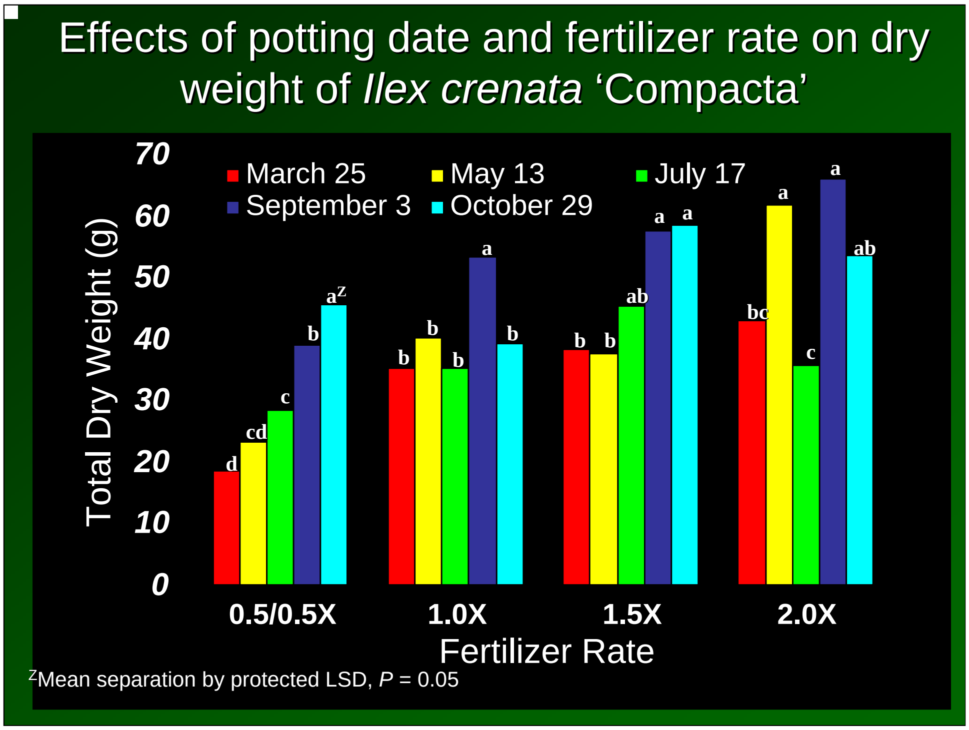
- 5 potting dates: March, May, July, Sept, and Oct
- 2 fertilizers: (10 month @ 80F)
- Harrells/Polyon 15-4-9 (12 #/yd^3/4.0g N/pot)
  Scotts 23-4-8 (10 #/yd^3/5.0g N/pot)
  4 fertilizer rates: 0.5/0.5X, 1.0X, 1.5X & 2.0X
- 5 x 2 x 4 factorial in a split-split plot design with 5 replications

Potting dates, fertilizer products and rates and study design are shown in this slide. Growers are frequently reluctant to apply full rates of fertilizers except in late winter or spring months due to concern of high rates interfering with winter acclimation of container grown nursery crops.

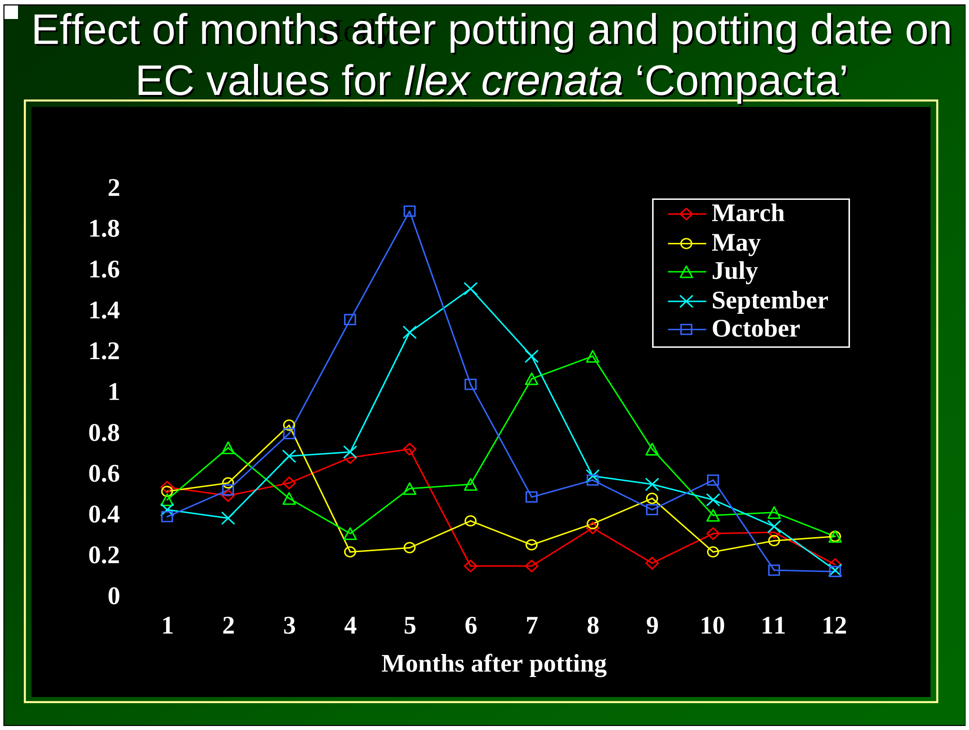
Materials and Methods

- Overwintered: December to February
- Harvested 1 year after potting
  - Evaluated for winter injury
  - Shoots (stems and leaves) and roots separated
    - dry weight
    - nutrient analysis (N, P, and K)

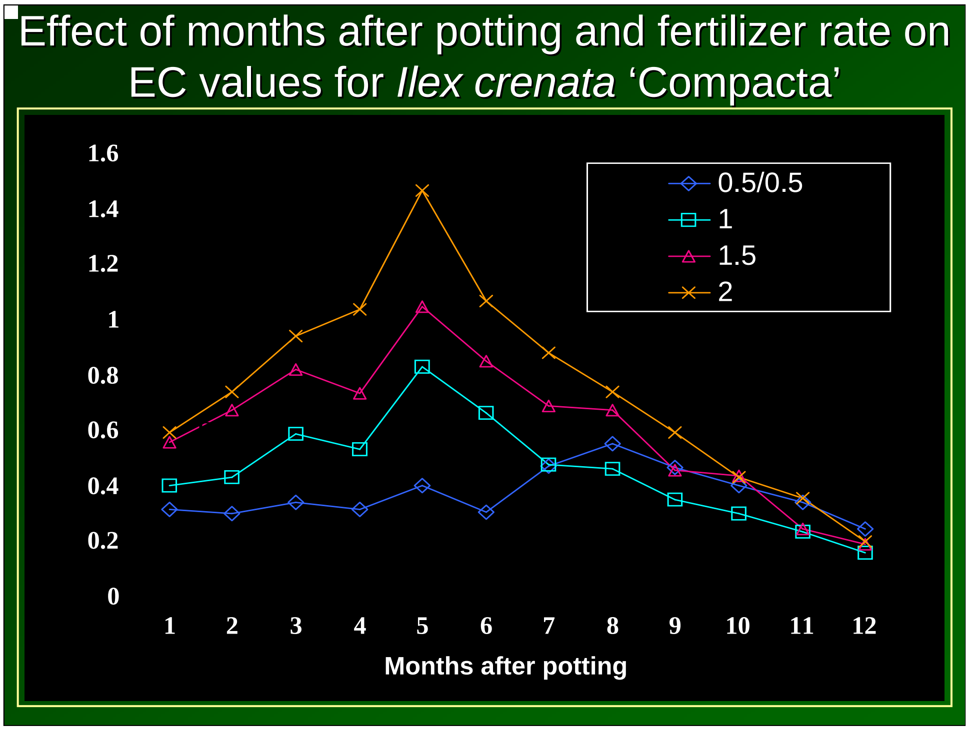
All plants were harvested at the end of one calendar year from the potting date. All plants were over-wintered by covering with winter protection blankets and evaluated for winter injury the following spring. Plant growth was evaluated using a destructive harvest and determination of total plant dry weight. Foliar analysis was conducted for all treatment combinations.



Results: Planting dates are represented by color bars in the figure shown in the slide. The height of the bars indicate plant growth seen on the vertical (y) axis. Fertilizer rates are shown on the horizontal (x) axis. In general, when fertilizers were applied at ½ rate at potting with the remaining ½ rate applied at six months, growth was reduced compared to the 1.0 rate even though the same amount of fertilizer was applied during the course of the study. The greatest growth was achieved when plants were fall potted (September and October). Least growth was generally achieved when plants were potted in March. In most cases, growth achieved with the 1.0 rate (medium label rate) produced as much growth as higher application rates (the May potting date was an exception).



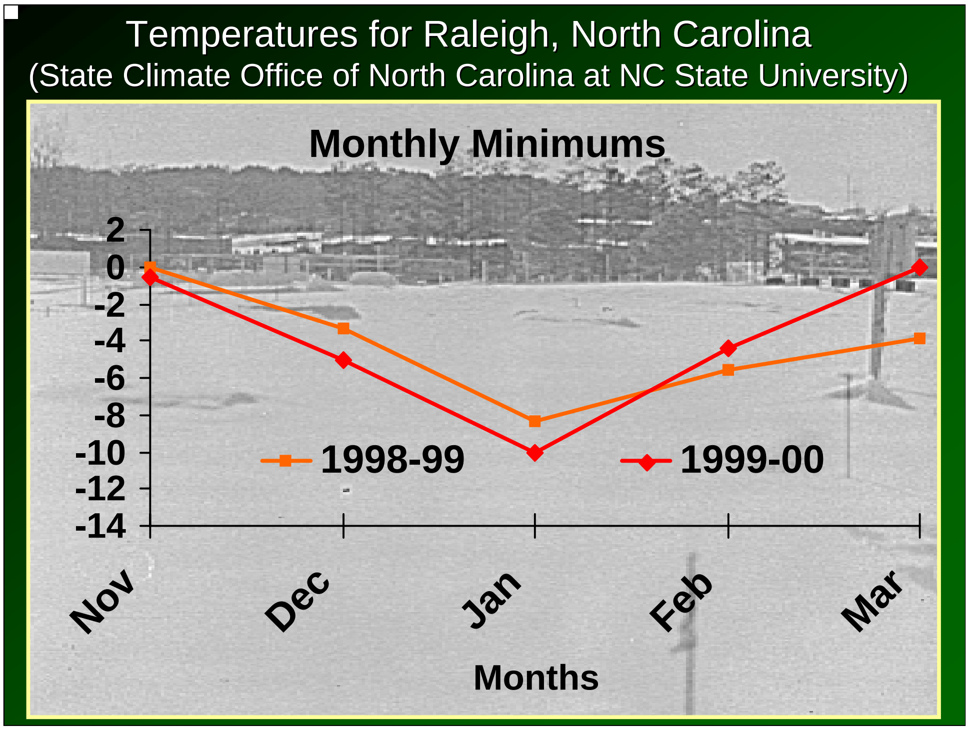
Monitoring EC using the PourThru extraction procedure provides a excellent tracking method to follow nutrient levels in containers. The vertical axis shows EC levels (2.0 is approaching highest levels desired; 0.2 indicates levels below nutrient levels required for growth). The horizontal axis show months after application of fertilizers. For all potting dates except the March potting date, highest EC levels occurred in March (For example, the blue line represents the October potting date, the first EC sample date was November, counting each of the following months the highest peak occurred in March). The peaks correspond to uncovering plants, initiation of irrigation and higher ambient temperatures. The lowest EC levels occurred during the months of November, December and January. Less growth of the March potted plants is explained by EC as well, EC levels never were high enough to enhance growth compared to other pot-up dates. The data also shows that when ambient temperatures are low (less than 40°F average) and irrigation is not frequently applied, CRF's either do not release nutrients or release at very low levels.



The accuracy of monitoring EC with the PourThru extraction procedure is evident in this slide. The ½ rate fertilizer application (dark blue line) never attained EC levels high enough to enhance plant growth, the peak at 8 months is a response to the remaining ½ rate applied at 6 months. EC levels were exclusive to the rate of fertilizer applied.

Winter Injury ?

No winter injury was noted for any of the potting dates or fertilizer product or fertilizer application rates included in the study.



The lowest temperatures recorded during the two winters during the study were 14º F and 17º F, respectively. Snow cover was experienced for short period during each winter.

Significance to the industry

- Fall potting may give opportunity to match seasonal growth with CRF release
- High fertilizer rates increased growth in March, May and October
- High rates of fertilization did not result in winter injury
- No benefit from split applications

The two fertilizer products used in the study produced similar growth for all rates and pot-up dates. Results indicated that growers can use full CRF fertilizer rates for best growth, regardless of the season of potting.

Comparing Growth of 75 Gallon Nursery Stock Fertilized by Drill & Fill Compared to Top Dress

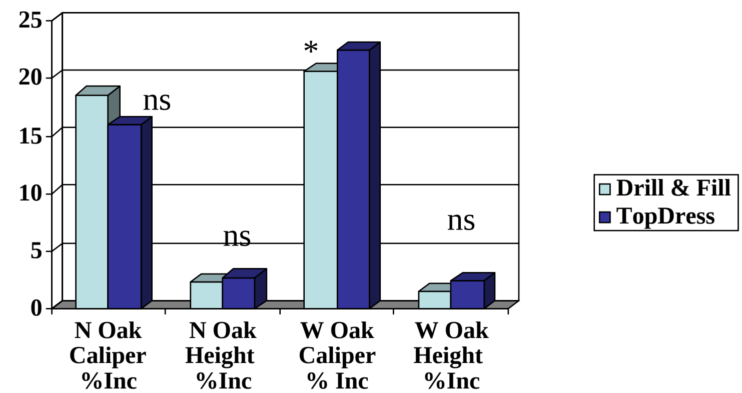
The largest expansion in nursery crop production in recent years has been large container plant production. Growers have become conscious of placement of CRF fertilizers for best plant growth. If fertilizer is incorporated into the potting substrate, much of the fertilizer will be in the lower profile of large containers, ultimately reducing the rate of fertilizer available during the first growing season unless high rates are incorporated. Production practices at some nurseries are not adapted to incorporate fertilizer. Therefore, growers have been experimenting with fertilizer placement and the effect on plant growth.

Comparing Growth of 75 Gallon Nursery Stock Fertilized by Drill & Fill Compared to Top Dress

This study compared topdress application of a CRF compared to drilling 4 holes (North,South,East and West sides of the container) in the backfill soil just beyond the root ball to a depth corresponding to the height of the root ball of the transplanted tree.

At the end of a growing season, tree height and caliper were measured for trees topdressed and for trees fertilized by the “Drill and Fill” method.

Fertilizer Application at TreeSource Nursery



Plant growth was generally the same for both fertilizer application techniques although caliper growth was slightly less for the "Drill and Fill" caliper growth for Willow Oak.

Several university studies have compared topdressed versus incorporation of CRF’s with mixed results depending upon the CRF’s studied and nursery crops included in the studies. No studies had been conducted comparing nutrient leaching associated with these fertilizer application techniques.

Carry over crops from previous seasons, can only be top-dressed (unless fertilized through the irrigation systems).

Top-dressed containers however spill fertilizer if they are turned over. Fertilizer may also be spilled onto the nursery floor during top dress applications or may be blown from the surface of the substrate resulting in increased nutrients in run off from production beds and reduced growth of plants due to low fertility.

Incorporating fertilizer places all the nutrients in the growing substrate. However, not all nurseries have mixing equipment.

The SNA – BMP manual suggests that incorporation of CRF's is a better management practice than top-dress application of fertilizers.

Production conditions

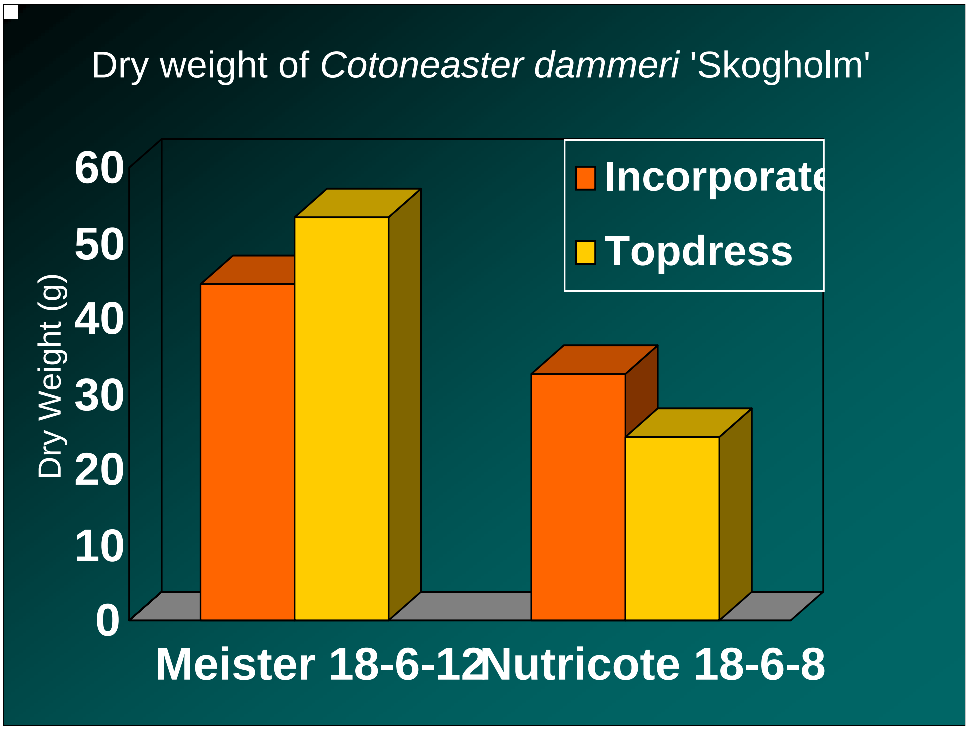
- *Cotoneaster dammeri* ‘Skogholm’
- 1 gallon containers
- 8 pine bark : 1 sand substrate
- 5 lbs / yd^3 dolomitic limestone

Warren and Bilderback conducted a study to compare top-dress versus incorporation of CRF fertilizers.

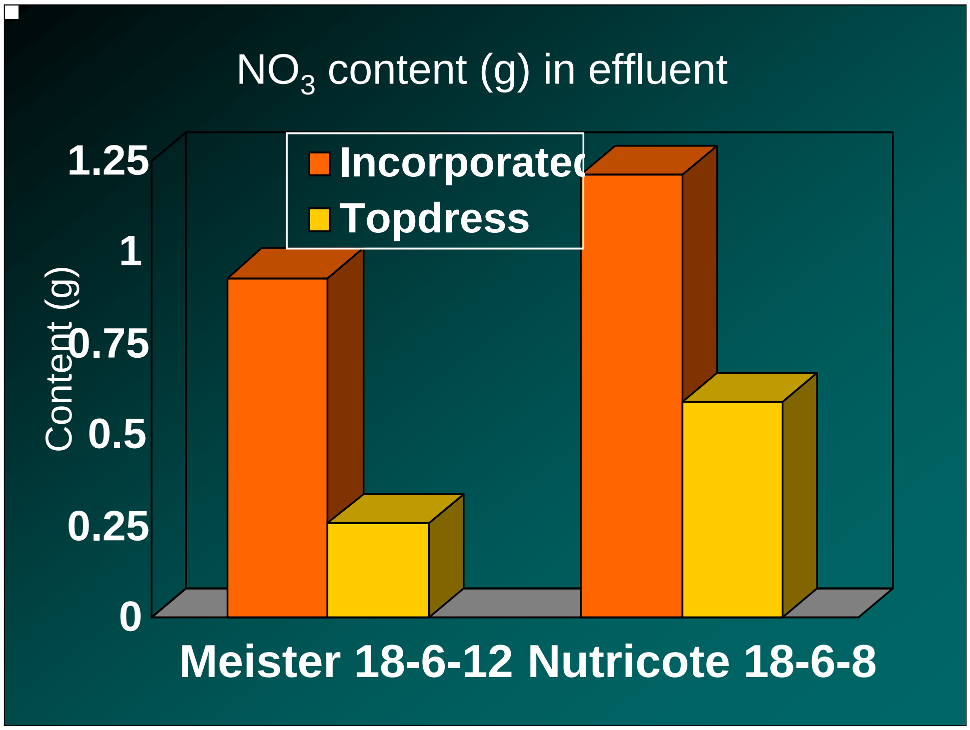
Data collected

- Effluent
  - At 9:00 AM daily, volume of effluent measured, collected, analyzed for NH_4, NO_3 and P
- Plant growth
  - Harvested shoots and roots of cotoneaster

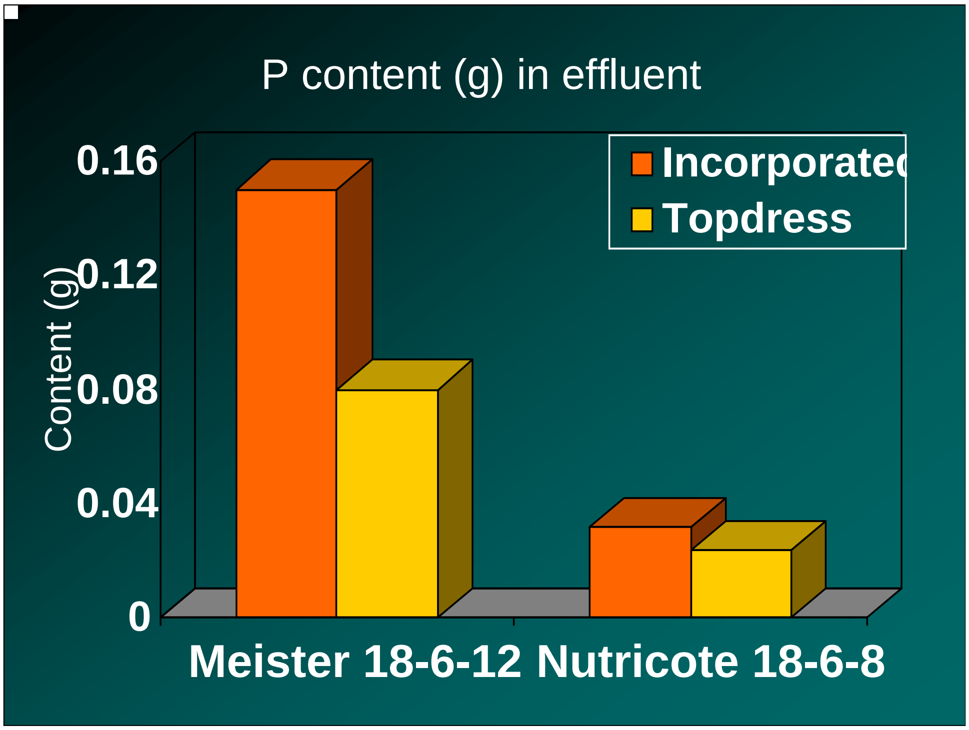
Effluent was collected from top-dressed and incorporated CRF’s during a 100 day study. Leachate was analyzed for 8 effluent samples collected each day during the 100 day study. Plant growth was also compared for the fertilizer application techniques.



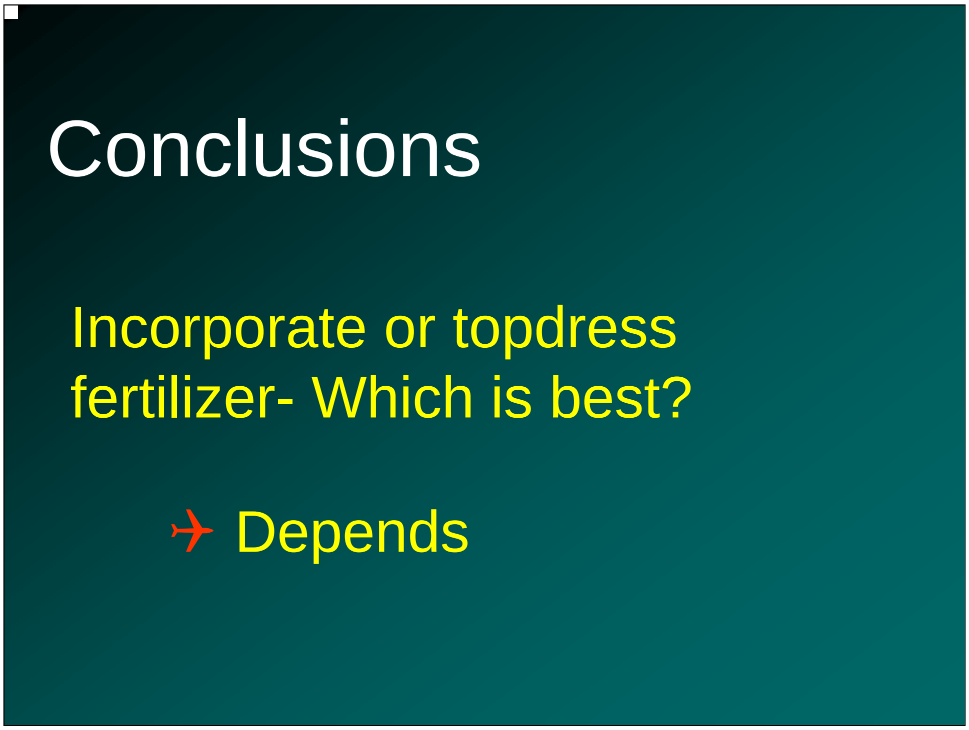
Plant growth was variable depending on which CRF fertilizer was used. These results were similar to previously reported university studies.



Both CRF’s had greater NO_3 concentrations in effluent from incorporated fertilizer compared to top-dressed fertilizer



Phosphorous content in effluents was also greater in incorporated CRF application compared to top-dressed applications.



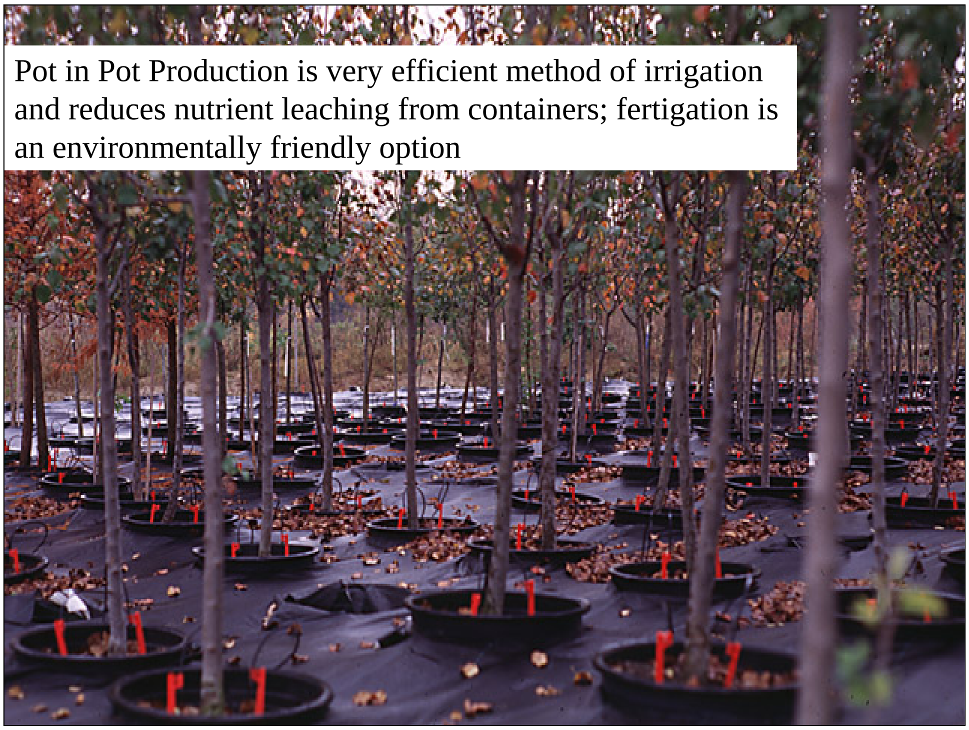
So which CRF application technique is best? It depends on cultural practices of individual nurseries. If spilled fertilizer is a common event at nurseries, incorporation might be more environmentally friendly. This research does emphasize that irrigation management is important and excessive leaching will produce greater concentrations of nitrogen and phosphorus in leachates and effluents leaving nursery production beds.

Facts About Container Production:

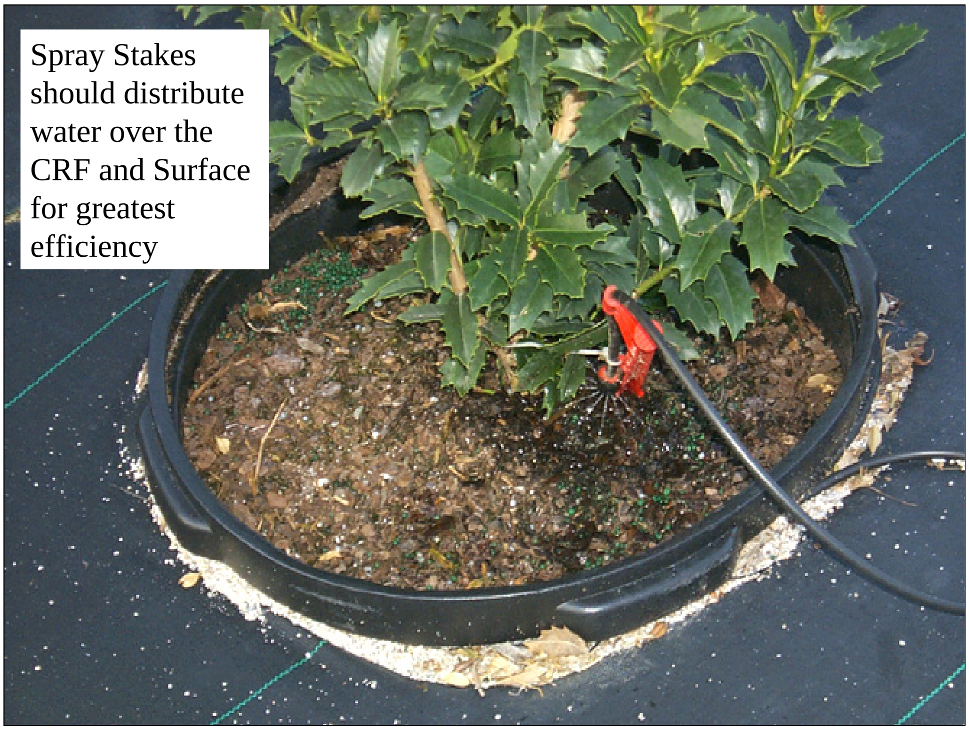
- Absorption into Plant Occurs when Nutrients are Soluble
- Environmental Impact MUST

  address irrigation and runoff
  Strategies

All the studies discussed in this presentation emphasize that nutrient levels in container solution directly influence plant growth. Low nutrient levels reduce growth of plants, high fertilizer rates may not significantly increase plant growth but will increase nutrients lost from containers. Irrigation management is key to manipulating nutrient concentrations in container solutions.



Pot in Pot and production of nursery crops in large containers usually utilize low volume irrigation where water is applied directly to the container substrate surface. The interception efficiency is in theory, 100%, however, if the length of irrigation is not managed, the leaching fraction can far exceed 20%. CRF’s are most commonly used to provide nutrients in large containers, however, fertigation or a combination of CRF’s and fertigation can also be an environmentally friendly if irrigation practices are well managed.



Spray stakes in containers should apply water over as large an area of the substrate surface as possible. Fertilizer placement is also important since CRF's require water for activation and release of nutrients. However, fertilizer should not be placed in a pile in one location as high EC will result directly below the placement and little lateral movement of nutrients will occur across pine bark substrates in the container. Large containers generally require more than one spray stake to accomplish uniform irrigation and nutrient release.

Leachate can be collected from representative containers as a means of monitoring EC, pH and nutrient levels in blocks of large containers.

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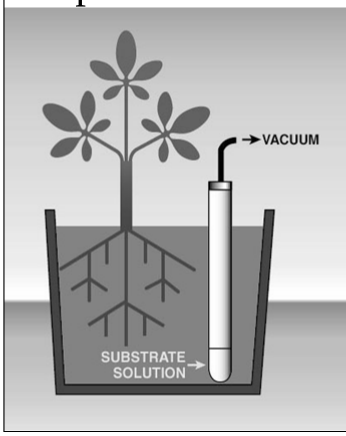

Soil Water Samplers in Horticultural Nursery Use

Nutrient Extraction from Large Containers

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The use of soil water samplers, also called suction cup lysimeters, are suggested for extracting nutrients from large containers (5 gallon and above) since it is a difficult task to elevate relatively heavy containers over a collection vessel. The samplers are installed to the bottom of the container (figure 1) and left in place for periodic sampling of the water in the container. The sampler consists of a porous ceramic cup attached to the bottom of a sampling tube. One to two hours following irrigation a vacuum pump is used to create a vacuum in the sampler, which draws water from the container through the ceramic cup and into the sampler. Adequate water collects in the sampler in 5 to 10 minutes which can be withdrawn with a syringe for subsequent EC, pH or a complete nutrient analysis. Three or four water samplers should be installed within a block of plants of similar size and nutritional program.
Soil sampler model 1900 L24 with a one-half bar air-entry value, vacuum pump 2005G2, and 1000K2 extraction kit are recommended. Other vacuum pumps and extraction methods are also acceptable.

Lysimeters can also be placed in representative containers to track EC, pH and nutrient levels. Various sized lysimeters can be purchased. In addition to the lysimeters, a vacuum pump is also required to pull a vacuum in the lysimeter which then pulls water from the substrate into the vacuum tube. An extraction kit can also be purchased to extract the solution from the tube without removing the lysimeter tube from the containers.

The composite of slides shows steps for installation and extraction of solution from lysimeters. The vacuum pump is seen in the upper right and lower left picture.