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North Carolina State University
North Carolina Association of Nurserymen

Nursery

Short Course

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Developments in *Buddleja* Breeding at NCSU

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The high amount of genetic variability present in *Buddleja* affords considerable opportunity to develop new and novel taxa through controlled breeding. Efforts in our *Buddleja* breeding have focused on compactness, silver-gray leaf color, flower color, sterility, unique architectural forms, and branched-panicle (inflorescence) architecture. Considerable effort has been made hybridizing the yellow-flowered *Buddleja* 'Honeycomb' with various cultivars with the objective of developing yellow-flowered taxa demonstrating more compact growth, greater flower production, and improved panicle architecture. The branched-panicle character presently found only in *B. davidii* cultivar 'Dartmoor' behaves as a recessive trait in controlled hybridizations with cultivars demonstrating normal (non-branched) panicle architecture. We have recovered several selections with cultivar potential from hybridizations with 'Dartmoor'. Efforts have also been initiated in hybridization of the unique compact cultivar 'White Ball' with other color forms in order to develop a series of compact forms demonstrating different colors.

Buddleja has come under scrutiny internationally and in various areas of the U.S. because of its potential for invasiveness. One aspect of addressing this problem is the development of cultivars that are male (pollen) and female (seed) sterile. Progress in this area will be presented.

Currently, we have numerous selections with cultivar potential under advanced trial at NCSU and with selected nurserymen. The characteristics of these most promising selections will be reviewed, and an update on the status of the other breeding objectives will be covered.

Effects of Overhead Irrigation Timing on Container Plant Growth and Substrate Temperature

Carroll Williamson, Drs. Stu Warren and Ted Bilderback

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Introduction

Until recently, irrigation of containerized plants was thought to be best applied during pre-dawn hours. In 2002, studies reported by Warren and Bilderback concluded that microirrigation applied at 12:00 p.m., 3:00 p.m., and 6:00 p.m. produced 63% greater total plant dry weight of *Cotoneaster dammeri* "Skogholm' compared to *C. dammeri* irrigated at 3:00 a.m., 5:00 a.m., and 7:00 a.m. Their results indicated that afternoon irrigation increased growth by reducing substrate temperature and minimizing water stress in the latter part of the day. Since many nurserymen in North Carolina use overhead irrigation, the question was often asked, "Does the timing of overhead irrigation produce the same results as the timing of microirrigation?" The purpose of this study was to determine the answer to that question.

Materials and Methods

Rooted cuttings of *Cotoneaster dammeri* 'Skogholm' were potted into one gallon containers of an 8 pine bark : 1 sand mix. Additionally, four other species, *Gardenia augusta* 'Chuck Hayes', *Rhododendron* 'Sunglow', *Ilex crenata* 'Compacta', and *Juniperus conferta* 'Blue Pacific' were used as comparison. The daily total volume of irrigation to maintain a 0.2 leaching fraction (LF) of *C. dammeri* was divided into three equal parts and applied at the following times: 2:00 a.m., 4:00 a.m., and 6:00 a.m. (predawn); 6:00 a.m., 12:00 p.m., and 6:00 p.m. (all day); and 12:00 p.m., 3:00 p.m., and 6:00 p.m. (PM). Because the other species were in the same plots as *C. dammeri*, they were subject to the same irrigation schedule, regardless of their need. Irrigation was applied overhead and leaching fraction was monitored weekly. Substrate temperatures were measured every 5 minutes in 8 containers per treatment throughout the summer.

Results and Discussion

A total of 40.5 L, 50.5 L, and 37.7 L of irrigation water was applied to predawn, all day, and PM treatments, respectively, resulting in LF's of 0.25, 0.22, and 0.19. *C. dammeri* plants irrigated during the all day treatment had significantly greater top dry weight compared to predawn irrigation. Top dry weight was ≈ 31% heavier when irrigated with PM and all day compared to predawn. Root dry weight was unaffected by irrigation timing. All day irrigation timing had higher water utilization efficiency (WUE) requiring 134 ml per g of plant dry mass compared to 175 ml per g of plant dry mass when irrigated predawn. This is an increase of 23%. Water use efficiency of predawn and PM were similar. This may be a consequence of irrigation water lost to evaporation when irrigating only during the afternoon. This data suggests that if daily irrigation at 0.2 LF is restricted to early morning hours, growth will be significantly reduced compared to plants grown with irrigation applied during the day.

Substrate temperatures reflected significant differences among the treatments. Containers irrigated with PM had significantly lower temperatures from 11:00 A.M. to midnight compared to predawn for most days. This difference in temperature in combination with available water could have a great impact on photosynthesis and subsequent plant growth.

Of the other 4 species, *Rhododendron* 'Sunglow' behaved similarly to *C. dammeri* , but less significantly. Both *J. conferta* and *I. crenata* showed insignificant differences among the treatments. *G. augusta*, however, showed opposite effects from *C. dammeri*. For *G. augusta,* growth was significantly **less** in the PM treatment compared to predawn and all day. Possible explanations for why cotoneaster and gardenia had contrasting growth results will be discussed in the presentation.

Significance to Industry

Overhead irrigation timing at 0.2 LF had a significant affect on plant growth and container temperature. Plants that were irrigated both during the afternoon (12:00 pm, 3:00 pm, and 6:00 pm) and all day (6:00 am, 12:00 pm, and 6:00 pm) significantly outperformed plants irrigated during predawn hours (2:00, 4:00, and 6:00 am). Our data suggests that growers may want to investigate irrigating at times other than early morning. Additionally, the data of the other species suggests that grouping plants according to water needs and maintaining 0.2 LF are as critical to water conservation as timing.

Vermicompost – Potential as Pine Bark Amendment for the Nursery

Michelle McGinnis, Stuart Warren, and Ted Bilderback

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Introduction

Organic material has long been known to aid in horticultural endeavors. One organic material, compost, is often referred to as "gardener's gold". Yes, compost is wonderful in the garden, but it useful when growing plants in containers? A good bit of research has been conducted addressing this question, both with greenhouse and nursery environments. And the answer – it just depends. It depends on the growers operation and it depends on the growers' philosophy.

Vermicompost (VC) is a type of compost in which earthworms transform organic wastes into a stable by-product (vermicompost or worm castings). Livestock wastes are a common "food source" for the worms, but wastes from supermarkets, pulp mills, and beer factories have also been managed by vermicomposting. Many anecdotal reports have been put forth by farmers, gardeners, and horticulturalists as to the beneficial effects of VC on plant growth.

A study was conducted at the NC State University Horticultural Sciences greenhouse to determine if VC is a viable amendment to pine bark substrate to increase plant growth and/or water use efficiency. Most horticultural research using VC has been conducted on greenhouse crops grown in a peat based media. Results of these studies have been mixed, but there seems to be an indication that VC can affect plant growth, but the "magic" has yet to be determined. Previous reports have also stated that increasing VC rates increases container capacity or water holding capacity, but not studies have been conducted to evaluate water use efficiency (WUE).

The scope of the project included an evaluation of VC rates as well as an evaluation on whether the type of fertilizer used affects the response of the VC. The objective of our study was to determine the effect of VC on fertility, pH, growth, water holding capacity, and WUE in a pine bark substrate. The study was a 4 x 5 factorial in a randomized complete block design with six single plant replications. There were four VC rates (0%, 5%, 10%, and 20% by vol.) and five fertilizers (none, 8-5-5, 10-2-8, 19-5-9, and 19-5-13). VC was produced using hog waste as the food stock (Vermicycle Organics, Charlotte, NC). Fertilizers 8-5-5 and 10-2-8 are organic-based (fertilizer nutrients were obtained from naturally occurring materials such as meat meal, bone meal, blood meal, feather meal) (Nature Safe, Cold Spring, KY). The fertilizers 19-5-9 and 19-5-13 are controlled release fertilizers (CFR) (Harrell's, Sylacauga, AL). Fertilizer was applied at a rate of 5 g N per gallon. Dolomitic lime at a rate of 3 pounds per cubic yard was added to the 0% VC treatment. No lime was added to the remaining treatments. Irrigation was managed by irrigating when the container lost 50 to 60% available water (AW) and irrigated to achieve a 0.2 leaching fraction.

Substrate solution was collected weekly on three replications via the pourthrough technique to measure pH and electrical conductivity (EC). Plants were grown for five weeks. On Nov. 12, 2003 plants were harvested and separated into roots, stems, and leaves. Leaf area was obtained on three replications. Plants were dried at 105°F (65°C) for 5 days prior to obtaining dry weights. All data were subjected to analysis of variance and regression where appropriate (SAS Institute, Cary, NC). Treatments means were separated by Fishers protected LSD, $P = 0.05$.

Results and Discussion

The no fertilizer treatments produced very small, unsalable plants, as indicated by the total dry weight (Table 1). Electrical conductivity indicated low soluble salts in the substrate solution of the no fertilizer treatment (data not shown), thus, we concluded that Vermicycle VC alone did not provide adequate fertility to grow a containerized basil crop. The 5% VC treatment dry weights had significantly less growth compared to 0%, 10%, and 20% treatments (data not shown). The cause for the response is not clear, however, it is suspected that low substrate pH in the 5% treatments contributed to the lack of growth, particularly with the organic fertilizers, thus, we concluded that a 5% Vermicycle VC rate is not sufficient to raise the pH of an aged pine bark. Based on the above two points indicating that no fertilizer and 5% VC groups are in a different population than the rest of the plants (a population with inadequate pH/fertility for healthy plant growth), these two groups were removed from the dataset.

Basil growing in the 20% VC rate showed a significantly greater growth response than basil grown in the 0% or 10% VC rate (Table 2). These results are consistent with other reports that VC increases plant growth. However, the "magic" has not been determined. Possible variables associated with the VC that may be responsible for increase growth include fertility, pH adjustment, substrate physical properties, microbial activity, and/or organic matter components.

The 20% VC rate significantly increased WUE (Table 2). The 20% VC rates used a total average 100 ml less water per plant per gram of dry tissue than the 0% and 10%. This translates into an approximate 350 ml less water per plant (1 qt container) in a five week period. Data herein suggest that VC has potential for increasing water and nutrient efficiency in the nursery. If similar results are observed during studies with nursery crops, amending nursery substrate with VC could result in significant water savings at nurseries.

Table 1. Mean of total dry weight[z] of basil plants after five weeks

Fertilizer	Vermicompost Rate (% by volume)			
	0%	5%	10%	20%
None	0.26	0.25	0.75	0.24
8-5-5	3.67	1.72	2.72	3.01
10-2-8	2.91	1.45	3.16	3.23
19-5-9	3.91	3.42	4.03	5.24
19-5-13	4.16	3.87	4.37	5.11

[z]Total plant dry weight = leave + stem + root.

Table 2. Effect of vermicompost rate on total plant dry weight and water use efficiency.

Rate of Vermicompost (% by volume)	Total dry weight[z] (g)	Water Use Efficiency (WUE)[y] (ml/g)
0	3.7 a[w]	796 a
10	3.6 a	788 a
20	4.3 b	694 b

[z]Total plant dry weight = leave + stem + root.
[y]WUE = millliters water ÷ g total dry mass.
[w]Means within columns followed by the same letter are not significantly different as determined by Fisher's protected LSD, $P = 0.05$

Pine Bark Substrates: Addressing the Age-Old Topic

Tiffany Harrelson, Stuart L. Warren, and Ted E. Bilderback

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Why Age Matters
Research has reported reduced plant growth with fresh bark due to competition for nitrogen. Does this mean plants need more N when planted in fresh bark? Also, available water in fresh pine bark averages 10% to 15% (by volume), whereas available water in aged pine bark averages 25% to 35% (by volume). Does this mean growers need to irrigate plants grown in fresh bark more than plants grown in aged bark? Limited studies have been conducted to further investigate these issues.

With the increase in nursery production in North Carolina over the past ten years, there have been, and will be times, when fresh pine bark may be all that is available for nursery substrates. How does this affect plant production? Should plants grown in fresh bark substrates be managed differently than plants grown in aged bark substrates?

Chemical Properties
During the aging process, several major changes occur in pine bark. First, the C/N ratio decreases from as high as 300:1 for fresh pine bark to 80:1 for aged pine bark (Bilderback, personal communication). This reduction in C/N ratio reduces the substrates need for nitrogen. This should allow the majority of N from the fertility program to be available for plant growth. In addition, as pine bark ages, there is a dramatic shift in its physical properties.

Physical Properties
As bark ages, the percentage of larger particle sizes decreases with a subsequent increase in smaller particle sizes. From some of our preliminary data, bark particles less than 0.5 mm increased from around 15% - 20% to 25% - 35%. This change in particle size distribution changes the physical properties of pine bark with the biggest change occurring in available water and wettability.

As pine bark ages, it becomes less hydrophobic or water resistant and begins absorbing moisture within each particle. These changes increase available water from fresh pine bark which averages 10% to 15% (by volume), to 25% to 35% (by volume) in aged pine bark. This could have profound effects on growers' irrigation scheduling.

Managing Your Age
To grow high quality plants in fresh or aged pine bark, growers may need to adjust their fertility and/or water regimes. This research sought to answer some of these questions. The nature of this project was to determine what role the age of pine bark plays in determining both the chemical and physical properties of nursery substrates.

Research at the NCSU Horticulture Field Lab, Raleigh in 2003 compared growth of 'Skogholm' cotoneaster in aged and fresh pine bark using three rates of fertilizer, high, medium and low. Leaching fractions, LF, were measured weekly, and irrigation volumes adjusted to achieve 20% LF. Particle size of each bark was determined at the beginning and end of the experiment. Electrical conductivity and pH were monitored throughout the study as well as C:N ratios.

Conclusions from 2003

Top dry weight and total plant dry weight of cotoneaster grown in aged pine bark were 12% larger than cotoneaster grown in fresh pine bark (data not presented). Root dry weight and root : top ratio were unaffected by age of bark. The reduction in growth in fresh pine bark may have been due to differences in physical properties.

Container capacity and available water in aged pine bark were significantly greater than fresh pine bark throughout the study (Table 1). This was also reflected in the volume of irrigation water required to maintain a 0.2 LF in each bark (Fig. 1). With the increase in available water, AW, aged pine bark required greater volume of water. Plant growth may have been limited by available water content in fresh pine bark.

The lowest rate of N produced significantly smaller tops and total plant dry weight than the medium and high rates of N. The high rate of N did not produce bigger plants compared to the medium rate of N. Thus, plants grown in fresh pine bark did not appear to need additional N to maximize growth. This may be due to differences in pine bark.

On most sample dates, EC increased with increasing rate of fertilization, whereas EC was unaffected by age of bark. Age of bark and rates of fertilization had little effect on substrate pH with the pH ranging between 6.1 and 6.4 throughout the study (data not presented).

Table 1. Effect of age of bark on physical properties.

Bark	Total Porosity (%)	Air Space (%)	Container Capacity (%)	Available water (%)	Unavailable water (%)	Bulk density (g/cm3)
		Prior to treatment initiation (pine bark substrate)				
Aged	87.3 a	25.2 b	61.1 a	26.3 a	35.8 b	0.19 a
Fresh	88.3 a	39.3 a	49.0 b	9.8 b	39.2 a	0.17 b
		56 days after treatment initiation (8 pine bark : 1 sand substrate)				
Aged	82.8 b	25.9 b	56.9 a	22.7 a	34.3 a	0.32 a
Fresh	85.4 a	36.3 a	49.1 b	15.8 b	33.3 a	0.32 a
		336 days after treatment initiation (8 pine bark : 1 sand substrate)				
Aged	74.9 b	17.0 b	57.9 a	30.0 a	27.9 b	0.35 a
Fresh	80.1 a	24.9 a	55.2 b	22.3 b	32.6 a	0.35 a

yMeans within columns and weeks after treatment initiation followed by the same letter are not significantly different as determined by Fisher's protected LSD, $P = 0.05$.

Lessons Learned

'Skogholm' cotoneaster grown in fresh pine bark was significantly smaller than cotoneaster grown in aged pine bark. The reduction in growth did not appear, however, to be due to a competition for N. Additional N did not increase plant growth in fresh bark. The reduction in growth in fresh bark may have been due to differences in container capacity and available water. Container capacity and available water in aged pine bark were significantly greater than fresh pine bark throughout the study. Growers using fresh pine bark do not need any additional fertilizer but may need to be very diligent in maintaining adequate water within the substrate. This may require applying less water more frequently.

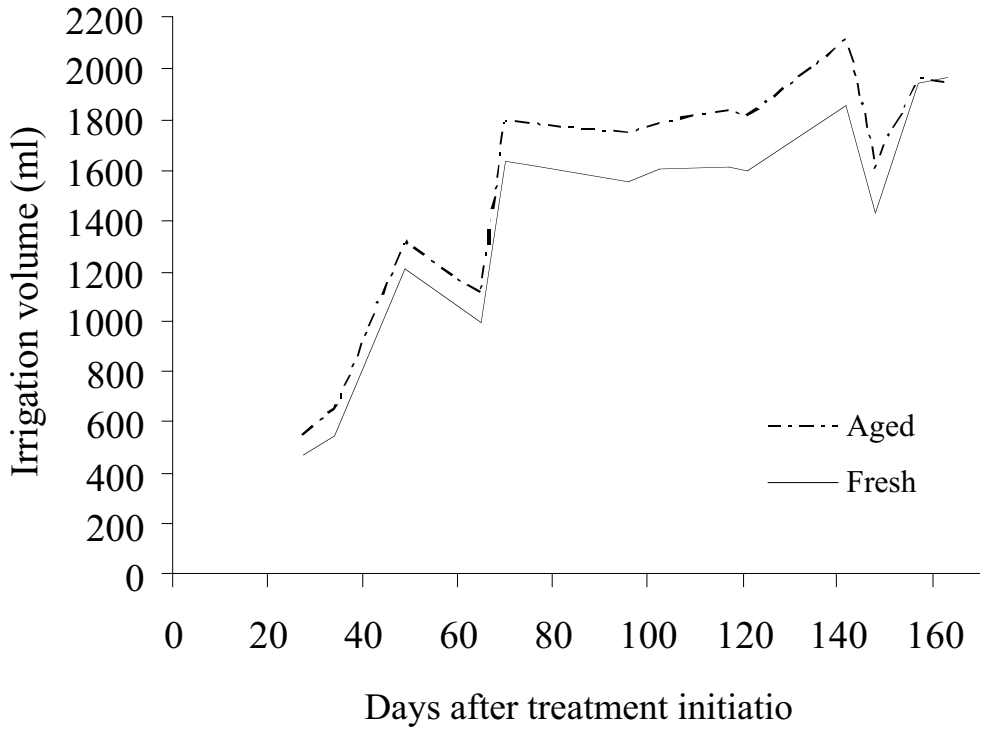

Fig. 1. Effect of age of bark on irrigation volume required to maintain 0.2 leaching fraction.

Clay Substrate Amendment Saves and Pays!

James S. Owen, Jr.

North Carolina State University Department of Horticulture Science

Soilless substrate is the 'green' industry standard for growing ornamental plants, yet soilless substrates do not offer the nutrient retention or water buffering capacity provided by soil. Clay minerals and humic matter are the dominant soil components that provide these beneficial attributes. With little nutrient or water buffering capacity, high water and nutrient inputs are required to yield a salable plant quickly.

The majority of containerized nursery crops in the United States are grown in bark based container substrate (West Coast and Eastern United States). Pine bark, common in the Eastern United States, when combined with frequent irrigation and high fertility levels produces rapid plant growth. However, environmental concerns and water restrictions are forcing growers to rethink production practices, particularly, in regards to water and fertilizer usage. Due to pine bark's limited water and nutrient buffer capacity, growers cannot simply reduce water or fertilizer usage without sacrificing plant growth and quality. Modifying container substrate to increase water and nutrient buffering capacity might increase water and nutrient efficiency.

Prior to 2002, there were seven research studies focused on adding clay to soilless container substrate in the United States. Of those only two looked at clay and bark combinations. The remaining five were with peat based substrate. In addition, the research done with clay in Europe was with peat. Therefore, it was not surprising that little was known about using clay in bark. Prior to 2002, the most detailed study had been conducted with arcillite (a calcined montmorillonite and illite clay) by Warren and Bilderback in 1992. Arcillite was incorporated into pine bark with rates from 0 to 136 lbs/yd3. Container capacity, available water, and bulk density increased with increasing rate of arcillite. Substrate NH_4, P, and K concentrations increased with increasing arcillite rate suggesting that arcillite improved retention within the container substrate. Plant growth increased curvilinearly with arcillite rate, with maximum dry weight occurring at 112 lbs/yd^3.

The value of adding clay to soilless substrates has been debated for years. Even though amending soilless substrates with clay has many potential benefits, there was little empirical evidence to answer this question. 'Clay' is often used generically to describe soils that have high water and nutrient holding capacity. Clays, like soils, are not the same due to differences in physical and chemical properties as a result of handling, source, and packaging. The effectiveness of clay will differ with type (2:1 versus 1:1), handling (temperature treatment, particle size), and source or location mined (chemical composition). The type of clay and heat treatment (pasteurized or calcined) are important factors affecting water holding capacity and available water content, thus determining water buffering capacity. These factors, in addition to the chemical composition and particle size, determine phosphorus retention in the substrate and availability to the plant.

Phosphorus retention is a function of the abundance of exposed aluminum and iron oxides which can be a result of handling, source, and type of clay. Therefore, it is misleading to simply talk about 'clay' soils. Will any clay soil improve the water and nutrient capacity of a soilless substrate? That led us to begin looking at the differing types of clay, particles sizes, and heat treatments to see how these factors might affect the response of clay amended pine bark substrates.

An international research conference in 2001 re-ignited our interest in using clay as an amendment with pine bark substrates. Research conducted in the Netherlands suggested that clay as a peat substrate amendment was worth the additional cost and that particle size along with the type (2:1 and 1:1) of clay had an impact on the effect of clay.

In 2002, we examined several types of clay in combination with several particle sizes and heat treatments [calcined (~800 F) or pasteurized (~250 F)] as a pine bark amendment. Most 2:1 clays treatments increased water and nutrient buffering capacity compared to the 8 pine bark : 1 sand substrate. However, there was a wide range of results. Cumulative water applied to the substrate amended with small (24-48 mesh) or large (4-20 mesh size) particle size clay was ~ 6 and 3 gallons less, respectively, than the 8 pine bark : 1 sand substrate. This translates to 100,000 to 200,000 gallons per growing acre per season. Even though the clay amended substrates required less water, plant growth was not affected since *Cotoneaster dammeri* 'Skogholm' root and shoot dry weight were similar in all treatments. In addition to water savings, the 2:1 clays gave us increased phosphorous retention, with maximum retention being obtained from the small particle size, calcined clay amended pine bark substrate.

The increased water and nutrient buffering capacity of a clay amended pine bark substrate could allow growers more flexibility in cultural management. This could allow nurseries to incorporate best management practices (BMP's) while maintaining maximum plant growth, making the BMP's a more attainable goal.

Calcined Clays and Phytophthora Root Rot in Pine Bark Substrates

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Calcined clays are under investigation as a component of nursery potting mixes where water retention and frequency of irrigation are an issue in plant production. With the increased water holding capacity of pine bark potting mixes amended with calcined clays the question arises "Are plants grown in mixes with calcined clays more susceptible to Phytophthora root rot?"

What was done?
Two types of calcined clays (Oil-Dry Corp. America, Chicago) were evaluated as amendments at 8% to a pine bark mix in 2003. One was RVM clay a low temperature formulation heated to 192 – 212 F that tends to clump with addition of water. The second was LVM a high temperature formulation heated to more than 570 F that does not clump with addition of water. These clay types were compared to a pine bark (6) – sand (1) standard mix. To evaluate the effect of these two calcined clays on development of Phytophthora root rot caused by *Phytophthora cinnamomi,* Hinodegiri azaleas were potted in pine bark mixes amended with the clays in June 2003. Plants were inoculated on 17 June, by placing three rice grains colonized with *P. cinnamomi* in each of three 3-cm deep holes around the root ball of the transplanted liner. Later that same day, Subdue Maxx (1 fl oz/100 gal) was drenched in a volume of 250 ml per pot (#300) to a sub-set of each clay type mix or the pine bark – sand mix standard. There were 10 replications in a randomized complete block design. Plants were top-dressed with Willbro 16-5-10 at 0.08 oz per pot. Sprinkler irrigation twice a day provided about 0.9 in/day. The Subdue Maxx drench was re-applied on 25 August. Plants were rated for foliar symptoms of Phytophthora root rot throughout the summer on a scale of 1 = healthy foliage, 2 = slight chlorosis, 3 = moderate to severe stunting and chlorosis, and 4 =dead plant. At the end of the experiment on 22 September, plant fresh top weight was measured and the roots were rated for root rot. The root rot rating scale was 1 = healthy roots, 2 = fine roots necrotic, 3= coarse roots necrotic, 4= crown rot and 5 = dead plant.

Results and Discussion.
Foliar symptoms of Phytophthora root rot were evident on azaleas in the two clay mixes and the standard pine bark – sand mix 6 wk after inoculation with *P. cinnamomi* and progressed throughout the summer (Fig. 1). However, use of the fungicide drench slowed but did not prevent development of Phytophthora root rot in all three mixes. By the end of the experiment, plants inoculated with *Phytophthora* produced unsaleable plants with the most root rot regardless of potting mix. No difference in top weights and root rot ratings among the pine bark –clay mixes and the pine bark – sand mix were found for these plants (Fig 2-3). It was a wet summer in Raleigh in addition to the regular irrigation of 0.9 in/day; conditions that were very favorable for Phytophthora root

rot. Amendment of pine bark with the calcined clay did not result in more root rot than that observed in the standard pine bark – sand mix and thus it does not appear that calcined clay amendments enhance Phytophthora root rot. Additional experiments are planned for 2004 to look at the effect of the clay amendments in mixes on Phytophthora root rot where plants are grown under low and high irrigation regimes.

Significance to the Industry.
From a disease perspective, the use of calcined clay amendments to pine bark potting mixes did not result in more severe development of Phytophthora root rot than what was observed in a standard pine bark –sand mix.

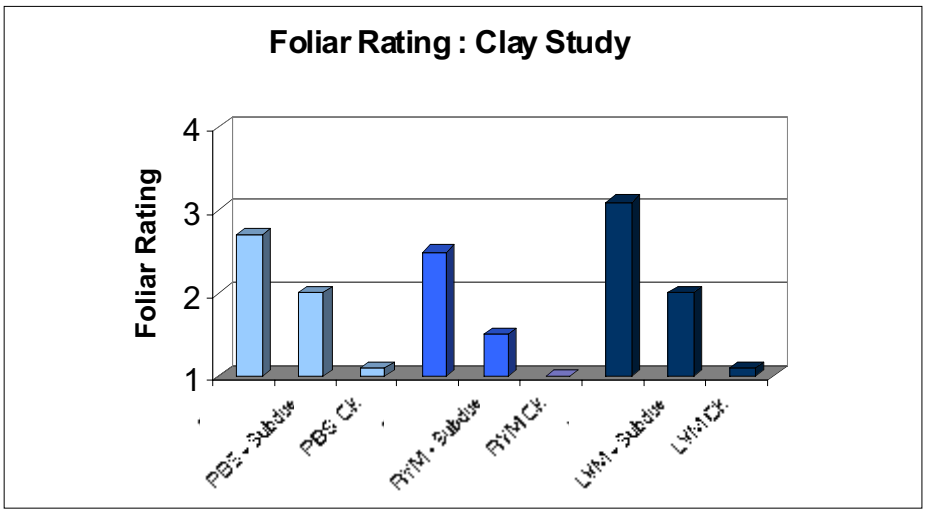

Figure 1. Foliar ratings for Phytophthora root rot on Hinodegiri azalea on 21August. See text for rating scale. PBS, RVM (RYM in figure) and LVM are plants inoculated with *P. cinnamomi* in mixes with pine bark- sand (PBS) or pine bark amended with the RVM-clay or LVM-clay, while PBS + Subdue, RVM + Subdue and LVM + Subdue are plants drenched with the fungicide. PBS CK, RVM CK, and LVM CK represent azaleas grown in the absence of *Phytophthora* across the three mixes.

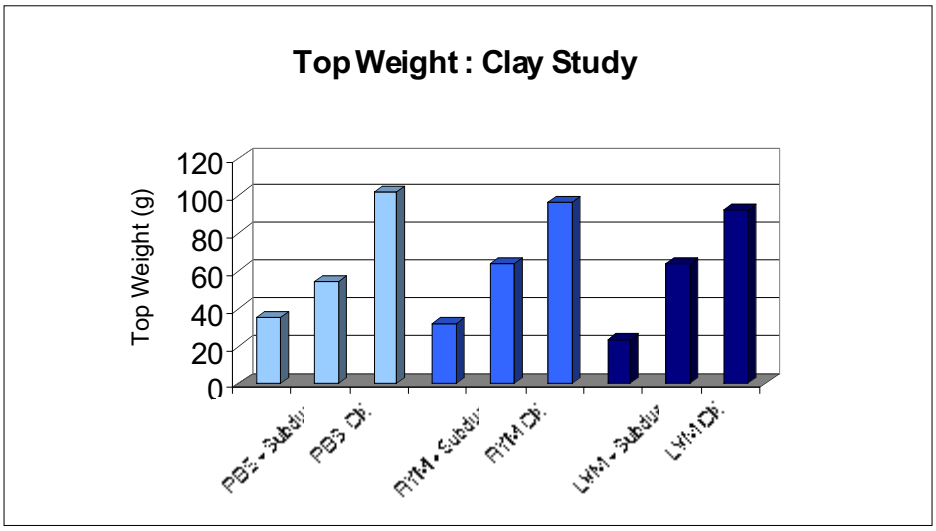

Figure 2. Top weight of Hinodegiri azalea on 22 September. See figure 1 for symbol key.

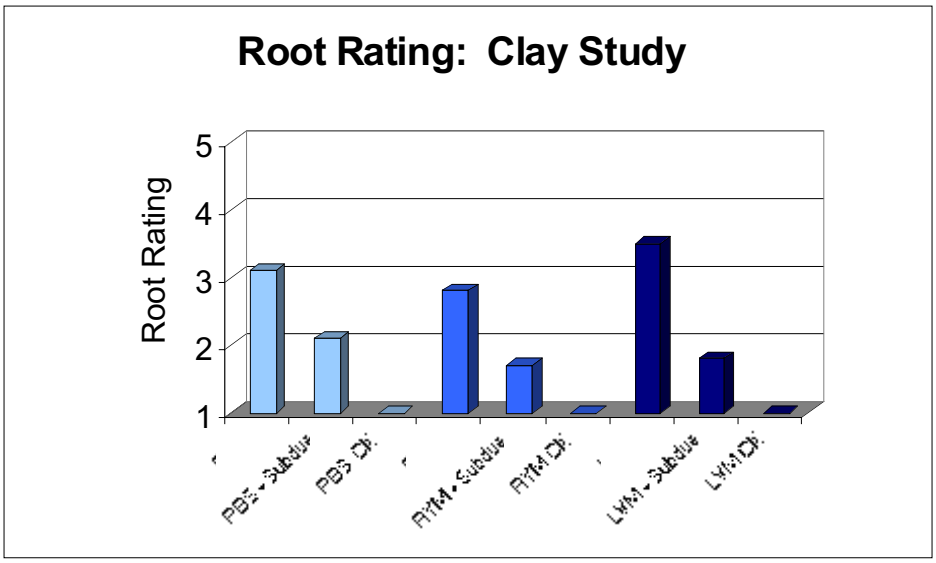

Figure 3. Root rot ratings for Hinodegiri azalea on 22 September. The root rot scale was 1 = healthy roots, 2 = fine roots necrotic, 3= coarse roots necrotic, 4= crown rot and 5 = dead plant. See figure 1 for symbol key.

Green Industry Opportunities in Bioretention

Cliff Ruth

Area Agricultural Extension Agent, NCCES

Water is the most precious of all our natural resources. It is the life blood of the green industry. Protecting the quality of this resource is imperative for all of us. One way to help protect our water resources is through the use of Bioretention areas.

Bioretention areas can be either classified as “constructed wetlands”, rain gardens, or simply planted ditches that are planted with native, water, loving plants to capture and filter the runoff from nurseries, parking lots, roof tops, or other impervious surfaces. These areas can be used in conjunction with any other landscaping to provide places of ornamental interest as well as protect our water quality and recharge our aquifers.

Bioretention areas have be used successfully in nurseries to capture runoff from the growing areas and filter it prior to its entering an adjacent stream. Similar structures have been used in landscape settings to capture storm water runoff from parking lots and large roof tops. Rain gardens are modified Bioretention areas that are frequently used in home landscapes to capture rain water from gutters or patio areas. They also fill a niche where water tends to puddle in low lying areas, allowing an array of beautiful plants to be used, that tolerate infrequent flooding.

A list of plants typically used in constructed wetlands/rain gardens could take several pages to discuss. However one must become acquainted with many of the plants that are found in these ecosystems to truly appreciate their qualities and attractiveness. A well built, constructed wetland doesn't need to be just another "patch of weeds" but can be a collection of attractive plants in a simple but naturalistic garden design.

Several attractive ornamental plants have wetland origins and work well in constructed wetlands, aiding in the filtration of excess nutrients and other pollutants from our streams. Indeed many of these plants have such a high eye appeal that in season they can cause the wetland area to be the most enjoyed focal point of a nursery or landscape.

Here are a few native plants that one should consider in constructing a wetland area in their nursery or landscape. Plants indigenous to wet areas should be identified in your part of the state of country before making your choices. Before non-native plants are used, please consider their tendencies to become invasive. Potentially invasive wetland plants should not be used.

Trees

Acer rubrum- Red Maple- D. Colorful leaves in the fall, red flowers in spring
****Alnus serrulata***- Tag Alder- D. Interesting brown fruit and yellow catkins

Asimina triloba- Paw Paw- D. Attractive fall foliage, maroon flowers, edible but unusual fruits
Cornus alternifolia- Pagoda Dogwood- D. Interesting bark structure, white flowers in spring followed by deep blue fruit.
Betula nigra- River Birch- D. Attractive exfoliating bark
Cornus amomum- Silky Dogwood- D. Easily propagated from live stakes, good red stems, white flowers in spring and attractive blue fruits in fall
****Liquidamber styraciflua***- Sweetgum- D. A deciduous tree with a kaleidoscope of fall colors
****Nyssa aquatica***- Swamp tupelo- D. Good deep maroon fall color
Platanus occidentalis- Sycamore- D. Large leaves, attractive structure and patchwork quilt bark
****Salix nigra***- Black Willow- D. Easily rooted, yellow fall color, attractive catkins turn lemon yellow with slight fragrance
****Taxodium distichum***- Bald Cypress- D. Interesting feathery foliage turns apricot orange in fall

Shrubs:
Callicarpa americana- American Beautyberry- D. Attractive fall fruit in purple, white, and pink
Cephalanthus occidentalis- Buttonbush- D. Attractive white flowers, yellow fall color
Hibiscus moscheutos- Rose Mallow- D. Large flowers in summer in pink or white, cultivars in maroon-red
Ilex decidua- Possumhaw- D. Attractive red fruit in late fall to early winter
Ilex glabra- Inkberry - E. Attractive green foliage with white or black fruits
Ilex verticillata- Winterberry- D. Similar to Ilex decidua but larger red fruits
****Itea virginica***- Virginia Sweetspire- D. Attractive fragrant flowers, deep maroon fall foliage
Physocarpus opulifolius- Ninebark- D. Easily propagated, interesting exfoliating bark, attractive spirea-like flowers
****Rhododendron viscosum***- Swamp Azalea D. Fragrant white to occasional pink flowers
Rosa palustris- Swamp Rose- D.-E. Attractive pink flowers- single petaled roses in May-June
****Sambucus canadensis***- Common Elderberry- D. Attractive White flowers in May, dark blue-black fruit in fall used in jellies, wines, medicine
****Spireae latifolia***- Meadowsweet- D. Pink flowers in Spring
****Spireae tomentosa-*** Hardhack- D. Similar to above but darker pink flowers

Herbaceous Plants:
****Asclepias incarnata***- Swamp milkweed-Pink to white flowers- Mid to late summer
****Carex crinata-*** Fringed sedge- Golden fringed seed heads
Chelone glabra- Turtlehead- Pink to purple flowers- mid to late summer
Eupatorium fistulosum- Joe-pye-weed- Mauve to pink flowers- mid to late summer
Impatiens capensis- Jewelweed- Yellow to orange flowers- June-August
****Iris versacolor***- Swamp Iris- Flags in several shades of blue-lavender, late April to May)

******Juncus effusus***- Soft Rush- Soft round stems with a star-like seed structure
Lobelia cardinalis**-** Cardinal flower- Deep red flowers- flowers in late summer
Panicum virgatum- Switchgrass
****Pontedara cordata***- Pickerelweed
****Scirpus. sp*****.** Bullrush
Veronia noveborecensis**-** Ironweed- Deep blue-purple flowers in fall

* Plants with asterisks are more suited to constructed wetlands

Consider growing some of these to fill a special marketing niche. State Storm Water rules and legislation will increase the demand for the use of Bioretention areas in landscapes, remediation areas, and in urban settings. These areas will require several plants to fill this need.

2004 ECONOMIC OUTLOOK GROWTH IS BACK

M.L. Walden

William Neal Reynolds Distinguished Professor and Extension Economist

The National Economy: Finally, Jobs Will Return

Recent Challenges

The national economy grew in 2003 for the second straight year. Indeed, the recent national recession is now dated from March to November, 2001. After stalling in 2001, the broadest measure of national economic activity, real U.S. Gross Domestic Product, is calculated to have increased 2.2% in 2002 and 3.1% in 2003 (Table 1). Yet the expansion in the economy has not been strong enough to generate job growth. While the national unemployment rate declined in 2003, the drop in the jobless rate was entirely due to "discouraged workers" leaving the labor force and not being included in the unemployment numbers.

In addition to the slow recovery from the recession, two other factors have restrained employment growth. One is the continuing rise in labor productivity. Although this is a desired trend for the long run and a trend that should lead to higher living standards, in the near term improvements in labor productivity have allowed businesses to expand production with the same number of workers, or fewer.

Second, the recent acceleration in employer-paid benefit costs has increased the cost of labor to businesses even while wage and salary increases have been modest. As a result, total compensation costs (including wages, salaries, and benefits) per employee have increased even while the labor market has remained slack.

Both industrial production and real (inflation-adjusted) personal income recorded better growth rates in 2003 compared to the previous year. Motivated by generation-low interest rates, households increased purchases at retail outlets faster than the increase in their personal income. Consequently, relative household debt loads edged higher in both 2002 and 2003. Some economists think this portends trouble for the future, both from the viewpoint of individual debt-laden households and from the "drag" that household debt will put on future retail purchases.

The inflation rate, measured by the percentage change in the Consumer Price Index, continued to be mild, hovering around 2%. The rate was under 2% in 2002 and modestly above 2% in 2003. However, a large part of the rise in prices in 2003 was driven by higher gasoline prices. Excluding food and fuel prices, the inflation rate in 2003 was only 1.4%.

Interest rates continued their decline to generation-low levels in 2002 and 2003. The decline slowed for short-term rates (the 3 month T-bill rate) but accelerated slightly for long-term rates (the10 yr. T-note rate) in 2003.

The most dramatic turnaround in the economic numbers presented in Table 1 is the change in the stock market, as measured by the S&P 500 Stock Price Index. After falling 27% in 2002, the market came roaring back in 2003 with a 35% gain. If the stock market is a barometer of future economic activity, then the market's jump in 2003 can be interpreted as a return of confidence in the business community and a forecast that a new economic expansion is underway.

Table 1. Key U.S. Economic Measures

	2002	**2003**	**2004 Forecast**
Real U.S. GDP[a]	2.2%	3.1%	4.5%
Employment[a]	-0.4%	0.0%	2.5%
Unemploy. Rate	6.0%	5.7%	5.2%
Industrial Product.[a]	1.4%	2.3%	6.0%
Real Personal Inc.[a]	0.8%	1.0%	3.0%
Hsehld. Debt Serv.[b]	0.01% pts.	0.01% pts.	0.02% pts.
Real Retail Sales[a]	3.4%	3.1%	3.5%
CPI Inflation Rt.[a]	1.6%	2.3%	2.3%
3 Mon. T-bill Rate[b]	-1.8% pts.	-0.6% pts.	0.6% pts.
10 Yr. T-note Rate[b]	-0.4% pts.	-0.6% pts.	0.4% pts.
S&P 500 Stock Ind.[a]	-27%	35%	12%

[a] Percentage change
[b] Change in percentage points
Sources: U.S. Dept. of Commerce, Federal Reserve System, author's forecasts

What's in Store for 2004?

National economic growth is expected to accelerate in 2004. Two factors are behind the projected faster growth. First, the two economic polices controlled by the federal government - monetary policy and fiscal policy - have been stimulative in recent years. Aggressive monetary policy has reduced interest rates and increased the money supply. Equally aggressive fiscal policy has resulted in federal tax reductions and significant increases in federal spending. Both these policies will continue to fuel the economy in 2004.

Secondly, business inventories have been reduced to such low levels that increases in production will be necessary to meet buyers' demands. Also, with low interest rates and low inflation, businesses will find it relatively inexpensive to expand.

Average real U.S. Gross Domestic Product (GDP) growth of 4.5% in 2004 should be strong enough to increase national employment by 2.5%, or 3.5 million jobs. Consequently, the national unemployment rate will fall to near 5%, and both industrial production and real household income will expand at more than twice their rates in 2003.

However, historically high household debt levels will restrain consumer retail spending to only marginal improvements in 2004, compared to 2003.

The inflation rate will remain near a modest 2% level in 2004. Yet, with a faster growing economy, both short and long-term interest rates are expected to rise, especially after mid-year. The rise in short-term rates will be larger, meaning the "yield curve" (the difference between short and long-term rates) will flatten. Reflecting a growing economy, the stock market should rise in 2004, but at about one-third the rate in 2003. Most of this increase could take place in the first half of 2004, before the upward trend in interest rates.

What Could Go Wrong?
There are always risks to economic forecasts, so it's useful to ask what could derail continued economic growth in 2004.

At the top of the list would be unexpected major terrorist attacks on U.S. interests, either domestically or abroad, that would shatter business and consumer confidence. Also, with federal economic policy already highly stimulative, there's the added concern that little short-run economic action could be taken by the federal government to counter the shocks of terrorist attacks.

The level and direction of oil prices are also concerns. At the beginning of 2004, world oil prices stood above $30/barrel, far higher than analysts had expected in the post-Iraqi War period. Further increases in oil prices would reduce expected economic growth. Futures markets, however, suggest declining oil prices during the year.

As the world has become more commercially interrelated, economic problems can be more easily transferred between countries. The emerging economic powers China and India have enjoyed very high growth rates in recent years. Some economists worry that "speculative bubbles" have developed in these countries, and if so, their "bursting" could have negative consequence for both the world and U.S. economies.

Last, some economists are beginning to caution that recent low inflation rates may not persist. The recession-busting monetary policy of the Federal Reserve has resulted in large increases in the nation's money supply. Past experiences with similar policies show that they ultimately can result in faster increases in prices - that is, a higher inflation rate - perhaps not this year, but next year and beyond.

The North Carolina Economy: Growth with Challenges

The North Carolina economy continued to struggle in 2003. Growth in both real personal income and real retail sales was modest and slower than for the nation. North Carolina did eke out a very small increase in employment, but the state unemployment rate continued to be higher than the national rate in 2003 (Table 2).

By many measures, North Carolina has been more adversely affected by the national recession and its aftermath than most other states. One reason is the concentration of manufacturing facilities in the state. Traditionally, manufacturing is more negatively affected by recessions than other industries due to the ability of buyers to postpone purchasing durable manufactured products when economic prospects are dim. In 2003, North Carolina lost 5% of her manufacturing employment base, after losing 10% of her job base in 2002.

The downsizing of employment in North Carolina's traditional manufacturing industries, including textiles, apparel, tobacco, and furniture, has also been a major element in the state's jobs picture. Most of the job losses have been in textiles and apparel, where over 60% of jobs have been cut since 1990. Although the reduction in trade barriers and the movement of many jobs to foreign countries have certainly contributed to the losses, factory modernization and the replacement of labor with machinery and technology have also been factors related to the downsizing.

Table 2. Key North Carolina Economic Measures

	2002	**2003**	**2004**
Real Personal Inc.[a]	0.8%	0.3%	5.0%
Real Retail Sales[a]	3.1%	2.3%	3.6%
Total Employment[a]	-2.0%	0.5%	2.0%
Manuf. Employ.[a]	-8.8%	-5.1%	-2.5%
Unemploy. Rate	6.4%	6.3%	5.8%

[a] Percentage change
Sources: U.S. Dept. of Commerce, Employment Security Commission of North Carolina, North Carolina Dept. of Revenue, author's forecasts

A noticeable improvement in the North Carolina economy is predicted for 2004. Real personal income growth will be a robust 5%, employment growth of 2% will add over 75,000 net new jobs to the state's payroll, and the statewide unemployment rate will fall to under 6%. However, downsizing in traditional manufacturing, particularly textiles and apparel, will cause total factory employment to drop even though many manufacturing sectors will add jobs during the year.

Economic growth will vary by region within North Carolina in 2004. In fact, two regions, Greater Charlotte and the Research Triangle area, will account for half of the state's net job growth. Counties and regions with large investments in traditional manufacturing will face a much less optimistic outlook in the year. Addressing such disparities in economic growth across North Carolina will continue to be a major economic development issue.

The economic world has permanently changed, and North Carolina is re-structuring in light of those changes. Manufacturing is going the way of agriculture - production is

rising but machinery and technology are taking the places of workers. Consumers are spending a greater share of their income on services. And the reduction in trade barriers is putting North Carolina companies in competition with foreign companies.

These changes present challenges and opportunities. While some companies may lose production to foreign countries, but at the same time, open trade allows North Carolina companies to vie for the business of the growing number of middle class consumers in Asia and other regions. And while the state has lost thousands of manufacturing jobs in the past decade, the service job that have been added are not all low paying. In fact, the salaries of 60% of the added service jobs have been as high or higher than the pay of the cut factory jobs.

Controlling Weeds With Less Oxyfuorfen

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Oxyfluorfen is one of the most commonly used preemergence herbicides in container nursery crop production. It is the primary active ingredient in Scotts Ornamental Herbicide 2, Rout, Regal OO, Weedfree 63, and Weedfree 75. Applied preemergence to weeds, oxyfluorfen controls most annual broadleaf and grass weeds and is safe on most woody ornamental plants. With such a broad spectrum of weeds controlled and crop safety, the oxyfluorfen-containing herbicides have become the preferred standard for preemergence weed control in container nurseries.

The use-rate for oxyfluorfen in container nurseries is 2 lb active ingredient per treated acre per application. This dose provides about 60 days of weed control, after which emerged weeds are removed and the herbicide re-applied. Depending upon the management philosophy, herbicides may be applied up to 6 times per year. This is equal to 12 lb oxyfuorfen per acre per year. But due to The Food Quality Protection Act (FQPA) this is going to change.

FQPA – What does that have to do with nursery crops?
The Food Quality Protection Act changed how the Environmental Protection Agency evaluates potential toxicity of pesticides. In the past the EPA evaluated each pesticide exposure individually. The new standard evaluates composite exposure from all pesticides with similar modes of toxicity, and all modes of exposure. The impact of this on oxyfuorfen was to require a reduction in annual use-rates. The new maximum use-rate in container nurseries is 6 lb active ingredient per acre – this equates to no more than 3 applications of oxyfuorfen-containing herbicide per year. Existing supplies of labeled herbicides can be used according to label instructions. However, as new herbicides are shipped the reduced use-rates will apply. For nurseries that rely on more than 3 herbicide applications per year, growers will need to diversify the herbicides used and rotate to other active ingredients.

Herbicide Rotation.
We can still use the oxyfluorfen-containing herbicides but will need to rotate other herbicides into the system. Rotating between OH2 and Rout and Regal OO is NOT an option. You get 3 applications per year, total, of any oxyfluorfen-containing herbicides. Many other herbicides are labeled for use in container nursery crop production, but most lack the broad spectrum. Two products that will be important rotational options are Snapshot TG and Broadstar.

Snapshot TG is a granular combination of isoxaben (Gallery) plus trifluralin (Treflan). Most growers are familiar with this herbicide. It has a broad spectrum of weed control,

and is safe on most woody ornamentals and some herbaceous ornamentals. However, efficacy on broadleaf weeds is generally not as good as oxyfluorfen. Snapshot TG tends to be very effective on winter annual weeds but less effective on summer annual broadleaf weeds. Therefore, Snapshot TG will be a good alternative for fall, winter or early spring applications.

Broadstar is a granular formulation of flumioxazin. This new herbicide is similar to oxyfluorfen in mode of action, weed control spectrum and safety to ornamentals. It is more effective on summer annual broadleaf weeds than Snapshot TG, and would be a good alternative for spring or summer treatments. Some important nursery weeds controlled by Broadstar include bittercress, spurge, phyllanthus, doveweed, and oxalis. It has also been equal to or better than oxyfluorfen on eclipta.

One possible rotation of six applications per year on container grown woody nursery crops might look like this:

1. Early spring: OH2, Regal OO, or Weedfree;
2. 8 weeks later: re-treat with OH2, Regal OO, Weedfree or Rout
3. Summer: Broadstar
4. Late summer: Broadstar
5. Fall: OH2 or Rout
6. Late fall: Snapshot TG

Broadstar may be rotated into the system either in the spring or summer. Snapshot can be utilized anytime of year but recent research has demonstrated that it provides better control of winter weeds, such as pearlwort, annual bluegrass, and chickweed, than OH2 or Broadstar. Many nurseries utilize fewer applications per year and the rotational pattern will need to be adjusted accordingly. We have relied upon a few herbicides for weed control in woody nursery crops. These changes in oxyfluorfen use-rates will slightly complicate weed management programs, but effective alternatives are available and can be integrated into production practices with relative ease.

New Fungicides for Phytophthora Root Rot in Nursery Crops

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Phytophthora root rot, caused primarily by *Phytophthora cinnamomi*, is an ongoing problem on many nursery crops grown in North Carolina due to the persistence of this pathogen in nurseries. A number of fungicides are available as preventatives for disease control, and new products are continuously being registered and introduced into the market. We evaluated two relatively new phosphite materials, Biophos (potassium phosphonate/dipotassium phosphate) and Vital (potassium phosphite), along with another newly registered fungicide, Stature DM (dimethomorph), as well as several other fungicides applied as preventatives for Phytophthora root rot control in azalea and rhododendron production.

What was done?

Liners of the highly susceptible azalea cultivar, *Rhododendron obtusum* 'Hinodegiri,' were transplanted to pine bark –sand (6:1) mix with 5 lb dolomitic limestone per cu. yd. in #300 pots on 27 May 2003 and allowed to establish. SoilGard and Trichoderma (T382), both biologicals, were incorporated at transplanting. On 4 June, Biophos, Vital, and Aliette were applied by spraying plants to run-off. Five days later on the morning of 9 June, each potted plant was inoculated with nine rice grains colonized by *P. cinnamomi*. In the afternoon, the fungicides listed in the table as drenches were applied in volumes of 8.8 fl oz /pot. Truban, Quell, the Aliette drench, and Subdue MAXX were re-applied once at 60 days, while the other fungicides were re-applied three times at 30-day intervals. The biologicals were surface applied at 30-day intervals after the initial incorporation. Controls included untreated, inoculated and non-inoculated plants. A separate study with rhododendron 'Roseum Elegans' was done in the same manner but only Stature DM was tested.

Plants were rated for foliar symptoms of Phytophthora root rot throughout the summer on a scale of 1 = healthy foliage, 2 = slight chlorosis, 3 = moderate to severe stunting and chlorosis, and 4 =dead plant. At the end of the experiment on 23 September, plant fresh top weight was measured and the roots were rated for root rot. The root rot rating scale was 1 = healthy roots, 2 = fine roots necrotic, 3= coarse roots necrotic, 4= crown rot and 5 = dead plant.

Results and Discussion.

Aliette applied as either a spray or drench, Vital, Biophos, and Stature DM were all very effective in controlling Phytophthora root rot. Symptoms of Phytophthora root rot began to develop within 30 days after inoculation on azaleas not protected by fungicides. By 03 September symptoms of root rot were severe on plants in most treatments except for the Aliette, Biophos, Stature DM and Vital treatments (Table 1). At the end of the experiment on 23 September, the top weight of the azaleas in the untreated control group averaged 0.83 oz compared to 2.1 oz in the non-inoculated control group. Azaleas

treated with Aliette, Vital, and Stature DM had weights comparable to the non-inoculated control group. Likewise the root rot rating was 3.5 for azaleas inoculated with *Phytophthora* but not treated with a fungicide, compared to a root rating of 1.0 for plants in the non-inoculated control group. Plants treated with Aliette, Biophos, and Stature-DM had root rot ratings less than 2, which were similar to the plants in the non-inoculated control group (Table 1). Banol, Quell, Subdue MAXX, SoilGard, Trichoderma (t382), Truban, and Zerotol failed to protect plants from Phytophthora root rot. The unusually wet summer in Raleigh coupled with the daily irrigation provided extremely favorable conditions for development of Phytophthora root rot. The poor performance of Quell and Subdue MAXX was probably related to the low rate of application and 60-day schedule. In the rhododendron study, Stature DM provided excellent protection of plants from Phytophthora root rot at all rates tested (Table 2). Biophos and Vital are thought to activate host defense symptoms in a manner similar to that for Aliette. Therefore, it is important to apply these materials before the initial exposure of the plant to *Phytophthora*. Repeat applications are necessary to maintain the elevated level of resistance in the host. Stature DM is a locally systemic, root and foliar penetrant fungicide with a unique mode of action that makes it a choice for rotation with other fungicides where fungicide resistance is a question. No phytotoxicity was found on azaleas with any fungicide tested.

Significance to the Industry.
Several new fungicides have been recently registered for Phytophthora root rot control in nursery crops. Fungicides like Biophos, Vital, and Stature DM offer nurserymen new alternatives for Phytophthora control compared to standards like Aliette and Subdue MAXX.

This article mentions fungicides tested for disease control. Use of trade names does not imply endorsement by the North Carolina Agricultural Research Service of the products named or criticism of similar ones not mentioned. Always refer to the North Carolina Agricultural Chemicals Manual available online at <http://ipm.ncsu.edu/agchem/agchem.html> for current information on labeled products.

Table 1. Efficacy of several fungicides for control of Phytophthora root rot in azalea 'Hinodegiri' caused by *P. cinnamomi*

Treatment	Rate oz / 100 gal	Method of application	Foliar rating (1-4)[z]		Top wt (oz)	Root rot (1-5)[y]
			10 Jul	03 Sep		
Untreated check	--		1.6 bc[z]	2.9 ab	0.83 efg	3.5 bc
Biophos 43L	128.0 fl oz	Spray	1.0 d	2.6 bc	1.37 cde	1.9 ef
Biophos 43L	256.0 fl oz	Spray	1.1 cd	1.8 edfg	1.68 bcd	1.3 fg
Vital 4L	32.0 fl oz	Spray	1.2 cd	2.4 bcde	2.06 ab	1.1 g
Vital 4L	64.0 fl oz	Spray	1.5 bcd	2.1 cdef	1.78 bc	1.1 g
Aliette 80W	80.0 oz	Spray	1.1 cd	1.7 edfg	2.03 ab	1.2 fg
Banol	25.0 fl oz	Drench	1.1 cd	2.6 bc	1.35 cde	3.1 cd
Truban 25EC	8.0 fl oz	Drench	1.2 cd	2.8 abc	1.23 cdef	3.5 bc
Quell 2EC	0.5 fl oz	Drench	1.3 cd	2.5 bc	1.27 cdef	2.7 ed
Aliette 80W	12.8 oz	Drench	1.0 d	1.3 g	2.24 ab	1.3 fg
StatureDM 50W	6.4 oz	Drench	1.0 d	1.4 fg	2.54 a	1.0 g
Subdue MAXX 2E	0.5 fl oz	Drench	1.5 bcd	2.9 ab	1.19 efg	3.6 bc

ZeroTol 27L	256.0 fl oz	Drench	2.3 a	3.4 a	0.48 g	4.4 a
SoilGard 12G	1.5 lb/yd^3	Incorp.	1.5 bcd	3.0 ab	0.83 efg	3.8 abc
Trichoderma hamatum 382	3.0 oz/yd^3	Incorp.	1.9 ab	3.1 ab	0.78 fg	3.9 ab
Non-inoculated control	--		1.0 d	1.7 efg	2.10 ab	1.0 g

[z] Foliar rating based on 1 to 4 scale where 1 = healthy foliage, 2 = slight chlorosis, 3 = moderate to severe chlorosis and/or necrosis, 4 = dead plant.

[y] Root rot rating scale was 1= healthy, full root ball, 2= some root rot, less than full root ball, 3= severe root rot, 50% of root system necrotic, 4= very severe root rot, root ball falls apart, and 5 = plant dead, all roots necrotic.

[x] Means within a column followed by the same letter are not different according to the Waller-Duncan k ratio, t-test, k=100, *P*=0.05.

Table 2. Control of Phytophthora root rot in rhododendron 'Roseum Elegans' with Stature DM applied at three rates applied on a 30-day schedule during the summer

Treatment	Rate oz /100 gal	Foliar rating 23 Jul	Foliar rating 3 Sep	Top wt. (g)	Root rot rating (1-5)
Untreated control	--	2.3 a	2.9 a	13 a	3.9 a
Stature DM (6.4)	6.4	1.0 b	1.3 b	46 b	1.0 b
Stature DM (12.8)	12.8	1.0 b	1.2 b	43 b	1.0 b
Stature DM (25.6)	25.6	1.0 b	1.2 b	47 b	1.1 b
Non-inoculated control	--	1.0 b	1.0 b	51 b	1.0 b

Foliar rating and root rot rating as in table 1. Means within a column followed by the same letter are not different according to the Waller-Duncan k ratio, t-test, k=100, *P*=0.05.

Foliar Nematodes – Are These a Problem You Can Afford to Ignore?

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Foliar nematodes are becoming increasingly common and injurious on a wide range of herbaceous and woody ornamental plants grown in nurseries, but these pests are talked about so infrequently that the importance of the problem has been seriously overlooked. One of the primary reasons for this is due to the lack of effective options for management. Unfortunately this has allowed the problem to go unchecked, with devastating results for many growers. Growers in North Carolina heavily impacted by foliar nematodes have literally destroyed up to 100% of their plant stocks to eradicate this pest from their growing facilities. Recent contacts by a nursery inspector in Missouri, and a wholesale perennial grower in Pennsylvania seeking advice on how to handle this problem, is testament to the prevalence of this problem across the industry.

Foliar nematodes are microscopic roundworms that penetrate and feed within the leaf cells. These organisms generally will not kill a host plant, but they can cause plants to become unthrifty and severe defoliation is common in midsummer when the population of foliar nematodes is peaking. Foliar nematode infected Lantana, Abelia, Salvia, and Viburnum are common hosts among the 250+ known plant species that are susceptible to foliar nematodes.

Nematicides based on nervous system blockers were removed from the US market several years ago due to toxicity issues, as well as the threat of groundwater contamination. The miticide Pylon® was recently labeled for nematode control, but this product has failed to eliminate these pests from naturally infested plants evaluated in nursery trials conducted over the past two years in North Carolina. The lack of management options is of particular concern because greenhouse and nursery crops are especially susceptible to foliar nematodes, and the introduction of nematode-infested material (on cuttings, seedlings, and other vegetatively propagated material) may result in rapid spread of the nematode. Foliar nematodes generally go undetected until physical plant damage is observed. There is no cure for foliar nematodes, and exclusion is currently the best option for control.

A study was undertaken in Summer 2003 to assess how quickly foliar nematodes can spread in a nursery setting. Twenty, healthy (nematode-free) 1 gal lantana plants were intermixed with an equal number of foliar nematode-infested1 gal lantana plants. One set of plants was irrigated by overhead sprinklers, and the second set was irrigated by low

volume spray stakes that directed the water away from the foliage onto the surface of the potting substrate. Plants were not pruned, nor handled during this period. The original healthy plants were evaluated 54 days after placement with infested plants. In the overhead-irrigated plot, 100% of the healthy plants became infested with foliar nematodes and 90% of the healthy, low volume-irrigated plants became infested.

Several miticides, a disinfestant, and an experimental biological compound (data now shown) were tested for efficacy against foliar nematodes in nursery trials during Summer 2003 on naturally infested plants of lantana cultivar 'Miss Huff," buddleia cultivar 'White Bouquet' at one nursery, and abelia cultivar "Little Richard" at the second nursery. The experimental design was a randomized complete block with 10 single-plant replications for each plant species. At one nursery the experimental design was repeated, concurrently, in two, physically separated plots within the nursery. One plot was irrigated with overhead sprinklers, the second plot by low volume spray stakes. Plants were sampled for foliar nematodes on 7 Aug prior to the first spray application. For the lantana, ten symptomatic leaves were randomly collected from each plant at each sampling date. For the buddleia, three symptomatic leaves were randomly collected from each plant at each sampling date. Symptomatic and senescent leaves with yellow discoloration were not sampled. Treatments were applied approximately every 7 days on 13, 20, 26 Aug, and 3 Sep for a total of four sprays. The pesticides were applied until run-off using a hand-pump sprayer. Plants were re-sampled at 13, 27 or 30, and 42 days after the first spray application on 13 Aug. Nematode counts were based on the fresh weight of the leaf tissue collected.

Nematode populations were higher for both lantana and buddleia non-treated control plants irrigated with the low volume spray stakes compared to overhead sprinklers. It was an unusually wet summer, and measurable rain was recorded on 18 of 47 days from 7 Aug to 24 Sep. On days without rain, leaf wetness was detected on the overhead irrigated plants for about 15 hr per day versus 10 hr per day for the low volume plants as measured by leaf wetness sensors placed within the plant canopies.

	Nematodes per g leaf tissue							
Treatment and rate /379 L	7 Aug		26 Aug		9 Sep		24 Sep	
Lantana	Lv[w]	Ovh[w]	Lv	Ovh	Lv	Ovh	Lv	Ovh
Floramite SC 2L 237 ml	766 a[x]	712 a[x]	484 b[y]	591 a[y]	202 ab[y]	369 a[y]	1019 a[y]	1116 a[y]
Pylon 2SC 154 ml	908 a	744 a	271 b	400 a	65 b	143 a	373 b	401 a
ZeroTol 27%L 37 ml then 15 ml[z] .	1272 a	342 a	934 a	335 a	289 a	449 a	1331 a	374 a
Non-treated control	1237 a	906 a	603 a	446 a	370 a	296 a	911 a	649 a
	7 Aug		26 Aug		12 Sep		24 Sep	
Buddleia	Lv	Ovh	Lv	Ovh	Lv	Ovh	Lv	Ovh
Floramite SC 2L 237 ml	109a[x]	36a[x]	319 a[y]	163 a[y]	1902 a[y]	476 a[y]	997 a[y]	516 a[y]
Pylon 2SC 154 ml	145a	73a	425 a	34 a	31 b	100 a	21 b	2 b
ZeroTol 27%L 37 ml then 15 ml[z] .	101a	74a	314 a	131 a	1765 a	662 a	375 a	401 a
Non-treated control	104a	74a	453 a	104 a	865 a	434 a	1032 a	202 a

[z]Applied at 37 ml /379 L for the first application. The 15 ml /379 L rate was applied in all subsequent applications.

[y]Analysis of covariance using a log transformation was used to test the change in population based on the initial population, and Dunnets-Hsu's test was used to compare all treatments to the non-treated control for

levels of significance in population changes among treatments at the level of P=0.05. Actual means are shown.
[x]Means by plant species within a rating followed by the same letter are not significantly different from each other according to Waller-Duncan k ratio, t-test, k=100, P=0.05.
[w]Irrigation method was by low volume spray stakes (Lv) or overhead sprinklers (Ovh).

Pylon significantly reduced populations of foliar nematodes at the second (26 Aug), third (9 Sep), and fourth (24 Sep) sampling dates compared to the non-treated controls for lantana grown under low volume irrigation, but there was no difference in populations among lantana grown under overhead sprinkler irrigation. The Pylon treatment reduced the nematode population on buddleia at the third sampling date (12 Sep) for plants grown under low volume irrigation, and at the fourth sampling date (24 Sep) for plants grown under both irrigation methods. There was an overall decline among the buddleia plants over the course of the experiment, and plants began to defoliate by late Aug. However, the decline appeared to be related to a fungal leaf spot disease in combination with low fertility.

None of the treatments were effective in eliminating foliar nematodes from infested plants under either irrigation regime. Pylon is labeled for control of foliar nematodes on nursery-grown ornamentals, but it is not labeled for outdoor use.

Got Physical Properties? A Field Quantification Strategy

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Nature of Work:
Plant nurseries in the southeastern United States need a container substrate that does not waterlog after frequent rains over a period of several days. Under such conditions a substrate must provide excellent drainage and aeration capacity to avoid plant disease and death associated with fungal pathogens and/or excessive moisture. For nearly half a century the medium of choice in many areas has been screened pine bark.

Depending on the crop, container size, grower practices, and irrigation resources, growers may add sand or gravel screenings to the bark to improve water retention and to provide sufficient weight to the container to reduce blow-over. Growers receive bark inventory from bark processors. Processors may provide a bark and sand mix or growers may blend components themselves.

Unfortunately for growers, bark is an unstable organic compound and may continue to decompose, depending on how long it has been in inventory. Variation in bark supplies also occurs in relation to how it has been handled at the bark supplier's location. Some bark supply companies turn and moisten inventory piles during an aging process; other bark supplies may be considered fresh inventory with little aging before processing and shipping.

The moisture content of pine bark at the time of processing also affects particle size. Dry pine bark moves rapidly through a hammer mill and will have fewer fine particles compared to moist bark that tends to clump together and stay in the grinder longer creating more fines during processing. Consequently, when the bark is received from the processor, the range in particle size may vary from one delivery to the next. Since particle size directly affects the substrate's aeration and water retention, bark age and quality may dictate changes in a nursery's irrigation regime.

Experienced growers develop a sense of how a bark mix will perform and how they need to handle it in order to insure good crop response. Even experienced growers, however, can misjudge the "feel" of the bark or overestimate the capacity of employees to judge how to handle the bark. If growers have the space and time to submit bark samples for laboratory analysis, they may have better data on which to base irrigation decisions. But routine laboratory analysis has not been sufficiently convenient. Growers could benefit from a field strategy for comparing one delivery of bark to a previous delivery in order to make quick decisions about how to manage irrigation. However, procedures for field methods to compare potting materials have been complicated, confusing, difficult to perform, and highly variable in results. It is our objective to develop procedures and identify specific measurements that would be useful for comparing potting components and potting mixes on site at nurseries.

Wet Bulk Density
One of the easiest methods to determine variability in physical properties of container substrates is to fill 10 containers with the potting substrate to be tested. This method can be used to determine differences in pine bark inventories or potting mix substrates comparing one batch of potting substrate with a previous mix or with mixes for future potting substrates in a potting season. Procedures should follow uniform practices. Steps include filling each container by placing substrate over the top of the container, then scraping the excess substrate to level with the top of the pot. Tap each container 3 times on a potting bench or flat surface to create a uniform bulk density (uniform height of substrate in the container). Following the filling of containers and tapping, irrigate containers thoroughly and allow all containers to drain for at least 30 minutes. Weigh all 10 containers and calculate an average wet drained weight. Variability of more than 10% in weight between pots filled with substrate compared to previous supplies suggests that pine bark shipments have significant differences in particle size distribution or component composition.

This procedure can also be used to compare potting practice among potting crew members. To determine differences in potting practices choose 10 containers, weigh containers after irrigation and allow approximately 1/2 hour to drain. Then weigh the irrigated containers. If containers in a block of newly potted plants have more than 10% difference in weight, the results suggest that practices related to filling pots and planting liners in the potting operations need to be examined to determine if filling pots and practices related to potting are uniform among potting crew members.

Drained Pore Space (Air Space)
Drained pore space is a method to determine the approximate air space of a container potting substrate by saturating the substrate, then draining water from the container to calculate the drained pore space. The water collected from a saturated potting mix provides a measurement of air space. The water volume that drains from a saturated substrate drains from large pores that hold air in the substrate. This measurement is usually considered to be an approximate estimate of air space since the bottom of the pot restricts complete drainage of the substrate from the container.

Procedures necessary to determine drained spore space are as follows: place each of the 10 containers in buckets or trays large enough to contain water drained from the containers, approximately 1/3 of the volume of the container. For example, a 3 quart container has a volume of 2700 ml; therefore approximately 900 ml volume to collect drained pore space is required. Line ten containers with plastic bags. Fill bagged containers with growing media. Tap containers to settle and top off to the inner lip as described for wet weight above. (Or follow grower's normal practices; consistency is essential.) Pour water gradually over the containers allowing water to infiltrate into all air spaces. Continue application of water until the water level is just at the surface of the media. Punch holes into the plastic bag liners and collect water that drains into the tray or bucket. Since the container was saturated, when drainage is complete, the container is at water holding capacity and drainage volume equals air space in the media (1 ml water

= 1 cc).

Drainage divided by the volume multiplied by 100 = percent air space.

Significance to the Industry

Although conducting "home remedy" analysis of physical property results would not be expected to be as precise as those conducted at the NCSU Horticultural Substrates Lab, weighing drained containers and measuring drained pore space volume at grower sites can provide evidence related differences in batches of potting substrates of excessive moisture retention or excessive aeration characteristics. Determining drained pore space (air space), using a simple procedure outlined here can be very useful in providing insight as to how to manage irrigation of crops discovered to have drainage or aeration problems and possibly diagnosis of how to make changes to avoid future problems.

Table 1. A comparison of air space percentage in a recent comparison of 3 substrate supplies at two nurseries with laboratory analyses for fresh and aged bark and bark sand mixes

Substrate	Nursery Bark 1	Nursery bark 2	Nursery bark-sand	Lab fresh bark[z]	Lab aged bark[z]	Lab fresh bark + sand[z]	Lab aged bark + sand[z]
Air Space	34%	32%	26%	42%	31%	31%	27%

[z] "Potting Mix Choices and Recommendations" by Ted Bilderback in *Nuts and Bolts of the Nursery Industry: A Reference and Resource Manual 2001*