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Media influence on post-harvest container plant quality in a retail nursery setting

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MEDIA INFLUENCE ON POST-HARVEST CONTAINER PLANT QUALITY IN A RETAIL NURSERY SETTING

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Sigue para delante

no mires para atras

ni para cojer impulso

-A favorite saying of my father,

Dr. Emeterio López Belen.

DEDICATION

This is dedicated to all the people who have been the wind beneath my wings. To all the people that have sacrificed a lot and have put all their faith in me blindly rooting for me from across the sea and to those that are here with me, in this journey through this different world.

To the light of my eyes, and the strength of my soul, my family. 'Mis más grandes tesoros', my parents, Dr. Emeterio López and Estrella del Castillo de López for being my greatest source of inspiration. Thank you for all your love, wisdom, patience and for always believing in me. To my sister and angel, Miguelina del Carmen López del Castillo, words can not explain how I value your love and motivation. You give me strength and hope thet anything is possible! To my brothers, Jóse Anibal López del Castillo, Miguel Angel López del Castillo and Juan Carlos López del Castillo and my grandparents Valentina del Castillo de Trinidad, Herman Trinidad and Aurora Belen de López de for all your love. To my grandfather Angel del Rosario López, I hope I made you proud. To my beautiful nieces, Aurora Estrella López and Estrella Valentina López for inspiring me to be a better person.

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ABSTRACT

Media amendments can be added to pinebark to increase its water holding capacity. Hydrogels are amendments which can hold 20 to1000 times their weight in water. The objective of this study is to determine the effects of media and a hydrogel on the post-harvest quality of ornamentals likely to have poor post-harvest quality in the retail nursery setting. The selected species were *Buddleia davidii* 'Nanho Blue', *Salvia leucantha* and *Verbena* x *canadensis* 'Homestead Purple'. Treatments were arranged in a randomized complete block design. It consisted of eight replications of three species, three media treatments and a hydrogel amendment for two planting dates and three retail nursery settings, totaling 576 pots. The three media were 100% pinebark, 9 pinebark:1 peat and 9 pinebark:1 sand. The hydrogel was applied post-harvest, to a portion of the plants grown in 100% pine bark. Once harvested, plants were transferred to three retail nursery settings where they remained for 4 months.

There were differences in specie response to the different media. At the end of production, growth for *Salvia leucantha* was similar except for plants assigned to one retail nursery setting, where pinebark:peat and pinebark:sand had the highest growth indices. *Buddleia davidii* 'Nanho Blue' had the highest growth index in pinebark:peat for plants assigned to two retail nursery settings. *Verbena* x *canadensis* 'Homestead Purple'had the highest growth index in pinebark and pinebark to be amended with hydrogel assigned to one retail nursery setting. The hydrogel increased growth index of *Buddleia davidii* 'Nanho Blue' by 13% at one retail nursery setting and maintained plant quality at another retail nursery setting, where it increased dry shoot weight by 46% and 103.8% for crop 1 and crop 2 respectively. For *Salvia leucantha*, the hydrogel increased growth index in two retail nursery settings by 5% and 19%, and maintained plant quality in two retail nursery settings. For *Verbena* x *canadensis* 'Homestead Purple', the hydrogel increased dry shoot weight by 72%, and maintained the best plant quality in one retail nursery setting. Overall plant quality was lowest at the two retail nursery settings where the irrigation water had a higher alkalinity.

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Introduction

Ornamental horticulture, especially the retail sector for woody ornamentals and perennials, is an important contributor to the economy of the United States. The state of Louisiana generated a wholesale crop production value of $161.5 million in 2003. Woody ornamentals were responsible for $72 million of this total amount (Hinson *et al.*, 2003).

Buddleia davidii 'Nanho Blue', *Salvia leucantha*, and *Verbena* x *canadensis* 'Homestead Purple' are popular herbaceous ornamentals for gardening consumers in the southeastern United States.. Upon reviewing the current literature it can be deduced that little is known about how the post harvest quality of these three ornamental species is influenced by different media in a retail nursery setting. Therefore, research into how media influences post-harvest container plant quality in a retail nursery setting is needed.

Selected Ornamentals

Buddleia davidii 'Nanho Blue', from the Buddleja family, is native to northwestern China and Japan and grows in USDA hardiness zones 5-10. It is a deciduous to semi-evergreen shrub with a compact weeping habit, and can grow to a height and width of five feet. The leaves are gray green and opposite lance shaped, growing along arching stems. The flowers are borne in six-inch long cone-shaped drooping clusters. These drooping clusters may cause the branches to arch. The lavender blue flowers have an orange throat in the center making them attractive to butterflies. Blooming of *Buddleia davidii* occurs between May and October, and it thrives in various soils and dry conditions once established. Water, however, is essential for its establishment, but once rooted, it becomes drought tolerant. Furthermore, excessive moisture can lead to*Phytopththora* spp. Propagation of *Buddleia davidii* may be achieved via root cuttings (Anonymous 2006; Odenwald and Turner 1996).

Salvia leucantha, a member of the Labitae family, is native to Central America and Mexico and grows in USDA hardiness zones 8-10. In the southern United States, it is considered a perennial. It has a mounded growth habit and can grow between 2-4 feet tall and wide. The leaves are opposite lance shaped, 1-5 inches long on square stems. Young stems are thick and fleshy white. Bi-colored inflorescens are borne in 6 to 12-inch long, showy clusters. The flowers of *Salvia leucantha* are white and extend from velvety lavender calyces. Flowering typically occurs from autumn through the first frost. *Salvia leucantha* grows in full sun and tolerates acidic, alkaline, sandy, loam and clay soils. It is easy to propagate from root cutting, stem cuttings, and cuttings that have rooted once in contact with the ground (Anonymous, 2006; Odenwald and Turner, 1996).

Verbena x *canadensis* 'Homestead Purple' is a member of the Verbenacae family. It is composed of twisting trailing clumps about one-foot tall and can spread to 3 feet or more in a growing season becoming very rampant. It is the most winter hardy of trailing verbenas and has been used in breeding programs to increase hardiness in other varieties. It is characterized for being low maintenance and drought tolerant (Anonymous, 2006b).

Value of Selected Ornamentals

Ornamentals are an integral component of the landscapes in which we live. They are desirable enhancements in both urban and non-urban environments. Visual interest and property value are augmented in the areas where ornamentals are grown. The selected ornamentals, commonly called verbena, salvia, and buddleia, are practical choices for consumers in the southern United States because of their horticultural, landscape, ecological, and economic values. Additionally, all three species are relatively drought resistant and require minimal maintenance that increases their value even more.

Salvia leucantha blooms in the fall when a smaller number of plants are blooming, while *Verbena* x *canadensis*, ‘Homestead Purple’ and *Buddleia davidii* ‘Nanho Blue’ bloom profusely throughout the year. *Verbena* x *canadensis* ‘Homestead Purple’ is considered the most winter hardy of the trailing verbenas. Ecologically, *Verbena* can also aid in soil erosion because of its profuse spread and ability to grow in drought stressed soils. All three species are ecologically valuable for their attractiveness to butterflies, hummingbirds, and bees. Their economical value, in addition to increasing property value as a flowering plant, is further enhanced since both *Salvia* and *Buddleia* can be used in cut flower arrangements, contributing to the floriculture industry.

For the year 1995, Salvia was among the top 20 plants sold to consumers in the entire United States while *Verbena* x *canadensis* ‘Homestead Purple’was among the top 20 sold in the southern United States (Burnett *et al*., 2000). *Verbena* x *canadensis* ‘Homestead Purple’is also considered a Louisiana Select and Athens Select making it popular among gardening consumers.

Irrigation Systems

The design and efficiency of irrigation systems in container nurseries is vitally important to the performance of ornamental crops. Irrigation is dependent on three factors; uniformity of application, amount of water retained in the substrate following irrigation and the amount of water that enters containers in comparison to the amount which falls between the containers (Yeager *et al*., 1997). Overhead irrigation is the most common irrigation system used for ornamental crops in 5-gallon pots or smaller throughout the United States (Wilmer et *al.,* 1998; Beeson and Knox, 1991). Overhead irrigation consists of risers, 3-feet tall or greater, located above the plant canopy. Research has shown that overhead irrigation is inefficient due to the water falling between containers and excessive leaching from the container substrate (Karam and

Niemiera, 1994). As a result, plant nutrition is affected and in turn growth and quality. It has been reported that overhead irrigation does not provide 100% water penetration through the plant canopy and into the substrate (Beeson and Knox, 1991). Due to this inefficiency, large volumes of water applied through overhead irrigations are wasted. Water distribution and uniformity in irrigation systems can be influenced by the height of irrigation nozzle, nozzle spacing, system hydraulics, wind, and canopy density (Yeager *et al.,* 1997). It is therefore important to monitor these factors to obtain optimum water use efficiency.

The manner in which irrigation is applied may also influence substrate and plant performance. Two common methods of irrigation application are continuous and cyclic irrigation. In continuous irrigation, the daily water is applied in a single application, while in cyclic irrigation the daily water is applied through two or more applications throughout the day with intervals in between (Yeager *et al.,* 1997).

Research has shown that cyclic irrigation can improve irrigation application efficiency by allowing time for water to move through the pore system of the container substrate (Tyler *et al.,* 1996). Cyclic irrigation also reduces water and nutrient loss from containers allowing the plant to use nitrogen more efficiently (Karam *et al.,* 1994). Gray (1999) stated that cyclic irrigation improved irrigation efficiency by reducing effluent. In a study of the effects of irrigation on *Quercus acutissima*, it was found that when continuous irrigation was applied it resulted in an irrigation efficiency of 78%. When cyclic irrigation was applied in cycles of three or six, it resulted in efficiencies of 98% and 99% respectively (Fain *et al.,* 1997).

Irrigation Water Quality

Irrigation water quality is the most critical and limiting factor for production of container grown plants. Overhead irrigation, coupled with poor water quality, can result in aesthetic and physiological damage to the plants reducing their value. Damages include foliar residue , phytotoxicity to foliage and substrate and pH alteration (Yeager *et al.,* 1997). There are various factors which affect plant growth that are analyzed to diagnose the quality of water.

High pH, a measure of hydrogen ions in solution, can affect nutrient availability to plants. Even though pH requirement varies with species, desirable pH for irrigation water should be within the 5.5-6.5 range to ensure nutrient solubility (Bailey *et al*., 1999).

Alkalinity is a measure of the ability of water to neutralize acids. It is the concentration of soluble alkalis in a solution. Bicarbonates and carbonates are the major chemicals contributing to alkalinity of irrigation water while hydroxides are minor contributors (Bailey *et al.,* 1999). High alkalinity can increase pH of the growing medium thus reducing the availability of micronutrients, the efficiency of pesticides, and growth regulators. High alkalinity can also cause foliar residue and leaching of nutrients (Bailey *et al.,* 1999).

A measure of the electrical conductivity of irrigation water (EC) is related to salinity. The ability of water to conduct an EC is related to the amount of dissolved salts present. A high concentration of salts will result in a high EC reading (Bailey *et al.,* 1999). The desired EC should be under 2.0 mmho x 10^{-3} cm for nursery crops.

The Sodium Absorption Ratio (SAR) measures the relative concentration of sodium to that of calcium and magnesium in water. Irrigation water with 3 meq/L or more of sodium should not be used for overhead irrigation. If used, it may lead to sodium toxicity in sensitive species, expressed as marginal leaf burn on older foliage.

Chloride concentration in excess of 2 meq/L increases the osmotic pressure of substrate solution which reduces the availability of water to plants causing wilt. It can also lead to toxicity expressed as leaf edge burn, leaf necrosis and leaf abscission (Bailey *et al.,* 1999).

The desirable calcium:magnesium ratio should be 3 Ca to 1 Mg if expressed as meq/L or 5 Ca to 1 Mg if expressed as parts per million (ppm). If there is a shift in this ratio, a deficiency of the least present nutrient will occur.

The macronutrients nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) are elements essential for plant growth. The microelements aluminum (Al), boron (B), copper (Cu), fluoride (F^-), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn) are also essential for plant growth. The amount and balance between macronutrient and micronutrient concentrations in irrigation water is critical to its quality and usability since excess of certain components can lead to toxicities in plants. Micronutrient toxicities are more probable when the pH of substrate solution is low. This is because low pH causes an increase in availability of micronutrients available for plant intake (Bailey *et al.,* 1999).

Container Media

Container media is the material or combinations of materials used to grow horticultural crops. Container media should serve four functions: 1) provide water to the plants, 2) supply nutrients to the plants, 3) permit gas exchange to and from the roots and 4) provide mechanical support to the plants. In nursery production, a variety of media components is available and is classified as either organic or inorganic. Organic components consist of pinebark and other wood products, bagasse and other agricultural bi-products, sludges and composts such as peatmoss. Inorganic components consist of sand, perlite, vermiculite, rockwool and styrofoam.

Media Components

Pinebark is the most widely used medium in the South and it is considered a good single component for growth of container plants due to having a low initial fertility. Sand is a media component that is mainly used to add bulk density to media and it is useful for providing support to tall plants. It is characterized for having good drainage and aeration properties when used alone. However, once it is combined with pinebark or peat, it can decrease aeration and increase water retention in the media. Coarse concrete grade sand is preferred instead of fine sand, since the fine sand particles can clog the pores of the pinebark or peat particles. Peat is a component derived from partially decomposed mosses or sedges, accumulating in bogs over hundreds or thousands of years. There are several types of peats such as moss peat, hypnum peat, peats derived from sedges, reeds, and grasses and sphagnum peat. Spahgnum peat has a high water holding capacity, adequate air space for plant growth and a high cation exchange capacity.

Properties of Media

To understand how media works, it is important to understand their different physical and chemical properties. Interactions between the different media properties, irrigation water applied, the environment the media is subjected to, and the cultural practices they undergo, influence media structure through time and, in turn, plant performance. A measure of the concentration of hydrogen ions found in media solution (pH) influences the availability of nutrients. The desired pH is species specific but it should be about 5.4 to 6.0 (Fonteno, 1996). Container media can increase 0.5 to 1.0 pH units during the growing season if irrigated with alkaline water. Media pH can also influence microorganism activity. Bacteria involved in nitrification (the process of organic decomposition) are found at pH levels of greater than 5.5. At a neutral pH, nitrification occurs by the transformation of ammonium-nitrogen cation (NH^{4+}) to nitrate-nitrogen ion (NO^{3-}). This transformation increases nitrogen leaching and therefore depletes nutrients from the plants.

Cation exchange capacity (CEC) is the sum of the exchangeable cations that the media can retain per unit weight. Media with a high CEC has a high capacity for retaining nutrients after irrigation.

Dissolved mineral salts in media are referred to as soluble salts. These dissolved salts originate from fertilizers, irrigation water and organic matter. Soluble salts are the nutrients available for absorption by the plants. An initial low level of soluble salts is desired to avoid damage to young plants (Fonteno, 1996).

Bulk density is a ratio of the mass of dry solids to the bulk volume of media. A light bulk density is desired for ease of shipping and handling (Fonteno, 1996). Porosity is the amount of pore space in container media. It affects water and nutrition absorption and gas exchange. It is the fraction of media that provides water and aeration (Fonteno, 1996). Aeration porosity is described as the percentage of large pore spaces that remain filled with air as a result of the effects of gravity on water. The total porosity is the sum of the aeration porosity and water holding porosity of the media. Ideally, the total porosity should constitute over 50% of media volume. Bulk density and total porosity are inversely related in that a very dense material will have a low total porosity while a less dense material will have a high total porosity (Beardsell *et al.*, 1979). Media with a higher proportion of large particles have greater aeration porosity, while media with a higher proportion of smaller particles have greater water holding capacity.

Media Influence on Post-Harvest Container Plant Quality

Pinebark is the most popular and readily available media in the southern United States. It has good physical and chemical qualities, good water holding capacity. Research has shown that a variety of plants can be grown in pinebark resulting in good quality plants (Beardsell *et al*., 1979). In a retail nursery setting, media can very easily dry out due to inefficiency of irrigation used, transpiration, evaporation and irrigation scheduling. Container plants can suffer from mild water stress since retail nurseries can not irrigate during the day when customers are there. Media that dries out, particularly pinebark becomes difficult to rewet because of its hydrophobic nature (Airhart *et al.,* 1978; Gehrig and Lewis, 1980). In an experiment by Beardsell and Nichols (1981) to determine the wetting properties of various media, it was found that in a period of 96 days of drying, the wetability of pinebark decreased from 98% after 10 days of drying to 38% at the end of the drying period.

Certain media components or amendments can be added to pinebark such as peat, peat moss, sand, vermiculite, and hydrophilic polymers or hydrogels to improve its wetability and increase its water holding capacity. In finding ways to improve the wetability of pinebark, Beardsell and Nichols (1981) found that coarse sand had good wetting properties when dry. When it was compared to other media that had completely dried out, a 2 pinebark:1 brown coal:1 coarse sand (by volume) had a 60% re-wetting as compared to a 2 pinebark:1 brown coal (by volume) which had a 20% rewetting.

Media with different properties can significantly influence plant growth, development, and post-harvest quality. Quality of crops can be affected by ceratain media but not others. Fonteno *et al.* (1981) performed a study to determine how three different media affect *Euphorbia pulcherrima* Klotzsch ex. Willd. (poinsettia) growth. The three media treatments used were 3 pinebark:1 sphagnum peat moss:1 sand (by volume), 2 loamy soil:1 peat moss:1 perlite (by volume), and a peat-lite mix. Results showed that all three media tested, despite having initial differing water holding capacities, bulk density and particle size distribution, produced high quality plants. Growth differences between cultivars and media tested were observed. For *Euphorbia pulcherrima* ‘Annette Heggy Diva’ grown in 3 pinebark:1 peat:1 sand medium (by volume), shorter plants were observed when compared to the other media. For *Euphorbia pulcherrima* 'Eckerpoint C-1 Red' shorter plants were observed in the 3 pinebark:1 peat:1 sand medium (by volume) than in the 2 loamy soil:1 peat:1 perlite medium (by volume).

Bilderback *et al*. (1982) found that high quality *Rhododendron indicum* 'George L. Tabor' (azaleas) could be produced when grown under five different combinations of media consisting of peanut hulls, pinebark and Canadian sphagnum peatmoss. Plants in pinebark:peat media had the lower top dry weight while the peanut hulls and pinebark media had the highest percent growth increase.

Armitage (1986) conducted a study in which *Petunia hybrida* and *Tagetes patula* were grown in 1 soil:1 peat:1perlite medium (by volume), 1 peat:1 vermiculite medium (by volume) and 3 vermiculite:1 peat medium (by volume) and found that the different media only produced small differences in their post-production life. He noted that there were no significant differences as affected by media in their visual rating or dry weight post-production.

A study by Tomlinson and Bilderback (1984) was conducted to determine the effects of media amendments on the growth of *Ilex* x 'Nellie R Stevens'. The media treatments consisted of an unamended pinebark medium, pinebark amended with sand and pinebark amended with sand and a moisture extender, TerraSorb®. It was found that the amendments had no positive effect on top dry weight since unamended pinebark produced plants with the greatest top dry weight while pinebark amended with TerraSorb® reduced top dry weight and the lowest top dry weight was produced by the pinebark amended with sand. This decrease in plant growth and negative effect can be attributed to the fact that the sand amendment reduced total porosity and air space of the medium while TerraSorb® decreased air space.

In a study by Fain *et al.* (1998) to test how three different media and cyclic versus continuous irrigation would affect *Acer rubrum* 'Franksred' in pot in pot production, it was found that growth was affected by substrate and irrigation used. The three different media used were pinebark, 4 pinebark:1 peat (by volume) and 4 pinebark:1 coir (by volume). The irrigation treatment consisted of three different applications of the same volume applied in one continuous application, three applications and six applications of the same volume. The highest shoot dry weight was observed in the 4 pinebark:1 peat medium (by volume). When compared to pinebark, the 4 pinebark:1 coir medium (by volume) had a 12% increase in height and the 4 pinebark:1 coir medium (by volume) had a 17% increase in height. Cyclic irrigation also produced the highest shoot dry weight. Plants grown under the three cycle had a 23% higher shoot dry weight than the ones under continuous irrigation, while the six cycle had a 17% higher shoot dry weight.

On studying the influence of different growing media on the growth of *Tagetes erecta* 'Inca orange', *Salvia splendens* 'Burgundy', *Bacopa suternova* 'Pearl', *Scaveola aemula* 'Blue Wonder' and *Verbena hybrida tapien* 'Salmon Pink', Strojny and Nowak (2004) found that all six media combinations produced satisfying quality plants. The media combinations consisted of white peat, black peat, brown peat, sand, perlite, vermiculite and polyamine foam. Results indicated that growth and final plant size varied depending on the medium used and appeared to be pronounced in some plants and not in others. It was observed that for *Bacoba suternova* 'Pearl', there was a significant difference between media effects on growth and final plant size. Plants grown in the 1 white peat:1 black peat medium (by volume) resulted in the highest number of flowers and shoots and highest fresh weight. For *Verbena hybrida tapien* 'Salmon Pink' and *Scaveola aemula* 'Blue Wonder', the effects of media on growth and plant size were less pronounced. *Salvia splendens* 'Burgundy' displayed a rapid growth and it appeared to be more resistant to the least favorable properties of media. It was also noted that the difference in fresh weight for *Salvia splendens* 'Burgundy' under different media was not significant.

Plants need to be attractive to consumers in the marketing stage and also have a good and prolonged post-production quality once they are planted in consumer's homes. Graf-van der Zande (1990) carried out experiments on *Verbena* F1 hybrid 'Blaze' to determine how it responds to four media treatments and two watering regimes. The media treatments consisted of 100% peat, 2 peat:1 peat moss (by volume), 1 peat:2 peat moss (by volume) and 100% peat moss media. The watering treatment consisted of a low moisture level and a variable moisture level. It was found that plant height, number of side shoots, inflorescences and fresh weight were higher for plants grown in the variable moisture level. However, compared to the plants grown in the low moisture level, dry weight was lower for plants grown in the variable moisture level. The different media did not affect plant growth and development, but dry weight and flower stem were highest in the 100% peat. There was a difference in visual quality in the marketing stage. The variable moisture level produced plants with the highest visual quality while quality of plants in the low moisture level was unsatisfactory. Once the plants were planted outdoors, regrowth and visual quality of plants in the low moisture level was high, whereas plants in the variable moisture level had regrowth problems and decreased leaf quality.

A study by Knowles *et al.* (1993) was conducted to determine response of *Salvia farinacea* Benth. to slow-release fertilizer in two media. The two treatments consisted of 2 bark: 1 sand medium (by volume) and 2 bark:1 vermiculite medium (by volume). There was a medium and fertilizer interaction which had a significant effect on shoot dry weight. A greater shoot growth was achieved in the 2 bark:1 sand medium (by volume) in comparison to the 2 bark:1 vermiculite medium (by volume) when the media were treated with fertigation or slow-release fertilizer rates exceeding 0.5 g N/m^3. It was noted that the greater water holding capacity of the 2 bark:1 sand medium (by volume) might have been the cause of the higher shoot dry weight.

Even though *Buddleia davidii* 'Nanho Blue', *Salvia leucantha*, and *Verbena* x *candensis* 'Homestead Purple' have increased in popularity over the past ten years, research on how media influence their post-harvest quality in a retail nursery setting is not extensive. Past research on *Buddleia davidii* 'Nanho Blue' concentrates on its performance during the production stage, which includes the effects of a rockwool medium on its growth (Verwer, 1974), its sensitivity to ozone (Findley *et al.,* 1995) and how Cutless®, a plant growth regulator (PGR) affects its growth and flowering (Keever and Gillam, 1994). Some attention has been given to its post-harvest quality through the study of handling of it as a specialty cutflower in order to increase its longevity (Redman *et al.,* 2001).

Both *Verbena* x *canadensis* 'Homestead Purple' and *Salvia leucantha* present a challenge to nurserymen due to their excessive growth. *Verbena* x *canadiensis* 'Homestead Purple' can spread 3 feet or more while *Salvia leucantha* can grow 3 to 4 feet tall in a single season, becoming very leggy and unattractive. Constant pruning and/or transplanting are required to combat legginess (Burnett *et al.,* 2000). This excessive growth in both species can lead to blow over and drying between irrigations, resulting in unmarketable plants. Due to this, research on these two species concentrates on controlling their growth (Banko and Stefani, 1997, Banko *et al.* 2000, Burnett *et al.* 1999, Burnett *et al*. 2000).

Even though the selected species are drought tolerant they are prone to drying in the retail nursery setting. There is a need for research on how they behave under different media in a retail nursery setting in order to improve post-harvest quality and extended longevity in the retail nursery setting.

Hydrophilic Polymers

Hydrophilic polymers, or hydrogels, are used in the field of horticulture as media amendments in the form of a liquid, powder, or granules. The hydrogels are designed to absorb water that enters the container plant substrate during irrigation, releasing it when the soil around it dries up. These hydrogels can hold anywhere between 20X to 1000X their own weight of water and are advertised to improve shelf-life of plants in retail outlets (James and Richards, 1986). Hydrogels used in horticulture are classified into three main chemical families: starch acrylate copolymers, polyvinylalcohol copolymers, and polyacrylamide copolymers

The hydrogel used in the study is a member of the polyvinylalcohol family and its active ingredient is 100% polyethylene oxide (PEO). They are obtained from polyethylene glycols which are water soluble substances that are converted into water insoluble hydrogels. This is achieved through the reaction of the hydroxylic end groups with disocyanates and the addition or not of other polyols as cross-linking agents. The cross-linking can be achieved by urethane, urea, biuret, or allophanate groups (El-Sayed *et al.*, 1991):

Water soluble polymer | **Chain extending agent**
$HO[CH_2CH_2\text{-}O]n\text{-}H$ | Diisocynate

Cross - linker
$+HO\text{-}CH_2CH_2CH_2CH(OH)CH_2OH+$
Cross–linked Poly(ethylene oxide) Co-polyurethane hydrogel

A study conducted by Graham *et al*. (1982) on the absorbency of hydrogel suggests that under periods of high temperatures their swelling ability decreases. From this they deduced that perhaps water that is absorbed by the hydrogel in the cooler night temperatures can be released during the warmer day temperatures. Since retail nurseries can not water during the morning or afternoon because of the customers, hydrogels can help to reduce water stress.

Polymer Influence on Post-Harvest Container Plant Quality

Post–harvest container plant quality is important in a nursery setting. Visual quality and plant longevity ensure greater income and fewer losses to the nurseries. In Louisiana, the spring is the most popular time for nursery sales but not all plants are sold at this time. The plant material remains in the retail nurseries throughout the hot summer and their quality diminishes. The fate of plant material that stays in the nursery after spring, is decreased post harvest quality, and, in turn, decreased market value. This contributes to losses for the retail nurseries as they are either sold at a fraction of the original worth or they are thrown away. Post-harvest container plant quality is dependent on the physical and chemical composition of media, the environment, and cultural practices. The physical and chemical composition of the media may be manipulated during the production phase to maximize growth and post-harvest quality. However, once container plants reach a retail nursery, it may not be feasible to alter the physical composition of the media due to the labor intensive and time consuming tasks of remixing and repotting.

A post production amendment which increases water holding capacities of media, such as a hydrophilic polymer which can hold between 20 and 1000 times its weight of water, appears to be a solution. There is conflicting data on the performance of hydrophilic polymers or hydrogels. Hydrogels appear to be beneficial under certain situations, significantly enhancing the quality of some crops but not others and at times they perform better at rates well above the recommended level. In some cases no significant differences have been encountered or the differences have been small to justify its use. The performance of some hydrogels can be hindered by salts present in irrigation water or media amendments (James, 1985; Foster and Keever 1990). Also it has been found that it can potentially clog pores of certain media while expanding, decreasing aeration porosity (Still, 1976).

Foster and Keever (1990) performed a study on the water absorption of hydrogels as influenced by media amendments. The treatment consisted of four hydrogels, Agrosoke4, Liqua-Gel 3 (Miller Chemical Co. Hanover, Pa 17331), Mizuace6 and TerraSorb HB7 (Industrial Services International, Inc. P.O. Box 10834, Bradenton , FL 34282-0834) used at manufacturer's rates blended with either Micromax®, Osmocote®, dolomitic limestone or gypsum placed in beakers with 200 ml of deionized water. Each treatment was accompanied by controls consisting of deionized water with the respective hydrogel. Results showed that amendments reduced absorbency of the hydrogels when compared to the controls. The reduction in absorbency varied within hydrogel and amendment. The absorption was reduced by Micromax® 67.5%-95%, by Osmocote® 4.4%-50.1%, by dolomitic limestone 14.9%-53.6%, by gypsum 71.4%-84.5% and a combination of all the amendments reduced it by 56.8%-97.9%. Osmocote® and dolomitic limestone resulted in the least effect on absorbency while Micromax® or addition of all the amendments combined resulted in the greatest reduction followed by gypsum.

Davies and Castro-Jimenez (1989) compared the performance of two different types of hydrogels to determine if they could increase growth of containerized *Lagerstroemia indica* under water stress conditions. The hydrogels tested were a starch and an organic (polyethylene oxide). They reported that water stressed plants had lower shoot and root dry weight than non-stressed plants. The starch hydrogel increased the shoot dry weight of stressed and non-stressed plants while the organic hydrogel was only able to increase the shoot and dry weight of plants that were under non stressed conditions. They suggested that the performance of hydrogel could have been hindered by salts in irrigation water or fertilizer or water stress.

El Sayed *et al.* (1991) designed a study to determine the effect of salinity on the growth of *Lycopersicon esculentum* Mill. (tomato), *Lactusa sativa* L.(lettuce) and *Cucumis sativus* L.

(cucumber) under sandy soil unamended or amended with a hydrogel, seeds of each crop were germinated in a 25 sand:75 polymer mixture with Hoagland's nutrient solution. Once plants reached the true leaf stage, they were transplanted into growbags. They were grown in sand-hydrogel combinations of 0:100, 25:75, 50:50, 75:25, and 100:0. Saline solutions were added at concentrations of 2000, 4000, and 8000 and 32,000 ppm. For the three species, shoot dry weight decreased as the salinity concentration increased. However, for *Cucumis sativus*, shoot dry weight did not decrease at the 2000 ppm and 4000 ppm salinity concentrations. At the higher salinity concentrations, the decrease in shoot weight was reversed by hydrogel incorporation. Succulence decreased at high salinity concentrations, but increased in all the rates of incorporated hydrogel.

Drought stress affects plant quality and can be detrimental to young citrus seedlings and trees decreasing their yield, fruit size, and quality. Arbona *et al.* (2005) conducted a study to determine the efficiency of a hydrogel in delaying water stress in citrus plants. The treatments tested were a perlite medium and a 80 sphagnum peat:20 perlite amended with 0.2% or 0.4% Stockosorb Agro hydrogel (Degussa-Huls Iberica, S.A., Barcelona, Spain). The seedling survival of the two different citrus rootstocks that underwent drying and recovery cycles benefited by the hydrogel incorporated at the 0.4% rate. Hydrogel increased the substrate water content at the beginning and end of a drought cycle.

A study by Szmidt and Graham (1990) was designed to test the effectiveness of a PEO hydrogel in various combinations of saline sand and on its own. The crops grown under the different treatments were *Lycopersicon esculentum* Mill. (tomato), *Lactusa sativa* L.(lettuce) and *Cucumis sativus* L. (cucumber). They were irrigated with different concentrations of saline water. Results for *Lycopersicon esculentum* grown in hydrogel:sand ratios of 100:0, 75:25, 50:50, 25:75 and 0:100 indicate that PEO hydrogel influenced growth. The maximum height was obtained when hydrogel was incorporated at the 75% rate. It was also found that as rate of hydrogel in substrate increased, tolerance to salinity increased. For *Cucumis sativus*, results were not statistically significant.

Bearce and McCollum (1977) performed an experiment to compare two media for production of *Chrysanthemum morifolium* (chrysanthemums), *Lycopersicon esculentum* (tomato), and *Lilium longiflorum* (Easter lilies) and the effects of hydrogel on their performance. The four treatments tested for *Chrysanthemum morifolium* and *Lilium longiflorum* were peat-lite with fertilizer, noncomposted hardwood bark with fertilizer, peat-lite with fertilizer amended with Viterra® 2 hydrogel and noncomposted hardwood bark with fertilizer amended with Viterra® 2 hydrogel (Nepera Chemical Co., Route 17, Harriman, NY 10926). Results indicated that for chrysanthemums, the Viterra® 2 hydrogel amendment improved plant quality and increased shelf life. They also studied the physical properties of the unamended and amended media and found that the unamended media had less available water than the hydrogel amended media. In the peat–lite medium amended with hydrogel, there was 57% more available water and 37% more available water for the hydrogel amended hardwood bark medium. For *Lilium longiflorum*, it was found that both media performed well, but addition of hydrogel resulted in large full plants with higher numbers of stems and buds and higher dry weights. When studying the physical properties of the media, it was noted that the practical available water for the peat–lite medium was lower than the hardwood bark medium. In the treatments with hydrogel, there was an increase in available water. In the peat–lite medium this increase in available water extended shelf life by 38%, in the hardwood bark medium shelf life was extended by 21%.

Wang and Boogher (1987) conducted an experiment to determine the influence of Agrosoke (Agrosoke International, 1004 N. Bowen, Arlington, Texas 76012), a polyacrylamide hydrogel amendment, at the recommended rate of 5% by volume of potting medium and twice the recommended rate, 10% by volume of potting medium on the growth, and water use of *Chlorophytum comosum* (Thumb.) Jacques 'Vittatum' (spider plant) and *Nephrolepis exaltata* (L.) Schott 'Rooseveltii' (boston fern). The medium was composed of equal parts peat and pinebark amended with 10 lb/yd^3 of Nutricote 14N–6P–11.6K, 3.14 lb/yd^3 Micromax® and 5lb/yd^3 dolomite. It was found that the *Chlorophytum comosum* Jacques 'Vittatum' grown in the medium amended with hydrogel at the 10% rate were 50% larger, resulted in more lateral shoots and had better root systems than the ones grown in the medium amended with hydrogel at the recommended rate. The fresh weight of *Nephrolepis exaltata* 'Rooseveltii' or the water use of either species was unaffected by hydrogel amendment. It was also noted that the hydrogel amended media had a higher EC, suggesting that more nutrients and salts were held in the amended media. The increase in EC did not appear to influence the growth of the plants but it could be detrimental to plants that are sensitive to salt buildup or it can cause toxicity of some nutrients.

Still (1976) tested the effect of various rates of poly ethylene oxide hydrogel on the growth and shelf life of *Chrysanthemum morifolium* Ramat Cv 'Sunny Mandalay.' The medium used was a composed of 2 hardwood bark:1 sand (by volume) amended with Osmocote® 14N–14P–14K at 200 g/0.03m^{3}of hardwood bark. The hydrogel amendment rates used were 1/8 lb, 1/4 lb, 3/8 lb, 1/2 lb, 5/8 lb, 3/4 lb, 7/8 lb and 1 lb per 0.03m^3. The manufacturer's recommended rates were 1/2 or 3/4 lb. Still found that there was no significant difference between the dry weight of amended or unamended media. The media amended with the two highest rates of hydrogel produced dry weights significantly lower than the control. Still concluded that this was attributed to the fact that as the hydrogel swells, it probably expands into free open pores reducing aeration, which results into poor plant development. All except one rate of hydrogel produced plants with significantly longer shelf life than the unamended media. The increase in shelf life ranged from 11-33%.

In a study by Keever *et al.* (1989), to observe the effects of a polymer amendment on growth of container grown plants, four experiments were conducted over a period of three years. The hydrogel tested was Mizuace, a starch acrylate sodium hydrogel. In experiment 1, *Rhododendron* x 'Sherwood Red' (azalea) and *Ligustrum japonicum* 'Aureo margintum' (privet) liners were planted in full gallons while *Buxus microphylla koreana* 'Wintergreen' (boxwood) and *Ilex vomitoria* 'Stokes dwarf' (holly) were planted in trade gallons. The container medium used was 100% milled pinebark with hydrogel at 0, 1.5 lb/yd^3, 3 lb/yd^3, 4.5 lb/yd^3, 6 lb/yd^3 and dibbled at a rate of 3.0 lb/yd^3. Results showed that growth medium temperature, growth index, foliar color rating, root density and shoot dry weight were not affected by the two hydrogel application methods. When compared to the incorporated hydrogel and control, dibbled hydrogel showed lower growth indices and shoot dry weight. For *Rhododendron* x 'Sherwood Red', *Buxus microphylla koreana* 'Wintergreen', and *Ligustrum japonicum* 'Aureo margintum' the root density was similar for the dribbled or incorporated method, but both methods resulted in lower root densities when compared to the control. A second experiment was carried out with *Ligustrum japonicum* 'Aureo marginatum' and *Rhododendron* x 'Sherwood Red' with hydrogel incorporated into the medium at the rates previously mentioned. The plants were irrigated based on the water needs of the plants growing in the 3.0 lb/yd^3 hydrogel amended medium. It was found that with the higher rate of hydrogel foliar levels of Mg and N for both plants and medium

Mg content for *Ligustrum japonicum* 'Aureo marginatum' increased with increased rate of hydrogel. In experiment three, the foliar and medium Mg content for *Ligustrum japonicum* 'Aureo marginatum' also increased with higher hydrogel rates. In both experiments, leachate-soluble salts decreased with increased rates of hydrogel. In a fourth experiment, liners of *Rhododendron* x 'Hino Crimson' were grown in 100% pinebark and amended with dolomite, gypsum and Micromax® as experiment one. Hydrogel was incorporated at a rate of 3 lb/yd^3 and 6 lb/yd^3 and Osmocote® 17N 3P 10K at 4 lb/yd^3, 8 lb/yd^3 and 16 lb/yd^3. Results showed reduced growth indices and shoot dry weight. Medium Mg increased and foliar levels of N were unaffected. However, increased fertilizer rates, growth indices, shoot dry weight and foliar N levels were observed. In contrast, medium Mg was decreased. Medium soluble salts were not different due to rate of hydrogel with increasing fertilizer rates.

Lamont and O'Connel (1987) performed an experiment to determine effects of media components and hydrogels on the shelf life and shoot dry weight of *Petunia* 'Blue Petticoat'. The potting medium used was 1 german peat moss:3 sand:2 rice hulls amended with lime and dolomite. The hydrogel used, TerraSorb® was incorporated at rates of 0, 250, 500 and 1000gm^{-3} with fertilizer N-P-K supplied twice daily. When plants reached marketable size, final irrigation was applied and combined plant and pot weight was measured on a daily basis until plants reached wilting point. Results indicated that rates of hydrogel up to 1000 gm^{-3} had no significant effect on time for plants to reach first or final stage of wilting. Hydrogel did not significantly affect shoot dry weight at the $p \leq 0.05$ level.

Wang (1989) conducted an experiment on tropical plants to determine the effect of three media and two rates of hydrogel amendment (Viterra®) on medium properties, plant growth and shelf life. The tropical plants were *Codiaeum variegatum* 'Nana', *Diffenbachia* 'Camille' and

Hibiscus rosa-sinensis ‘Brilliant Red’. The media used were Sunshine Mix No. 1, a commercial peat–lite mix (SUN), a 1 sphagnum peat:1 pinebark:1 sand medium (by volume) and a 1:peatmoss:1 pinebark medium (by volume). The last two media were amended with 4.0 kgm^{-3} dolomitic lime and 2.0 kgm^{-3} Micromax®. All the media were amended with Osmocote® 13N-5.6P-10.8K at a rate of 4.2 kgm^{-3}. From the results, Wang determined that there were no medium and hydrogel interaction on plant growth. The hydrogel did not affect growth or medium pH.

The overall objectives of this research were to determine the effects of a pinebark, a 9:1 pinebark:sand and a 9:1 pinebark:peat media on the post harvest quality of container grown *Buddleia davidii* ‘Nanho Blue’, *Salvia leucantha* and *Verbena* x *canadensis* ‘Homestead Purple’ for two planting dates in three different settings. To determine the effect of a polyethylene oxide hydrogel amendment incorporated post–production on post-harvest quality of the three ornamentals.

CHAPTER 2

MEDIA INFLUENCE ON POST-HARVEST PLANT QUALITY OF *BUDDLEIA DAVIDII* 'NANHO BLUE'

Introduction

Ornamentals are desirable enhancements and integral components of the landscapes we live in. *Buddleia davidii* 'Nanho Blue' is a deciduos semi-evergreen which blooms profusely throughout the year. It is a popular ornamental among gardening consumers in the southern United States.

Pinebark is the most popular and widely used media in the southern United States, and a variety of plants can be grown in it. In a retail nursery setting, media can dry out very easily due to several factors such as inefficiency of irrigation, mild water stress, transpiration and evaporation. Pinebark media that dries out becomes difficult to rewet due to its hydrophobic nature (Airhart *et al.*, 1978; Gehrig and Lewis, 1980). Media components such as peat and sand can be added to pinebark to increase its wettability and water holding capacity.

Media with different properties can influence plant growth, development and post-harvest quality of some plants and not others. Bilderback *et al*. (1982) found that high quality *Rhododendron indicum* 'George L. Tabor' could be produced when grown under five different combinations of media consisting of peanut hulls, pinebark and canadian sphagnum peatmoss. The differences resulted from the pinebark:peat media which had the lower top dry weight while the peanut hulls and pinebark media had the highest percent growth increase. However, Armitage (1986) found the different media only produced small differences in their post-production life. He noted that there were no significant differences for *Petunia hybrida* and *Tagetes patula* as affected by media, in their visual rating or dry weight. The media treatments 1 soil:1 peat:1perlite (by volume), 1 peat:1 vermiculite (by volume) and 3 vermiculite:1 peat (by volume) only produced small differences in their post-production life.

The physical and chemical composition of the media may be manipulated during the production phase to maximize growth and post-harvest quality. However, once container plants reach a retail nursery, it may not be feasible to alter the physical composition of the media due to the labor intensive and time consuming tasks of remixing and repotting.

Hydrophilic polymers or hydrogels are media amendments which increases water holding capacities of media and can be incorporated post-production. Research on hydrogel efficiency is conflicting. Bearce and McCollum (1977) performed an experiment to compare two media for production of *Chrysanthemum morifolium* and the effects of a hydrogel on its performance. Results indicated that for chrysanthemums, the hydrogel amendment improved plant quality and increased shelf life. However, Wang (1989) determined that there were no medium and hydrogel interaction on plant growth for tropical plants grown under three media and two rates of hydrogel.

The objective of this study is to determine the effects of different media and a hydrogel amendment on the post-harvest quality of *Buddleia davidii* 'Nanho Blue' for two planting dates and three retail nursery settings.

Materials and Methods

This study was initiated on the Louisiana State University campus at the Burden Center container production yard located in Baton Rouge, Louisiana. Burden Center lies at latitude 30° 24' 27" and longitude 91° 8' 45" in the USDA Hardiness zone 8b. Prior to the initiation of the study, a nursery study was devised to determine which species would be selected for the study. Nurseries were visited and nurserymen were asked which species were prone to dry out and have poor post-harvest quality. The selected species for the study were *Buddleia davidii* 'Nanho Blue', *Salvia leucantha* and *Verbena* x *canadensis* 'Homestead Purple'.

Three potting media recipes were used for production and a hydrogel amendment was used post-production. The media consisted of 90% pinebark, 10% mason sand (by volume); 90% pinebark, 10% peat moss (by volume), and 100% pinebark. The pinebark used was obtained from Phillip's Bark Processing, Brookhaven, Mississippi.

To determine the media properties, 1-gallon pots (trade gallon) were filled with the three different media and dried at 60°C for 48 hours in a convection oven. An empty one gallon container lined with a plastic bag was filled with water to the medium surface line. The volume of water used was measured with a graduated cylinder and recorded. This was to measure container volume. One-gallon pots lined with plastic bags were filled with different dried media. Water was slowly applied onto the medium surface at one edge of the container for each media. The volume of water required for the medium to reach saturation was recorded. The drain hole of each gallon pot was pierced with a knife and the water collected in a basin. Each pot was elevated from the bottom of the basin to prevent suction. The volume of water drained was recorded as the aeration pore volume. Using these values, porosity, aeration porosity, and water retention porosity for each medium was calculated. Media porosity was obtained by dividing the pore volume by the container volume and multiplying by 100%. Media aeration porosity was obtained by dividing the aeration pore volume by container volume and multiplying by 100. Media water retention porosity was obtained by subtracting aeration porosity from porosity.

Potting medium was amended with Osmocote® 15-9-12 fertilizer (The Scotts Company, Earthgro-Hyponex-Miracle Gro, Scotts-Scotts, Sierra-Swiss Farms, 14111 Scotts Lawn Road, Marysville, OH 43041) incorporated at a rate of 15.5 lbs/yd^3. Dolomitic limestone was also applied at a rate of 8 lbs/yd^3. The different potting media were uniformly mixed in ¼ cubic yard increments using a commercial concrete mixer. Once each medium was thoroughly mixed, the media were transferred into 1-gallon (trade gallon) black plastic nursery pots and irrigated upon arrival of liners. Liners of *Buddleia davidii* 'Nanho Blue' 6" in height were planted August 2004 and grown for 10 months (crop 1). Each pot was topdressed with ornamental herbicide. To determine how the post harvest quality of crops of different age in a retail nursery setting is influenced by media, a second crop of *Buddleia davidii* 'Nanho Blue' was planted in February 2005 and grown for 4 months (crop 2).

Treatments were arranged in a randomized complete block design. It consisted of eight replications of three species, three media treatments and a hydrogel amendment for two planting dates and three retail nursery settings totaling 576 pots.

Plants were irrigated with overhead irrigation on a container yard consisting of 24 separate plots. Each plot was 10' x 10' with 3' risers on all four corners and at the center. An irrigation water sample test was carried out (Soil Testing Lab, Louisiana State University). The irrigation water had an alkalinity of 170.8 ppm and a pH of 8.44 (Appendix 2). All pots were irrigated uniformly two times per day. The 2x irrigation treatment was applied at 6:00 am and 4:00 pm for 30 minutes. The irrigation then changed to 6:00 am, 11:00 am and 4:00 pm for 21 minutes. Finally, the plants were irrigated at 6:00 am and 2:00 pm for 15 minutes until the end of post-harvest. In periods of heavy rain, the irrigation was turned off. Water was monitored to ensure 20% to 40% effluent using a closed capture system (Harris, 2004). This was done by dividing the amount of water applied by the amount of water leached.

Media influence on the growth indices of the plants was determined throughout production and post-harvest and measurements were taken every eight weeks. One plant height and two widths perpendicular to each other were measured to determine growth indices. Growth indices were determined by the equation:

$$GI = (\text{height } 1 + \text{width } 1 + \text{width } 2)/3.$$

In June 2005 once production terminated and the post-harvest study initiated, half of the plants growing in 100% pinebark were treated with a dibbled hydrogel amendment, Saturaid® (Debco PTY LTD, 12 McKirdys Road, Tyabb, Victoria 3913, Australia) at a rate of 25 ml of Saturaid® for every 15L of water. After this amendment, a third of the plants were transported to Clegg's Nursery in Denham Springs, LA. Clegg’s Nursery lies at latitude 30° 31’ 17.7” and longitude 90° 57’ 28.09” in the USDA Hardiness zone 8b. Before transportation, all plants were thoroughly irrigated, placed in a truck, irrigated once more and covered with a shade tarp to prevent desiccation and wind damage. At Clegg's Nursery, the plants were separated by species and placed in a randomized block design. The portion that remained at Burden Center were placed under two simulated retail nursery settings, Burden 1 and Burden 2. One-third of the plants remained in the original plots (Burden 2) and one-third were placed on a separate container production yard at Burden Center (Burden 1). The plot in this location was on gravel ground lined with black geotech fabric.

The irrigation for the plants in Burden 2 remained the same while the irrigation system for Burden 1, consisted of four, 5’ tall risers at a corner with rotary nozzles. At Burden 1, pots were irrigated with a twice daily treatment at 8:00 am and 4:00 pm for 30 minutes. In July, this was then changed to 6:30 am and 4:00 pm for 30 minutes until the end of the study. In periods of heavy rain, the irrigation was turned off. The irrigation at Clegg’s consisted of four, 5’ tall risers at each corner with rotary nozzles. All pots were irrigated twice daily at 2:00 am and 5:30 am for 42 minutes. An irrigation water sample test was carried out (Soil Testing Lab, Louisiana State University). The irrigation water used at Clegg's Nursery had a pH of 7.06 and an alkalinity of 78 ppm (Appendix 3). Water distribution and amount applied at the three different locations was monitored with rain gauges.

Leachate samples were collected over a period of 120 days for May, June, July, and September 2005 for all plants. The samples were collected using the modified Virginia Tech Extraction Method. Sampling pots were placed on top of oil catch basins and 300 milliliters of distilled, deionized water was gently poured onto the media surface. Leachate samples were collected for plants of each treatment into plastic containers and stored in a standard refrigerator until processed. Before EC or pH was tested, impurities were extracted from leachate samples by pouring leachate through 11 c.m. paper filters (Scheicher & Schuell, Inc., Keene, N.H.). Once filtered, leachate samples were tested with a calibrated EC and pH reader (Model 5800-00, Cole Palmer Instrument Co., Chicago, IL).

All the plants were rated on their post-harvest quality over a period of 120 days. The initial measurement was taken before the plants were placed in the three retail nursery settings. The plants were rated using a rating scale of 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above mean, 5=optimum.

Plants in all three retail nursery settings were treated for mites and white flies with Ortho® Systematic Insect Killer (The ORTHO Group, P.O. Box 1749, Columbus, Ohio 43216) at a rate of 3 Tbs. per gallon of water.

All the plants were harvested on September 2005. The top of each plant was cut from the media surface and placed in paper bags. All plants were dried in a conventional oven (VWR-1660) at 60°C for two days. Their shoot dry weight was measured on a Mettler PC 440 scale and their weights recorded.

Data was analyzed using the SAS program for Windows (SAS Institute, Inc. 1998) using proc GLM. Means were separated using Duncan's Multiple Range Test at the $p \leq 0.05$ level.

Results

***<u>Buddleia davidii</u>* <u>'Nanho Blue' Leachate EC and pH</u>**

In the analysis for both leachate EC and pH values of *Buddleia davidii* 'Nanho Blue', media, repetition and crop were not significantly different. These were pooled for analysis.There were differences on leachate EC and pH measurements between weeks. The leachate pH value was lowest after 4 weeks, coinciding with the plants being fertilized. The pH gradually increased after fertilization to initial levels after 16 weeks. Leachate EC increased over time with the first measurement and the measurement 4 weeks later being significantly different to the measurements 8 and 16 weeks later at the $p \leq 0.05$ level. Leachate EC was highest at 16 weeks (Table 1).

Table 1. Leachate analysis for *Buddleia davidii* 'Nanho Blue'.

Weeks	EC(dS/m)	pH
1	0.37 b	6.9 a
4	0.42 b	5.5 c
8	0.66 a	6.3 b
16	0.74 a	6.9 a

Note: first measurement taken before plants placed in retail nursery and every 4 weeks after placement.Means with the same letters are not significantly different at the $p \leq 0.05$ level.

***<u>Buddleia davidii</u>* <u>'Nanho Blue' Grow Index</u>**

Burden 1

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops. The data were pooled for analysis (Appendix 5). Growth indices were similar for pinebark and pinebark:sand. The highest growth index was produced in pinebark:peat which was 12% higher than pinebark. Even though the media had different water holding capacities (Appendix 1), they were all suitable for production of *Buddleia davidii* ‘Nanho Blue’. At the end of post-harvest, after a portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, the highest growth index was produced in pinebark amended with hydrogel. Growth index for pinebark amended with hydrogel was 13% higher than pinebark. Growth indices for pinebark and pinebark:peat were similar. Pinebark:sand was not different to the other media (Figure 1).

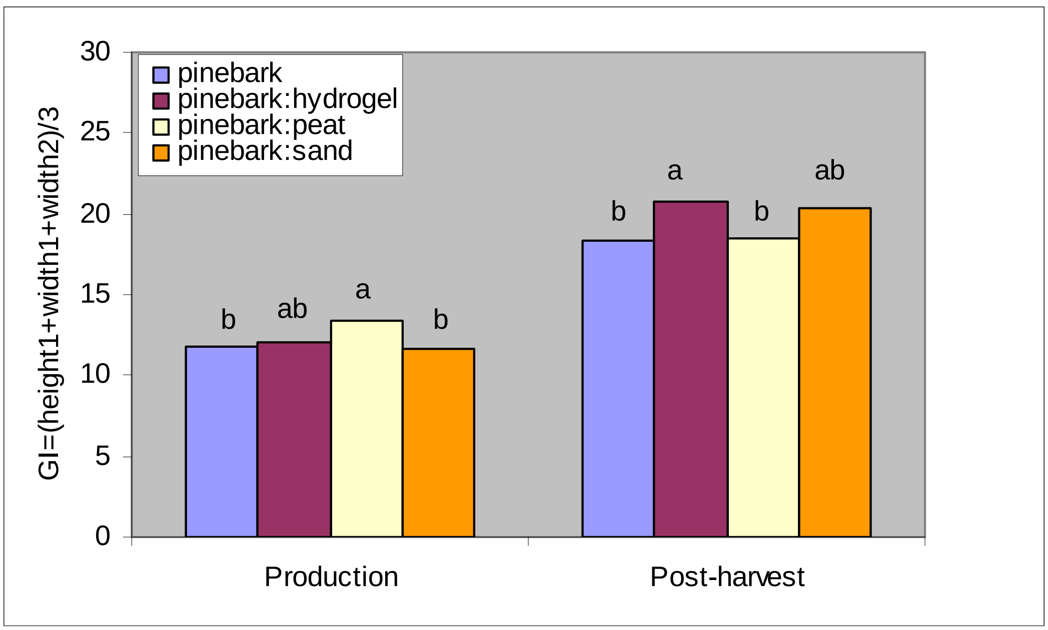

Figure 1. Media influence on growth index of *Buddleia davidii* ‘Nanho Blue’ for Burden 1. Means with the same letter are not significantly different at the $p \leq 0.05$ level.

Clegg’s Nursery

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops so the data were pooled for analysis (Appendix 5). Growth indices for pinebark to be amended with hydrogel, pinebark:peat and pinebark:sand were similar. Pinebark produced the lowest mean growth index. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, there were no significant differences between mean growth indices due to media at the $p \leq 0.05$ level (Figure 2).

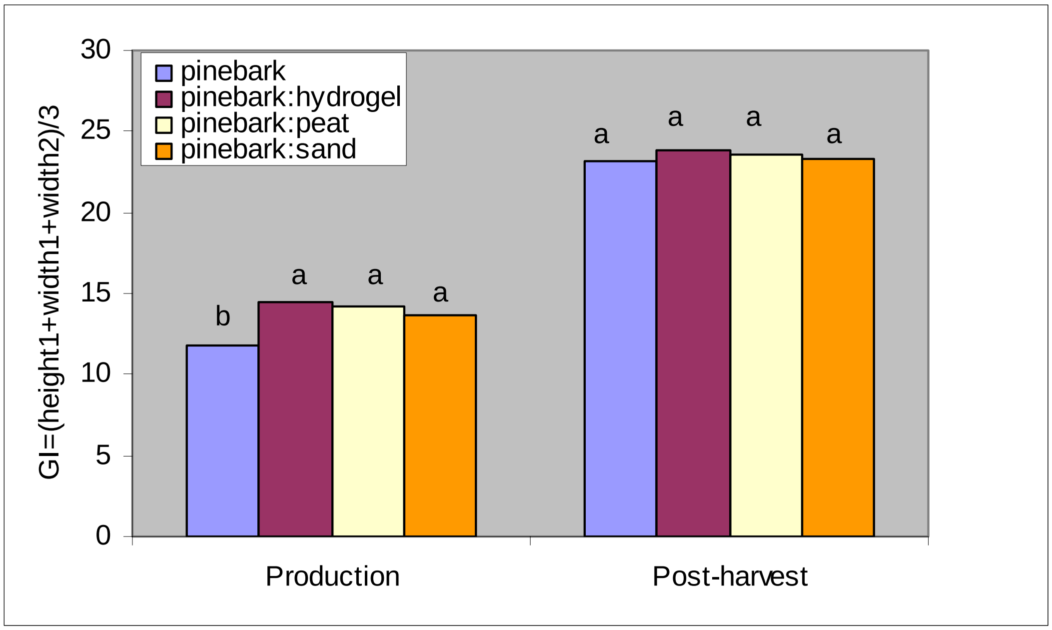

Figure 2. Media influence on growth index of *Buddleia davidii* 'Nanho Blue' for Clegg's Nursery. Means with the same letter are not significantly different at the $p \leq 0.05$ level.

Burden 2

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops so the data were pooled for analysis (Appendix 5). Pinebark and pinebark:peat produced similar growth indices and also the highest. Pinebark:sand produced the lowest growth index. Pinebark to be amended with hydrogel was not different to the other media. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, growth indices for pinebark, pinebark amended with hydrogel and pinebark:sand were similar. The lowest growth index was produced in pinebark:peat. The growth index for pinebark:peat was 15% lower than pinebark (Figure 3).

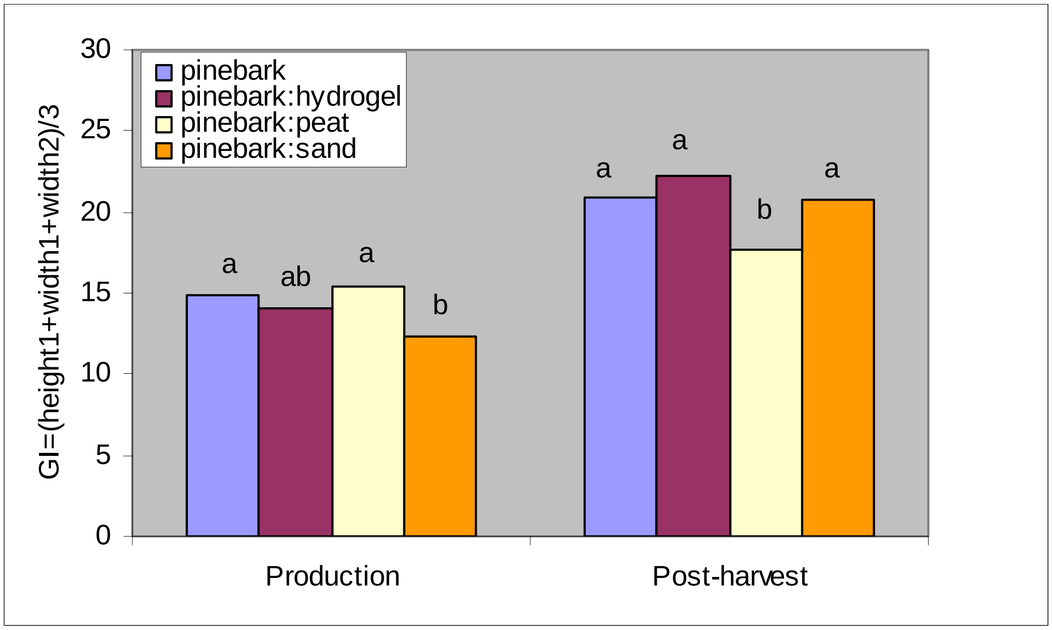

Figure 3. Media influence on growth index of *Buddleia davidii* 'Nanho Blue' for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level.

Buddleia davidii **<u>'Nanho Blue' Growth Index Compared by Retail Nursery Setting</u>**

The hydrogel amendment had a positive effect on growth indices for plants in Burden 1 increasing growth index by 13% when compared to pinebark.

At the end of production, overall growth indices of plants were similar. Overall growth index for plants assigned to Burden 1 was 12.1, 13.4 for plants assigned to Clegg's Nursery and 14.5 for plants assigned to Burden 2. After placement in the different settings, the final overall growth index was highest for Clegg's Nursery. Final growth index for Burden 1 was 19.5, for Clegg's Nursery; 23.5 and for Burden 2; 20.3. These trends show that growth indices after post-harvest were different due to setting (Table 2).

Table 2. *Buddleia davidii* 'Nanho Blue' retail nursery setting comparison of growth index, plant quality and shoot weight.

	Burden 1	Clegg's Nursery	Burden 2
pH	8.44	7.06	8.44
Alkalinity	170.80	78.08	170.80
Avg. Weekly Water	3.85"	4.4"	3.36"
Growth Index Means (Production)	12.1	13.4	14.5
Growth Index Means (Post-harvest)	19.5	23.5	20.3
Plant Quality Means	3.0	3.76	3.2
Shoot Weight Means	13.4	34.5	17.2

Note: Means for crop 1 and crop 2 were pooled.

***Buddleia davidii* 'Nanho Blue' Post Harvest Quality Rating**

Burden 1, Crop 1

At the end of production, there were significant differences in plant quality due to media and all plants were above a commercially acceptable quality. Pinebark:peat and pinebark to be amended with hydrogel had similar quality and the highest quality, while pinebark:sand and pinebark had the lowest quality. After 6 weeks of post-harvest, there was a decrease in mean quality rating due to media. The mean quality rating for pinebark decreased from 3.9 to 2, a decrease of 49%. Over the same period, pinebark amended with hydrogel decreased from a mean quality rating of 5 to 2.63, a decrease of 47% while pinebark:peat decreased from 5 to 3.06, a decrease of 39% and pinebark:sand decreased from 4.5 to 2.38, a 47% decrease. Pinebark:peat medium better maintained plant quality relative to the other media being the only one to remain slightly above commercially acceptable quality.

The mean quality rating decreased quickly after 6 weeks and all plants were below commercially acceptable quality. Pinebark showed a decrease in mean quality rating from 2 to 1.38, a 31% decrease; pinebark amended with hydrogel decreased from 2.63 to 1.56 a 41% decrease, pinebark:peat decreased from 3.06 to 2.00, a 35% decrease, and pinebark:sand decreased from 2.38 to 1.13 a 53% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 65%. Similarly, pinebark amended with hydrogel decreased 69%, pinebark decreased 60% and pinebark:sand decreased 75% over the same period. Overall, the post-harvest quality of plants decreased in all media. Pinebark amended with hydrogel and pinebark:peat maintained the highest quality, however they were below commercially acceptable quality (Figure 4).

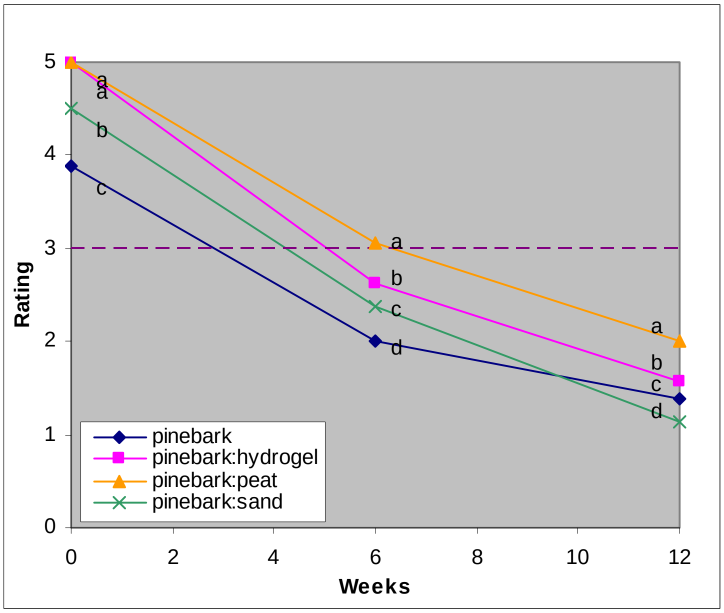

Figure 4. Media influence on post-harvest quality rating of *Buddleia davidii* 'Nanho Blue' crop 1 for Burden 1. Means with the same letter are not significantly different at the $p \leq 0.05$ level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Burden 1, Crop 2

At the end of production all plants were above commercially acceptable quality and there were significant differences due to media with pinebark:sand and pinebark to be amended with hydrogel having the highest mean quality ratings. Pinebark had a higher quality rating than pinebark:peat which had the lowest quality. After 6 weeks of post-harvest all media retained quality ratings above commercially acceptable quality. Pinebark amended with hydrogel decreased from a mean quality rating of 3.75 to 3.63, a decrease of 3.2% while pinebark:peat increased from 3.25 to 3.38, an increase of 13%. Pinebark:sand decreased from 3.75 to 3.38, a

9.9% decrease. At this time, pinebark and pinebark amended with hydrogel had the same plant quality rating and also the highest quality rating. Pinebark:peat and pinebark:sand had the same quality rating and also the lowest quality rating.

The mean quality rating declined quickly after 6 weeks and all media were below commercially acceptable quality. Pinebark showed a decrease in mean quality rating from 3.63 to 1.68, a 53.7% decrease; pinebark amended with hydrogel decreased from 3.63 to 2.25, a 38% decrease, pinebark:peat decreased from 3.38 to 2.69, a 20% decrease, and finally pinebark:sand decreased from 3.38 to 2.66, a 21% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 55%. Similarly, pinebark amended with hydrogel decreased 40% while pinebark:peat decreased 17% and pinebark:sand decreased 29%. Overall, the post-harvest quality of plants decreased in all media. Pinebark:peat decreased the least over time and maintained the highest quality rating (Figure 5). At the end of post-harvest all plants were below commercially acceptable quality.

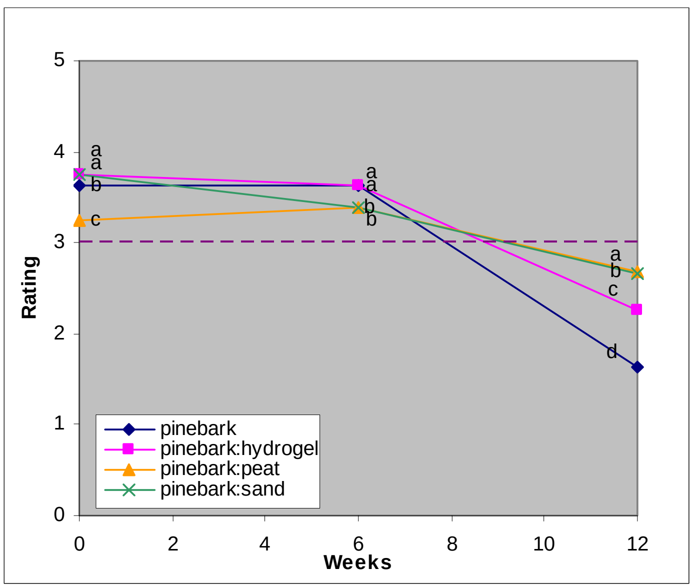

Figure 5. Media influence on post-harvest quality rating of *Buddleia davidii* 'Nanho Blue' crop 2 for Burden 1. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Clegg's Nursery, Crop 1

At the end of production all plants were above average quality. Pinebark:sand produced the highest mean quality rating. Pinebark:peat, pinebark to be amended with hydrogel and pinebark produced similar quality ratings. After 6 weeks of post-harvest, even though there was a decrease in mean quality rating, all media remained above commercially acceptable quality. The mean quality rating for pinebark decreased from 4.63 to 3.86 a 17% decrease. Over the same period, pinebark amended with hydrogel decreased from a mean quality rating of 4.63 to 4.00, a decrease of 14%, pinebark:sand decreased from 4.88 to 3.88, a 21% decrease while pinebark:peat remained unchanged. At this time, pinebark:peat and pinebark amended with hydrogel had the highest quality rating.

The mean quality rating increased for all media after 6 weeks except for pinebark:peat which decreased in quality. All media having above commercially acceptable quality. Pinebark increased in mean quality rating from 3.86 to 4.25, a 10% increase; pinebark amended with hydrogel increased from 4 to 4.14, a 4% increase; pinebark:peat decreased from 4.63 to 4.25, a 9% decrease, and finally pinebark:sand increased from 3.88 to 4.38, a 13% increase. From the initial rating to the final, pinebark decreased in mean quality rating 8%. Similarly, pinebark amended with hydrogel decreased 11% while pinebark:peat decreased 8% and pinebark:sand decreased 10%. Overall, the post-harvest quality of plants decreased in all media for the first six weeks except for pinebark:peat. In the subsequent 6 weeks, all media increased in quality rating except pinebark:peat. Pinebark:peat decreased in quality rating, but it remained above commercially acceptable quality (Figure 6).

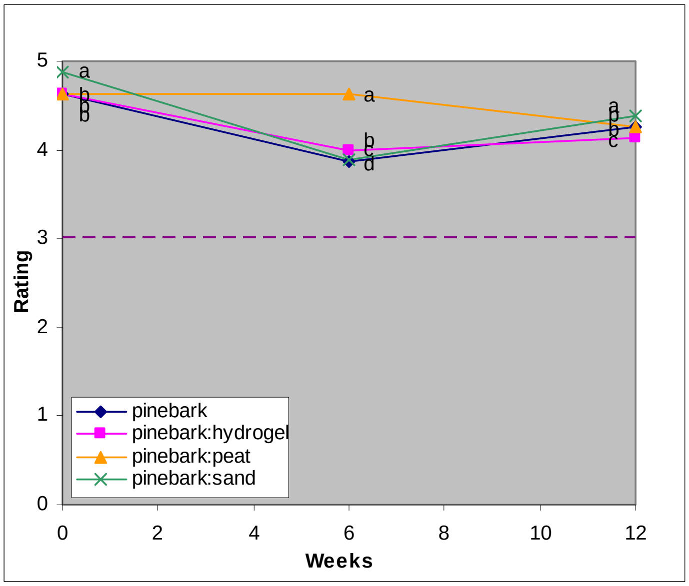

Figure 6. Media influence on post-harvest quality rating of *Buddleia davidii* 'Nanho Blue' crop 1 for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Clegg's Nursery Crop 2

At the end of production all plants were above commercially acceptable quality and there were significant differences due to media. Plants in pinebark:peat had the highest mean quality rating. Pinebark:sand and pinebark had similar quality and pinebark to be amended with hydrogel had the lowest rating. After 6 weeks of post-harvest, pinebark and pinebark amended with hydrogel decreased in quality while pinebark:peat increased in quality and pinebark:sand remained unchanged. All plants were above commercially acceptable quality. The mean quality rating for pinebark decreased from 3.5 to 3.25, a 7% decrease, and for pinebark amended with hydrogel mean quality rating decreased from 3.38 to 3.13, a decrease of 7%. On the other hand, pinebark:peat increased from 3.85 to 3.88, a 1% increase and pinebark:sand remained unchanged at 3.5. At this time, pinebark:peat and pinebark:sand had the highest quality rating. Pinebark and pinebark amended with hydrogel had the lowest quality rating.

The mean quality rating decreased for all media after 6 weeks, except for pinebark amended with hydrogel which remained unchanged. All plants displayed similar quality ratings throughout all media with pinebark:sand having the highest mean quality rating. Pinebark decreased in mean quality rating from 3.25 to 3.13 a 4% decrease; pinebark amended with hydrogel remained the same; pinebark:peat decreased from 3.88 to 3.13, a 19% and pinebark:sand decreased from 3.5 to 3.25 a 7% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 11%. Similarly, pinebark amended with hydrogel decreased 7%, pinebark:peat decreased 19% and pinebark:sand decreased 7% over the same period. Overall, even though post-harvest quality rating decreased, plants had commercially acceptable quality in all media. Pinebark:sand had the highest quality rating at the end of post-harvest (Figure 7).

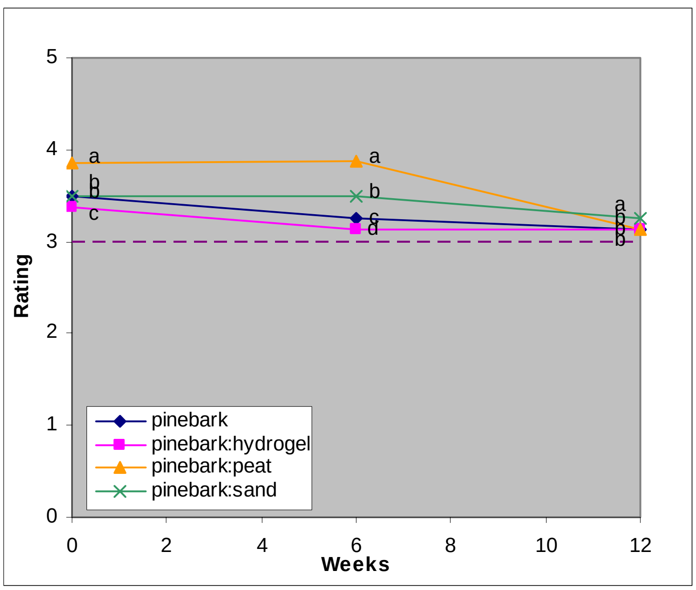

Figure 7. Media influence on post-harvest quality rating of *Buddleia davidii* ‘Nanho Blue’ crop 2 for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Burden 2, Crop 1

At the end of production all plants were above average quality and there were significant differences due to media. Pinebark to be amended with hydrogel and pinebark:sand had the same quality and highest quality ratings. Pinebark:peat had the lowest quality rating. After 6 weeks of post-harvest, all media decreased in mean quality rating, with pinebark and pinebark:sand decreasing the most. Pinebark amended with hydrogel had the highest mean quality rating and pinebark:peat had the second highest mean quality rating, both above commercially acceptable quality. The mean quality rating for pinebark decreased from 4.72 to 2.63, a 44% decrease. Over the same period, pinebark amended with hydrogel decreased from a mean quality rating of 4.88 to 3.81, a decrease of 22%, pinebark:peat decreased from 4.25 to 3.44, a 19% decrease, and pinebark:sand decreased from 4.88 to 2.88, a 41% decrease.

The mean quality rating decreased due to media after 6 weeks, with pinebark amended with hydrogel decreasing the least, remaining above commercially acceptable quality. Pinebark decreased in mean quality rating from 2.63 to 2.25, a 14%; pinebark amended with hydrogel decreased from 3.81 to 3.75, a 2 % decrease; pinebark:peat decreased from 3.44 to 2.13, a 38% decrease, and pinebark:sand decreased from 2.88 to 1.63 a 43% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 52%; pinebark amended with hydrogel decreased 23%; pinebark:peat decreased 49.9% and pinebark:sand decreased 67% over the same period. Overall, the post-harvest quality of plants decreased in all media. The highest quality rating was achieved with the pinebark amended with hydrogel (Figure 8).

Burden 2, Crop 2

At the end of production there were significant differences due to media. Plants in pinebark, pinebark to be amended with hydrogel and pinebark:sand displayed mean quality ratings above commercially acceptable quality while plants in pinebark:peat had a mean quality rating below commercially acceptable quality. After 6 weeks of post harvest, the mean quality rating for pinebark decreased from 3.38 to 3, an 11% decrease. Over the same period, pinebark amended with hydrogel increased from a mean quality rating of 3.25 to 4, an increase of 23%, while pinebark:peat increased from 2.71 to 2.75, a 2% increase. At this time, pinebark amended with hydrogel and pinebark:sand had the highest quality rating. Pinebark:peat and pinebark had the lowest quality rating but pinebark had a commercially acceptable quality while pinebark:peat was below commercially acceptable quality.

The mean quality rating decreased due to media after 6 weeks, except for pinebark:peat which increased, reaching commercially acceptable quality. Even though pinebark amended with hydrogel decreased, it remained slightly above commercially acceptable quality. Pinebark showed a decrease from 3.0 to 1.5, a 50% decrease; pinebark amended with hydrogel decreased from 4 to 3.31, a 17.4 decrease; pinebark:peat increased from 2.75 to 3.06, a 10% and pinebark:sand decreased from 3.13 to 2 a 36% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 55%, pinebark amended with hydrogel increased 2% while pinebark:peat increased 13% and pinebark:sand decreased 36% over the same period. Overall, the post-harvest quality of plants was best under the pinebark amended with hydrogel and pinebark:peat media (Figure 9).

***Buddleia davidii* 'Nanho Blue' Post Harvest Quality Rating Crop Comparison**

For crop 1, mean quality rating decreased over time due to media in Burden 1 and Burden 2. At Clegg's Nursery, after 6 weeks of post-harvest, the mean quality rating due to media decreased but after a further 6 weeks there was an increase in quality for all media except pinebark:peat. At the end of post-harvest, for plants in Burden 1, pinebark:peat produced the highest mean quality ratings, but it was below commercially acceptable quality. At Clegg's Nursery, pinebark:sand produced the highest mean quality rating. At Burden 2 all plants were below commercially acceptable quality except for pinebark amended with hydrogel which produced the highest mean quality rating.

For crop 2, the mean quality rating decreased over time due to media in all three settings with some exceptions. At Burden 1, after 6 weeks of post-harvest, there was an increase in quality rating for pinebark amended with hydrogel. After a further 6 weeks, its quality decreased but it remained at commercially acceptable quality. Pinebark:peat, on the other hand, increased both 6 weeks and 12 weeks after post-harvest.

Crop 1 had the highest quality at the end of production, while crop 2 had the highest quality at the end of post-harvest.

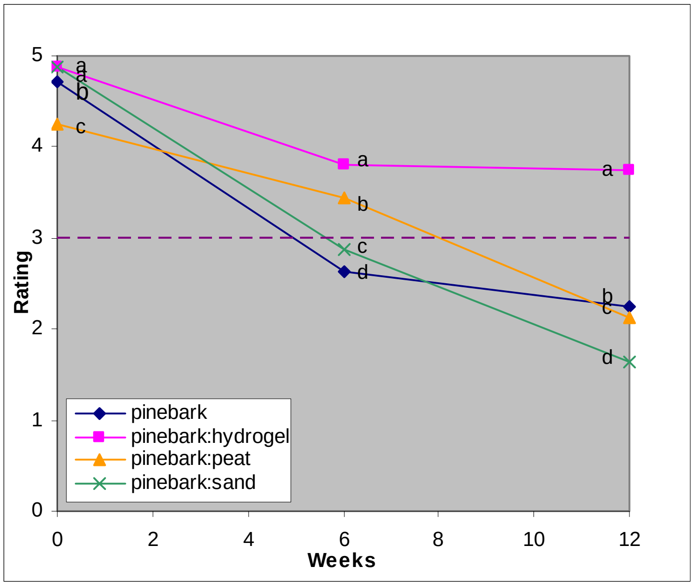

Figure 8. Media influence on post-harvest quality rating of *Buddleia davidii* 'Nanho Blue' crop 1 for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

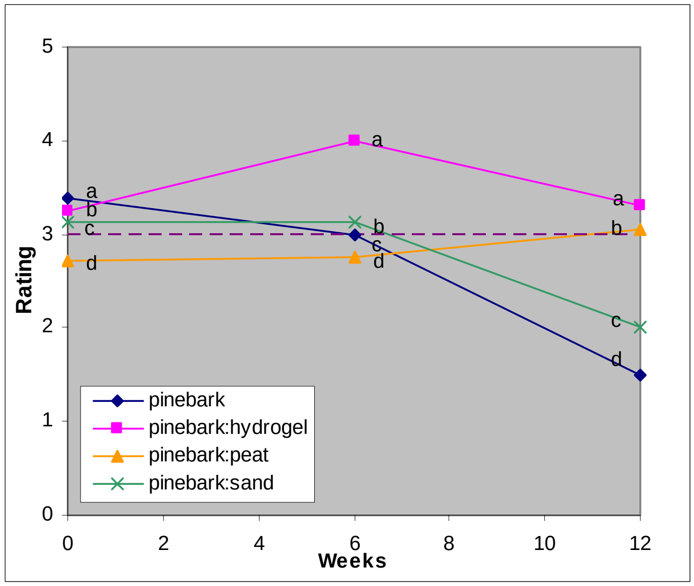

Figure 9. Media influence on post-harvest quality rating of *Buddleia davidii* 'Nanho Blue' crop 2 for Burden 2. Means with the same letter are not significantly different at the $p \leq 0.05$ level Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Buddleia davidii **'Nanho Blue' Post-Harvest Quality Rating Compared by Retail Nursery Setting**

To compare locations, mean quality ratings at 6 weeks after placement in three retail nursery settings were isolated and data for crops 1 and 2 were pooled. The mean plant quality rating was 3 for Burden 1, 3.76 for Clegg's Nursery, and 3.2 for Burden 2. This shows that quality ratings were impacted by not only media but also by retail nursery setting (Table 2).

Buddleia davidii **'Nanho Blue' Dry Shoot Weight**

Crop 1

At Burden 1 and Clegg's Nursery, there were no significant differences in dry shoot weight due to media at the $p \leq 0.05$level. However, at Burden 2, the dry shoot weight was influenced by media with pinebark amended with hydrogel displaying the highest dry shoot weight means. Pinebark, pinebark:peat and pinebark:sand had similar dry shoot means while pinebark amended with hydrogel had a 46% higher dry shoot weight mean relative to pinebark

(Figure 10). Dry shoot weight means for Burden 1 and Burden 2 where very similar with 17.4g and 25.6g respectively. The highest dry shoot mean was produced at Clegg's Nursery with 49.8g.

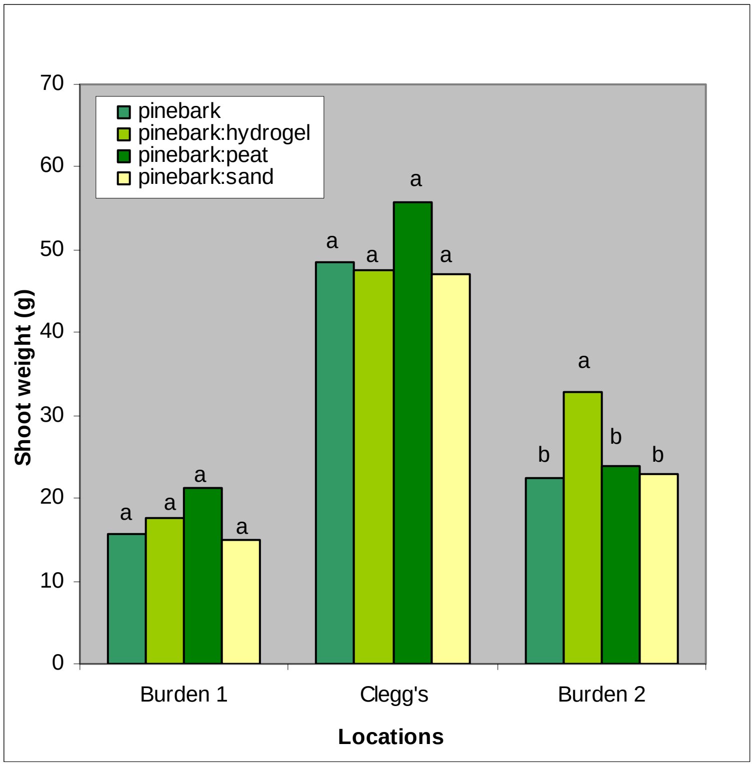

Figure 10. Media influence on dry shoot weight of *Buddleia davidii* 'Nanho Blue' crop 1. Means with the same letter are not significantly different at the p≤0.05 level.

Crop 2

At Burden 1 and Clegg's Nursery, there were no significant differences in dry shoot weight due to media at the p≤0.05 level. At Burden 2, dry shoot weight was influenced by media with pine bark amended with hydrogel displaying the highest dry shoot weight mean with the exception of pinebark:peat. Pinebark and pinebark:sand had similar dry shoot weight means while pinebark:peat was not different to the other media. There was at least a 100% increase in dry shoot weight for pinebark amended with hydrogel relative to pinebark and pinebark:sand (Figure 11). Dry shoot weight means for Burden 1 and Burden 2 where similar, with 9.4g and 8.7g respectively, while the dry shoot weight doubled to 18.5g at Clegg's Nursery.

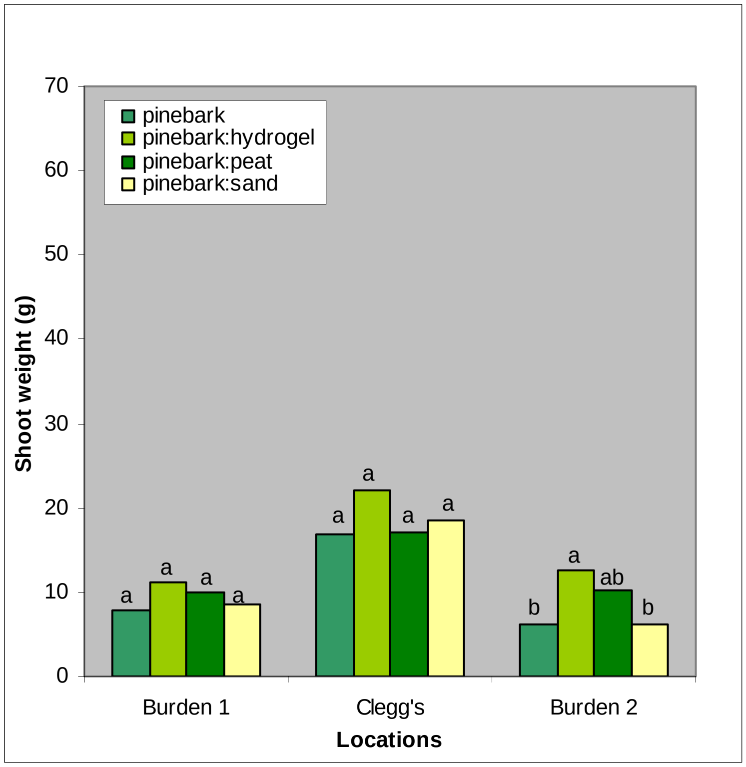

Figure 11. Media influence on dry shoot weight of *Buddleia davidii* 'Nanho Blue' crop 2. Means with the same letter are not significantly different at the $p \leq 0.05$ level.

Buddleia davidii **'Nanho Blue' Dry Shoot Weight Compared by Retail Nursery Setting**

To compare between retail nursery settings, the mean quality rating after 6 weeks of post-harvest was isolated and data for crop 1 and crop 2 were pooled. Shoot weight means for Burden 1 and Burden 2 were similar with 13.4g and 17.2g, respectively, while Clegg's Nursery had more than double the shoot weight at 34.47. These trends show that there was a difference in shoot weight due to retail nursery setting (Table 2).

Discussion

Leachate EC was at acceptable levels after 16 weeks remaining below 2.0 dS/m as required for pinebark based substrates (Anonymous, 2006c). Leachate pH did not change significantly over time except 4 weeks after placement in the three retail nursery settings, coinciding with a fertilizer treatment.

Out of the three media treatments, it was observed that at the end of production, pinebark:peat increased growth index of plants assigned to Burden 1 and Burden 2. Pinebark:peat had the highest water holding capacity and in turn increased plant growth. One characteristic of peat observed by Michel *et al.* (2004) further influences plant growth. They stated that it is less affected to periods of dessication and rehydration than pinebark, with its water content remaining constant. Also, Brown, (1987) found that 5% to 10% peat added to pinebark, increased quality of *Rhododendron* sp. (azalea) and *Vaccinium myrtilloides* Michx. (blueberry) .

At the end of post-harvest, there were no significant differences on mean growth indices at Clegg's Nursery. These results show that growth index was not significantly influenced by media treatments or amendments as found in previous research. Tomlinson and Bilderback (1985) stated that sand, bentonite clay and Terra-Sorb 200® hydrogel added to pinebark did not increase growth of *Ilex* x 'Nellie R Stevens' (holly) and X *Cupressocyparis leylandii* (leyland cypress). This also agrees with a study by Strojny and Nowak (2004) where it was found that a range of media made up of sphagnum peat with different additives, did not significantly affect plant growth of *Verbena tapien* 'Salmon Pink' or *Bacopa suternova* 'Pearl'.

The hydrogel amendment increased growth index of plants at Burden 1 by 13% when compared to pinebark. The hydrogel amendment was more beneficial in environments where less water was applied as opposed to where plants were heavily watered. At Burden 1, the hydrogel amendment increased growth index by 13%, while it did not influence growth index Clegg's Nursery. At Burden 1, the average weekly water applied was lower, so plants benefited from the use of a hydrogel amendment, which supplied extra moisture to the plants.

All media produced quality plants with commercially acceptable quality or above average quality at the end of production. At the end of post-harvest, the mean quality ratings for crop 1 and crop 2 were highest in pinebark:peat and pinebark amended with hydrogel at Burden 1 and Burden 2 respectively. At Clegg's Nursery, pinebark:sand produced the highest plant quality rating and all plants were above commercially acceptable quality. The hydrogel amendment was most pronounced at Burden 2, where the hydrogel amendment produced plants above commercially acceptable quality as opposed to plants in Burden 1 which were below commercially acceptable quality. This positive influence in plant quality rating for plants in Burden 2, agrees with research by Conover and Poole (1979) who found that Viterra® improved shelf life of *Maranta* sp. and *Pilea* sp. by approximately 10%. Also, in a study by Martyn and Szot (2001) it was found that addition of a hydrogel increased the retention of water available for plants. At the retail nursery setting were less water was supplied, the hydrogel helped media retain more water for plant use.

There were crop differences with crop 1 having a higher decrease in quality than crop 2 at both Burden 1 and Burden 2. Crop 1 had a longer production time, which could have resulted in compaction of media and roots due to impact of overhead irrigation, insufficient space for growth, decreased aeration, degradation of media and becoming pot bound. Thus, crop 1 would decrease in quality quicker than crop 2, which had a shorter production time.

Dry shoot weights were not significantly different due to media at the $p \leq 0.05$ level at Burden 1 and Clegg's Nursery. These results agree with findings by Ingram and Van der Weken (1982), who found that dry shoot weight of *Ilex crenata* 'Green Luster' Thunb. and *Juniperus horizontalis* Moench. were not affected by three different media. Specht and Jones (2000) stated that the drought tolerant *Flindersia australis* amended with hydrogel, displayed no significant increase in dry shoot weight. Dehgan *et al.* (1994) found that dry shoot weight for *Podocarpus macrophyllus* (japanese yew) were similar for hydrogel amended and unamended media. Still (1976) concluded that *Chrysanthemum morifolium* (chrysanthemum) grown in a pinebark:sand medium amended with various rates of hydrogel showed no significant differences in dry shoot weight between amended or unamended media. Also, Austin and Bondari, (1992) found that adding hydrogel to pinebark or peatmoss did not improve plant growth or weight of *Vaccinium myrtilloides* Michx. (blueberry). Similarly, Ingram and Yeager, (1987) found that dry weight of *Ligustrum japonicum* grown in a 2 pinebark:1 canadian peat:1 sand medium amended with hydrogel at different rates were not affected.

For Burden 2, dry shoot weights were significantly different due to media at the $p \leq 0.05$ level. The highest dry shoot weight was produced in pinebark amended with hydrogel. The hydrogel amendment produced plants with 45.74% and 103.8% higher mean shoot weight when compared to pinebark for crop 1 and crop 2 respectively. Boatright *et al*. (1997) found that *Petunia parviflora* experienced an increase in dry shoot weight due to a hydrogel amendment in dry conditions. Also, Bilderback (1987) concluded that a hydrogel amendment increased shoot dry weight of *Pyracantha cocinnea* and *Rhododendron* sp.

Overall, at the end of post-harvest, growth index, plant quality ratings and dry shoot weight for Burden 1 and Burden 2 were lower than at Clegg's Nursery. These trends show that mean growth indices after post-harvest were affected by irrigation water quality and amount of water applied. The irrigation water quality at Burden 1 and Burden 2 had a higher alkalinity and than Clegg's Nursery. High alkalinity over time can reduce the availability of nutrients and in turn decreases plant growth and quality (Bailey *et al*., 1999).

CHAPTER 3

MEDIA INFLUENCE ON POST-HARVEST PLANT QUALITY OF *SALVIA LEUCANTHA*

Introduction

Ornamentals are desirable enhancements and integral components of the landscapes we live in. *Salvia leucantha* is a perennial which blooms profusely throughout the year and in the fall, when there are few things of interest. It is a popular ornamental among gardening consumers in the southern United States.

Pinebark is the most popular and widely used media in the southern United States, and a variety of plants can be grown in it. In a retail nursery setting, media can dry out very easily due to several factors such as inefficiency of irrigation, mild water stress, transpiration and evaporation. Pinebark media that dries out becomes difficult to rewet due to its hydrophobic nature (Airhart *et al*., 1978; Gehrig and Lewis, 1980). Media components such as peat and sand can be added to pinebark to increase its wettability and water holding capacity.

Media with different properties can influence plant growth, development and post-harvest quality of some plants and not others. Bilderback *et al*. (1982) found that high quality *Rhododendron indicum* 'George L. Tabor' could be produced when grown under five different combinations of media consisting of peanut hulls, pinebark and canadian sphagnum peatmoss. The differences resulted from the pinebark:peat media which had the lower top dry weight while the peanut hulls and pinebark media had the highest percent growth increase. However, Armitage (1986) found the different media only produced small differences in their post-production life. He noted that there were no significant differences for *Petunia hybrida* and *Tagetes patula* as affected by media, in their visual rating or dry weight. The media treatments 1 soil:1 peat:1perlite (by volume), 1 peat:1 vermiculite (by volume) and 3 vermiculite:1 peat (by volume) only produced small differences in their post-production life.

The physical and chemical composition of the media may be manipulated during the production phase to maximize growth and post-harvest quality. However, once container plants reach a retail nursery, it may not be feasible to alter the physical composition of the media due to the labor intensive and time consuming tasks of remixing and repotting.

Hydrophilic polymers or hydrogels are media amendments which increases water holding capacities of media and can be incorporated post-production. Research on hydrogel efficiency is conflicting. Bearce and McCollum (1977) performed an experiment to compare two media for production of *Chrysanthemum morifolium* and the effects of a hydrogel on its performance. Results indicated that for chrysanthemums, the hydrogel amendment improved plant quality and increased shelf life. However, Wang (1989) determined that there were no medium and hydrogel interaction on plant growth for tropical plants grown under three media and two rates of hydrogel.

The objective of this study is to determine the effects of different media and a hydrogel amendment on the post-harvest quality of *Salvia leucantha* for two planting dates and three retail nursery settings.

Materials and Methods

This study was initiated on the Louisiana State University campus at the Burden Center container production yard located in Baton Rouge, Louisiana. Burden Center lies at latitude 30° 24’ 27” and longitude 91° 8’ 45” in the USDA Hardiness zone 8b. Prior to the initiation of the study, a nursery study was devised to determine which species would be selected for the study. Nurseries were visited and nurserymen were asked which species were prone to dry out and have poor post-harvest quality. The selected species for the study were *Buddleia davidii* ‘Nanho Blue’, *Salvia leucantha* and *Verbena* x *canadensis* ‘Homestead Purple’.

Three potting media recipes were used for production and a hydrogel amendment was used post-production. The media consisted of 90% pinebark, 10% mason sand (by volume); 90% pinebark, 10% peat moss (by volume), and 100% pinebark. The pinebark used was obtained from Phillip's Bark Processing, Brookhaven, Mississippi.

To determine the media properties, 1-gallon pots (trade gallon) were filled with the three different media and dried at 60°C for 48 hours in a convection oven. An empty one gallon container lined with a plastic bag was filled with water to the medium surface line. The volume of water used was measured with a graduated cylinder and recorded. This was to measure container volume. One-gallon pots lined with plastic bags were filled with different dried media. Water was slowly applied onto the medium surface at one edge of the container for each media. The volume of water required for the medium to reach saturation was recorded. The drain hole of each gallon pot was pierced with a knife and the water collected in a basin. Each pot was elevated from the bottom of the basin to prevent suction. The volume of water drained was recorded as the aeration pore volume. Using these values, porosity, aeration porosity, and water retention porosity for each medium was calculated. Media porosity was obtained by dividing the pore volume by the container volume and multiplying by 100%. Media aeration porosity was obtained by dividing the aeration pore volume by container volume and multiplying by 100. Media water retention porosity was obtained by subtracting aeration porosity from porosity.

Potting medium was amended with Osmocote® 15-9-12 fertilizer (The Scotts Company, Earthgro-Hyponex-Miracle Gro, Scotts-Scotts, Sierra-Swiss Farms, 14111 Scotts Lawn Road, Marysville, OH 43041) incorporated at a rate of 15.5 lbs/yd^3. Dolomitic limestone was also applied at a rate of 8 lbs/yd^3. The different potting media were uniformly mixed in ¼ cubic yard increments using a commercial concrete mixer. Once each medium was thoroughly mixed, the media were transferred into 1-gallon black plastic nursery pots and irrigated upon arrival of liners. Liners of *Salvia leucantha* 10” in height were planted August 2004 and grown for 10 months (crop 1). Each pot was topdressed with ornamental herbicide. To determine how the post harvest quality of crops of different age in a retail nursery setting is influenced by media, a second crop of *Salvia leucantha* was planted in February 2005 and grown for 4 months (crop 2).

Treatments were arranged in a randomized complete block design. It consisted of eight replications of three species, three media treatments and a hydrogel amendment for two planting dates and three retail nursery settings totaling 576 pots.

Plants were irrigated with overhead irrigation on a container yard consisting of 24 separate plots. Each plot was 10’ x 10’ with 3’ risers on all four corners and at the center. An irrigation water sample test was carried out (Soil Testing Lab, Louisiana State University). The irrigation water had an alkalinity of 170.8 ppm and a pH of 8.44 (Appendix 2). All pots were irrigated uniformly two times per day. The 2x irrigation treatment was applied at 6:00 am and 4:00 pm for 30 minutes. The irrigation then changed to 6:00 am, 11:00 am and 4:00 pm for 21 minutes. Finally, the plants were irrigated at 6:00 am and 2:00 pm for 15 minutes until the end of post-harvest. In periods of heavy rain, the irrigation was turned off. Water was monitored to ensure 20%-40% effluent using a closed capture system (Harris, 2004). This was done by dividing the amount of water applied by the amount of water leached.

Media influence on the growth indices of the plants was determined throughout production and post-harvest, and measurements were taken every eight weeks. One plant height and two widths perpendicular to each other were measured to determine growth indices. Growth indices were determined by the equation:

$$GI = (\text{height } 1 + \text{width } 1 + \text{width } 2)/3.$$

In June 2005 once production terminated and the post-harvest study initiated, half of the plants growing in 100% pinebark were treated with a dibbled hydrogel amendment, Saturaid® (Debco PTY LTD, 12 McKirdys Road, Tyabb, Victoria 3913, Australia) at a rate of 25 ml of Saturaid® for every 15L of water. After this amendment, a third of the plants were transported to Clegg's Nursery in Denham Springs, LA. Clegg's Nursery lies at latitude 30° 31' 17.7" and longitude 90° 57' 28.09" in the USDA Hardiness zone 8b. Before transportation, all plants were thoroughly irrigated, placed in a truck, irrigated once more and covered with a shade tarp to prevent desiccation and wind damage. At Clegg's Nursery, the plants were separated by species and placed in a randomized block design. The portion that remained at Burden Center were placed under two simulated retail nursery settings, Burden 1 and Burden 2. One-third of the plants remained in the original plots (Burden 2) and one-third were placed on a separate container production yard at Burden Center (Burden 1). The plot in this location was on gravel ground lined with black geotech fabric.

The irrigation for the plants in Burden 2 remained the same while the irrigation system for Burden 1, consisted of four, 5' tall risers at a corner with rotary nozzles. At Burden 1, pots were irrigated with a twice daily treatment at 8:00 am and 4:00 pm for 30 minutes. In July, this was then changed to 6:30 am and 4:00 pm for 30 minutes until the end of the study. In periods of heavy rain, the irrigation was turned off. The irrigation at Clegg's consisted of four, 5' tall risers at each corner with rotary nozzles. All pots were irrigated twice daily at 2 am and 5:30 am for 42 minutes. An irrigation water sample test was carried out (Soil Testing Lab, Louisiana State University). The irrigation water used at Clegg's Nursery had a pH of 7.06 and an alkalinity of 78.08 ppm (Appendix 3). Water distribution and amount applied at the three different locations was monitored with rain gauges.

Leachate samples were collected over a period of 120 days for May, June, July, and September 2005 for all plants. The samples were collected using the modified Virginia Tech Extraction Method. Sampling pots were placed on top of oil catch basins and 300 milliliters of distilled, deionized water was gently poured onto the media surface. Leachate samples were collected for plants of each treatment into plastic containers and stored in a standard refrigerator until processed. Before EC or pH was tested, impurities were extracted from leachate samples by pouring leachate through 11 c.m. paper filters (Scheicher & Schuell, Inc., Keene, N.H.). Once filtered, leachate samples were tested with a calibrated EC and pH reader (Model 5800-00, Cole Palmer Instrument Co., Chicago, IL).

All the plants were rated on their post-harvest quality over a period of 120 days. The initial measurement was taken before the plants were placed in the three retail nursery settings. The plants were rated using a rating scale of 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above mean, 5=optimum.

Plants in all three retail nursery settings were treated for mites and white flies with Ortho® Systematic Insect Killer (The ORTHO Group, P.O. Box 1749, Columbus, OH 43216) at a rate of 3 Tbs. per gallon of water.

All the plants were harvested on September 2005. The top of each plant was cut from the media surface and placed in paper bags. All plants were dried in a conventional oven (VWR-1660) at 60°C for two days. Their shoot dry weight was measured on a Mettler PC 440 scale and their weights recorded.

Data was analyzed using the SAS program for Windows (SAS Institute, Inc. 1998) using proc GLM. Means were separated using Duncan's Multiple Range Test at the $p \leq 0.05$ level.

Results

***Salvia leucantha* Leachate EC and pH**

In the analysis for both leachate EC and pH of *Salvia leucantha*, media, repetition and crop were not significantly different. These were pooled for analysis. There were differences on leachate EC and pH measurements between weeks. The pH value was lowest after 4 weeks, coinciding with the plants being fertilized. The pH gradually increased after fertilization to initial levels after 16 weeks. Leachate EC increased over time with similar levels for the first measurement and the measurement 4 weeks later. The first measurement and the measurement 4 weeks later were significantly different to the measurements 8 and 16 weeks later at the $p \leq 0.05$ level. Leachate EC was highest at 16 weeks (Table 3).

Table 3. Leachate analysis for *Salvia leucantha*.

Weeks	EC(dS/m)	pH
1	0.38 c	6.8 a
4	0.43 c	5.7 b
8	0.61 b	6.7 a
16	0.81 a	6.8 a

Note: first measurement taken before plants placed in retail nursery and every 4 weeks after placement. Means with the same letters are not significantly different at the 0.05 level

***Salvia leucantha* Grow Index**

Burden 1

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops so the data were pooled (Appendix 5). There were no significant differences in mean growth indices due to media at the $p \leq 0.05$ level. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail settings for 4 months, there were significant differences between mean growth indices due to media at the p≤0.05. Pinebark, pinebark amended with hydrogel and pinebark sand had similar growth indices while pinebark:peat had the lowest growth index (Figure 12).

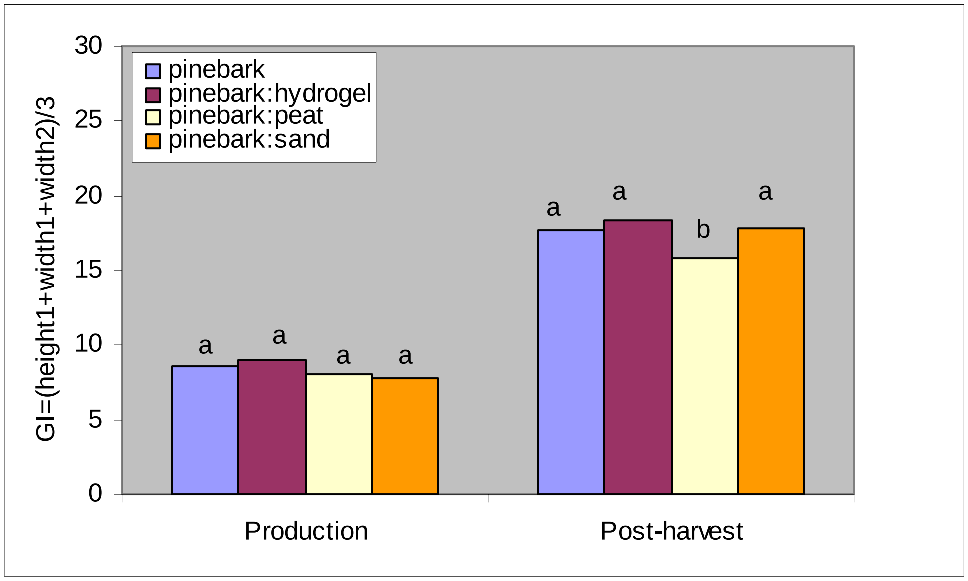

Figure 12. Media influence on growth index of *Salvia leucantha*' for Burden 1. Means with the same letter are not significantly different at the p≤0.05 level.

Clegg's Nursery

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops so the data was pooled (Appendix 5). There were no significant differences due to media at the p≤0.05 level. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, there were significant differences between mean growth indices due to media at the p≤0.05 level. Pinebark amended with hydrogel produced the greatest a mean growth index, 5% higher than pinebark and all the other media. Pinebark:peat and pinebark produced similar growth indices, while pinebark:sand produced the lowest growth index, 7% lower than pinebark (Figure 13).

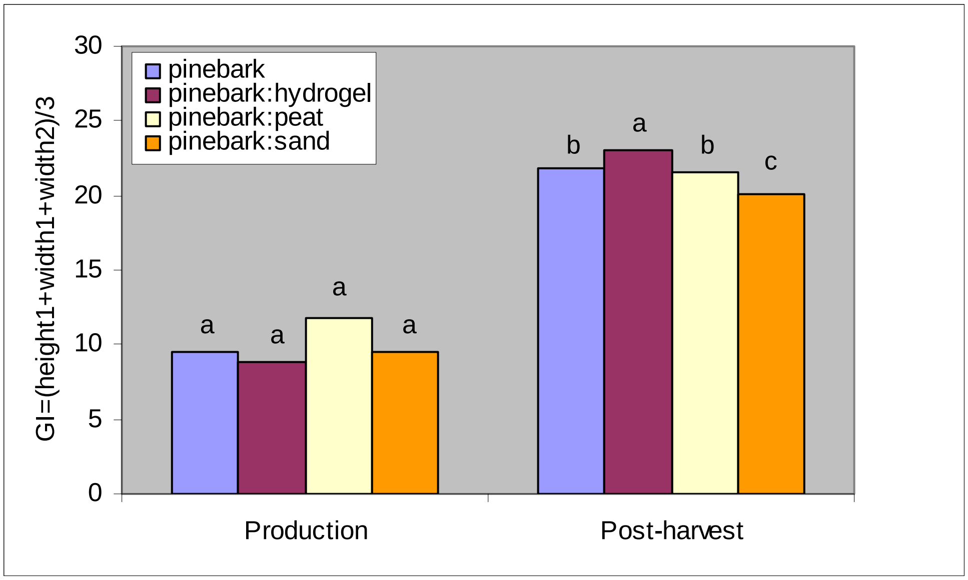

Figure 13. Media influence on growth index of *Salvia leucantha*' for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level.

Burden 2

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops so the data were pooled (Appendix 5). There were significant differences on mean growth indices due to media at the p≤0.05 level. Pinebark to be amended with hydrogel and pinebark had similar growth indices significantly different to pinebark:peat and pinebark:sand which had similar growth indices and also the highest. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, there were significant differences between mean growth indices due to media at the p≤0.05 level. Pinebark amended with hydrogel produced the highest mean growth index, which was 19% higher than pinebark. Pinebark, pinebark:peat and pinebark:sand produced similar growth indices (Figure 14).

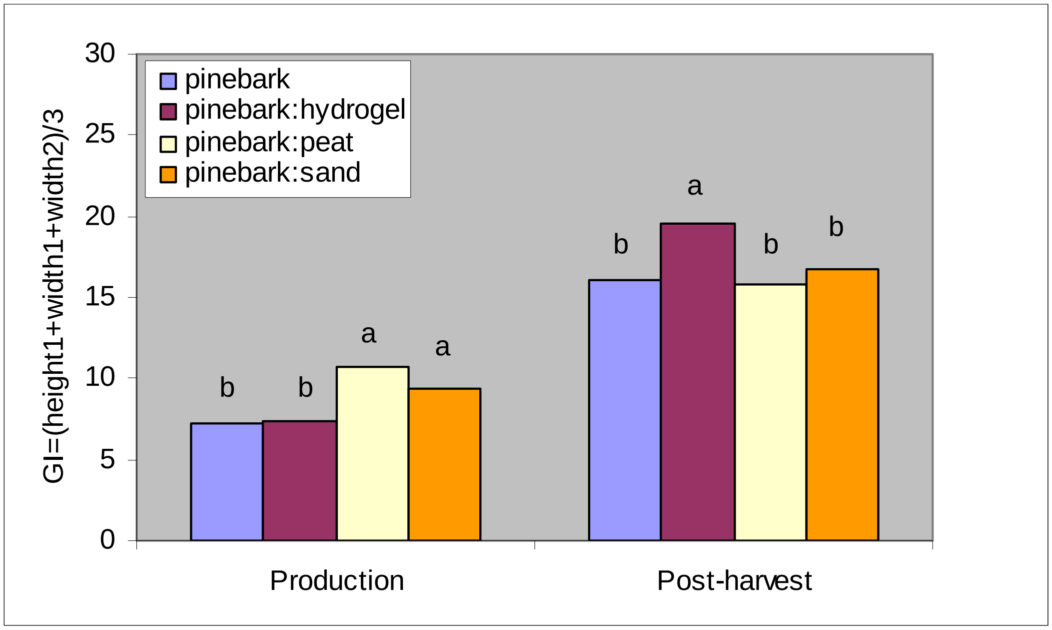

Figure 14. Media influence on growth index of *Salvia leucantha*' for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level.

***Salvia leucantha* Growth Index Compared by Retail Nursery Setting**

Overall, all media produced acceptable growth indices in all retail nursery settings. The hydrogel amendment had a positive effect on growth indices for plants in Burden 2 and Clegg's Nursery, increasing mean growth indices by 19% and 5% respectively when compared to pinebark. The hydrogel amendement had no effect on growth index of plants at Burden 1.

Growth indices of plants before hydrogel treatment and placement in three settings where similar, mean growth indices of all plants assigned for Burden 1 was 8.34, 9.89 for plants assigned to Clegg's Nursery and 8.68 for plants assigned to Burden 2. After placement in the different settings, the final mean growth index was highest for Clegg's Nursery. Final growth index for Burden 1 was 17.43, 21.64 for Clegg's Nursery; and 17 for Burden 2. These trends show that mean growth indices after post-harvest were different due to retail nursery setting (Table 4).

Table 4. *Salvia leucantha* retail nursery setting comparison of growth index, plant quality and shoot weight.

	Burden 1	Clegg's Nursery	Burden 2
pH	8.44	7.06	8.44
Alkalinity	170.80	78.08	170.80
Avg. Weekly Water	3.85”	4.4”	3.36”
Growth Index Means (Prod.)	8.34	9.89	8.68
Growth Index Means (Post-harvest)	17.43	21.64	17.0
Plant Quality Means	2.79	3.27	2.47
Shoot Weight Means	21.34	49.41	18.50

Note: Means of crop 1 and crop 2 were pooled

***Salvia leucantha* Post Harvest Quality Rating**

Burden 1, Crop 1

At the end of production, all plants were below commercially acceptable value except for the plants in pinebark to be amended with hydrogell. Pinebark:peat and pinebark had similar ratings while pinebark:sand had the lowest rating. After 6 weeks of post harvest, there was a gradual decrease in mean quality rating for all media with pinebark:peat having the highest quality rating folllowed by pinebark, pinebark amended with hydrogel and pinebark:sand. The mean quality rating for pinebark decreased from 2.75 to 1.88, a decrease of 32%. Over the same period, pinebark amended with hydrogel decreased from an mean quality rating of 3 to 1.75, a decrease of 42%, pinebark:peat decreased from 2.75 to 2, a decrease 27% and pinebark:sand decreased from 1.75 to 1.38, a 21% decrease.

The mean quality rating increased after 6 weeks for all treatments, but all plants were below commercially acceptable value. Pinebark increased in mean quality rating from 1.88 to 2.13, an increase of 13%, pinebark amended with hydrogel increased from 1.75 to 2.25, a 29% increase, pinebark:peat decreased from 2 to 1.86, a 7% decrease and pinebark:sand increased from 1.38 to 1.56, a 13% increase. From the initial rating to the final, pinebark decreased in mean quality rating 23%. Similarly, pinebark amended with hydrogel decreased 24%, pinebark:peat decreased 31% and pinebark:sand decreased 11% over the same period. Overall, the post-harvest quality of plants decreased in all media, had a slight increase after 6 weeks of placement but they did not obtain commercially acceptable value. At the end of post-harvest, pinebark amended with hydrogel had the highest quality rating (Figure 15).

Burden 1, Crop 2

At the end of production, all plants were above commercially acceptable quality or above average quality and there were significant differences due to media with pinebark:peat and pinebark to be amended with hydrogel having the highest mean quality ratings. Pinebark:sand had a higher quality rating than pinebark which had the lowest quality rating. After 6 weeks of post harvest, there was a linear decrease in mean quality rating in all media except pinebark. Pineabark increased in quality rating producing the highest mean quality rating along with pinebark amended with hydrogel. Pinebark:peat had a higher quality rating than pinebark:sand which had the lowest quality rating. The initial mean quality rating of pinebark increased from 3.38 to 4, a 3% increase. Over the same period, pinebark amended with hydrogel decreased from a mean quality rating of 4.5 to 4, a decrease of 11%, pinebark:peat decreased from 4.5 to 3.75, a decrease of 17% and pinebark:sand decreased from 4.13 to 3.5, a 15% decrease. At this time all plants were still above commercially acceptable quality.

The mean quality rating decreased after 6 weeks and all media were below commercially acceptable value. Pinebark decreased in mean quality rating from 4 to 2, a 50% decrease, pinebark amended with hydrogel decreased from 4 to 2.28, a 43% decrease, pinebark:peat decreased from 3.75 to 1.91 a 49% decrease and pinebark:sand decreased from 3.5 to 2.3, a 34% derease. From the initial rating to the final, pinebark decreased in mean quality rating 49%. Similarly, pinebark amended with hydrogel decreased 49%, pinebark:peat decreased 58% and pinebark:sand decreased 44% over the same period. Overall, the post-harvest quality of plants decreased in all media and pinebark:sand decreased the least over time. At the end of post-harvest, pinebark:sand had the highest quality rating but it was below commercially acceptable quality (Figure 16).

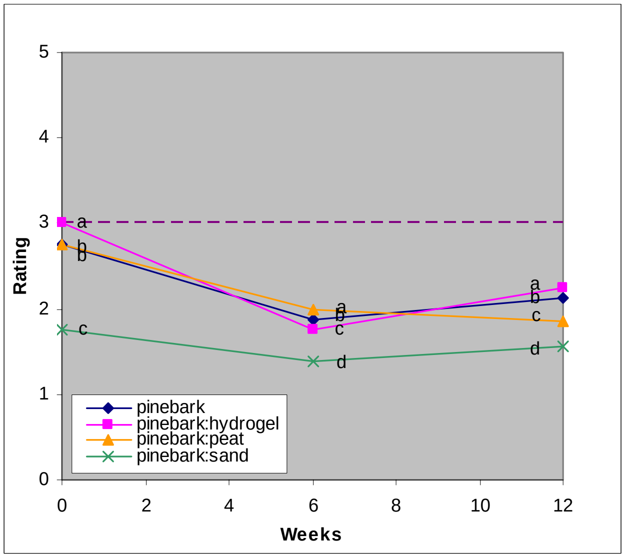

Figure 15. Media influence on post-harvest quality rating of *Salvia leaucantha* crop 1 for Burden 1. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

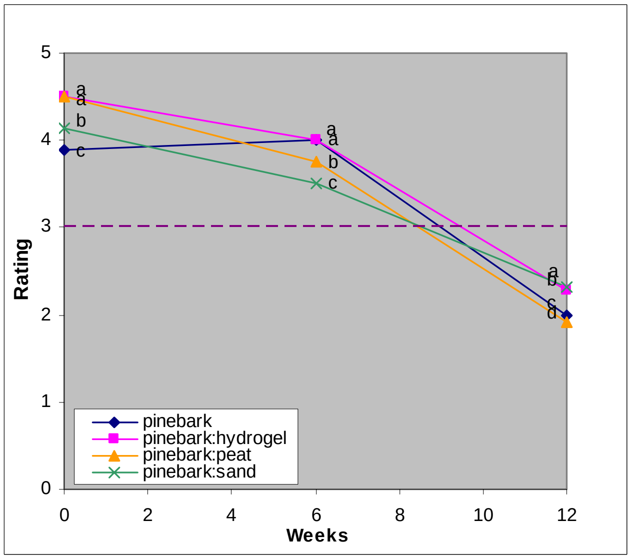

Figure 16. Media influence on post-harvest quality rating of *Salvia leucantha* crop 2 for Burden 1. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Clegg's Nursery, Crop 1

At the end of production, all plants were below market value and there were significant differences due to media. Pinebark had the highest mean quality rating followed by pinebark:sand. Pinebark to be amended with hydrogel and pinebark peat had similar ratings and the lowest quality rating. After 6 weeks of post harvest, there was a decrease in mean quality rating for pinebark and pinebark:sand and a linear increase for pinebark amended with hydrogel and pinebark:peat. For pinebark, the mean quality rating decreased from 2.75 to 2.56 a 7% decrease and for pinebark:sand it decreased from 2.57 to 2.5 a 3% decrease. Pinebark amended with hydrogel increased from a mean quality rating of 2 to 2.25, an increase of 13% while pinebark:peat increased from 2 to 2.13 an increase of 7%. At this time, pinebark followed by pinebark:sand had the highest quality rating but they were below commercially acceptable quality. Pinebark amended with hydrogel had a higher quality rating than pinebark:peat which had the lowest quality rating.

The mean quality rating decreased after 6 weeks for all media except pinebark amended with hydrogel which had a small increase. However it was below commercially acceptable quality like the rest of the media. Pinebark showed a decrease in mean quality rating from 2.56 to 2.38, a 7% decrease, pinebark:peat decreased from 2.13 to 1.75, an 18% decrease, and pinebark:sand decreased from 2.5 to 1.26, a 50% decrease. At this time pinebark followed by pinebark amended with hydrogel had the highest quality ratings but they were below commercially acceptable quality. Pinebark:peat had a higher quality rating than pinebark:sand which had the lowest quality rating. From the initial rating to the final, pinebark decreased in mean quality rating 14%, pinebark amended with hydrogel increased 15%, pinebark:peat decreased 13% and pinebark:sand decreased 51% over the same period. Overall, the post-harvest quality of plants decreased in all media, except pinebark amended with hydrogel which increased 15% overtime. Its increase was insufficient since the plants were below commercially acceptable quality. At the end of post-harvest, pinebark had the highest quality rating (Figure 17).

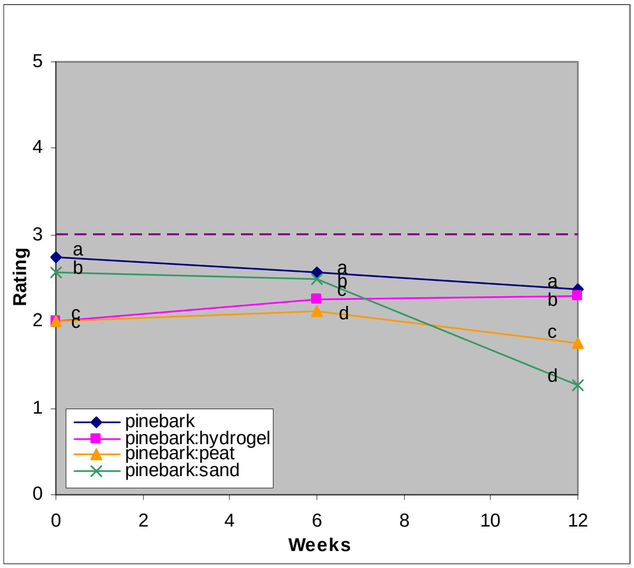

Figure 17. Media influence on post-harvest quality rating of *Salvia leucantha* crop 1 for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Clegg's Nursery, Crop 2

At the end of production, all plants were above commercially acceptable quality or above average quality and there were significant differences due to media. Pinebark had the highest mean quality rating followed by pinebark to be amended with hydrogel. Pinebark:peat had a higher quality rating than pinebark:sand which had the lowest quality rating. After 6 weeks of post harvest, there was an increase in mean quality rating for all media. Pinebark had the highest mean quality rating followed by pinebark amended with hydrogel. Pinebark:peat had a higher quality rating than pinebark:sand which had the lowest quality rating. For pinebark, the mean quality rating increased from 4.38 to 4.5 a 3% increase, pinebark amended with hydrogel increased from a mean quality rating of 4.18 to 4.43, a 6% increase, pinebark:peat increased from 3.88 to 4.13, a 6% increase and pinebark:sand increased from a 3.38 to 3.64 an 8% increase.

The mean quality rating increased after 6 weeks for all treatments except pinebark which had a 6% decrease. Pinebark amended with hydrogel had the highest quality rating followed by pinebark:sand. Pinebark:peat had a higher quality rating than pinebark which had the lowest quality rating. All plants were above commercially acceptable quality. Pinebark amended with hydrogel increased from 4.43 to 4.75, a 7%, pinebark:peat increased from 4.13 to 4.29, a 4% increase and pinebark:sand increased from 3.64 to 4.38, a 20% increase. From the initial rating to the final, pinebark decreased in mean quality rating 3%, pinebark amended with hydrogel increased 14%, pinebark:peat increased 11% and pinebark:sand increased 30% over the same period. Overall, the post-harvest quality of plants increased over time in the different media except for pinebark which had a 3% decrease over time. At the end of post-harvest, pinebark amended with hydrogel had the highest quality rating (Figure 18).

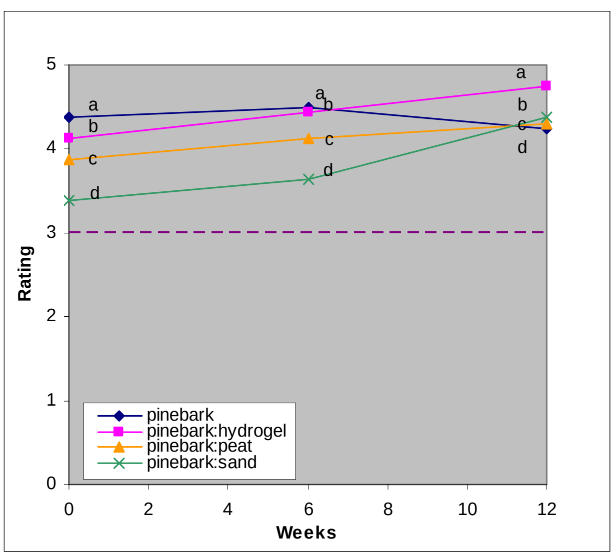

Figure 18. Media influence on post-harvest quality rating of *Salvia leaucantha* crop 2 for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Burden 2, Crop 1

At the end of production, there were significant differences due to media. All plants were below commercially acceptable quality except for pinebark:peat. Pinebark:peat had the highest mean quality rating followed by pinebark. Pinebark sand had a higher quality rating than pinebark to be amended with hydrogel which had the lowest quality rating. After 6 weeks of post harvest, there was a decrease in mean quality rating. Pinebark:peat had the highest quality rating followed by pinebark. Pinebark amended with hydrogel was unchanged and had a higher quality rating than pinebark:sand which had the lowest quality rating. The mean quality rating for pinebark decreased from 2.38 to 1.75 a 27% decrease, pinebark:peat decreased from 3.38 to 2.44 a 28% decrease and pinebark:sand decreased from 2 to 1.68 a 16% decrease.

The mean quality rating increased after 6 weeks for pinebark and pinebark:sand while quality decreased for pinebark:peat and pinebark amended with hydrogel the quality decreased. Pinebark increased in mean quality rating from 1.75 to 1.81, a 3% increase, pinebark:sand increased from 1.68 to 1.94, a 16% increase, pinebark amended with hydrogel decreased from 1.71 to 1.57, an 8% decrease and pinebark:peat decreased from 2.44 to 2.38, a 3%. From the initial rating to the final, pinebark decreased in mean quality rating 24%. Similarly, pinebark amended with hydrogel decreased 8%, pinebark:peat decreased 30% and pinebark:sand decreased 3% over the same period. Overall, the post-harvest quality of plants was below commercially acceptable quality. Pinebark:peat maintained the highest quality; however, it was below commercially acceptable quality (Figure 19).

Burden 2, Crop 2

At the end of production, all plants were above average quality and there were significant differences due to media. Pinebark had the highest mean quality rating followed by pinebark:sand. Pinebark to be amended with hydrogel and pinebark:peat had similar and the lowest quality ratings. After 6 weeks of post harvest, there was a decrease in the mean quality rating of all media. Pinebark amended with hydrogel decreased the least and had the highest mean quality rating followed by pinebark. Pinebark:peat had a higher quality rating than pinebark:sand which had the lowest quality rating. At this time, pinebark and pinebark amended with hydrogel were above commercially acceptable quality while pinebark:sand and pinebark:peat were below commercially acceptable quality. Pinebark decreased from 4.71 to 3.33, a 29% decrease, pinebark amended with hydrogel decreased from 4 to 3.5, a 13% decrease, pinebark:peat decreased from 4 to 2.75, a 31% decrease, and pinebark:sand decreased from 4.38 to 2.68, a 39% decrease.

The mean quality rating decreased after 6 weeks for all treatments. Pinebark had the highest quality rating followed by pinebark amended with hydrogel. Pinebark:peat had a higher quality rating than pinebark:sand which had the lowest quality rating. Pinebark decrease in mean quality rating from 3.33 to 2.33, a 30% decrease, pinebark amended with hydrogel decreased from 3.5 to 1.69, a 52% decrease, pinebark:peat decreased from 2.75 to 1.38, a 50% decrease and pinebark:sand decreased from 2.68 to 1, a 63% decrease. All plants were below commercially acceptable quality. From the initial rating to the final, pinebark decreased in mean quality rating 51%, pinebark amended with hydrogel decreased 58%, pinebark:peat decreased 66% and pinebark:sand decreased 77% over the same period. Overall, the post-harvest quality of plants was best under the pinebark but it was below commercially acceptable quality at the end of post-harvest (Figure 20).

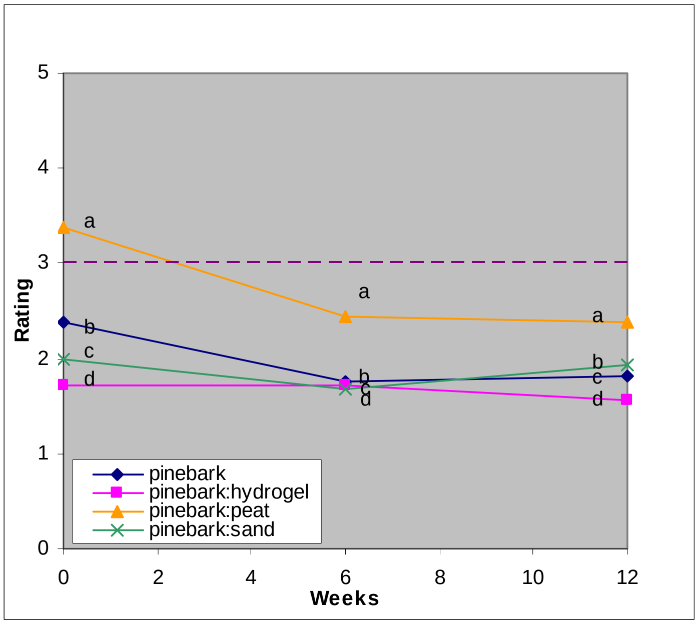

Figure 19. Media influence on post-harvest quality rating of *Salvia leaucantha* crop 1 for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

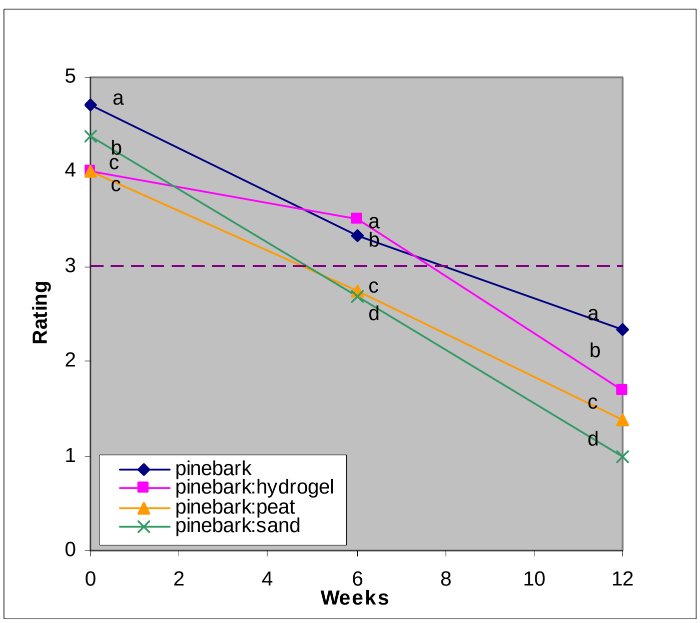

Figure 20. Media influence on post-harvest quality rating of *Salvia leaucantha* crop 2 for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

***Salvia leucantha* Post Harvest Quality Rating Crop Comparison**

For crop 1, mean quality rating decreased after 6 weeks of post-harvest due to media at Burden 1 and Burden 2 while at Clegg's Nursery mean quality rating increased for pinebark amended with hydrogel and pinebark:peat. After another 6 weeks, the mean quality rating due to media at Burden 1 increased for pinebark, pinebark amended with hydrogel and pinebark:sand, while it decreased for pinebark:peat. Similarly, for Burden 2 the mean quality rating increased for pinebark and pinebark:sand while it decreased for pinebark:peat and pinebark amended with hydrogel. At the end of post-harvest, for Burden 1 and Clegg's Nursery, pinebark amended with hydrogel and pinebark had the highest quality rating respectively. For Burden 2, pinebark:peat had the highest mean quality rating. At the end of post-harvest all plants were below commercially acceptable quality in all retail nursery settings.

For crop 2, the mean quality rating decreased over time due to media at Burden 1 and Burden 2. However, after 6 weeks of post-harvest, pinebark had an increase at Burden 1 but decreased once again after another 6 weeks. All plants were above commercially acceptable quality after the first 6 weeks of post-harvest at Burden 1 and Clegg's Nursery. At Burden 2, pinebark amended with hydrogel and pinebark were above commercially acceptable quality while pinebark:peat and pinebark:sand were below commercially acceptable quality. For Burden 1 and Burden 2, all plants were below commercially acceptable quality at the end of post-harvest. At Clegg's Nursery, there was an increase in mean quality rating after the initial 6 weeks and a subsequent 6 weeks of post-harvest for all plants except the ones in pinebark amended with hydrogel which decreased in mean quality rating at the end of post-harvest. At the end of post-harvest, all plants at Clegg's Nursery were above commercially acceptable quality. For Burden 1 and Clegg's Nursery, pinebark:sand and pinebark amended with hydrogel, respectively, had the highest rating at the end of post-harvest. However at Burden 1, plants in pinebark amended with hydrogel were below commercially acceptable quality. For Burden 2, pinebark and pinebark amended with hydrogel had highest quality rating at the end of post-harvest but they were below commercially acceptable quality.

At the end of production, crop 2 had a higher quality than crop 1. At the end of post-harvest, both crops were below commercially acceptable quality, except for crop 2 in pinebark amnended with hydrogel at Clegg's nursery.

*Salvia leucantha* Post-Harvest Quality Rating Compared by Retail Nursery Setting

To compare locations, measurement of quality rating 6 weeks after post-harvest was isolated and crops 1 and 2 were pooled. The mean plant quality rating was 2.79 for Burden 1, 3.27 for Clegg's Nursery, and 2.47 for Burden 2. This shows that quality ratings were impacted by not only media but also by retail nursery setting (Table 4).

*Salvia leucantha* Dry Shoot Weight

Crop 1

There were no significant differences in mean dry shoot weights due to media for the three locations at the $p \leq 0.05$ level (Figure 21). Shoot weight means for Burden 1 and Burden 2 were very similar with 10.92g and 9.05g respectively, while for Clegg's Nursery dry shoot weight means tripled at 31.27 g.

Crop 2

There were no significant differences in mean dry shoot weighs due to media for Burden 1 and Clegg's Nursery. However, for Burden 2 there were significant differences due to media at the $p \leq 0.05$ level. At Burden 2, the shoot weight of plants in pinebark:peat were 30% lower than pinebark, while pinebark amended with hydrogel had a 38.5% increase in dry shoot weight when compared to pinebark. Dry shoot weight means for Burden 1 and Burden 2 crop 2 were similar with 29.6g and 22.03g respectively while for Clegg's Nursery the shoot weight was doubled at 59.47g (Figure 22).

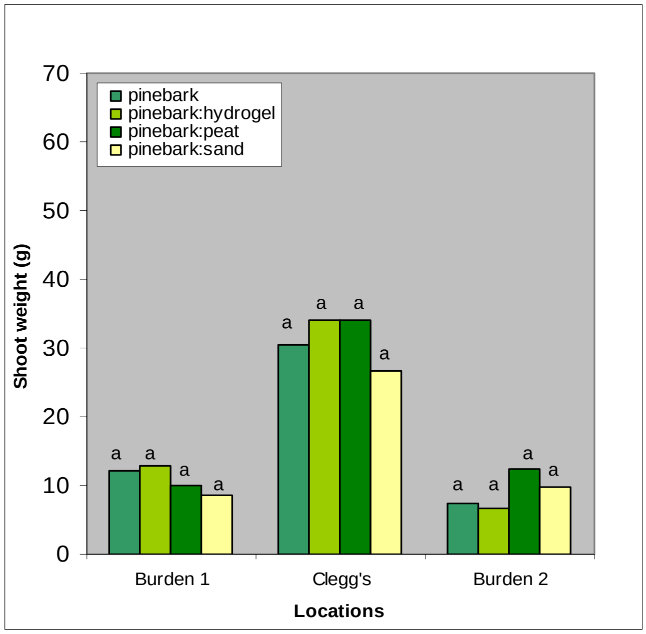

Figure 21. Media influence on dry shoot weight of *Salvia leaucantha* crop 1. Means with the same letter are not significantly different at the p≤0.05 level.

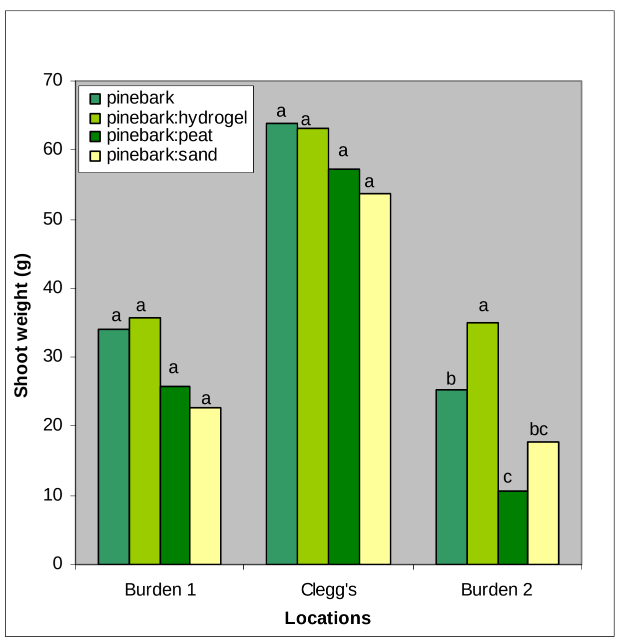

Figure 22. Media influence on dry shoot weight of *Salvia leaucantha* crop 2. Means with the same letter are not significantly different at the p≤0.05 level.

***Salvia leucantha* DryShoot Weight Compared by Retail Nursery Setting**

In order to compare between retail nursery settings, the mean quality rating after 6 weeks of post-harvest was isolated and data from crop 1 and crop 2 were pooled. Shoot weight means for Burden 1 and Burden 2 were similar with 21.34g and 18.5g respectively, while Clegg's Nursery doubled at 49.41 g. These trends show that there was a difference in shoot weight due to retail nursery setting (Table 4).

Discussion

Leachate EC was at acceptable levels after 16 weeks and remained below 2.0 dS/m as required for pinebark based substrates (Anonymous, 2006c). Leachate pH did not change significantly over time except 4 weeks after placement, coinciding with a fertilizer treatment.

At the end of production there were no significant differences on mean growth indices due to media for plants assigned to Burden 1 and Clegg's Nursery. These results agree with Tomlinson and Bilderback (1985) and Stroyny and Nowak (2004). There were however significant differences in growth index for plants assigned to Burden 2 with pinebark and pinebark to be amended with hydrogel producing the lowest growth indices. Pinebark:peat and pinebark:sand produced the highest growth indices. These results agree with Knowles *et al.* (1993) who concluded that *Salvia farinacea* grown under a 2 perlite:1 vermiculite or 2 pinebark:1 fine sand had a higher shoot growth in the pinebark:sand medium.

At the end of post-harvest, there were significant differences in mean growth indices due to media in all three retail nursery settings. Pinebark amended with hydrogel produced the highest growth index at Burden 2 and Clegg's Nursery. At Burden 2, pinebark amended with hydrogel produced mean growth indices 19% higher than pinebark. At Clegg's Nursery, pinebark amended with hydrogel produced mean growth indices 5% higher than pinebark. Salvia grows very rapidly increasing in plant canopy. Beeson and Knox (1991) stated that container spacing, canopy shedding and canopy retention of water lost by evaporation reduce irrigation efficiency, suggesting that plants should be transplanted before reaching maximum canopy. Plants were not transplanted, contributing to reductions in water capture. The hydrogel amendment supplied extra moisture. Raviv *et al.* (2004) stated that water stress can occur if water loss from the canopy of plants is higher than the water uptake by the roots. This might have contributed to the lower performance of the unamended media.

At the end of production, all crop 1 were below commercially acceptable quality while all crop 2 were above commercially acceptable quality. *Salvia leucantha* grows very rapidly, so crop 1 which had been grown for 10 months was probably under stress due to being pot bound. Also, the excessive growth of *Salvia leucantha* makes it very susceptible to blow over, potentially drying out media and decreasing plant quality. This excessive growth is difficult to maintain and research has been done to control growth with regulators (Burnett *et al.*, 2000).

At the end of post-harvest, all crop 1 and crop 2 were below commercially acceptable quality, except for crop 2 at Clegg's Nursery. Since crop 2 was a younger crop, it was less stressed than crop 1, and was able to retain post-harvest quality longer. For crop 1 and crop 2 at Burden 1, the highest quality was produced in pinebark amended with hydrogel and pinebark:sand, respectively. For crop 1 and crop 2 at Clegg's Nursery, the highest quality was produced in pinebark and pinebark amended with hydrogel respectively. For crop 1 and crop 2 at Burden 2, the highest quality was produced in pinebark peat and pinebark, respectively.

Dry shoot weights were not significantly affected by media at Burden 1 and Clegg's Nursery as found by Dehgan *et al*. (1994) who concluded that dry shoot weight of *Podocarpus macrophyllus* were similar in hydrogel amended media or unamended media. Ingram and Van der Weken (1982), found that dry shoot weight of *Ilex crenata* ‘Green Luster’ Thunb. and *Juniperus horizontalis* Moench. were not affected by three different media. Specht and Jones (2000) stated that the drought tolerant *Flindersia australis* amended with hydrogel, displayed no significant increase in dry shoot weight. For crop 2 at Burden 2, the hydrogel amendment increased shoot dry weight as found by Bilderback (1987) who concluded that a hydrogel amendment increased shoot dry weight of *Pyracantha cocinnea* and *Rhododendron* sp.

Overall, growth indices, plant quality and shoot dry weight were higher at Clegg's Nursery than at Burden 1 and Burden 2. The higher alkalinity of irrigation water at Burden 1 and Burden 2 influenced overall plant quality, decreasing it.

CHAPTER 4

MEDIA INFLUENCE ON POST-HARVEST PLANT QUALITY OF *VERBENA* x *CANADENSIS* 'HOMESTEAD PURPLE'

Introduction

Ornamentals are desirable enhancements and integral components of our landscapes. *Verbena x canadensis* 'Homestead Purple' is a low maintenance perennial which blooms profusely. It is a popular ornamental among gardening consumers in the southern United States.

Pinebark is the most popular and widely used media in the southern United States, and a variety of plants can be grown. In a retail nursery setting, media can dry out very easily due to several factors such as inefficiency of irrigation, mild water stress, transpiration and evaporation. Pinebark media that dries out becomes difficult to rewet due to its hydrophobic nature (Airhart *et al.*, 1978; Gehrig and Lewis, 1980). Media components such as peat and sand can be added to pinebark to increase its wettability and water holding capacity.

Media with different properties can influence plant growth, development and post-harvest quality of some plants and not others. Bilderback *et al*. (1982) found that high quality *Rhododendron indicum* 'George L. Tabor' could be produced when grown under five different combinations of media consisting of peanut hulls, pinebark and canadian sphagnum peatmoss. The differences resulted from the pinebark:peat media which had the lower top dry weight while the peanut hulls and pinebark media had the highest percent growth increase. However, Armitage (1986) found the different media only produced small differences in their post-production life. He noted that there were no significant differences for *Petunia hybrida* and *Tagetes patula* as affected by media in their visual rating or dry weight. The media treatments 1 soil:1 peat:1perlite (by volume), 1 peat:1 vermiculite (by volume) and 3 vermiculite:1 peat (by volume) only produced small differences in their post-production life.

The physical and chemical composition of the media may be manipulated during the production phase to maximize growth and post-harvest quality. However, once container plants reach a retail nursery, it may not be feasible to alter the physical composition of the media due to the labor intensive and time consuming tasks of remixing and repotting.

Hydrophilic polymers or hydrogels are media amendments which increases water holding capacities of media and can be incorporated post-production. Research on hydrogel efficiency is conflicting. Bearce and McCollum (1977) performed an experiment to compare two media for production of *Chrysanthemum morifolium* and the effects of a hydrogel on its performance. Results indicated that for chrysanthemums, the hydrogel amendment improved plant quality and increased shelf life. However, Wang (1989) determined that there were no medium and hydrogel interaction on plant growth for tropical plants grown under three media and two rates of hydrogel.

The objective of this study is to determine the effects of different media and a hydrogel amendment on the post-harvest quality of *Verbena* x 'Homestead Purple' for two planting dates and three retail nursery settings.

Materials and Methods

This study was initiated on the Louisiana State University campus at the Burden Center container production yard located in Baton Rouge, Louisiana. Burden Center lies at latitude 30° 24' 27" and longitude 91° 8' 45" in the USDA Hardiness zone 8b. Prior to the initiation of the study, a nursery study was devised to determine which species would be selected for the study. Nurseries were visited and nurserymen were asked which species were prone to dry out and have poor post-harvest quality. The selected species for the study were *Buddleia davidii* 'Nanho Blue', *Salvia leucantha* and *Verbena* x *canadensis* 'Homestead Purple'.

Three potting media recipes were used for production and a hydrogel amendment was used post-production. The media consisted of 90% pinebark, 10% mason sand (by volume); 90%

pinebark, 10% peat moss (by volume), and 100% pinebark. The pinebark used was obtained from Phillip's Bark Processing, Brookhaven, Mississippi.

To determine the media properties, 1-gallon pots (trade gallon) were filled with the three different media and dried at 60°C for 48 hours in a convection oven. An empty one gallon container lined with a plastic bag was filled with water to the medium surface line. The volume of water used was measured with a graduated cylinder and recorded. This was to measure container volume. One-gallon pots lined with plastic bags were filled with different dried media. Water was slowly applied onto the medium surface at one edge of the container for each media. The volume of water required for the medium to reach saturation was recorded. The drain hole of each gallon pot was pierced with a knife and the water collected in a basin. Each pot was elevated from the bottom of the basin to prevent suction. The volume of water drained was recorded as the aeration pore volume. Using these values, porosity, aeration porosity, and water retention porosity for each medium was calculated. Media porosity was obtained by dividing the pore volume by the container volume and multiplying by 100%. Media aeration porosity was obtained by dividing the aeration pore volume by container volume and multiplying by 100. Media water retention porosity was obtained by subtracting aeration porosity from porosity.

Potting medium was amended with Osmocote® 15-9-12 fertilizer (The Scotts Company, Earthgro-Hyponex-Miracle Gro, Scotts-Scotts, Sierra-Swiss Farms, 14111 Scotts Lawn Road, Marysville, OH 43041) incorporated at a rate of 15.5 lbs/yd^3. Dolomitic limestone was also applied at a rate of 8 lbs/yd^3. The different potting media were uniformly mixed in ¼ cubic yard increments using a commercial concrete mixer. Once each medium was thoroughly mixed, the media were transferred into 1-gallon black plastic nursery pots and irrigated upon arrival of liners. Liners of *Verbena* x *canadensis* 'Homestead Purple' 3" in height were planted August

2004 and grown for 10 months (crop 1). Each pot was topdressed with ornamental herbicide. To determine how the post harvest quality of crops of different age in a retail nursery setting is influenced by media, a second crop of *Verbena x canadensis* 'Homestead Purple' was planted in February 2005 and grown for 4 months (crop 2).

Treatments were arranged in a randomized complete block design. It consisted of eight replications of three species, three media treatments and a hydrogel amendment for two planting dates and three retail nursery settings totaling 576 pots.

Plants were irrigated with overhead irrigation on a container yard consisting of 24 separate plots. Each plot was 10' x 10' with 3' risers on all four corners and at the center. An irrigation water sample test was carried out (Soil Testing Lab, Louisiana State University). The irrigation water had an alkalinity of 170.8 ppm and a pH of 8.44 (Appendix 2). All pots were irrigated uniformly two times per day. The 2x irrigation treatment was applied at 6:00 am and 4:00 pm for 30 minutes. The irrigation then changed to 6:00 am, 11:00 am and 4:00 pm for 21 minutes. Finally, the plants were irrigated at 6:00 am and 2:00 pm for 15 minutes until the end of post-harvest. In periods of heavy rain, the irrigation was turned off. Water was monitored to ensure 20%-40% effluent using a closed capture system (Harris, 2004). This was done by dividing the amount of water applied by the amount of water leached.

Media influence on the growth indices of the plants was determined throughout production and post-harvest, and measurements were taken every eight weeks. One plant height and two widths perpendicular to each other were measured to determine growth indices. Growth indices were determined by the equation:

$$GI = (\text{height } 1 + \text{width } 1 + \text{width } 2)/3.$$

In June 2005 once production terminated and the post-harvest study initiated, half of the plants growing in 100% pinebark were treated with a dibbled hydrogel amendment, Saturaid® (Debco PTY LTD, 12 McKirdys Road, Tyabb, Victoria 3913, Australia) at a rate of 25 ml of Saturaid® for every 15L of water. After this amendment, a third of the plants were transported to Clegg's Nursery in Denham Springs, LA. Clegg's Nursery lies at latitude 30° 31' 17.7" and longitude 90° 57' 28.09" in the USDA Hardiness zone 8b. Before transportation, all plants were thoroughly irrigated, placed in a truck, irrigated once more and covered with a shade tarp to prevent desiccation and wind damage. At Clegg's Nursery, the plants were separated by species and placed in a randomized block design. The portion that remained at Burden Center were placed under two simulated retail nursery settings, Burden 1 and Burden 2. One-third of the plants remained in the original plots (Burden 2) and one-third were placed on a separate container production yard at Burden Center (Burden 1). The plot in this location was on gravel ground lined with black geotech fabric.

The irrigation for the plants in Burden 2 remained the same while the irrigation system for Burden 1, consisted of four, 5' tall risers at a corner with rotary nozzles. At Burden 1, pots were irrigated with a twice daily treatment at 8:00 am and 4:00 pm for 30 minutes. In July, this was then changed to 6:30 am and 4:00 pm for 30 minutes until the end of the study. In periods of heavy rain, the irrigation was turned off. The irrigation at Clegg's consisted of four, 5' tall risers at each corner with rotary nozzles. All pots were irrigated twice daily at 2 am and 5:30 am for 42 minutes. An irrigation water sample test was carried out (Soil Testing Lab, Louisiana State University). The irrigation water used at Clegg's Nursery had a pH of 7.06 and an alkalinity of 78.08 ppm (Appendix 3). Water distribution and amount applied at the three different locations was monitored with rain gauges.

Leachate samples were collected over a period of 120 days for May, June, July, and September 2005 for all plants. The samples were collected using the modified Virginia Tech Extraction Method. Sampling pots were placed on top of oil catch basins and 300 milliliters of distilled, deionized water was gently poured onto the media surface. Leachate samples were collected for plants of each treatment into plastic containers and stored in a standard refrigerator until processed. Before EC or pH was tested, impurities were extracted from leachate samples by pouring leachate through 11 c.m. paper filters (Scheicher & Schuell, Inc., Keene, N.H.). Once filtered, leachate samples were tested with a calibrated EC and pH reader (Model 5800-00, Cole Palmer Instrument Co., Chicago, IL).

All the plants were rated on their post-harvest quality over a period of 120 days. The initial measurement was taken before the plants were placed in the three retail nursery settings. The plants were rated using a rating scale of 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above mean, 5=optimum.

Plants in all three retail nursery settings were treated for mites and white flies with Ortho® Systematic Insect Killer (The ORTHO Group, P.O. Box 1749, Columbus, OH 43216) at a rate of 3 Tbs. per gallon of water.

All the plants were harvested on September 2005. The top of each plant was cut from the media surface and placed in paper bags. All plants were dried in a conventional oven (VWR-1660) at 60°C for two days. Their shoot dry weight was measured on a Mettler PC 440 scale and their weights recorded.

Data was analyzed using the SAS program for Windows (SAS Institute, Inc. 1998) using proc GLM. Means were separated using Duncan's Multiple Range Test at the $p \leq 0.05$ level.

Results

***Verbena* x *canadensis* 'Homestead Purple' Leachate EC and pH**

In the analysis for both leachate EC and pH of *Verbena* x *canadensis* 'Homestead Purple', media, repetition and crop were not significantly different. These were pooled for analysis. Leachate EC and pH measurements were different between weeks. The pH value was lowest after 4 weeks, coinciding with the plants being fertilized. The pH gradually increased after fertilization to initial levels after 16 weeks. Leachate EC increased over time with similar levels for the first measurement and the measurement 4 weeks later. The first measurement and the measurements 4 and 8 weeks later were significantly different to the measurement 16 weeks later at the $p \leq 0.05$ level. Leachate EC was highest after 16 weeks (Table 5).

Table 5. Leachate analysis for *Verbena* x *canadensis* 'Homestead Purple'.

Weeks	EC(dS/m)	pH
1	0.45 b	7.1 a
4	0.42 b	5.8 b
8	0.81 b	6.7 a
16	1.45 a	7.1 a

Note: first measurement taken before plants placed in retail nursery and every 4 weeks after placement. Means with the same letters are not significantly different at the $p \leq 0.05$ level.

***Verbena* x *canadensis* 'Homestead Purple' Grow Index**

Burden 1

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on growth index of the two crops (Appendix 5). These were pooled for analysis. There were no significant differences in mean growth indices due to media at the $p \leq 0.05$ level. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, pinebark, pinebark amended with hydrogel and pinebark:sand had similar growth indices. Pinebark:peat produced the lowest growth index, 16% lower than pinebark (Figure 23).

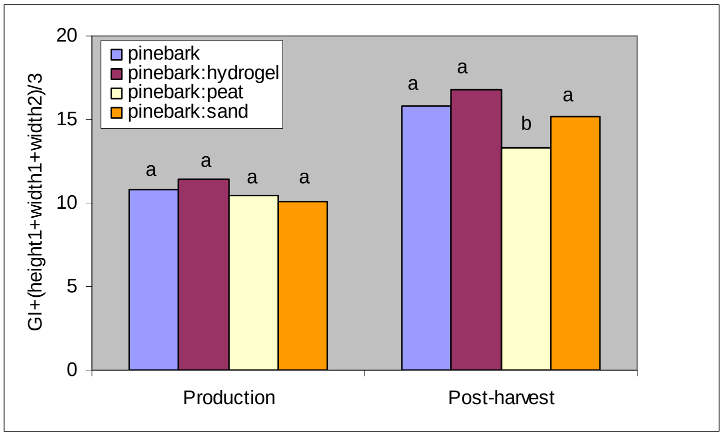

Figure 23. Media influence on growth index of *Verbena x canadensis* 'Homestead Purple' for Burden 1. Means with the same letter are not significantly different at the p≤0.05 level.

Clegg's Nursery

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on the growth index of the two crops (Appendix 5). These were pooled for analysis. There were significant differences due to media with pinebark and pinebark to be amended with hydrogel producing similar growth indices, while pinebark:sand produced the lowest growth index. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, there were no significant differences between mean growth indices due to media at the p≤0.05 level (Figure 24).

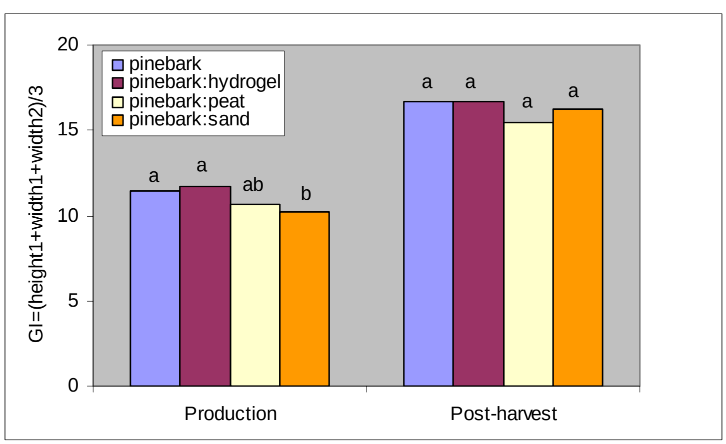

Figure 24. Media influence on growth index of *Verbena x canadensis* 'Homestead Purple' for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level.

Burden 2

At the end of production, after crop 1 was grown for 10 months and crop 2 was grown for 4 months, there were no significant differences on the growth index of the two crops (Appendix 5). These were pooled for analysis. There were no significant differences on mean growth indices due to media at the $p \leq 0.05$. At the end of post-harvest, after the portion of plants grown in pinebark were amended with hydrogel and all plants were placed in three retail nursery settings for 4 months, there were no significant differences between mean growth indices due to media at the $p \leq 0.05$ (Figure 25).

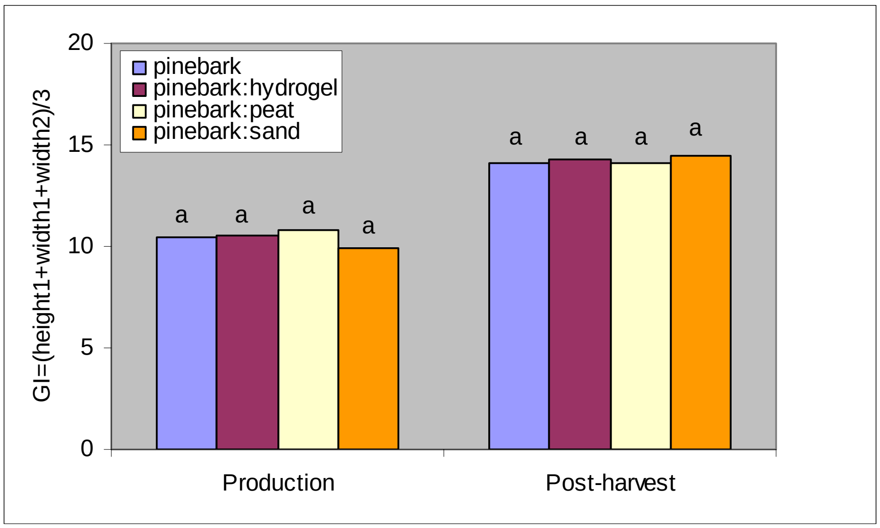

Figure 25. Media influence on growth index of *Verbena x canadensis* 'Homestead Purple' for Burden 2. Means with the same letter are not significantly different at the $p \leq 0.05$ level.

***Verbena* x *canadensis* 'Homestead Purple' Growth Index Compared by Retail Nursery Setting**

Growth indices of plants before hydrogel treatment and placement in three settings were similar, mean growth indices of all plants assigned for Burden 1 was 10.7, 10.9 for plants assigned to Clegg's Nursery, and 10.4 for plants assigned to Burden 2. After placement in the different settings, the final mean growth index was highest for Clegg's Nursery. Mean growth indices for all plants at Burden 1 was 15.3, 16.3, for Clegg's Nursery; and 14.26 for Burden 2.

These trends show that mean growth indices after post-harvest were different due to location (Table 6).

Table 6. *Verbena* x *canadensis* 'Homestead Purple' retail nursery setting comparison of growth index, plant quality and shoot weight.

	Burden 1	Clegg's Nursery	Burden 2
pH	8.44	7.06	8.44
Alkalinity	170.80	78.08	170.80
Avg. Weekly Water	3.85"	4.4"	3.36"
Growth Index Means (Production)	10.71	10.98	10.44
Growth Index Means (Post-harvest)	15.27	16.26	14.26
Plant Quality Means	2.29	2.49	2.93
Shoot Weight Means	7.9	12.44	19.56

Note: Means of crop 1 and crop 2 were pooled.

***Verbena* x *canadensis* 'Homestead Purple' Post Harvest Quality Rating**

Burden 1, Crop 1

At the end of production, all plants were below commercially acceptable quality. There were significant differences due to media with pinebark and pinebark to be amended with hydrogel having similar quality ratings and the highest mean quality ratings. Pinebark:sand had a higher quality rating than pinebark:peat which had the lowest quality rating. After 6 weeks of post harvest, there was a decrease in mean quality rating for all media. For pinebark the mean quality rating decreased from 2.63 to 2.13, a decrease of 19%. Over the same period, pinebark amended with hydrogel decreased from an mean quality rating of 2.63 to 2.25, a decrease of 14.4% while pinebark:peat decreased from 2.38 to 2, a decrease of 16%. Pinebark:sand decreased from 2.57 to 1.63, a 36.6% decrease. At this time, pinebark amended with hydrogel and pinebark had the highest quality rating but they were below commercially acceptable quality. The mean quality rating decreased after 6 weeks and all plants senesced. Overall, the post-harvest quality of plants decreased in all media resulting in death of crop at the end of post-harvest (Figure 26).

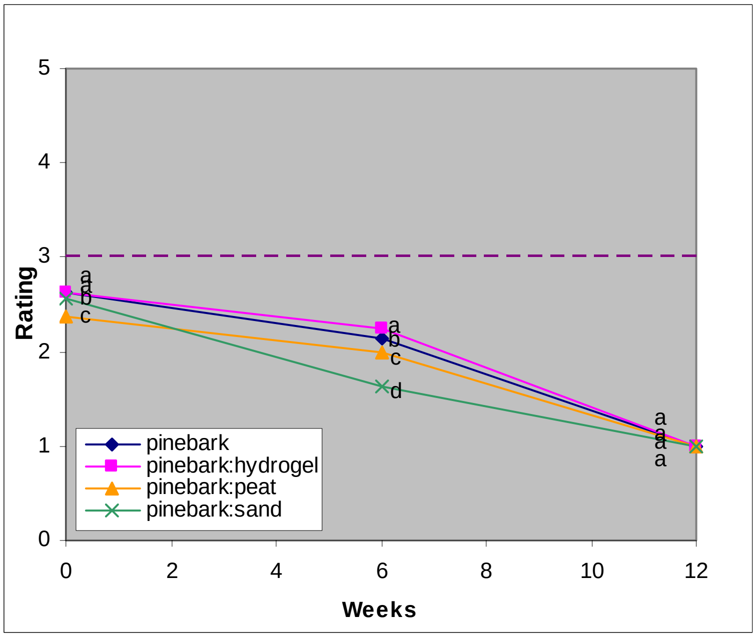

Figure 26. Media influence on post-harvest quality rating of *Verbena* x *candensis* 'Homestead Purple' crop 1 for Burden 1. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Burden 1, Crop 2

At the end of production, all plants were above commercially acceptable quality and there were significant differences due to media with pinebark to be amended with hydrogel and pinebark:peat having the highest quality ratings. Pinebark had a higher quality rating than pinebark:sand, which had the lowest quality rating. After 6 weeks of post harvest, there was a linear decrease in mean quality rating for all media with pinebark amended with hydrogel and pinebark having the highest quality ratings. However they were below commercially acceptable quality. For pinebark, the mean quality rating decreased from 3.5 to 2.63 a 24.9% decrease. Over the same period, pinebark amended with hydrogel decreased from an mean quality rating of 4 to 2.75, a decrease of 31.25% while pinebark:peat decreased from 3.63 to 2.5, a decrease of 31.1%. Pinebark:sand decreased from 3.25 to 2.5, a 23.1% decrease.

The mean quality rating decreased after 6 weeks and all plants senesced. Overall, the post-harvest quality of plants decreased in all media (Figure 27).

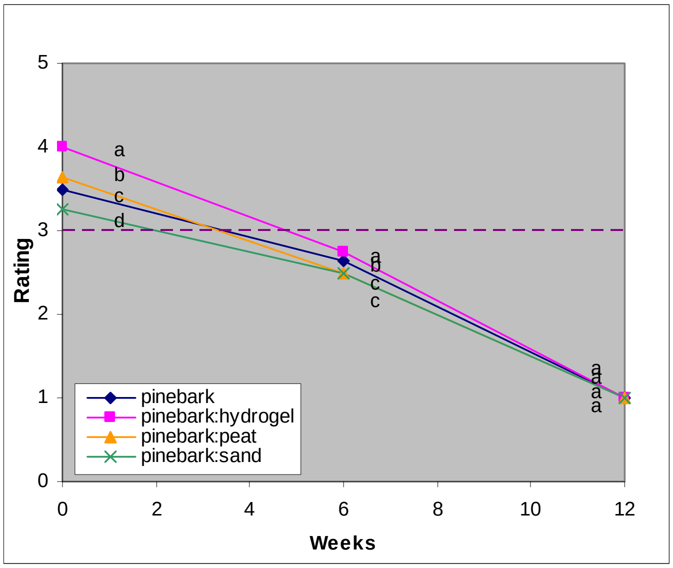

Figure 27. Media influence on post-harvest quality rating of *Verbena* x *candensis 'Homestead Purple'* crop 2 for Burden 1. Means with the same letter are not significantly different at the $p \leq 0.05$ level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Clegg's Nursery, Crop 1

At the end of production, there were significant differences due to media with pinebark to be amended with hydrogel and pinebark:sand being above commercially acceptable quality while pinebark and pinebark:peat were below commercially acceptable quality. After 6 weeks of post harvest, there was a decrease in mean quality rating for all media except for pinebark:peat which remained the same. For pinebark, the mean quality rating decreased from 2.75 to 2.13 a 22.5% decrease. Over the same period, pinebark amended with hydrogel decreased from an mean quality rating of 3.5 to 2.38, a decrease of 32% while pinebark:peat remained the same at 2.5 and pinebark:sand decreased from 3.63 to 2.75 a 24.2% decrease. At this time, pinebark:peat and pinebark:sand had the highest quality rating. Pinebark amended with hydrogel and pinebark had the lowest quality rating.

The mean quality rating decreased after 6 weeks. From the initial rating to the final, pinebark decreased in mean quality rating 58.8%, pinebark amended with hydrogel decreased 47.7%, while pinebark:peat decreased 63.2% and pinebark:sand decreased 48.2% over the same period. Overall, the post-harvest quality of plants decreased over time in the different media with pinebark:sand and pinebark:peat maintaining the highest growth index over time, however, they were below commercially acceptable quality (Figure 28).

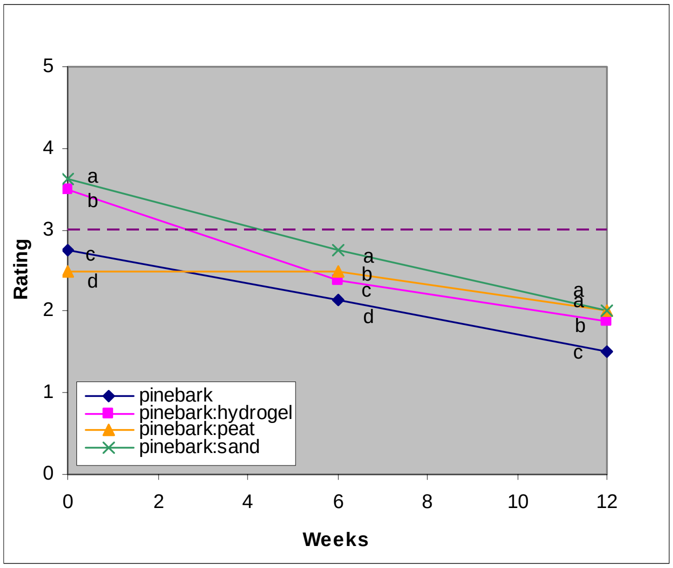

Figure 28. Media influence on post-harvest quality rating of *Verbena* x *candensis* ‘Homestead Purple’ crop 1 for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Clegg's Nursery, Crop 2

At the end of production, there were significant differences due to media with pinebark:peat followed by pinebark to be amended with hydrogel having the highest quality rating. Pinebark had a higher quality than pinebark:sand, which had the lowest quality rating. All plants were above commercially acceptable quality. After 6 weeks of post harvest, there was a linear decrease in mean quality rating for all media with pinebark:peat and pinebark amended with hydrogel decreasing the most and resulting below commercially acceptable quality.

Pinebark and pinebark:sand had the highest quality rating. Pinebark:peat had a higher quality rating than pinbark amended with hydrogel, which had the lowest quality rating. Pinebark was above market value even though quality rating decreased from 4.25 to 3.07, a 27.8% decrease. Over the same period, pinebark amended with hydrogel decreased from a mean quality rating of 4.38 to 2.14, a decrease of 51.1% while pinebark:peat and pinebark also decreased from 4.75 to 2.38, a 49.9 % decrease and from 3.63 to 2.63, a 27.5% decrease, respectively.

The mean quality rating decreased after 6 weeks except for pinebark amended with hydrogel which increased 7% and had a 30.9% higher mean quality rating than pinebark. From the initial rating to the final rating, pinebark decreased in mean quality rating 45.5%, pinebark: hydrogel decreased 46.3% while pinebark:peat decreased 20% and pinebark:sand decreased 44.9% over the same period. Overall, the post-harvest quality of plants decreased over time in the different media. Towards the end of post-harvest, pinebark amended with hydrogel produced an increase in quality rating but it was below commercially acceptable quality (Figure 29).

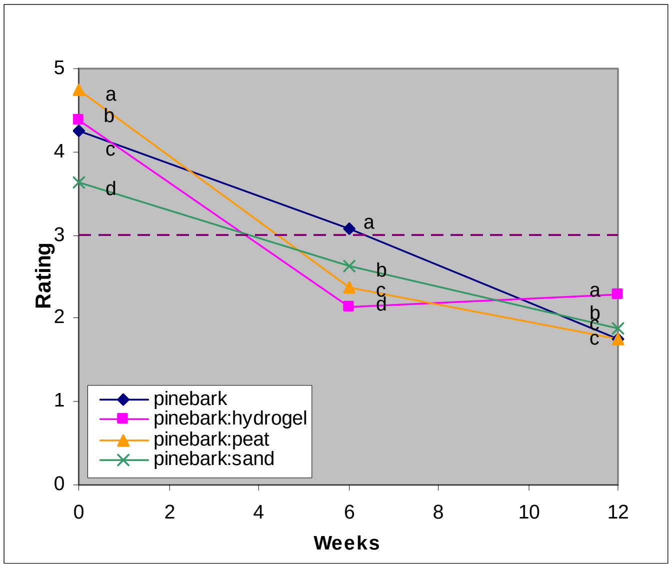

Figure 29. Media influence on post-harvest quality rating of *Verbena* x *candensis* 'Homestead Purple' crop 2 for Clegg's Nursery. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Burden 2, Crop 1

At the end of production, there were significant differences due to media with pinebark:peat and pinebark:sand being significantly different to pinebark and pinebark to be amended with hydrogel. Pinebark:peat and pinebark:sand were the only ones with commercially acceptable quality. After 6 weeks of post harvest, there was a linear decrease in mean quality rating for all media except pinebark amended with hydrogel which increased 25% in mean quality rating. For pinebark the mean quality rating decreased from 2.75 to 2, a 27.3% decrease. Over the same period, pinebark to be amended with hydrogel increased from an mean quality rating of 2.75 to 3.44, an increase of 25% while pinebark:peat decreased from 3 to 2.75, a 8.3% decrease. Pinebark:sand decreased from 3.to 2.81, a 6.3% decrease. At this time, pinebark amended with hydrogel followed by pinebark:sand had the highest quality rating, but pinebark:sand was below commercially acceptable quality. Pinebark:peat had a higher quality rating than pinebark, and they were both below commercially acceptable quality.

The mean quality rating decreased after 6 weeks for all media except pinebark which had a 6.5% increase in mean quality rating but it was below commercially acceptable quality. Pinebark amended with hydrogel decreased from 3.44 to 3.25, a 5.5% decrease, pinebark:peat decreased from 2.75 to 1.38, a 49.8% decrease, and finally pinebark:sand decreased from 2.81 to 2.13, a 24.2% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 22.5%, pinebark amended with hydrogel increased 18.2% while pinebark:peat decreased 54% and pinebark:sand decreased 23% over the same period. Overall, the post-harvest quality of plants decreased in all media except pinebark amended with hydrogel which had an 18.2% increase overall and was above commercially acceptable quality (Figure 30).

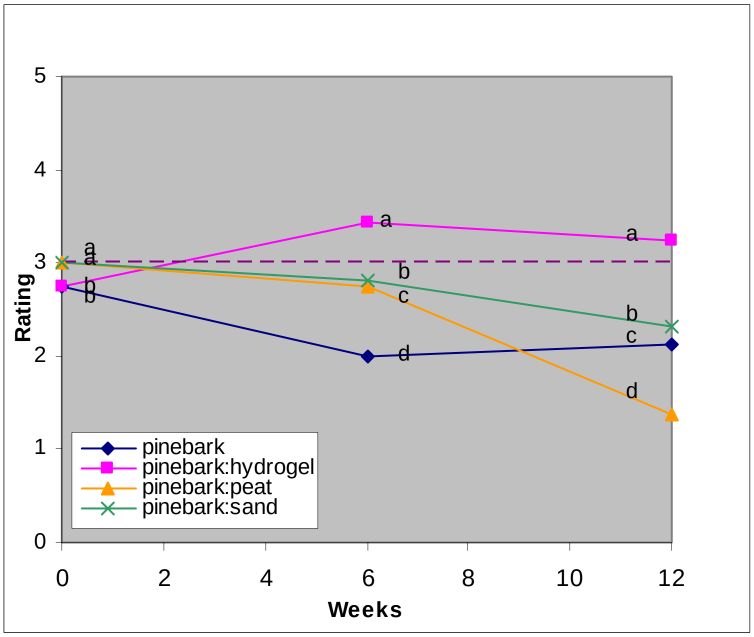

Figure 30. Media influence on post-harvest quality rating of *Verbena* x *candensis* 'Homestead Purple' crop 1 for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Burden 2, Crop 2

At the end of production, all plants were above commercially acceptable quality and there were significant differences due to media with pinebark having the highest mean quality rating. Pinebark to be amended with hydrogel and pinebark peat had similar quality, while pinebark:sand had the lowest quality rating. After 6 weeks of post harvest, there was a linear decrease in mean quality rating for all media except pinebark amended with hydrogel which had an increase of 6.2%. For pinebark, the mean quality rating decreased from 4.29 to 3.21, a 25.2% decrease. Over the same period, pinebark:peat decreased from 3.89 to 3.63, a 6.7% decrease, and pinebark:sand decreased from 3.63 to 2.56, a 29.5% decrease. At this time, all media were above commercially acceptable quality except for pinebark:sand. Pinebark amended with hydrogel had the highest quality followed by pinebark:peat and pinebark.

The mean quality rating decreased after 6 weeks for all media and the highest mean quality rating was produced pinebark amended with hydrogel followed by pinebark but they were below commercially accepatable quality. Pinebark:peat had a higher quality than pinebark:sand. Pinebark showed a decrease in mean quality rating from 3.21 to 2.79, a 13.1% decrease, pinebark amended with hydrogel decreased from 4.13 to 2.88, a 30.3% decrease, pinebark:peat decreased from 2.75 to 1.38, a 49.8% decrease, and pinebark sand decreased from 3.63 to 1.5, an 8.7% decrease. From the initial rating to the final, pinebark decreased in mean quality rating 35%. Similarly, Pinebark amended with hydrogel decreased 28.3% while pinebark:peat decreased 61.4% and pinebark:sand decreased 65.6% over the same period. Overall, the post-harvest quality of plants was the best under the pinebark amended with hydrogel media (Figure 31).

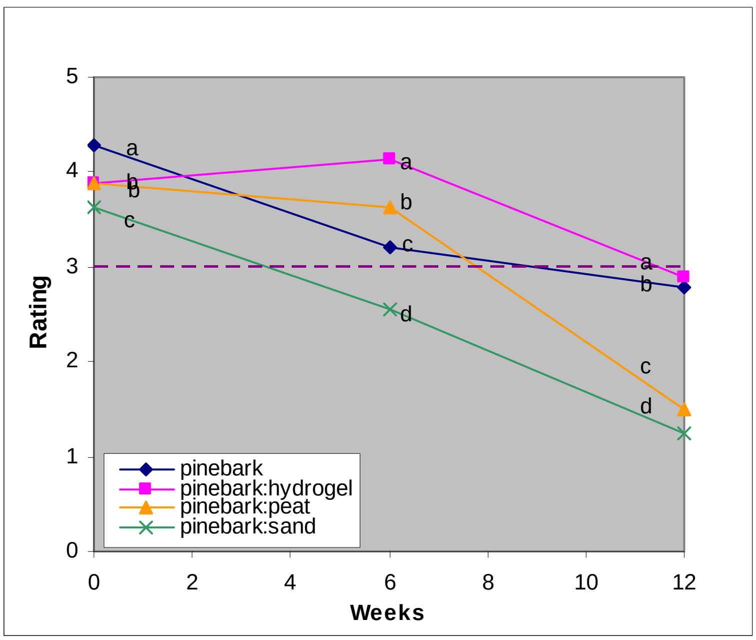

Figure 31. Media influence on post-harvest quality rating of *Verbena* x *candensis* 'Homestead Purple' crop 2 for Burden 2. Means with the same letter are not significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

***Verbena* x *canadensis*'Homestead Purple' Post Harvest Quality Rating Compared by Retail Nursery Setting**

To compare locations, the rating after the first 6 weeks of post-harvest was isolated and crops 1 and 2 were pooled. The mean plant quality rating was 2.29 for Burden 1, 2.49 for Clegg's, and 2.93 for Burden 2. This shows that quality ratings were impacted by not only media but also by location (Table 6).

***Verbena* x *canadensis* 'Homestead Purple' Dry Shoot Weight**

Crop 1

The mean shoot weights for Burden 1 and Clegg's Nursery had no significant differences due to media at the $p \leq 0.05$ level. For Burden 2, there were significant differences due to shoot weight with pinebark amended with hydrogel producing the highest mean dry shoot weight. Mean dry shoot weight for pinebark amended with hydrogel was 72% higher than pinebark (Figure 32). Shoot weight means for Burden 1 and Clegg's Nursery where 5.65g and 15.16g respectively and 21.47g for Burden 2. These trends show that there was a difference in shoot weight due to retail nursery setting (Table 6).

Crop 2

For crop 2, there were no significant differences in shoot dry weight due to media at the $p \leq 0.05$ level in all three locations (Figure 33). Shoot weight means for Burden 1 and Clegg's Nursery for crop 2 where similar with 10.29g and 10.17g respectively while in Burden 2 the shoot weight was 17.55g once again displaying differences between locations (Table 6).

Discussion

Leachate EC increased after 16 weeks and was close to unacceptable level. However, it remained below 2.0 dS/m. as required for pinebark based substrates (Anonymous, 2006c).

Leachate pH did not change significantly over time except 4 weeks after placement, coinciding with a fertilizer treatment.

At the end of production, there were no significant differences in growth index by media for plants assigned to Burden 1 and Burden 2 at the $p \leq 0.05$ level. For plants assigned to Clegg's Nursery, pinebark and pinebark to be amended with hydrogel produced similar growth indices and the highest. Pinebark had the lowest water retention porosity of the media, suggesting that *Verbena* x *canadensis* 'Homestead Purple' favours dry environments.

At the end of post-harvest, there were no significant differences in the mean growth index by media for Clegg's Nursery or Burden 2. In a study by Strojny and Nowak (2004), it was found that media effects on growth and plant size of *Verbena hybrida tapien* 'Salmon Pink' were not pronounced. However, at Burden 1, pinebark:peat had the lowest mean growth index, while pinebark, pinebark amended with hydrogel and pinebark:sand had similar growth indices. The hydrogel amendment did not affect growth indices. One reason why this might have happened is suggested in a study by Wang and Gregg (1990) which states that if media goes through repeated drying and rehydration cycles, it will reduce the ability of a hydrogel.

At the end of production, quality was not uniform for crop 1. Crop 1 was below commercially acceptable quality for plants assigned to Burden 1. However, for plants assigned for Clegg's Nursery plants were above commercially acceptable quality in pinebark:sand and pinebark to be amended with hydrogel, and below commercially acceptable quality in pinebark and pinebark:peat. Plants assigned for Burden 2 were above commercially acceptable quality in pinebark:peat and pinebark:sand, and below commercially acceptable quality for pinebark and pinebark to be amended with hydrogel. For crop 2, all plants were above commercially acceptable quality. Plants assigned to Burden 1 had highest quality in pinebark to be amended with hydrogel and pinebark peat. While plants assigned to Clegg's Nursery had the highest quality in pinebark:peat and plants assigned to Burden 2 had the highest quality in pinebark.

At the end of post-harvest, all plants for crop 1 and 2 were below commercially acceptable quality except for crop 1 at Burden 2 in pinebark amended with hydrogel. Pinebark amended with hydrogel had an 18.2% increase in quality when compared to pinebark. Overall quality of *Verbena* x *canadensis* 'Homestead Purple' was better at Burden 2.

There were no significant differences in dry shoot weight of crop 1 for Burden 1 and Clegg's Nursery. However for Burden 2, pinebark amended with hydrogel produced dry shoot weight 72% higher than pinebark. These results agree with Bilderback (1987) who stated that hydrogel amendment increased dry shoot weight of *Pyracantha coccinea* and *Rhododendro* sp. For crop 2, there were no significant differences in shoot dry weight by media agreeing with results from Dehgan *et al.* (1994) who found that dry shoot weight of *Podocarpus macrophyllus* were similar for hydrogel amended and unamended media.

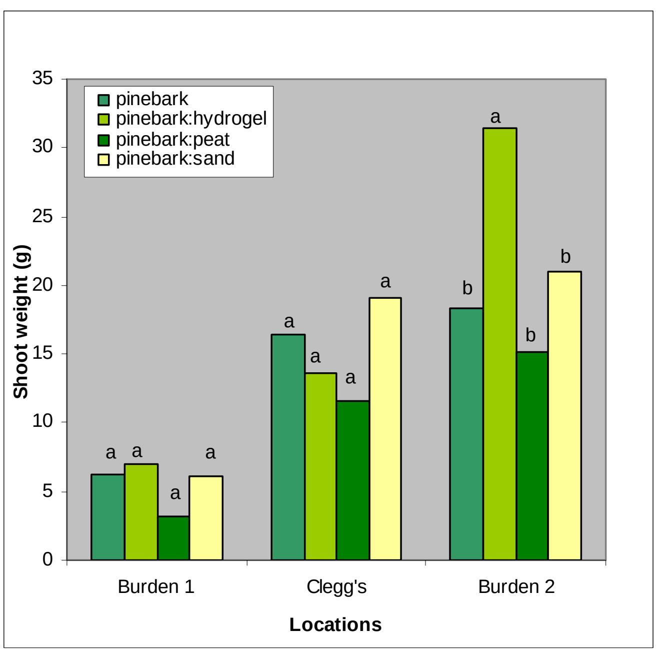

Figure 32. Media influence on dry shoot weight of *Verbena* x *canadensis* 'Homestead Purple' crop 1. Means with the same letter are not significantly different at the p≤0.05 level.

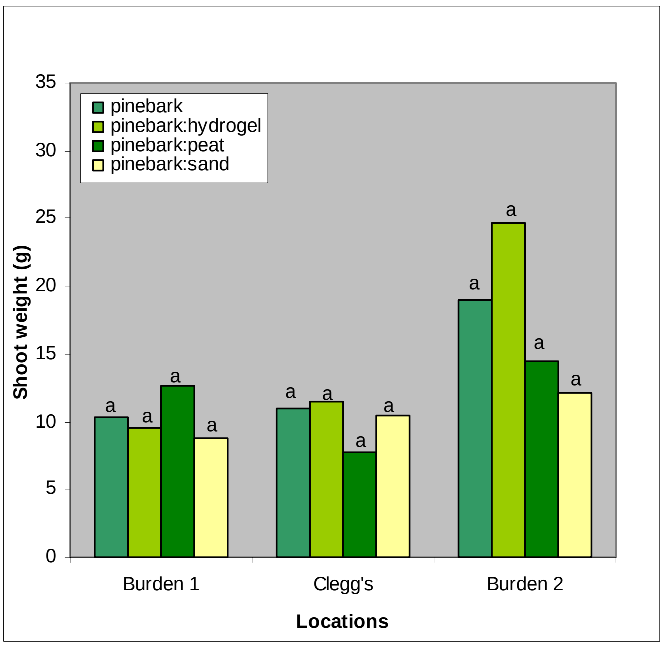

Figure 33. Media influence on dry shoot weight of *Verbena* x *canadensis* 'Homestead Purple' crop 2. Means with the same letter are not significantly different at the $p \leq 0.05$ level.

CHAPTER 5

CUSTOMER POST-HARVEST QUALITY RATINGS

Introduction

Media amendments can be used in the retail nursery to increase quality of crops, making them attractive to consumers. However, consumers tend to rate quality of plants in a subjective way and may not always detect the increase in quality that an amendment might produce. Therefore, products must be tested by the consumers so that the nurserymen can decide if benefits of applying it outweigh the cost and labor.

Materials and Methods

A plant quality rating survey was carried out for plants at Clegg's Nursery, Denham Springs and at the Department of Horticulture, Baton Rouge, La. Three different rating groups were asked to rate the plants consisting of consumers, students and professionals in the field of horticulture. Two plants representative of each specie and treatment were selected. Individuals were asked to rate the plants with the same rating scale used to rate post-harvest quality of plants. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, and 5=optimum (Appendix 4).

Results

Factors such as age and type of rating group significantly affected the way that crops were rated (data not shown). Since the consumer group affects sales in a retail nursery, data on how they rated will be presented.

Buddleia davidii 'Nanho Blue' Customer Survey

There were significant differences due to media at the $p \leq 0.05$ level. Pinebark amended with hydrogel produced the highest post-harvest quality rating, while pinebark and pinebark:peat had similar quality ratings. All crops were rated below commercially acceptable quality except for pinebark amended with hydrogel which had a commercially acceptable quality (Figure 34).

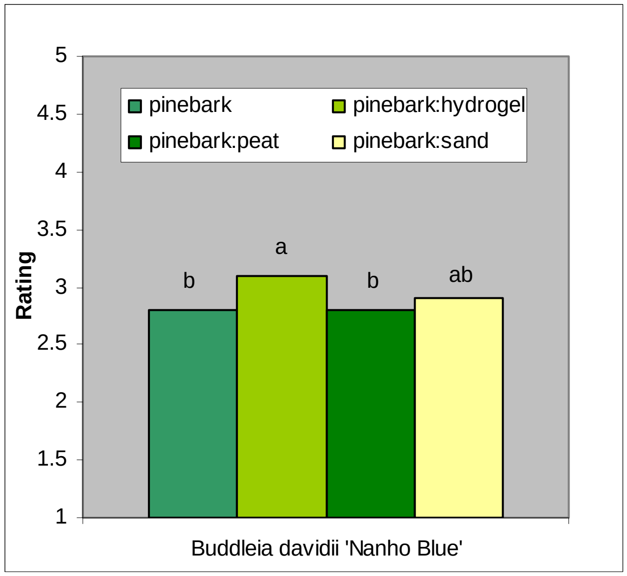

Figure 34. Customer post-harvest quality rating of *Buddleia davidii* 'Nanho Blue'. Means with the same letter are significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Salvia leucantha **Customer Survey**

There were no significant differences due to media at the p≤0.05 level (Figure 35).

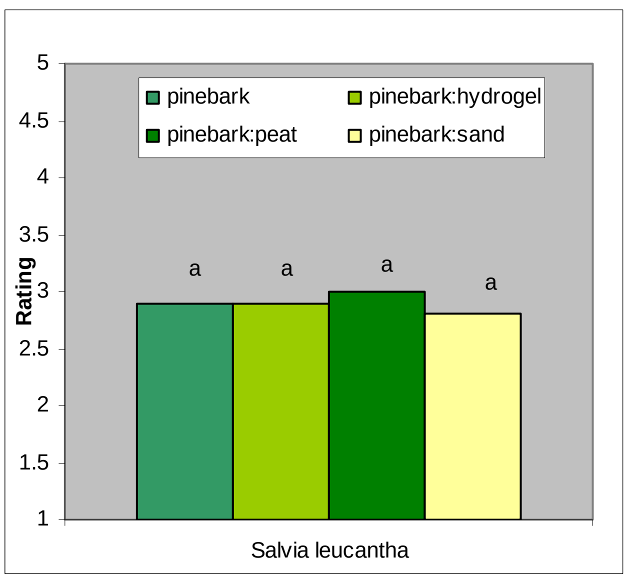

Figure 35. Customer post-harvest quality rating of *Salvia leucantha*. Means with the same letter are significantly different at the p≤0.05 level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

***Verbena* x *canadensis* ‘Homestead Purple’ Customer Survey**

There were significant differences due to media at the $p \leq 0.05$ level. Pinebark amended with hydrogel produced the highest quality rating, while pinebark:peat and pinebark:sand had similar ratings. Quality rating for pinebark was not different to the other media. All crops were below commercially acceptable quality (Figure 36).

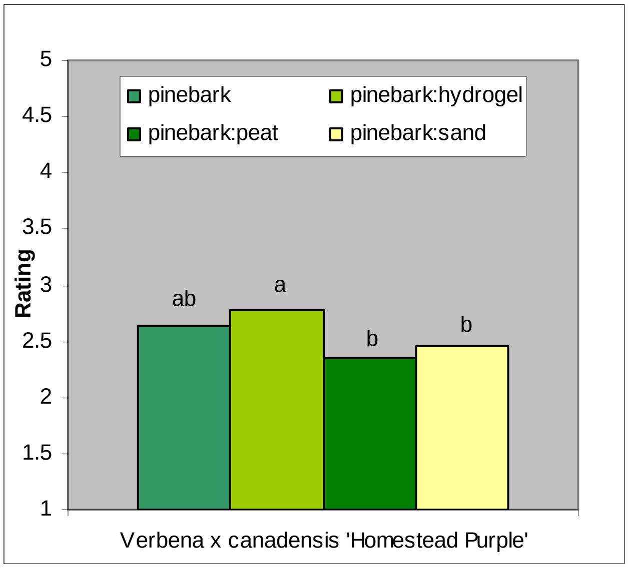

Figure 36. Customer post-harvest quality rating of *Verbena* x *canadensis* ‘Homestead Purple’. Means with the same letter are not significantly different at the $p \leq 0.05$ level. Rating scale: 1=dead, 2=commercially unacceptable, 3=commercially acceptable, 4=above average, 5=optimum.

Discussion

Consumers rated *Buddleia davidii* ‘Nanho Blue’and *Verbena* x *canadensis* ‘Homestead Purple’ with the highest rating, in the pinebark amended with hydrogel medium. This shows that in the eyes of consumers, the hydrogel amendment produced a positive effect on the quality of treated plants. For *Buddleia davidii* ‘Nanho Blue’ the increase in rating when compared to that of pinebark was 11%. For *Verbena* x *canadensis* ‘Homestead Purple’, the hydrogel amendment increased plant quality by 18% when compared to pinebark:peat, and 13% when compared to pinebark:sand. These increases though not very high, were detectable by the consumers.

CHAPTER 6

CONCLUSIONS

Pinebark:peat had the highest water holding capacity, and it produced the highest growth indices for *Buddleia davidii* 'Nanho Blue' plants assigned to Burden 1 and Burden 2 at the end of production. Plants in pinebark:peat assigned to Burden 1 had a 12% higher growth index when compared to pinebark. On the other hand, plants assigned to Clegg's Nursery displayed similar growth indices, with pinebark producing the lowest growth index. All media treatments produced plants with above commercially acceptable quality. The highest quality was produced in pinebark:peat or pinebark:sand except for crop 2 assigned to Burden 2 which had the highest quality in pinebark. There were differences between crops, with crop 1 having a higher quality than crop 2. This was attributed to the slow growth of *Buddleia davidii* 'Nanho Blue'. Since crop 1 had a longer production interval it had a higher density and growth.

The hydrogel amendment positively influenced growth index of *Buddleia davidii* 'Nanho Blue' at the end of post-harvest. Growth index of plants was increased by 13% in comparison to pinebark. For plants at Burden 2, pinebark, pinebark amended with hydrogel and pinebark:sand had similar growth indices. At Clegg's Nursery, media treatments did not influence the growth index. Plant quality declined in all retail nursery settings and only remained above average quality at Clegg's Nursery. This decline in quality was expected due to the time of year in which the study was carried out. Plant quality as influenced by media treatments was different in the three retail nursery settings. For Burden 1, plants in pinebark:peat had the highest quality, but it was below commercially acceptable quality. For Clegg's Nursery, plants in pinebark:sand had the highest quality, while at Burden 2 plants in pinebark amended with hydrogel had the highest quality and were the only ones to remain above commercially acceptable quality. Crop 1 had a higher decrease in quality than crop 2, perhaps due to its longer production resulting in stresses due to insufficient space for growth, compaction of media and roots, decreased aeration and degradation of media. The hydrogel amendment influenced dry shoot weight of plants at Burden 2, increasing shoot weight by 46% and 103.8% for crop 1 and crop 2, respectively. However, at Burden 1 and Clegg's, media treatments and hydrogel amendment did not influence dry shoot weight. Of the retail nursery settings, Clegg's Nursery had the highest growth index, plant quality and dry shoot weight. This may be due to the high alkalinity of the irrigation water at the Burden 1 and Burden 2. Alkalinity has been shown to reduce the availability of nutrients and therefore decreasing plant growth and quality. The relative efficiency of the hydrogel amendment appeared to be influenced by the environment in which it was used. Burden 1 and 2 differed in average weekly water applied in comparison to Clegg's Nursery, which had the highest average weekly water applied. The hydrogel amendment had no influence on growth index, plant quality or dry shoot weight were abundant water was applied to plants, and appeared to be beneficial where less water was applied.

Pinebark:peat and pinebark:sand produced the highest growth for *Salvia leucantha* plants assigned to Burden 2 at the end of production. However, plants assigned to Burden 1 and Clegg's displayed no significant differences in growth indices due to media. All media treatments produced plants with above commercially acceptable quality for crop 2, with pinebark producing the highest quality for plants assigned to Clegg's Nursery and Burden 2. For plants assigned to Burden 1, pinebark:peat and pinebark to be amended with hydrogel, produced similar and also the highest quality rating. For crop 1, all media produced plants below commercially acceptable quality, except for plants grown in pinebark to be amended, assigned to Burden 1. There were differences between crops with crop 2 having a higher quality than crop 1. *Salvia leucantha* grows very rapidly, so crop 1 was probably under stress due to its longer production.

The hydrogel amendment influenced growth index of plants at Clegg's Nursery and Burden 2 at the end of post-harvest. Growth index of plants was increased by 5% at Clegg's Nursery and 19% at Burden 2 in comparison to pinebark. For plants at Burden 1, pinebark, pinebark amended with hydrogel and pinebark:sand produced plants with similar growth indices. Plant quality declined in all three settings as expected for the time of year, but it remained above commercially acceptable quality for crop 2 in pinebark amended with hydrogel at Clegg's Nursery. Plant quality as influenced by media treatment was different in the three retail nursery settings. For crop 1 at Burden 1, plants in pinebark amended with hydrogel had the highest quality. For crop 1 at Clegg's Nursey, pinebark produced the highest quality while at Burden 2, pinebark peat produced the highest quality. For crop 2 at Burden 1, plants in pineb*ark:sand had the highest quality, at Clegg's Nursery pinebark amended with hydrogel had the highest quality and at Burden 2, pinebark had the highest quality. Media treatments did not influence dry shoot weight at Burden 1 or Clegg's Nursery. The hydrogel amendment influenced dry shoot weight at Burden 2, increasing dry shoot weight by 39% for crop 2 in comparison to pinebark.

At the end of production, there were no significant differences in growth indices due to media treatments for *Verbena* x *canadensis* 'Homestead Purple' plants assigned to Burden 1 and Burden 2. For plants assigned to Clegg's Nursery, pinebark and pinebark to be amended with hydrogel had the highest growth index. All media treatments produced plants with above commercially acceptable quality for crop 2. For crop 1 assigned to Burden 1, pinebark and pinebark to be amended with hydrogel had the highest quality but were below commercially acceptable quality. For crop 1 assigned to Clegg's Nursery, pinebark:sand and pinebark to be amended with hydrogel produced the highest quality and they were above commercially acceptable quality while pinebark and pinebark:peat were below commercially acceptable quality. For crop 1 assigned to Burden 2, pinebark:peat and pinebark:sand were above commercially acceptable quality while pinebark and pinebark to be amended with hydrogel were below commercially acceptable quality.

There were no significant differences in growth index due to media treatments at the end of post-harvest at Clegg's Nursery and Burden 2. However, at Burden 1 pinebark and pinebark amended with hydrogel produced similar growth indices and the highest. The hydrogel amendment produced a positive influence in plant quality at Burden 2 and for crop 2 at Clegg's Nursery. Quality of plants was expected to decline, but hydrogel amendment maintained commercially acceptable quality for crop 1 at Burden 2. Media treatments did not influence dry shoot weight for plants at Burden 1 or Clegg's Nursery. At Burden 2, the hydrogel amendment increased shoot weight by 72% for crop 1 in comparison to pinebark.

The customer survey carried out at Clegg's Nursery displayed how the influence of the hydrogel amendment was perceived by consumers. There was an increase 11% in quality rating for *Buddleia davidii* 'Nanho Blue' with the hydrogel amendment when compared to pinebark. Quality rating for *Verbena* x *canadensis* 'Homestead Purple' with the hydrogel amendment increased 18% when compared to pinebark:peat, and 13% when compared to pinebark:sand. Since differences where perceived by the consumer, nurserymen could benefit from the hydrogel amendment. However an assessment of how feasible it is to use it compared to the benefits would be needed.

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APPENDIX

MEDIA PROPERTIES, WATER QUALITY AND CUSTOMER SURVEY

APPENDIX

Appendix 1. Media properties.

Media	Porosity [%]	Air Space[%]	Water Holding Capacity [%]
100% Pine Bark	64.31	35.69	28.62
90% Pine Bark, 10% Peat	67.84	33.92	33.92
90% Pine Bark, 10% Sand	63.42	31.56	31.86

Appendix 2. Burden irrigation water quality analysis.

Constituent	Results
Alkalinity	170.8 ppm
Calcium	1.06 ppm
Chloride	17 ppm
Conductivity	327 µmho/cm
Hardness (Ca, Mg)	2.705 ppm
Iron	0.011 ppm
Magnesium	0.014 ppm
Manganese	0.010 ppm
Nitrate	4.526 ppm
pH	8.44
Potassium	0.763 ppm
Salts	209 ppm
SAR	20.4 ppm
Sodium	77.00 ppm
Sulfur	3.7 ppm

Appendix 3. Clegg's Nursery irrigation water quality analysis.

Constituent	Results
Alkalinity	78.08 ppm
Calcium	11.340 ppm
Chloride	13.730 ppm
Conductivity	182 µmho/cm
Hardness (Ca, Mg)	37.6 ppm
Iron	1.2 ppm
Magnesium	2.3 ppm
Manganese	0.107 ppm
Nitrate	1.116 ppm
pH	7.060
Potassium	2.831 ppm
Salts	116.544 ppm
SAR	1.3 ppm
Sodium	18 ppm
Sulfur	1.1 ppm

Appendix 4. Customer nursery survey for post-harvest study.

Louisiana State University
Retail Nursery Survey

Circle your answer!

1. What is your gender? M   or   F

2. Age Group?   20 to 30,   31 to 40,   41 to 50,   >50

3. How often do you garden?
   Once a week,   Once a month,

   4 times a year   Less than 4 times a year

Appendix 4. Continued.

Please rate each group of plants by species using the scale (1=dead, 2=unacceptable, 3=acceptable, 4=above average, 5=superior quality).

Circle your choice!

BUDDLEIA

Crop A:

PB	PBH	PBS	PBP
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Crop B:

PB	PBH	PBS	PBP
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Appendix 4. Continued.

Please rate each group of plants by species using the scale (1=dead, 2=unacceptable, 3=acceptable, 4=above average, 5=superior quality).

Circle your choice!

SALVIA

Crop A:

PB	PBH	PBS	PBP
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Crop B:

PB	PBH	PBS	PBP
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Appendix 4. Continued.

Please rate each group of plants by species using the scale (1=dead, 2=unacceptable, 3=acceptable, 4=above average, 5=superior quality).

Circle your choice!

VERBENA

Crop A:

PB	PBH	PBS	PBP
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Crop B:

PB	PBH	PBS	PBP
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Appendix 5. Media influence of *Buddleia davidii* 'Nanho Blue' in three retail nursery settings.

Burden1 Media treatments	Production growth index	Post-harvest growth index	Production plant quality rating		Post-harvest plant quality rating		Dry shoot weight	
			Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2
100% pinebark	11.72	18.39	3.88	3.63	1.38	1.63	15.80	7.73
100% pinebark and hydrogel	12.04	20.78	5.00	3.75	1.56	2.25	17.61	11.13
90% pinebark 10 % peat	13.36	18.49	5.00	3.25	2.00	2.69	21.20	10.05
90% pinebark 10 % sand	11.66	20.35	4.50	3.75	1.13	2.66	15.07	8.64
Significance	NS	*	****	****	****	****	NS	NS
Clegg's Nursey Media treatments								
100% pinebark	11.78	23.11	4.63	3.50	4.25	3.13	48.50	16.74
100% pinebark and hydrogel	14.45	23.86	4.63	3.38	4.14	3.13	47.59	21.98
90% pinebark 10 % peat	14.13	23.56	4.63	3.86	4.25	3.13	55.81	17.01
90% pinebark 10 % sand	13.60	23.22	4.88	3.50	4.38	3.25	47.17	18.39
Significance	NS	NS	****	****	****	****	NS	NS
Burden 2 Media treatments								
100% pinebark	14.84	20.89	4.75	3.38	2.25	1.50	22.56	6.13
100% pinebark and hydrogel	14.01	22.21	4.88	3.25	3.75	3.31	32.88	12.48
90% pinebark 10 % peat	15.38	17.72	4.25	2.71	2.13	3.06	23.96	10.11
90% pinebark 10 % sand	12.37	20.78	4.88	3.13	1.63	2.00	22.99	6.23
Significance	NS	****	****	****	****	****	**	*

Means are different at 0.05 [*], 0.01 [**], 0.0001 [****] NS = not significant.

Appendix 5, cont. Media influence of *Verbena* x *canadensis* 'Homestead Purple' in three retail nursery settings.

Burden1 Media treatments	Production growth index	Post-harvest growth index	Production plant quality rating		Post-harvest plant quality rating		Dry shoot weight	
			Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2
100% pinebark	10.84	15.79	2.63	3.50	1	1	6.28	10.29
100% pinebark and hydrogel	11.40	16.82	2.63	4.0	1	1	6.98	9.51
90% pinebark 10 % peat	10.47	13.25	2.38	3.63	1	1	3.19	12.61
90% pinebark 10 % sand	10.11	15.21	2.57	3.25	1	1	6.15	8.78
Significance	NS	**	****	****	---	---	NS	NS
Clegg's Nursey Media treatments								
100% pinebark	11.40	16.67	2.75	4.25	1.50	1.75	16.40	10.96
100% pinebark and hydrogel	11.67	16.72	3.50	4.38	1.89	2.29	13.57	11.46
90% pinebark 10 % peat	10.68	15.45	2.50	4.75	2.00	1.75	11.58	7.75
90% pinebark 10 % sand	10.20	16.21	3.63	3.63	2.00	1.88	19.09	10.52
Significance	NS	NS	****	****	****	****	NS	NS
Burden 2 Media treatments								
100% pinebark	10.47	14.13	2.75	4.29	2.13	2.79	18.29	18.99
100% pinebark and hydrogel	10.50	14.31	2.75	3.88	3.25	2.88	31.38	24.63
90% pinebark 10 % peat	10.82	14.13	3.00	3.88	1.38	1.50	15.18	14.46
90% pinebark 10 % sand	9.95	14.46	3.00	3.63	2.31	1.25	20.94	12.11
Significance	NS	NS	****	****	****	****	**	NS

Means are different at 0.05 [*], 0.01 [**], 0.0001 [****] NS = not significant.

Appendix 5, cont. Media influence of *Salvia leucantha* in three retail nursery settings.

Burden1 Media treatments	Production growth index	Post-harvest growth index	Production plant quality rating		Post-harvest plant quality rating		Dry shoot weight	
			Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2
100% pinebark	8.61	17.71	2.75	3.88	2.13	2.00	12.05	34.17
100% pinebark and hydrogel	8.92	18.32	3.00	4.50	2.25	2.28	12.93	35.62
90% pinebark 10 % peat	8.00	15.82	2.75	4.50	1.88	1.91	10.09	25.84
90% pinebark 10 % sand	7.75	17.87	1.75	4.13	1.56	2.31	8.60	22.76
Significance	NS	*	****	****	****	****	NS	NS
Clegg's Nursey Media treatments								
100% pinebark	9.57	21.85	2.75	4.38	2.37	4.25	30.42	63.86
100% pinebark and hydrogel	8.80	22.98	2.00	4.13	2.29	4.75	33.96	63.19
90% pinebark 10 % peat	11.72	21.60	2.00	3.88	1.75	4.29	33.98	57.14
90% pinebark 10 % sand	9.49	20.14	2.57	3.38	2.26	4.38	26.70	53.69
Significance	NS	****	****	****	****	****	NS	NS
Burden 2 Media treatments								
100% pinebark	7.24	16.08	2.38	4.71	1.81	2.33	7.32	25.29
100% pinebark and hydrogel	7.42	19.16	1.71	4.00	1.57	1.69	6.71	35.03
90% pinebark 10 % peat	10.66	15.81	3.38	4.00	2.38	1.38	12.34	10.66
90% pinebark 10 % sand	9.37	16.80	2.00	4.38	1.94	1.00	9.83	17.72
Significance	**	*	****	****	****	****	NS	****

Means are different at 0.05 [*], 0.01 [**], 0.0001 [****] NS = not significant.

VITA

Angelina de los Rosarios López del Castillo, daughter of Dr. Emeterio López Belén and Estrella del Castillo de López, was born in La Romana, Dominican Republic, on 1 July 1979. She graduated with honors from Abraham Lincoln School in La Romana, Dominican Republic. She entered college in the fall of 1997. During her undergraduate studies Ms. López completed an independent study on Parc Andre Citroen in Paris, France, and traveled throughout Asia and Europe observing landscape architecture and culture. Mrs. López completed her undergraduate studies with the title of "Design Award" presented by the faculty of the School of Landscape Architecture and graduated from Louisiana State University Agricultural and Mechanical College in Baton Rouge on May of 2003 with a Bachelor of landscape architecture and a minor in French. Following graduation she worked as a landscape architect preparing designs for high end residence and resorts in La Romana, Dominican Republic, prior to her enrollment in the Graduate School at LSU in the spring 2004. During her time as a graduate student, Ms. López received the 2005 Louisiana Nursery and Landscape Association scholarship and worked as a graduate assistant at LSU Landscape Services. Ms. López is a candidate for the degree of Master of Science in horticulture at LSU.