EFFECT OF ACACIA GUM ON BARE ROOT NURSERY CROPS AND IN

CUTTING PROPAGATION

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Sarah Frances Creel

Certificate of Approval:

J. Raymond Kessler, Jr. Associate Professor Horticulture	J. David Williams, Chair Professor Horticulture
Kenneth Tilt Extension Specialist/ Professor Horticulture	Floyd M. Woods Associate Professor Horticulture

Stephen L. McFarland
Dean
Graduate School

EFFECT OF ACACIA GUM ON BARE ROOT NURSERY CROPS AND IN CUTTING PROPAGATION

Sarah Frances Creel

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Sarah Frances Creel

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Signature of Author

____

Date of Graduation

THESIS ABSTRACT

EFFECTS OF ACACIA GUM ON BARE ROOT NURSERY CROPS AND IN CUTTING PROPAGATION

Sarah Frances Creel

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The effects of acacia gum on bare root 'Karl Sax forsythia' (*Forsythia* × *intermedia* 'Karl Sax') and 'Merrill' magnolia (*Magnolia stellata* 'Merrill') were examined, along with the effects of acacia gum on 'Merlot' Virginia sweetspire (*Itea virginica* 'Merlot'); 'Sky Pencil' holly (*Ilex crenata* 'Sky Pencil'); 'Daisy' gardenia (*Gardenia jasminoides* 'Daisy') in cutting propagation. Tests were conducted to: (1) assess the efficiency of acacia gum in inhibiting the loss of water throughout storage of bare root nursery crops, (2) examine the effects of the acacia gum on post transplant growth of bare root *Forsythia* × *intermedia* 'Karl Sax' and *Magnolia stellata* 'Merrill', and (3) examine the effectiveness of acacia gum in preventing desiccation during storage and rooting of cuttings.In the bare root study, plants treated with acacia gum had more growth than those treated with the traditional methods of peat and hydrophilic polymer in some cases. It may somewhat reduce water loss of the plants during storage though

further testing is necessary to investigate reasons for inconsistent results. Success of acacia gum was highly variable between the two species and acacia gum concentrations. Acacia gum did not prevent the loss of water of cuttings during propagation. Furthermore it was found to harm cuttings with increased concentration.

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INTRODUCTION AND LITERATURE REVIEW

Bare Root Nursery Crops

According to the Economic Research Service (ERS), nursery crops are defined as "woody perennial plants that are usually field-grown in containers or in-ground." These include ornamental trees, shrubs, vines, groundcovers, and also fruit and nut trees. Nursery crops are mainly used in landscaping, and are classified as evergreen, deciduous, or nursery stock. Various numbers of plants are grown as liners in pots or trays, and some are grown in fields to be harvested balled and burlapped or bare-root. Bedding plants, garden plants, flowering plants, foliage plants, and cut flowers are considered floriculture crops. Floriculture crops are mainly herbaceous and are usually grown in flats, trays, pots, or hanging baskets (11). Many herbaceous perennials are also harvested and handled bare-root (12). Nursery crops and floriculture crops are collectively known as the Green Industry. In 2002, Green Industry sales reached $13.8 billion in the U.S., and were estimated at $14.3 billion in 2003. Greenhouse and nursery crops are considered the fourth largest crop group, and constitute one third of the total farm cash receipts from horticulture crops nationally (9,10).

Due to the problem of root desiccation, plants are primarily shipped balled and burlapped or in containers. Shipping is very expensive for these plants because of the weight of the soil (10). Many plants are harvested bare root to they reduce the expense of shipping plants with soil. Also, the loss of valuable topsoil from production fields is a factor that requires more bare-root harvesting (12). For these reasons, bare-root plants are considered to be the most economical nursery stock (10). Large wholesale and mail-order nurseries harvest a large number of trees, shrubs, and herbaceous perennials bare-root in order to reduce shipping costs (12). Also, export of plants require roots to be soil free and shipping distance and government regulations increase the time exposure for desiccation and quality reduction of the plants (2).

Problems do exist with bare-root harvesting and shipping that limit widespread application. Desiccation during post-harvest handling and storage is the major problem with bare-root plants (29). Desiccation stress is considered the main cause of inadequate regrowth of bare-root nursery stock (25). In addition, dessication can cause poor performance and even plant death. Bare-root plants can be subjected to water loss during harvesting, processing, storage, shipping, and planting (12). Plants subject to desiccation during any of these phases are likely to have reduced growth potential and poor quality after transplanting (5).

Extensive research has documented methods and products to reduce post harvest desiccation of bare-root nursery stock. Current research has shown that success of a number of species can be improved when plants are harvested at certain times of year when desiccation tolerance is highest. This tolerance usually occurs in January or February when the plants are dormant (13,25). One study was undertaken to determine the seasonal variation of desiccation tolerance in bare-root plants. Three bare-root deciduous species were tested for desiccation tolerance at monthly harvest intervals from

September 1990 through April 1991. The trees tested were red oak (*Quercus rubra* L.), most tolerant to desiccation, Norway maple (*Acer platanoides* L.), and Washington hawthorn (*Crataegus phaenopyrum* Med.), which are less tolerant. January and February were months of maximum desiccation tolerance for all three tree species (13). The problem with harvesting during dormancy is that digging can be difficult or even impossible because of frozen soil in some areas (12).

Other studies have measured the success of using polyethylene wraps around roots in storage. A study by Lefevere et al. (19) indicated that polyethylene provides sufficient protection from water loss. The study showed that plants can be stored up to 7 months using polyethylene. A limiting factor with polyethylene is that it is labor intensive (12). Lefevere's study also mentioned that desiccation is still possible using any storage technique that leaves the shoots exposed. Bates et al. (5) analyzed the impact of cold storage treatments on the desiccation of bare-root Norway maple and Washington hawthorn by measuring shoot and root water potentials. Stems of the hawthorn were more susceptible to desiccation during cold storage than maple stems. Roots of both species were prone to water loss during cold storage. The research showed that while precautions should be taken to protect the roots of all bare-root plants from desiccation, desiccation sensitive plants need both shoot and root protection to reduce water loss.

Clay dipping has also been used in attempt to prevent desiccation of white spruce, white pine, and red pine but this method was observed to be of no benefit to any of the three species, and even damaging to survival and growth of some plants (24).

Waxes and antitranspirants have been tested for the reduction of water loss. In a study by Simpson (30), six antitranspirants, XEF-4-3561, Wilt Pruf, Plant Gard, Folicote, Clear Spray, and Vapor Gard, were applied to the stems and foliage of container grown lodgepole pine (*Pinus contorta* Doug.), white spruce (*Picea glauca* (Moench) Voss), western hemlock (*Tsuga heterophylla* (Raf). Sarg.), and douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Only XEF-4-3561 and Wilt Pruf, were successful in reducing water loss of lodgpole pines. On the other hand, all six antitranspirants had adverse effects on the other three plant species in the experiment. Antitranspirants either reduced plant performance, photosynthesis, or caused plant death. Waxes have also been successful in reducing desiccation in some species but when tested on roses, were found to be ineffective (29).

Schuch et al. (29) performed a study on growth and flowering of bare-root roses (*Rosa)* after dipping canes in hot wax, or in one of three film forming anti-transpirants: Moisturin, Glascol, and Alcoprint. Plants were stored for 13 weeks at -2C after treatment. Plants treated with hot wax resumed growth faster than control plants and faster than plants treated with antitranspirants. More than 60% of plants treated with hot wax had severe damage and dieback, whereas less than 20% of plants treated with antitranspirants were damaged. Hot wax treatment was the most effective in reducing water loss, because it reduced weight loss from stem sections by 85% in comparison to the control. Antitranspirant treatments reduced weight loss by 27% in comparison to control. The disadvantage of hot wax treatment is moderate to severe cane damage and dieback occured, therefore it is not recommended for use on bare-root plants.

Englert et al. (13) studied the effects of 20 film-forming antidesiccant compounds on 10 cm stem sections of Washington hawthorn and maple seedlings. Of the 20 antidesiccants used, 8 that performed well on the stems were applied as a dip to roots and shoots of bare root Washington hawthorn and Norway maple seedlings. Moisturin was the most effective in reducing water loss as well as improving survival and performance during re-establishment. Plants treated with Moisturin retained 80% more water than control plants. Washington hawthorn, a species sensitive to dessication, was exposed to severe drought conditions and treated with Moisturin. These plants had the highest survival, least plant dieback, and highest root growth ratings of the antitranspirants tested, demonstrating that Moisturin can be effective in reducing post harvest desiccation stress in plants sensitive to desiccation.

Carbohydrate depletion during storage is also a concern with bare root nursery crops. Carbohydrates serve as the energy source for growth and plant cellular metabolism. Stored seedlings depend on carbohydrate reserves for cellular respiration and to repair damaged tissues. If subsequent carbohydrate reserves are unable to meet the respiratory requirement during cold storage and planting, the plant will die. (21)

Cutting Propagation

A common method of rapidly increasing product numbers in the nursery industry today is vegetative propagation by stem cuttings. Vegetative propagation is preferred over seed propagation because plants resulting are clones of the parent plant. Therefore, characteristics such as plant height, plant form, and flowering are maintained in the product, while seed propagation often results in genetic variability. Vegetative propagation involves obtaining plant tissue segments from stock plants and placing them in a rooting environment with the expectation that roots will develop and thus produce independent plants.

In today's containerized nurseries, many cuttings are propagated using intermittent mist. This type of system maintains high humidity environment by producing droplets of fine mist that maintain a film of water covering the foliage of the cuttings. Water on the leaf surface evaporates instead of the internal water from leaf tissues. Misting reduces water loss from cuttings by lowering ambient leaf and air temperature and raising the relative humidity thus reducing transpiration loss. The frequency and amount of misting necessary to maintain a film of water on the foliage without over or under watering is influenced by the environment. Cloudy days with low light intensity and high relative humidity require less frequent misting, while sunny days with high light intensity and low relative humidity require more frequent misting. If the propagator does not react to these changing conditions and make the necessary adjustments to mist frequency and amount, under application of mist can result in moisture stress and delayed rooting or death, while over applied mist causes dripping from the foliage keeping the rooting medium saturated, and resulting in rotting of the cuttings. Constant presence of water on the leaves causes rapid depletion of essential nutrient reserves from cuttings. Intermittent misting lowers medium temperature, which can produce suboptimal temperatures that may reduce root growth (14).

The process of using intermittent mist rooting system requires a number of steps that increase labor costs. These steps include taking cuttings, trimming cuttings to the appropriate length, wounding, filling flats, dipping cuttings in hormones and sticking, cleaning and maintaining mist system, removing rooted cuttings from mist and potting into appropriate containers, transporting containers, and cleaning benches and pots following removal (36).

Another problem with cutting propagation is that when large numbers of cuttings are harvested from stock plants time is crucial. Cuttings require storage in a cooler for a certain period of time before the scheduled labor can place them in the propagation environment. Storage of unrooted cuttings can be effective, though little is known about the practical side of storing cuttings on a commercial scale. Storage duration depends on the storage conditions such as temperature and relative humidity, conditions of cuttings, and species. Water loss, dry matter loss, and disease incidence must be minimized. Optimal relative humidity must be almost 100%, and optimal temperature must be as low as tolerable as determined by species. Also, low oxygen and ethylene levels are beneficial in maintaining ability to root. The question remains of how long cuttings can be stored practically in a forced-air cool chamber with plastic covering. (6)

According to Whitcomb and Davis, a possible solution is the use of intermittent misting with antitranspirants to coat the surface of leaves and stems of cuttings, thereby reducing water loss and possibly the need for continuous misting. Results of one study indicated that the use of antitranspirants on *Podocarpus macrophylla* D. Don and *Juniperus chinensis* Hort. Ex. Endl 'Hetzi' produced better cuttings than those rooted under mist. This study showed that for some plants misting was not required. Cuttings can be inserted directly in growing medium with necessary nutrients incorporated, thus saving time and increasing cutting growth by eliminating the need to transplant later. Additionally, problems of disease and leaching of nutrients from leaves may be reduced or eliminated. Use of antitranspirants could reduce the number of laborious steps associated with mist propagation and also reduce overall cost of production (36).

The effectiveness of antitranspirants in maintaining plant quality has been evaluated on many different plant species with various application times, methods, and conditions. For example, the effectiveness of antitranspirants were evaluated in transplanting oak trees (*Quercus virginiana)* (17), tissue cultured chrysanthemum (*Chrysanthemum morifolium* Ramat 'Bright Golden Anne') and carnation (*Dianthus caryophyllus* L.) (31), postharvest handling of Christmas trees (*Abies fraseri* (Pursh) Poir.), and (*Juniperus virginiana* L.) (15), cold storage of container grown lodgepole pine, white spruce, western hemlock, and Douglas fir (30), transplant of impatiens (*Impatiens wallerana* Hook.f.) seedlings (16), and dogwood (*Cornus florida)* (37). Antitranspirants have also been evaluated on apple trees (*Malus domestica* Borkh.) (35), Rabbiteye blueberry (*Vaccinium ashei* Reade) (3), tomato (*Lycopersicon esculentum* Mill. 'Early Giant') (18), packaged roses (29), bare root nursery trees (13), highway oleander plantings (*Nerium oleander* L.) (8), and rooting of cuttings (20,36).

However, the effectiveness of antitranspirants is extremely variable. In tissue cultured chrysanthemum (*Chrysanthemum morifolium* Ramat 'Bright Golden Anne'*)* and carnatations (*Dianthus caryophyllus* L.), DC 200 significantly reduced transpiration, however plants were stunted, whereas other antitranspirants such as Aquawiltless, Clear Spray, Exhalt 4-10, Folicote, Protec, Vapor Gard, and Wiltpruf, were ineffective compared to the controls (31). In another study using tomato, antitranspirants increased water use efficiency without negatively affecting plant growth (18). An experiment evaluating transplanting live oaks (*Quercus virginiana* Mill.) in August in central Florida concluded that the antitranspirant Cloud Cover did not improve survival but did improve the appearance of the trees after transplanting whereas trees treated with Wilt-Pruf had the highest survival rate (17). An additional factor that affected post harvest stress of summer-dug Fraser photinia *(Photinia × fraseri)* was that the use of Vapor Gard on morning-dug plants showed a high survival rate even without irrigation. Afternoon digging with or without irrigation resulted in a low survival rate, however all plants survived with the use of Vapor Gard plus irrigation in the afternoon (28). One antitranspirant, Crop-Life, was tested on Fraser fir [*Abies faseri* (Pursh) Poir.] and eastern red cedar (*Juniperus virginiana* L.) to determine its ability to reduce water loss and was found to be ineffective (15). Six antitranspirants, Plantco, Cloudcover, Dow X2-1337, Clearspray, Vapor Gard, and Folicote, were used in a study on black spruce. Plantco, Cloudcover, DowX2-1337, and Vapor Gard reduced transpiration, though Vapor Gard treated plants showed toxicity symptoms and abnormal bud flushing. Folicote and Clearspray did not reduce water loss (7). The effects of the antitranspirant, CS-6432, on oleander (*Nerium Oleander* L.) in a greenhouse and highway planting were positive. The study showed that transpiration in potted oleanders in a greenhouse decreased by 25-30% for two weeks after treatment. The results of the study demonstrated that CS-6432 slowed the depletion of soil water in highway plantings of oleander (8). In a bare-root rose study comparing growth and flowering of plants treated with either one of three film-forming antitranspirants, Moisturin, Glascol, and Alcoprint, or hot wax, wax treated plants resumed growth faster than control or antitranspirant treatments. Wax treated plants also performed better in the following two weeks. Fewer antitranspirant treated plants were damaged than those treated with wax, but the wax treated plants had reduced weight loss by 85% and the antitranspirants only by 27% (29). Water loss of hydrangea (*Hydrangea macrophylla* Ser. 'Improved Merveille') was reduced by antitranspirants, Elvanol, Folicote, Cloudcover, Vapor Gard, and All Safe (22). Clearspray and Vapor Gard were effective in a cineraria (*Senecio cruentus* DC.) study on hot days (23). A study using Foli-Gard, Vapor Gard, and experimental coating No. 30 on cuttings of *Juniperus chinensis* L. 'Hetzi' and *Podocarpus macrophylla* suggested that the use of antitranspirants can increase rooting in cutting propagation (36). But in a study using cuttings of *Prunus persica* 'Harmony' and 'Cresthaven', the use of Vapor-Gard significantly decreased the amount of rooting with or without mist (20). In another propagation experiment, unfolding of the first leaf of un-misted *Epipremnum aureum* (Linden ex Andre) Bunting cuttings was delayed by Folicote. Cuttings taken from stock plants sprayed with Stressguard resulted in slow growth, while cuttings taken from plants sprayed with Folicote were not affected (34). Comparison of 5 antitranspirants on *Citrus sinensis* L. showed that Mobileaf, Vapor Gard, Nu-Film-17, and Wilt Pruf NCF improved leaf coatings and prevented weight loss in fruit compared to the controls. This study also concluded that Mobileaf and Vapor Gard decreased the use of water by containerized trees, Mobileaf for 2 months and Vapor Gard for 5 (1). A study on *Camellia sinensis* L. showed that the antitranspirant phenyl mercuric acetate reduced transpiration for about 20, with lessening intensity as each day passed. The spray reduced vegetative growth of immature plants under drought and non-drought conditions, and yield of mature plants under drought conditions (26).

Acacia gum

A new possibility for enhancing the post harvest shelf life of bare root plants is a naturally occurring preservative known as acacia gum.

Acacia gum, also known as gum Arabic, is defined as “the gummy exudate flowing naturally or obtained by incision of the trunk and branches of *Acacia senegal* Willd. and other species.” Acacia gum is unique in that it is soluble at high concentrations in water (32). It consists of polysaccharides and calcium, magnesium, and potassium salts, which upon hydrolysis generates glalactose, arabinose, rhamnose and glucuronic acid (27). There are currently about 1200 known species of *Acacia* and they vary considerably in gum quality and usage (4). The gum is used as a food hydrocolloid, natural emulsifier, flavor encapsulator, stabilizer, texturizing agent, and source of soluble fiber in low calorie drinks (27). It is also used to clarify wine, also used as an adhesive, and to encapsulate pharmaceuticals. Lower quality grades of gum are used in printing, textiles, and in the production of explosives (4). Currently Auburn University is conducting research to evaluate the potential use of acacia gum to preserve microorganisms. Acacia gum is used to isolate and preserve a microorganism in a suspended state without harm. The specimen can later be brought back to its earlier condition (33). No research has currently evaluated the use of acacia gum in green industry.

There are no standardized methods of bare root storage and shipping, therefore there is a need for a more effective postharvest handling product. Acacia gum may offer a way to reduce desiccation of bare root nursery stock and allow more plants to be successfully shipped bare-root. This would in turn offer more savings to industry and consumers. Acacia gum may also have use in cutting propagation industry. A new, more efficient way to reduce water loss of cuttings after harvest and during rooting could help solve the problems and costs associated with mist systems and cutting propagation without damaging the cuttings. The objective of this research was to evaluate the effectiveness of Acacia gum in reducing water loss during storage of bare root nursery crops and in cutting propagation.

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CHAPTER 2

EFFECTS OF ACACIA GUM ON BARE ROOT NURSERY CROPS

Abstract

The effects of acacia gum were evaluated on bare root *Forsythia × intermedia* 'Karl Sax' and *Magnolia stellata* 'Merrill'. Plants received one of six root treatments: roots dipped in water, roots packed in moist sphagnum peat moss, roots packed in hydrophilic polymer, and whole plant dipped for 5 seconds in 5%, 10%, and 20% concentrations of acacia gum. Cuttings were then stored in a walk-in cooler at 38F (3.3C) for 0, 3, 6, 9, or 12 weeks. Acacia gum treatments were more successful at concentrations of 5% and 10% than treatments of peat and hydrophilic polymer for forsythia, and at 20% for magnolia. Increasing cooler time caused a decrease in growth of both forsythia and magnolia.

Index words: sphagnum peat moss, hydrophilic polymer

Species used in this study: Karl Sax forsythia (*Forsythia × intermedia* 'Karl Sax') and Merrill magnolia (*Magnolia stellata* 'Merrill')

Significance to the Nursery Industry:

Nursery growers often harvest and transport plants bare root. The loss of water from bare root plants during storage and shipping is often problematic. Desiccation during post harvest handling can result in reduced plant performance and even death after out planting. There are many commercial products on the market today that are used in an attempt to reduce desiccation of bare root crops, but they all have their disadvantages. There is a need for an improved product on the market. This study evaluated the ability of acacia gum to reduce water loss of bare root forsythia and magnolia. Different rates of acacia gum were tested against two standard nursery products, sphagnum peat moss and a hydrophilic polymer. Acacia gum treatments were equal or better than the traditional treatments of peat and hydrophilic polymer in some cases, though success varied between species and acacia gum concentrations. Further testing of acacia gum at different rates with different species is necessary before any recommendation should be made to the nursery industry

Introduction

Bare-root plants are considered to be the most economical nursery stock (3). Many plants are harvested and transported bare root because of the expense of shipping plants with soil. The loss of valuable topsoil from production fields is a factor that requires alternative methods of bare-root harvesting. Large wholesale and mail-order nurseries import and harvest a large amount of trees, shrubs, and herbaceous perennials bare-root (4). Also, export of plants requires roots to be soil free. Commercial shipping and governmental regulations increase time exposure for desiccation and quality reduction of these plants (1).

Desiccation during post-harvest handling and storage is the major problem with bare-root plants that prevents its more widespread use (10). Desiccation stress is considered the main cause of reduced regrowth of bare-root nursery stock (8) and can result in inadequate performance and senescence. Bare-root plants can be subjected to water loss during harvesting, processing, storage, shipping, and planting (4). Plants subject to desiccation during any of these phases are likely to have reduced growth potential and quality after transplanting (2).

Extensive research has documented methods and products to reduce post harvest desiccation of bare-root nursery stock. Success of a number of species can be improved when plants are harvested at certain times of year when desiccation tolerance is highest. This tolerance usually occurs in January or February when the plants are dormant (5,8). Other studies have measured the success of using polyethylene wraps around roots in storage. A study by Lefevere et al. (6) indicated that polyethylene provides sufficient protection from water loss. Potentially, plants can be stored up to 7 months using polyethylene. A limiting factor with polyethylene is that it is labor intensive (4). Lefevere's study also mentioned that desiccation is still possible using any storage technique that leaves the shoots exposed.

Clay dipping has been used in attempt to reduce desiccation of white spruce, white pine, and red pine however this method failed to alter water loss in any of the three species, and in certain instances damage occurred (7). Waxes and antitranspirants have also been evaluated for the reduction of water loss. Simpson (11) used six antitranspirants were tested on container grown lodgepole pine (*Pinus contorta* Doug.), white spruce (*Picea glauca* (Moench) Voss), western hemlock (*Tsuga heterophylla* (Raf). Sarg.), and douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Two of the six antitranspirants tested were successful in reducing water loss of lodgepole pines. On the other hand, all six antitranspirants had adverse effects on white spruce, western hemlock, and douglas-fir. The antitranspirants reduced plant performance, reduced photosynthesis, or caused plant death. Waxes have been successful in reducing desiccation in some species however when tested on rose canes, moderate to severe cane damage and plant dieback was observed (10).

A new possibility for enhancing the post harvest shelf life of bare root plants is a naturally occurring preservative known as acacia gum. Acacia gum is also known as gum Arabic. It is defined as "the gummy exudate flowing naturally or obtained by incision of the trunk and branches of *Acacia senegal* Willd. and other species." Acacia gum is unique in that it is soluble at a very high concentration in water (12). Auburn University is conducting research to evaluate the potential use of acacia gum to preserve microorganisms. Acacia gum is used to isolate and preserve a microorganism in a suspended state without harm. The specimen can later be brought back to its earlier condition (13). No reported trials have been cited of the use of acacia gum in green industry. The objective of this study was to evaluate the effectiveness of acacia gum in reducing water loss during storage of bare root nursery crops, and to test the effects of the acacia gum on post transplant growth of bare root *Forsythia* × *intermedia* 'Karl Sax' and *Magnolia stellata* 'Merrill'.

Materials and Methods

On January 28, 2005, Karl Sax forsythia (*Forsythia* × *intermedia* 'Karl Sax') and Merrill magnolia (*Magnolia stellata* 'Merrill') bare-root cuttings were received in Auburn, AL from Schaefer Nursery, Winchester, TN. Cuttings arrived packaged in cardboard boxes surrounded with moist sphagnum peat moss, wrapped in plastic, and topped with shingle tow. Upon arrival boxes were placed in a walk-in cooler set at 3.3C (38F) at Paterson Greenhouse complex on Auburn University campus. Cuttings were examined and found to be in excellent condition. Transit time was approximately 4 days.

Treatment of the cuttings began on February 1, 2005. Roots were surface sterilized by dipping into a 3.8 liter (1 gallon) bucket containing ZeroTol Broad Spectrum Algaecide/Fungicide (Biosafe Systems, Glastonburg, CT) for five seconds at the labeled rate of 78 g per 3.8 liter (2.75 oz per gallon) of water. Cuttings were divided into groups of 5 and randomly assigned one of six root treatments. All treatments included placing roots in 3.8 liter (1 gallon) plastic bag wrapped with a rubber band leaving shoots exposed. Treatments were as follows: 1) roots dipped in water (0% water control), 2) roots packed in moist sphagnum peat moss, 3) roots packed in 25 oz (750 ml) of wet hydrophilic polymer Terra Sorb Super Absorbent Planting Gel, Medium grade (Plant Health Care Inc., Pittsburg, PA), and treatments 4, 5, and 6) whole plant dipped for 5 seconds in 5%, 10%, and 20% acacia gum (Instagum AS, CNI, Normandy, France), respectively. Six cutting treatments of the 2 species were divided into four different storage durations with 10 plants per treatment to be removed at 4 different intervals: group 1 after 3 weeks of storage (February 21, 2005), group 2 after 6 weeks of storage (March 14, 2005), group 3 after 9 weeks of storage (April 4, 2005), group 4 after 12 weeks of storage (April 25, 2005). Control consisted of 5 plants of each species potted on February 1, 2005 and receiving no treatment or cold storage time.

Acacia gum was previously mixed on January 31, 2005 using Fisher Scientific stirrers (Fisher Scientific International Inc., Hampton, NH). The acacia gum was mixed on a weight/volume basis. The 5%, 10%, and 20% solutions were mixed using 100g (3.5 oz), 200g (7.1 oz.), and 400g (14.1 oz) of acacia gum and 1900 mL (0.5 gal), 1800 mL (0.48 gal), and 1600 mL (0.42 gal) of deionized water, respectively. Solutions were continuously mixed for 24 hours.

After treatment, cuttings were placed in plastic boxes according to their storage time, covered in clear plastic, and stored in a walk-in cooler set at 3.3C (38F). At the end of each storage time plants were removed from the cooler and divided to two groups (five plants of each treatment). The first group of cuttings was washed; roots removed, weighed on a Mettler AE 100 balance (Thomas Scientific, USA) and placed in labeled paper bags. Roots were subsequently dried in a drying oven set at 70C (158F) and weighed again. The second group of cuttings were washed and potted into containers for growth analysis using a media mix of 0.45 cubic meters (16 cu ft) of pine bark and .057 cubic meters (2 cu ft) of sand. Also included in the mix was 4.22 kg (9 lbs 5 oz) of Polyon 17-6-12 fertilizer (Pursell, Sylacauga, AL), 1.5 kg (3 lbs 4 oz) of dolomitic limestone, and 0.45 kg (1 lb) of Micro-max (Scotts, Marysville, OH).

Data collected was dry weight of roots of forsythia and magnolia. Also, the original shoot lengths of potted magnolia and forsythia were taken and shoot length and lateral shoot number of plants 4 months after potting.

Data were analyzed using PROC GLM in PC-SAS as a split plot design with preservative treatment as the main plot and cooler time as the sub plot. Trends of acacia gum rate were analyzed using linear and quadratic orthogonal polynomials, P = 0.05. Sphagnum peat and hydrophilic polymer were compared to acacia gum treatments using Dunnett's Comparison to a control, P = 0.05 (9).

Results and Discussion

Table 1 shows the interaction between date and acacia gum concentration was significant with percent water of forsythia**.** There was no trend in percent water after 3 and 12 weeks of storage**.** There was a quadratic trend in percent water after 6 weeks of storage with highest values at 5% and 10% acacia gum concentration**.** There was a linear and quadratic trend after 9 weeks with highest value at 5% acacia gum. After six weeks in cooler, percent water at 5% and 10% acacia gum was significantly higher than peat. After 12 weeks, percent water at 10% acacia gum was significantly higher than peat (Table 1).

In Table 2, the interaction between date and acacia gum was not significant on shoot length and lateral shoot number. As cooler time increased, shoot length and lateral shoot number of forsythia decreased regardless of acacia gum concentration.

Table 3 shows lateral shoot number of forsythia at 5% and 10% acacia gum concentration was higher than the hydrophilic polymer. There was no significant trend with increasing acacia gum concentration. The interaction between date and acacia gum concentration was not significant, which suggests that 5% and 10% acacia gum was better than hydrophilic polymer regardless of time in cooler.

No treatment had any effect on percent water loss of magnolia. The interaction between date and acacia gum was not significant on shoot length and lateral shoot number with regard to root treatment. Shoot length of magnolia was significantly higher at 20% acacia gum concentration than peat. There was no significant trend with increasing acacia gum concentration (Table 4).

There was no significant interaction between date and acacia gum concentration on lateral shoot number of magnolia. There was a linear decrease in lateral shoot number of magnolia with increasing time in cooler (Table 5).

Acacia gum treatments were more effective than peat and hydrophilic polymer in some cases. The effectiveness of acacia gum treatments varied between species and acacia gum concentration. Further research is necessary before any recommendation can be made to the nursery industry.

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Table 1. Effect of cooler time and root treatment on percent water[1] of forsythia (*Forsythia* × *intermedia* 'Karl Sax')[2] after storage in a cooler at 38F (3.3C)

	Root Treatment						
Weeks	**Peat**	**Hydro-philic polymer**	**0%**	**5%**	**10%**	**20%**	**Significance**
3	78.7	83.7	74.3[h]	79.2	80.2	80.9	NS
6	64.9	77.2[p]	71.5	81.1[p]	77.7[p]	67.6	Q*
9	96.9	95.7	80.4[ph]	96.5	95.3	95.9	L***Q***
12	73.8	78.2	76.5	77.0	88.5[p]	82.4	NS

[1] (fresh weight - dry weight)/fresh weight x 100
[2] Interaction between date and acacia gum significant.
[h] Significantly different from hydrophyllic polymer (HP).
[p] Significantly different from peat.

Table 2. Effect of cooler time on lateral shoot number and shoot length of forsythia (*Forsythia* × *intermedia* 'Karl Sax')[1] after storage in a cooler at 38F (3.3C)					
Week	**3**	**6**	**9**	**12**	**Significance**
Shoot number	5.1	3.9	3.6	2.8	L***
Shoot length (cm)	40.2	38.3	27.6	17.3	L***

[1] Interaction between date and acacia gum concentration not significant.

Table 3. Effect of root treatment on lateral shoot number of forsythia (*Forsythia* × *intermedia* 'Karl Sax')[1] after storage in a cooler at 38F (3.3C)							
			Acacia gum Concentration				
Root Treatment	**Peat**	**Hydrophilic polymer**	**0% (water control)**	**5%**	**10%**	**20%**	**Sig.**
Shoot number	3.8	2.9	3.8	4.8 [h]	4.2 [h]	3.8	NS

[1] Interaction between date and acacia gum concentration not significant.
[h] Significantly different from HP (nursery standard).

Table 4. Effect of root treatment on shoot length of magnolia (*Magnolia stellata* 'Merrill') [1] after storage in a cooler at 38F (3.3C)							
			Acacia gum Concentration				
Root Treat-ment	**Peat**	**Hydro-philic polymer**	**0% (water control)**	**5%**	**10%**	**20%**	**Sig.**
Shoot length (cm)	32.5	36.4	37.7	38.9	37.1	41.3[p]	NS

[1] Interaction between date and acacia gum concentration not significant.
[p] Significantly different from peat (nursery standard).

Table 5. Effect of cooler time on lateral shoot number of magnolia (*Magnolia stellata* 'Merrill')[1] after storage in a cooler at 38F (3.3C)					
Week	**3**	**6**	**9**	**12**	**Significance**
Shoot number	1.7	1.3	0.8	0.5	L***

[1] Interaction between date and acacia gum concentration not significant.

CHAPTER 3

EFFECTS OF ACACIA GUM IN CUTTING PROPAGATION

Abstract

The effects of acacia gum were evaluated on cuttings of ‘Merlot’ Virginia sweetspire (*Itea virginica* ‘Merlot’), ‘Sky Pencil’ holly (*Ilex crenata* ‘Sky Pencil’), and ‘Daisy’ gardenia (*Gardenia jasminoides* ‘Daisy’). The purpose of this study was to assess the effectiveness of acacia gum in reducing water loss during storage and rooting of cuttings. Cuttings were treated with 0%, 5%, 10%, or 20% concentrations of acacia gum and stored for either 0, 4, 8, or 12 days in a walk in cooler at 38F (3.3C). Data was taken after 8 weeks under either intermittent mist or a humidity tent. Overall, acacia gum had a detrimental effect on cuttings, with the exception of Virginia Sweetspire. Rooting percentage of Virginia Sweetspire was higher at 5%, 10%, and 20% acacia gum concentration than at 0%, with 10% resulting in the highest rooting percentage. Both holly and gardenia showed a decrease in shoot dry weight, root dry weight, and percent rooting as acacia gum concentration increased. Sky Pencil holly also showed a decrease in root rating with increasing acacia gum percentage. A four day cooler time improved rooting compared to controls. Longer durations resulted in a decline in rooting. Also, intermittent mist was more effective in rooting than the humidity tent.

Index words: humidity tent, intermittent mist,

Species used in this study: 'Merlot' Virginia sweetspire (*Itea virginica* 'Merlot'); 'Sky Pencil' holly (*Ilex crenata* 'Sky Pencil'); 'Daisy' gardenia (*Gardenia jasminoides* 'Daisy')

Significance to the Nursery Industry:

Most growers today use intermittent mist system for vegetative propagation by stem cuttings. Use of intermittent mist causes many problems for the propagator from constant regulation to maintenance and extra labor. The purpose of this study was to evaluate the potential use of acacia gum in reducing water loss during storage and rooting of cuttings, and therefore reduce the need for intermittent mist. .More cuttings of Virginia sweetspire treated with acacia gum rooted than those that were not treated with acacia gum. However, acacia gum had the opposite effect on holly and gardenia and overall, had a negative impact on the cuttings. Acacia gum is not recommended for use in propagation of cuttings without further testing. However, storage of cuttings for up to 4 days prior to sticking had a positive effect on rooting.

Introduction:

A common method of rapidly increasing product numbers in the nursery industry is vegetative propagation by stem cuttings. In today's containerized nurseries, many of these cuttings are propagated using intermittent mist. The frequency and amount of mist necessary to maintain a film of water covering the foliage without over or under watering is influenced by the environment. Cloudy days with low light intensity and high relative humidity require less frequent misting, while sunny days with high light intensity and low relative humidity require more frequent misting. Changing environmental conditions from sunup to sundown on a given day can mean frequent mist adjustments. If the propagator does not react to these changing conditions and make the necessary adjustments to mist frequency and amount, under application of mist can result in moisture stress and delayed rooting or senescence. Over applications of mist causes excessive dripping from the foliage keeping the rooting medium saturated, and resulting in rotting of cuttings. Constant presence of water on the leaves causes rapid depletion of essential nutrient reserves from the cuttings. Intermittent misting lowers medium temperature, which can produce suboptimal temperatures that may reduce rooting (1). Another problem with cutting propagation is that when large numbers of cuttings are harvested from stock plants time is crucial. Cuttings require storage in a cooler for a period of time until labor is available to prepare cuttings and place them in the propagation environment. In addition, the process of using an intermittent mist system requires a number of steps that increase labor costs. These steps include taking cuttings, trimming cuttings to the appropriate length, wounding, filling flats, dipping cuttings in hormone and sticking, cleaning and maintaining mist system, removing rooted cuttings from mist and potting into appropriate containers, transporting containers, and cleaning benches and pots following removal (5).

A new possibility for reducing water loss of propagated cuttings is a naturally occurring preservative known as acacia gum. Acacia gum is also known as gum Arabic. It is defined as “the gummy exudate flowing naturally or obtained by incision of the trunk and branches of *Acacia senegal* Willd. and other species." Acacia gum is unique in that it is soluble at high concentrations in water (3). Auburn University is conducting research to evaluate the potential use of acacia gum to preserve microorganisms. Acacia gum is used to isolate and preserve a microorganism in a suspended state without harm. The specimen can later be brought back to its earlier condition (4). No reported trials have been cited of the use of acacia gum in green industry.

Acacia gum could possibly reduce the need for intermittent mist systems in cutting propagation. Application of Acacia gum to the leaves and stems of cuttings could decrease water loss, therefore reducing the need for frequent mist application. This could ultimately help minimize the problems of over or under watering often associated with cutting propagation. Acacia gum could also lessen the burden of constantly adjusting the frequency and amount of mist during changing weather conditions. Acacia gum may provide an effective way to prevent desiccation of cuttings after harvest during storage and rooting without damaging the cuttings. The objective of this study was to evaluate the effectiveness of acacia gum in preventing water loss during storage and rooting of cuttings.

Materials and Methods

Plant Material. Cuttings were taken (October 4, 2005) of *Itea virginica* 'Merlot', (October 5, 2005) *Ilex crenata* 'Sky Pencil', and *Gardenia jasminoides* 'Daisy', from Greenehill Nursery in Waverly, AL.

Cuttings were placed in coolers of ice cold water following collection where they remained overnight and also during transportation to Paterson Greenhouses at Auburn

University, Auburn AL. After overnight storage, cuttings were treated with Acacia gum (Instantgum AS, CNI, Normandy, France) and stuck at 0, 4, 8, and 12 day intervals and placed under either intermittent mist or a humidity tent for a total of 8 weeks. The cuttings treated on day 0 were trimmed from the base to a 10.2 cm (4 in) length. All leaves were removed from the lower third of each cutting. The basal 1 cm (0.4 in) of each cutting was wounded and dipped in Hormodin 2 (E.C. Geiger Inc., Harleysville, PA). The rest of the cutting was then treated by dipping in 0% (water control), 5%, 10%, or 20% Acacia gum solution. The Acacia gum was mixed on a weight/volume basis. The 5%, 10%, and 20% solution was mixed using 100g (3.5 oz), 200g (7.1 oz.), and 400g (14.1 oz) of acacia gum and 1900 mL (0.5 gal), 1800 mL (0.48 gal), and 1600 mL (0.42 gal) of deionized water, respectively. Solutions mixed for 24 hours. After treatment, cuttings were inserted into 606 market flats containing a medium of peat:perlite (1:1 by vol) with 187 g (6.6 oz) of dolomitic lime incorporated. Flats were placed in trays lined with punctured plastic layered with 0.64 cm (.25 in) of wet sand. Cuttings were then placed under either intermittent mist covered by a 50% shade cloth or a humidity tent enclosed in plastic on all sides and then covered with an identical shade cloth. Temperatures under the tent ranged from 26.7C (80F) to 35C (95F). Intermittent mist operated for 5 sec at 5 min intervals from sunrise to dusk. Both the tent and the mist structures were inside a greenhouse which was also covered by a 50% shade cloth. Greenhouse temperatures ranged from 21C (70F) to 26.7 (80F). Cuttings were inserted at 0, 4, 8, and 12 day intervals were treated with one of the 4 (including control) acacia gum concentrations, placed in separate labeled Ziploc bags, weighed using a Mettler AE 100 balance (Thomas Scientific, USA) and stored inside a walk-in cooler at 5.6C (42F) until the appropriate removal date. After cuttings had been stored for the allotted time, they were removed from the cooler, cut to the proper length, bottom leaves removed, base wounded, treated with Hormodin 2, and inserted into medium. Light measurements were taken in the greenhouse and under both structures at different times within the 8 week period. In the greenhouse the light measurements had an average of 5541 lux. Under humidity tent and mist, averages were 1498 lux and 2223 lux, respectively. Each group of cuttings was checked at four weeks from the actual date of insertion to note rooting. Shade cloth was removed (November 18, 2005) from both the mist and the humidity tent. Also, the intermittent mist was reset to 5 sec every 10 min. One application of Banrot 40WP (Etri diazole and Thiophanate-Methyl, The Scotts Company, Marysville,OH), drench at the labeled rate of 113-340 g per 379 liters (4-12 oz per 100 gal) was applied to control disease (November 22, 2005).

After 8 weeks, cuttings were harvested and various data recorded. Data taken included a visual root rating for each species ranging from 0 to 6. Virginia Sweetspire root ratings were: 0= dead, 1 =alive but no roots, 2 = 1-40 roots, 3 = 40-60 short roots, 4 = 50-70 long roots, 5 = 70-100 roots, through 6 = 100-200 roots. Sky pencil holly root ratings were as follows: 0 = dead, 1 = no roots, 2 = 1-10 roots, 3 = 10-20 roots, 4 = 20-30 roots, 5 = 30-50 roots, and 6 =50-100 roots. For gardenia, the root ratings were: 0=dead, 1= no roots, 2=1-5 roots, 3=5-10 roots, 4=10-20 roots, 5=20-30 roots, 6=30-50 roots.

Figure 1. Root Ratings for Virginia Sweetspire (*Itea virginica* 'Merlot')

2 3 4 5 6

0=dead, 1=no roots

Figure 2. Root Ratings for 'Sky Pencil' Holly (*Ilex crenata* 'Sky Pencil')

2 3 4 5 6

0=dead, 1=no roots

Figure 3. Root Ratings for 'Daisy' Gardenia (*Gardenia jasminoides* 'Daisy')

2 3 4 5 6

0=dead, 1=no roots

Other data taken included root dry weight and shoot dry weight. Also, root to shoot ratio was calculated.

Data were analyzed using PROC GLM in PC-SAS as a split-split plot design with days in cooler as the main plot, tent as sub plot, and acacia gum treatment as sub-sub-plot. Trends over days in cooler and acacia gum rate were analyzed using linear and quadratic orthogonal polynomials, P = 0.05 (2).

Results and discussion

Virginia Sweetspire

There was no treatment effect on root to shoot ratio of Virginia Sweetspire cuttings.

There was a significant propagation method x days in cooler interaction for root root dry weight (RDW), shoot dry weight (SDW), and root rating (RR) for Virginia Sweetspire cuttings under either mist or humidity tent (Table 1). Under both tent and mist there was a 22% and 38% linear decrease in SDW of Virginia Sweetspire cuttings, respectively. There was no change in RDW under tent, but under mist there was a 33% decrease in RDW. RR of the cuttings showed a 16% and 31% linear decrease under tent and mist, respectively. SDW, RDW, and RR were higher under mist than tent with 0 days in the cooler. There was no difference in RR between tent and mist with 4 days of cooler time. However SDW and RDW were higher under mist than tent with 4 days in the cooler. With 8 days of cooler time there was no difference between tent and mist with RDW or RR. SDW under mist was higher with 8 days of cooler time than under tent. There was no difference in RDW and RR between tent and mist with 12 storage days, however, SDW under mist was higher than under tent with 12 days (Table 1). Overall, increasing cooler times had no effect on RDW of cuttings under humidity tent, but had a negative effect on SDW and RR under humidity tent. Also, increasing cooler times caused a decrease in SDW, RDW, and RR of Virginia Sweetspire cuttings under mist. RDW and RR were higher under mist than tent with shorter storage time. SDW was higher under mist than tent with all storage times.

Table 2 shows that only main effects were significant for rooting percentage of Virginia Sweetspire. There was a quadratic response with a 39 % increase in rooting percentage with increasing acacia gum rate, the highest percentage being at 10% acacia gum concentration. There was a 10% linear decrease in rooting percent with increasing days in cooler. Percent rooting was higher under mist than humidity tent for all the Virginia Sweetspire cuttings.

Overall results were more positive for Virginia Sweetspire cuttings under mist than humidity tent. Shoot dry weight, root dry weight, root rating, and rooting percentage decreased with increased storage time. This indicates that Virginia Sweetspire cuttings may perform better without cold storage prior to soil insertion. More testing should be done to determine effects of storage of cuttings prior to insertion. Acacia gum had a positive effect on rooting percentage of Virginia Sweetspire. 5%, 10%, and 20% were all higher than 0% Acacia gum, 10% having the highest rooting percentage. Acacia gum may have been successful in reducing water loss of cuttings of Virginia Sweetspire. Further testing is necessary to evaluate the effectiveness of Acacia gum of reducing water loss of Virginia Sweetspire cuttings. It would also be beneficial to test acacia gum on many different species at different concentrations.

Sky Pencil Holly

Root to shoot ratio of Sky Pencil holly was not affected by any treatment. Table 3 shows that there were propagation x acacia gum concentration interactions for SDW under mist or tent for Sky Pencil holly cuttings. Also, there was a main effect for days in cooler. Under both tent and mist there was a 30% linear decrease in SDW. SDW decreased linearly by 11% after storage in cooler with increasing acacia gum rate. With 0% and 5% acacia gum rates, there was no difference in SDW between tent and mist.

With 10% and 20% rates however, SDW was higher under mist than tent. In summary for Table 3, under both tent and mist, there was a decrease in SDW with increasing acacia gum rate. SDW decreased with days in cooler as acacia gum rate increased.

Table 4 shows that there were interactions among days in cooler x propagation method, acacia gum concentration x propagation method, and acacia gum concentration x days in cooler interactions for root dry weight and root rating under either mist or tent for Sky Pencil holly cuttings. RDW for the cuttings did not change under mist with increasing cooler time, and increased by 83% linearly under tent with increasing cooler time. There was no difference in RDW between humidity tent and mist at 0 and 8 days in cooler but at 4 and 12 days in cooler RDW was higher under mist. RDW under mist was not affected by increasing acacia gum rate. However, there was a quadratic response under the humidity tent with a 99% decrease in RDW from 0% to 20% acacia gum. There was no difference in RDW between tent and mist at 0%, 5%, and 10% acacia gum rate. RDW was higher under mist than under tent at 20% acacia gum rate. With increasing acacia gum rate, there was no change in RDW at 0, 4, and 12 days in cooler. There was however, a quadratic response at 8 days in cooler with a 50% increase in RDW with increasing acacia gum concentration. At 0% acacia gum rate, there was a quadratic response from 0 to 12 days in cooler with a 100% increase in RDW. With 5%, 10%, and 20% there was no change in RDW with increasing cooler time. Root rating increased linearly by 77% under tent with increasing cooler time, and did not change under mist. RR was higher under mist than tent at 0, 4, 8, and 12 days in cooler. Under the humidity tent, there was a quadratic response as acacia gum rate increased with an 87% decrease in RR. Also, under mist, there was a 15% linear decrease in RR as acacia gum rate increased. At all acacia gum rates, RR was higher under mist than tent. On days 0, 4, 8, and 12 of cooler time, there was a 40%, 25%, 52%, and 66% linear decrease in RR, respectively. RR showed a 57% linear increase at 0% acacia gum rate with increasing days in cooler. There was no change in RR at 5%, 10%, and 20% acacia gum rate with increasing days in cooler. RDW and RR (Table 4) under humidity tent increased as days in cooler increased. Both RDW and RR decreased quadratically under tent as % acacia gum increased. Also, as % acacia gum increased, RR decreased over all cooler times. RDW and RR at 0% acacia gum increased with increasing cooler times, whereas 5%, 10%, and 20% showed no change with storage in cooler. RR decreased with increasing % acacia gum at 0, 4, 8, and 12 days in cooler. Finally, RR was higher under mist than under humidity tent.

There were significant propagation method × acacia gum concentration interactions on percent rooting of Sky Pencil holly cuttings under either intermittent mist or humidity tent after storage in a cooler (Table 5). There was a 100% linear decrease in percent rooting under humidity tent with increasing acacia gum rate. There was no change under mist with increasing acacia gum rate. Under mist, percent rooting for 5%, 10%, and 20% acacia gum was higher under humidity tent

Sky pencil holly cuttings had more positive results under mist than under humidity tent. Overall, shoot dry weight, root dry weight, root rating, and percent rooting decreased as acacia gum concentration increased. The acacia gum seemed to have a negative effect on sky pencil holly. It appeared to be unsuccessful in reducing water loss and should probably not be used in cutting propagation of Sky Pencil holly. The results of this study did not support the possibility of acacia gum reducing the need for mist on this species. Testing on different species at different acacia gum rates may have more encouraging results. Root dry weight, and root rating seemed to increase with increased cooler time at 0% Acacia gum, so it appears that without Acacia gum, storage in a cooler prior to sticking might be beneficial to sky pencil holly.

Gardenia

No treatment had any effect on root dry weight or root to shoot ratio of gardenia cuttings. However, significant main effects for acacia gum concentration and days in cooler x propagation method interactions for SDW of gardenia cuttings under either mist or tent. (Table 7) Under humidity tent, SDW decreased linearly by 23% as cooler time increased. There was a quadratic response under mist with a 44% decrease in SDW with increasing cooler time. At 0 days in cooler SDW was higher under mist, and at 8 days in cooler SDW was higher under humidity tent. On days 4 and 12 there was no difference in SDW between tent and mist. The gardenia cuttings showed an 18% linear decrease in SDW with increasing acacia gum rate. SDW (Table 7) under tent and mist decreased with more time in the cooler. Also, SDW decreased as acacia gum rate increased.

The results in Table 8 show that there were significant days in cooler x propagation method, acacia gum concentration x propagation method, and acacia gum concentration x days in cooler interactions for root rating of gardenia cuttings under either mist or humidity tent. Under the tent there was a quadratic response with a 175% increase in RR with increasing cooler time, with the lowest RR being at 0 days, then highest at 4 days, then decreasing from there. Under mist there was a 29% linear decrease in RR with increasing cooler time. On day 0, RR was higher under mist. On day 8 RR was higher under the tent. On days 4 and 12 there was no difference in RR between tent and mist. There was a 57% linear decrease in RR for gardenia cuttings under tent with increasing acacia gum rate. Under mist there was a 34% linear decrease in RR of the cuttings with increasing acacia gum rate. At 0% and 5% acacia gum rate there was no difference in RR between tent and mist. However, at 10% and 20% RR was higher under mist than under tent. On days 0, 8, and 12 there was a 53%, 47%, and 68% linear decrease in RR with increased acacia gum rate, respectively. On day 4 there was no significant change in RR with increased acacia gum rate. At 0%, 5%, 10% and 20% acacia gum rate there was a quadratic response with a 41%, 63%, 78%, and 133% increase in RR with increased storage time, respectively. Starting on day 0, RR for all 4 concentrations of acacia gum was highest on day 4 and decreased on days 8 and 12. Overall, under both tent and mist RR for gardenia cuttings was highest after 4 days of storage and decreased from there. Under both tent and mist, RR decreased as acacia gum rate increased. With all four of the acacia gum concentrations, RR was highest after 4 days of storage.

Table 9 shows that there were significant days in cooler × propagation method and days in cooler × acacia gum concentration interactions on percent rooting of gardenia cuttings under either mist or humidity tent after storage in a cooler. There was a quadratic change with a 275% increase in percent rooting under humidity tent with increasing days in cooler. The lowest percent was on day 0, the highest on day 4, and then decreased from there. There was a 36% linear decrease in % rooting under mist with increasing days in cooler. After 0 and 8 days in the cooler, percent rooting under mist was significantly higher than the tent. However, there was no difference between tent and mist after 4 and

12 days of storage. There was no trend in % rooting of cuttings at 0% acacia gum with increasing days in cooler. For 5%, 10%, and 20% acacia gum rate, there was a quadratic change with a 77%, 125%, 160% increase with increasing cooler time, respectively. At all three acacia gum rates, the highest rooting percentage occurred after four days of storage and then decreased from there. There was a 50%, 64%, and 70% linear decrease in percent rooting with increasing acacia gum rate after 0, 8, and 12 days in the cooler, respectively. There was no change in percent rooting on day 4 with increasing acacia gum rate.

The results for gardenia were variable between mist and humidity tent. This is possibly due to gardenia's waxy cuticle which would slow water loss from the leaves under shade. Shoot dry weight, root rating, and rooting percentage decreased with increased acacia gum %, therefore acacia gum had a negative effect on gardenia rooting. It appeared that many of the plants treated with acacia gum rotted and died. Shoot fresh weight and dry weight decreased as cooler time increased. Root rating increased after 4 days of storage with all four acacia gum concentrations and decreased from there. It is possible that storing gardenia cuttings for four days before sticking could be beneficial.

Acacia gum generally had a negative impact on cutting propagation. It did not appear to decrease the loss of water from cutting. Acacia gum is not recommended for use in propagation of cuttings. However, storage of cuttings prior to sticking had a positive effect on rooting. Up to four days in cooler improved rooting compared to controls. Longer durations resulted in a decline in rooting. Also, intermittent mist was more effective than the humidity tent.

The results indicate that acacia gum may aid rooting of Virginia Sweetspire cuttings at the appropriate concentration. Acacia gum was ineffective overall in preventing water loss of Sky Pencil holly and gardenia. It had either no effect or a negative effect on rooting of the cuttings and is not recommended for use on these species. Acacia gum is not recommended for use in propagation of cuttings without further testing. However, storage of cuttings for up to 4 days prior to sticking had a positive effect on rooting.

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Table 1. Effect of number of days in cooler on root dry weight, shoot dry weight, and root rating of Virginia Sweetspire (*Itea virginica* 'Merlot') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z].

# Days in Cooler	Shoot dry weight (g)		Root dry weight (g)		Root rating[y]	
	Tent	Mist	Tent	Mist	Tent	Mist
0	0.23	0.42***[x]	0.01	0.03***	3.2	4.2***
4	0.21	0.31***	0.02	0.02**	3.4	3.7
8	0.17	0.24**	0.01	0.01	2.6	2.6
12	0.18	0.26***	0.01	0.02	2.7	2.9
Significance[w]	L**	L***	NS	L**	L***	L**

[z] There were significant propagation method × days in cooler interactions, $P = 0.05$.
[y] Root Ratings:0= dead, 1 =alive but no roots, 2 = 1-40 roots, 3 = 40-60 short roots, 4 = 50-70 long roots, 5 = 70-100 roots, through 6 = 100-200 roots
[x] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P =$ 0.01(**) or 0.001(***).
[w] Non-significant (ns) or significant linear (L) trends at $P = 0.01$ (**), or 0.001 (***).

Table 2. Effect of Acacia gum concentration, number of days in cooler, and propagation method on percent rooting of Virginia Sweetspire (*Itea virginica* 'Merlot') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z].

Acacia gum concentration	% rooting	Days in cooler	% rooting	Propagation method	% rooting
0% (water control)	49.9	0	43.8	Tent	48.6b[y]
5%	65.9	4	48.0	Shade	54.9a
10%	69.4	8	39.6		
20%	60.8	12	39.6		
Significance[x]	Q**		L***		

[z] Main effects only were significant, $P = 0.05$.
[y] Based on significance of main effect, $P = 0.05$.
[x] Significant linear (L) or quadratic (Q) trends at $P = 0.01$ (**), or 0.001 (***).

Table 3. Effect of Acacia gum concentration on shoot dry weight of Sky Pencil holly (*Ilex crenata* 'Sky Pencil') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z.] .				
Shoot dry weight (g)				
Acacia gum concentration	Tent	Mist	Days in cooler	
0% (water control)	0.67	0.67	0	0.70
5%	0.63	0.63	4	0.58
10%	0.58	0.58*** [y]	8	0.64
20%	0.47	0.47***	12	0.62
Significance[x]	L***	L*	Significance	L**

[z] There were significant propagation method × acacia gum concentration interactions. Main effects for days in cooler were significant, $P = 0.05$.
[y] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P = 0.001$(***). Non-significant (ns).
[x] Significant linear (L) trends at $P = 0.05$(*), 0.01 (**), or 0.001 (***).

Table 4. Effect of Acacia gum concentration and number of days in cooler on root dry weight of Sky Pencil holly (*Ilex crenata* 'Sky Pencil') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z].

Root dry weight (g)										
						# Days in cooler				
# Days in cool-er	Tent	Mist	Acacia gum concen-tration	Tent	Mist	0	4	8	12	Sig.[y]
0	0.06	0.06	0% water control	0.08	0.08	0.06	0.06	0.06	0.12	Q*
4	0.04	0.07**[x]	5%	0.06	0.07	0.06	0.06	0.09	0.07	NS
8	0.06	0.07	10%	0.03	0.06	0.06	0.06	0.05	0.07	NS
12	0.11	0.08**	20%	0.001	0.07***	0.07	0.07	0.06	0.05	NS
Sig.	L*	NS		Q***	NS	NS	NS	Q*	NS	

[z] There were significant days in cooler × propagation method, acacia gum concentration × propagation method, and acacia gum concentration × days in cooler interactions, $P = 0.05$.
[y] Non-significant (ns) or significant linear (L) or quadratic (Q) trends at $P = 0.05$(*), 0.01 (**), or 0.001 (***).
[x] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P = 0.01$(**) or 0.001(***).
[w] Root ratings: 0 = dead, 1 = no roots, 2 = 1-10 roots, 3 = 10-20 roots, 4 = 20-30 roots, 5 = 30-50 roots, and 6 =50-100 roots

Table 5. Effect of Acacia gum concentration and number of days in cooler on root rating of Sky Pencil holly (*Ilex crenata* 'Sky Pencil') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z].

Root rating[w]										
						# Days in cooler				
# Days in cooler	Tent	Mist	Acacia gum concen-tration	Tent	Mist	0	4	8	12	Sig.
0	1.3	4.3***	0%(water control)	3.7	4.6**	3.5	4.4	3.3	5.5	L***
4	2.2	5.3***	5%	2.0	4.4***	2.9	3.8	2.8	3.3	NS
8	2.0	3.2***	10%	1.2	4.3***	2.7	3.4	2.5	2.3	NS
12	2.3	4.4***	20%	0.5	3.9***	2.1	3.3	1.6	1.9	NS
Sig.	L**	NS		Q**	L*	L**	L**	L***	L***	

[z] There were significant days in cooler × propagation method, acacia gum concentration× propagation method, and acacia gum concentration × days in cooler interactions, $P = 0.05$.

[y] Non-significant (ns) or significant linear (L) or quadratic (Q) trends at $P = 0.05$(*), 0.01 (**), or 0.001 (***).

[x] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P =$ 0.01(**) or 0.001(***).

[w] Root ratings: : 0 = dead, 1 = no roots, 2 = 1-10 roots, 3 = 10-20 roots, 4 = 20-30 roots, 5 = 30-50 roots, and 6 =50-100.

Table 6. Effect of Acacia gum concentration on percent rooting of Sky Pencil holly (*Ilex crenata* 'Sky Pencil') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z].

Acacia gum concentration	Tent	Mist
0% (water control)	68.2	83.3
5%	36.1	84.7***[y]
10%	9.7	83.3***
20%	0.0	74.1***
Significance[x]	L***	NS

[z] There were significant propagation method × acacia gum concentration interactions, $P = 0.05$.
[y] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P = 0.001$(***).
[x] Non-significant (ns) or significant linear (L) trend at $P = 0.001$ (***).

Table 7. Effect of Acacia gum and number of days in cooler on shoot dry weight of Gardenia (*Gardenia jasminoides* 'Daisy') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z].				
Shoot dry weight (g)				
# Days in cooler	Tent	Mist	Acacia gum concentration	Tent and Mist
0	0.66	0.73*** [y].	0% (water control)	0.60
4	0.51	0.53	5%	0.57
8	0.50**	0.41	10%	0.53
12	0.51	0.48	20%	0.49
Significance[x]	L**	Q***	Significance	L***

[z] There were significant main effects for acacia gum concentration and days in cooler × propagation method interactions, $P = 0.05$.

[y] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P =$ 0.01(**) or 0.001(***).

[x] Non-significant (ns) or significant linear (L) or quadratic (Q) trends at $P =$ 0.01 (**) or 0.001 (***).

Table 8. Effect of Acacia gum concentration and number of days in cooler on root rating [z] of Gardenia (*Gardenia jasminoides* 'Daisy') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[y].

						# Days in cooler				
# Days in cooler	Tent	Mist	Acacia gum concentration	Tent	Mist	0	4	8	12	Sig.[x]
0	1.6	3.4***[w]	0% (water control)	3.5	3.5	3.2	4.5	3.0	3.4	Q**
4	4.4	4.2	5%	3.4	3.0	2.7	4.4	3.0	2.8	Q**
8	2.7**	1.7	10%	2.2	3.1**	2.7	4.8	1.2	1.4	Q***
12	2.0	2.4	20%	1.5	2.3*	1.5	3.5	1.6	1.1	Q**
Sig.	Q***	L***	Sig.	L***	L***	L***	NS	L***	L***	

[z] Root ratings: 0=dead, 1= no roots, 2=1-5 roots, 3=5-10 roots, 4=10-20 roots, 5=20-30 roots, 6=30-50 roots.
[y] There were significant days in cooler × propagation method, acacia gum concentration × propagation method, and acacia gum concentration × days in cooler interactions, $P = 0.05$.
[x] Non-significant (ns) or significant linear (L) or quadratic (Q) trends at $P = 0.01$ (**) or 0.001 (***).
[w] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P = 0.05$(*), 0.01(**) or 0.001(***).

Table 9. Effect of Acacia gum concentration, number of days in cooler, and propagation method on percent rooting of Gardenia (*Gardenia jasminoides* 'Daisy') cuttings under either intermittent mist or humidity tent propagation after storage in a cooler at 38F (3.3C)[z]

			Acacia gum concentration				
# Days in cooler	Tent	Mist	0% (water control)	5%	10%	20%	Sig.[y]
0	22.2	65.3***[x]	55.7	47.2	44.5	27.8	L*
4	83.3	84.7	80.6	83.4	100.0	72.2	NS
8	51.4	27.8**	61.1	55.6	19.5	22.2	L***
12	37.5	41.7	63.9	50.0	25.0	19.5	L***
Significance	Q***	L***	NS	Q*	Q**	Q**	

[z] There were significant days in cooler × propagation method and days in cooler × acacia gum concentration interactions, $P = 0.05$.

[y] Non-significant (ns) or significant linear (L) or quadratic (Q) trends at $P = 0.05$ (*), 0.01 (**), or 0.001 (***).

[x] Comparison of tent and mist in rows using single degree of freedom orthogonal contrasts, $P = 0.01$(**) or 0.001(***).

CHAPTER 4

FINAL DISCUSSION

The purpose of this research was to evaluate the effectiveness of acacia gum in reducing water loss during storage of bare root nursery crops, and to test the effects of the acacia gum on post transplant growth of bare root *Forsythia x intermedia* 'Karl Sax' and *Magnolia stellata* 'Merrill' . The objective of the second study was to evaluate the effectiveness of acacia gum in reducing water loss during storage and rooting of *Itea virginica* 'Merlot', *Ilex crenata* 'Sky Pencil', and *Gardenia jasminoides* 'Daisy' cuttings.

In the bare-root study, acacia gum dips of forsythia at 5% and 10% offered equal or better growth of plants in the nursery than the traditional treatments of peat and hydrophilic polymer and the control water treatment. Given the labor required for handling peat moss and the expense of hydrophilic polymer, acacia gum at the appropriate root-dip concentration was equal or better than other treatments on forsythia. Additional testing is necessary before any commercial recommendations can be made to the nursery industry.

In the propagation study, more cuttings of Virginia Sweetspire rooted at 10% Acacia gum concentration, followed by 5% and 20%, than cuttings not treated with acacia gum. These results suggest that acacia gum may aid rooting of Virginia Sweetspire cuttings at the appropriate concentration. Acacia gum was ineffective overall in reducing water loss of Sky Pencil holly and gardenia. It had either no effect or a negative effect on rooting of the cuttings and is not recommended for use on these species.

In conclusion, the results of this study indicate that acacia gum is not a better alternative to the current products on the market used in reducing water loss of bare root plants. It is also not recommended to reduce water loss of cuttings.