Propagation of blueberries in compost amended media

By

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The objective of this study was to determine the effects of propagation media containing composted material on the rooting of hardwood and softwood blueberry cuttings. The physical properties were measured at the end of the experiment. The media used were pine bark fines, composted pine bark with ammoniated nitrogen added, hardwood bark and composted chicken manure, pine bark and cotton gin waste, and control (peat moss and perlite, 1:1). All treatments resulted in a low number of rooted hardwood cuttings compared to the control. The total number of roots per cutting and alive cuttings hardwood cuttings was increased by pine bark and ammoniated nitrogen compared to the remaining treatments. The control treatment resulted in the highest number of roots per softwood cutting. None of the treatments increased the number of roots of softwood cuttings and the number of alive cuttings was increased by all treatments compared to the control.

DEDICATION

Dedicate this to my loving husband Tony, who has inspired and encouraged me to seek my dreams. Also to my grandparents who instilled in me at a young age the love of plants and gardening.

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Heart-felt gratitude goes to so many people that I would like to thank for their support for the last three years. First to my major professor, Dr. Frank Matta, without whose patience, prompting, and support my research would not have happened. My other committee members, Dr. Eric Stafne and Dr. Juan Silva, for their help and advice. A special thanks go to Dr. Hamid Borazjani and Dr. Crofton Sloan, for the undying faith and support that they have shown over the past years. Gene Penick and Gina Bridgeman, Penick Organics Macon, MS for being visionaries and willing to try new ideas that support agriculture and ag-related products produced in Mississippi. And to all my class mates and co-workers nudging me to finish this long project.

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CHAPTER I

INTRODUCTION

Blueberries (*Vaccinium* spp.) are popular with consumers for their nutrition and antioxidant properties. Blueberries are native to the United States and have economic and health benefits due to the high antioxidant content. The antioxidant content has made blueberries valuable for cancer fighting components (North American Blueberry Council, (NABC, 2000).

These market demands increase opportunities for growers to produce more blueberries and, therefore, increase the need for more blueberry plants (Ballinger et al., 1982). Stafne, (personal communication, 2012,) estimated that Mississippi has approximately 2500 acres of blueberries. Mississippi is ranked 9th in the United States for blueberry production and has a net production value of $10 million for fresh and processed fruit. Mississippi's blueberry production adds considerably to the market value in the southeast United States. (Agriculture Fact Sheet MS. Blueberry, 2014).

Cornell University developed the first peat moss based soil mix formulas for containers for commercial use in the 1960s. The researchers developed formulas that combined peat moss, perlite, and vermiculite in various amounts to make a uniform, light weight, and consistent soil mix. The formulas were developed because soil-based media was not uniform and the physical properties were variable causing subsequent crops have variable quality (Boodley and Sheldrake, 1982).

Cost and availability of material for media in horticultural crops is variable. This variability has led to the introduction of other ingredients for potting media. The use of composted agricultural waste products, industrial waste products, and other waste products such as sewage sludge (Guerrero et al., 2002), bark from loblolly pine and Douglas fir, composted rice hulls (Laiche and Nash, 1990), cotton gin waste (Cole, 2003; Owings, 1993), and poultry litter (Tyler et al., 1993). The ideal media pH for blueberry production is 4.2-5 (Krewer and NeSmith, 2006). Some composts will have pH that is not suitable for blueberry production. Potting medias with very low or high pH need to be adjusted to the proper range. This is generally done with elemental sulfur to increase acidity or with dolomitic or calcitic lime to increase alkalinity. The use of compost as a component in propagation media has not been thoroughly investigated and there is a limited amount of literature reported. There is a need to investigate cost effective and sustainable compost as a component of propagation media for blueberries.

A trend among some nursery growers and plant propagation nurseries in Mississippi to move towards using more sustainable soil components that are locally available. The objectives of this study were: 1) to evaluate the effect of composted pine bark with a ammoniated nitrogen (PB+N), pine bark fines (PB), hardwood bark with poultry litter (HW+CM), pine bark with cotton gin waste (PB+CGW), and peat moss plus perlite, (control (C) on rooting of hard wood and soft wood cuttings of blueberry cultivars 'Tubule', 'Climax',' Columbus', and 'Onslow'. 2) the physical and chemical properties of each media after the rooting investigation. The physical properties that were measured: the bulk density, pore space %, water holding capacity, and air space. The pH and electrical conductivity were also measured.

CHAPTER II

LITERATURE REVIEW

Blueberries, native to the North America, are a fruit crop that has economic importance and health benefits due to the high antioxidant content (Hanson and Hancock, 1990). Anitoxidants are cancer fighting components. Blueberries are also low in calories, low sodium, high in fiber and pectin, and have been found to lower cholesterol (US Highbush Blueberry Council, 2014). Ellagic acid and reserveratrol, found in grapes and blueberries, are known for reducing the risk of cancer and heart disease (Gough, 1997).

Blueberries belong to the Ericaceae family and the genus *Vaccinium*. There are four types of commercial blueberries. Lowbush blueberry (*Vaccinium angustifolium* Aiton) are considered the wild type. The habit is a small, woody, deciduous bush that are found in many northern states and into eastern Canada (Trehane, 2004). Northern highbush (*Vaccinium corymbosum* L.) is native in the northern regions ranging from the Carolinas to Nova Scotia (

Trehane, 2004). They are taller than the shrubby lowbush blueberry (Bowerman, 2012). Rabbiteye blueberries (*Vaccinium ashei* syn. *Vaccinium virgatum* Reade) are native to the southern states ranging from central Florida, eastern North Carolina, west to northern Arkansas, and eastern Texas (Lyrene,2004). It is more adaptable to the South, often requiring fewer chilling hours. The southern highbush blueberry is an interspecific cross between the rabbiteye and the northern highbush to have the characteristics of both types (Trehane, 2004). The southern highbush has a lower chilling hour requirement than northern highbush blueberries allowing producers to bring fruit to market faster than the rabbiteye type.

North America dominates the world's production of blueberries by providing provides 57% of the world's supply of blueberries. South America produces 23%, European produces 11%, Asian and Pacific produces 8%, and African produces 1%. The dominant type is the highbush blueberry (Villata, 2012). The production of blueberries worldwide has increased by more than 140,000 acres from 50,000 in 1995 to 190,000 in 2010 (Villata, 2010). North America leads in the production of fresh (57%) and processed (85 %) blueberry product. Northern acreage increased by 55% from 71,125 to 110,290 acres (1995-2010). The southern states have the fewest acres in production among blueberry producing regions, but are an expanding area. Mississippi and Louisiana have 3,850 acres in production (Suszkiw, 2012). Georgia leads the southeast region with 20,000 acres in production (NABC, 2014).

Stafne (2012) estimated that Mississippi blueberry growers produced $16,000,000 worth of fresh and processed blueberries in 2012. This is a valuable crop for Mississippi's agriculture economy. Mississippi has 2000-2500 acres in commercial blueberry production with 170 producers. The dominant blueberry type grown in Mississippi is the rabbiteye; however, southern highbush cultivars beginning to be planted in order to give growers the advantage of earlier ripening fruit for early fresh market sales. The bulk of blueberry production in Mississippi is south of U.S. highway I-20 and located in the southeast quarter of the state (Stafne, 2012).

The first published accounts of blueberry propagation were made in a bulletin for USDA Bureau of Plant Industry entitled, *Experiments in Blueberry Culture* by Dr. F.V. Coville. (Coville, 1910). Coville described the methods of blueberry propagation where he experimented with seeds germination and vegetative stem cuttings (Coville, 1910). Half of the current acreage of blueberries is comprised of hybrids he developed during 1908-1937. Much of the work Coville pioneered and documented is still in practice today (Mainland, 1998).

Blueberries are propagated by many methods, including softwood cuttings, hardwood cuttings, suckers, and tissue culture (Krewer and Cline, 2003). Vegetative propagation has success depending on many factors: ease of rooting the species or cultivar, type of cutting (hardwood, softwood, or semi-hardwood), age of the stock or cutting plant- juvenile or older plant, and location of cutting taken on parent plant (Dirr, 1983). Tissue culture, also known as in-vitro or micro propagation, is another method of propagation that tends to have as high as 95% propagule success rate (Isutsa et al., 1994). Blueberry plants propagated in this manner lead to plants that have bushier growth, which allows for more flower buds per plant (Miller et al., 2006). Tissue cultured plants tend to produce more fruit than plants produced by vegetative cuttings (El-Shiekh et al., 1996). There are a few drawbacks to tissue cultured plants; the main one is the cost of expensive laboratory set up and maintenance of aseptic facilities. Also, the tendency toward bushier plants makes harvesting with a mechanical harvester more difficult. The mechanical harvester grasps the base of the plant and shakes it to remove the berries. A plant with a low number of branches makes it difficult to reach the collection platform and thereby landing on the ground (Miller et al., 2006).

Softwood cuttings are made when the best quality cutting can be taken after the first flush of growth occurring in May - June. Hardwood cuttings are made from dormant plants that are in good health. In general, soft wood cuttings root more easily than hardwood (Krewer and Cline, 2003).

In Mississippi, softwood cuttings are made in late spring from the tips of current year's growth. The desired stage of cutting material is to have stems flexible and terminal leaves half to full grown. If the cuttings are taken too soon the wood has little moisture reserves and will wilt. When the cuttings are made too late, the percentage of rooting is also poor (Krewer and Cline, 2003). A second flush of growth occurs in late July–early August. Many growers take advantage of the late flush of growth for softwood cutting propagation (Hartmann et al., 2011).

Hardwood cuttings are made in the late fall and winter (generally after the first frost) into January and February after the plants have reached dormancy. Whips or branches are cut 30-90 centimeters long and subdivided into 12-13 cm sections. The flower buds are removed and the terminal tip is discarded.

The same technique for preparing the cuttings for propagation is used for hardwood and softwood cuttings. The cutting is inserted in the propagation soil 1/3-1/2 of the length of the cutting. The media needs to be pressed firmly around the base of the cutting. The spacing of the cuttings in a propagation bed or trade gallon pot or larger needs to be spaced 5 x5cm (2 inches) apart. This spacing has two benefits: aids in air flow to prevent disease and promotes root retention and quality after removal from propagation bed or pot (Harelson, 2009). After the cuttings are placed in media, then mist must be applied to keep them from drying.

Propagation of blueberries is achieved primarily in a raised bed system or in propagation trays with soilless media. The raised bed system consists of beds constructed 15-20 cm high with a wire screen attached to the bottom. This is placed on top of pea gravel or a courser grade material for drainage, and suspended on legs or concrete blocks. Generally, the beds are filled with sand or media and cuttings are place until rooted. A mist system and/or tenting is used to keep the cuttings moist during the rooting process. The propagator needs to monitor the sand-filled bed for soil compaction, disease, and pooling of excess moisture (Spiers et al., 1987).Container or propagation sheets can also be used and have the advantage of fewer pathogens because they can be sterilized. The only disadvantage of containers is finding the proper depth for blueberry cuttings. Blueberries root better in deeper containers, as this avoids placing ends in the saturated area at the bottom of the container.

Historically, the traditional propagation media was well composted saw dust. It was a by-product from the local sawmill or lumber yard and was cheap or free. Currently, the acquisition of sawdust, peat moss, and the pine bark fines is more difficult because of the competition with other industries. Industries that use the by-products in the process of making manufactured wood products, fuel products, and other agricultural enterprises are the major competitors for bark products However, there are many different components that can be used in the make-up of propagation media. Standard mixes are composed of course sand, milled pine bark, and peat moss. (1:1:1), perlite and milled pine bark fines (1:1), or pine bark fines.. (Cline and Mainland, 2008).

A survey of 18 producers in Georgia was conducted in 2005 regarding methods of blueberry propagation. Ninety-eight percent of the respondents used pine bark as the media for propagation. Generally, non-composted pine bark was preferred to composted bark due to the time required to complete composting and the greater volume of material required. Two percent of the survey respondents used an alternative media material such as sawdust or a mix of aged sawdust and peat (Harelson, 2009).

The components used in propagation media such as pine bark and peat moss have been plentiful in the past. They are by-products of the forest industry. Other industries such as the fuel products and building industry have taken former waste products and found uses for them. The manufacturing of wood products in Mississippi produces several million tons of wood and bark waste that is dumped or burned (Borazjani et al., 2004).

Media for blueberry propagation should be acidic, porous, and well drained (Cline and Mainland, 2008). Potting media should be free of disease pathogens, weeds, pests, nematodes, have excellent water holding capacity, and provide good drainage (Hartmann et al., 2011). The optimal peat content is 25-50 % (1/4-1/2) of the propagation mix (Currey 2013). If other components are used such as course sand, pine bark fines, or perlite then it should be in a 1:1:1 ratio (Krewer and Cline, 2003). Composted materials cbeen shown to be successfully substituted for peat or pine bark in growing mixes (Boyer et al.,2008, Tyler at al.,1993,Owings, 1993). The components such as composted bio-solids, municipal solid wastes, and yard trimmings have been shown to improve vegetable, fruit, and field crop yields (Chen et al., 2003).

Soilless potting media are substrates that are primarily used in the production of greenhouse crops produced in containers (Adams and Fonteno, 2011). Soil-less media is popular because of consistency, excellent aeration, reproducible, and has low bulk density. These blends can be composed of a single ingredient such as, peat or rock-wool, but generally are made by combining two or more ingredients. The ingredients range from peat moss, coir, vermiculite, perlite, sand, shredded and milled bark, parboiled rice hulls, and potentially some type of composted product (Hanan,1998).

Use of composts in propagation media has potential to become a benefit to the horticulture and nursery industry because it can be produced sustainably and homogenously. Modern technology has advanced the composting industry by introducing procedures and processes that produce a product that is uniform and reproducible (Clark, and Cavigelli,2005). The lack of quantity, variable quality, and unknown compost maturity were the drawbacks of using compost as part of propagation mixes. Modern compost facilities are beginning to produce composted material that is of consistent quality and quantity for regular use in horticultural production (Chen, 2003). Many facilities have the compost ingredients set up in windrows and have proper testing to ensure the bacteria and moisture content are optimal for quality break down of the organic constituents.

Soilless, peat-lite potting mixes have desirable physical characteristics including freedom from disease pathogens, weeds, insect pests, nematodes, good water holding capacity, and adequate water drainage. Soilless potting mixes also have known physical and chemical properties. Bagged potting mix, containing soil-less media, have benefits over soil-based media such as uniformity, excellent aeration, reproducible, and low bulk density (Robbins and Evans , 2008). Propagation media needs to have good drainage and air space (Currey et al., 2013).

CHAPTER III

MATERIALS AND METHODS

The substrate components for this study were obtained from various sources. Non-ammoniated pine bark fines were obtained from a King's Nursery, Pontotoc, MS. The ammoniated pine bark, composted hardwood- poultry litter media, and pine bark and composted cotton gin waste media were obtained from Penick Forest Products in Macon, Mississippi. The control which consisted of 50% peat and 50 % horticultural grade perlite v/v was obtained from BWI Companies Inc., Memphis, TN.

This stud y consists of five treatments that were replicated four times. The experiments were conducted in an environmentally controlled greenhouse at the North Mississippi Research and Extension Center, Verona, MS. The treatments were as follows:

- Control containing a half and half (50/50 v/v) mix of peat moss and horticultural grade perlite.
- Pine bark fines 75% with composted cotton gin waste 25%.
  Pine bark fines
- Pine bark fines with a one-time application of ammonium nitrate added to reduce the nitrogen draw down caused by bacteria
- Hardwood bark (90%) and chicken manure (10%).

The hardwood-poultry media was sieved to particle size (¼,½,2 cm screen) to eliminate the larger hardwood bark size so that it would be suitable for propagation media. The control was made by adding 210 L of peat moss, 210 L of perlite, and two gallons(7.5 L) of water to moisten the media to avoid dry areas in the mixture. The soil physical properties that were determined at the beginning of this study were bulk density, soil porosity, water holding capacity, and moisture content.

Hardwood Cutting

Cuttings of rabbiteye blueberry cultivars 'Tifblue' and 'Climax' were taken November, 2012. The cutting material was taken from the terminal portion of the bush. The parent plant material was dormant and had been exposed to several frost events to ensure dormancy. There was evidence of plant dormancy demonstrated by foliage loss and red-orange coloring as shown in Fig 1.

Figure 1 Fall coloration on dormant ‘Tifblue’ blueberry stock material.

The majority of the cuttings were made from terminal wood. Cuttings were prepared by trimming the branch to approximately 15 cm, leaves were removed from the lower portion of the cutting prior to insertion in the media. The basal end of the cutting was inserted in the media about 7-10 centimeters. Deep cell propagation sheets that had 18 cells with a volume of 2.32 liters (0.13 l. per cutting) were used. Intermittent mist was operated daily 10 seconds every ten minutes from 9:00 – 12:00 p.m. The misting system was turned off on overcast or rainy days to prevent fungal pathogen and rotting of the cuttings. Hardwood cuttings generally can be harvested after 6 months. Cuttings were harvested on May 13, 2013. However, the cuttings from ‘Climax’ did not survive. Therefore, ‘Tifblue’ was the only cultivar evaluated in the hardwood cutting study. The treatments were as follows: control containing a half and half mix of peat moss and horticultural grade perlite (50/50 v/v) (pine bark fines with composted cotton gin waste , pine bark fines, pine bark fines with a one-time application of ammonium nitrate added for a one time nitrogen source to reduce the nitrogen draw down caused by bacteria, and hardwood bark and chicken manure.

The data collected was the rooting response (rooted, un-rooted, or callus) of all cuttings with any sign of rooting emerging from the stem. Additional data collected include the cultivar response, number of roots per cutting, number of rooted cuttings with laterals, number of cuttings that were dead, number of cuttings that formed callus, root quality rating, soil physical properties, and soil chemical properties.

The experimental design was a randomized complete block in a factorial arrangement of treatments (cultivars and media) with four replications. The experimental unit consisted of four cuttings of each cultivar-media combination. The data collected during the trial were analyzed by SAS PROC MIXED (SAS Institute Inc., Cary, NC). Means separation was conducted with Fisher's Protected LSD at the 0.05 significance level.

Softwood Cutting

Cuttings of rabbiteye blueberry cultivars 'Tifblue', 'Climax', and 'Premier' were taken May 21, 2013. 'Tifblue' had excellent growth and was used as a source of stock. Due to the lack of available cutting wood on the cultivars, 'Climax' and 'Premier', new cultivars were chosen, 'Onslow' and 'Columbus'. The condition of the stock plant used for cuttings is illustrated in Figure 2. 'Columbus' was chosen because of its reputation for being difficult to root (Stafne, personal communication,need to be listed in reference list).

The cutting material was taken from the terminal portion of the bush. The parent plant material was growing well and had terminal growth that was excellent propagation material, Figure 2. The majority of the cuttings were made from terminal wood. Cuttings were trimmed to 15 cm and the lower leaves were removed prior to insertion in the media. The basal end of the cutting was inserted in the media about 7-10 centimeters. The same deep propagation sheets were used as described in the hardwood cutting section. Intermittent mist was operated daily 10 seconds every ten minutes from 9:00 – 5:00 p.m. Softwood cuttings root in 6-8 weeks (Krewer and Cline, 2003). The cuttings were harvested on October 14, 2013.The data collected included rooted, unrooted, or callus of all cuttings, number of roots per cutting, number of cutting with laterals, number of cuttings that were dead, number of cuttings that formed callus, root quality ratings, physical and soil chemical properties, electrical conductivity, and pH.

Figure 2 Stock plants for propagation of softwood cuttings, May 21,2013.

Physical Properties

The soil physical properties that were determined at the beginning of the study were bulk density, soil porosity, water holding capacity, and moisture content. The methodology used to determine the physical properties was based on procedures developed at North Carolina State University, Horticultural Substrates Laboratory, Raleigh, North Carolina. (Fonteno,1993).

A randomized complete block design was used with a factorial arrangement of treatments (cultivars and media) four cuttings per treatment with four blocks. The data was analyzed by SAS PROC MIXED (SAS Institute Inc., Cary, NC). Means separation was conducted with Fisher's Protected LSD at the 0.05 significance level.

The data collected was the rooting response (rooted, unrooted, or callus) of all cuttings with any sign of rooting emerging from the stem. Additional data collected include the cultivar response, number of roots per cutting, number of rooted cuttings with laterals, number of cuttings that were dead, number of cuttings that formed callus, root quality rating, soil physical properties, and soil chemical properties. The soil pH and electrical conductivity was conducted using the North Carolina State University Pour-through method (Wright, 1986).

CHAPTER IV

RESULTS AND DISCUSSION

Hardwood Cuttings

All treatments resulted in a low number of rooted cuttings compared to the control(table 1). The total number of roots per cutting was increased by PB+N compared to the remaining treatments. None of the treatments influenced the number of callused cuttings compared to the control. The number of alive cuttings was increased for PB +N but not for the remaining media. PB+CGW increased the number of dead cuttings, the remaining treatments did not differ from the control. The number of laterals was increased by PB and the Control compared to PB+N and PB+CGW. However, the number of laterals did not differ between the control, PB and Hardwood + Chicken manure. Root quality was reduced by Hardwood+ Chicken Manure and PB+ CGW compared to the Control, PB+N, but did not differ from PB. The hardwood results are listed in Table 1.

Table 1 Hardwood rooted cutting, total number of roots per cutting, number of callused cutting, number of alive, number of dead, number of laterals per cutting, and root quality as influenced by rooting media.

Treatment	Number Rooted Cuttings	Total Number of Roots	Number Callused Cuttings	Number Alive-no root or callus	Number Dead	Number of Laterals	Root Quality
Control	2.31a[z]	.62 b	.31 ab	.06 b	.00 b	3.12 a	2.37 a[y]
PB +N	.50 b	3.06 a	.12 ab	.37 a	.06 b	1.25 b	2.93 a
PB	.43 b	.87 b	.62 a	.06 b	.12 b	3.12 a	1.25 ab
HW+ CM	.18 b	.31 b	.43 ab	.12 b	.01 b	2.31 ab	.31 b
PB+CGW	.06 b	.18 b	.37 ab	.06 b	.50 a	1.43 b	.32 b

[z] Means followed by the same letters within a column are not statistically different based on Fisher's protected LSD = 0.05.
[y] Root quality rating: this was developed on a scale of 1-10, where 0-means no visible root meristem tissue,1- just the visible hairs to the naked eye or magnified eye, 5-atleast half of the callus area has visible well rooted, branched hairs,10-entire callus area and other nodes show substantial rooting and well diversified.

The initial bulk density measurements report that PB+N, PB,PB + CGW and HW+CM had the greatest bulk density. Control and PB+CGW had the lowest bulk density. The bulk density rates fall within acceptable ranges for potting media but may not be suitable for propagation media since high bulk density results in increased moisture content and decreased pore space (Chen, et al.,2003).

Differences in rooting response may be due to greater bulk density, less pore space and air space of the various propagation media as indicated in Table 2. In addition, the water holding capacity of the treatments was greater than the control which may have resulted in excessive moisture and less oxygen available to the roots. Table 2

Table 2 Soil physical properties of composted media used in the propagation of hardwood and softwood cuttings prior to inserting the cuttings.

Soil	Bulk Density ($g \cdot cm^{-3}$ dry)	Pore Space (%)	Air Space (%)	Water Holding Capacity (%)
Control	.16 c[z]	.66 a	.17 a	.49 b
PB +N	.39 a	.63 ab	.01 b	.61 a
PB	.32 ab	.59 b	.03 b	.55 ab
HW+ CM	.32 ab	.60 b	.01 b	.58 a
PB + CGW	.23 bc	.59 b	.03 b	.56 ab

[z]Means followed by the same letters within a column are not statistically different based on Fisher's protected LSD (P=0.05) .

Furthermore, difference in rooting response may also have been due to media pH and electrical conductivity (EC). The EC rating in propagating most plants has been reported to be in the range of 1-2.5 mS/m. (Chen and McConnell, 2003). Control media was more acidic and the treatment media -(all -treatments) were alkaline ranging from pH 7.16 to 7.79 (Table 3). The rooting response of hardwood cuttings of 'Tifblue' to the various composted materials are shown in figures 3-8.

Table 3 Chemical properties, pH and electrical conductivity,of the various propagation media after the experiment for hardwood cuttings.

Media	pH	EC(mS/cm)
Control	6.29 d[z]	235.2. c
PB +N	7.16 c	236.80 c
PB	7.28 bc	275.00 bc
Hardwood + Chicken Manure	7.79 a	270.00 bc
PB + CGW	7.54 ab	354.30a

[z]Means followed by the same letters within a column are not statically different based on Fisher's protected LSD (P=0.05).

Figure 3 ‘Tifblue’ hardwood blueberry rooting response to control treatment.

Figure 4 The response of ‘Tifblue’ blueberry to hardwood and chicken rooting media.

Figure 5 The response of ‘Tifblue’ hardwood blueberry cutting to pine bark and cotton gin waste rooting media.

Figure 6 The response of ‘ Tifblue’ hardwood cutting response to pine bark rooting treatment.

Figure 7 The response of 'Tifblue' hardwood cutting rooting response to nitralized pine bark treatment taken as a hardwood cutting.

Softwood Cuttings

The rooting media treatments resulted in a low number of cuttings compared to the control (peat moss plus perlite) (Table 4). The control treatment also resulted in the highest number of roots per cutting. None of the other treatments increased the number of roots compared to the control. The media treatments containing HW +CM and PB+CGW resulted in the lowest number of rooted cuttings and number of roots (Table 4). This corresponds with (Ingram et al., 2003) stating that as compost ages the particle size and percent air space decrease often making it difficult for roots to receive the proper amount of oxygen. There was no statistical significance in number of cuttings exhibiting callous among the treatments. The number of alive cuttings, i.e. plants not showing any root or callus, was increased by all treatments compared to the control, except PB+N. However, PB +N and pine bark increased the total number of roots compared to the control (Table 4). The difference in formation of callus material was not impacted by any of the treatments. However, the control was greater than PB. Hardwood + chicken manure and Pine bark + cotton gin waste resulted in the highest number of dead plants compared to the other treatments. The control and pine bark increased the number of laterals compared to the other treatments. All treatments decreased root quality compared to the control. HW+ CM and PB+CGW had the greatest reduction in root quality, followed by PB+N and PB.

Table 4 Softwood rooted cutting, total number of roots, callused cutting, number alive, number dead, laterals, and root quality as influenced by media containing composted material.

Treatment	Number Rooted Cuttings	Total Number of Roots	Number Callused Cutting	Number Alive- no root or callus	Number Dead	Number of Laterals	Root Quality
Control	0.80 a[z]	15.72 a	0.02 a	0.17 c	0.02 c	1.35 a	3.87 a[y]
PB+N	0.37 b	6.27 b	0.00 a	0.29 bc	0.35 ab	.27 c	1.91 b
PB	0.33 b	5.13 b	0.06 a	0.43 ab	0.20 b	.65 b	1.16 b
HW + CM	0.00 c	0.00 c	0.02 a	0.48 a	0.52 a	0.31 c	0.00 c
PB+ CGW	0.14 c	0.29 c	0.02 a	0.39 ab	0.43 a	0.08 c	0.18 c

[z]Means followed by the same letters within a column are not statistically different based on Fisher's protected LSD = 0.05).
[y]Root quality rating: This was developed on a scale of 1-10, where 0-means no visible root meristem tissue,1 – just the bare visible hairs to the naked or magnified eye, 5-at least half of the callus area has visible well rooted ,branched hairs,10-entire callus area and other nodes show substantial rooting and well diversified.

None of the treatments influenced the number of alive cuttings of 'Columbus compared to the control (Table 5). HW+CM increased the number of dead cuttings compared to the remaining treatments. The control resulted in the lowest number of dead cuttings and did not differ from PB. PB and HW+CM increased the number of alive cuttings of ‘Onslow’ compared to the remaining treatments, which did not differ. PB+N and PB +CGW increased the number of dead cuttings of ‘Onslow’ compared to the Control. In regards to ‘Tifblue, none of the treatments effected the number of alive cuttings. However, HW+CM increased the number of dead cutting compared to the control only.

The number of dead and alive cuttings resulting from each media did not vary depending on cultivar (Table 6). Results of the physical properties (Table2) indicated that PB+N, PB, and HW+CM had the highest bulk density. The PB+CGW and Control had the lowest of the media blends. Bulk density at the range of 0.19- 0.52 g/cc dry weight is acceptable for most potting media (Bilderback, 1999). Generally, as bulk density increases the moisture retention capacity increases (Bilderback, 1982). However the desirable characteristics for propagation media should be light, fluffy, well drained, and able to retain acceptable moisture for rooting. The Control had the highest air and pore space due probably to the high content of perlite in the mix compared to other substrates. Water holding capacity should be with in these ranges 0.5-0.7 % (Chen, 2003). PB+N and HW+CM had the greatest water holding capacity, while Control had the least.

Postharvest measurements of media pH and electrical conductivity were made to determine the changes in the media during the rooting process. Table 7 shows that the Control had the lowest pH of all the substrates while HW+CM had the highest of all the treatments. PB + CGW had the highest electrical conductivity of all treatments. Cotton gin waste added to potting medias often raise the E.C. levels The results are similar for both hardwood and softwood cutting treatments and lack of rooting response may be due to a high bulk density, less pore space, and air space in media containing composted components (Table 3). The recommended E.C. of the media should be in the range of 30.0 mS/cm for proper root initiation growth. (Chen, et al 2003, Robins and Evans, 2009). The E.C. of the HW + CM, PB +CGW was very high, and difference in rooting response may also be a high pH and electrical conductivity of the media containing composted components. The recommended pH for potting media that contains composted materials is 5.5-7.0 (Chen and McConnell, 2003). (Table 7). Figures 8-13 pictorially show the rooting response of softwood cuttings to the various media treatments.

Table 5 The effect of rooting media on alive and dead cuttings of three blueberry cultivars, softwood cuttings, June 2013.

	Cultivar					
Media	Columbus		Onslow		Tifblue	
	Percentage					
	Alive	Dead	Alive	Dead	Alive	Dead
Control	0.25 a[x]	0.00 c	0.13 b	0.00 c	0.12 a	0.06 b
PB+N	0.25 a	0.31 b	0.31 b	0.37 ab	0.31 ab	0.37 ab
PB	0.37 a	0.18 cb	0.69 a	0.13 bc	0.25 ab	0.31 ab
Hardwood + C M	0.18 a	0.81 a	0.68 a	0.31 b	0.56 a	0.43 a
PB +CGW	0.37 a	0.43 b	0.31 b	0.62 a	0.50 a	0.25 ab

[x]Means followed by the same letter within are not statistically different according to Fisher's protected LSD, P=.05.

Table 6 Effect of cultivar on alive and dead cuttings of softwood blueberry cuttings.

Cultivar	Alive	Dead
Columbus	0.28ax	0.35 a
Onslow	0.42a	0.28 a
Tifblue	0.35a	0.28 a

[x]Means followed by the same letter within are not statistically different according to Fisher's protected LSD, P=.05.

Table 7 Chemical properties, pH and electrical conductivity, of the various propagation media after the experiment for softwood cuttings.

Treatment	pH	EC mS/cm
Control	6.23 dz	244.75c
PB+N	6.82 c	291.81b
PB	7.03 bc	232.88c
HW+CM	7.68 a	338.94 a
PB+CGW	7.10 b	301.75 ab

[z]Means followed by the same letters within a column are not statically different based on Fisher's protected LSD (P=0.05).

Figure 8 The rooting response of softwood cuttings to the control soil treatment.

Figure 9 The rooting response of softwood cuttings to hardwood mulch and chicken manure soil treatment.

Figure 10 The rooting response of softwood cuttings to pinebark and cotton gin waste treatment.

Figure 11 The rooting response of softwood cuttings to nitralized pinebark.

Figure 12 The rooting response of softwood cuttings to pinebark fines.

Conclusion

In this study the overall rooting percentage of hardwood and softwood cuttings as influenced by composted media was low compared to the control. In this study, PB+N enhanced the number of roots and live cuttings of hardwood cuttings and may have potential in the propagation of blueberries. In addition, PB, HW+CM increased the number of alive cuttings and also may have potential in the propagation blueberries. The local availability of the composted media, the media being inexpensive, and the sustainability of the product could potentially make these composted media with useful in the propagation of blueberries if adjustments are made tp modify the ratio of the composted ingredients.

In this study, composted media was used because it is inexpensive and environmentally friendly product. Poultry litter and cotton gin waste are waste products that producers need to find a viable and economical disposal option . The shortage of pine bark for the horticulture industry has prompted mulch and soil producers to explore other materials such as hardwood bark (Boyer et al,2008), cotton gin waste(Cole,2005), and poultry litter(Tyler et al,1993) for use in mulch, soil mixes, and soil amendment blends. In terms of using the media for propagation, it is clear that cotton gin waste, poultry litter, and hardwood bark were thought to be comparable with pine bark, peat moss, and perlite in terms of suitability (ability to provide adequate aeration, moisture retention, pH, and low electrical conductivity) so as not to inhibit root formation(Currey et al,2013). Therefore, it was expected that its performance would at least be satisfactory. Previous research using composted media in propagation is very limited, and findings have shown satisfactory results with foliage and ornamental crops. This study will add to the limted information on this subject, especially as it relates to the physical properties of the composted media. Future research is needed to document changes in physical properties of composted media for propagation of blueberries.

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