Landscape

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Selecting the Right Rain Garden Substrate Composition to Maximize Stormwater Remediation

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Significance to the Industry: Rain gardens, also known as bioretention cells or bioinfiltration devices are one of the most commonly utilized stormwater control measures (SCMs) in the country (4, 8). Plants in rain gardens have a positive impact on remediation of pollutants from stormwater runoff (3, 13, 16). However, plant growth and remediation can be impacted by filter bed substrate, organic matter amendment, and combination method (14). This study had two filter bed substrates (sand and slate), two organic matter amendments [composted yard waste (CYW) and pine bark (PB)], and eight combination methods (banding of 1, 2, 3, or 4 inches and incorporation of 5, 10, 15, or 20% of organic matter amendment). *Panicum virgatum* 'Shenandoah' was able to accumulate significantly more nitrogen (N) and phosphorus (P) with the CYW than the PB as the organic matter amendment to the rain garden filter bed substrates. Effluent N and P content still needs to be examined before CYW is recommended as an organic matter amendment.

Nature of Work: Half (3.2 billion) of the world's population is living in cities, while the urban population is expected to increase to around 5 billion by 2030 (1). Due to this continual increase in population, the amount of urban infrastructures will also continue to increase. The increase of impervious urban infrastructures (roads, driveways, parking lots, and rooftops) causes precipitation that was once able to infiltrate into native vegetation and soils to become surface runoff (1). With the rapid runoff created by impervious surfaces, the urbanized watershed becomes more open to possible pollution, flooding, and droughts (10). As the water moves along the impervious surfaces it picks up pollutants (nitrogen, phosphorus, metals, and sediment) that are harmful to water quality (10).

Rain gardens are non-irrigated, planted landscape features designed to capture polluted stormwater runoff. They are built by excavating and creating depression areas within the landscape so that the stormwater can be captured (5). After excavation rain gardens are refilled with a filter bed substrate and planted with vegetation creating an environment within the rain garden where adsorption, filtration, sedimentation, volatilization, ion exchange, plant uptake and biological decomposition occur to remediate the polluted stormwater (11). Plants growing in rain gardens face two challenges: periodic drought conditions and low nutrient loads. Passeport and Hunt (12) reported that the average total nitrogen (N) ranged from 1.13 to 2.19 $mg \cdot L^{-1}$ and average total phosphorus (P) ranged from 0.07 to 0.33 $mg \cdot L^{-1}$ for stormwater runoff from eight asphalt parking lots in North Carolina. These N and P concentrations are much lower than the N (50 to 100 $mg \cdot L^{-1}$) and P (10 to 15 $mg \cdot L^{-1}$) rates recommended for application during containerized nursery production (2).

Rain gardens effectively remediate polluted urban stormwater runoff (9). Hunt et al. (9) reported that a rain garden with a loamy sand filter bed substrate capturing runoff from an asphalt parking lot had effluent concentrations of total N, total kjeldahl N, and ammonium that were 32.2%, 44.3%, and 72.3% lower than that of the influent concentrations. Also, total P effluent was reported to be 31.4% lower than that of the influent (9). Turk et al. (16) reported that a slate filter bed substrate had the best retention of N (86% initially and 99% by the end of the study) when compared to a sand and soil filter bed substrate. These researchers also reported that slate and sand had better P removal, 99% and 96%, than the soil filter bed substrate (16). However, during the second season of this study there were fewer remediation differences between the filter bed substrates indicating that plant uptake was greatly impacting remediation (16). Read et al. (13) and Bratieres et al. (3) both reported that vegetation in rain gardens improved the remediation of N and P from simulated polluted stormwater when compared to non-vegetated rain gardens. Hsieh et al. (7) reported having a permeable sand layer over a less permeable soil layer increased stormwater retention within the filter bed substrate. This method allowed nitrification in the well aerated portion of the substrate and denitrification in the saturated, low permeable layer (7). The less permeable bottom soil layer also allowed increased contact time between dissolved P and the media and was found to be more effective in total P removal (6). However, Hsieh et al.'s (6, 7) experiments did not include plants.

As seen in the above paragraph, research evaluating rain garden substrates is copious and thorough. However, evaluating the organic matter amendment such as pine bark (PB) or composted yard waste (CYW) has not been considered as an option for providing the organic matter for the microbes or creating a low permeability layer that allows denitrification to occur within the rain garden filter bed substrate. Both organic matter and anaerobic conditions are required for denitrification. Additionally, some research has looked at varying filter bed substrate combinations and the impact of vegetation however; little research has examined the actual plant uptake of pollutants for remediation. Therefore, the objective of this research was to determine the roll of different sources of organic matter amendments and combination methods in two common rain garden filter bed substrates on nutrient uptake.

The experimental design was a randomized complete block design with a factorial treatment arrangement of thirty-two substrates that resulted from combinations of two filter bed substrates, two organic matter amendments, and eight combination methods. The two filter bed substrates used were sand (80% washed sand, 15% clay and silt fines and 5% pine bark v/v/v) (Wade Moore Equipment Company, Louisburg, NC) and slate (Permatill, Carolina Stalite Company, Salisbury, NC). Both, sand and slate were amended with two different organic matter amendments, PB or CYW (City of Raleigh Yard Waste Recycling Center, Raleigh, NC). PB and CYW were added as either a band in the depths of 1, 2, 3, or 4 inches or by incorporation using approximately the same amounts of organic matter in the amounts of 5, 10, 15, and 20% (v/v) (Figure 1). For the banded treatments, four inches of either sand or slate were added to the bottom of the container. Then the 1, 2, 3, or 4 inch band of CYW or PB was added and finally the container was topped off with either sand or slate to within one inch from the top to allow for irrigation ponding. Black Pecan King 1020 containers (6.06 gallons) (Haviland Plastic Products, Haviland, OH) were filled with the thirty-two filter bed substrate compositions and *Panicum virgatum* L. 'Shenandoah' was planted on June 1, 2012. The plants were watered without added nutrients for the first two weeks daily to allow establishment. Thereafter, plants had simulated stormwater runoff applications with 1.6 $mg \cdot L^{-1}$ of P (supplied by diammonium phosphate, 18-46-0) and 11.9 $mg \cdot L^{-1}$ of N (supplied by ammonium sulfate 21-0-0-24) to simulate polluted stormwater runoff (12). One inch of simulated polluted stormwater runoff was applied once a week (June, 2012-October, 2012), once a month (November, 2012-March, 2013), and every two weeks (April, 2013-May, 2013) using a low-volume spray stake (PC Spray Stake, Netafim, Ltd., Tel Aviv, Israel) to mimic rainfall patterns for Raleigh, NC. On May 7, 2013, shoots were harvested and dried at 62C (144F) for 5 days. After drying, the samples were weighed and then submitted to the North Carolina Department of Agriculture and Consumer Services, Agronomic Division, Raleigh, NC for grinding and tissue N and P analysis. Foliar nutrient content = shoot dry weight (g) x % shoot nutrient concentration. This study was conducted at North Carolina State University's Horticultural Field Laboratories, Raleigh, NC (longitude: $35^{o}47'29.57''$N; latitude: $78^{o}41'56.71''$W; elevation 136 m). Square root transformations of foliar nutrient content data were used to normalize the data prior to analysis of variance procedures. Tukey's honestly significant difference means separations procedures were used to separate means ($P \leq 0.05$) (15).

Results and Discussion: Foliar nutrient content did not have a significant filter bed substrate x organic matter amendment x combination method interaction (Table 1). However, the two-way interactions of organic matter amendment x combination method, filter bed substrate x combination method, and filter bed substrate x organic matter amendment were significant for both foliar nitrogen (N) and phosphorus (P) contents. *P. virgatum* 'Shenandoah' was able to take up more N and P when substrates were amended with CYW than with PB (Figure 2A, 2B). *P. virgatum* 'Shenandoah' has been reported to have larger shoot dry weights with sand and slate amended with CYW than PB which could be why there is increased N and P uptake (14). However, within each organic matter amendment (CYW and PB) there were no differences in N and P uptake with banding and incorporation. When averaging over organic matter amendment, the differences in N and P uptake by the plant between banding and incorporation in sand and slate were generally not significant (Figure 3A, 3B). With CYW as the organic matter amendment, *P. virgatum* 'Shenandoah' was able to take up similar amounts of N regardless of the filter bed substrate (Figure 4A). However, when PB was the organic matter amendment, plants were more able to take up more N in sand than in slate. P uptake by the plant was greater in sand regardless of the organic matter amendment (Figure 4B). This is likely due to slate's high calcium (Ca) content and occurrence of $CaPO_4$ fixation making the P unavailable for plant uptake. Precipitation of P as $CaPO_4$ is hypothesized to be the reason of slates excellent P remediation (16).

In conclusion, rain gardens are popular stormwater control measures because of their aesthetics, their potential to reduce flooding, and their improvements to stormwater runoff (9). The organic matter amendment of CYW appeared to have the greatest impact on N and P uptake by the plant. These results show that amending either sand or slate with CYW allows more plant uptake of N and P by the plant. Additionally, N and P uptake is the same regardless of whether the composted yard waste is banded or incorporated. Banding the organic matter amendment is likely easier than incorporating it into the substrate when the rain garden is large and requires many cubic yards of substrate. The next step in determining the right rain garden substrate composition to maximize polluted stormwater remediation is an investigation of the pollutant remediation of rain garden effluent. If the N and P contents in the effluent of CYW substrates are high then it will not be an acceptable source of organic matter due to the potential increase in ground water nutrient contamination.

Literature Cited:

1. Baker, Lawrence A. 2009. *The Water Environment of Cities*. New York: Springer.
2. Bilderback, T., C. Boyer, M. Chappell, G. Fain, D. Fare, C. Gilliam, B. Jackson, J. Lea-Cox, A. LeBude, A. Niemiera, J. Owen, J. Ruter, K. Tilt, S. Warren, S. White, T. Whitwell, R. Wright, T. Yeager. 2013. 3rd Ed. Best Management Practices: Guide for Producing Nursery Crops. Southern Nursery Association, Acworth, GA.
3. Bratieres, K., T.D. Fletcher, A. Deletic, and Y. Zinger. 2008. Nutrient and Sediment Removal by Stormwater Biofilters: A Large-scale Design Optimisation Study. Water Research 42:3930-3940.
4. Davis, Allen P., William F. Hunt, Robert G. Traver and Michael Clar. 2009. Bioretention Technology: Overview of Current Practice and Future Needs. Journal of Environmental Engineering 135(3):109-117.
5. Dietz, M. E. 2007. Low impact development practices: A review of current research and recommendations for future directions. Water, Air and Soil Pollution 186:351-363.
6. Hsieh, C., A.P. Davis, and B.A. Needelman. 2007a. Bioretention Column Studies of Phosphorus Removal from Urban Stormwater Runoff. Water Environment Research 79(2): 177-184.
7. Hsieh, C., A.P. Davis, and B.A. Needelman. 2007b. Nitrogen Removal from Urban Stormwater Runoff Through Layered Bioretention Columns. Water Environment Research 79(12): 2404-2411.
8. Hunt, W.F., A.P. Davis, and R.G. Traver. 2012. Meeting Hydrologic and Water Qulity Goals Through Targeted Bioretention Design. Journal of Environmental Engineering 138(6):698-707.

9. Hunt, W.F., J.T. Smith, S.J. Jadlocki, J.M. Hathaway, and P.R. Eubanks. 2008. Pollutant Removal and Peak Flow Mitigation by a Bioretention Cell in Urban Charlotte, N.C. Journal of Environmental Engineering 134(5):403-408.
10. Li, Houng, Lucas J. Sharkey, William F. Hunt and Allen P. Davis. 2009. Mitigation of Impervious Surface Hydrology Using Bioretention in North Carolina and Maryland. Journal of Hydrologic Engineering 14(4): 07-415.
11. North Carolina Division Environment and Natural Resources (NCDENR). 2009. Stormwater Best Management Practice Manual. http://portal.ncdenr.org/web/wq/ws/su/bmp.
12. Passeport, E. and W.F. Hunt. 2009. Asphalt Parking Lot Runoff Nutrient Characterization for Eight Site in North Carolina, USA. Journal of Hydrologic Engineering 14.4: 352-361.
13. Read, J, T. Wevill, T. Fletcher, and A. Deletic. 2008. Variation Among Plant Species in Pollutant Removal from Stormwater in Biofiltration Systems. Water Research 42:893-902.
14. Riley, E.D., H.T. Kraus, and T.E. Bilderback. 2013. Preliminary Discoveries of Varied Rain Garden Substrate Compositions. Southern Nursery Association Research Conference. 58:178-183.
15. SAS Institute, Inc. 2001. SAS/STAT User's Guide: Release 9.3 Edition, SAS Inst., Inc., Cary, NC.
16. Turk, R.L., H.T. Kraus, T.E. Bilderback, W.F. Hunt, and W.C. Fonteno. 2014. Rain Garden Filter Bed Substrates Affect Stormwater Nutrient Remediation. HortScience 49(5):645-652.

Table 1. Analysis of variance interactions for nitrogen and phosphorus foliar nutrient content.

	Combination Method[x]	Organic Matter Amendment[w]	Filter Bed Substrate[v]	Organic Matter Amendment x Combination Method[u]	Filter Bed Substrate x Combination Method[t]	Filter Bed Substrate x Organic Matter Amendment[s]	Filter Bed Substrate x Organic Matter Amendment x Combination Method[r]
Foliar[z] Nitrogen Content	0.0005[y]	<0.0001	0.0001	<0.0001	0.0011	0.0509	NS
Foliar Phosphorus Content	<0.0001	<0.0001	<0.0001	0.0507	0.0237	0.0003	NS

[z] Foliar nutrient content = shoot dry weight (g) x % shoot nutrient concentration.
[y] Interactions were considered significant at $P \leq 0.05$. NS = Non-significant.
[x] Main effect of combination method where the two organic matter amendments were added as either a band in the depths of 1, 2, 3, or 4 inches or by incorporation using approximately the same amounts of organic matter in the amounts of 5, 10, 15, and 20% (v/v).
[w] Main effect of organic matter amendment [composted yard waste (CYW) and pine bark (PB)].
[v] Main effect of filter bed substrate (sand and slate).
[u] Two-way interaction of organic matter amendment x combination method.
[t] Two-way interaction of filter bed substrate x combination method.
[s] Two-way interaction of filter bed substrate x organic matter amendment.
[r] Three-way interaction of filter bed substrate x organic matter amendment x combination method.

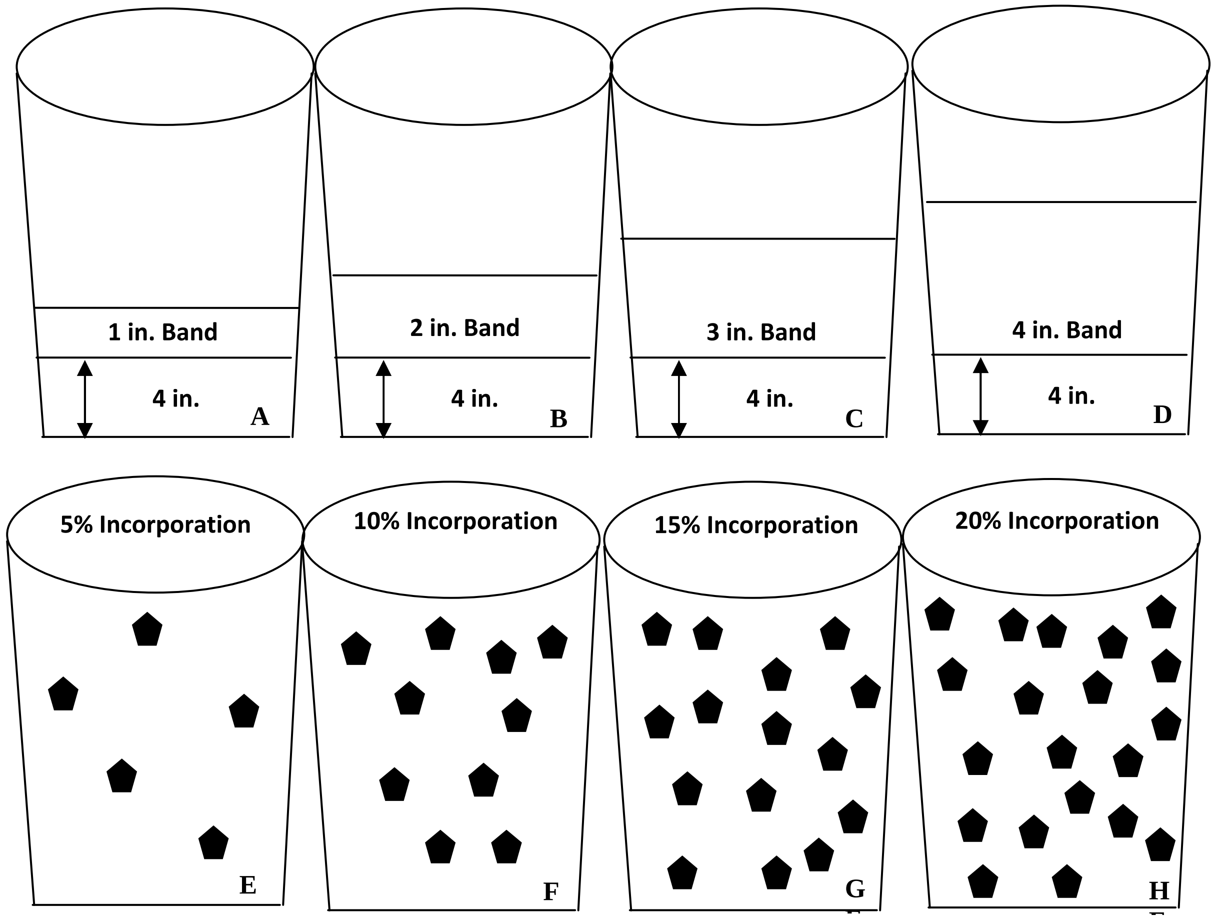

Figure 1. Schematic of different filter bed substrate combination methods. The two organic matter amendments were added as either a band in the depths of 1, 2, 3, or 4 inches or by incorporation using approximately the same amounts of organic matter in the amounts of 5, 10, 15, and 20% (v/v). A: Combination method of banding with 1 inch, B: Combination method of banding with 2 inches, C: Combination method of banding with of 3 inches, D: Combination method of banding with 4 inches, E: Combination method of incorporation with 5%, F: Combination method of incorporation with 10%, G: Combination method of incorporation with 15%, and E: Combination method of incorporation with 20%.

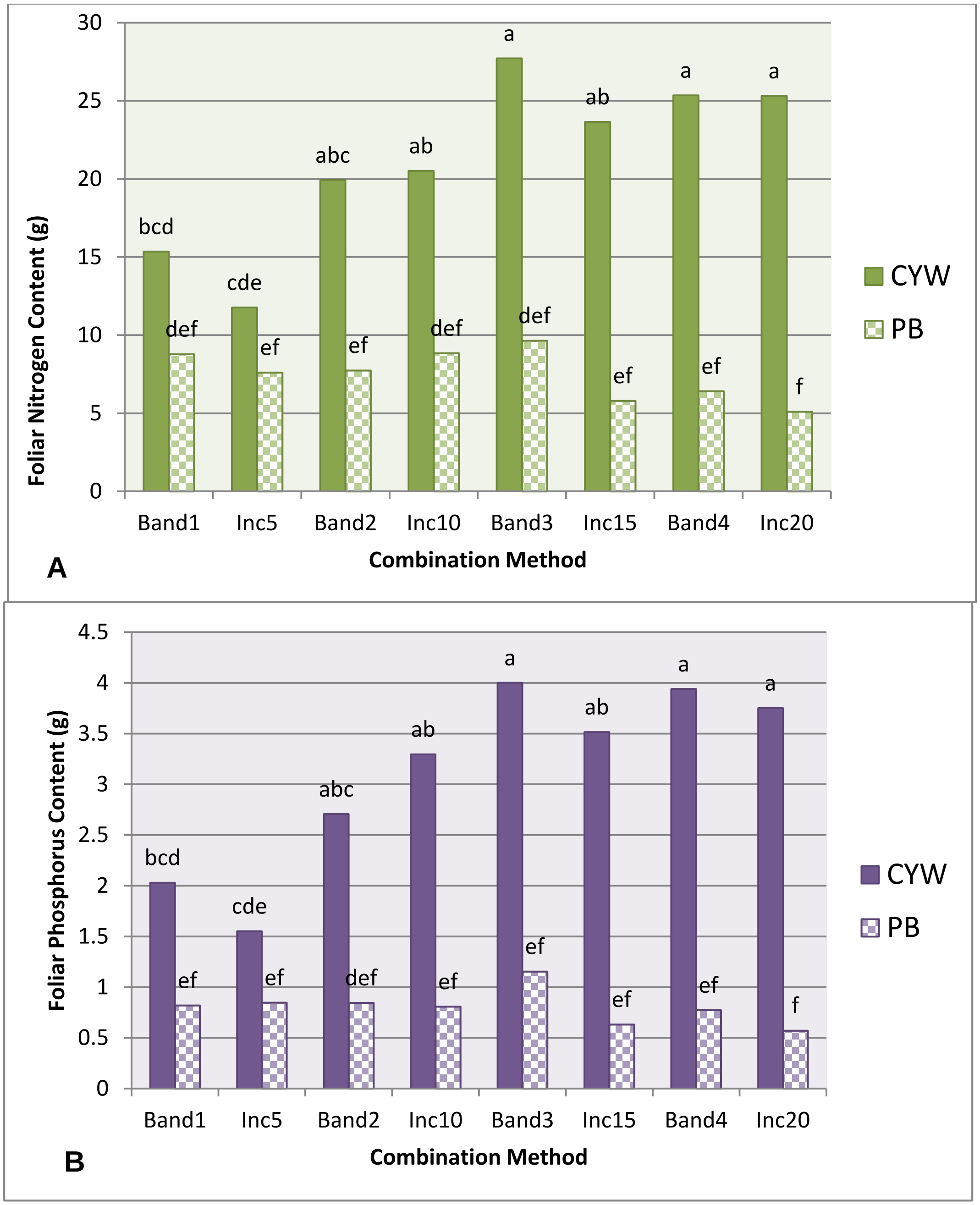

Figure 2. Two-way interaction of organic matter amendment x combination method effect on organic matter amendment [composted yard waste (CYW) and pine bark (PB)] and combination method on nitrogen (A) and phosphorus (B) uptake by *Panicum virgatum* 'Shenandoah'. The two organic matter amendments were added as either a band in the depths of 1, 2, 3, or 4 inches or by incorporation (Inc) using approximately the same amounts of organic matter in the amounts of 5, 10, 15, and 20% (v/v). Means between substrates with different letters are significantly different from each other based on Tukey's honestly significant difference means separation procedures ($P \leq 0.05$).

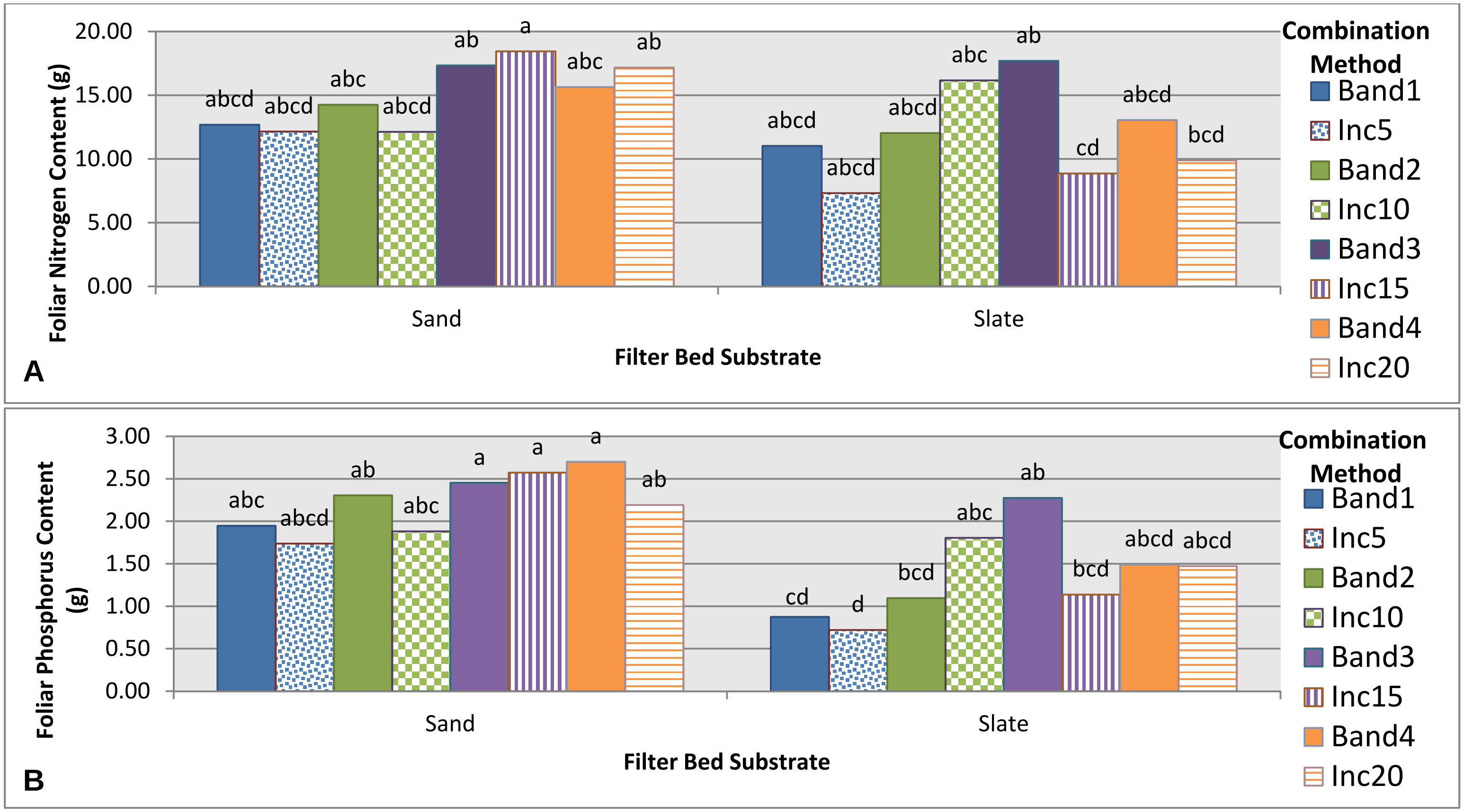

Figure 3. Two-way interaction of filter bed substrate x combination method effect on filter bed substrates (sand or slate) and combination method on nitrogen (A) and phosphorus (B) uptake by *Panicum virgatum* 'Shenandoah'. The two organic matter amendments were added as either a band in the depths of 1, 2, 3, or 4 inches or by incorporation (Inc) using approximately the same amounts of organic matter in the amounts of 5, 10, 15, and 20% (v/v). Means of filter bed substrates and combination methods are compared, different letters are significantly different from each other based on Tukey's honestly significant difference means separation procedures ($P \leq 0.05$

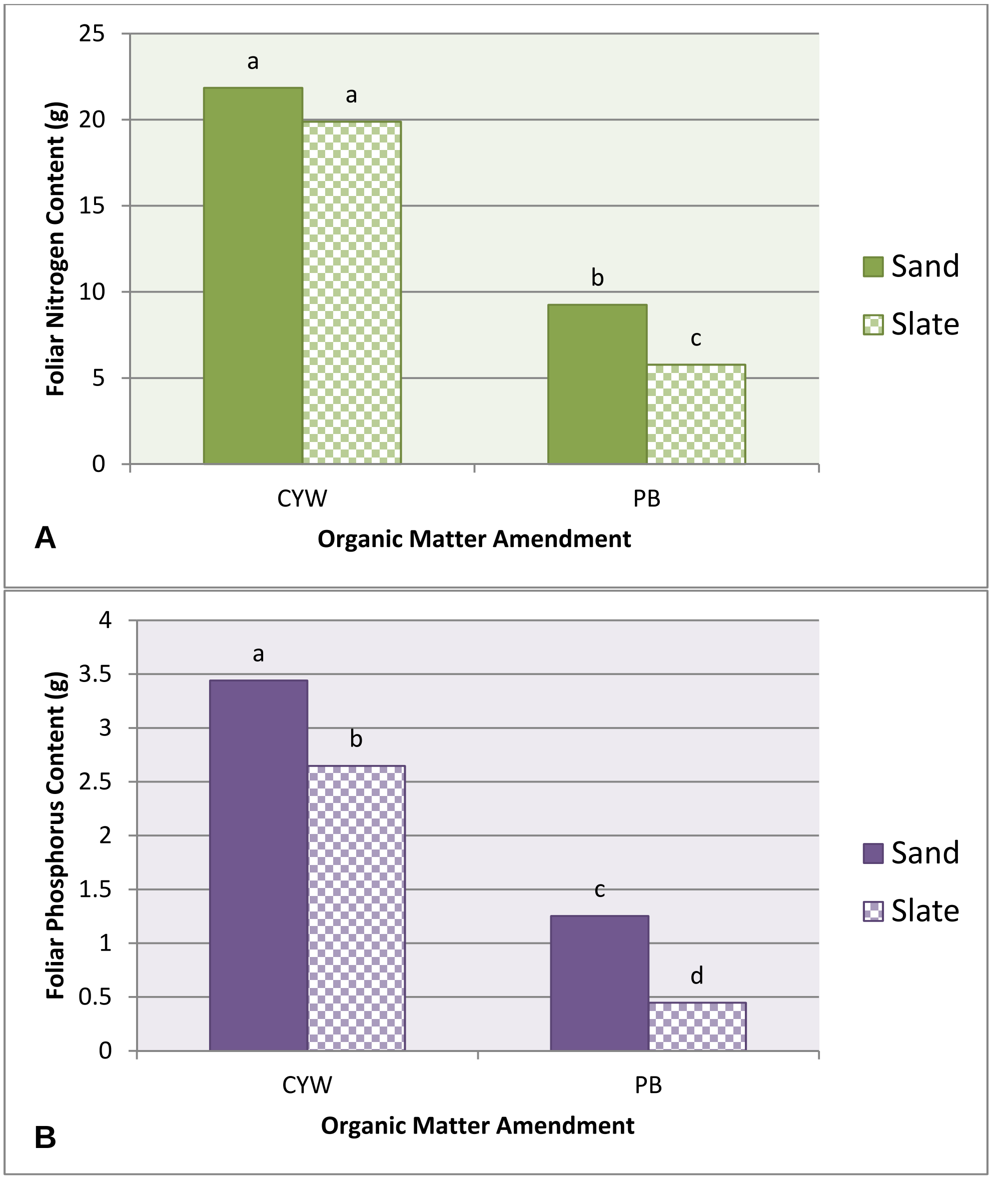

Figure 4. Two-way interaction of filter bed substrate x organic matter amendment effect on filter bed substrates (sand or slate) and organic matter amendments [composted yard waste (CYW) and pine bark (PB)] on nitrogen (A) and phosphorus (B) uptake by *Panicum virgatum* 'Shenandoah'. Means between substrate compositions with different letters are significantly different from each other based on Tukey's honestly significant difference means separation procedures ($P \leq 0.05$).

Survival of Ornamental Grasses from North Florida to South Florida

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Significance to Industry: In 2012, ten cultivars of *Panicum virgatum* and two cultivars of *Schizachyrium scoparium* were planted at four University of Florida research and education centers (REC): North Florida, Quincy (NFREC), Gulf Coast, Wimauma (GCREC), Indian River, Fort Pierce (IRREC) and Fort Lauderdale (FLREC). In addition to growth and aesthetic qualities, data on winter survival is important to help identify new ornamental plant options of cultivars that can be introduced into Florida; plants that can survive low-input landscapes, conserve water, and retain their landscape value and aesthetics for several years.

Nature of work: Urbanization along with the ever-growing tourist industry is increasing the demand for aesthetically pleasing Florida landscapes, public, and recreational areas (4). Managed landscape irrigation is causing increased water consumption and escalating demands for potable water in Florida and other urban areas (5). Environmental concerns and water conservation are the driving forces that will continually pressure horticulture to search and provide new low input plant options. The objective of this study was to evaluate winter survival of ornamental grasses for *Panicum* and *Schizachyrium* taxa planted in north, central, and south Florida. The plants were grown with minimal input (no fertilization and zero to low irrigation) under full sun in diverse climatic conditions (USDA Cold Hardiness Zones; FLREC 10b, IRREC 9b, GCREC 9a, NFREC 8b) (Table 1).

Four single plant replicates of *Panicum virgatum* (Switch grass), 'Cheyenne Sky', 'Cloud Nine', 'Dust Devil', 'Heavy Metal', 'Hot Rod', 'Prairie Fire', 'Rotstrahlbusch', 'Shenandoah'; *Schizachyrium scoparium* (Little Bluestem), 'Jazz', 'Prairie Blues'; and two Florida Ecotypes (Switch grass) 'Miami' and ‘Stuart’ were planted 4 feet apart using either a completely randomized design (FLREC) or randomized complete block (IRREC, GCREC, NFREC). Space and labor restrictions varied plantings at each site. Initial planting at all locations was in June 2012. Plants were irrigated three times a week for 45 minutes until established (4 weeks at all locations). Irrigation was terminated at FLREC and GCREC after establishment but weekly irrigation during the growing season continued at NFREC and IRREC. Mulches were used to control weeds at each location. Plants were not fertilized and no chemical control was used for insects or disease.

Grasses were cut-back to 4 inches above soil-line in February 2013 and 2014, before spring green-up. Winter survival was recorded at this time. Winter survival was rated on a scale of 1 to 5 with 1 equal dead, 3 equal 50% alive and 5 all plants alive. Weather data was collected by the Florida Automated Weather Network (FAWN) station located on each test site. Comparison of average survival ratings between sites was generated by Duncan multiple range test within SAS.

Results and Discussion: The average survival rating in 2013 of the ornamental grasses examined was greater at NFREC and GCREC than at IRREC or FLREC (Table 2). All sites had an average survival rating of 3 or greater indicating that approximately 50% of the plants survived. However, in 2014 the winter survival ratings went down at each site. In 2014 both NFREC and GCREC had average winter survival ratings greater than 3 while IRREC and FLREC had survival ratings less than 3 (Table 2). Climatic differences may have attributed to the differences in plant survival from north to south Florida.

In both 2013 and 2014, winter survival ratings were lower for the sites in southern Florida compared to the northern sites. For example, at the FLREC site (southernmost site), in spring 2013 the following plants had winter survival ratings of 5: *Panicum virgatum* cultivars; ‘Heavy Metal’, ‘Miami’, ‘Shenandoah’, ‘Thundercloud’, and ‘Warrior’. However, in spring 2014 only *Panicum virgatum* ‘Shenandoah’ had a survival rating greater than 3. Research on the heat stress response of switch grass using the cultivar ’Alamo’ resulted in nearly a 50% reduction of the total biomass under elevated temperatures of 100/86°F (day/night) (7). Grasses at FLREC site were exposed to days with maximum temperatures greater than 92°F from May to September 2013 and average temperatures ranging from 80 to 82°F (3). We suspect that the climate at FLREC prevented the grasses from establishing deep root systems. Adventitious roots form the bulk of grasses and provide support for new growth necessary for long-term survival (2).

We expected the native Florida ecotypes ‘Miami ‘and ‘Stuart’ to perform better than the other species examined. Native species are often assumed to be more tolerant of local conditions but there is not always enough research to support these claims (5). Native plants that are removed from their natural habitats and placed in artificially managed settings must still be evaluated for their suitability in landscaping (1, 6). In our trials, the performance of the two Florida ecotypes ‘Miami’ and ‘Stuart’ varied among the sites. In 2013,’Miami’ survival ratings were greater than 3 at FLREC and GCREC while ‘Stuart’ ratings were 4 or greater at all sites (Table 3). In 2014, only GCREC has a survival rating of 3 for ‘Miami’ while ‘Stuart’ survival ratings were greater than 4 at all sites except FLREC.

Trial gardens are important for the introduction of new plant material in horticulture, not only providing valuable information on landscape suitability but also potential for invasiveness. Urban green spaces are dependent on trial gardens and the information they can provide growers, landscapers and consumers. This Information can help in making responsible environmental choices and avoid potential loss in profits.

Literature Cited

1. Cole, J.T. and Cole, J.C., (2000), Ornamental Grass Growth Response to Three Shade Intensities, J. Environ. Hort. 18(1):18-22.
2. Drake, R. (1999), *The Color Encyclopedia of Ornamental Grasses*, Timber press (pp 30-31). Portland, Oregon
3. FAWN-Florida Automated Weather Network, retrieved 1/31/2014, 6/4/14, http://fawn.ifas.ufl.edu/data/reports/?res
4. Moore, K., (2012), Urban Irrigation Challenges and Conservation, In T. S. Lee, *Irrigation Systems and Practices in Challenging Environments*, In Tech Publishing, (pp 343-360). Rijeka, Croatia
5. Scheiber, S.M., Gilman, E.F., Sandrock, D.R., Paz, M., Wiese, C. and Brennan, M. M., (2008), Postestablishment Landscape Performance of Florida Native and Exotic Shrubs Under Irrigated and Nonirrigated Conditions, HortTechnology, 18(1):59-67
6. Thetford, M., Norcini, J. G., Ballard, B., and Aldrich, J.H. (2009), Ornamental Landscape Performance of Native and Nonnative Grasses under Low-input Conditions, HortTechnology, 19(2):267-285
7. Yong-Fang, L., Wang, Y., Tang, Y., Kakani, V.G. and Mahalingam, R., (2013), Transcriptome analysis of heat stress response in switchgrass (*Panicum virgatum* L.), Plant Biology 13:153

Table 1. Total monthly rain fall and average monthly temperatures from June 2012 to March 2014 at four Florida sites: Quincy (NFREC), Wimauma (GCREC), Fort Pierce (IRREC) and Fort Lauderdale (FLREC) (USDA Cold Hardiness Zones- FLREC 10b, IRREC 9b, GCREC 9a, NFREC 8b). Data was collected from the Florida Automated Weather Network (FAWN). The FAWN system was unable to retrieve data for IRREC for November 2013 to March 2014.

Month-year	NFREC	GCREC	IRREC	FLREC
	Total Monthly Rainfall (inches)			
June 2012	5.91	14.87	5.13	7.64
July 2012	2.68	2.61	2.77	6.03
August 2012	7.26	12.31	2.95	12.08
September 2012	4.51	4.1	6.19	5.66
October 2013	0.98	3.32	7.00	4.92
November 2012	0.53	0.10	0.50	0.45
December 2012	6.62	2.46	0.97	1.03
January 2013	1.29	0.30	1.18	0.25
February 2013	13.72	1.01	17.08	1.67
March 2013	5.46	1.02	0.47	0.22
April 2013	4.07	4.16	3.97	6.39
May 2013	0.61	3.57	5.09	9.57
June 2013	4.97	16.52	6.66	7.31
July 2013	11.37	8.70	6.21	14.22
August 2013	4.58	6.97	5.59	4.06
September 2013	3.73	5.47	7.48	4.77
October 2013	0.73	1.78	0.66	5.95
November 2013	2.96	0.54		8.29
December 2013	3.84	1.51		1.39
January 2014	3.95	2.87		4.22
February 2014	5.35	0.26		1.27
March 2014	9.29	5.20		2.75
	Average Monthly Temperature (˚F)			
June 2012	76.4	77.4	78.9	81.5
July 2012	76.1	79.6	80.6	82.2
August 2012	77.4	79.3	80.5	82.6
September 2012	74.8	77.6	78.3	80.6
October 2012	66.2	72.5	74.6	77.5
November 2012	55.6	62.1	66.5	69.2
December 2012	54.4	62.7	66.2	70.6
January 2013	57.5	64.2	66.9	71.4
February 2013	54.2	62.9	65.2	70.1
March 2013	54.1	59.2	61.1	66.4
April 2013	65.3	72.5	73.4	76.6
May 2013	70.3	73.4	74.4	77.4
June 2013	78.2	78.2	79.3	81.4
July 2013	76.9	77.9	76.7	80.7
August 2013	78.4	79.5	80.7	82.1
September 2013	76.1	77.4	78.3	80.1
October 2013	67.5	73.5	75.4	77.5
November 2013	57.9	68.3		74.2
December 2013	56.4	65.9		72.6
January 2014	45.3	56.5		65.9
February 2014	54.7	63.9		71.4
March 2014	56.7	64.6		70.7

Table 2. Winter survival ratings (2013 and 2014) for ten cultivars of *Panicum virgatum* and two cultivars of *Schizachyrium scoparium* planted at four University of Florida research centers: Quincy (NFREC), Wimauma (GCREC), Fort Pierce (IRREC) and Fort Lauderdale (FLREC). Winter survival was rated on a scale of 1 to 5 with 1 equal dead, 3 equal 50% alive and 5 all plants alive. Grasses were planted in June 2012 and winter survival was rated in February 2013 and 2014. Letters within the row for average rating followed by a different letter are significantly different at the 0.05 level.

2013				
Cultivar	NFREC	GCREC	IRREC	FLREC
P. v. 'Cheyenne Sky'	5	4	4	3
P. v. 'Cloud Nine'	5	4	5	3
P. v. 'Dust Devil'	2	5	1	3
P. v. 'Heavy Metal'	5	5	5	5
P. v. 'Hot Rod'	5	5	5	4
P. v. 'Miami'	2	4	2	5
P. v. 'Prairie Fire'	5	5	3	2
P. v. 'Rotstrahlbusch'	5	5	5	1
P. v. 'Shenandoah'	4	4	5	5
P. v. 'Stuart'	5	5	5	4
S. s. 'Jazz'	2	3	1	1
S. s. 'Prairie Blues'	4	3	2	2
Average rating	4.1a	4.3a	3.5b	3.2b
2014				
Cultivar	NFREC	GFREC	IRREC	FLREC
P. v. 'Cheyenne Sky'	5	4	1	1
P. v. 'Cloud Nine'	5	4	5	1
P. v. 'Dust Devil'	2	4	1	2
P. v. 'Heavy Metal'	5	2	3	1
P. v. 'Hot Rod'	4	3	1	1
P. v. 'Miami'	2	4	2	1
P. v. 'Prairie Fire'	5	4	1	1
P. v. 'Rotstrahlbusch'	4	4	4	1
P. v. 'Shenandoah'	4	3	1	4
P. v. 'Stuart'	5	4	5	2
S. s. 'Jazz'	2	3	1	1
S. s. 'Prairie Blues'	4	3	1	1
Average rating	3.9a	3.5a	2.2b	1.4c

Developing an Online Environmental Landscape Certification Program for South Carolina: Stakeholder Survey Results

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Significance to Industry. The Environmental Landscape Certification (ELC) program is currently being developed by Clemson faculty, extension agents, students, landscape industry professionals, and their clients. The knowledge and skill set that certified landscape professionals gain will attract clients and subsequently increase their economic bottom-line by being known as learned in management practices that maximize urban landscape aesthetics, as well as good stewards of the environment that protect and conserve the natural resources.

Nature of Work. The landscape industry within South Carolina is very large and unregulated. It is a rapidly growing small business sector for the state. Beyond a pesticides applicators license, no experience or training is required. In the future, it is anticipated that South Carolina will follow by example of other states such as Florida, Maryland and Oregon, in which landscape contractors must be certified in order to bid on and or perform certain jobs. For example, the state of Oregon requires that each landscape construction professional or business must have a landscape construction professional license (Oregon.gov, 2014).

Untrained contractors may manage landscapes improperly. The subsequent effects to the environment are potentially deleterious (McCarthy, 2000). Professionals that are certified will have the knowledge-base needed to better understand and meet client needs and expectations using conservation-based management techniques. Conservation-based best management practices are designed with the intent to protect and conserve water resources and protect natural habitats. Improper irrigation systems installation and scheduling, improper application of fertilizers and pesticides, the use of fountains and impervious paving materials, and poor plant selection can hinder the water resources and ecosystem function in the environment.

The ELC program coordinators are facilitating collaboration among municipalities, trade associations, and stakeholders to help implement the ELC to its fullest potential. The targeted stakeholders for the certification programs include: supervisors and employees in the lawn care and landscape maintenance and design industry, municipal parks and recreation facility supervisors and employees, school board facility supervisors and employees, maintenance supervisors and employees of large campuses, irrigation industry workers, commercial property managers, builders and developers, and landscape designers and architects. The ability to provide an on-line, on-demand certification for the stakeholders, who work long and nontraditional hours, is very important.

The program has partnered with personnel in four key counties throughout South Carolina, to help implement this certification. The four counties are Greenville, Spartanburg, Florence, and North Charleston; a meeting was held in each location to help determine the critical skill sets for inclusion in the program and program framework. During the 2014 South Carolina Horticulture Industry Conference, sponsored by the SC Nursery and Landscape Association, stakeholders were recruited to complete a needs-assessment survey about the ELC program. The survey was developed as a baseline to help determine module content and stakeholder preference for various aspects of the ELC program. The input ranged from questions regarding individual need for the certification to the cost of the certification. Additional key points included learning options, comparison with other certifications, and economic value of this certification.

Results and Discussion. While determining the factors important to the ELC framework, five well-known certifications were compared (Table 1). These certifications are available, but are not mandatory. Comparison of participant cost, time to complete, written exams, hands-on exams, continuing education credits, retest fees, and online testing help guide the basic structure for the new ELC program. Topics now included in the ELC certification are as follows: general information, turfgrass, landscape plantings: shrubs/herbaceous, tree management, water, low impact development strategies, plant identification, integrated pest management, and equipment maintenance and calibration. These modules are being created by students, faculty, and extension agents from Clemson University. Modules will be reviewed by members of the industry to ensure that content is easily digestible and practical. Each module will be available in Spanish, however testing will only be offered in English.

Most survey respondents indicated that having Clemson University administer the ELC was extremely important to them (Figure 1), most indicated that the ELC would provide both professional (Figure 2) and personal value (data not shown). Respondents understand that completing the ELC will improve their skills, and subsequently improve their marketability to clients.

In order to gauge feasibility of using an on-demand, Web based delivery system for ELC program content, we surveyed industry professionals about the availability of a computer with internet access. Ninety-two percent of the respondents had access to a computer connected to the internet. Respondents preferred to work through learning modules and take respective tests from home (65 and 60%, respectively) as compared to the office (34 and 35%, respectively). Respondents prefer to learn on-line by viewing and listening to a narrated video (44%), with only 24% preferring to read PowerPoint slides and 21% preferring to read PowerPoint slides while listening to a narrator/ speaker. All other learning options were preferred by < 5% of the respondents.

The preferred costs for completing an on-line ELC program and annual recertification was $100-149 (55% of respondents) and $50-99 (72% of all respondents) respectively. In each case, these were the lowest options available that respondents could select.

The three main benefits of developing the ELC program in SC include: (1) enhancing landscape contractor marketability and economic profitability, (2) enhanced landscape aesthetics with better plant survival and subsequent long-term return on-investment for urban landscape owners, and (3) conservation and protection of natural resources via enhanced planting, irrigation, pest, and stormwater management practices.

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Literature Cited

Oregon.gov. 2014. Landscape Contractors Board Licensing. *Accessed* 19 June 2014. <http://www.oregon.gov/LCB/pages/licensing.aspx - section0>.

McCarthy, Kevin . 2000. Environmental Effects of Lawn Treatment. *Accessed* 19 June 2014. <http://www.cga.ct.gov/2000/rpt/2000-R-0597.htm>.

Table 1: Program framework comparison to assist with re-developing an online-South Carolina Environmental Landscape Certification program.

	ELC	GGIA[z]	PLANET[y]	UGA[x]	NCNLA[w]
Participant Cost		$165	$700	$379	$225
How long to complete		2 yrs	3 yrs	1 yr	
Written exam	Y	Y	Y	Y	Y
Hands-on exam	Y	Y	Y	N	Y
Continuing education requirement		15 hrs		12 hrs	PLANET
Retest fee (hands-on / written)		$45	$50	$30	$25
Online testing			Y	N	N

[z] Georgia Green Industry Association – Georgia Certified Landscape Professional Program
[y] PLANET – Professional Landcare Network, Landscape Industry Certified Technician – Exterior
[x] University of Georgia – Principles of Turfgrass Management Certificate Program
[w] North Carolina Nursery and Landscape Association – Landscape Industry Certified
[v] Abbreviations: Y = Yes, N = No, if left blank, information not provided.

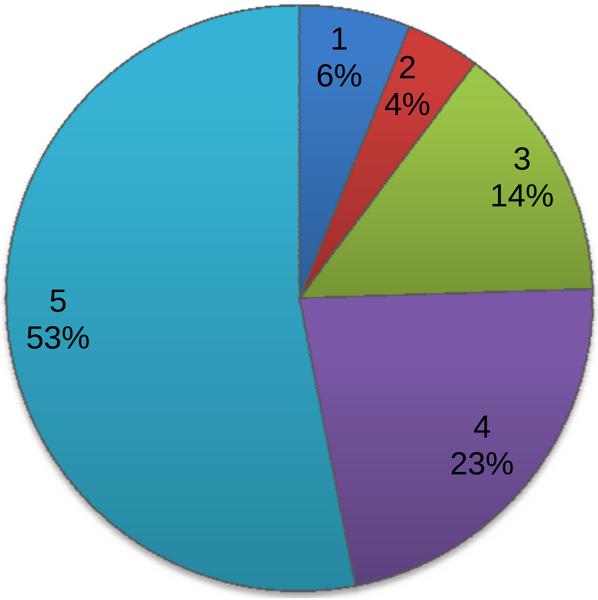

Figure 1: Value of an on-line SC ELC administered by Clemson University. The numbers represent respondent opinion and the relative percent frequency of each response. 1 = not important, 2 = somewhat important, 3 = moderately important, 4 = very important, and 5 = extremely important.

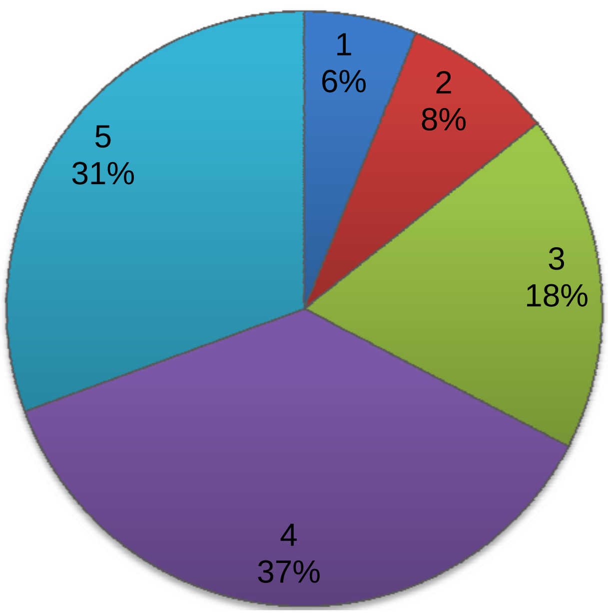

Figure 2: Survey respondent perception of professional importance of earning green industry certification. The numbers represent respondent opinion and the relative percent frequency of each response. 1 = not important, 2 = somewhat important, 3 = moderately important, 4 = very important, and 5 = extremely important.

Landscape Evaluation and Introductory Overview of New *Lagerstroemia* Series and Cultivars

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Significance to Industry: This is the very preliminary early results and introductory discussion of a new research trial. There is much interest in side by side comparisons of the many new *Lagerstroemia* and this research project will yield good results in a few more years. The additional planting in Nacogdoches, TX will provide some data from another geographical location and plants have additionally been distributed to Tom Ranney at the North Carolina State University Mountain Crop Improvement Lab, Mills River, NC.

Introduction: The LSU AgCenter's Hammond Research Station, Hammond, LA (USDA hardiness zone 8B) has begun a field landscape evaluation that includes many of the recently introduced crape myrtle varieties. Some of the trial plant varieties are also in a cooperative planting at SFA Gardens, Nacogdoches, TX (USDA hardiness zone 8A). We also have a few additional trial plants from Stan Brown in Arkansas and John Davy in Florida in evaluations.

Nature of Work: The collection of trial plants include the Early Bird, Enduring Summer, Delta, Barnyard, Magic and Ebony (aka Black Diamond), series.

The Early Bird series has been on the market the longest and was bred by John Davy at Panhandle Growers in Florida. They were released by Plant Development Services Inc. as part of the Southern Living Plant Collection. These are dwarf-growing plants maturing at 4 feet tall. Early Bird Lavender (soft lavender) is promoted as a very heavy earlier bloomer and is the earliest-flowering crape myrtle in LSU AgCenter trials. Other varieties include Early Bird Purple and Early Bird White.

For several years, the burgundy foliaged Delta Jazz (Chocolate Mocha), a semi-dwarf, brilliant pink from Plant Development Services Inc. has been on the market. This variety is part of the Southern Living Plant Collection series of Delta crape myrtles. Five-year-old plants of Delta Jazz are 8 feet tall in south Louisiana locations. Plants are classified as semi-dwarf, which generally indicates heights ranging from 8 to 12 feet. New for 2014 are four color additions – Delta Breeze (light lavender), Delta Eclipse (brilliant purple), Delta Moonlight (white) and Delta Flame (dark red).

The new dark burgundy-foliaged Ebony series from Cecil Pounders at the USDA - Agricultural Research Service (Poplarville, MS) are also being sold under the Black Diamond name by J. Berry Nursery, Grand Saline, TX. These plants supposedly mature at 8-10 feet tall and retain leaf color spring through fall. These plants have darker foliage than the Delta varieties. Flower colors include three shades of red, white and blush. Varieties are Black Diamond Best Red (Ebony Flame), Black Diamond Red Hot (Ebony Embers), Black Diamond Crimson Red (Ebony Fire), Black Diamond Pure White (Ebony and Ivory), and Black Diamond Blush (Ebony Glow).

Red Rooster (brilliant red), Purple Cow (deep purple) and Pink Pig (soft pale pink) are being sold as mid-sized growers and are promoted collectively as the “Barnyard Favorites” in the Gardener’s Confidence Collection. Red Rooster is “something to crow about,” Pink Pig is “something to squeal with delight” and Purple Cow can be used to create an “udderly majestic garden.”

The Magic series from Plant Introductions, now part of the First Editions program by Bailey Nurseries, includes Coral Magic (salmon pink), Purple Magic (dark purple), Plum Magic (fuchsia pink), Moonlight Magic (white) and Midnight Magic (dark pink). Most of these have reddish, plum or burgundy spring leaves, and some of these varieties retain this color through the fall. Mature height is supposedly 8-12 feet.

The Princess series is a new dwarf group developed by Dow Whiting at Garden Adventures Nursery in Missouri. It is being marketed as part of the Garden Debut program by Greenleaf Nursery, Park Hill, OK. This series includes Holly Ann (cherry red), Kylie (magenta pink), Zoey (cherry red with cotton candy pink), Jaden (lavender) and Lyla (rose pink).

Ball Ornamentals has the new Enduring Summer collection of crape myrtles. Varieties are Enduring Summer Red, Enduring Summer Fuchsia, Enduring Summer Pink, Enduring Summer White and Enduring Summer Lavender. The Enduring Summer varieties have an upright habit. Mature height is 5-6 feet with a 4 1/2-foot spread.

A replication field study was established in spring 2013. A field was established in a full sun area at the LSU AgCenter Hammond Research Station. The soil is a cabana silt loam. Soil pH was adjusted to 6.0-6.5 with dolomitic lime. Plants are spaced in five foot wide rows spaced ten feet apart with turf maintain in middles. Plants are spaced 10 feet within rows. Drip irrigation via 1 gal/hour emitters are on each individual plant. Plants will be fertilized each spring at new growth initiation with approximately 1 lb. N/1000 ft^2 from a three month controlled released fertilizer. Fungicides and insecticides are not being applied. Weeds are controlled via hand removal at plant bases along with pre-emergent and post-emergent herbicide applications.

Data collection in 2013 and the future will include plant height (data not show), date of first flower, number of weeks in bloom, visual quality ratings, and *Cercospora* leaf spot ratings (Table 1). A winter damage rating was taken spring 2014 (Table 1).

Observations for bacterial leaf spot (*Xanthomonas axonopodis*) will also be conducted. This study will continue through 2016.

Results and Discussion: Due to a slight variation in planting time in the spring of 2013, data for all varieties is not included in this preliminary reporting. The Early Bird varieties are generally earlier bloomers based on this first year of observations and previous years studies. Early Birds have higher susceptibility to *Cercospora* leaf spot (and possibly bacterial leaf spot). Quality ratings were highest for the Delta and Black Diamond series in 2013, followed by the Enduring Summer varieties. An important observation from 2013 trials is the winter damage experienced between December 2013 and March 2014. Temperatures in the mid-teens were recorded several times in Hammond. Terminal dieback in plants ranged from none to 90%. Enduring Summer varieties and some varieties in the Magic and Black Diamond series were most affected.

Table 1. Date of first flower, average weeks in bloom, visual quality ratings, *Cercospora* leaf spot ratings and winter damage of varieties in seven new series of *Lagerstroemia* at the LSU AgCenter Hammond Research Station, Hammond, LA. 2013.

	First Flower[z]	Weeks in Bloom[y]	Quality Rating[x]	*Cercospora* Leaf Spot[w]	Winter Damage[v]
Early Bird					
• Lavender	May 5	16	2.6	high	28%
• White	May 24	10	2.7	high	50%
• Purple	May 30	12	2.8	high	50%
Princess					
• Zoey	---	---	---	---	40%
• Kylie	---	---	---	---	0%
• Holly Ann	---	---	---	---	0%
• Lyla	---	---	---	---	---
• Jaden	---	---	---	---	---
Magic					
• Coral	June 13	5	2.7	medium	75%
• Plum	June 17	5	3.2	low	50%
• Purple	---	---	2.9	low	20%
• Moonlight	---	---	---	---	---
• Midnight	---	---	---	---	---
Black Diamond					
• Best Red	---	---	3.5	low	50%
• Red Hot	---	---	3.9	low	30%
• Crimson Red	---	---	3.6	low	50%
• Pure White	---	---	3.5	low	70%
• Blush	---	---	3.5	low	25%
Barnyard					
• Red Rooster	June 18	9	2.8	medium	53%
• Purple Cow	June 16	6	2.6	medium	3%
• Pink Pig	---	---	---	---	---
Enduring Summer					
• Red			3.5	medium	50%
• Purple			3.2	medium	70%
• White			3.2	low	90%
• Pink	---	---	---	---	---
• Fuchsia	---	---	---	---	---
Delta					
• Jazz	June 5	15	4.2	low	0%
• Breeze	---	---	4.5	low	13%
• Flame	---	---	4.2	low	20%
• Eclipse	---	---	4.4	low	40%
• Moonlight	---	---	4.3	low	27%

[z] First flower is date of first open bloom.
[y] Weeks in bloom is date of first open bloom until no visible flower.
[x] Visual quality ratings taken twice monthly spring through fall and based on a scale from 1 to 5 (1=dead, 2=below average, 3=average, 4=above average, and 5=superior landscape performance)
[w] *Cercospora* leaf spot ratings based on 1 to 6 where 1=no leaf spot, 2=1-10% foliage with leaf spot, 3= 11-25% foliage with leaf spot, 4=26-50% foliage with leaf spot, 5=51-75% foliage with leaf spot, and 6=76-100% foliage with leaf spot but listed here as a summary (low, low/medium, medium, medium/high or high).
[v] Winter damage (% terminal dieback) taken spring 2014.
Princess varieties added to planting September 2013 and June 2014. Moonlight Magic and Midnight Magic added to planting April 2014. Enduring Summer Pink, Enduring Summer Fuchsia and Pink Pig not yet added to planting.