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Abstract

This project will evaluate the drought tolerance of 4 native plants suitable for ornamental planting, across a gradient of rainfall typically found in the US Virgin Islands. Survival and growth rates will be measured. Other physiological parameters will be measured for use in future studies. An undergraduate student will be employed to help produce plants for the study, help with data collection and statistical analysis of the data. The results from this research will provide vital information about for operators of plant nurseries and landowners on the water requirements of native plants used for landscaping. It is hoped that the more wide spread use of native plants around buildings will conserve both water and biodiversity.

Evaluating Drought Tolerance of Virgin Islands Native Trees Suitable For Landscaping

Statement of Regional or State Water Problem

The focus of the proposal is to study drought tolerance of native trees in a nursery setting in order to conserve water usage and promote the conservation of biodiversity.

New urban and residential developments require landscape planting. Research in the Biotechnology and Agroforestry Program at the University of the Virgin Islands Agriculture Experiment Station (UVI-AES) supports the preservation of native flora through investigations into the propagation of native plant species. One of the program's goals is to provide research supporting local plant nurseries growing native plants for their use in landscaping around homes and businesses. The demand for ornamental plants is rising as the islands of St. Croix, St. Thomas, and St. John become more urbanized. Plant nurseries are a growing segment of the local economy. Programs that promote using native, ornamental plants within their native range have recently become successful in several states and a similar approach in the US Virgin Islands is strongly advocated by the US Forest Service (Overton, et al., 2006).

Fresh water is limited on the island of St. Croix. Rainfall is seasonal. There are no perennial streams or lakes to provide fresh water. Fresh water can be obtained by collecting rainwater in cisterns for later use, from wells that tap the subterranean aquifer, or buying it from the Virgin Islands Water and Power Authority. Fresh water provided by the Virgin Islands Water and Power Authority is expensive because it comes from a desalination plant.

Plant nurseries, particularly, those specializing in showy "tropical" plants such as species in the *Heliconaceae*, *Musaceae,* and *Zingiberaceae* families, need abundant water. They can not depend on rainfall alone in the US Virgin Islands. During the dry season, access to well, municipal water or a pond is necessary to keep these plants alive. In order to remain profitable and stay in business, plant nurseries need to produce plants at a price people are willing to pay, while generating sufficient demand for landscaping plants. Two ways to reduce costs are to closely monitor water use and to grow native plants that are adapted to the dry environment of the U.S. Virgin Islands.

The University of the Virgin Islands, Agriculture Experiment Station (UVI-AES) has led native ornamental plant research in the territory on over 30 species of woody plants, including federally and territorially endangered species.

Statement of Results or Benefits

The primary outcome of this project will be a rich data set describing growth rates of a subset of the wide range of native plants used capable of being used for ornamental plantings under varying moisture regimes. This will help property owners select the appropriate plants for their properties and nursery operators will know how much water they need to apply to their plants to either optimize growth or conserve water, depending on circumstances.

The results of this experiment will be written for publication in a peer-reviewed scientific journal. Three possible outlets are Restoration Ecology, Journal of Forest Ecology and Silviculture and The Journal of Fruit and Ornamental Plant Research. The results will also be presented at the Urban Forestry Conference. Fact sheets with photos about the species studied and the results of the experiment will be written for the general public.

Methods, Procedures and Facilities

Four species of native plants with potential for use as ornamental plants will be subjected to 3 regimes of water stress. The plants will be grown in a peat, top soil, and sand (2:1:1) planting substrate, whose soil water will be maintained at field capacity, 2/3 field capacity and 1/3 field capacity. Research will be performed in a green house at the University of the Virgin Islands' St. Croix campus.

The four species chosen for study are: Kapok, (*Ceiba pentandra*), Inkberry, (*Randia aculeata*), Turpentine tree,(*Bursera simaruba*), and Torchwood, (*Jacquinea arborea*). Kapok is a tree that visually dominates the landscape due to its very large size. It makes a good center piece or focal point in a park or large garden. When it flowers at the beginning of the dry season in December, it has showy pinkish white flowers. When it loses its leaves in the dry season, its architecture of heavy branches is on display. Inkberry is a small tree with fragrant white flowers year round. Its reduced size makes it ideal to plant in small gardens. It is a culturally significant tree, because in the past, islanders used it as a Christmas tree, because there are no conifers native to the island. Turpentine tree has attractive smooth coppery bark that makes it stand out on forested hillsides. Its medium size makes it good to plant around houses and along streets. It resists wind and salt. It casts a light shade which does not inhibit the growth of grasses underneath. Torchwood is another tree resistant to wind and salt. Its compact size makes it good to plant in small gardens. The flowers are white and bell shaped with an attractive fragrance. It has a dense compact crown of stiff dark green leaves. The fruit is an inedible, dry orange berry.

Seedlings will be grown in containers for 11 months. They will be started from seed in germination trays in the green house. When the seedlings have extended two adult leaves they will be transplanted into 11 liter pots filled with a mix of potting mix and sand and top soil in a 2:1:1 ratio (O'Donnell, 1994).

Peat and sand are known to be nutrient poor substrates. In order to determine the correct amount of fertilizer to add, soils tests will have to be performed on the planting substrate. Based on the results, applications of fertilizer can be determined. To compensate for any nutrient deficiencies that develop over time, 4 grams of slow release Osmacote ™ 14-14-14 fertilizer will be added to the pots 2 weeks after transplant as per (Svenson, 1993, Docherty, 1997, O'Donnell, 1994). Fertilizer will be added three times during the course of the study; once two weeks after transplant to the pots, then again at the 5 month point and the 10 month point.

The seedlings will be allowed to grow and firmly establish themselves in the containers for 4 months prior to the start of the drought experiment. They will be kept well irrigated and fertilized, in order that the seedlings are in good health and growing vigorously when the treatments start. It is hoped that by this time, stems will have lignified.

Plants will be established in a randomized complete block design. The experimental unit will be an individual plant. There will be 2 blocks. Each block will be a greenhouse bench with 6 individuals of each species for a total of 48 plants per bench. Each plant will be randomly assigned a treatment (or level of irrigation) and a place on the bench. Since there are 3 irrigation treatments, 4 plants of each species in each block will be subjected to each drought treatment.

In order to determine proper irrigation levels, a subset of the plants will be watered, until field capacity is reached. The moment where field capacity is reached is the moment where excess water runs out of the bottom of the planting container (Brady & Weill, 2002). This water will be collected in a pan and weighed in order to determine the volume of water necessary, to apply to each plant to the different watering regimes (Arndt et al., 2001., Gullo et al., 1998., Angelopoulos et al. 1996). We will subtract the weight of the water that runs out from the total amount of water applied. One gram of water is equal to one cubic centimeter. Also, in order to cross validate our method, a subset of plants will be subjected to another technique of calculating the water necessary for the planting substrate to reach field capacity. Pots of dry substrate will be weighed, and then water will be added until field capacity is reached and all the excess water runs out. Then, these moist pots will be weighed again. The difference between the moist and dry pots is the amount of water that needs to be applied.

The amount of water present in the soil and the amount of water available to plants are of equal importance (Brady & Weill, 2002). Soil moisture will be measured via digital moisture meter and plant water potential via tensiometers. There will be 16 tensiometers, with one tensiometers randomly assigned to each row.

Plants will be watered every 3 days, because a prior study of Mahogany, (*Swietenia mahagoni)*, Caoba, (*Swietenia macrophylla)* , and the hybrid mahogany (*Swietenia mahagoni x macrophylla*), at UVI showed that daily watering decreased plant growth (O'Donnell, 1994). We are using the same planting substrate that O'Donnell used. Temperatures on St. Croix are not limiting to plant growth and day length varies two hours between the summer and the winter (Sloan et al. 2006). Both Mahogany and Caoba evolved in seasonally dry tropical forests, although Mahogany is the more drought resistant of the two species.

Plant growth will be measured by taking monthly measurements of stem diameter at the root collar, total height, number of branches, and crown diameter. Crown diameter is the average of diameter measured in the perpendicular and the parallel. Other more descriptive plant recorded will be biomass of leaf fall and date of leaf fall, if the plants lose their leaves due to water stress. Finally, at the end of the experiment, all the plants will be harvested and dried in an oven. The dried biomass of the plants will be separated into its respective components: roots, shoots, and leaves. Root shoot ratios per species will be calculated. A higher proportion of roots to shoots suggest better drought tolerance.

Statistical analysis on the final data set will allow for meaningful comparison of the variables between treatments and among tree species. Analysis of variance (ANOVA) will be used to detect statistically significant differences between treatment means. Where differences are detected, pair-wise comparisons will be made using t-tests. Growth biometrics will be charted against the different watering regimes. Non parametric tests will be used to determine whether the data is normally distributed.

Related Research

The primary investigator wrote his masters thesis about quantifying the drought resistance and physiological responses of *Bursera graveolens*, a deciduous tree native to the tropical dry forests of coastal Ecuador and Peru. One of the subject species of this research proposal, Turpentine Tree, (*Bursera simaruaba*), is a congener of *B. graveolens* .

Training Potential

An undergraduate student will be hired to help with experiment set up, data collection and analysis. It is expected that he or she will work for 20 hours a week during the course of the experiment. He or she will learn about experimental design, production of plants in a green house, use of scientific instruments, and the statistical analysis of data.

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Gullo, M. A., Nardini, A., Salleo, S., and Tyree, M. T., 1998. Changes in root hydraulics conductance (K_R) of *Olea oleaster* seedlings following drought stress and irrigation. New Phytologist. 140:25-31

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Svenson, S.E., 1993.Growth response of West Indian mahagony to Continumem^tm or Osmocote ^tm during transplanting. TropicLine. 6(1):1–6

Investigators Qualifications

Michael John Morgan

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Biotechnology & Agroforestry, RR 1 Box 10,000	FAX: (340) 692-4035
Kingshill, St Croix, VI 00850	Email: mmorgan@uvi.edu

PROFESSIONAL EXPERIENCE

Agro-forestry Research Specialist: (August, 2010 - Present)
Agricultural Experiment Station,
University of the Virgin Islands, St Croix, USVI

- Collect seeds of federally and locally endangered tropical dry forest trees native to the US Virgin Islands, and determine how to best propagate these species in a greenhouse or nursery.
- Record phenology data, such as leaf flush, flowering and fruiting of these species.

- Plant seedling of the propagated species in field, and record growth and survival.

Research Assistant: (January 2010 to July 2010)
Forestry Dept and Soils Department
University of Florida, Gainesville, Florida

- Layout of a clonal pine field trial, Collection of growth and plant architecture data from a 2 year loblolly pine old plantation.
- Collection of algal and water samples for a study using algae to reduce nitrogen and phosphorus content in river water. General lab work.

Teaching & Research Assistant, (August 2006 to December 2009)
Forest Ecology and Ecosystem Restoration Lab
University of Florida, Gainesville, Florida

- Collect baseline vegetation data and marking of trees for uneven-aged forest management in a hardwood hammock forest and in a slash pine plantation.
- Translate scientific articles for publication from Spanish into English.
- Occasional international forestry consultant; marked 10 hectare teak plantation for a thinning, & writing silvicultural guide for 20 tropical dry forest species.

Manager of Forestry Operations, (February 1998 to July 2006)
Fundación Pro-Bosque, Guayaquil, Ecuador

- Supervised the production of dry tropical forest tree seedlings and native fruit trees in a nursery with an annual production of 40,000 plants.
- Designed and executed tropical dry forest and mangrove restoration projects. Wrote the proposals and budgets for funding these projects
- Mapped park land and future land acquisitions for the Cerro Blanco Protected Forest using traditional maps and satellite images with the help of GIS and AUTOCAD programs.
- Participated in the drawing up of environmental impact statements as a forest expert.

Peace Corp Volunteer, (February 1995 to December 1997)
Fundación Pro-Bosque, Guayaquil, Ecuador.

- Propagated little known tree species such as Seca (*Geoffroae spinosa*) and Palo Santo (*Bursera graveolens*).Collected seeds of dry forest trees to produce seedlings for reforestation projects.
- Performed tree inventories of existing plantations and permanent forest plots.

Forestry Technician (April, 1992 to January, 1995)
The USDA Forest Service, Center for Forested Wetlands, Charleston, South Carolina

- Managed a network of computerized weather stations for project studying the effects of climate and soils on the growth of Loblolly Pine (*Pinus taeda*).
- Worked as a wild lands fire fighter in Montana and Idaho.

Forest Firefighter (May, 1991- October, 1991)
The US Fish and Wildlife Service: Long Island Complex of Refuges. Shirley, New York.

- Trained as a wild lands firefighter. Cut firebreaks around reserve with a chainsaw.

EDUCATION

Masters of Science in Forest Resources and Conservation, the University of Florida, Graduation December, 2009

- Thesis title: Physiological adaptations to drought of the tropical dry forest tree, *Bursera graveolens*, its suitability for use in the restoration of minelands, plus increasing its seed germination through pretreatments.

Bachelor of Science, Forest Science, the Pennsylvania State University, December 1990

Co -Investigator's Qualifications

THOMAS W. ZIMMERMAN
Biographical Sketch/CV

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Education:

PhD	Horticulture, Texas A&M University 1990
MS	Crop Science, Texas Tech University 1987
BS	Horticulture, University of Minnesota 1982

Continuing Education:

2007 Six month sabbatical leave at Wageningen University, Plant Research International, The Netherlands. Research focused on the development of *Manihot esculenta* embryogenic callus lines for genetic engineering from commercially important cassava cultivars.

Research Positions:

2005 to present-- University of the Virgin Islands Agricultural Experiment Station, VI Research Associate Professor/Program Leader Biotechnology & Agroforestry

1999 to 2005--University of the Virgin Islands Agricultural Experiment Station, VI Research Assistant Professor/Program Leader Biotechnology & Agroforestry.

1995 to 1999--UVI-AES, VI Research Assistant Professor/Program Leader Biotechnology.

1993 to 1994--UVI-AES, VI Research Specialist III/Biotechnology Developed a Biotechnology lab and program for tropical crop plants.

1990 to 1993--USDA-ARS Appalachian Fruit Research Station, WV Research Associate/Plant Physiology Research involved development of systems for micropropagation and meristem genetic transformation of peach cultivars.

Teaching:

1999-present	Biology 495: Directed Independent Research, UVI, St Croix, VI
2002-present	Science 301: Principles of the Natural World, UVI
2003	Science 100: The Natural World and the Caribbean, UVI
2003-present	Adjunct Professor University of Florida

Professional Activities:

1998-present	Caribbean Plant Genetic Resources Technical Advisory Committee
1999-present	Southern Regional Germplasm Technical Advisory Committee
2004-present	Southern Regional USDA-SARE Technical Advisory Committee

Editor

2000 Proceedings of the 5th Annual Caribbean Urban Forestry Conference, St. Croix, USVI, May 22-25, 2000. pp170.

2002 Proceedings of the 7th Annual Caribbean Urban Forestry Conference & 11th Caribbean Foresters Meeting, St Thomas, USVI, June 9-14, 2002. pp205.

2004 Proceedings of the 9th Annual Caribbean Urban and Community Forestry Conference, St John, USVI. June 14-18, 2004. pp116.

Selected Publications:

Daley, B.F., T.W. Zimmerman. 2009. Germinating five forest tree species native to the Virgin Islands. Tree Planter' Notes 53(1):10-15.

Dhekney, S. A., Z. T. Li., Z. T., Zimmerman, T. W., and Gray, D. J. 2009. Factors influencing genetic transformation and plant regeneration of *Vitis*. Am. J. Enol. Vitic. 60(3):285-292

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Kowalski, J.A., T.W. Zimmerman 2004. Trials of passion fruit in the U.S. Virgin Islands. Proc. 40th Caribbean Food Crops Society 40:72-78.

Kowalski, J.A., T.W. Zimmerman 2006. Papaya Characteristics under different Spacing Regimes. Proc. 42nd Caribbean Food Crops Society. 42:399-402.

Wiltshire, J., T.W. Zimmerman 2005. Early Use of Cassava in the Virgin Islands. Agfest 2005 34:34.

Zimmerman, T.W., J.A. Kowalski. 2004. Breeding and Selection for Early Bearing Papayas. Acta Hort. 632:53-55.

Zimmerman, T.W., N. de Vetten, K. Raemakers. 2006. Two Years of Cassava Field Trials from Micro-propagated Plants. First International meeting on Cassava Breeding, Biotechnology and Ecology. Brasilia, Brazil, 11-15 November, 2006. 1: 69-77.

Zimmerman, T.W., J.A. Kowalski 2007. Development and Selection for Homozygous Transgenic Papaya Seedlings. Acta Hort. 740:177-182.

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Zimmerman, T.W., J.A. Kowalski and D.J. Gray. 2007. Field evaluation of transgenic grapes for disease resistance in the US Virgin Islands. Proc. 43rd Caribbean Food Crops Society. 43:226.

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Abstracts

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Dhekney, S.A., Z.T. Li., M. Dutt, T.W. Zimmerman, and D.J. Gray, Greenhouse Screening and Field Testing of Transgenic Grapevine for Fungal Resistance. 2007 Annual Meeting Society for In Vitro Biology, In Vitro, 43, 2007, S40.

Dhekney, S.A., Z.T. Li., M. Dutt, T.W. Zimmerman, and D.J. Gray, Overcoming obstacles to genetic transformation in *Vitis*. 2008 Soc. In Vitro Biol. Ann. Meeting, Tucson AZ, In Vitro Cell. Dev. Biol. 44, 2008, S40, P-1013.

Gray, D.J., Z.T. Li, S.A. Dhekney, D.L. Hopkins and T.W. Zimmerman. 2009. Green genetic engineering technology: Rearrangement of endogenous functional genetic elements to create improved grapevines. Society for In Vitro Biology, June 2009, Charleston, SC

Zimmerman, T.W. 2008. Evaluation of the growth and production of sorrel germplasm on calcareous soils. HortSci. 43(3):618.

BUDGET:

Item	Unit type	Quantity	Unit Price	Total Cost
Student Assistant	unit	1	$12,554.85	$ 12,554.85
Plant pots,(11 liters)	stack of 45	4	$37.00	$ 148.00
Promix .Spagnum moss	sack (107 liters)	6	$50.00	$ 300.00
Tensiometers	unit	16	$121.00	$ 1,936.00
Tensiometer service kit	unit	1	$270.00	$ 270.00
Digital Moisture Meter	unit	1	$249.95	$ 249.95
Soil Sieve Set	unit	1	$151.50	$ 151.50
Osmocote 19-6-12 fertilizer	jar, 1.25 lbs	5	$10.00	$ 50.00
Felco Pruners hand pruners	unit	2	$54.80	$ 109.60
GRAND TOTAL				$ 15,769. 90