

2007

# Evaluating seashore Paspalum seed germination and enhancement, erosion abatement and potential use as a vegetative landfarm cap

Dexter Paul Fontenot

*Louisiana State University and Agricultural and Mechanical College*

Follow this and additional works at: [https://digitalcommons.lsu.edu/gradschool\\_theses](https://digitalcommons.lsu.edu/gradschool_theses)

---

## Recommended Citation

Fontenot, Dexter Paul, "Evaluating seashore Paspalum seed germination and enhancement, erosion abatement and potential use as a vegetative landfarm cap" (2007). *LSU Master's Theses*. 1787.

[https://digitalcommons.lsu.edu/gradschool\\_theses/1787](https://digitalcommons.lsu.edu/gradschool_theses/1787)

This Thesis is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Master's Theses by an authorized graduate school editor of LSU Digital Commons. For more information, please contact [gradetd@lsu.edu](mailto:gradetd@lsu.edu).

EVALUATING SEASHORE PASPALUM SEED GERMINATION AND  
ENHANCEMENT, EROSION ABATEMENT AND POTENTIAL USE AS A  
VEGETATIVE LANDFARM CAP

A Thesis

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in the partial fulfillment of the  
requirement for the degree of  
Master of Science

in

The School of Plant, Environmental and Soil Sciences

by  
Dexter Paul Fontenot  
B.S., Louisiana State University, 2003  
December 2007

## **ACKNOWLEDGEMENTS**

I would like to thank my major professor, Dr. Edward Bush and my committee members Drs. Charles Johnson and Jeffery Beasley for their knowledge, support, and guidance throughout this study. I would also like to thank members of the faculty and staff of the Horticulture Department for their continued support. I would specifically like to thank Ms. Ann Gray and Mrs. Gloria McClure for assisting me with lab and field work. I would like to fondly express thanks to my wife Kathryn Fontenot for her help and encouragement during my graduate program. Finally, I would like to thank my family and friends for their support and interest in my academic endeavors.

## TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....	ii
LIST OF TABLES .....	v
LIST OF FIGURES .....	vi
ABSTRACT.....	vii
CHAPTER 1 .....	1
INTRODUCTION.....	1
Introduction.....	2
Salt Tolerance.....	2
Cold Tolerance .....	3
Wear Tolerance.....	4
Shade Tolerance.....	4
Maintenance .....	5
CHAPTER 2.....	7
LITERATURE REVIEW .....	7
Germination Studies Based on Temperature, Light, Seed Enhancement, and Salinity .....	8
Previous Studies on Rain Induced Erosion .....	14
Previous Studies on Brine Impacted Areas .....	18
CHAPTER 3.....	21
OPTIMUM TEMPERATURE FOR GERMINATION OF <i>PASPALUM VAGINATUM</i> ‘SEASPRAY’ .....	21
Introduction.....	22
Materials and Methods.....	22
Results .....	24
Discussion .....	26
CHAPTER 4.....	28
EFFECTS OF PRIMING ON <i>PASPALUM VAGINATUM</i> ‘SEASPRAY’ SEED ....	28
Introduction.....	29
Materials and Methods.....	29
Results .....	30
Discussion .....	34
CHAPTER 5.....	36
RAIN SIMULATION AND RUNOFF.....	36
Introduction.....	37
Materials and Methods.....	37
Results .....	39
Discussion .....	43

<b>CHAPTER 6.....</b>	<b>44</b>
<b>UTILIZATION OF <i>PASPALUM VAGINATUM</i> FOR A BRINE</b>	
<b>LANDFARM CAP .....</b>	<b>44</b>
<b>Introduction.....</b>	<b>45</b>
<b>Materials and Methods.....</b>	<b>46</b>
<b>Results .....</b>	<b>48</b>
<b>Initial Soil Nutrient Sampling.....</b>	<b>48</b>
<b>Initial Plant Nutrient Sampling .....</b>	<b>48</b>
<b>Final Nutrient Sampling.....</b>	<b>49</b>
<b>Biomass Results.....</b>	<b>51</b>
<b>Visual Rating Results.....</b>	<b>52</b>
<b>Seedling Coverage Results .....</b>	<b>53</b>
 <b>CHAPTER 7 .....</b>	 <b>57</b>
 <b>CONCLUSIONS .....</b>	 <b>57</b>
 <b>LITERATURE CITED .....</b>	 <b>60</b>
 <b>APPENDIX.....</b>	 <b>65</b>
 <b>VITA.....</b>	 <b>68</b>

## LIST OF TABLES

Table 6.1. Baseline plant tissue nutrition analysis.....	49
Table 6.2. Biomass yield of three grass species growing on a brine landfarm.....	51
Table 6.3 Visual ratings of three grass species grown on a solid waste surface impoundment .....	52
Table 6.4 Mean percent seed coverage by species according to depth.....	53
Table 6.5. Mean percent seedling canopy coverage by depth of river silt according to species .....	54
Table A.1. Baseline soil nutrition analysis .....	66
Table A.2. Monthly total precipitation at Georgia Gulf Vinyls, LLC .....	67
Table A.3. Monthly high and low mean temperatures.....	67

## LIST OF FIGURES

Figure 3.1. Schematic of placement of germination plates on thermal-gradient table .....	23
Figure 3.2. Germination % of <i>Paspalum vaginatum</i> ‘Seaspray’ seeds after 14d at four different germination temperatures.....	25
Figure 3.3. Mean germination time of <i>Paspalum vaginatum</i> ‘Seaspray’ seed after 14 days at four constant temperatures.....	26
Figure 4.1 Comparison germination percentage after soaking seed of <i>seashore paspalum</i> ‘Seaspray’ in various solutions.....	31
Figure 4.2. Seed germination as affected by light .....	32
Figure 4.3. Mean time germination by priming solution.....	33
Figure 4.4. Mean time to germination as influenced by light.....	34
Figure 5.1. Seed loss means.....	40
Figure 5.2. Soil loss means .....	41
Figure 5.3. Mean growth after rain simulation .....	42
Figure 6.1 Mean mass of grass tissue by treatment depth. ....	52

## ABSTRACT

Four temperatures were tested to determine the optimum temperature for seed germination of *Paspalum vaginatum* 'Seaspray' seed. Results indicated that *Paspalum vaginatum* germination percentage was greatest at 30°C. Three seed enhancement treatments were applied to *Paspalum vaginatum* seed to determine improvements in germination percentage and MTG of the seed. Potassium nitrate, GA, and soaking seed in distilled water yielded greater germination percentages than the dry control. Seeds subjected to enhancement treatments had significantly faster MTG rates than the dry control seeds. Seeds also had higher germination percentage with exposure to light when compared to seeds that germinated in conditions not exposed to light. MTG was not significantly different.

*Paspalum vaginatum* seed was allowed to germinate at 0, 14, 28, and 42 days, before a simulated rainfall. Mean seed loss was significantly greater at 0, 14 and 28d before the rainfall, then 42d before the rainfall was significantly lowest in soil loss. Mean growth of seedlings after the rain simulation was highest at 0 and 14d planted before rainfall.

*Paspalum vaginatum* was compared with *Cynodon dactylon* and *Eragrostis curvula* as a possible turfgrass selection for usage as a vegetative cap over a brine landfarm. Grasses were planted in depths of 0, 5.08, 10.16, and 15.24 cm of river silt over the brine field. Results indicated that *Paspalum vaginatum* assimilated significantly greater quantities of Na than *Cynodon dactylon*, and *Eragrostis curvula*. Chloride was the only analyte that was measured in significantly greater amounts when compared by species and depth. *Paspalum vaginatum* growing in 5.08 cm contained highest



concentrations of chloride in the plant tissue, indicating that *Paspalum vaginatum* would be a potential brine remediator species. The combined results from the four projects indicate that *Paspalum vaginatum* 'Seaspray' is a suitable turfgrass selection for the Gulf Coast states, especially in areas with saline soils.

**CHAPTER 1**  
**INTRODUCTION**

## **Introduction**

Seashore paspalum, *Paspalum vaginatum* Swartz, is a grass that is increasing in use as a turfgrass among southern state golf courses, athletic fields, and home lawns. As a turfgrass it is salt tolerant with other valuable characteristics, such as, flood tolerance, low fertility needs, and fast establishment. Currently there are only a few cultivars of seashore paspalum from which growers can choose. Some cultivars available on the market are ‘Seaspray’, ‘SeaIsle1’, ‘SeaIsle2000’, ‘SeaIsle Supreme’, and ‘Salam’. ‘Seaspray’ is the only cultivar for which seeds are available, while the others are only available as sod or plugs. This study will focus on the feasibility of seashore paspalum as a potential turfgrass selection for the Gulf Coast states.

## **Salt Tolerance**

Halophytes are defined as salt tolerant, salt loving, or salt water plants that have genetic, morphological, and physiological characteristics that enable survival in high salinity conditions where most domesticated crop species rarely survive (Glen *et al.*, 1999; Khan and Duke, 2001). *Paspalum vaginatum* is classified as a salt tolerant grass. This halophytic grass has been found to grow on coastal sites having seawater with 34,486mg L<sup>-1</sup> total soluble salts (Lee, 2004). Seashore paspalum was actually found growing on sand dunes exposed only to ocean water in South Africa (Duncan, 2002). Duncan, (1997), found that seashore paspalum can withstand ocean water at about 34,000ppm salt, sodium absorption ratios greater than 26 and soluble salts with electrical conductivity exceeding 22.5 decisiemens per meter. The use of irrigation water with high soluble salt content is feasible with seashore paspalum.

The effect of Na is measured as Sodium Absorption Ratio (SAR) as shown in the following equation;

$$\text{SAR} = \sqrt{\frac{\text{Na}^{++}}{\text{Ca}^{++} + \text{Mg}^{++}}}$$

The USGS defines SAR as “the expression of relative activity of sodium ions in exchange reactions within soil and is an index of sodium or alkali hazard to the soil. Sodium hazard in water is an index that can be used to evaluate the suitability of water for irrigating crops” (USGS, 2005).

Trenholm (2006) reports from work in Florida that seashore paspalum has excellent tolerance to saline or recycled water. Duncan (2002) reported short-term use of ocean water with proper management will not adversely affect the seashore paspalum grass. It is known that some golf courses irrigate seashore paspalum with seawater, however, Ralish (2006) reported that it is beneficial to irrigate seashore paspalum occasionally with freshwater to prevent a build up of salt in the soil.

### **Cold Tolerance**

Seashore paspalum, a warm season turf-grass, has a low chilling tolerance that enables it to retain its green color into the winter months. It is reported that ‘SeaIsle2000’ has the highest degree of winter hardiness among the current list of cultivars (Duncan, 2002). Although the grass has good winter hardiness, Ralish (2006) found that seashore paspalum goes dormant at 13°C. To ensure a green lawn during the winter months, seashore paspalum can be over-seeded with most cool season grasses but the dense canopy warrants the use of a verticutter to ensure good seed to soil contact for the cool

season grass (Duncan, 2002). Duncan (1997) stated that ecotypes of seashore paspalum such as 'Adalayd' and its derivatives normally die at about -8°C; however newer and fine-textured ecotypes can survive to -22°C. When the weather warms, seashore paspalum has the tendency to recover more slowly after freezing conditions than bermudagrass (Cardona, 1997).

### **Wear Tolerance**

Reports on wear tolerance of seashore paspalum have generally been favorable. Trenholm (1999) reported that Temple1 and SIPV-2, two paspalum ecotypes are suitable for use in areas where high quality, traffic tolerant turf-grass is required. Vanatta (2005) reported that seashore paspalum was used to replace bermudagrass on a grass horse track. Studies were conducted both on the track and in a laboratory that showed seashore paspalum recovered faster than bermudagrass after being trampled by the horses. Research was also conducted to enhance the wear tolerance of the grass. Researchers at the University of Georgia conducted experiments on the effects of N and K applied to seashore paspalum. Field studies were conducted on U.S. Golf Association specification greens at Tifton, Georgia with N rates of 196 and 392 kg/ha and K rates of 92 and 392 kg/ha (Trenholm, 2001). They found that turf recovery was sufficient with moderate applications of N. K had no major effects on wear tolerance (Trenholm, 2001).

### **Shade Tolerance**

Seashore paspalum is more tolerant to shade than bermudagrass, but is less tolerant than zoysia or St. Augustinegrass (Duncan, 1997). Seashore paspalum has been reported to withstand about 30% shade and remain green and lush. Tolerance to shade is a very important trait when choosing a turfgrass specie for home lawns.

## **Maintenance**

Seashore paspalum is adapted to many different soil types and drainage conditions. Seashore paspalum is often referred to as a low maintenance grass. Seashore paspalum has the ability to root and live in sand, heavy clay, and mucks or bogs equally (Duncan, 2002). Also, paspalum is ideal for wet, boggy areas where drainage can be a problem (Ralish, 2006). Seashore paspalum is reported to have few insect and disease problems in most environments; its dense growth habit discourages weed competition; and has a relatively low fertility input needed to produce a dark green lawn (Trenholm, 2006). The general recommendations suggest that grass be mowed at 2.5 to 5.1 cm. Also, Trenholm (2006) reported seashore paspalum can become “thatchy” if over fertilized or over irrigated requiring verticutting. Another positive aspect of this grass is that it requires less N than other warm season grasses. Trenholm (2006) found that grass clippings used on the lawn serve as a nutrient source that reduce fertilizer requirements of seashore paspalum, however, it is recommended that no more than 5 pounds of N/1000 sq ft be used per year (Ralish, 2006). Duncan (1997) stated that with 1 to 2 pounds of K/1000 sq ft, paspalum will produce more roots, and have accelerated establishment and grow-in. Few herbicides are labeled for seashore paspalum at this point. Trenholm (2006) reported that seashore paspalum is sensitive to many common herbicides and can be killed by their use. Ralish (2006) reported that researchers at the University of Guam used seawater as a selected herbicide for seashore paspalum.

The objectives of this study were to determine: 1) Optimum temperature of germination of seashore paspalum ‘Seaspray’ seed. 2) Priming affects on seed condition. 3) Effects of seed priming and the loss of seashore paspalum seed during a heavy rain

event. 4) Establishment of seashore paspalum on an industrial site in which the soil contained a high concentration of NaCl. 5) Nutrient and elemental uptake by seashore paspalum grass from an industrial site with a high NaCl content soil.

**CHAPTER 2**  
**LITERATURE REVIEW**



## **Germination Studies Based on Temperature, Light, Seed Enhancement, and Salinity**

The most cost effective method of establishing a turfgrass at optimum temperatures is by seeding producing a stand quickly. If seashore paspalum is to be used as a turfgrass in Louisiana, it is important to determine the optimum temperature in which seeds will germinate. This experiment was undertaken to determine if seed would germinate when exposed to temperatures that would be expected to occur in Louisiana during spring and summer months. Seashore paspalum is classified as a warm season grass. Germination is most likely to occur at a time when seedlings can survive (Grappin et al., 2000). In addition to investigating temperature effects on mean time germination and germination percentage, it is important to take into account light exposure. In many plant species, light is one of the most important environmental regulatory signals that interacts with temperature to regulate seed germination (Baskin and Baskin, 1998).

Previous studies have also focused on optimum temperatures of other grass species. Kambizi, Adebola, and Afolayan (2006) studied temperature and light effects on seed germination of the *Withania somnifera* plant. This is a high-valued medicinal plant that researchers would like to germinate commercially. The study found that “the optimum condition for germination of the seeds in this experiment was alternating temperatures of 18 and 25°C under a 16/8 photoperiod” (Kambizi, 2006). Seeds were stored at constant temperatures of 45°C, 25°C, 35°C, and alternating day/night temperature (18-25°C). Researchers were trying to grow this plant in portions of Africa for medicinal purposes; therefore the high temperatures they studied were relevant. We looked at germinating *Paspalum vaginatum* ‘Seaspray’ under slightly cooler temperatures of 20, 25, 30, and 35°C temperatures because these temperatures reflect those typically

occurring in Louisiana. In a different study, temperature and light period effects on germination were studied for two caespitose shrubs, *Juncus actutus* and *Schoenus nigricans*. The shrubs used in Martinez-Sanchez's study are similar to *Paspalum vaginatum* in that these shrubs are typically found in salt marshes and *Paspalum vaginatum* is a halophyte grass species (Martinez-Sanchez *et al.*, 2006). Ungar (1977), Khan and Ungar (1997), and Khan and Gulzar (2003) all describe the process of light enhancing germination of halophyte seeds. Martinez-Sanchez *et al.* (2006) studied the germination of two halophyte shrubs under two photoperiods 12h:12h light: dark photoperiod and 24h dark environment and seven temperature regimes (10°C, 15°C, 20°C, 25°C, 30°C, 15:25°C, and 20:30°C). Researchers found that in the dark the optimum germination percentages were found at constant temperatures of 15 and 20°C, and alternating temperatures of 15:25°C. Little, to no germination occurred in the 30°C dark. However when the seeds were exposed to light and 30°C, very high rates of germination occurred  $97 \pm 3.8$  compared to  $1 \pm 2.0$  light photoperiod 30°C and complete dark 30°C conditions respectively. This study is relevant to ours because the seed germination percentage of these two halophyte shrubs increased in warm and light photoperiod conditions. Using this information we can anticipate similar results in our halophyte species *Paspalum vaginatum* 'Seaspray'.

Germination of *Prosopis juliflora* (Sw.) D.C., a mesquite tree, was evaluated for its ability to survive in desert, tropical, and subtropical regions, and potential use in saline soils. El-Keblawy (2004) noted that optimum germination of halophyte species often occurs under freshwater conditions or rainy seasons when salinity levels are decreased. Therefore, El Keblawy *et al.* (2005) tested different combinations of salinity, light, and

temperature affects germination. Germination experiments were conducted using three temperature conditions, 15, 25, and 40°C in either continuous light or dark photoperiods. Seven NaCl solutions of, DI only, 100, 200, 300, 400, 500, and 600 mM NaCl were tested under the treatment temperatures and photoperiod conditions. They used a modified Timson index of germination velocity =  $\Sigma G/t$ , where  $G$  is the percentage of seed germination at 2d intervals and  $t$  is the total germination period (Khan and Ungar, 1984). The maximum value possible was  $1000/20=50$ , the greater the value the more rapid the germination. El-Keblawy (2005) found significant effects for light, temperature, and salinity on final germination of *P. juliflora*. Non-salt treated seeds germinated well in all temperatures and light and dark photoperiods. However, as NaCl concentrations and temperature increased seed germination decreased. Optimal germination occurred at 25°C in both light and dark conditions. Germination at 15°C and 25°C were both significantly higher than 40°C. “The interaction effect of temperature and NaCl concentration on final germination was significant ( $p \leq 0.001$ ), indicating that the germination response to salinity depended on temperature” (El-Keblawy, 2005). The data also shows that at high salinity solutions germination was reduced more at 40°C than 15 or 25°C. Germination at 40°C was drastically reduced in the 200mM NaCl solution and no germination occurred in the 400mM NaCl solution. Light also played a factor in seed germination in this experiment. The interaction between light and temperature on final germination was significant ( $P \leq 0.01$ ) there were no differences in germination in 15 and 25°C conditions in light or dark; however, at 40°C germination was significantly greater in the light than the dark. The interaction between salinity, temperature, and light on final germination was also significant ( $p \leq 0.05$ ). At 40°C germination in light was significantly greater in

light than dark for seeds treated with lower salinities 0-100mM NaCl. Few seeds germinated in the 300mM and none in the 400mM NaCl at 40°C. Germination in 0 and 100mM NaCl increased from 45 and 38.7 percent for seeds incubated in dark to 68.7 and 61.2 percent for seeds incubated in light respectively. This data is relevant to our study because saline soils can be a problem in coastal Louisiana where flooding from brackish waters sometimes occurs. This information is important when determining optimum temperature and mean time germination of *P. vaginatum* in certain saline soil areas in Louisiana.

Delouche (1961) tested priming and light effects on the germination of centipede grass. Seeds were soaked for 16h in various solutions of GA concentrations. Seeds were allowed to dry before planting. One hundred seeds were planted in each petri dish and placed in a 20-30°C germinator. Some treatments were exposed to 100 foot candles of light for 8h each day. Other treatments were placed in black boxes in the germination chamber. Delouche found that under dark conditions 1000ppm GA was required to obtain maximum germination while under light conditions only 100ppm GA was required (Delouche, 1961). Bush et al. (2000) completed a study focused on increasing germination percentage and decreasing mean time of germination of centipede grass and common carpet grass. Four germination temperatures of 15, 20, 25, and 30°C were studied. These temperatures were obtained by using a thermo-gradient table. Six enhancement treatments were also studied. The treatments were DI water, 1%, 2%, 3%, and 4% KNO<sub>3</sub> solutions and an untreated control. Seeds were soaked for 48h in aerated distilled water or primed for 48h with KNO<sub>3</sub> solutions at 25°C. They found that priming common carpet grass and centipede seeds has the potential to improve seed

germination by reducing mean time germination when seed is planted at temperatures between 20 and 30°C. The results of the Delouche (1961) and Bush et al. (2000) studies show that GA and KNO<sub>3</sub> have positive effects on seed germination. Therefore, we will study the effect of both GA and KNO<sub>3</sub> on germination of *Paspalum vaginatum* ‘Seaspray’ seed.

Puppala (2002) conducted a study on *Lesquerella fendleri*, a potential oilseed crop, using GA and KNO<sub>3</sub> in solution, to improve germination while reducing light requirement for germination. Seeds were exposed to solutions with and without GA and KNO<sub>3</sub>. The carrier solvents used were distilled water, 95% ethanol, and acetone. The seeds were soaked in the solutions for 4 or 8h in a dark incubator at 25°C or dipped into the solutions for 2 to 3 minutes. Following treatments, seeds were allowed to dry. All treatments were evaluated under light and dark conditions in an incubator which provided alternating 15°C night and 25°C days with a 12h photoperiod. Germination counts were made every 3d for a 12d duration. Results show that all seed treatments germinated in light had 12 to 18 percent higher germination rates than those germinated in the dark. Additionally, presoaking seeds in an aqueous solution of 100mg GA for 4h and allowing the seeds to completely dry, enhanced early germination of seeds grown in light and “appeared to satisfy the light requirement when treated seeds were germinated in the darkness”(Puppala, 2002). The researchers also found that presoaking seeds in water alone deactivated the light requiring dormancy factor in seeds. In conclusion these researches found that seeds treated with GA enhanced germination effects of *L. fendleri* in the dark, however water alone, also enabled the seeds to germinate in the dark. This

suggests that GA as a presoaking treatment is not more effective than soaking seeds in water for germinating in the dark.

Nadjafi et al. (2006) aimed to determine a treatment that would stimulate and enhance germination of *Ferula gummosa* and *Teucrium polium*. *Ferula gummosa* and *Teucrium polium* are two important medicinal plants in Iran. The seeds of both plants have very low germination rates. Knowing that GA is a proposed hormone to control primary dormancy by inducing germination (Iglesias and Babiano, 1997), the researchers used it (GA) in their treatments for seed germination. The seed used in this study was collected sorted and sterilized by soaking in a 1% sodium hypochlorite solution for 5min. The seeds were then rinsed in sterilized water and subjected to the following treatments; soaking in HNO<sub>3</sub> for 10min, and for 30min; soaking in cool water for 72h; soaking in cool water plus GA<sub>3</sub> (250ppm, 48h); soaking in cool water (24h)+ 5°C (48h); cold stratification 5°C , 7d); ethanol 96% (24h); GA 100ppm, 250ppm, 500ppm, 1000ppm, 1500ppm, 2500ppm for 72h. Researchers found that regardless of the applied treatments to seeds of both species, germination rate positively correlated with germination percentage ( $r = 0.85$ ,  $p \leq 0.05$ ). This indicates that the faster seeds germinate the more seeds will germinate. As for treatments, the highest germination rate and percentage of germinated *T. polium* seeds were obtained at concentrations of 500 to 2500ppm GA<sub>3</sub>. For *F. gummosa*, increasing the concentration of GA<sub>3</sub> above 500ppm and increasing the duration of soaking from 48 to 72h, improved both the germination rate and percentage significantly ( $p \leq 0.05$ ) (Nadjafi et al., 2006). Sozzi and Chiesa (1995) studied breaking seed dormancy to improve seed germination of *Capparis spinosa* L. seed (Caper seeds). Their main objectives were to investigate a suitable pretreatment to overcome poor seed

germination and to better understand mechanisms responsible for seed dormancy in *Capparis spinosa* L. seed. They subjected the seed to 10 treatments including, soaking seeds, chilling seeds, dipping seeds in hot water, subjecting seeds to potassium nitrate, a potassium permanganate aqueous solution, GA, and sulfuric acid in various combinations. All seed treatments were placed in plastic bags and kept at  $25 \pm 1^\circ\text{C}$  in a germination cabinet with florescent light for 12h daily. Focusing on the GA treatment of this study, the researchers found that caper seeds were only sensitive to GA when they have been  $\text{H}_2\text{SO}_4$  pretreated. “In other species there is evidence that GA promotes seed germination by effecting the rate and extent of micropilar endosperm weakening prior to radical protrusion (Bewley et al., 1983; Groot and Karssen, 1987; Groot et al., 1988). The researchers decided that the primary control of germination in caper seeds must lie within the seed coat and GA helps only when the seed coat has previously been disrupted. Therefore GA alone did not improve seed germination of caper seeds.

### **Previous Studies on Rain Induced Erosion**

Carey et al. (2000) conducted a research project to determine if a product “Terra-Control” aided in the establishment of and prevented erosion in several turfgrass species including; Kentucky bluegrass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), fine fescue (*Festuca rubra*), and creeping bentgrass (*Argrostis palustris*). Carey et al. (2000) set up a complete randomized block (CRB) design of 8 treatments replicated five times. Treatments included Terra Control™ treatments and control treatments of the four newly planted turfgrass species. Each treatment plot was  $2 \text{ m}^2$  and on a  $15^\circ$  slope. All vegetation was removed from plots. A cm of topsoil was added and the 4 turfgrass species were seeded at recommended rates. 5mm/day water was applied to plots during the first week

of establishment. Plots were mowed once to 75 mm immediately before application of erosion to eliminate different height effects of vegetation. A rainfall simulator was set to feed water at a constant pressure of 10 psi. The nozzle was set at 1.25 m from ground level. The simulator was run for five minutes producing 50 mm of “rain” over each plot. Actual rainfall, over the plots, was calculated by rain gauges spaced every 1 meter on the treatment field plots. Researchers found that the Terra-control™ product did not aid establishment of the turfgrass but it did significantly decrease erosion from 17% erosion in control plots to 6% erosion in Terra-control™ treatment plots. Terra-control™ treatments provided reduction in erosion of sloped turfgrass slopes. Researchers believed that the 30d period between planting the turf seed and applying the simulated erosion had an effect on the amount of erosion that occurred. Turf plots in this study received the erosion when they showed a 50% cover. Based on these results, we decided to apply simulated rainfall treatments at several intervals of 0d after seeding, 14d, 28d, and 42d after seeding. Our study could give more accurate erosion results in that natural rainfall can occur at anytime after seeding a lawn. The objective of our rainfall simulation project is to determine if soaked seed decrease the number of days need after planting to reduce seed loss and erosion.

Erosion is an important factor when determining what varieties of grasses to establish on highway roadsides. These roadsides can sometimes be very steep and prone to runoff from rains and drought on upper portions of the slopes. The Texas Department of Transportation (TXDOT)/Texas Transportation Institute (TTI) and Hydraulics and erosion control field laboratory conducted a test to determine if post-establishment, “do native grasses, forbs, and wildflowers reduce sediment and therefore provide erosion



protection that is equal to, or better than, the erosion protection provided by bermudagrass” (Harlow, 2007). Four native seed mixes were compared to control plots of common bermudagrass. Seed and fertilizer were applied to all seeded plots in accordance with standard TXDOT specifications for roadside establishment. Initial planting was conducted in 1997 during a drought, so researchers allowed the vegetation to establish for 2 years. Afterwards researchers subjected each test plot to vegetation establishment and sediment control tests used to test erosion control on slopes. They used a rainfall simulator to produce “rainfall” at intensities of 1.2, 5.75, and 7.25in/hr. Rainfall was applied to each plot twice. After the rainfall simulation events sediment was collected and weighed. Because of extreme climates researchers had difficulty making strong conclusions on erosion data. They found that the erosion control properties of native grasses did not appear as effective as bermudagrass and current TXDOT grass mixes in preventing erosion. Bermudagrass is commonly used as an erosion control preventative. Because seashore paspalum is a potentially successful grass for the Gulf Coast area, due to its salt and flood tolerance, we decided to test its ability to prevent erosion. In doing so, we will determine like the TXDOT study if a different grass can outperform commonly used grasses for erosion control.

Zhou et al. (2007) conducted a study on the effects of ryegrass roots and shoots on erosion under simulated rainfall. Four rainfall simulation experiments with a rainfall intensity of  $1.5 \text{ mm min}^{-1}$  were conducted at intervals of five weeks. Ten ryegrass planted pans and four fallow pans were prepared for the experiments. Rainfall simulation was conducted twelve weeks after planting. Researchers found runoff in planted pans decreased 25% and 70% in the 12<sup>th</sup> week and 27<sup>th</sup> week, respectively, when compared to

runoff in the fallow pans. Results also indicated that shoot effect on runoff reduction accounted for over 50% in the 12<sup>th</sup> week and 44% in the 27<sup>th</sup> week was greater than root effect. Roots contributed more to soil loss reduction than the shoots, and accounted for 90% of soil loss reduction at the 27<sup>th</sup> week. Researchers determined that soil loss reduction by vegetation is a result of the combined roots and shoots effects. Once again it is proved the vegetation aids in runoff prevention. We would not only like to determine if seashore paspalum seed prevents erosion but also the number of days needed after planting and before rainfall to prevent erosion.

Marques et al. (2007) studied the effects of vegetative cover on erosion and runoff. Study plots were set up in South Madrid on agriculture land with a sloping terrain. The specific soil tested is classified as Xeric Haplogypsid and has a pH of 7.4 and organic matter content between 1.7 and 2.3% in the top soil. Rain fall in this area is not homogeneous and sudden storms are usual in the summer. Erosion was measured using eight bounded 20m by 4m plots, with a slope of 10%. Four plots had bare soil and shrubs. The other four plots had full cover with spontaneous vegetation and shrubs. Shrubs were too small to present any significant difference among plots. Field experiments were conducted in the dry season and on dry profiles (July and early September, 2004). Two 25 min rainfalls were applied over each plot. The simulated rainfall was broken into three segments consisting of 5 min previous moisture, a 5 min break, and a 15 min simulation trail in the strict sense. The first 5 min light rainfall segment was conducted because natural rain storms in this area produce a gradual soil wetting before highly erosive rain periods. Runoff samples were collected every minute following the start of runoff. Runoff volume was recorded. Sediment was collected after each rain fall segment. In the

lab, water was separated from sediment. Water volume and sediment dry weight were recorded and sediment concentration was calculated. The rainfall simulator delivered water from 20 full cone nozzles positioned every 2m<sup>2</sup> and suspended 2.2m above the ground. A water pressure of 1.5kg cm<sup>-2</sup> delivered a rainfall intensity of 1.3mm min<sup>-1</sup> that was uniformly distributed over the plot. “The erosive power of a single light rainfall event of 20.75mm h<sup>-1</sup> with a kinetic energy of 13.5 J m<sup>-2</sup> mm<sup>-1</sup> is negligible when plots are covered with vegetation. However, it produces an average soil loss of 74kg ha<sup>-1</sup> when the soil is bare, and the runoff can range from 3-10 mm, giving runoff coefficients between 14 and 49%” (Marques et al., 2007). Researchers found soil loss is mainly produced in the form of suspended sediment in the runoff water. They found that as much as 77% of the sediment mass loss is contained in this fraction. Results from this study did not determine a specific plant species that reduces erosion. This information would be helpful when planting bare ground that is susceptible to erosion. Superior results could have been obtained if Marques et al. (2007) had classified the vegetation types in their study plots.

### **Previous Studies on Brine Impacted Areas**

Brine is a major source of non-point source pollution in oil producing areas (Atalay, 1999). It is also produced when chemical plants process phenol and acetone. Georgia-Gulf, a chemical company located in Plaquemine, Louisiana, produces brine as a waste product during the processing of phenol and acetone. Brine is composed of Na, Ca, Mg, K, Cl, SO<sub>4</sub>, HCO<sub>3</sub>, and CO<sub>3</sub> (Burley, 1988). In previous years Georgia-Gulf has disposed of the brine on a landfarm adjacent to the chemical plant. Common bermudagrass has voluntarily grown over this brine impacted area. However, the

bermudagrass and other weeds have not fully covered this brine impacted area. Without a cover crop, brine has the potential of degrading the soil structure and altering the osmotic gradient between plant roots and the soil (Pessaraki, 1991; Sherard et al., 1976). The salts that are in brine accumulate in the soil and reduce the availability of water and nutrients to plants (Pessaraki, 1991). As the osmotic gradient is reversed and less nutrients and water are available to plants, naturally plant populations will decline, leaving the brine-impacted soil vulnerable to erosion. Eroding soils and the washing away by rainwater has the potential of contaminating near-by rivers and streams. Atalay (1999) studied methods for remediating brine impacted areas. The area of concern in Atalay's study was located in Clearview, Oklahoma at an active oil exploration and production field. The brine from this area was impacting water quality at two nearby creeks, the Clearview and Alabama creeks. Atalay, 1999 took initial soil and water samples. He proposed several soil amendment blends be tested. The soil amendments blends were FBA (fluidized boiler ash), gypsum, sulfur dust, and turkey litter. The USDA Natural Resources Conservation Service in Stillwater, Oklahoma did extensive engineering work to improve drainage and add culverts to prevent additional runoff from entering the streams. The four amendments were applied to the brine impacted area after the area had been tilled. After each amendment was added, the land was overturned. The amendments were added in this order 1. FBA, 2.gypsum, 3.sulfur dust, 4. turkey litter. Bermudagrass was then sprigged and the entire area covered with hay mulch (Atalay, 1999). The additions of these amendments improved the visual quality and land value of this area. Six months after sprigging, the bermudagrass was fully established, and 2 years

after sprigging, native shrubs began colonizing the once disturbed land site (Atalya, 1999).

## CHAPTER 3

### OPTIMUM TEMPERATURE FOR GERMINATION OF *PASPALUM VAGINATUM* 'SEASPRAY'

## **Introduction**

Introduction of seashore paspalum into athletic fields and home lawns in the coastal parishes of Louisiana could provide a more durable and low maintenance alternative to commonly grown turf-grasses. If established by seed, seashore paspalum could also provide an affordable turfgrass selection. Currently, *Paspalum vaginatum* ‘Seaspray’ is the only cultivar of seashore paspalum seed available on the market. Optimum temperature of ‘Seaspray’ seed was investigated to determine if seed establishment of seashore paspalum is feasible in the Gulf Coast climate.

Bush et al. (2000) established a 14d study was initiated to evaluate several germination temperature regimes. Four temperatures, 20, 25, 30, and 35°C were observed under continuous light. Germination was recorded daily. Concluding the study, germination percentage and mean time of germination were determined to be 30°C for optimum temperature for seed germination.

## **Materials and Methods**

A seed germination study was initiated on 29 May 2006, using a thermal gradient table (Scientific Systems Corp., Baton Rouge, La.) at the Louisiana State University, Horticulture Laboratory. Both a hot water and cold water baths were connected to the thermal gradient table. The temperatures for the baths were 41°C for the hot bath and 10°C for the cold bath. Setting the baths at these temperatures helped maintain the temperature treatments needed for the study. Once the thermal gradient table was displaying treatment temperatures, a fluorescent light was placed over the table to provide a constant light source. Petri dishes containing *Paspalum vaginatum* ‘Seaspray’

seed were placed in parallel rows on the table. Each row was maintained at one of the treatments of 20, 25, 30, and 35°C (Figure 3.1).

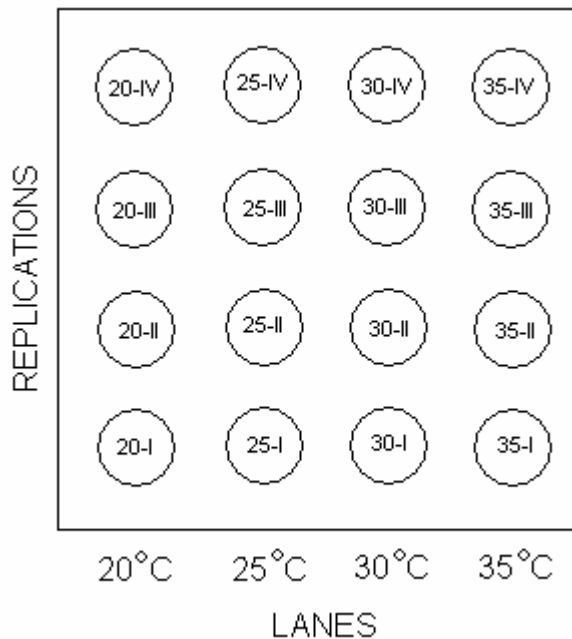


Figure 3.1. Schematic of germination plates on a thermal-gradient table.

Petri dishes (Falcon 1007) were lined with two sheets of filter papers (5.5 cm) and moistened with de-ionized (DI) water. Twenty-five seeds were placed on the moist paper for germination. A clear lid was placed on top of each petri dish. The lids were labeled denoting the temperature and replication.

Petri dishes were checked daily for germinated seeds and filter paper was moistened with DI water as needed. Germination was determined by observing a visible radical or shoot. Once germinated the number of seeds germinated were recorded and discarded. Petri dishes were observed for 14d. All seeds that did not germinate were subjected to a tetrazolium (TZ) test to determine seed viability as described by Bush (2006). The TZ test was administered by cutting seeds in half through the embryo. Half of each seed was placed back into the petri dish with embryo side facing up. A drop of



TZ was placed onto each of the seeds. Seeds remained in darkness for 24h. After 24h, seeds were viewed to determine viability. 2,3,5,-triphenyltetrazolium chloride (TTC) reacts with dehydrogenases, enzymes that are present only in living, respiring, tissue. In the living tissues of the seeds, active enzymes (dehydrogenases) produce free H<sup>+</sup> ions convert the TTC chemical to formazan, an insoluble red dye that stains the living tissues red (FRSA, 2007). Seeds with a pink color were considered viable and seeds without color were considered nonviable. Results were recorded and seeds were discarded. The experiment was replicated three times.

Mean time germination (MTG) for this study was calculated as described by Hartmann et al. (1990):

$$MTG = (\sum T_i N_i) / G$$

$T_i$  is the day of germination,

$N_i$  is the number of seeds germinating on  $T_i$ ,

G is the total number of germinated seeds

## Results

There were significant differences in mean germination percentage of ‘Seaspray’ seed when subjected to four different constant temperatures. Germination percentages of the four treatment temperatures are presented in Figure 3.2. Germination percentages significantly increased when seeds were subjected to 30°C compared to 20, 25, and 35°C. However, 40% of seeds did germinate at a temperature of 35°C. There were no significant differences in germination percentages of seed germination between 20 and 25°C.

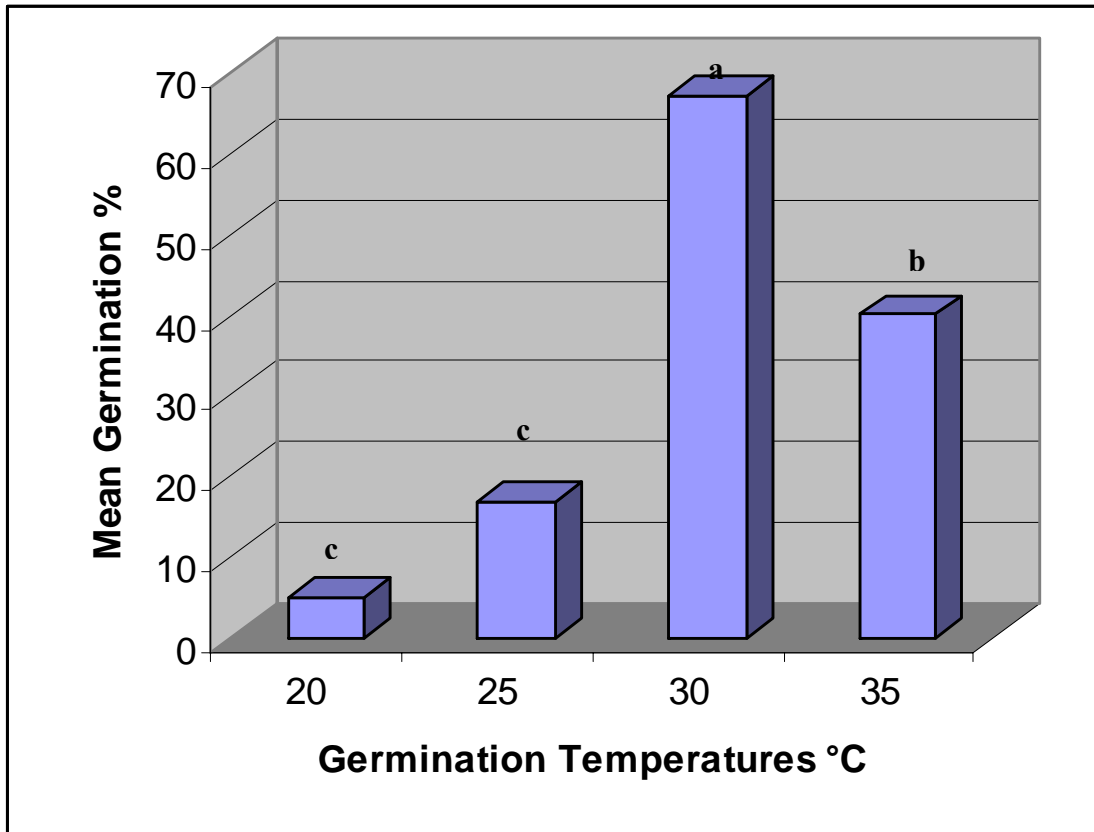


Figure 3.2. Germination % of *Paspalum vaginatum* 'Seaspray' seeds after 14d at four different germination temperatures. Means were separated using Duncan's multiple range test ( $P \leq 0.05$ )

Data from this experiment indicated that 25, 30, and 35°C had a significantly shorter MTG than seeds grown at 20°C (Figure 3.3).

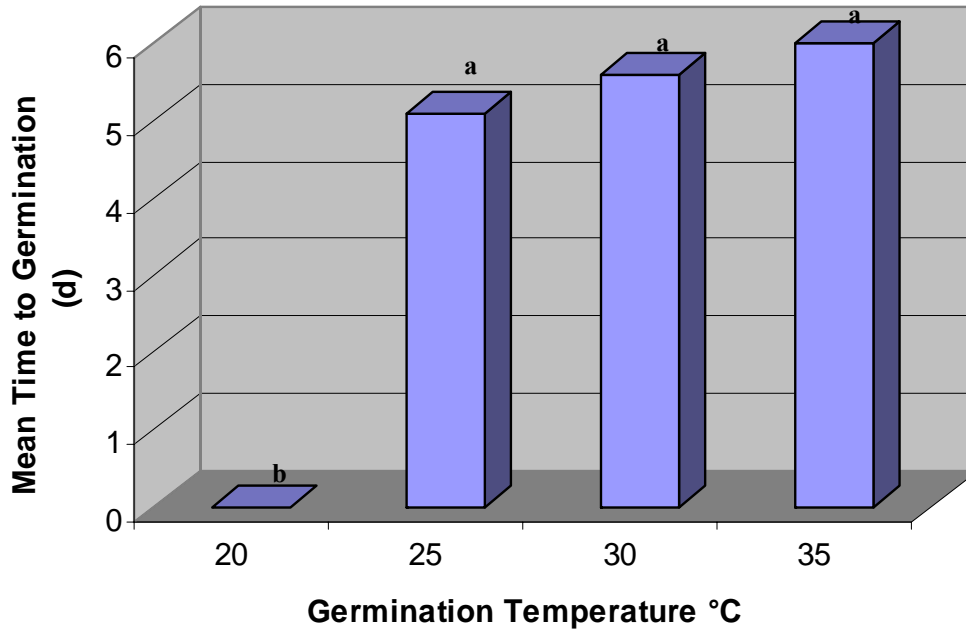


Figure 3.3. Mean germination time of *Paspalum vaginatum* ‘Seaspray’ seed after 14d at four constant temperatures. Means were separated using Duncan’s multiple range test ( $P \leq 0.05$ ).

### Discussion

The optimum seed germination temperatures were determined to be 30-35°C as identified in this study. In the coastal parishes of Louisiana this optimum temperature range normally occurs between the dates of May 15 and September 15. Therefore, the recommended time period to plant and establish an area by seashore paspalum seed would occur during these months. Determining optimum germination temperatures for seashore paspalum is critical for establishment of turfgrass in the Gulf Coast by seed due to the high cost of establishment by sod or plugs. Many areas of coastal Louisiana are susceptible to flooding from hurricanes. Brackish waters from storm surges can be devastating to turfgrass that are not tolerant to saline conditions. Therefore, it is important to plant turf species that can withstand long periods of brackish inundation during flooding events in areas susceptible to saline inundation. Having a salt tolerant turfgrass

will save homeowners and turfgrass managers the cost and effort of reestablishment. The results of this study indicated that *Paspalum vaginatum* 'Seaspray' is a suitable turfgrass selection for Louisiana and other Gulf Coast areas.

## CHAPTER 4

### EFFECTS OF PRIMING ON *PASPALUM VAGINATUM* 'SEASPRAY' SEED

## **Introduction**

Seed enhancements are defined as treatments that improve germination or seedling growth, or facilitate the delivery of seeds and other materials required at the time of sowing (Taylor et al., 1998). This definition describes three methods of seed enhancements; priming, coating technologies, and seed conditioning. In our study we chose to use the priming method for treating the paspalum seed using GA, KNO<sub>3</sub> and DI water as pre-sowing hydration treatments. After determining 30°C as the optimum temperature for germination, we compared seed enhanced using gibberellic acid, potassium nitrate, and deionized water to non-treated seed. Light (L) [14h L/10h D] and dark (D) [24h D] germination was also incorporated. This study was conducted to enhance germination rates at 30°C.

## **Materials and Methods**

Four treatments were used to determine improvement in germination percentage of *Paspalum vaginatum* 'Seaspray' seed at 30°C. Treatments were 1) 50µm solution of gibberellic acid (GA), 2) 2% solution of potassium nitrate (KNO<sub>3</sub>), 3) de-ionized water only, and 4) dry control. Two hundred seeds were soaked in each of the treatment solutions for 48h, during which seeds were aerated using a standard aquarium air pump. Seeds were divided into two lots of one hundred seeds, each. After 48h, seeds were removed from the solutions and placed into petri dishes lined with two sheets of No. 1 filter paper. The one hundred seed lot was then randomly placed in four petri dishes; twenty-five seeds per petri dish. Each treatment had a total of eight petri dishes. Four dishes from each treatment were placed in a clear box (14h L/ 10h D) and four dishes were placed in a clear box completely covered with aluminum foil (24h D). The two

boxes were placed in a growing chamber. The temperature in the growing chamber was set at 30°C. Florescent light was set for 14h light and 10h dark. The florescent lamp produced 90 foot candles of light. Seeds were observed daily for germination and moisture was maintained by wetting the filter paper with deionized water as needed. Seeds in the dark treatment were observed only under a green light in a completely dark room. Seeds that showed visible germination were recorded each day and discarded from the dish. The experiment lasted for 14d. At the end of the 14d, non-germinated seed were subjected to a tetrazolium (TZ) test to determine seed viability. The TZ test was administered by cutting seeds in half through the embryo. Half of the seed were placed back into the petri dish with embryo facing up. A drop of TZ was placed onto each of the seeds. The seeds remained in a dark chamber for 24h. After 24h, the seeds were viewed to determine viability. Seeds with a pink color were considered viable and seeds without color were considered nonviable. Results were recorded and seeds were discarded. The experiment was replicated twice.

## **Results**

Significant differences were observed in germination percentages (%) of seashore paspalum ‘Seaspray’ seeds when pretreated or soaked in DI water (Figure 4.1). To determine light requirements for seed germination, seeds were exposed to two light treatments. The treatments consisted of either seeds planted under 14h of light followed by 10h of dark each day for 14d or 24h of dark each day for 14d. Light was supplied by florescent bulbs producing 90 foot candles in a germination chamber. Figure 4.2 indicates that a significant difference was observed between the 14h L/ 10h D and 24h D florescent light treatments.

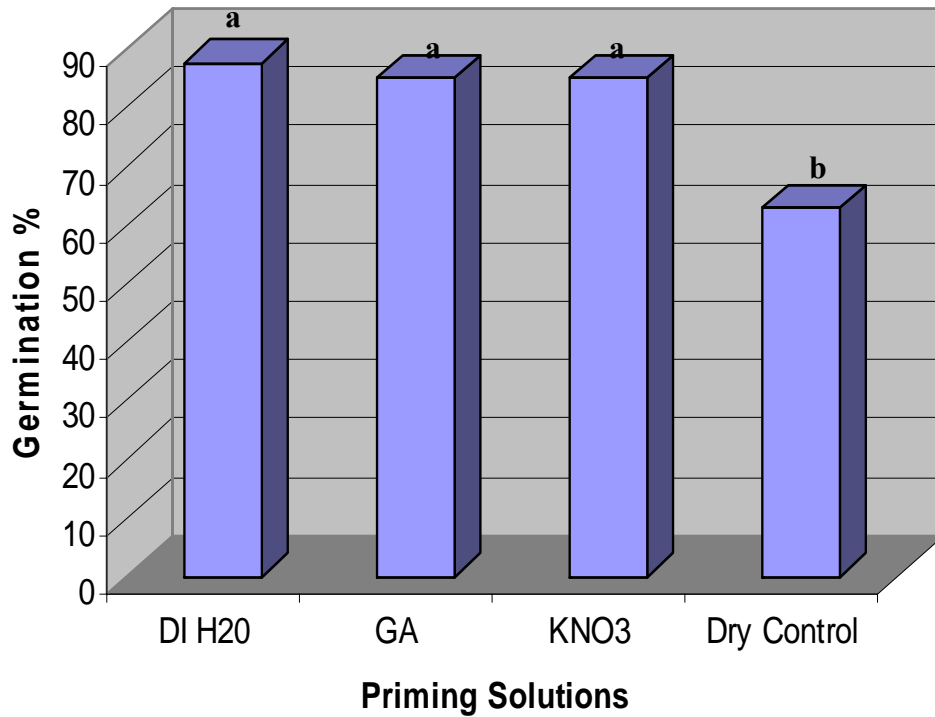


Figure 4.1 Comparison of germination percentages after soaking seed of *seashore paspalum* ‘Seaspray’ in various solutions. Means were separated using Duncan’s multiple range test ( $p \leq 0.05$ ).

To determine light requirements for seed germination, seeds were exposed to two light treatments. The treatments consisted of either seeds planted under 14h of light followed by 10h of dark each day for 14d or 24h of dark each day for 14d. Light was supplied by florescent bulbs producing 90 foot candles in a germination chamber. Figure 4.2 indicates that a significant difference was observed between the 14h L/ 10h D and 24h D florescent light treatments.



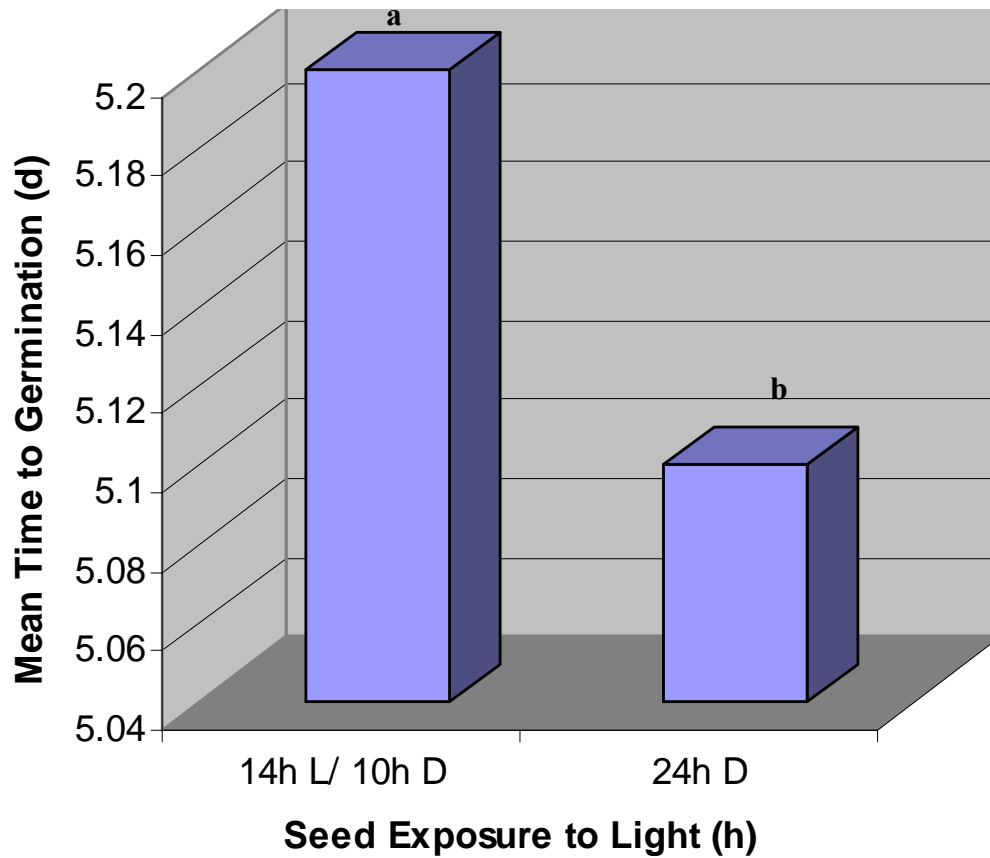


Figure 4.2. Seed germination as affected by light. Means were separated using a Duncan's multiple range test ( $p \leq 0.05$ ).

Mean time germination (MTG) was also calculated as follows for both solution treatments and light treatments for this study:  $MTG = (\sum T_i N_i) / G$ , where  $T_i$  is the day of germination,  $N_i$  is the number of seeds germinating on  $T_i$ , and  $G$  is the total number of germinated seeds (Hartmann *et al.*, 1990).

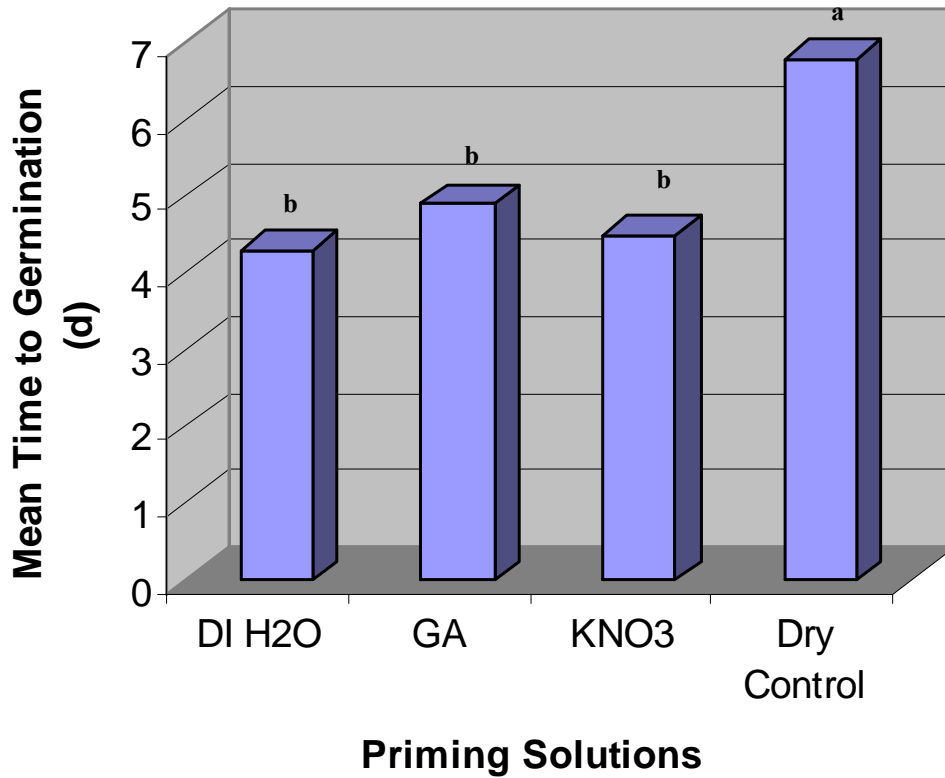


Figure 4.3. Mean time germination by priming solution. Means were separated using a Duncan's multiple range test ( $p \leq 0.05$ ).

Figure 4.3 illustrates that only the dry control was significantly different from the solution treatments. DI, GA, and  $KNO_3$  treatments all germinated in a quicker time period than the dry control. This indicates that conditioning seeds decreases mean time germination thus providing a faster germination of turf.

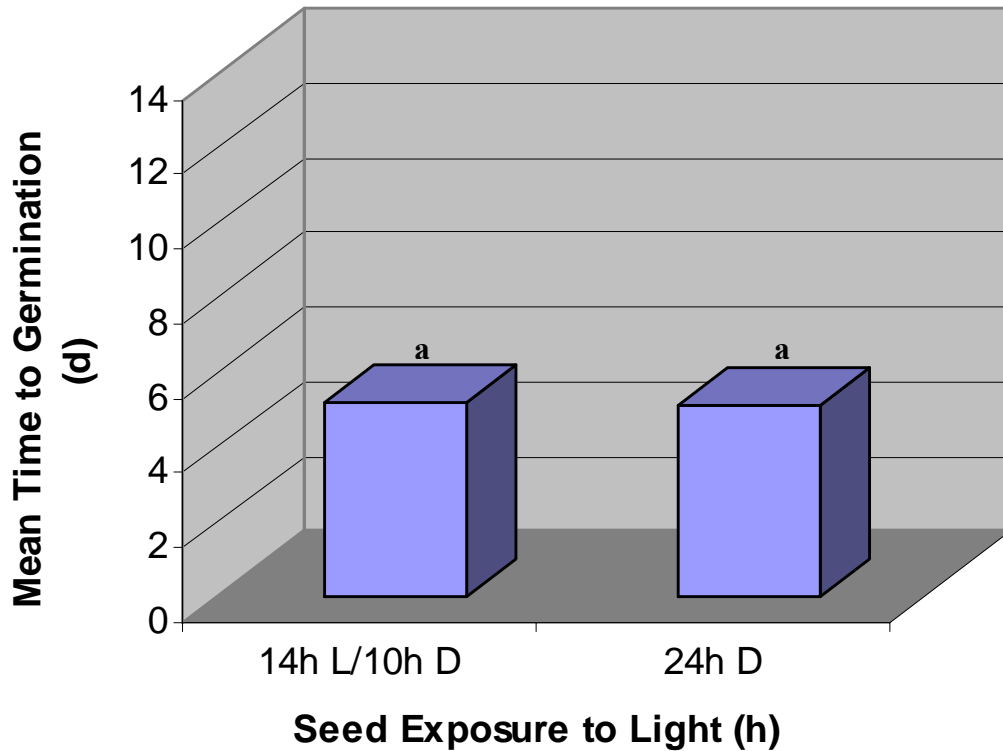


Figure 4.4. Mean time to germination as influenced by light. Means were separated using a Duncan's multiple range test ( $p \leq 0.05$ ).

Figure 4.4 illustrates that there were no significant differences in MTG of seeds germinated in the light or dark control treatments. Results indicate that the absence of light will not affect speed of germination; however, germination percentage will be significantly decreased.

### Discussion

Based on these data, all three seed enhancements yielded significantly greater germination than the dry control. We also found that there is a significant difference in the light and dark treatments. We concluded from these results that when establishing this seed, soaking the seed in water will raise germination percentages and that the seed will have higher germination percentages in light conditions. In addition, there were no

differences in mean time to germination between seed enhancement treatments; however, there was a difference between all seed enhancement treatments and the dry control treatment. Also, there was no significant difference found between the light and dark treatment for mean time germination indicating that light will not affect speed of germination.

**CHAPTER 5**  
**RAIN SIMULATION AND RUNOFF**

## **Introduction**

Seeding is the most cost efficient methods of establishing turf. Many variables should be considered when seeding a lawn or athletic field. One important factor is weather. A heavy rain could cause erosion and loss of seed causing slower establishment of turf. Therefore, we conducted a study, using *Paspalum vaginatum* ‘Seaspray’ seed, to determine the number of days between seeding and rainfall to minimize erosion and seed lost. Prior studies, concluded that soaking seed in DI water enhances germination rate and mean time to germination of *Paspalum vaginatum* ‘Seaspray’ seed. We have incorporated these findings into this study to determine number of days needed between seeding and rain that will minimize erosion and seed loss.

## **Materials and Methods**

*Paspalum vaginatum* ‘Seaspray’ seed was used to determine the optimum number of days between seeding and simulated rainfall on erosion and seed loss. Three treatments were used in this study. Two treatments applied were a treatment soaked in deionized water for 48h and a non-soaked treatment. These two will receive the simulated rainfall. The third treatment was a non-soaked control which will not be subject to the simulated rainfall. The soaked seeds were placed in aerated de-ionized water for 48h prior to planting. After soaking was complete, seeds were air dried for 1h then immediately planted. Soaked and non-soaked seed were subject to simulated rain while the control seeds were not subject to rain. Approximately 1,695 (0.902 g) seeds were used per treatment plot and each treatment replicated four times. Seeds were sown in 25x37cm galvanized trays. Trays were lined with ground cover cloth to prevent excess media from passing through drainage holes. The media consisted of 80% sand and 20% peat moss.

The trays were filled with media and firmed to remove air space and media was level with the surface of trays. A simulated rain was imposed at 0, 14, 28, and 42d after seeding. The first treatment was seeded at the rate of 4lbs/1000sqft, 42d before the rain simulation with seashore paspalum seed. The 42d treatment included 4 trays for each of the following treatments; soaked, non-soaked, and control (no rain) totaling 12 planted trays. This procedure was repeated at 28, 14, and 0d before the rain simulation would occur. A total of 48 trays were seeded for the rain simulation event. During the time before rain, seeds were placed under an intermittent mist irrigation system, to allow for proper moisture for germination and growth, in a greenhouse with 30/20°C temperature regime. A complete randomized block design was used for this experiment.

All treatments were subjected to simulated rain on the same day and time to reduce variability. Using a rain simulation system developed by Miller *et al.* (1998) we produced a severe rainfall event received in southern Louisiana. The simulator consisted of a hose equipped with a spraying systems full jet 1/2HH30WSQ nozzle mounted 2.5m above the trays.

The rain simulation was conducted 42d after the first planting. The soaked and non-soaked treatments were placed under the simulator for a 15 minute period. The rate of rain was 5cm every 15 minutes. Each tray was placed in a larger plastic container with a 12.5% slope to create a runoff model. After the rain simulation, seed and soil were collected from the runoff water in the plastic containers by using a 0.0104 cm sieve which held all the material and was then transferred to vials. Seed and soil were separated by using three sieves of different sizes. A 0.1409 cm sieve was used first to collect large material. A 0.0706 cm sieve was used to collect the seed. Finally, a 0.0104 cm sieve was

used to collect the soil. Once seed and soil were separated, they were placed in a dryer at 65°C until completely dried. Remaining media mixed with seed was removed using air flow seed separator. The seed and soil were then weighed and recorded.

Seed and media remaining in trays after the rain simulation were immediately placed back into the greenhouse. The 42d treatment was fertilized with 3.72g of Nursery Special™ fertilizer 12-6-6 (N-P-K) and each of the other three time treatments were fertilized at two week intervals. After fertilization, the grass was grown for three additional weeks. Then, top growth of grass was removed, dried, and weighed to compare establishment of the different treatments following rain. This experiment was replicated twice.

## **Results**

Data indicated that there was significantly less seed loss at 42 and 14d compared to 28 and 0d before rain at  $p \leq 0.0001$  (Figure 5.1). Results also indicated that 42d treatments had significantly less soil loss compared to the other treatments at  $p \leq 0.0001$  (Figure 5.2).



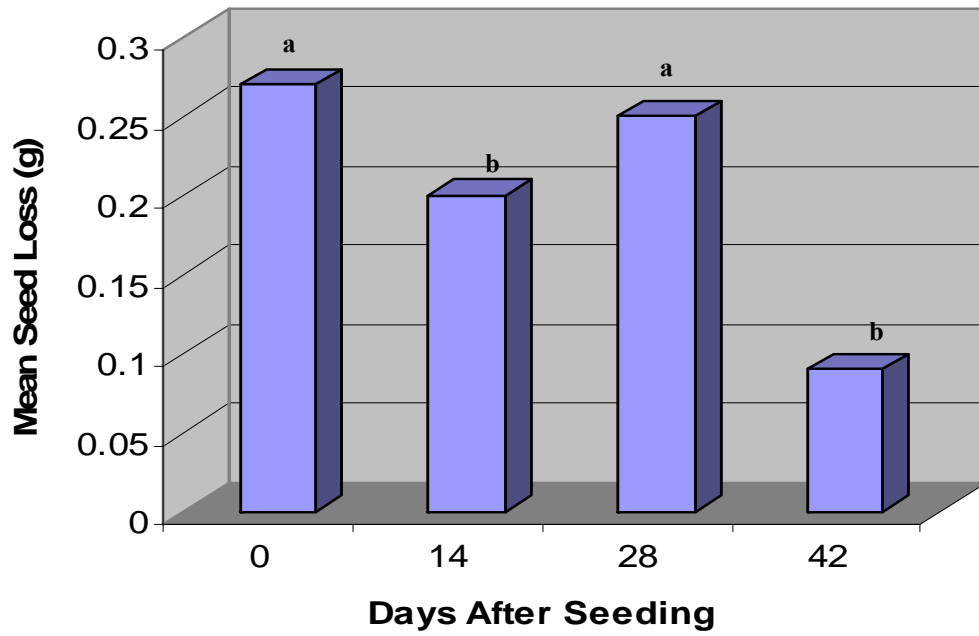


Figure 5.1. Seed loss means were separated using a Duncan's multiple range test ( $p \leq 0.05$ )

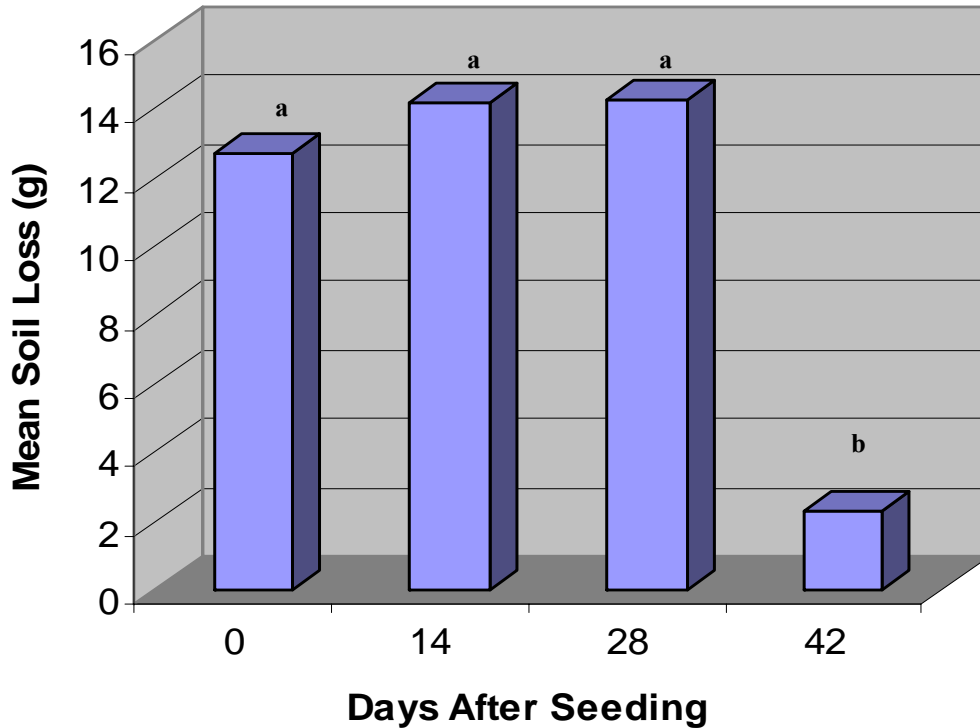


Figure 5.2. Soil loss means were separated using a Duncan's multiple range test ( $p \leq 0.05$ ).

Immediately following rain simulation, trays were placed in the greenhouse. Each tray was allowed to grow for 42d. Therefore, the day of the rain simulation the 42d treatment trays were fertilized, two weeks later the 28d treatment trays were fertilized. Two weeks following fertilization of the 28d treatment trays, the 14d treatments were fertilized. Finally, two weeks after fertilization of the 14d treatment, the 0d treatment trays were fertilized. After each treatment was fertilized they were allowed to grow for three weeks. The last day of the three week period, leaf clippings were taken and measured in grams dry weight. Leaf clippings consisted of all top growth being removed from each treatment. Clippings were statistically analyzed to determine the growth of remaining (not eroded) seed in trays. Figure 5.3 depicts the mean growth of grass leaf tissue after rain simulation, and fertilization had occurred.

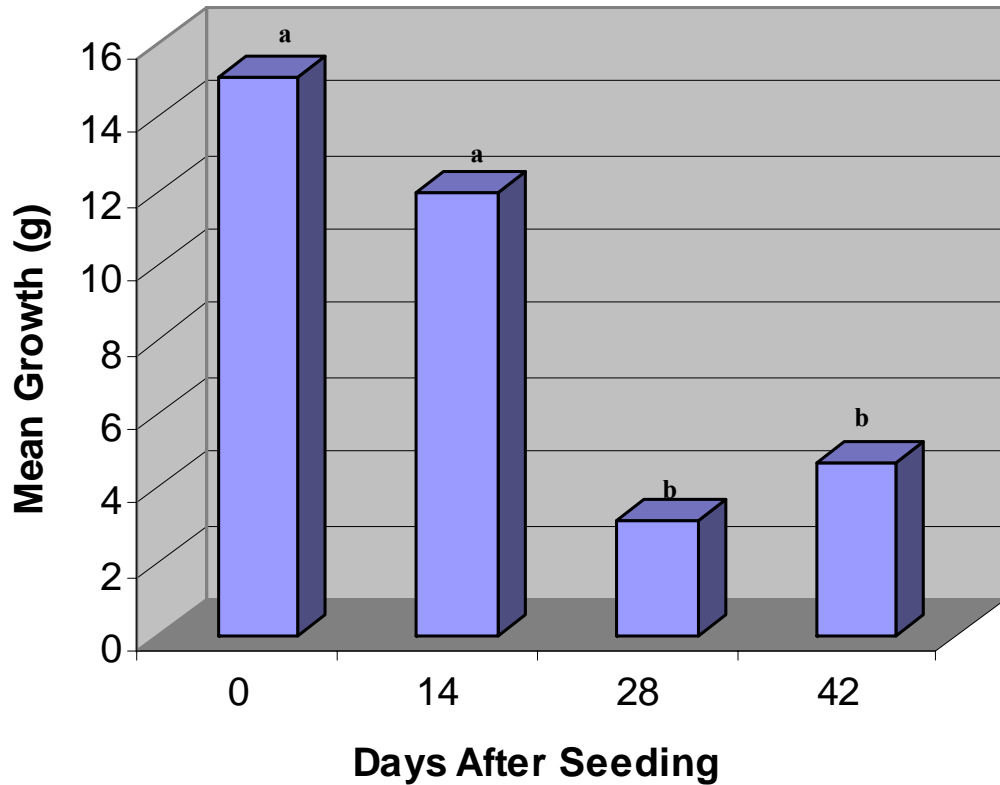


Figure 5.3. Mean growth after rain simulation. Values were separated using a Duncan's multiple range test ( $p \leq 0.05$ ).

Results indicate that plants subjected to rain simulation at 0 and 14d before rain had statistically larger mean growth of leaf tissue when compared to those trays allowed to establish 28 and 42d before rain simulation. Plants were allowed to grow to the full 42d period after rain simulation and then was fertilized and allowed to grow 3 weeks longer. Even with the additional time to grow, the 42d treatment was hypothesized to have the largest amount of leaf tissue growth and the 0d treatment the least. This is because seeds in the 42d treatment would have the full 42d to germinate before rain was applied. Whereas seeds that were planted at 0d before rain should have had less germination and less roots therefore more erosion and less seed remaining to germinate and growth following rain simulation. Statistical results from this same study indicated

that during the rain simulation the largest amount of soil that was eroded was from the 0, 14, and 28d treatments. This supports our hypothesis that the 42d treatment should have the most growth because less seed should be lost due to runoff when compared to the other treatments. Results from the seed loss during rain simulation study indicate that the largest amount of seed was lost from the 0 and 28d treatment; indicating still that the 0d treatment should have had the least amount of growth following rain simulation. All plants were given equal amounts of fertilizer, grown in the same greenhouse, and subjected to the same environmental conditions. We reject the hypothesis that 28d and 42d treatments would have the most leaf tissue growth because these treatments actually had less growth than the 0d and 14d treatments. Future studies may be able to better determine the factors that influence leaf growth after rain simulation.

## **Discussion**

*Paspalum vaginatum* 'Seaspray' seeds should be planted more than 28d before a rain to help prevent seed and soil loss from occurring. Because there is rarely 28d between rain periods along the Gulf Coast, turf established by seed will need erosion prevention. It was found that seed germinate at a significantly higher rate when germinated in the presence of light. Although ground covers do prevent some light from penetrating, it is recommended to use them to prevent loss of seed and soil due to erosion. A loss in germination percentage would be better than losing seed and soil to erosion which can cause long term problems.

## CHAPTER 6

### UTILIZATION OF *PASPALUM VAGINATUM* FOR A BRINE LANDFARM CAP

## **Introduction**

Brine fields are common problems associated with chemical manufacturing companies. Brine is a by-product of manufacturing acetone and other chloro-vinyls. Because it holds no value to chemical manufacturing companies or other business, brine is often spread over vast areas of land. The brine spread over land is often referred to as a landfarm. While landfarms are used for more than just brine, the objective of most landfarms is the same being to spread the constituent of concern over a large area of land then cover it with top soil and repeat the process. Sometimes microorganisms are added to the landfarm to reduce the constituent of concern, other times the layering process is repeated until a certain depth of layers occur and then the landfarm is permanently closed. Most chemical manufacturing companies are required to comply with environmental laws and regulations enforced by federal agencies such as the Environmental Protection Agency (EPA) and state agencies such as the Louisiana Department of Environmental Quality (LDEQ).

Georgia Gulf Vinyls LLC is a leading North American manufacturer and international marketer of two integrated chemical product lines, chloro-vinyls and aromatics as well as custom and other vinyl-based and products (Georgia Gulf, 2007). Georgia-Gulf sells the produced chemicals to other companies who manufacture final products. When phenol and acetone are made, brine, an unusable by-product is created. Currently, Georgia-Gulf transports the brine product to a landfarm located on the plant's property. Here, the brine is spread over a large area of land, which is considered a landfarm. Georgia-Gulf would like to close the brine field in compliance with LDEQ regulations. To do so, a vegetative cap must be placed over the entire landfarm,

preventing the brine from eroding and moving to other locations and preventing rainwater from penetrating the landfarm. Environmental engineers at Georgia-Gulf approached the horticulture staff at Louisiana State University for recommendations for a vegetative cover for the brine landfarm. In order to make scientifically based recommendations, a research study was initiated to determine the optimum grass species for a brine landfarm cover. Bermudagrass was the dominate plant species growing over portions of the brine field before the study was initiated. However, the bermudagrass was patchy leaving much of the brine exposed; leaving environmental engineers at Georgia-Gulf wondering if a better grass species was available. The primary objective of the experiment was to evaluate the influence of saline conditions on the growth and establishment of three grass species.

### **Materials and Methods**

On 26 September 2006, a 12.5 x 10.05 m plot was marked off on the edge of the landfarm at Georgia Gulf facilities in Plaquemine, Louisiana. This area was subdivided into 4 blocks of treatment plots. Three species were selected for the study, seashore paspalum (*Paspalum vaginatum sp.*), common bermudagrass (*Cynodon dactylon*), and weeping lovegrass (*Eragrostis curvula*). Each grass species was represented within each block. A grouping of 91.44 cm<sup>2</sup> boxes were constructed to hold soil treatments consisting of 0, 5.08, 10.16, and 15.24 cm of river silt layered on top of the brine. Initial tissue samples of all three grass species were collected and analyzed for P, K, Ca, Mg, Na, B, Cl, Zn, Mn, Mo, Cu, Hg, Cr, Cd, S, and Fe. The experimental plots were planted with sod of one of the three treatment grass species on one-half of the plot. The other half of the plots were left unplanted so that seed of each grass species could be planted in the

following spring. The soil and grass treatments were planted in a complete randomized block design. An irrigation system was constructed in such a way that each plot would receive water for grass establishment. During establishment, the plots were irrigated 3 times a day. After sod was established the irrigation frequency was reduced to once every other day. A municipal source of water was used to irrigate the plots. Three days after the sod side of the plots were planted, initial grass ratings were taken. The sod was rated on a scale of 1 to 9. Rating consisted of 1-dead, 9- excellent, and 6.5-commercially acceptable. Fertilizer was applied to the sod side of the plots at a rate of 16.93 g of Nursery Special™ 12-6-6 (N-P-K) per plot during the following spring or 7 months after planting. Approximately 2 weeks after the turf was fertilized, grass was mowed with a rotary mower so that new growth would emerge for the first sampling. On 12 June 2007 the final rating of the sod side of the plots took place. On this same day the top growth of the sod side of the plots were harvested for final nutrient analysis. Grass samples were dried, weighed, and ground. Tissue samples were analyzed by the Agricultural Chemistry Department, Baton Rouge, LA for the nutrients P, K, Ca, Mg, Na, B, Cl, Zn, Mn, Mo, Cu, Hg, Cr, Cd, S, and Fe. These elements, with the exception of Cl, were analyzed with the EPA3052 test by microwave acid digestion. Cl was analyzed using the titration method AOAC 969.10. Samples were taken from 4 blocks, all treatments, and 3 grass species. The initial samples were statistically compared to final grass samples to determine if the grass translocated the elements from the brine into the grass tissue.

The seeded sides of the plots were planted on 26 March 2007. Three months after planting, a visual rating on a scale of 1-9 was taken on each seeded side of the plots. After the visual ratings occurred, the seeded sides of the plots were fertilized with



Nursery Special™ 12-6-6 (N-P-K) at a rate of 16.93 g per plot. The seeded sides of the turf plots were not harvested for element analysis because not enough growth occurred. However, statistical analysis was run to determine visual rating differences between soil treatments and seeded grass species.

## **Results**

### **Initial Soil Nutrient Sampling**

Table A.1 located in Appendix A presents the initial results of nutrition sampling from the river silt and brine soil treatments. This table represents the differences between the brine and river silt soils. Table A.1 indicates that the brine soil treatment had higher concentrations of calcium, sodium, barium, chloride, and sulfur. While no statistical tests were run between the initial sampling of these two soil types, the listed analytes are important elements in plant growth.

### **Initial Plant Nutrient Sampling**

Table 6.1 presents nutrient concentrations in grass tissue samples prior to planting them in treatment soils. These results will serve as background levels that the final plant tissue samples will be compared.

Table 6.1. Baseline plant tissue nutrition analysis

<b>Bermuda</b>		<b>Seashore Paspalum</b>		<b>Weeping Lovegrass</b>	
<b>Analyte</b>	<b>Result</b>	<b>Analyte</b>	<b>Result</b>	<b>Analyte</b>	<b>Result</b>
<b>P</b>	.410%	<b>P</b>	.146%	<b>P</b>	.203%
<b>K</b>	1.46%	<b>K</b>	.624%	<b>K</b>	2.00%
<b>Ca</b>	.459%	<b>Ca</b>	.137%	<b>Ca</b>	.248%
<b>Mg</b>	.129%	<b>Mg</b>	.071%	<b>Mg</b>	.180%
<b>Na</b>	.112%	<b>Na</b>	.179%	<b>Na</b>	.030%
<b>Ba</b>	25.4ppm	<b>Ba</b>	9.56ppm	<b>Ba</b>	30.2ppm
<b>Cl</b>	3150ppm	<b>Cl</b>	2380ppm	<b>Cl</b>	2730ppm
<b>Zn</b>	641ppm	<b>Zn</b>	201ppm	<b>Zn</b>	132ppm
<b>Mn</b>	115ppm	<b>Mn</b>	16.5ppm	<b>Mn</b>	125ppm
<b>S</b>	.419ppm	<b>S</b>	.100ppm	<b>S</b>	.405ppm
<b>Mo</b>	2.94ppm	<b>Mo</b>	2.64ppm	<b>Mo</b>	3.84ppm
<b>Cu</b>	28.3ppm	<b>Cu</b>	12.5ppm	<b>Cu</b>	18.7ppm
<b>Hg</b>	<80.0ppb	<b>Hg</b>	<80ppb	<b>Hg</b>	<80ppb
<b>Cr</b>	1.49ppm	<b>Cr</b>	2.54ppm	<b>Cr</b>	7.16ppm
<b>Cd</b>	.554ppm	<b>Cd</b>	.425ppm	<b>Cd</b>	.589ppm
<b>Fe</b>	316ppm	<b>Fe</b>	106ppm	<b>Fe</b>	5454ppm

ppm= parts per million, ppb= parts per billion

#### **Final Nutrient Sampling**

Final plant tissue samples were taken from each grass species in every soil treatment and treatment depth. Concentrations of Cr, Cd, Fe, and Zn in the plant tissue

were not significantly different from each other by species, or depth. There were nutrient concentration differences by plant species. Seashore paspalum and bermudagrass had significantly higher concentrations of P than weeping lovegrass ( $p \leq 0.0001$ ).

Concentrations of K were greatest in seashore paspalum followed by bermudagrass then weeping lovegrass ( $p \leq 0.0001$ ). Weeping lovegrass was significantly greater in Ca ( $p \leq 0.0001$ ), Ba ( $p \leq 0.0224$ ), and Hg ( $p \leq 0.0001$ ) concentrations than both seashore paspalum and bermudagrass. Seashore paspalum had significantly higher concentrations of Mg ( $p \leq 0.0001$ ) and Mo ( $p \leq 0.0001$ ) than weeping lovegrass. However, weeping lovegrass has significantly higher concentrations of Mn and Mo than bermudagrass. Seashore paspalum and weeping lovegrass had significantly higher concentrations of Cu than bermudagrass ( $p \leq 0.0009$ ). Seashore paspalum has significantly higher levels of Na than both bermudagrass and weeping lovegrass ( $p \leq 0.0001$ ). Bermudagrass had significantly higher concentrations of Mn ( $p \leq 0.0001$ ) than seashore paspalum which had significantly higher concentrations of Mn than weeping lovegrass. Chloride was the only analyte that was significantly different by species and depth. Seashore paspalum had significantly higher concentrations of Cl than bermudagrass, which was significantly higher in Cl than weeping lovegrass ( $p \leq 0.0001$ ). Seashore paspalum planted in varying depths of river silt above the brine was significantly higher in Cl concentrations. The 5.08 cm of river silt had significantly higher levels of Cl in the plant tissue than 10.16 and 15.24 cm of river silt ( $p \leq 0.0452$ ).

## Biomass Results

Table 6.2. Biomass yield of three grass species growing on a brine landfarm.

Species	Depth (cm)	Mean Mass (g)
<b>Bermudagrass</b>	0	21.09a
<b>Bermudagrass</b>	5.08	22.33a
<b>Bermudagrass</b>	10.16	26.26a
<b>Bermudagrass</b>	15.24	24.52a
<b>Seashore Paspalum</b>	0	7.68a
<b>Seashore Paspalum</b>	5.08	12.62a
<b>Seashore Paspalum</b>	10.16	9.78a
<b>Seashore Paspalum</b>	15.24	15.70a
<b>Weeping Lovegrass</b>	0	13.72b
<b>Weeping Lovegrass</b>	5.08	15.39b
<b>Weeping Lovegrass</b>	10.16	16.40b
<b>Weeping Lovegrass</b>	15.24	41.96a

**$p \leq 0.0002$  for species and  $p \leq 0.001$  for depth**

Table 6.2 indicates that there was no significant difference in biomass at differing depths for bermudagrass species. Indicating that bermudagrass biomass is not improved by additional river silt added on top of the brine. Likewise, there was no significant difference in biomass for seashore paspalum grass species at differing depths of river silt. However, weeping lovegrass biomass was significant improved by the addition of river silt added on top of the brine. The 15.24 cm of river silt added on top of the brine

significantly improved the growth of aboveground biomass of weeping lovegrass at  $p \leq 0.0058$ . Figure 6.1 serves as a visual representation of the data in Table 6.3.

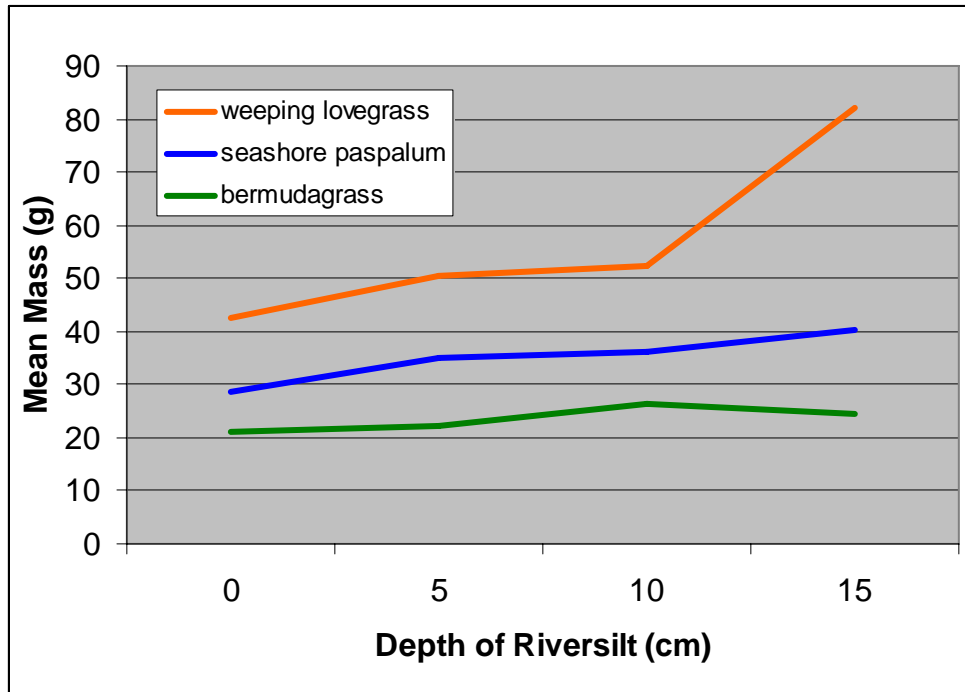


Figure 6.1 Mass of grass tissue by treatment depth.

### Visual Rating Results

Table 6.3 gives the visual ratings for each species. The means for each species include all soil types and depths.

Table 6.3 Visual ratings of three grass species grown on a solid waste surface impoundment

Species	15 October 2006	12 June 2007
Seashore Paspalum	6.84 a	6.84 a
Bermudagrass	5.03 b	5.59 b
Weeping Lovegrass	4.94 b	4.63 c

Numbers in columns represent mean averages of visual ratings. Ratings were based on a scale of 1-9. 1 representing dead; 6.5 representing commercially acceptable; and 9 representing superior quality. Means within column were statistically analyzed using a Duncan's multiple range Test ( $p \leq 0.05$ ).

### Seedling Coverage Results

Table 6.4 represents seedling canopy coverage by species at differing depths.

Seedling canopy coverage of bermudagrass was significantly greater at 15.24 and 10.16 cm of additional river silt ( $p \leq 0.0004$ ) than only adding 0 or 5.08 cm of river silt to the brine. There was no statistical difference in 15.24 and 10.16 cm of additional river silt for the bermudagrass suggesting that 10.16 cm is sufficient for optimal seed coverage.

Seashore paspalum seed coverage was significantly greater at 15.24 cm than 10.16, 5.08 and 0 cm of additional river silt ( $p \leq 0.0007$ ). The 10.16 and 5.08 cm of additional river silt were yielded significantly greater seed coverage than 0 cm of soil ( $p \leq 0.0007$ ).

Optimal river silt addition for seashore paspalum is 15.24 cm of river silt. Weeping lovegrass did not germinate at any of the depths.

Table 6.4 Mean percent seedling canopy coverage by species according to depth

Species	Depth (cm)			
	0	5.08	10.16	15.24
Bermudagrass	3.25b	16.25b	60.00a	58.75a
Seashore paspalum	3.25c	21.25Cb	42.50b	67.50a
Weeping lovegrass	0a	0a	0a	0a

Means within rows were statistically analyzed using a Duncan's multiple range Test ( $p \leq 0.05$ )

Seed coverage was also statistically analyzed by depth according to species. This test was run to determine which species has the greatest percent coverage by depth as reported in Table 6.5.

Table 6.5. Mean percent seedling canopy coverage by depth of river silt according to species

Species	Depth (cm)			
	0	5.08	10.16	15.24
Bermudagrass	3.25a	16.25a	60.00a	58.75a
Seashore paspalum	3.25a	21.25a	42.50a	67.50a
Weeping lovegrass	0a	0a	0b	0b
Significance	NS	NS	**	***

Numbers in columns represent mean averages of percent seed coverage. Means within column were statistically analyzed using a Duncan's multiple range Test ( $p \leq 0.05$ ) NS= not significant; \*\*  $p \leq 0.005$ ; \*\*\*  $p \leq 0.0005$ .

Bermudagrass and seashore paspalum had significantly greater percent seed coverage than weeping lovegrass when 4 inches of river silt was added on top of the brine. However, the most significant increase in percent seed coverage occurred when 15.24 cm of river silt was added on top of the brine for both bermudagrass and seashore paspalum.

## Discussion

Results from visual ratings indicate that seashore paspalum was the only grass that was considered commercially acceptable when growing over the brine impoundment area. Visual ratings give a relative measurement of plant vigor. Chlorosis and necrosis on the grass blades can indicate poor nutrition levels which will affect grass growth and survivability. Seashore paspalum was significantly higher than bermudagrass and weeping lovegrass in chloride concentrations. This result indicates that the seashore paspalum is not only able to survive contact with the brine, but also able to translocate chloride into its tissue. Indicating that seashore paspalum be further studied for its phytoremediation capabilities of chloride in brine fields. Of the three grass species

studied, Seashore paspalum and bermudagrass are the two species that LSU recommends for the brine cap planting.

All three species were tolerant of growing in the brine. However, when river silt in depths of 5.08, 10.16, and 15.24 cm were added to the brine, bermudagrass and seashore paspalum species had significantly greater levels of percent seed coverage than weeping lovegrass. Indicating that if planting the cap by seed, adding 10.16 or 15.24 cm of river silt would be recommended for optimal seed coverage.

While it was found that planting bermudagrass and seashore paspalum by seed in 10.16 and 15.24 cm of additional river silt on top of the brine yielded the greatest percent seed coverage; it did not prove beneficial to add river silt when planting the grass species by sod. The biomass of sod of the three species was not significantly affected by the addition of river silt on top of the brine. Therefore, if planting the cap with seed, river silt will improve the overall effectiveness of the cap, in that the cap cover will be greater with the addition of river silt preventing penetration of rainwater into the contaminated area below the cap and the additional cover will prevent additional runoff of soil from beneath the cap. However, if planting the cap with sod, there is no need for the addition of river silt as the biomass of the grass species was not higher with the addition of river silt. Percent coverage was not determined for grass species planted by sod because it covered the entire portion of the individual plot, instead visual ratings were recorded. However, if planting the cap with sod, the addition of 5.08 cm of river silt on top of the brine, will significantly increase uptake of Cl. Seashore paspalum assimilated significantly greater quantities of Cl with 9,109ppm, whereas bermudagrass the second significantly highest



concentration of Cl with 5,016ppm Cl, followed by weeping lovegrass which translocated 3,055ppm of Cl.

Because Georgia Gulf already has the majority of the brine land form covered in bermudagrass, it is recommended for them to plant additional bermudagrass by sod in areas of no grass coverage. Results from this study indicate that no additional river silt is necessary if planting bermudagrass by sod. This recommendation would be the most cost-effective means of complete cap coverage for Georgia Gulf. Three recommendations would be made if a company needed a cap. 1) Identify a suitable topsoil free of contaminants. Plant the entire cap with seashore paspalum or bermudagrass seed after covering the brine with the top soil. Seedling coverage was greatest using seashore paspalum in this study. Planting the cap by seed would be more cost effective than planting the cap by sod. 2) The second recommendation is to cover the entire brine area with at least 5.08 cm of suitable topsoil and then plant seashore paspalum or bermudagrass by sod. This method would cost more than the first method but would provide an instant coverage. 3) The third recommendation would be to plant the entire cap area with seashore paspalum sod and not top-dress with a suitable top soil. Seashore paspalum is the recommended grass species for cap coverage because it had the highest visual ratings of all three species tested, however, bermudagrass provided suitable coverage.

**CHAPTER 7**  
**CONCLUSIONS**

Four studies were conducted using *Paspalum vaginatum*. Optimum temperature for seed germination, optimum seed enhancements and light requirements for germination, optimum number of days before a rain for erosion prevention and minimizing seed loss, and usage of *Paspalum vaginatum* as a vegetative brine landfarm cap were determined in 2006 and 2007. All four studies indicate that *Paspalum vaginatum* is a plausible turfgrass species for the Gulf Coast states.

The optimum germination temperature for *Paspalum vaginatum* was determined using a thermal gradient table. Maximum seed germination percentage and MTG occurred at 30°C. Most horticulturalists recommend that lawns be seeded in the spring, throughout the summer months. Therefore, *Paspalum vaginatum* is ideal for seeding lawns in Louisiana and other Gulf Coast states.

Once optimum temperature for germination was determined, testing different seed enhancements began. Results indicated greater germination percentages for GA, KNO<sub>3</sub>, and DI water soaked seeds compared to dry control seeds. Mean time germination was also significantly affected by priming the seeds with all three treatments. This indicated that to reduce the time needed for a germinated lawn, priming seeds with GA, KNO<sub>3</sub>, or soaking seeds will decrease the number of days to a full lawn. The most economical treatment is soaking seeds, since there was no significance between treatments for mean time germination studies. Germination percentage was increased when seeds were germinated in the presence of light; however mean time germination was not significantly affected if seeds were placed in the light or dark. Therefore, it is recommended to not cover *Paspalum vaginatum* seeds when establishing a lawn to promote higher germination.

Determining the number of days needed after seeding before a rain was the next step in determining if *Paspalum vaginatum* is a suitable turf selection for the Gulf Coast area. Mean seed loss and mean soil loss was significantly greater at 0, 14, and 28d before a rain event when compared to 42d before rain. Results indicated that *Paspalum vaginatum* germinates best and prevents the most erosion when it has time to germinate before a heavy rainfall. Surprisingly, mean growth of grass was significantly greater when seeds were planted at 0 and 14d before rain when compared to 28 and 42d before rain. The first three studies all illustrate that *Paspalum vaginatum* is a viable turfgrass selection for the Gulf Coast states.

The last study conducted determined if *Paspalum vaginatum* would be viable for use as a vegetative cap for a brine landfarm. *Paspalum vaginatum* translocated a significantly larger amount of Cl than the other turf species. This result indicates that *Paspalum vaginatum* may be a phytoremediator of Cl in brine impacted soils. *Paspalum vaginatum* had significantly higher visual ratings at the end of the study when compared to the other turf grass species. *Paspalum vaginatum* averaged a 6.84 on a 1 to 9 scale where 6 represents commercially acceptable. The results of the vegetative landfarm cap indicate that *Paspalum vaginatum* is an acceptable turf selection for remediating and covering brine impacted areas.

## LITERATURE CITED

- Atalay, A., T.A., Pyle, R.A. Lynch, 1999. Strategy for restoration of brine disturbed land. *Journal of Soil Contamination*. Vol. 8 Iss. 3:307-328.
- Baskin, C.C., Baskin, J.M., 1998. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, San Diego.
- Bewley JD., DWM Leung, and FB. Ouellette, 1983. The Cooperative Role of endo- $\beta$ -manganese, beta-mannosidase and alpha galactosidase in the mobilization of endosperm cell wall hemicelluloses of germinated lettuce seed. *Recent Advances in Phytochemistry*. 17:137-151.
- Braman, S.K., Duncan R.R., Hanna, W.W., Engelke, M.C., 2004. Turfgrass species and cultivar influences on survival and parasitism of fall armyworm. Vol. 97, number 6:1993-1998.
- Burley, M. J., 1988. Reclamation of brine spill sites. *Spill Technology Newsletter*. 3-16.
- Bush, Edward W., Paul Wilson, Dennis Shepard, Gloria McClure, 2000. Enhancement of seed germination in common carpetgrass and centipedegrass seed. *Hort Science*. Vol. 35 (4):769-770.
- Cardona, C.A., R.R. Duncan, and O. Lindstrom, 1997. "Low temperature tolerance assessment in Paspalum." *Crop science*, Vol. 37:1283-1292.
- Cardona, C.A., Duncan, R.R., 1997. Callus induction and high efficiency plant regeneration via somatic embryogenesis in paspalum. Vol. 37, Number 4:1297-1302.
- Carey, K. and E. Gunn, 2000. Effects of Terra-Control soil amendment on soil stability of seeded Kentucky bluegrass, perennial ryegrass, creeping bentgrass, and fine fescues populations. *Guelph Turfgrass Institute 2000 Annual Research Report*.
- Couillard, Andree-Anne, Ph.D. and Greg Wiecke, Ph.D. May 1998 "A saline solution" *Seawater a Selective Herbicide*". *Golf Course Management*, Vol. 66, Number 5.
- Delouche, James C., 1961. Effect of Gibberellins and light on germination of centipedegrass seed (*Eremochloa ophiuroides*). *Proceeding of the Association of Official Seed Analysts* Vol. 51 pg 147-150.
- Duncan, R.R., Ph.D. Feb. 1998. "Keys to Success with Paspalum vaginatum on Golf Courses." *Gulf Course Management*, Vol. 66, Number 2.
- Duncan, R.R., 2000. Seashore paspalum: A turfgrass for tomorrow. *Diversity*, Vol. 16:45-46.

- Duncan, R.R. and R.N. Carrow, 2000. Seashore paspalum. The environmental turfgrass. Sleeping Bear Press, Chelsea, MI.
- Davis, S.D., R.R. Duncan, and B.J. Johnson, 1997. Suppression of seashore paspalum in bermudagrass with herbicides. *Environmental Horticulture*, Vol. 15, Number 4:187-190.
- Duncan, R.R., 1997. Seashore paspalum responds of stewardship. *Golf Course management*, Vol. 65, Number 2:49-51.
- Duncan, R.R., 1998. Seashore paspalum herbicide management. *USGA Green Section Records*, Vol. 36, Number 2:17-19.
- Duncan, R.R., 1999. Environmental compatibility of seashore paspalum for golf courses and other recreational uses. *Management Protocols. International turfgrass research*, Vol. 8:1216-1229.
- El-Keblawy, A. and A. Al-Rawai, 2005. Effects of salinity, temperature, and light on germination of invasive *Prosopis juliflora* (Sw.) D.C. *Journal of Arid Environments*. 61:555-565.
- FRSA, 2007. Seed Analysis Fact Sheet: TZ. <http://www.frsa.org/SAfacts/SAFTZ.html>. Aug. 2007.
- Georgia Golf. At a Glance. <http://www.ggc.com/aboutus/at-a-glance.cfm> , September 2007.
- Grappin, P., Bouinot, D., Sotta, B., Miginiac, E., Jullien, M., 2000. Control of seed dormancy in *Nicotiana plumbaginifolia*: post-imbibition abscisic acid synthesis imposes dormancy maintenance. *Planta*. 210:279-285.
- Groot, SPC, and C.M. Karssen, 1987. Gibberellins regulate during seed germination in tomato endosperm weakening: a study with gibberellins-deficient mutants. *Planta*. 171:525-531.
- Groot, SPC, B. Kieliszewska-Rokicka, E. Vermeer, and C. Karssen, 1988. Gibberellins-induced hydrolysis of endosperm cell walls in gibberellins-deficient tomato seeds prior to radical protrusion. *Planta*. 174:500-504.
- Harivandi, M.A., C.L. Elmore, and J.M. Henry, 1987. An evaluation of herbicides on seashore paspalum. *California Turfgrass Culture*, Vol. 27, Number 1,2: 2-5.
- Hartmann, H. T., D. E. Kester, and F. D. Davies, Jr. 1990. *Plant propagation; Principles and practices*, 5<sup>th</sup> ed. Prentice Hall, Englewood Cliffs, N. J.

- Hixson, A. C., Crow, W.T., McSorley, R., Trenholm, L.E., 2004. Host status of ‘SeaIsle 1’ seashore paspalum (*Paspalum vaginatum*) to *Belonolaimus longicaudatus* and *Hoplolaimus galeatus*. Vol. 36, Number 4:493-498.
- Ibitayo, O.O. and J.P. Butler, 1981. Cold Hardiness of Bermuda and paspalum vaginatum SW. Hortscience, Vol. 16:683-684.
- Iglesias, R.J., M.J. Babiano, 1997. Indigeneous abscisic acid during the germination of chickpea seed. *Physiologia Plantarum*. Vol. 100:500-504.
- Jiang, Y., R.N. Carrow, and R.R. Duncan, 2003. Effects of morning and afternoon shade in combination with traffic stress on seashore paspalum. Hortscience, Vol. 38: 1218-1222.
- Johnson, B.J. and R.R. Duncan, 1997. Tolerance of four seashore paspalum cultivars to post emergence herbicides. *Weed Technology*, Vol. 11:689-692.
- Johnson, B.J., Duncan, R.R., 2000. Timing and frequency of ethofumesate plus flurpridol treatments on bermudagrass (*Cynodon* spp.) suppression in seashore paspalum (*Paspalum vaginatum*). Vol. 14, Number 4:675-685.
- Kambizi L., Adebola, P.O., Afolayan, A.J., 2006. Effects of temperature pre chilling, and light on seed germination of *Withania somnifera*; a high value medicinal plant. *South African Journal of Botany*. 72:11-14.
- Khan, M.A., Gulzar, B., 2003. Germination responses of *Sporobolus ioclados*: a saline desert grass. *Journal of Arid Environments*. 53:387-394.
- Khan, M.A., Ungar, I.A., 1997. Effects of light, salinity, and thermoperiod on the seed germination of halophytes. *Canadian Journal of Botany*. 75:835-841.
- Kim, K.S., Beard, J.B., 1988. Comparative turfgrass evapotranspiration rates and associated plant morphological characteristics. Vol. 28, Number 2:328-331
- Kuo, YuJen, Chang, YuSen, Lila, M.A., Chiu, HsinYi, 2005. Screening growth and root formation in cadmium-treated turfgrass using a whole-plant microculture system. *Journal of Plant Nutrition*, Vol. 28, Number 6:1041-1048.
- Landphair, H., J. Schutt, and J. McFalls, 2007. Native vegetation or bermudagrass? Testing the erosion control and engineering properties of roadside vegetation. Project summary report. 1504-S.
- Lee, G.J., 2000. Comparative salinity tolerance and salt tolerance mechanisms of seashore paspalum ecotypes. PH.D diss. (Diss. Abstract ATT 9994109 UGA.

- Lee, G.J., R.R. Duncan, and R.N. Carrow, 2004a. Salinity tolerance of seashore paspalum ecotypes: Shoot growth responses and criteria. Hort-science 39:1138- 1142.
- Lee, G.J., R. N. Carrow, and R.R. Duncan, 2004b. Salinity tolerance of selected seashore paspalum and bermudagrasses: Root and verdure responses and criteria. Hort-science. 39:1143-1147.
- Lee, G.J., Carrow, R.N., Duncan, R.R., 2005. Growth and water relation responses to salinity stress in halophytic seashore paspalum ecotypes. Vol. 104, Number 2: 221-236.
- Marques, N., R. Bienes, L. Jimenez, and R. Perez-Rodrigues, 2007. Effect of vegetal cover on runoff and soil erosion under light intensity events. Rainfall simulation over USLE plots. Science of the total environment. Vol 378, iss. 1-2 May, 161-165.
- Martinez-Sánchez, J.J., Conesa, E., Vicente, M.J., Jiménez, A., Franco, J.A. 2006. Germination responses of *Juncus acutus* (Juncaceae) and *Schoenus nigricans* (Cyperaceae) to light and temperature. Journal of Arid Environments. Vol 66:187-191.
- Meyer, J.L., Gibeault, V.A., 1986. Turfgrass performance under reduced irrigation. Vol. 40, Number 7,8:19-20.
- Nadjafi, F., M. Bannayan, L. Tabrizi, M. Rastgoo, 2006. Seed germination and dormancy breaking techniques for *Ferula gummosa* and *Teucrium polium*. Journal of Arid Environments Vol. 64:542-547.
- Peacock, C.H., Dubeck, A.E., 1985. Physiological and growth responses of seashore paspalum to salinity. Vol. 20, Number 1:111-112.
- Pessaraki, M., 1991. Formation of saline and sodic soils and their reclamation. Journal of Environmental Science Health. Vol 26:1303-1320.
- Puppala, Naveen, James L. Fowler, 2002. *Lesquerella* seed pretreatment to improve germination. Industrial Crops and Products. Vol 17:61-69.
- Sherard, J. L., F. ASCE, L.P., Dunnigan, and R.S. Decker, 1976. Identification and nature of dispersive soils. Journal of Geotech Engineering Div. In. Proceedings of the American Society of Civil Engineers Vol. 102:287-301.
- Sozzi, G.O., A. Chiesa, 1995. Improvement of caper (*Capparis spinosa* L.) seed germination by breaking seed coat-induced dormancy. Scientia Horticulturae. Vol. 62:255-261.



- Taylor, A. G., P. S. Allen, M. A. Bennett, K. J. Bradford, J. S. Burris, and M. K. Misra, 1998. Seed Enhancements. *Seed Science Research*. Vol. 8:245-256.
- Trenholm, L.E., R.N. Carrow, and R.R. Duncan, 2000a. Mechanism of wear tolerance in seashore paspalum and bermuda. *Crop Science*, Vol. 40:1350-1357.
- Trenholm, L.E., R.R. Duncan, and R.N. Carrow, 1999. Wear tolerance, shoot performance, and spectral reflectance of seashore paspalum and bermudagrass. *Crop science*. 39:1147-1152. (Abstract)
- Trenholm, L.E., R.R. Duncan, R.N. Carrow, and G.H. Snyder, 2001. The influence of silica on growth, quality, and wear tolerance of seashore paspalum. *Plant Nutrition*, Vol. 24:1-15.
- Ungar, I.A., 1977. Salinity, temperature, and growth regulator effects on the seed germination of *Salicornia europaea* L. *Aquatic Botany*. 3:329-335.
- USGS, 2005. Water Resources Data, State, 2005, Definition of terms. [http://water.usgs.gov/ADR\\_Defs\\_2005.pdf](http://water.usgs.gov/ADR_Defs_2005.pdf) , Aug. 2007.
- Wiecko, G., 2003. Ocean water as a substitute for post emergence herbicide in tropical turf. Vol. 17, Number 4:788-791.
- Zhou, Z., and Z. Hanguan, 2007. The effects of ryegrass roots and shoots on loess erosion under simulated rainfall. *Catena*. Vol 70:350-355.

## APPENDIX

Table A.1. Baseline Soil Nutrition Analysis

<b>River Silt</b>		<b>Brine</b>	
<b>Analyte</b>	<b>Result</b>	<b>Analyte</b>	<b>Result</b>
<b>P</b>	.350%	<b>P</b>	.035%
<b>K</b>	.245%	<b>K</b>	.018%
<b>Ca</b>	.522%	<b>Ca</b>	24.7%
<b>Mg</b>	.361%	<b>Mg</b>	2.48%
<b>Na</b>	.015%	<b>Na</b>	1.82%
<b>Ba</b>	113ppm	<b>Ba</b>	1541ppm
<b>Cl</b>	<9.20ppm	<b>Cl</b>	21466.31ppm
<b>Fe</b>	1.18%	<b>Fe</b>	.273%
<b>Zn</b>	42.6ppm	<b>Zn</b>	19.0ppm
<b>Mn</b>	260ppm	<b>Mn</b>	248ppm
<b>S</b>	420ppm	<b>S</b>	1940ppm
<b>Mo</b>	3.27ppm	<b>Mo</b>	.787ppm
<b>Cu</b>	5.90ppm	<b>Cu</b>	<79.0ppm
<b>Hg</b>	<73.0ppb	<b>Hg</b>	<63.0ppb
<b>Cr</b>	109ppm	<b>Cr</b>	3.74ppm
<b>Cd</b>	.697ppm	<b>Cd</b>	.463ppm

ppm= parts per million, ppb= parts per billion

Table A.2. Monthly total precipitation at Georgia Gulf Vinyls, LLC

<b>Month</b>	<b>Monthly Precipitation (inches)</b>
October 2006	7.48
November 2006	4.05
December 2006	11.2
January 2007	5.31
February 2007	1.07
March 2007	2.52
April 2007	3.63
May 2007	3.24
June 2007	4.65
July 2007	1.93

Table A.3. Monthly high and low mean temperatures

<b>Month</b>	<b>High °F</b>	<b>Low °F</b>
October 2006	80.2	60.4
November 2006	70.3	46.6
December 2006	62.9	44.7
January 2007	60.6	44.5
February 2007	61.9	43.2
March 2007	74.8	55.5
April 2007	76.2	56.5
May 2007	82.4	67.2
June 2007	87.3	71.4
July 2007	86.4	73.4

## VITA

Dexter Paul Fontenot was born in 1981 to John Davis and Dianne Fontenot in Eunice, Louisiana. He graduated from Mamou High School in 1999. He received his bachelor's degree in science from Louisiana State University in 2003. He worked on his family's farm in Eunice, Louisiana, for two years; during this time he married Kathryn Karsh of Fort Worth, Texas. He attended Louisiana State University on an assistantship to earn a Master of Science degree in horticulture, which will be awarded in December 2007.