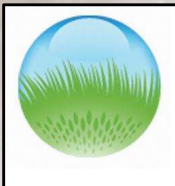


RESEARCH ON POTENTIAL USE OF VETIVER GRASS FOR BIOMASS/BIOFUEL FOR DRYLAND FARMING APPLICATIONS IN FLORENCE, SOUTH CAROLINA, USA



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INTRODUCTION

Hydromulch operates out of South Africa & has been proactive worldwide in Vetiver, propagation, marketing and environmental contracting for some five decades.

This paper covers the Clemson Pee Dee Research Education Center, Florence SC studies by Dr. James Fredericks to compare Vetiver grass (*Chrysopogon zizanioides*) to Switch grass (*Panicum virgatum*) as an alternative source of biomass to produce bio-fuel under dryland conditions on marginal soils suitable for crop production in Plant Hardiness Zones 8, 9 & 10 in the United States of America.

James Fredericks, a professor & agricultural science specialist at the Clemson Pee Dee Research Education Center. A leader in the study of using grasses and trees for making biofuels. He is the recipient of the 2022 South Carolina Environmental Awareness Award.



Biomass/Biofuel Studies

Additional studies were also carried out namely:

- **Plant density**
- **Fertiliser rates**
- **Plant spacing**
- **Grass harvest**
- **Bio-remediation using a floatation system.**

The USA Energy Information Administration (EIA) noted that there are 178 biomass power generating facilities in 2018 many of which utilise agricultural crops such as corn, soybeans, sugar cane, switch grass and other woody plants.

All Vetiver plants were supplied by Warren Sullivan of Mosquito Hawk Farms, Anahuac, TX. Harvesting of 6 000 top-quality plants and transported to Florence, SC by vehicle over the 1 040-mile distance.



Monthly rainfall totals in 2016, 2017 and 2018 and the long-term averages for each month.

	2016	2017	2018	Average
	Rainfall	Rainfall	Rainfall	Rainfall
Month	(inches)	(inches)	(inches)	(inches)
January	1.50	2.11	2.24	3.54
February	5.80	1.53	1.10	3.23
March	1.50	1.83	2.77	3.78
April	2.40	3.89	4.34	3.31
May	6.20	1.86	5.13	3.54
June	3.00	5.87	4.60	4.84
July	5.80	4.71	4.54	5.49
August	2.30	3.54	0.87	5.49
Sept.	7.60	2.98	12.00*	4.96
October	7.20***	2.26	5.89**	3.78
November	0.70	0.66	4.98	2.95
December	4.40	3.54	Not Avail.	3.30
*10.4 inches was from hurricane Florence on September 15, 2018				
**3.2 inches was from hurricane Michael on October 10, 2018				
*** 6.5 inches was from hurricane Mathew on October 16, 2016				

June 2015 – Initial Vetiver Trials

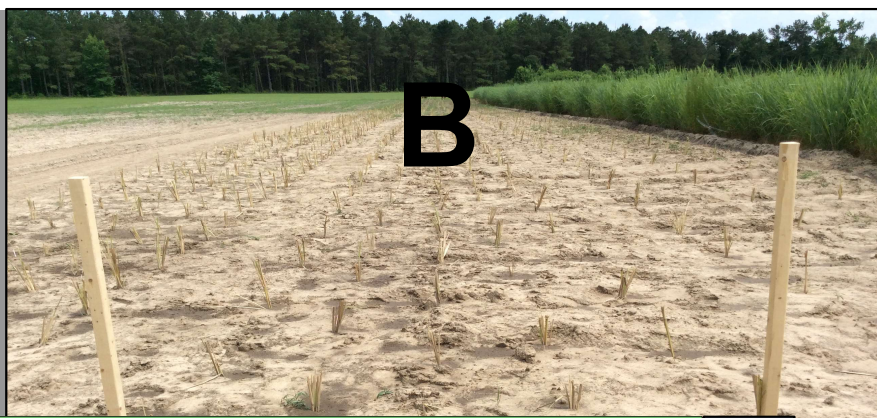
The initial Vetiver trial Area set up adjacent to the Abengoa Switch grass field trials in June 2015. Rows 150 yards long planted with 2 400 freshly harvested Vetiver plants during a dry June period. No irrigation provided with limited watering.

Hand augers used to create plant holes.



The 500-gallon water bowser used to irrigate vetiver slips at planting.

The planting sequence of the initial June 2015 Vetiver trial Area adjacent to the Switch grass field trials. Three rows, Sections A, B & C. planted at varying distances. All rows 10ft wide & 50ft long. 30ft border on each side.



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Switch Grass Field

Section A – 18" wide & plants 18" apart – 5 Rows

Section B – 18" wide & plants 36" apart – 5 Rows

Section C – 36" wide & plants 36" apart – 3 Rows

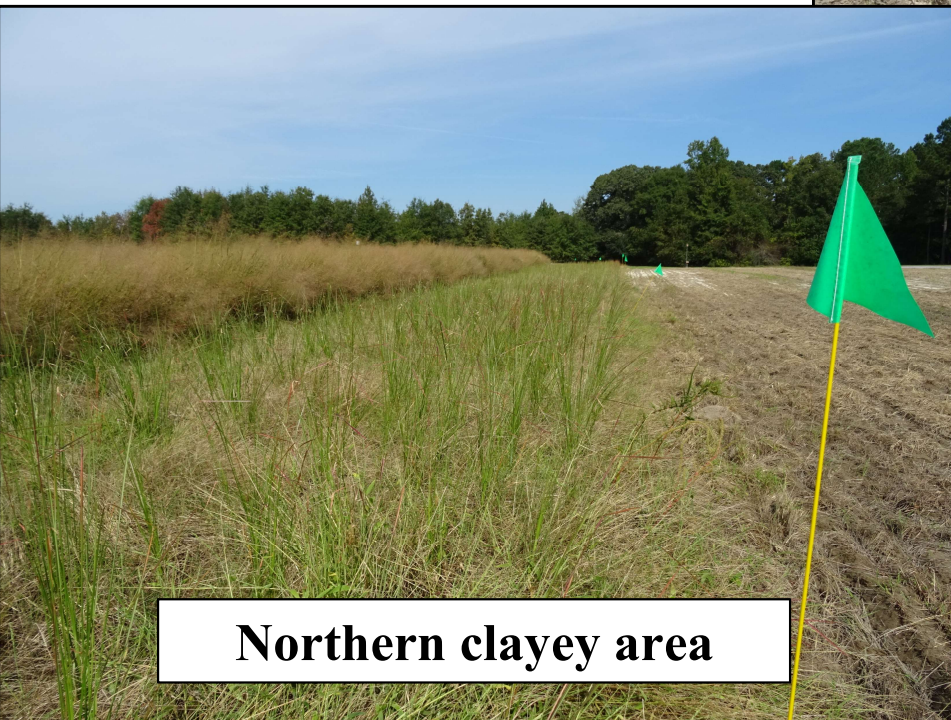


October 2015

Vetiver field as observed during October 2015 visit. Field overgrowth with crab grass. Plants well established considering dry conditions. Minimal dieback with fatality around 20% due to adverse conditions & dryland planting technique.



Southern sandy area



Northern clayey area

Note: Switch grass field adjacent to Vetiver field

June 2016 – Primary Study Area

An area of 15 040 ft² was added to the 2015 Vetiver area of 8 910 ft², totalling 23 950 ft². An additional 3 226 Vetiver slips were planted resulting in a total of 5 626 plants for the primary study area.



**Hand Auger used
for planting holes**

**Vetiver slips
planted at 8'
intervals**



October 2016 observation

The plant survival was low across the June 2016 planted field necessitated replanting during October 2016. Dieback of Vetiver plants on the drier sandy section was around 45% with an average plant height of 2 ft.



October 2016 observations.....

Dieback of the 2016 Vetiver plants on the clay-sandy loam soils showed as little as a 30% loss. Plant height was around 4 ft in average. The 2015 plants (Left side) were well established.



October 2016 observations.....

The Vetiver trial area was saturated from Hurricane Mathew that hit South Carolina on 8th October 2016 dumping 6.5 inches. The taller 2015 mature plants were pushed over at an angle of between 30° and 45° by the high winds.



Some interesting observations made in October 2016

- It was found that the Vetiver plants continued to grow late into the autumn season whereas the switch grass appears to have gone dormant.**

Switch Grass

Vetiver Grass



- **The number of harvested slips/tillers taken from the 2015 trial area varied between 38 and 54, indicating its multiple or exponential growth pattern.**



- **The stems of the Vetiver grass reached heights in excess of 7 foot in the wetter-clayey side of the field after only two years.**
- **About 60% of the final plant height was obtained by early July in each year.**
- **There was little change in plant height after early October in all 3 years.**

This response is typical of warm-season grasses in South Carolina as they reduce growth in the fall (Autumn) and begin to build up reserves for the winter. These reserves are translocated to the crown and roots of perennial grasses and used for initial growth the following spring.

Comparison of growth cycles of Switch grass & Vetiver grass during September 2018 – also heights (± 7 ft) reached by Vetiver grass after two years growth.



Dr. James Fredericks together with Bruce Coy (EBS)



2016, 2017, & 2018 biomass moistures & yields for Vetiver grass planted in 2015.

2016

2017

2018

Density	Plot	Moisture (%)	Dry Yield (tons/acre)	Moisture (%)	Dry Yield (tons/acre)	Moisture (%)	Dry Yield (tons/acre)
Section A	1	39.7	2.92	42.8	5.13	50.0	5.23
Thick	2	41.4	2.61	40.7	4.26	53.5	3.57
Density	3	45.7	3.33	45.3	7.20	45.8	6.86
	4	45.2	4.13	44.7	7.72	50.9	6.86
	5	42.8	5.10	47.0	7.42	50.9	7.12
	6	45.2	5.02	41.2	6.74	53.1	6.45
Ave.		43.3	3.85	43.6	6.41	50.7	6.02
Section B	1	41.6	2.51	38.3	3.71	54.5	3.65
Medium	2	44.5	2.26	38.3	3.98	48.2	3.34
Density	3	43.4	2.53	43.4	6.19	56.4	5.00
	4	46.4	3.70	49.2	7.13	54.3	6.04
	5	48.3	3.93	50.2	7.61	55.1	5.62
	6	47.4	3.61	49.8	6.66	51.9	5.74
Ave		45.3	3.09	44.9	5.88	53.4	4.90
Section C	1	36.5	1.26	37.7	2.27	48.1	3.11
Thin	2	34.0	1.84	39.0	2.42	43.5	2.84
Density	3	40.3	2.47	37.7	5.71	45.7	4.39
	4	43.0	2.61	43.2	6.54	54.3	5.62
	5	44.2	3.85	44.2	7.63	50.5	6.15
	6	44.5	3.78	50.0	7.82	55.2	6.02
Ave		40.4	2.64	42.0	5.40	49.6	4.69

2017 and 2018 biomass moistures and yields of Vetiver grass as a function of harvest date planted in 2016.

2017 Vetiver Data** 2018 Vetiver Data 2018 Vetiver Data

First Harvest First Harvest Second Harvest

Harvest Timing		Moisture (%)	Dry Yield tons/acre	Moisture (%)	Dry Yield tons/acre	Moisture (%)	Dry Yield tons/acre
Rep							
1	Early July	35.9	1.25	72.8	2.27	53.5	0.54
2	Early July	42.7	2.23	75.3	3.05	57.6	1.15
3	Early July	47.2	5.74	75.3	3.94	58.4	1.62
Ave		42.0	3.07	74.5	3.09	56.5	1.1
1	Early Sept	40.0	1.40	61.1	5.22	58.6	0.16
2	Early Sept	38.4	2.40	57.7	7.68	56.2	0.17
3	Early Sept	38.2	6.49	57.1	11.10	59.3	0.47
Ave		38.9	3.43	58.6	8.00	58	0.27
1	Winter	43.0	1.11	53.3	4.18	N/A	N/A
2	Winter	41.4	3.64	50.8	4.78	N/A	N/A
3	Winter	38.8	5.72	56.3	5.44	N/A	N/A
Ave		41.1	3.49	53.5	4.80	N/A	N/A

Vetiver Grown in Float System

Dr. Frederick arranged that, as part of the Clemson research program, Vetiver pontoons could be floated in a pond, situated on an adjacent farm to the Pee Dee Research Center, belonging to Mr. Edwin Dargan.

Four Vetiver pontoons (Control) was relocated from the portable pool located in Summerville, SC.



Vetiver Grown in Float System

The Dargan's Farm pond is spring-fed and has little to no water flow or exchange in most years. Four pontoons would be floated and monitored over time by Dr. Fredericks.



2017 -Preparing & placing Vetiver grass pontoons for pond float system at Dargan's Farm, Pee Dee, SC in Oct 2018.



Construction of Netlon cage to protect root system from turtles & other invertebrates

Placing Vetiver pontoons on Dargan Pond, Pee Dee, SC



Pictures of the Vetiver Grass grown in the pond float system.



2019 biomass nutrient concentrations of Vetiver grass grown in a pond float system at Dargan's Farm and grown in the field at the Pee Dee REC in early 2019.

Plant Part	Float No.	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe	Na	B	Al
		%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	Ppm	ppm
Leaves	1	0.80	0.06	1.81	0.19	0.17	0.06	54	4.0	71	54	23	3	27
Leaves	2	0.83	0.06	1.83	0.20	0.18	0.06	47	4.0	104	101	30	2	61
Leaves	3	0.88	0.06	1.80	0.19	0.17	0.06	45	5.0	81	69	40	3	36
Leaves	4	0.70	0.05	1.96	0.15	0.16	0.05	50	7.0	83	56	23	2	26
Ave.		0.80	0.06	1.85	0.18	0.17	0.06	49	5.0	85	70	29	3	38
Roots	1	1.67	0.13	0.72	0.14	0.15	0.15	218	11	1420	9479	187	4	994
Roots	2	2.24	0.18	0.60	0.18	0.16	0.17	236	13	1369	13326	257	5	1401
Roots	3	1.99	0.12	0.82	0.18	0.16	0.18	202	10	1283	9112	162	3	901
Roots	4	2.82	0.24	1.09	0.30	0.24	0.20	232	17	1395	15536	257	9	2063
Ave.		2.18	0.17	0.81	0.20	0.18	0.18	222	13	1367	11863	216	5	1340

Relocation of Vetiver grass plants from the field research plots at Pee Dee Research Center, to Hemingway, SC during June and July of 2019.



Approximately 55,000 slips were separated from the stalks/culms of the 5,626 vetiver plants and relocated to Hemingway, SC.



Conclusion

The research data results from the study carried out by Professor Fredericks, indicates that:

The biomass yield potential for Vetiver grass grown in South Carolina is greater than that of the other perennial warm-season grasses previously evaluated by Clemson University.

There should be few widespread limitations to producing Vetiver grass as a bio-energy crop on the sandy Coastal Plain of South Carolina and other locations situated within USDA/NRCS plant hardiness zones 8, 9 & 10.

Root harvest, more so than above-ground harvest, should be a greater consideration when using Vetiver grass for bio-remediation purposes.

The above study can be viewed on:

<https://drive.google.com/file/d/1bcQhF1S3gU2xxGGCatBjDEAbwpG30ZcN/view?usp=sharing>

or on The Vetiver Network International website – www.vetiver.org – “Recent studies on Vetiver supported by Hydromulch (Pty) Ltd, South Africa”.



Thank you