The effect of physical agents (Laser and EMR) on germination and biomass production of switchgrass (*P. virgatum*)

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Abstract

Panicum virgatum L. (switchgrass) seeds were treated with physical agents in an attempt to stimulate biomass production and increase germination percentages. 0.250 g (100-115 seeds) were treated with laser (1334.5 mWatt/plate) 20 or 30 minute and microwave electromagnetic radiation of (2.425 GHz, 0.1341 W, 21.27 dBm) for 20 min. The treated seeds were planted in 4" pots in topsoil, with a ~0.5 cm layer of peat moss on top. The pots were watered to saturation once every two days. The seeds were monitored and germination data was collected on day 10 and 30 from sowing. On the 30th day, the shoots were harvested at the soil level to determine fresh biomass yield (fresh weight). The biomass was dried at 60°C to constant weight before recording the dry biomass (dry weight).

Introduction

Switch grass is a perennial, warm season grass, able to be used for erosion control and bioenergy production, capable of being cultivated on marginal lands and thus not competing with food crops. However, switchgrass naturally has a low germination rate and field establishment rate, making it less cost effective to use. Chemical treatments and scarification enhance seed germination in switchgrass (Shen et al., 2007). Physical methods such as electromagnetic radiation and laser can also enhance seed germination in some plant species (Aladjadjiyan et al. 2007). Aladjadjiyan et al. (2007) also demonstrated that the effect, especially that of microwaves, is stronger in pretreated seeds due to the paramagnetic nature of water, but the application of moisture doesn't translate practically to large scale applications in industry. This research was aimed to discover the effect of short duration (20 and 30 min) laser and EMR treatments on germination of switchgrass seeds, and accumulation of biomass.

Methods

New season seeds of switchgrass variety Shelter kindly donated by Ernst Conservation Seeds, Meadville, PA were used in this study. Lots of 250 mg (100 to 115) seeds were thoroughly washed with tween 20 ® for 10 min. The foam was removed by repeated washing and floating seeds were removed by decanting off the wash water. Cleaned seeds were evenly planted in potting soil (4" pots) and covered with 0.5 cm peat moss. Pots were watered to saturation once every two days.

Treatment with Laser

An infrared laser (830 nm) was used in this experiment. The laser treatment was performed in a chromatography chamber at 4°–C to prevent possible overheating of seeds. The moist seeds were placed in the center of a 5 cm petri dish (Fig. 1). Seeds were irradiated with laser (strengths for 20 and 30 min). We used 10 replicates for each treatment with five plates of control (untreated) and the experiments were repeated.

Treatment with Microwave Electro Magnetic Radiation (EMR)

A set up for microwave EMR treatment was organized in collaboration with Dr. Tofighi and Mr. Li in the Electrical Engineering Department as shown in Fig. 2. Lots of cleaned, moist seeds, as well as lots of dry seed, were treated with EMR (2.425 GHz, 0.1341 W, 21.27 dBm) for 20 min. The temperature of the seeds was monitored before and after the treatment and there was little noticeable heating effect. The treated seeds were planted in the greenhouse and nurtured as detailed earlier.

Germination data was collected at 10 and 30 days from sowing, and on the 30th day, the shoots were harvested at the soil level to determine fresh biomass yield (fresh weight). The biomass was dried at 60°C to constant weight before recording the dry biomass (dry weight). Results were analyzed using a two tailed t-test, both for individual trials and for sets of treatments. In the case of sets of treatments, day 10 data was used for all trials unless day 30 data had been collected for each of them.

Figure 1: 830 nm laser in 4˚C chromatography chamber.

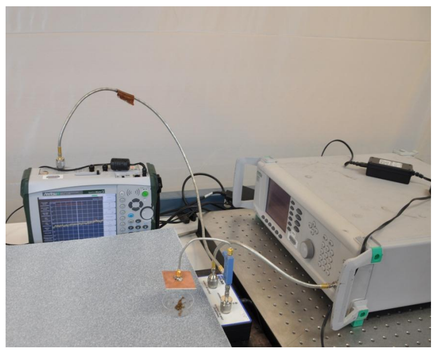

Figure 2: Anritsu continuous microwave signal generator was connected to a bidirectional amplifier and a patch antenna.

Results

Figure 3: Germinating switchgrass in the greenhouse (25 days)

Figure 4: Several trials of switchgrass seedlings

Figure 5: Treatment Schedule

Date	Treatment	Duration	Distance	Intensity
6/13	!R	20 min	19 cm	Full
6/20	IR	20 min	19 cm	full
6/21	IR	30 min	30 cm	partial
7/1	IR	20 min	30 cm	full
7/7	IR	20 min	19 cm	full
7/11	IR	20 min	19 cm	full
7/18	IR	30 min	19 cm	full
7/19	IR	30 min	19 cm	full
7/21	IR	30 min	30 cm	partial
7/26	EMR-wet	20 min	5 cm	21.3 dbm
7/29	EMR-wet	20 min	5 cm	21.3 dbm
7/29	EMR-dry	20 min	5 cm	21.3 dbm
8/4	EMR-wet	20 min	5 cm	21.3 dbm

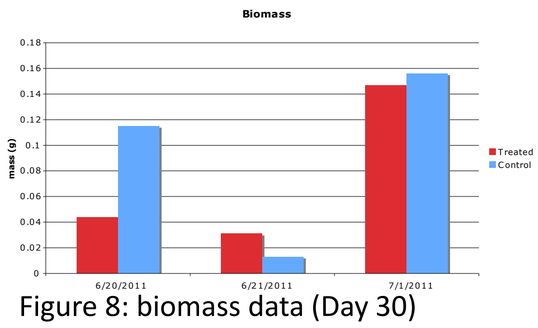

Figure 8: biomass data (Day 30)

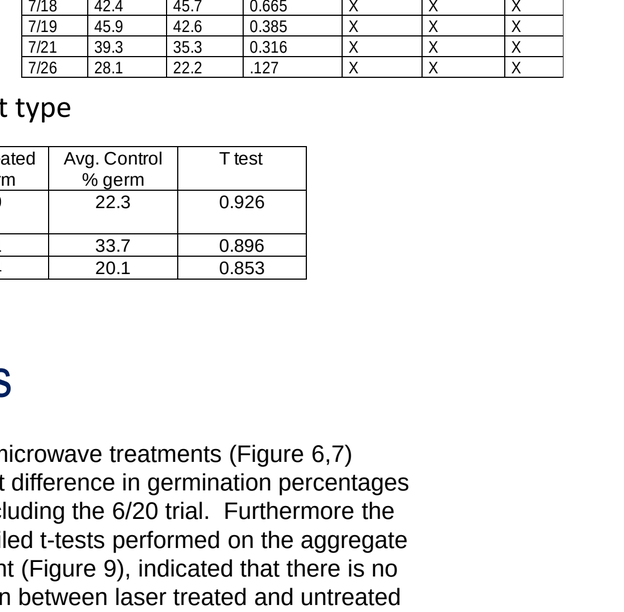

Figure 6: germination data, (Day 10 or 30)

Figure 7: average percent germination and t-test results

Date	Avg. Treated % Germ	Avg. Control % Germ	t (two tailed)	Avg. Treated Mass(g)	Avg. Control Biomass (g)	t
6/13	5.8	0.26	0.012736503	X	X	X
6/20	19.1	31.4	0.113	0.044	0.115	0.0383
6/21	23.3	11.1	0.039	0.031	0.013	0.118
7/1	26.7	31.5	0.429	0.147	0.156	0.764
7/7	26.0	27.7	0.595	X	X	X
7/11	7.8	3.1	0.221	X	X	X
7/18	42.4	45.7	0.665	X	X	X
7/19	45.9	42.6	0.385	X	X	X
7/21	39.3	35.3	0.316	X	X	X
7/26	28.1	22.2	.127	X	X	X

Figure 9: Trials by treatment type

Duration, Distance	Dates	Avg. Treated % germ	Avg. Control % germ	T test
20 min, 19 cm	6/13, 6/20, 7/7, 7/11	21.9	22.3	0.926
30 min, 30 cm	6/21, 7/21	34.1	33.7	0.896
30 min, 19 cm	7/18, 7/19	21.4	20.1	0.853

Results and Conclusions

Germination data from both IR laser and microwave treatments (Figure 6,7) demonstrated that there was no significant difference in germination percentages between treated and untreated seeds, excluding the 6/20 trial. Furthermore the biomass data (Figure 8), as well as two tailed t-tests performed on the aggregate sets of data for multiple trials of a treatment (Figure 9), indicated that there is no significant difference in biomass production between laser treated and untreated seeds. Application of Infrared laser thus has no significant effect in the seed germination of switchgrass. Microwave EMR trials are ongoing.

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