



## Research Report

# Evaluation of Intermediate Wheatgrass, Tall Wheatgrass and Reed Canarygrass for Biomass Production in Vermont

2009 – 2012



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# Evaluation of Intermediate Wheatgrass, Tall Wheatgrass and Reed Canarygrass for Biomass Production in Vermont

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Perennial forage grasses have the potential to be utilized as a biomass fuel for heating which could displace heating oil or propane, both important petroleum products in the Northeast subject to fluctuating prices. Many marginally productive fields in the Northeast are no longer utilized for forage production but could support perennial grasses for biomass production.

As part of a Vermont initiative to explore the potential of perennial grasses for biomass energy, field trials were conducted in Vermont from 2009 to 2012 in order to evaluate the production, fuel quality characteristics, and sustainability of various cultivars of intermediate wheatgrass (*Thinopyrum intermedium*), tall wheatgrass (*Thinopyrum ponticum*) and giant wildrye (*Leymus racemosus*).

These grasses have not historically been used in the Northeast because of their lack of high quality as dairy forage. Also, there is little knowledge about their adaptation to a temperate region in terms of long term sustainability. However, they do have characteristics conducive for their use as a biomass crop including:

- High production of culms
- High stem to leaf ratio
- Low mineral and ash content
- Late, single cut harvest system in late summer when it is better weather for hay



Figure 1. Intermediate wheatgrass (left) and tall wheatgrass (right) seed heads at the UVM Horticultural Farm, 7/23/2010.

## Materials and Methods

The trial was planted on August 18, 2009 at the University of Vermont Horticultural Research Farm in South Burlington, VT on a Duane/Deerfield fine sandy loam soil series, a moderate to well drained soil with 0 to 1% slope. Two cultivars of each tall wheatgrass, intermediate wheatgrass as well as one cultivar of reed canarygrass were included in the study (**Table 1**). Since reed canarygrass is so commonly found on marginal sites in Vermont and is a known potential biomass crop, it was used as a comparative species in this study. The design of the study utilized a completely randomized block design with four replications. Plot size was 10 x 23 feet for each treatment. All plots received 50 lbs of N per acre each year applied in late April/early May when grasses were about three to four inches tall. No other fertilizer was added during the time of the study. Initial soil test showed the site to be moderate for P and K soil levels.

Plots were harvested only once per year between late July to early August when the grasses were fully mature. A Carter research forage harvester was used to determine biomass yields by cutting a three foot wide by 20 foot strip out of each plot. Samples were collected to determine dry matter content and used for ash and mineral analysis. Samples were weighed wet and after drying in a forced air dryer for 48 hours, weighed dry. Samples were then ground in a Wiley mill and Udi mill to a 1 mm particle size for ash and mineral analysis conducted at the UVM Ag Testing Lab.



Figure 2. Carter forage plot harvester in a plot of intermediate wheatgrass.

**Table 1. Description of grass species and cultivars evaluated in the Cool Season Grass Evaluation Trial , Vermont Grass Biomass Project, 2009 – 2012.**

Grass Species	Origin	Species Description	Cultivar	Heading Period <sup>1</sup>	Breeding Development
<b>Tall wheatgrass</b> <i>Thinopyrum ponticum</i>	Non-native from Turkey, Asia Minor, Russia	Bunchgrass grown in Northern Great Plains U.S. for hay and pasture.	Alkar	late June	Nebraska
			Largo	late June	Albuquerque, NM and Logan, Utah by USDA-NRCS
<b>Intermediate wheatgrass</b> <i>Thinopyrum intermedium</i>	Non-native from Central Europe, Asia Minor, and Balkans	Rhizomatous sodgrass grown in Northern Great Plains U.S. for hay and pasture.	Big Flats	mid June	Big Flats, NY developed by USDA-NRCS
			Haymaker	mid June	Nebraska developed by USDA-ARS
			Beef Maker	mid June	Developed by USDA-ARS in Nebraska
<b>Reed Canarygrass</b> <i>Phalaris arundinacea</i>	Non-native from Europe <sup>2</sup>	Rhizomatous sodgrass commonly found in Vermont	Palaton	Late May to Early June	Developed by Land of Lakes in Minnesota

<sup>1</sup> Period in which seedheads are initially emerging as recorded and observed in the cool season grass trial in Vermont

<sup>2</sup> There are native types of reed canarygrass but most forage selections are from introduced ecotypes from Europe

## Results

**Biomass Yields** – In 2010, the first harvest year, biomass yields ranged from 1.7 to 2.4 tons of d.m. per acre with the intermediate wheatgrass cultivars yielding significantly higher than the tall wheatgrass cultivars (**Table 2**). Since the study was seeded in late summer of 2009, it is likely that the grass stands were not fully developed by 2010. Also, July of 2010 was quite dry with 2.6 inches less than normal rainfall (**Table 6**).

The reed canarygrass yielded low as well in 2010. This may have been due to a response to an application of 2,4-D in May to control an invasion of perennial broadleaf weeds. After the application of this herbicide, it became apparent that seed head production was inhibited forming only leafy, vegetative growth for the rest of the season. The other grasses were not in a vulnerable stage of



development at the time of the herbicide application; therefore, their reproductive development was complete. **Figure 3** shows the stage of development of a plot of RCG in each year of the study. This also, explains why the dry matter content was so low.

Biomass yields were higher and similar in 2011 and 2012 compared to the first year with no significant differences amongst the grass species or cultivars. A higher yield was expected since the stand was fully developed by the second production year.

**Dry Matter Content** - Differences in dry matter content varied most between the intermediate and tall wheatgrass species (**Table 2**), most likely due to their relative differences in maturity. Generally, the intermediate wheatgrasses began heading sooner than the tall wheatgrass. For both species, almost all of the tillers would develop into reproductive stems; whereas, the reed canarygrass varied from year to year which explains its variation in dry matter content (**Figure 3**).

**Table 2. Average biomass yield and dry matter content of cool season grasses harvested over three years in South Burlington, Vermont. Planted on 8/18/2009.**

<u>Species</u>	<u>Cultivar</u>	<u>Biomass Yield</u>			<u>Dry Matter Content</u>		
		<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2010</u>	<u>2011</u>	<u>2012</u>
		----- tons d.m./acre -----			----- % dry matter at harvest -----		
Inter. wheatgrass	Big Flats	2.4 a <sup>3</sup>	3.7	3.4	37 bc	58 a	59 a
Inter. wheatgrass	Haymaker	2.2 a	3.3	3.2	41 a	56 a	59 a
Inter. wheatgrass	Beef Maker	2.3 a	3.7	3.6	39 ab	56 a	59 a
Tall wheatgrass	Alkar	1.7 b	3.9	3.5	38 abc	47 b	52 b
Tall wheatgrass	Largo	1.7 b	3.7	3.1	35 bc	49 b	51 b
Reed canarygrass	Palaton	2.0 ab	3.6	2.9	34 c	48 b	44 c
<i>Significance</i> <sup>2</sup>		#	n.s.	n.s.	#	***	**

<sup>1</sup> Harvest dates were 7/29, 8/2, 8/7 for 2010, 2011, and 2012, respectively

<sup>2</sup> Significance: # P<0.10, \* P<0.05, \*\* P<0.01, \*\*\* P<0.001

<sup>3</sup> Means with the same letter are not significantly different (P<0.10)



Figure 3. The stage of development of the same plot of reed canarygrass in 2010, 2011, and 2012. In 2010, seed head development was inhibited by a late application of the herbicide 2,4-D when RCG had already began jointing phase. In 2011, the stand was in full head as would normally be expected. The lack of seed head production in 2012 may have been due to a lack of vernalization because of a previous mild winter.

**Lodging** - In two of the three years, lodging was a problem for some of the cultivars (**Table 3**). In 2011, a major thunderstorm occurred on July 3 when most all the grasses were at full head emergence causing serious lodging of both intermediate and tall wheatgrass. Although reed canarygrass was also at full head, it was resistant to lodging damage (**Figure 4**). In 2012, there was a higher amount of lodging with the intermediate wheatgrass cultivars compared to the other grasses. None of the lodging was great enough to affect yield.

**Table 3. Average lodging ratings of cool season grasses harvested over three years in South Burlington, Vermont. Planted on 8/18/2009.**

<u>Species</u>	<u>Cultivar</u>	<u>Lodging<sup>1</sup></u>		
		<u>2010</u>	<u>2011</u>	<u>2012</u>
Inter. wheatgrass	Big Flats	1.0 b <sup>3</sup>	3.4 a	3.1 ab
Inter. wheatgrass	Haymaker	1.0 b	3.0 a	3.8 a
Inter. wheatgrass	Beef Maker	1.0 b	2.9 a	2.3 ab
Tall wheatgrass	Alkar	1.0 b	2.5 ab	1.3 b
Tall wheatgrass	Largo	2.0 a	3.0 a	1.5 b
Reed canarygrass	Palaton	1.0 b	1.0 b	1.5 b
<u>Significance<sup>2</sup></u>		*	*	**

<sup>1</sup> Visual rating of the whole plot from 1 (none) to 5 (completely lodged)

<sup>2</sup> Significance: # - P<0.10, \* - P<0.05, \*\* - P<0.01

<sup>3</sup> Means with the same letter are not significantly different (P<0.05)



Figure 4. A plot of lodged intermediate wheatgrass (A) compared to a plot of reed canarygrass (B) that had no lodging damage in 2011. A strong windstorm on 6/24 caused this lodging and the affect persisted up until harvest on 8/2. By driving in the opposite direction of the lodged forage, we were able to minimize yield losses (C).

**Ash and Mineral Content** - Ash content and certain minerals can have a significant effect on the fuel properties of grasses used for combustion. There is generally a high correlation between ash content of biomass combustion fuels with levels of undesirable minerals such as potassium (K), silicon (Si), chloride (Cl), and sulfur (S) that affect burn efficiency, fouling and slagging (Cherney and Verma, 2013). Generally, ash content in perennial grasses can range from 2% up to over 10 % depending on

species, stage of maturity at time of harvest, soil texture and drainage, soil fertility and weather conditions, and soil contamination.

In this study, ash content varied from as low as 2.9% to as high as 7% across years and species. All of these levels were above optimum for newly proposed grass pellet fuel standards but still within an acceptable range (Cherney and Verma, 2013). Ash content was consistently lower for the intermediate wheatgrass cultivars as well as ‘Largo’ tall wheatgrass compared to reed canarygrass (**Table 4**). ‘Alkar’ tall wheatgrass was numerically lower but not significantly different than reed canarygrass in two of the three years. Reed canarygrass had much higher ash content in 2010 and 2012 probably because of a higher proportion of vegetative tillers in those years compared to 2011 (**Figure 3**). There appeared to be no relationship between lodging and ash content indicating little to no soil contamination occurred during harvest.

Potassium (K) content of grass biomass, along with other alkali metals and chloride, can have a significant effect on the potential to cause boiler corrosion along with fouling and slagging. In this study (**Table 4**), K levels were about 1.0% which is above both the optimum and acceptable range for newly proposed grass pellet fuel standards (Cherney and Verma, 2013). Within treatments, intermediate wheatgrass was lower than tall wheatgrass and reed canarygrass but not by a large amount. ‘Beef Maker’ intermediate wheatgrass had the lowest K content and ‘Largo’ tall wheatgrass, the highest.

Nitrogen (N) and sulfur (S) content of biomass can indicate potential for NO<sub>x</sub> and SO<sub>x</sub> emissions, respectively, and in this study, all the grass species and cultivars (**Table 4**) were above optimum but within acceptable ranges for quality fuel standards recently proposed for grass pellets (Cherney and Verma, 2013). Except for ‘Alkar’ tall wheatgrass, all the other cultivars had significantly lower S levels compared to reed canarygrass.

**Table 4. Ash and mineral content of cool season grasses harvested over three years in South Burlington, Vermont. Planted on 8/18/2009.**

<u>Species</u>	<u>Cultivar</u>	<u>Ash Content</u>			<u>Mineral Content in 2011</u>		
		<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>N</u>	<u>K</u>	<u>S</u>
		----- % of dry matter -----			----- % of dry matter -----		
Inter. wheatgrass	Big Flats	5.2 bc <sup>3</sup>	3.4 bc	3.2 b	0.85	0.97 abc	0.07 bc
Inter. wheatgrass	Haymaker	4.9 c	3.3 bc	3.5 b	0.88	0.93 bc	0.09 bc
Inter. wheatgrass	Beef Maker	5.1 bc	2.9 c	3.2 b	0.75	0.81 c	0.06 c
Tall wheatgrass	Alkar	6.1 ab	3.8 ab	4.4 b	0.97	1.23 a	0.11 ab
Tall wheatgrass	Largo	5.5 bc	3.3 bc	4.1 b	0.90	1.05 abc	0.09 bc
Reed canarygrass	Palaton	7.1 a	4.3 a	6.9 a	0.80	1.13 ab	0.15 a
Significance <sup>2</sup>		**	**	***	n.s.	**	***

<sup>1</sup> Harvest dates were 7/29/10, 8/2/11, 8/7/12

<sup>2</sup> Significance: # - P<0.10, \* - P<0.05, \*\* - P<0.01

<sup>3</sup> Means with the same letter are not significantly different (P<0.05)

**Nutrient Removal Rate** – Since biomass crops remove the total above ground portions of the crop, it is important to determine the potential removal rate of soil nutrients in order to assess replacement needs over time. Removal rates of macronutrients from this study (**Table 5**) averaged 63 lbs of N, 28 lbs of P<sub>2</sub>O<sub>5</sub>, 90 lbs of K<sub>2</sub>O, 5 lbs of Mg, and 7 lbs of S per acre for 2011. At such high P and K removal rates, annual or biennial applications of nutrients will be important to maintain a stand. Reed canarygrass removed a significantly higher amount of P<sub>2</sub>O<sub>5</sub> and Mg compared both wheatgrass species and, except for ‘Alkar’ tall wheatgrass, it removed more S the wheatgrass species.

**Table 5. Nutrient removal rates of cool season grasses harvested over three years in South Burlington, Vermont. Planted on 8/18/2009.**

Species	Cultivar	Nutrient Removal Rate				
		N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Mg	S
		----- lbs. / acre -----				
Inter. wheatgrass	Big Flats	64	27 b <sup>3</sup>	88	4.6 b	5.4 c
Inter. wheatgrass	Haymaker	59	23 b	76	4.8 b	5.8 c
Inter. wheatgrass	Beef Maker	55	27 b	71	4.6 b	5.2 c
Tall wheatgrass	Alkar	74	27 b	113	4.9 b	8.9 ab
Tall wheatgrass	Largo	68	24 b	93	4.7 b	6.7 bc
Reed canarygrass	Palaton	59	39 a	98	7.8 a	10.9 a
Significance <sup>2</sup>		n.s.	*	n.s.	**	*

<sup>1</sup> Harvest date was 8/2/2011

<sup>2</sup> Significance: # - P<0.10, \* - P<0.05, \*\* - P<0.01

<sup>3</sup> Means with the same letter are not significantly different (P<0.05)

**Table 6. Average monthly temperature and rainfall and the difference from normal at the University of Vermont Horticultural Research Farm, 2009 to 2012.**

UVM Horticultural Farm, South Burlington																
Average Monthly Temperature (F)									Average Monthly Precipitation (inches)							
	2009		2010		2011		2012		2009		2010		2011		2012	
	Ave.	DFN	Ave.	DFN	Ave.	DFN	Ave.	DFN	Ave.	DFN	Ave.	DFN	Ave.	DFN	Ave.	DFN
April	47	2.4	49	4.4	45	0.5	46	1.6	2.1	-0.7	3.3	0.5	6.4	3.6	2.4	-0.4
May	57	0.1	61	4.2	59	2.4	61	5	5.0	1.6	1.6	-1.8	6.2	2.7	3.9	0.4
June	64	-1.4	66	-0.1	67	1.3	67	1.4	4.2	0.5	5.2	1.5	1.9	-1.8	2.8	-0.9
July	68	-2.7	74	3.5	75	4.5	72	1.8	3.9	-0.3	1.6	-2.6	2.5	-1.7	3.5	-0.6
August	71	1.9	70	1.5	72	3.1	72	2.9	2.3	-1.7	2.2	-1.7	5.7	1.8	0.0	-3.9
September	60	-0.5	63	2.7	65	4.5	62	1.4	3.3	-0.4	3.7	0.1	3.9	0.3	5.1	1.5
October	47	-1.7	49	0.7	51	2.4	53	4.7	2.7	-0.9	3.9	0.3	1.9	-1.7	5.0	1.4



Based on this the findings of this study, the use of tall wheatgrass or intermediate wheatgrass may be questionable for Vermont. The yields were relatively low and the nutrient removal rates were relatively high compared to the potential of warm season grasses. Also, ash and potassium content were higher than a desirable level. In addition, the regrowth of these grasses after the biomass harvest was relatively small compared to the reed canarygrass indicating that they would not provide a dual purpose of biomass and late season forage (**Figure 5**). By 2012, the stands were also starting to appear thinner and with a higher amount of weeds. An assessment of the stands in 2013 will be made to determine stand density.



Figure 5. Amount of regrowth and stand condition of 'Big Flat' intermediate wheatgrass (A) and 'Palaton' reed canarygrass (B) on October, 2012.

## References

Cherney JH and VK. Verma. 2013. Grass pellet Quality Index: A tool to evaluate suitability of grass pellets for small scale combustion systems. *Applied Energy* 103: 679-684.  
<http://dx.doi.org/10.1016/j.apenergy.2012.10.050>

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For More Information on Grass Biomass, go to: <http://pss.uvm.edu/vtcrops/?Page=energycrops.html>

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