Tall wheatgrass for Biofeedstock Energy: Yield, Seeding Rate and Time of Harvest Study

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Introduction

The objective of this study is to evaluate three commercially available plant releases of tall wheatgrass, *Thinopyrum ponticum* (Podp.) Z.-W. Liu & R.-C. Wang, from the US to an improved commercial tall wheatgrass cultivar from Hungary “Szarvasi-1”, an intermediate wheatgrass cultivar and two reed canary grass cultivars for potential use as a biofuel crop in the Northeast. A time of cutting study was also conducted to look at the potential for single late harvest cutting on yield and quality.

Increased efforts are now underway to develop grass biofeedstocks for various biofuel applications. Much attention has been given to switchgrass for this effort. In the Northeast and other moist and cooler environments there is still a question about the long term competitiveness of switchgrass to other more adapted cool season grasses and weeds. The addition of increased herbicide use compared to cool season grass, slow establishment and difficulty in harvest may not make switchgrass the most economical and sustainable biofeedstock. The utilization of both cool and warm season grasses separately may also have a place in these regions. Cool season grasses like tall wheatgrass will allow for late summer establishment in these cooler environments. There may also be the potential to use a legume component reducing fertilizer N inputs. The late maturity of the tall wheatgrass allows for a single cutting to harvest 85% of the biomass with the potential for lower ash, K and Cl content then conventional forage species.

Material and Methods

A cultivar and time of cutting study was conducted at the Big Flats Plant Material Center on a Unadilla silt loam soil in Corning, NY. The soil was tested at Cornell University. For the cultivar study the pH was 6.0 with high P and K test results, the cutting study had a pH of 5.8 with a high P and medium K test results. For the cultivar study the field was conventionally tilled and cultipacked before and after seeding on 9/4/07 using a walk behind cone planter with plots 3.75 x 15 ft. the plots were fertilized with 66 lb/ac of N in late April and after the first cutting. The species, cultivars, fertilizer dates and seeding rates are outlined in Tables 1 & 2. The plots were set up in a randomized block design and harvested with a carter harvester. Over one thousand perennial grass samples harvested from trials were oven dried, ground to a 1 mm particle size and scanned on a Foss NIR Systems spectrophotometer (Foss NIR Systems, Model 5000, Silver Spring, MD). Approximately 10% of the samples were selected for calibration by principal component analysis method using WINISI II software (Intrasoft International, Port Matilda, PA). These calibration samples were analyzed through wet-chemistry by Dairy One Forage Testing Laboratory, Ithaca, NY. NIR equations were then developed for the sample set using ISI software (Intrasoft International, CAL version 1.5 and higher, Port Matilda, PA) to predict values of all perennial grass samples. Data from this analysis will be presented.

For the time of cutting study the field was conventionally tilled and cultipacked before and after seeding on 9/4/07 using a Truax Drill. The Tall wheatgrass cultivars ‘Alkar’ from Pullman WA PMC a selection out of PI-98526 from the former USSR and ‘Szarvasi-1’ from a commercial source in Hungary were used. The cultivars were seeded at the 20 and 40 lb/ac rate with no fertilizer applied at planting. The field was fertilized with 75 lb/ac of N in the form of calcium ammonium nitrate on 4/28/08. The cutting dates in 2008 for the 1st cut were 7/3, 7/10, 7/17 and 10/10. The first three cutting dates were cut a second time on 10/10/08. There were 4 replications per treatment and the cutting area was 2 x 2 ft^2 and the data analyzed by completely randomized design. In 2009, 75 lb/ac of fertilizer was applied on 4/24/09 the first cutting dates were 7/3, 7/13, 7/27, 8/7 with a final cutting on 10/15/09. The plot were harvested with a cutter bar mower with plots approximately 3.75 x 25 ft. sub samples were taken to determine dry matter. Due to the small amount of residue the 2nd cut material will not be harvested. A single forage quality sample was taken and evaluated at Dairy One, Ithaca, NY at each of the planting dates for both cultivars. w.w.w.dairyone.com/Forage/FactSheet/ForageAnalysis.html.

Intermediate wheatgrass 9051920 — “Chiefton” reed canarygrass — “Szarvasi-1” tall wheatgrass

Fig. 1 Photo 7/1/09 prior to first cutting

Results and Discussion

Wheatgrass Cultivar Study (Fig.1): In the first harvest year 2008 (Table 1) the intermediate wheatgrass 905190 (40 lb/ac) had the highest yield for both first and total cut of 4.22 and 5.72 t/ac. The “Largo” had the highest yield of the tall wheatgrasses at both seeding rates averaging 5.03 t/ac but was not significant from “Szarvasi-1” (40 lb/ac) at 4.47 t/ac or “Alkar” (40 lb/ac) at 4.19 t/ac. The reed canarygrasses averaged 3.91 t/ac they had the lowest first cutting but significantly more second cutting. There was no significant difference between the 20 and 40 lb/ac seeding rates. There were no significant differences between first cut yields in 2009 (Table 2). The “Szarvas-1” performed better in season two compared to its ranking in season one, this could have been due to problems in the germination rate which was not reflected in the seed tag information reducing first year yields. The “largo” yields were also lower in 2009 than “Jose” which performed better than in the establishment year 2008. The reed canary grass first cut yields were a little lower but second cutting regrowth looks superior for reed canarygrass (Fig. 2) data not shown. The chemical compositional analysis key is listed in Table 3, and a subset of wet chemistry analysis is given in Table 4. Early cut grasses had higher K and Cl then later first cutting tall wheatgrass (See discussion in time of cutting study and Tables 4 & 6).

Tall wheatgrass time of cutting study: The potential for realizing approximately 85% of yearly growth from a late first cutting and low regrowth yields averaging .6 t/ac does not warrant a second cutting for biomass. In 2008 (Table 5) the first cutting yield average over all cutting dates for “Alkar” and “Szarvasi-I” was 4.4 and 4.0 t/ac respectively (not significant). There was no significant difference between the 20 and 40lb/ac rates. In 2008 there was a trend for increasing yields up to the 7/17/08 first cutting date with a reduction in the 10/10/09 first cutting. In 2009 (Table 6) the first cut yield increased until 7/27/09 then leveled/declined at 8/7/09 (not significant). These late cutting dates (Fig. 3 & 4) are compatible with ground nesting bird management and occurs at a time with easier drying, low leaf:stem ratio and low standing moisture content. Chemical compositional analysis showed trends of decreasing K (1.0%), Cl (.15%) and Ash (3.4%) with later cutting dates. Early cut grasses Table 4, had an average K and Cl of 2.2% and .51% respectively and first cut ash of 6.4% and second cut ash of 7.6%. Fall harvested switchgrass has a reported ash content from 5.5 – 5.2% with K levels of .38 - .95% (Samson et. al).,

Table 1. 2008 Wheatgrass Cultivar Comparison Trial[1]

Cultivar	species	Seeding rate	1st cut Ave. t/ac	2nd cut Ave. t/ac	Total Ave. t/ac
Alkar	Tall wheatgrass	20 lb/ac	**3.00** cdef	**1.46** cde	**4.46** cde
		40 lb/ac	**3.27** bcde	**1.63** bcde	**4.90** bcde
Largo	Tall wheatgrass	20 lb/ac	**3.67** bc	**2.08** ab	**5.75** ab
		40 lb/ac	**3.84** bc	**1.9** abc	**5.74** ab
Jose	Tall wheatgrass	20 lb/ac	**2.44** def	**1.39** e	**3.83** e
		40 lb/ac	**2.59** def	**1.55** cde	**4.14** de
Szarvasi-1	Tall wheatgrass	20 lb/ac	**2.97** cdef	**1.33** e	**4.30** cde
		40 lb/ac	**3.35** bcd	**1.86** abcd	**5.21** bcd
9051920	Intermediate wheatgrass	20 lb/ac	**4.02** ab	**1.4** de	**5.42** abc
		40 lb/ac	**4.84** a	**1.72** bcde	**6.56** a
Bellevue	Reed canarygrass	20 lb/ac	**2.35** ef	**2.22** a	**4.57** bcde
Chiefton	Reed canarygrass	20 lb/ac	**2.18** f	**2.22** a	**4.40** cde
LSD$_{.05}$			0.93	0.47	1.21

[1]Fertilized with 66 lb/ac of calcium ammonium nitrate on 4/18/08 & 6/25/08
First cutting on 6/24/08, second cutting on 9/22/08.

2009 Wheatgrass Cultivar Comparison Trial[1]

Cultivar	species	Seeding rate	1st cut t/a	2nd cut t/a	Total DM t/a
Alkar	Tall wheatgrass	20 lb/ac	**3.60**	**1.21 bc**	**4.81**
		40 lb/ac	**3.32**	**1.15 bc**	**4.47**
Largo	Tall wheatgrass	20 lb/ac	**3.74**	**1.17 bc**	**4.91**
		40 lb/ac	**3.26**	**1.37 b**	**4.64**
Jose	Tall wheatgrass	20 lb/ac	**3.90**	**0.88 c**	**4.78**
		40 lb/ac	**3.92**	**1.10 bc**	**5.02**
Szarvasi-1	Tall wheatgrass	20 lb/ac	**4.16**	**1.00 bc**	**5.17**
		40 lb/ac	**4.13**	**0.91 c**	**5.03**
9051920	Intermediate wheatgrass	20 lb/ac	**3.91**	**1.10 bc**	**5.01**
		40 lb/ac	**4.79**	**1.16 bc**	**5.95**
Bellevue	Reed canarygrass	20 lb/ac	**3.22**	**1.90 a**	**5.11**
Chiefton	Reed canarygrass	20 lb/ac	**3.60**	**2.13 a**	**5.74**
LSD$_{.05}$			**N.S**	**0.43**	**N.S**

Fertilized with 66 lb/ac of calcium ammonium nitrate on 4/28/09
First cutting on 7/3/09, second cutting on 10/14/09

Fig. 2 Regrowth of reed canary grass photo 10/9/09

Table 3 . Compositional Analysis Key

CP	% Crude Protein
ADF	% Acid Detergent Fiber
NDF	% Neutral Detergent Fiber
Lignin	% Lignin
NFC	% Non Fiber Carbohydrates
WSC	% Water Soluble Carbohydrates
Ash	% Ash
TDN	% Total Digestable Nutrients
K	% Potassium
S	% Sulfur
CL Ion	% Chloride Ion
Gross Energy	Gross Energy, cal/g

Futher information regarding components of analysis can be found at www.dairyone.com/Forage/FactSheet/ForageAnalysis.html

Table 4. Composition of 2008 Cool Season Quality Samples For Two Harvests

Cultivar	species	Seeding rate	Harv[1]	CP	ADF	NDF	Lignin	NFC	WSC	Ash	K	S	Cl Ion	Gross Energy
Alkar	Tall wheatgrass	20 lb/ac	1st	8.04	44.4	75.3	4.1	13.0	5.9	6.11	2.3	0.10	0.50	4584
		40 lb/ac		9.20	43.8	74.2	4.3	13.1	5.6	6.13	2.4	0.11	0.46	4624
Largo	Tall wheatgrass	20 lb/ac	1st	7.84	44.7	75.1	3.9	13.4	5.9	6.14	2.3	0.08	0.50	4577
		40 lb/ac		8.51	44.4	75.0	4.1	12.8	5.4	6.19	2.4	0.10	0.49	4597
Jose	Tall wheatgrass	20 lb/ac	1st	10.29	43.3	73.3	4.1	12.5	5.6	6.86	2.4	0.14	0.50	4611
		40 lb/ac		8.64	43.9	74.2	4.2	13.2	6.4	6.18	2.1	0.11	0.52	4600
Szarvasi-1	Tall wheatgrass	20 lb/ac	1st	7.24	45.0	75.3	4.5	13.5	7.1	5.68	2.3	0.09	0.45	4584
		40 lb/ac		7.83	45.6	75.3	4.5	13.0	5.9	6.05	2.3	0.08	0.45	4603
9051920	Intermediate wheatgrass	20 lb/ac	1st	7.38	46.0	75.2	4.4	13.0	4.7	6.25	2.2	0.09	0.54	4585
		40 lb/ac		7.14	45.8	75.3	4.4	13.0	4.9	5.78	2.2	0.08	0.47	4854
Bellevue	Reed canarygrass	20 lb/ac	1st	10.54	38.9	67.0	5.0	17.1	10.6	6.75	2.3	0.15	0.48	4631
Chiefton	Reed canarygrass	20 lb/ac	1st	12.02	38.9	67.8	5.0	15.2	8.5	7.37	2.5	0.17	0.37	4642
				LSD$_{.05}$	**1.18**	**0.91**	**1.10**	**0.33**	**1.33**	**N.S**	**0.54**	**N.S**	**N.S**	**N.S**	**22.50**
Cultivar	species	Seeding rate	Harv[1]	CP	ADF	NDF	Lignin	NFC	WSC	Ash	K	S	Cl Ion	Gross Energy
Alkar	Tall wheatgrass	20 lb/ac	2nd	11.7	39.0	68	3.6	15.0	7.6	7.8	2.6	0.13	0.45	4621
		40 lb/ac		10.4	41.2	69.4	4.1	15.2	6.6	7.0	2.4	0.13	0.47	4629
Largo	Tall wheatgrass	20 lb/ac	2nd	10.8	42.2	70.9	4.2	14.4	6.5	6.9	2.2	0.12	0.46	4587
		40 lb/ac		10.2	42.3	70.3	4.6	14.6	6.3	6.7	2.3	0.13	0.48	4606
Jose	Tall wheatgrass	20 lb/ac	2nd	9.8	38.2	67.2	3.7	14.5	8.1	8.2	2.8	0.14	0.51	4606
		40 lb/ac		11.6	39.5	67.7	3.8	14.3	7.1	8.2	2.8	0.15	0.55	4603
Szarvasi-1	Tall wheatgrass	20 lb/ac	2nd	10.8	39.3	68.1	3.9	15.0	7.8	8.0	2.6	0.14	0.52	4598
		40 lb/ac		10.9	38.8	68.1	3.7	14.4	7.7	8.1	2.7	0.13	0.44	4604
9051920	Intermediate wheatgrass	20 lb/ac	2nd	10.0	42.8	70.0	4.1	14.9	5.7	6.8	2.2	0.13	0.41	4651
		40 lb/ac		10.4	41.7	68.8	4.1	14.9	6.1	6.8	2.1	0.13	0.37	4677
Bellevue	Reed canarygrass	20 lb/ac	2nd	9.0	34.0	60.0	4.0	22.7	19.8	7.8	1.5	0.15	0.46	4500
Chiefton	Reed canarygrass	20 lb/ac	2nd	9.2	34.8	61.0	4.1	21.8	18.3	8.3	1.6	0.16	0.56	4476
				LSD$_{.05}$	**1.33**	**1.35**	**1.48**	**N.S**	**1.43**	**1.80**	**0.85**	**0.23**	**N.S**	**N.S**	**36.87**

[1] Harvest dates: 1st cut 6/24/08, 2nd cut 9/22/08

Table 5.

Tall Wheatgrass 2008 Comparison of Seeding Rates and Cutting Dates[1]

Species	1st cut Date	Seeding rate	Ave. t/ac 1st cut		Ave. t/ac 2nd cut[2]	Ave. t/ac Total	Avg. Mg/ha 1st cut	Avg. Mg/ha 2nd cut[2]	Avg. Mg/ha Total
'Alkar' Tall Wheatgrass	7/3/2008	**20 lb/ac**	4.70	abc	0.54	5.24	10.52	1.22	11.74
		40 lb/ac	3.72	bcd	0.75	4.47	8.34	1.67	10.01
	7/10/2008	**20 lb/ac**	4.95	ab	0.52	5.46	11.08	1.16	12.24
		40 lb/ac	4.18	abcd	0.59	4.77	9.36	1.33	10.69
	7/17/2008	**20 lb/ac**	5.24	a	0.62	5.86	11.74	1.38	13.12
		40 lb/ac	4.07	abcd	0.80	4.88	9.13	1.79	10.92
	10/10/2008	**20 lb/ac**	4.00	abcd			8.96		
		40 lb/ac	4.22	abcd			9.46		
'Szarvasi-1' Tall Wheatgrass	7/3/2008	**20 lb/ac**	3.81	abcd	0.52	4.33	8.59	1.16	9.75
		40 lb/ac	4.58	abcd	0.75	5.33	10.26	1.67	11.93
	7/10/2008	**20 lb/ac**	3.26	d	0.49	3.74	7.30	1.09	8.39
		40 lb/ac	4.37	abc	0.58	4.95	9.79	1.30	11.09
	7/17/2008	**20 lb/ac**	4.66	abc	0.47	5.13	10.44	1.05	11.49
		40 lb/ac	4.11	abc	0.73	4.84	9.21	1.63	10.84
	10/10/2008	**20 lb/ac**	3.50	d			7.84		
		40 lb/ac	3.73	bcd			8.35		
	LSD.05 =		0.79						

[1]Tall wheatgrass was planted on 9/4/07, 75 lb/ac of N applied as calcium ammonium nitrate on 4/28/08
[2]All 2nd cuttings were done on 10/10/08

Table 6. Tall wheatgrass 2009 Comparison of Seeding rates and Cutting Dates1

Species	1st cut date	Seeding rate	1st cut ave. t/ac	Chemical composition %[2] NDF	ADF	Lig	ash	N	K	CL	S
'Alkar' Tall Wheatgrass	7/3/2009	20 lb/ac	**2.23** hi								
		40 lb/ac	**2.05** i								
	7/13/2009	20 lb/ac	**3.63** bcde	77.2	54.1	9.3	4.5	1.1	1.6	0.43	0.11
		40 lb/ ac	**3.62** bcde								
	7/27/2009	20 lb/ac	**4.61** a	74.3	55.8	7.4	3.6	0.8	1.1	0.18	0.09
		40 lb/ac	**4.30** ab								
	8/7/2009	20 lb/ac	**4.08** abcd	76.7	55.2	6.7	3.6	1.0	1.1	0.14	0.11
		40 lb/ac	**4.39** ab								
	10/20/2009	20 lb/ac	**2.15** i	82.8	58.2	9.9	3.5	0.8	0.7	0.13	0.09
		40 lb/ac	**2.96** efgh								
'Szarvasi-1' Tall Wheatgrass	7/3/2008	20 lb/ac	**2.58** ghi								
		40 lb/ac	**2.55** ghi								
	7/13/2009	20 lb/ac	**3.33** defg	81.1	54.1	8.0	4.2	0.9	1.4	0.12	0.09
		40 lb/ac	**3.45** cdef								
	7/27/2009	20 lb/ac	**4.07** abcd	79.1	55.3	10.1	3.1	0.9	1.0	0.21	0.09
		40 lb/ac	**4.00** abcd								
	8/7/2009	20 lb/ac	**3.67** bcde	77.7	53.5	8.0	3.2	0.8	1.0	0.15	0.09
		40 lb/ac	**4.12** abc								
	8/18/2009	20 lb/ac	**n/a**	74.1	53.2	7.9	3.6	0.8	1.1	0.30	0.09
	10/20/2009	20 lb/ac	**2.59** ghi	87.4	59.7	12	2.9	0.6	0.6	0.12	0.08
		40 lb/ac	**2.68** fghi								
	LSD.05 =		0.79								

[1]Tall wheatgrass was planted on 9/4/07, 75 lb/ac applied as calcium ammonium nitrate on 4/28/09 and 4/24/09
[2]Chemical compositon- www.dairyone.com/Forage/FactSheet/ForageAnalysis.html
Note: Second cut on 10/20/09 for all 1st cuttings, no significant difference average .38 t/a

Fig. 3 Tall Wheatgrass Cutting Study 2008

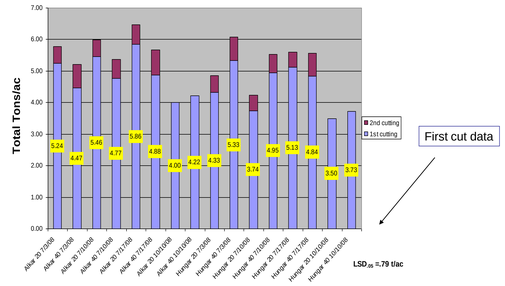

Fig. 4 Late cutting date, good standability, Photo 10/9/09

Fig. 5 Late cutting date, dried standing dry matter easy to harvest low leaf: stem ratio. Photo 10/9/09.

Conclusions

- Tall wheatgrass may be harvested as a biomass crop in the Northeast with a single harvest in late July to early August maximizing single cut yields of up to 4.5 t/ac with improved chemical composition over early cutting dates.
- Chemical compositional analysis indicates a substantial reduction in K, Cl, and ash from later cutting with low nitrogen and sulfur levels.
- There was no significant difference between the 20 and 40 lb/ac seeding rate in tall wheatgrass cultivars.
- Intermediate wheatgrass 905190 shows promise as a biomass crop only if cut with a 2 cut system due to potential lodging problems but could have issues with chemical components due to early cutting.
- Ranking between the tall wheatgrass varied between 2008 and 2009 indicating more years of data collection are warranted to access performance over time.
- Future cultivar evaluations of tall wheatgrass should be conducted as a single late cutting.

References

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Dairy One: www.dairyone.com/Forage/FactSheet/ForageAnalysis.html