



2012 Small Grain Forage Trial



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INTRODUCTION

Spring cereal grains such as oats, barley, triticale and wheat can have the potential to provide high yield and quality feed for livestock. These cool season annuals can provide early season grazing, as well as high quality stored feed. Spring grains are generally planted in mid to late April and can be harvested at various stages of development. The objective of this project was to evaluate yield and quality of various spring grain species harvested in the vegetative, boot or soft dough stage. The overall goal of this project is to help organic dairy producers reduce their reliance on expensive concentrates through the production of a variety of high quality annual forages. The data presented here is from one replicated research trial in Vermont. Crop performance data from additional tests in different locations, and often over several years, should be compared before you make conclusions. This project was supported through the Organic Valley Farmers Advocating for Organics fund.

METHODS

In 2012, a small grain forage trial was conducted at Borderview Research Farm in Alburgh, VT (Table 1). The previous crop in this location was sunflowers, and the seedbed was prepared by conventional tillage methods. The field was disked and spike-toothed harrowed in late March to prepare for planting. Plots were planted with a six-inch Kincaid cone seeder on 6-Apr at a seeding rate of 125 lbs/acre. The varieties and seed source are listed in Table 2. Each treatment was harvested at four development stages: vegetative stage, boot stage, soft dough stage and grain. Subsamples of approximately 2.5 ft² were cut to the ground, dried at 40°C, and weighed to determine dry matter yield. Oven dry samples were coarsely ground with a Wiley mill (Thomas Scientific, Swedesboro, NJ) and sent to Cumberland Valley Analytical Services, Inc. (Hagerstown, MD) for quality analysis. Results were analyzed with an analysis of variance or with a Tukey-Kramer method of comparison in SAS (Cary, NC).

Table 1. General plot management.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Sunflowers
Row width (in.)	6
Planting date	6-Apr
<u>Harvest dates:</u>	
Vegetative	6-Jun
Boot	6-Jun (Barley) 11-Jun (Oats, Triticale, Wheat)
Soft Dough	25-Jun (Forage Oats) 2-Jul (Barley) 6-Jul (Oats) 10-Jul (Wheat) 19-Jul (Triticale) 23-Jul (Forage Oats)
Grain	3-Aug
Seeding rate	125 lbs/acre
Tillage methods	Mold board plow, disk, and spike-toothed harrow

SILAGE QUALITY

Silage quality was analyzed by Cumberland Valley Analytical Forage Laboratory in Hagerstown, Maryland. Plot samples were dried, ground and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and various other nutrients. The Nonstructural Carbohydrates (NSC) and Total Digestible Nutrients (TDN) were calculated from forage analysis data. Performance indices such as Net Energy for Lactation (NEL) were calculated to determine forage value. Mixtures of true proteins, composed of amino acids and non-protein nitrogen make up the crude protein (CP) content of forages. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of the plant are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral detergent fiber (NDF). Chemically, this fraction includes cellulose, hemicellulose and lignin. Recently, forage testing laboratories have begun to evaluate forages for NDF digestibility. Evaluation of forages and other feedstuffs for NDF digestibility is being conducted to aid prediction of feed energy content and animal performance. Research has demonstrated that lactating dairy cows will eat more dry matter and produce more milk when fed forages with optimum NDF digestibility. Forages with increased NDF digestibility (dNDF) will result in higher energy values, and perhaps more importantly, increased forage intakes. Forage NDF digestibility can range from 20 – 80%. The NSC or non-fiber carbohydrates (NFC) include starch, sugars and pectins.

Table 2. Small grain forage varieties and seed source.

Type	Variety	Company
Forage Barley	Kawartha	Eldred Hay and Grain Company
Grain Barley	Traditional	Semican
Forage Oats	Everleaf	King's AgriSeeds
Grain Oats	Tack	Albert Lea Seedhouse
Forage Triticale	Tritical® 141	Syngenta Cereals
Hard Red Wheat	Magog	Semican
Hard Red Wheat	Sy Soren	Albert Lea Seedhouse

LEAST SIGNIFICANT DIFFERENCE (LSD)

Variations in yield and quality can occur because of variations in genetics, soil, weather and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real, or whether it might have occurred due to other variations in the field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant differences (LSD's) at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In the example below, A is significantly different from C but not from B. The difference between A and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

Variety	Yield
A	6.0
B	7.5*
C	9.0*
LSD	2.0

RESULTS AND DISCUSSION

Seasonal precipitation and temperature recorded at a weather station in Alburgh, VT are shown in Table 3. The 2012 growing season was warmer and drier than normal, especially in the months of June and July. From April to July, there was an accumulation of 3547 Growing Degree Days (GDDs) in Alburgh, which is 195 GDDs higher than the 30-year average. A warmer and drier early spring allowed for an exceptionally early planting date for the spring grains.

Table 3. Seasonal weather data collected in Alburgh, VT, 2012.

Alburgh, VT	April	May	June	July	August
Average Temperature (F)	44.9	60.5	67.0	71.4	71.1
Departure from Normal	0.10	4.10	1.20	0.80	2.30
Precipitation* (inches)	2.64	3.90	3.22	3.78	2.92
Departure from Normal	-0.18	0.45	-0.47	-0.37	-0.99
Growing Degree Days (base 32)	396	884	1046	1221	1241
Departure from Normal	12.0	128	32.0	23.0	102

Based on Davis Instruments Vantage pro2 weather station with Weatherlink data logger.

Historical averages for 30 years of NOAA data (1981-2010).

* Precipitation data for Jun-Aug 2012 based on Northeast Regional Climate Center data from observation station in Burlington, VT.

Harvest Stage

Comparing harvest stages, forage harvested in the soft dough stage yielded the greatest quantity of dry matter at 10,730 lbs dry matter acre⁻¹ (Table 4). Protein levels were highest during the vegetative stage, with a crude protein content of 18.2%. The lowest ADF and NDF levels were seen from the grain harvest, which we would expect since all the straw and chaff and fibrous materials are removed from the grain. Of the three forage harvest, the vegetative stage had the lowest fiber content and highest fiber digestibility. Fiber content generally increases as plants mature, but the formation of starch in the soft dough stage dilutes overall fiber content. The nonstructural carbohydrates (NSC), net energy for lactation (NEL), and non-fiber carbohydrates (NFC) were highest in the grain, followed by the soft dough stage, as a result of grain fill in the heads. Although the crude protein is highest in the vegetative stage, the additional starch from grain formation improves the overall quality of cereal grains harvested in the soft dough stage.

Table 4. Cereal grain yield and quality compared across harvest stages.

Harvest	DM %	Yield lb ac ⁻¹	CP %	ADF %	NDF %	dNDF %	Starch %	TDN %	NEL Mcal lb ⁻¹	NFC %	NSC %
Vegetative	16.2	3295	18.2	31.8	49.2	61.0	2.6	63.6	0.659	20.6	11.6
Boot	18.2	4908	14.8	35.8	56.7	59.4	2.3	61.2	0.631	18.1	10.7
Soft Dough	49.1	10730	8.9	32.9	52.5	45.4	22.4	64.2	0.663	32.7	26.0
Grain	90.1	1510	14.6	9.6	20.6	69.7	57.9	78.5	0.823	61.0	60.6
Trial Mean	45.5	5250	13.8	27.2	44.4	58.7	22.7	67.1	0.697	34.0	28.4
p-value	*	*	*	*	*	*	*	*	*	*	*

* p-value <.0001. Statistically analyzed with Tukey-Kramer method of comparison.

Top performer is in **bold**.

Small Grain Forage Species

Comparing forage species across all harvest stages may not be that useful because the values for grain, which are drastically different than the whole plant forage, are included in the overall value. However, values are presented in Table 5 for comparison. Triticale had the highest overall yields, 6,156 lbs ac⁻¹, while Soren wheat had the highest protein and lowest NDF levels. In general, the two species of barley had the most desirable forage quality characteristics.

Table 5. Small grain forage yield and quality averaged across four harvest stages (vegetative, boot, soft dough and grain).

Species	DM %	Yield lb ac ⁻¹	CP %	ADF %	NDF %	dNDF %	Starch %	TDN %	NEL Mcal lb ⁻¹	NFC %	NSC %
Kawartha Barley	52.0	4815	12.1	25.1	42.8	59.3	29.8	68.5	0.711	38.7	34.4
Traditional Barley	50.8	4822	12.0	23.6	40.5	61.3	29.1	69.5	0.723	40.6	34.3
Everleaf Oats	43.6	5683	13.9	30.2	47.5	59.5	16.8	65.5	0.681	29.2	23.2
Tack Oats	40.7	5218	12.2	32.1	49.8	55.4	16.6	64.3	0.666	29.2	23.1
Triticale 141	45.3	6156	14.0	27.9	45.9	58.3	22.8	66.2	0.684	32.4	27.9
Magog Wheat	44.4	4734	15.2	26.3	42.7	59.1	22.7	67.8	0.704	34.7	28.8
Soren Wheat	44.7	5106	16.4	23.9	40.2	58.9	24.7	69.2	0.719	36.2	30.3
Trial Mean	45.5	5250	13.8	27.2	44.4	58.7	22.7	67.1	0.697	34.0	28.4

Top performer is in **bold**.

Vegetative Stage Harvest

Forages were harvested at the vegetative stage to document the value of small grains as a potential early season grazing crop. At the vegetative stage harvest, the highest yielding treatment was Tack oats with 4183 lbs dry matter acre⁻¹ (Table 6). Barley is the fastest maturing spring grain, and unfortunately, vegetative stage harvest of barley was missed. Everleaf oats and Magog and Soren wheat had the highest protein levels, around 19% crude protein (Figure 1). In the vegetative stage, Everleaf forage oats had better quality than the other small grains, with the lowest ADF and NDF levels, and highest non-fiber carbohydrates (NFC) and nonstructural carbohydrates (NSC) levels (Figure 2).

Table 6. Small grain forage yield and quality when harvested in the vegetative stage, June 2012.

Vegetative Stage	DM %	Yield lb ac ⁻¹	CP %	ADF %	NDF %	dNDF %	Starch %	TDN %	NEL Mcal lb ⁻¹	NFC %	NSC %
Everleaf Oats	12.4	3180	19.9*	29.0*	42.7	60.3	2.8	65.2	0.678	23.7*	12.7*
Tack Oats	14.4	4183	15.0	33.2	51.7	61.9	2.2	62.6	0.648	21.6*	12.0*
Triticale 141	15.5	3344	18.2	33.6	51.4	58.8	2.9	62.1	0.640	18.1	10.8
Magog Wheat	21.2	3185	18.9*	32.2	50.4	62.6	2.2	63.7	0.660	19.3	11.1
Soren Wheat	17.5	2582	19.1*	31.2*	49.6	61.5	3.0	64.6	0.670	20.4	11.4
Veg Stage Mean	16.2	3295	18.2	31.8	49.2	61.0	2.6	63.6	0.659	20.6	11.6
LSD	NS	759	1.23	2.67	2.84	NS	NS	NS	NS	2.36	1.13

Varieties with an asterisk indicate that it was not significantly different than the top performer in column (in **bold**).

NS - None of the varieties were significantly different from one another.

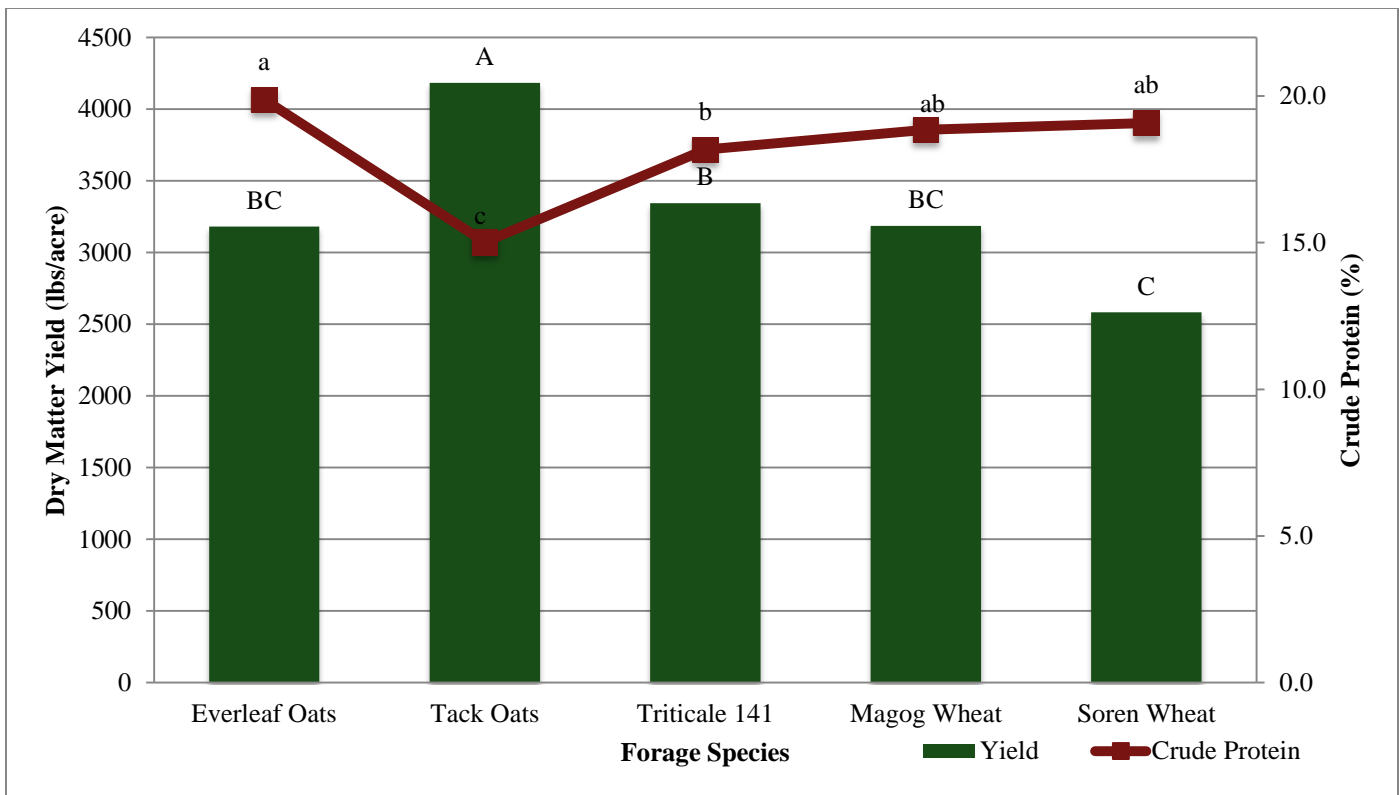


Figure 1. Yield and protein of small grain forage harvested in the vegetative stage. Treatments with the same letter did not differ significantly from one another.

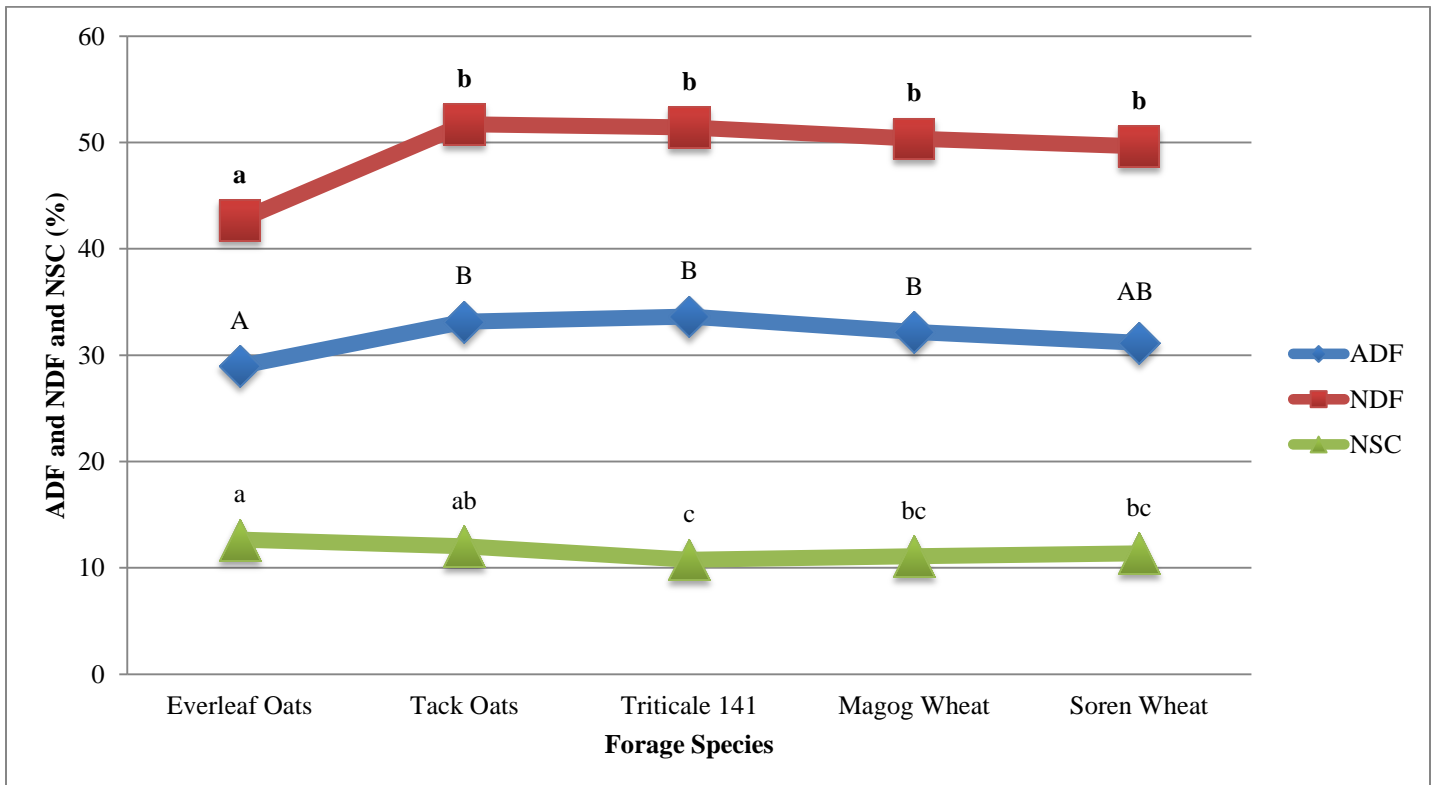


Figure 2. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and non-structural carbohydrates (NSC) of small grain forage harvested in the vegetative stage. Treatments with the same letter did not differ significantly from one another.

Boot Stage Harvest

In small grain development, the boot stage occurs when the grain head is just barely visible and about to emerge. Everleaf oats had the greatest dry matter yields when harvested in the boot stage, 6509 lbs dry matter acre⁻¹ (Table 7 and Figure 3). Soren wheat and triticale had the highest boot stage protein levels, over 16%. Traditional barley had the lowest boot stage ADF and highest digestible NDF levels (Figure 4). Soren wheat had the lowest NDF levels and highest starch, total digestible nutrients, net energy for lactation and non-fiber carbohydrates.

Table 7. Small grain forage yield and quality harvested in the boot stage, June and July 2012.

Boot Stage	DM %	Yield lb ac ⁻¹	CP %	ADF %	NDF %	dNDF %	Starch %	TDN %	NEL Mcal lb ⁻¹	NFC %	NSC %
Kawartha Barley	16.8	4350	15.1	36.4	58.2	61.2	2.3	61.3	0.633*	17.1	10.5
Traditional Barley	15.2	4094	15.3	34.5*	55.7*	64.4	1.9	62.2	0.643*	18.3*	11.0
Everleaf Oats	17.4	6509*	12.3	36.6	57.7	57.4	2.5*	60.9	0.630	19.6*	10.9
Tack Oats	19.1	5631*	12.6	37.5	58.5	55.9	2.0	59.9	0.613	18.7*	10.6
Triticale 141	17.5	5346	16.1*	35.4*	56.2*	59.3	2.3	60.6	0.623	16.4	10.5
Magog Wheat	19.7	4453	15.7	36.0	55.8*	59.0	2.1	61.4*	0.633*	18.2*	10.7
Soren Wheat	21.4	3973	16.9*	34.6*	54.8*	58.4	2.9*	62.5*	0.645*	18.4*	10.5
Boot Stage Mean	18.2	4908	14.8	35.8	56.7	59.4	2.3	61.2	0.631	18.1	10.7
LSD	1.28	1057	1.07	1.23	1.70	2.12	0.411	1.16	0.013	1.63	NS

* Varieties with an asterisk indicate that it was not significantly different than the top performer in column (in bold).

NS - None of the varieties were significantly different from one another.

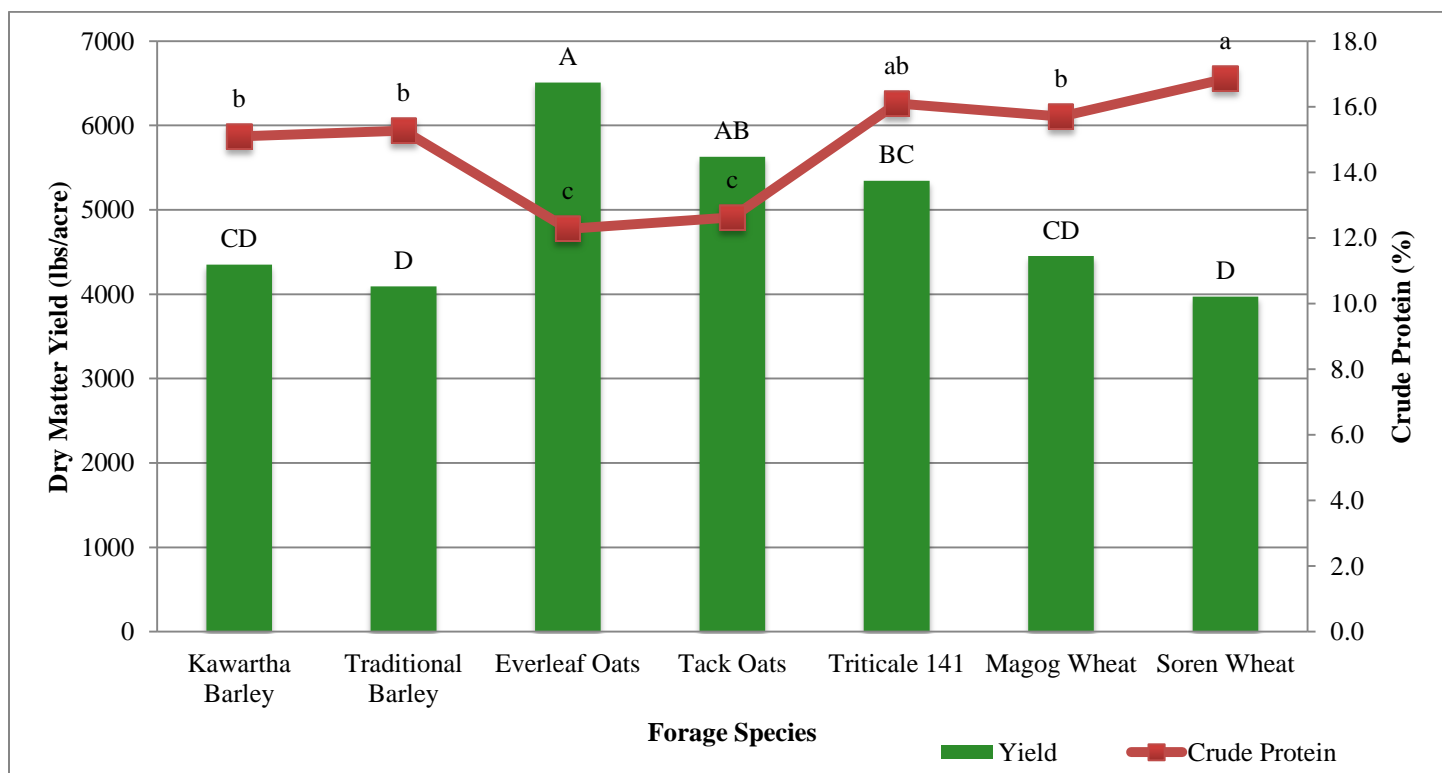


Figure 3. Yield and protein of small grain forage in the boot stage.

Treatments with the same letter did not differ significantly from one another.

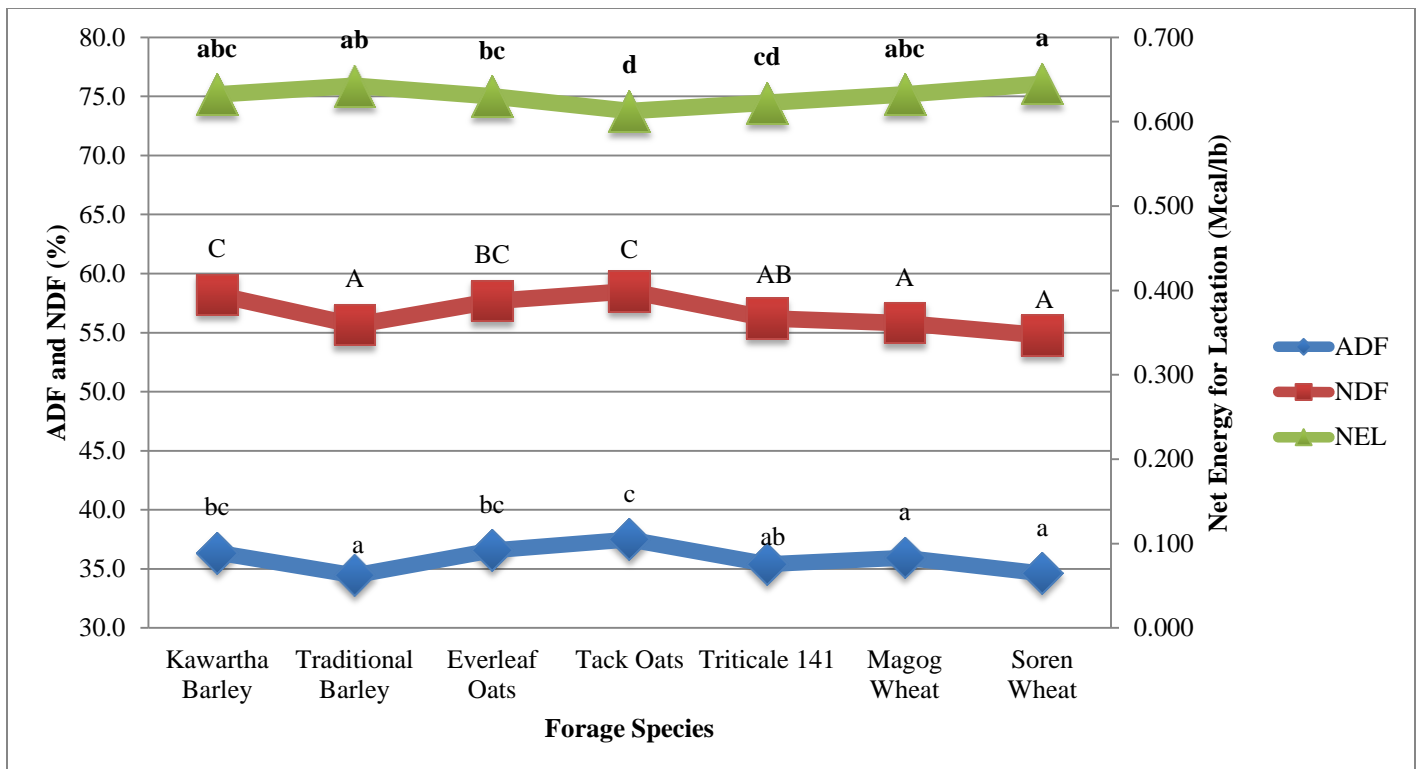


Figure 4. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and net energy for lactation (NEL) of small grain forage harvested in the boot stage. Treatments with the same letter did not differ significantly from one another.

Soft Dough Stage Harvest

Similar to the boot stage, triticale was the highest yielding treatment when harvested during the soft dough stage (Table 8 and Figure 5). Triticale yielded close to 15,000 lbs dry matter acre⁻¹, which is almost 2700 lbs acre⁻¹ more than the next highest yielding treatment, Everleaf oats. Soren wheat had the highest protein levels of the soft dough harvest at 12.0%. Soren wheat also had the highest quality characteristics with the lowest ADF and NDF, and highest starch, TDN, NEL and NSC. The barley varieties also had similarly low ADF and NDF levels and high digestible NDF, and non fiber carbohydrates, as well as high starch, total digestible nutrients, net energy for lactation and nonstructural carbohydrates (Figure 6).

Table 8. Small grain forage yield and quality harvested at the soft dough stage, July 2012.

Soft Dough Stage	DM %	Yield lb ac ⁻¹	CP %	ADF %	NDF %	dNDF %	Starch %	TDN %	NEL Mcal lb ⁻¹	NFC %	NSC %
Kawartha Barley	49.6	8993	8.5	31.3*	50.8	44.9	26.1*	64.8*	0.668*	35.2*	29.2*
Traditional Barley	47.9	8425	7.9	28.9*	47.1*	48.1*	26.7*	66.2*	0.685*	38.8*	30.7*
Everleaf Oats	52.3	12140	9.1	35.4	55.2	45.0	18.0	63.9	0.663	27.8	22.0
Tack Oats	37.3	10308	7.6	37.0	55.9	40.8	17.4	62.6	0.648	28.4	21.8
Triticale 141	58.9	14836	7.5	37.4	61.0	45.5*	20.7	60.6	0.620	28.1	22.6
Magog Wheat	48.0	9028	9.5	34.0	53.4	46.1*	20.2	63.7	0.658	31.8	24.4
Soren Wheat	50.0	11380	12.0	26.5*	44.1*	47.5*	27.7*	67.8*	0.703*	38.7*	31.7*
Soft Dough Mean	49.1	10730	8.9	32.9	52.5	45.4	22.4	64.2	0.663	32.7	26.0
LSD	4.32	2410	1.68	4.91	6.55	2.67	5.04	3.35	0.038	5.17	5.05

* Varieties with an asterisk indicate that it was not significantly different than the top performer in column (in **bold**).

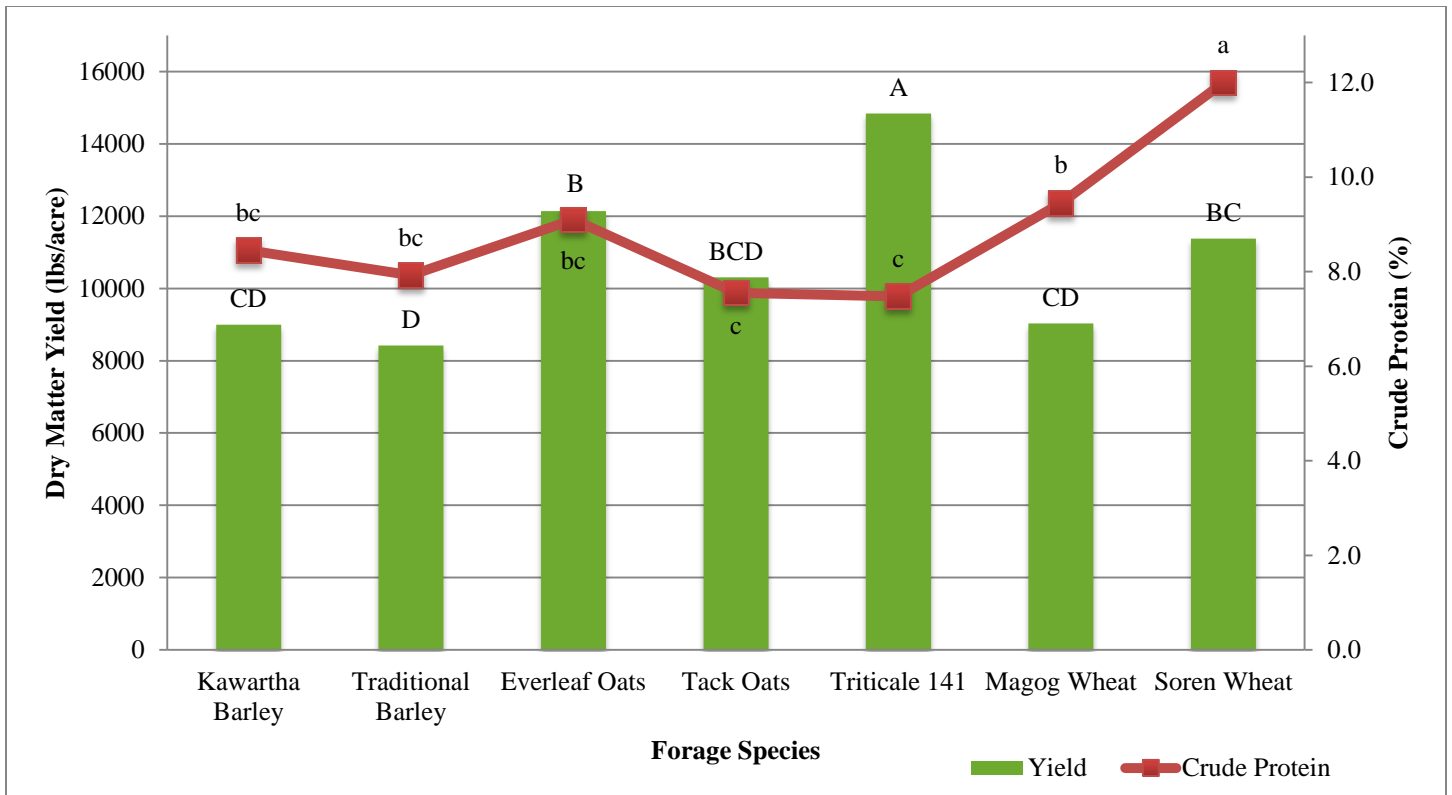


Figure 5. Yield and crude protein (CP) of small grain forage harvested in the soft dough stage. Treatments with the same letter did not differ significantly from one another.

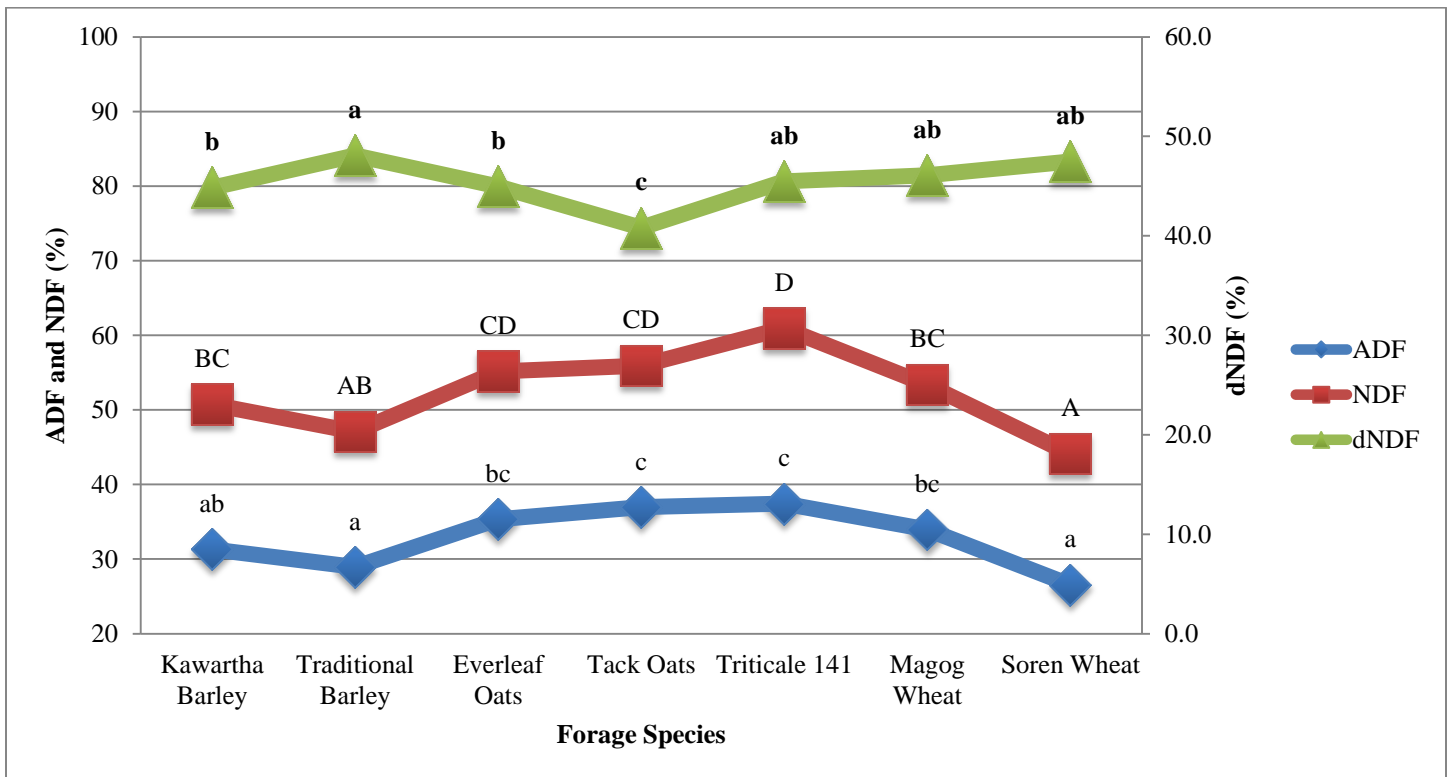


Figure 6. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and digestible neutral detergent fiber (dNDF) of small grain forage harvested in the soft dough stage. Treatments with the same letter did not differ significantly from one another.

Grain Harvest

Grain was harvested on 3-Aug 2012. Soren wheat had the highest grain yields of all the species, with almost 2500 lbs acre⁻¹ (Table 9, Figure 7). Both wheat varieties yielded significantly more than other species, with Traditional barley yields close behind. Soren and Magog wheat also had the highest crude protein levels, around 17%. Magog wheat had the lowest ADF and NDF, and highest starch, total digestible nutrients, net energy for lactation, non fiber carbohydrates and nonstructural carbohydrates (Figure 8). Soren wheat and Triticale 141 also had similarly high grain quality characteristics. The oats had higher fiber than the other grains due to the hulls that did not thresh freely from the grain, however this fiber was highly digestible.

Table 9. Small grain forage yield and quality of grain, August 2012.

Grain Stage	DM %	Yield lb ac ⁻¹	CP %	ADF %	NDF %	dNDF %	Starch %	TDN %	NEL Mcal lb ⁻¹	NFC %	NSC %
Kawartha Barley	89.6	1104	12.8	7.7	19.6	71.7	61.1	79.5	0.833	64.0	63.4
Traditional Barley	89.3	1949	12.8	7.3	18.7	71.6	58.8	80.0	0.840	64.8	61.1
Everleaf Oats	92.2*	905	14.2	19.8	34.6	75.4	43.8	72.0	0.753	45.8	47.3
Tack Oats	91.9*	751	13.6	20.9	32.9	63.1	44.6	72.2	0.755	48.2	48.2
Triticale 141	89.2	1099	14.4	5.1*	15.2*	69.5	65.5*	81.4*	0.855*	67.2*	67.8*
Magog Wheat	88.8	2271*	16.7*	3.2*	11.1*	68.6	66.4*	82.6*	0.868*	69.6*	69.1*
Soren Wheat	89.9	2489*	17.6*	3.5*	12.2*	68.1	65.1*	81.9*	0.858*	67.3*	67.5*
Grain Mean	90.1	1510	14.6	9.6	20.6	69.7	57.9	78.5	0.823	61.0	60.6
LSD	1.04	519	1.29	2.37	4.82	2.38	4.52	2.05	0.023	4.53	4.53

* Varieties with an asterisk indicate that it was not significantly different than the top performer in column (in **bold**).

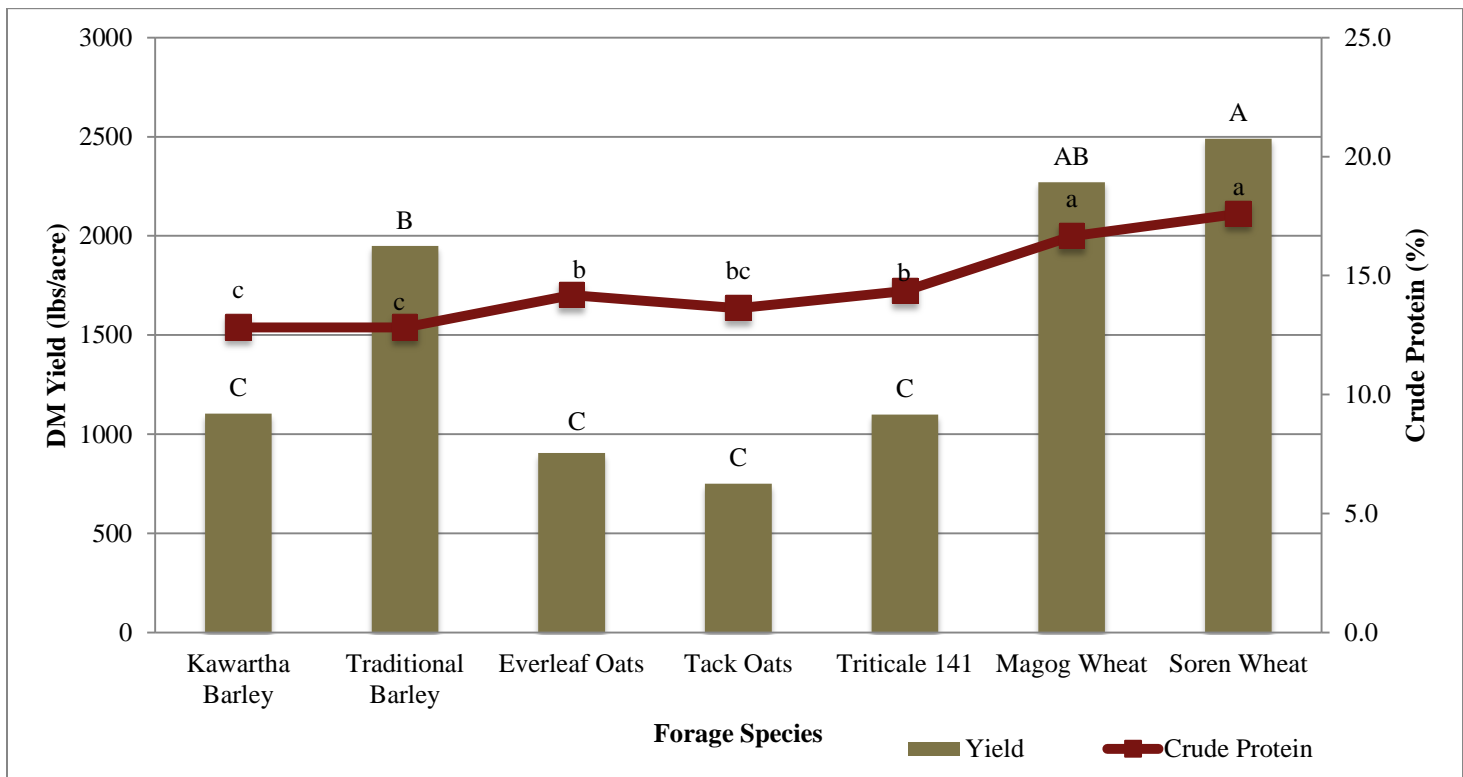


Figure 7. Yield and crude protein of small grain forage harvested as grain. Treatments with the same letter did not differ significantly from one another.

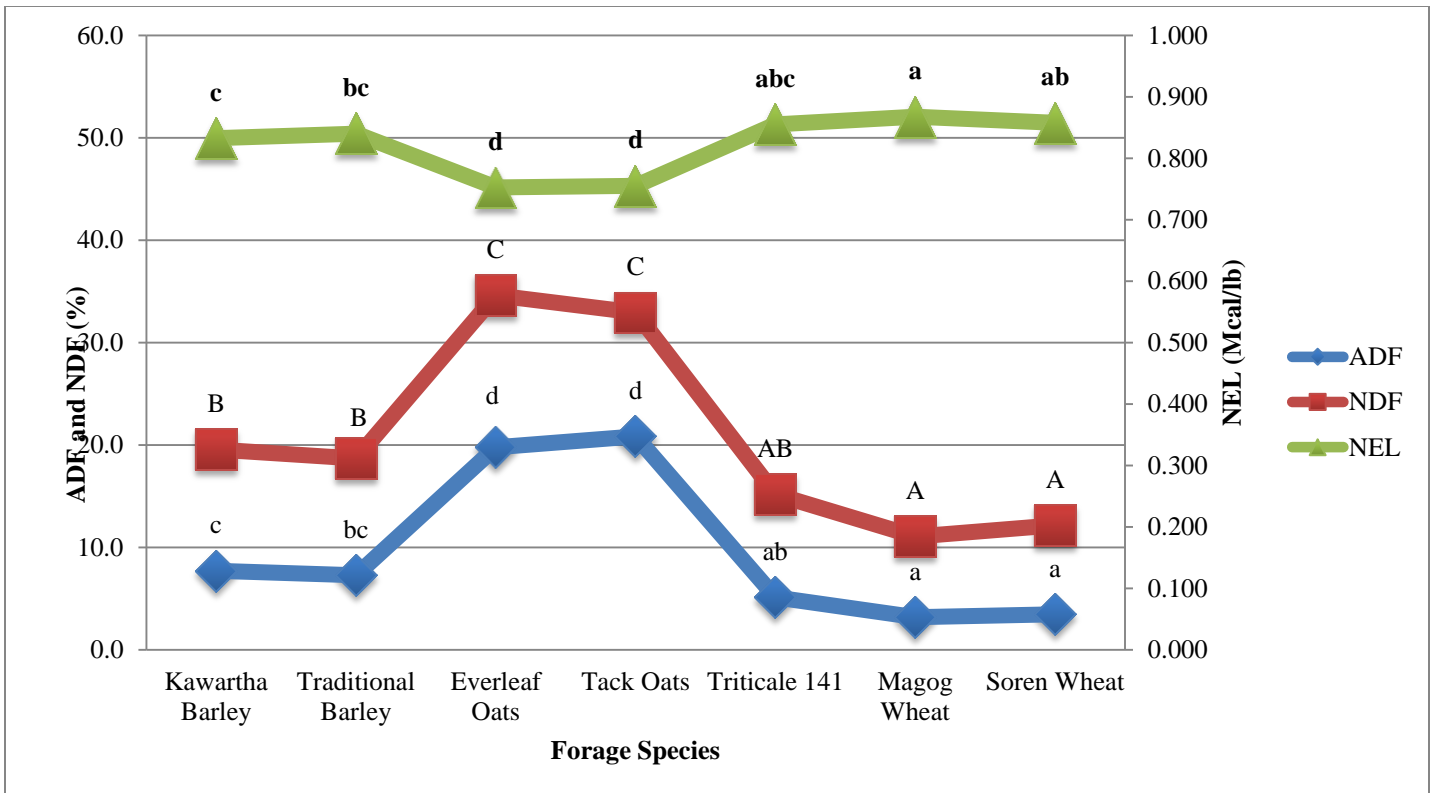


Figure 8. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and net energy for lactation (NEL) of small grain forage harvested as grain. Treatments with the same letter did not differ significantly from one another.

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