2012

Small Grain Forage Trial

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The UNIVERSITY of VERMONT EXTENSION

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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. In addition, production of high quality forage in the early season can improve the level of beneficial fats (i.e. Omege-3) in the milk. 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 ft^2 were cut to the ground, dried at 40^oC, 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
Harvest dates:	
Vegetative	6-Jun
Boot	6-Jun (Barley) 11-Jun (Oats, Triticale, Wheat) 25-Jun (Forage Oats)
Soft Dough	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.

Fatty acid content and profile of the feed samples were analyzed using a modified version of the direct transesterification method developed by Sukhija and Palmquist (1988). In brief, 1 mL of internal standard (1 mg C13:0 TAG/mL acetone), 2 mL of toluene, and 2 mL of 2% methanolic H_2SO_4 acid were added to 500 mg of ground feed composites samples. The solution was heated at 50°C overnight. After cooling the samples to room temperature, 5 mL of 6% $KHCO_3$ solution and 1 mL of hexane were added. The samples were mixed and centrifuged at 500 x *g* for 5 min. The resulting hexane layer was dried and cleaned over a mixture of Na_2SO_4 and charcoal. An aliquot of the solution, containing the fatty acid methyl esters (FAME), was taken for GLC analysis. The analysis of FAME extracts was performed on a GC-2010 gas chromatograph (Shimadzu, Kyoto, Japan) equipped with a split injector, a flame ionization detector, an autosampler (model AOC-20s; Shimadzu), and a 100 m CP-Sil 88 fused-silica capillary column (100 m × 0.25 mm i.d. × 0.2 µm film thickness; Varian Inc., Palo Alto, CA) The injector and detector were both maintained at 250°C. Hydrogen was used as carrier gas at a linear velocity of 30 cm/sec. The sample injection volume was 1 µL at a split ratio of 1:50. The oven program used was: initial temperature of 45°C held for 4 min, programmed at 13°C/min to 175°C held for 27 min, then programmed at 4°C/min to 215°C held for 35 min. Integration and quantification was based on the FID response and achieved with GC solution software (version 2.30.00, Shimadzu, Kyoto, Japan). Identification of FAME was accomplished by comparison of relative retention times with commercial FAME standards. Total fatty acid content was determined using C13:0 as an internal standard. The fatty acid results were expressed as percentages (weight/weight) of fatty acids detected with a chain length between 10 and 24 carbon atoms. The lowest level of detection was <0.001g/100g fatty acids and is reported as not detectable (ND).

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.

Species x Harvest Stage Interactions

There were species by harvest stage interactions for each of the fatty acid parameters tested. It is helpful to look at a graph of the data in order to understand the effects of both species and harvest stage. The total fatty acid concentration of Everleaf oats was higher than wheat and triticale in the vegetative and soft dough stage (Figure 1). However, during the boot stage, total fatty acid concentrations were relatively similar across forage species. Overall, levels of omega 3 FA decreased with maturity for each forage species (Figure 2).

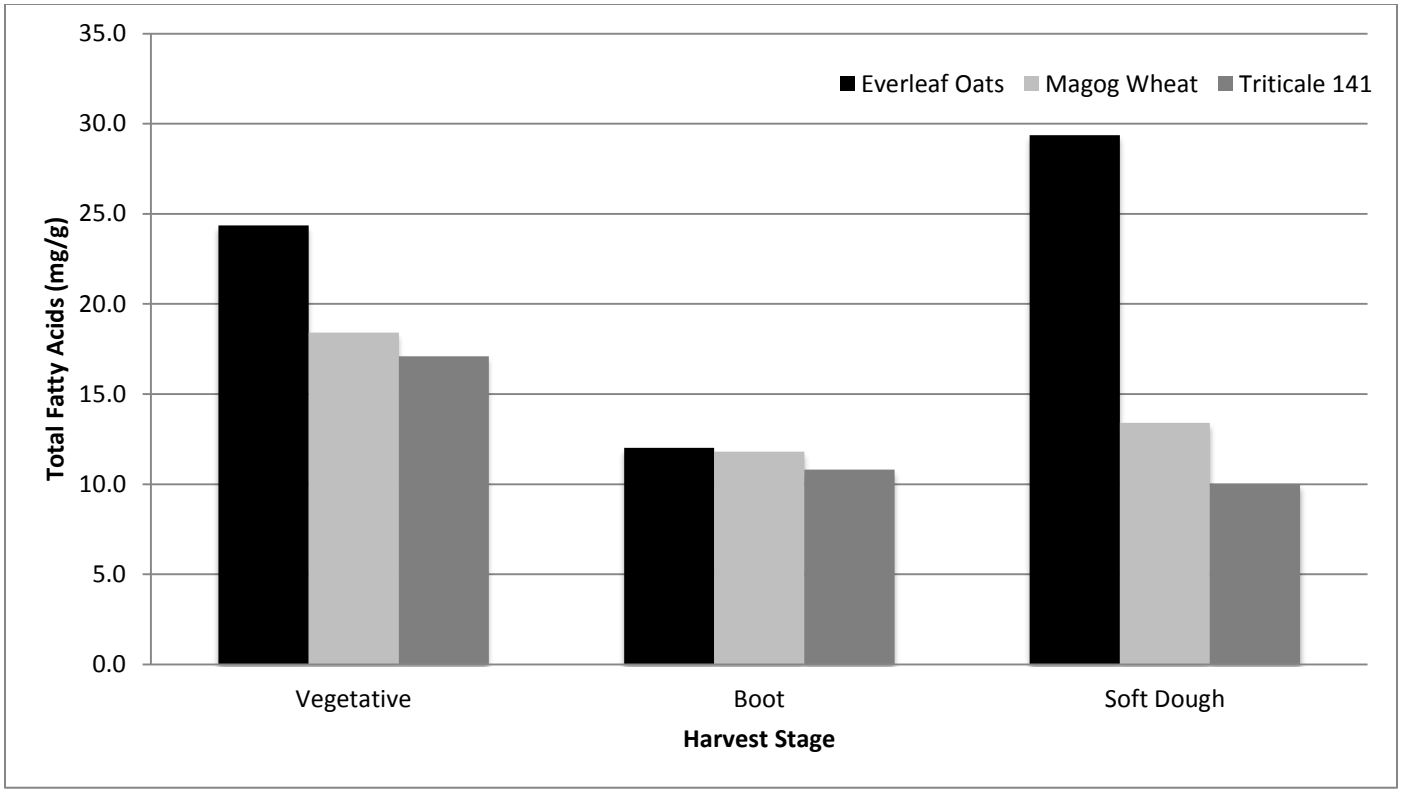

Figure 1. Total fatty acid concentration of three small grain forage species at three harvest stages.

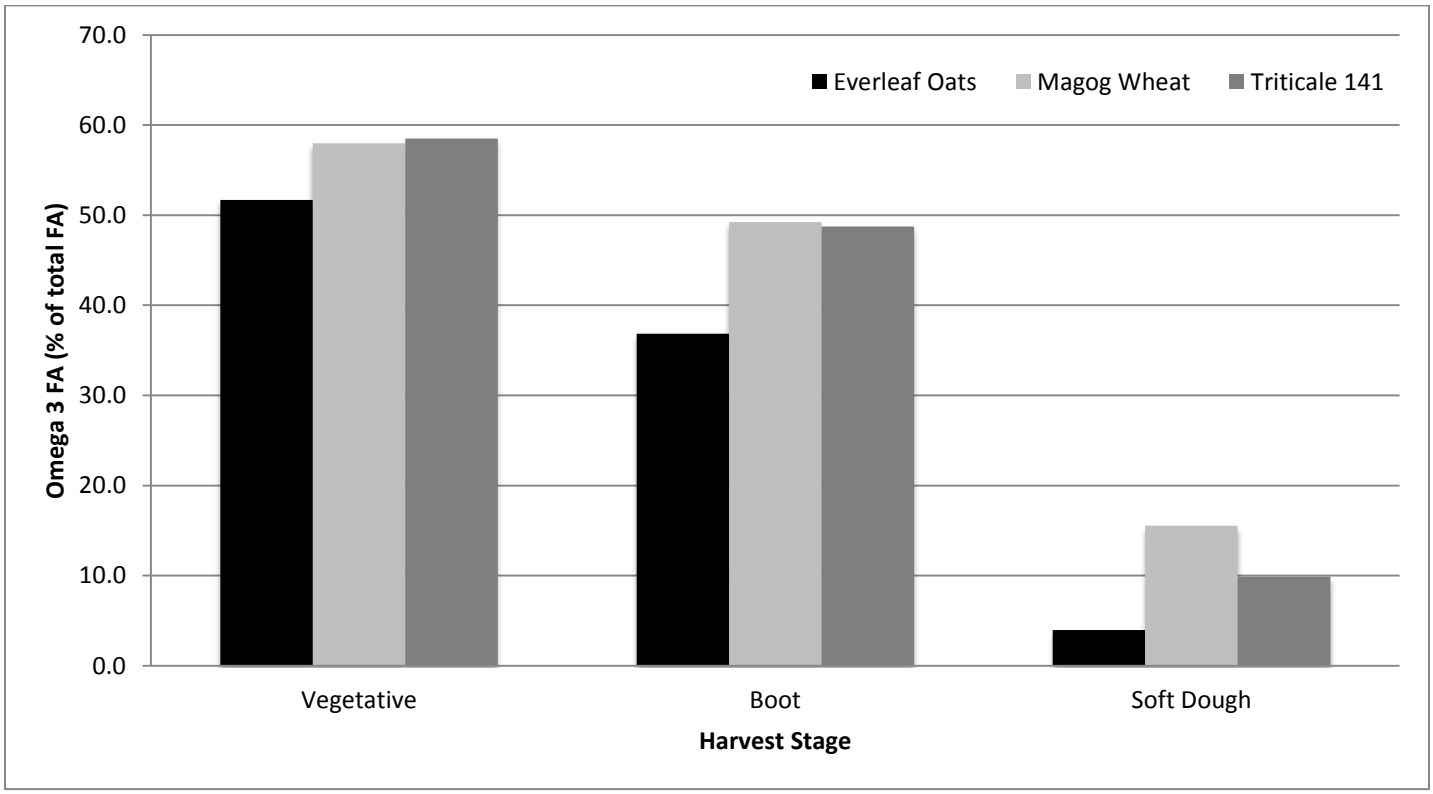

Figure 2. Omega 3 fatty acid profile of three small grain forage species at three harvest stages.

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.**

Total fatty acid concentration averaged across all small grain species was highest in the vegetative stage (Table 5). Interestingly, total FA decreased from 20.0 mg g^{-1} to 11.5 in the boot stage, and then increased to 17.6 mg g^{-1} in the soft dough stage. However, the level of Omega 3 FAs (profile and concentration) steadily decreased with forage maturity (Figure 3).

Table 5. Average forage fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) at three harvest stages.

	Vegetative	Boot	Soft Dough	Trial mean	LSD
SFA (%)	26.2	31.7*	27.1	28.3	1.2
SFA (mg g^{-1})	5.2*	3.6	4.5	4.4	0.3
C16 (%)	18.8	21.4*	20.5	20.2	0.7
C16 (mg g^{-1})	3.7*	2.4	3.4	3.2	0.3
MUFA (%)	2.7	3.3	18.8*	8.3	0.5
MUFA (mg g^{-1})	0.6	0.4	4.1*	1.7	0.3
PUFA (%)	71.3*	65.2	54.3	63.6	1.2
PUFA (mg g^{-1})	14.3*	7.6	9.0	10.3	1.2
C18:2 LA (%)	14.6	18.6	44.0*	25.7	1.1
C18:2 LA (mg g^{-1})	3.0	2.2	7.5*	4.2	0.5
C18:3 LNA (%)	55.8*	44.7	9.6	36.7	1.7
C18:3 LNA (mg g^{-1})	11.2*	5.2	1.4	5.9	1.0
Omega 3 FA (%)	56.1*	44.9	9.8	36.9	1.7
Omega 3 FA (mg g^{-1})	11.2*	5.2	1.4	5.9	1.0
Omega 6 FA (%)	15.3	20.3	44.5*	26.7	1.1
Omega 6 FA (mg g^{-1})	3.1	2.4	7.6*	4.3	0.4
Total FA (mg g^{-1})	20.0*	11.5	17.6	16.4	1.6
Ratio Omega 6: Omega 3 FA	0.28	0.47	6.05*	2.26	0.40

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.

* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

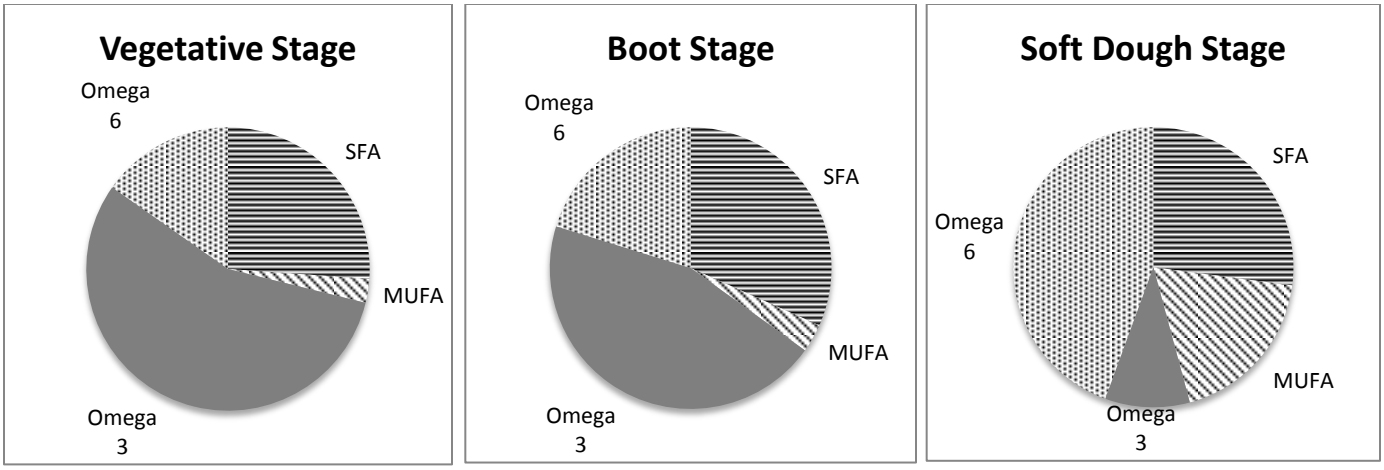

Figure 3. Fatty acid profile of small grain forages at three harvest stages. Omega 3 fatty acids (shown in solid grey) decreased with forage maturity.

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 6 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 6. 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**.

When averaged across harvest stages, Everleaf oats had the highest total FA concentration of any forage species (Table 7). Everleaf oats also had the highest ratio of omega 6 to omega 3 fatty acids (a lower ratio is considered beneficial), and the highest concentration of omega 6s (Figure 4).

Table 7. Average forage fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) at three small grain forage species.

	Everleaf Oats	Magog Wheat	Triticale 141	Trial mean	LSD
SFA (%)	30.1*	26.0	28.9*	28.3	1.2
SFA (mg g^{-1})	6.1*	3.7	3.5	4.4	0.3
C16 (%)	21.5*	19.3	19.9	20.2	0.7
C16 (mg g^{-1})	4.4*	2.7	2.4	3.2	0.3
MUFA (%)	13.0*	6.0	5.9	8.3	0.5
MUFA (mg g^{-1})	3.6*	0.8	0.7	1.7	0.3
PUFA (%)	57.1	68.2*	65.4	63.6	1.2
PUFA (mg g^{-1})	12.3*	10.0	8.5	10.3	1.2
C18:2 LA (%)	25.8*	26.6*	24.8	25.7	1.1

C18:2 LA (mg g^{-1})	6.1*	3.7	2.9	4.2	0.5
C18:3 LNA (%)	30.7	40.7*	38.8	36.7	1.7
C18:3 LNA (mg g^{-1})	6.1	6.2	5.4	5.9	NS
Omega 3 FA (%)	30.8	40.9*	39.1	36.9	1.7
Omega 3 FA (mg g^{-1})	6.1	6.2	5.5	5.9	NS
Omega 6 FA (%)	26.3	27.3	26.4	26.7	NS
Omega 6 FA (mg g^{-1})	6.2*	3.8	3.0	4.3	0.4
Total FA (mg g^{-1})	21.9*	14.5	12.6	16.4	1.6
Ratio Omega 6: Omega 3 FA	3.71*	1.27	1.82	2.26	0.40

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.

* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

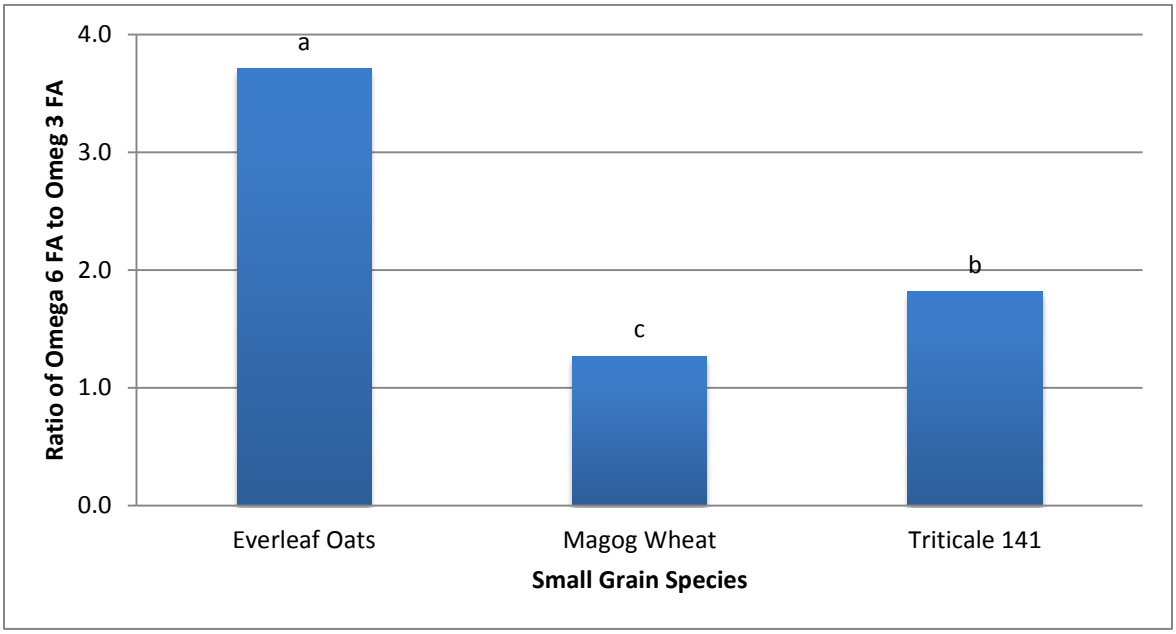

Figure 4. Ratio of Omega 6 to Omega 3 fatty acids of three forage species, averaged across three harvest stages. A lower ratio is considered beneficial.

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 8). 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 5). 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 6).

Table 8. 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.

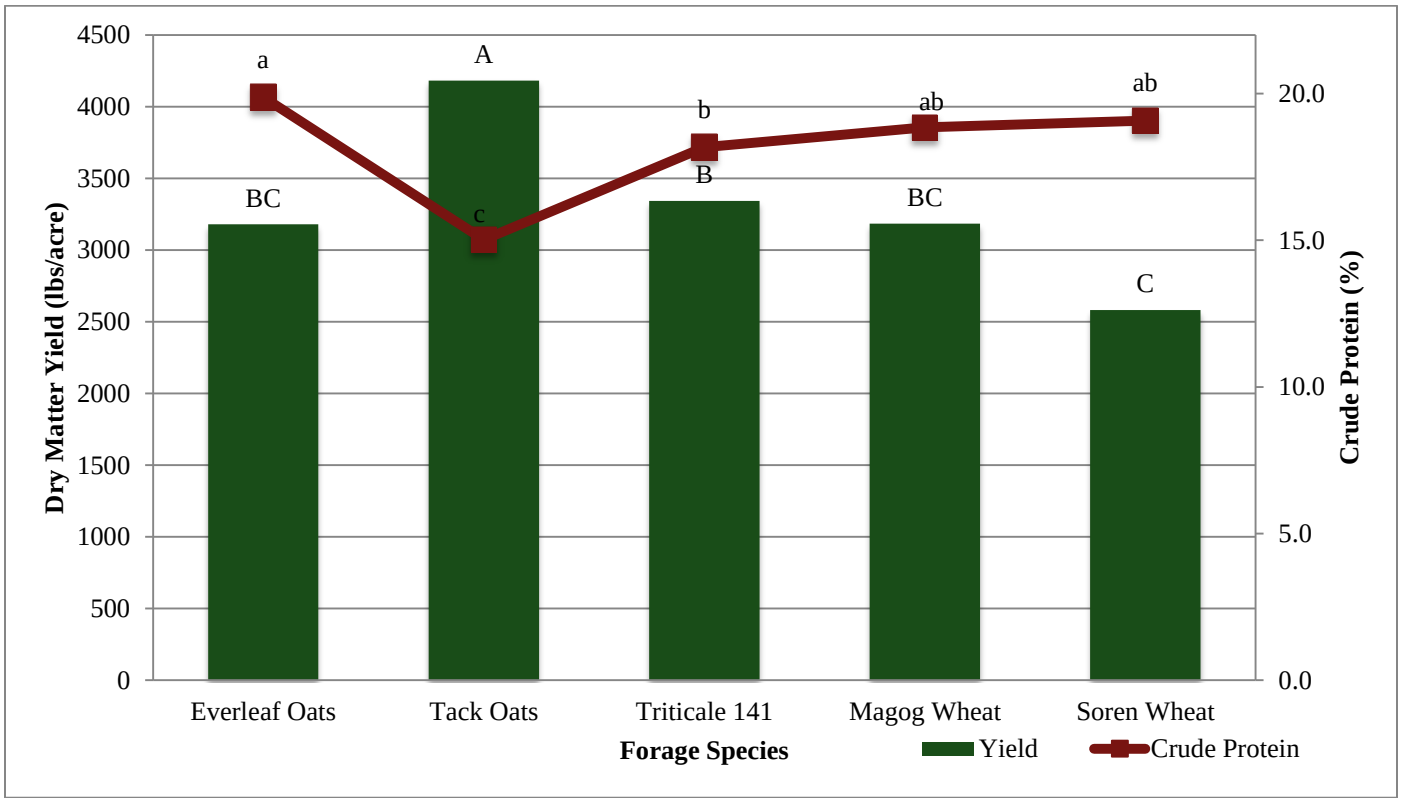

Figure 5. Yield and protein of small grain forage harvested in the vegetative stage.
Treatments with the same letter did not differ significantly from one another.

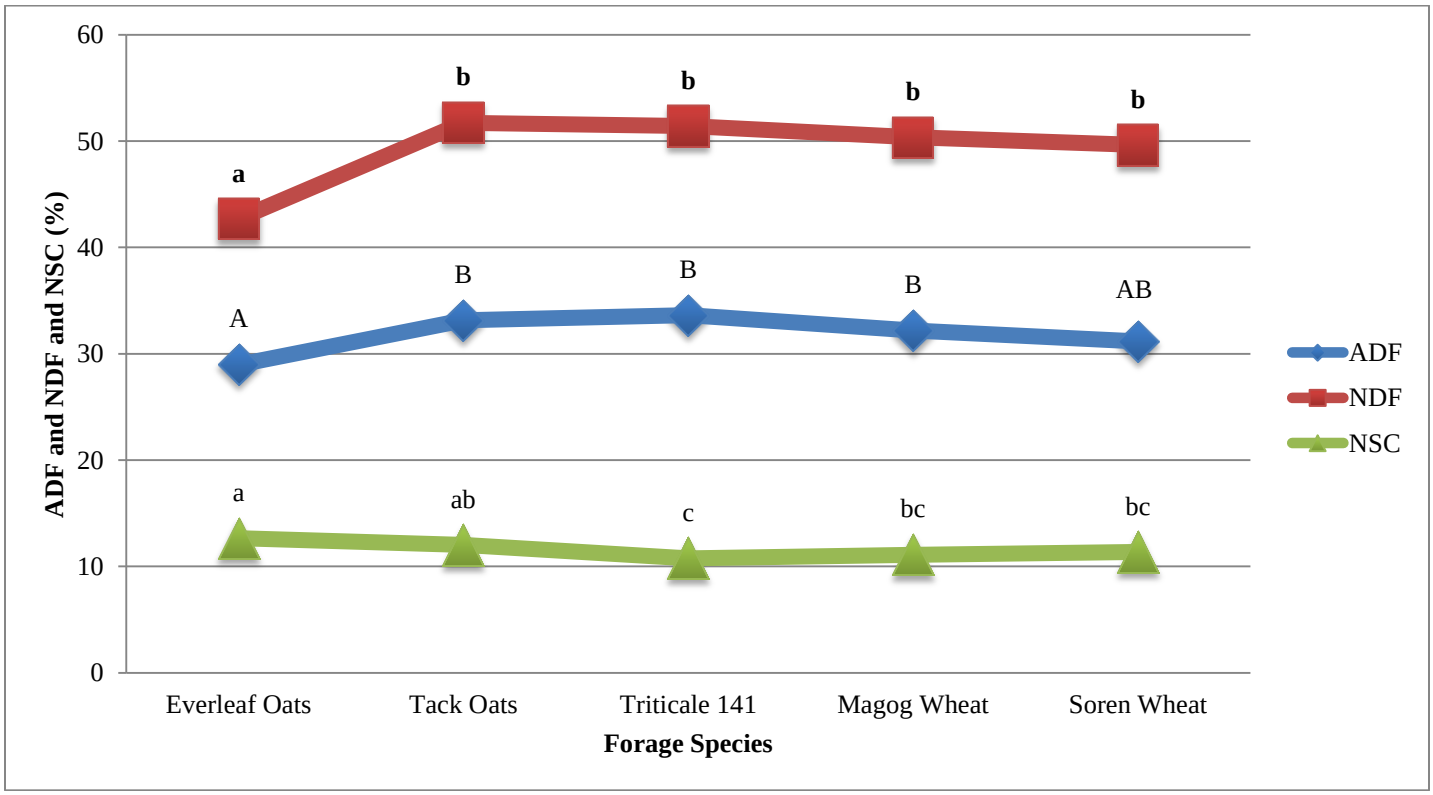

Figure 6. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and non-structural carbohydrates (NSC) of small grain forage harvested in the vegetative stage. Treatments with the same letter did not differ significantly from one another.

In the vegetative stage, Everleaf oats had the highest levels of total FA—24.4 mg g^{-1} (Table 9). But the omega 3 FA profile was lowest for Everleaf oats compared to wheat and triticale (Figure 7).

Table 9. Average forage fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) of small grains at the vegetative stage.

	Everleaf Oats	Magog Wheat	Triticale 141	Veg Mean	LSD
SFA (%)	29.2*	23.9	25.4	26.2	3.0381
SFA (mg g^{-1})	6.9*	4.3	4.3	5.2	0.888
C16 (%)	21.2*	17.5	17.7	18.8	1.7831
C16 (mg g^{-1})	5.1*	3.1	3.0	3.7	0.7465
MUFA (%)	3.1*	2.5	2.6	2.7	0.3481
MUFA (mg g^{-1})	0.8*	0.5	0.4	0.6	0.0996
PUFA (%)	67.9	73.8*	72.2*	71.3	3.2935
PUFA (mg g^{-1})	16.7	13.7	12.5	14.3	NS
C18:2 LA (%)	15.9*	15.*	12.7	14.6	1.0566
C18:2 LA (mg g^{-1})	3.9*	2.8	2.2	3.0	0.5591
C18:3 LNA (%)	51.5	57.7*	58.2*	55.8	4.1665
C18:3 LNA (mg g^{-1})	12.7	10.7	10.0	11.2	NS
Omega 3 FA (%)	51.7	58.0*	58.5*	56.1	4.1412
Omega 3 FA (mg g^{-1})	12.8	10.7	10.1	11.2	NS
Omega 6 FA (%)	16.2*	15.9*	13.7	15.3	1.1225
Omega 6 FA (mg g^{-1})	3.9*	2.9	2.4	3.1	0.5685
Total FA (mg g^{-1})	24.4*	18.4	17.1	20.0	4.4311
Ratio Omega 6: Omega 3 FA	0.32*	0.27	0.23	0.28	0.0422

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.

* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

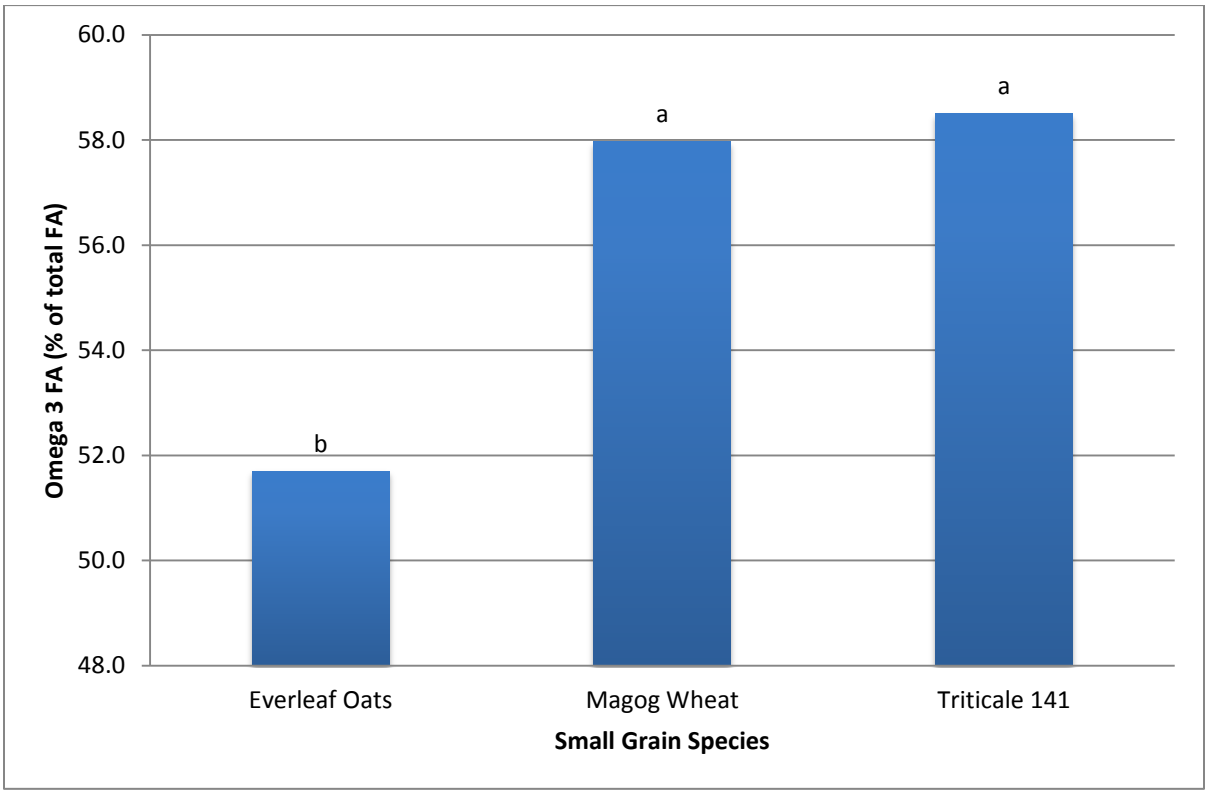

Figure 7. Omega 3 fatty acid profile of small grain forages harvested in the vegetative stage.

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 10 and Figure 8). 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 9). Soren wheat had the lowest NDF levels and highest starch, total digestible nutrients, net energy for lactation and non-fiber carbohydrates.

Table 10. 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.

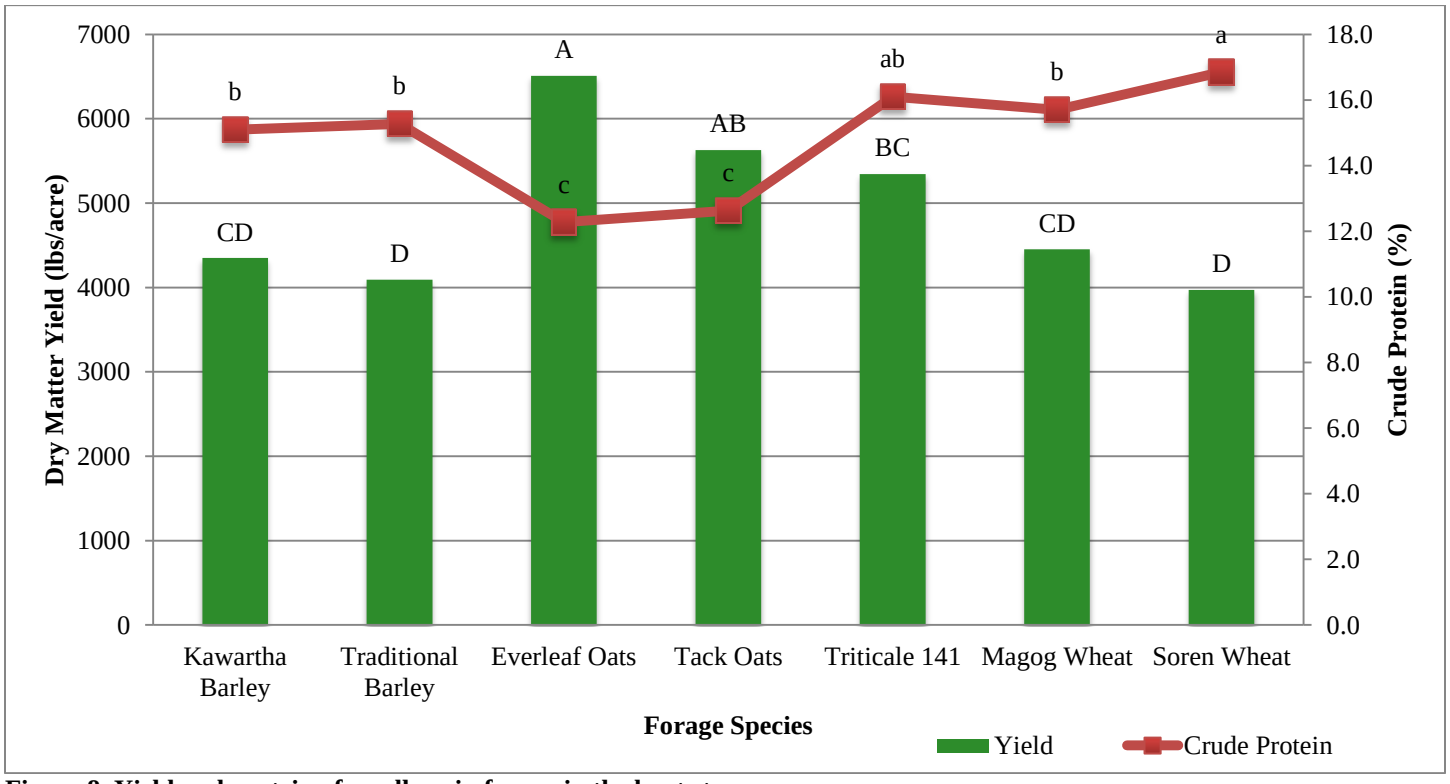

Figure 8. Yield and protein of small grain forage in the boot stage.
Treatments with the same letter did not differ significantly from one another.

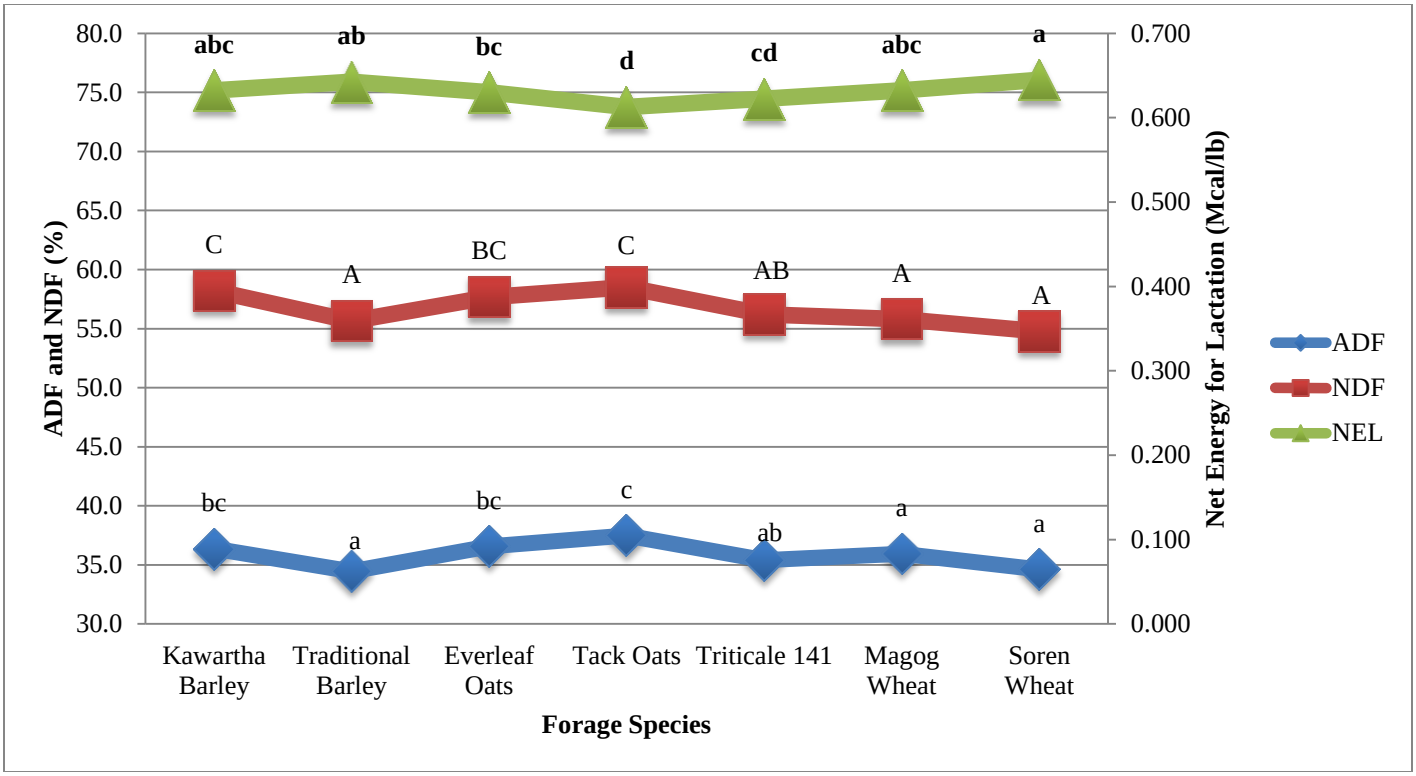

Figure 9. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and net energy for lactation (NEL) of small grain forage harvested in the boot stage. Treatments with the same letter did not differ significantly from one another.

In the boot stage, total FA concentrations were similar across forage species (Table 11). Everleaf oats had higher levels of omega 6 FA and a higher ratio of omega 6 to omega 3 FA than wheat and triticale. The omega 3 FA profile for Everleaf oats was over 12 percentage points lower than the omega 3 profile for wheat and triticale (Figure 10).

Table 11. Average forage fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) of small grain forages harvested in the boot stage.

	Everleaf Oats	Magog Wheat	Triticale 141	Boot Mean	LSD
SFA (%)	36.8*	27.5	30.9	31.7	1.4
SFA (mg g^{-1})	4.4*	3.2	3.3	3.6	0.6
C16 (%)	24.6*	19.4	20.2	21.4	0.7
C16 (mg g^{-1})	2.9*	2.3	2.1	2.4	0.4
MUFA (%)	3.6	3.3	2.9	3.3	NS
MUFA (mg g^{-1})	0.4*	0.4*	0.3	0.4	0.1
PUFA (%)	59.8	69.4*	66.4	65.2	1.7
PUFA (mg g^{-1})	7.2	8.2	7.2	7.6	NS
C18:2 LA (%)	21.8*	18.6	15.4	18.6	1.1
C18:2 LA (mg g^{-1})	2.6*	2.2	1.7	2.2	0.3
C18:3 LNA (%)	36.7	49.0*	48.6*	44.7	2.5
C18:3 LNA (mg g^{-1})	4.4	5.8*	5.3*	5.2	1.0
Omega 3 FA (%)	36.8	49.2*	48.8*	44.9	2.5
Omega 3 FA (mg g^{-1})	4.4	5.9*	5.3*	5.2	1.0
Omega 6 FA (%)	22.9*	20.2	17.6	20.3	1.2
Omega 6 FA (mg g^{-1})	2.8*	2.4	1.9	2.4	0.3
Total FA (mg g^{-1})	12.0	11.8	10.8	11.5	NS
Ratio Omega 6: Omega 3 FA	0.62*	0.41	0.36	0.47	0.05

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.

* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

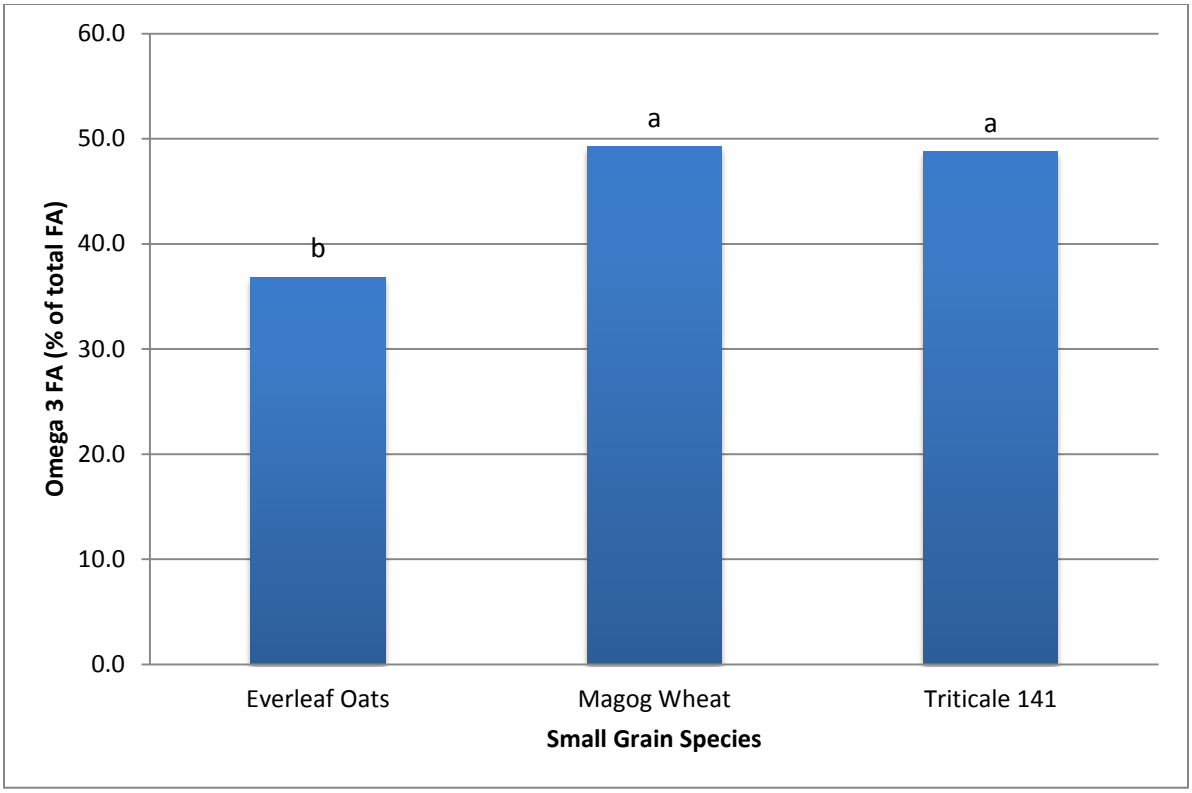

Figure 10. Omega 3 fatty acid profile of small grain forages harvested in the boot stage.

Soft Dough Stage Harvest

Similar to the boot stage, triticale was the highest yielding treatment when harvested during the soft dough stage (Table 12 and Figure 11). 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 12).

Table 12. 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**).

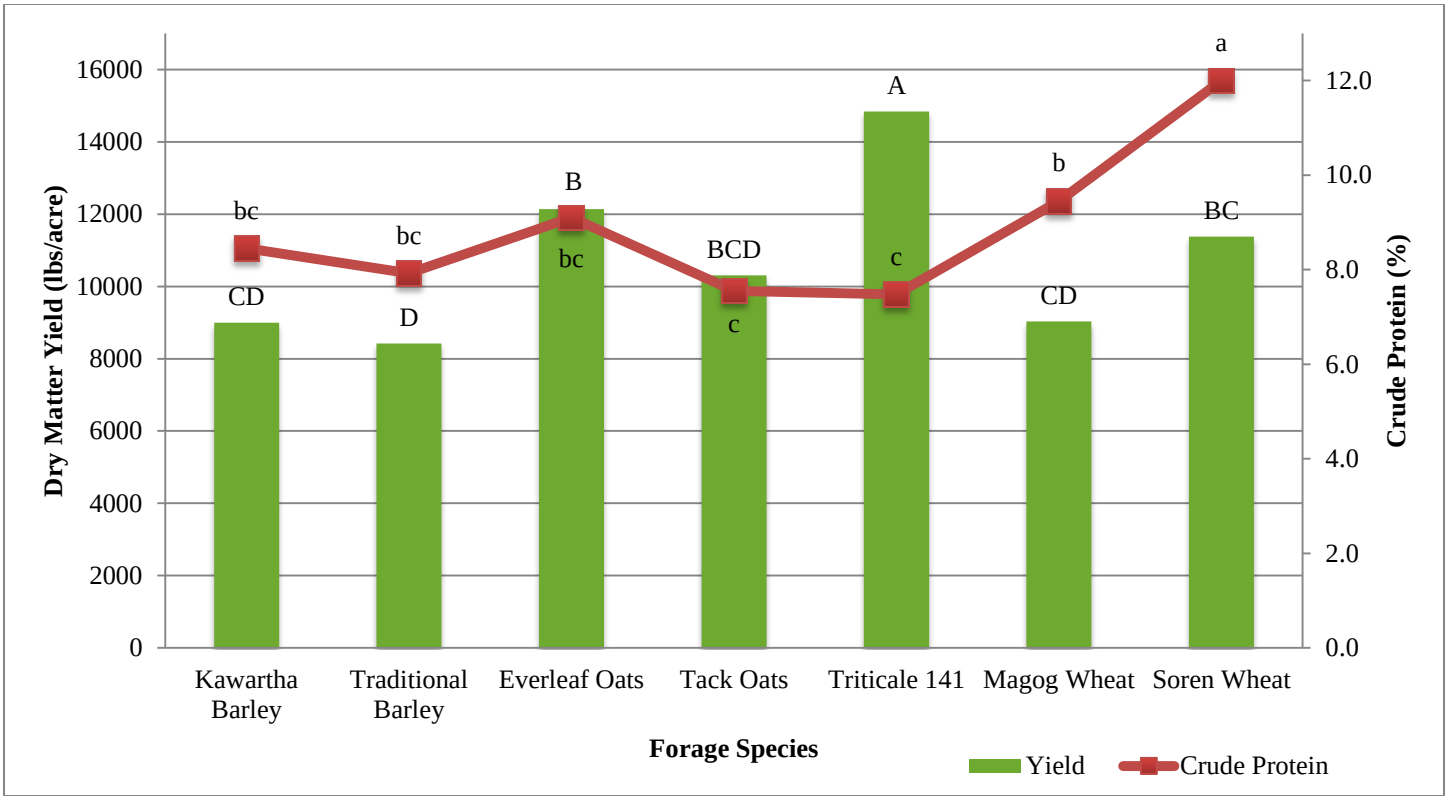

Figure 11. Yield and crude protein (CP) of small grain forage harvested in the soft dough stage.
Treatments with the same letter did not differ significantly from one another.

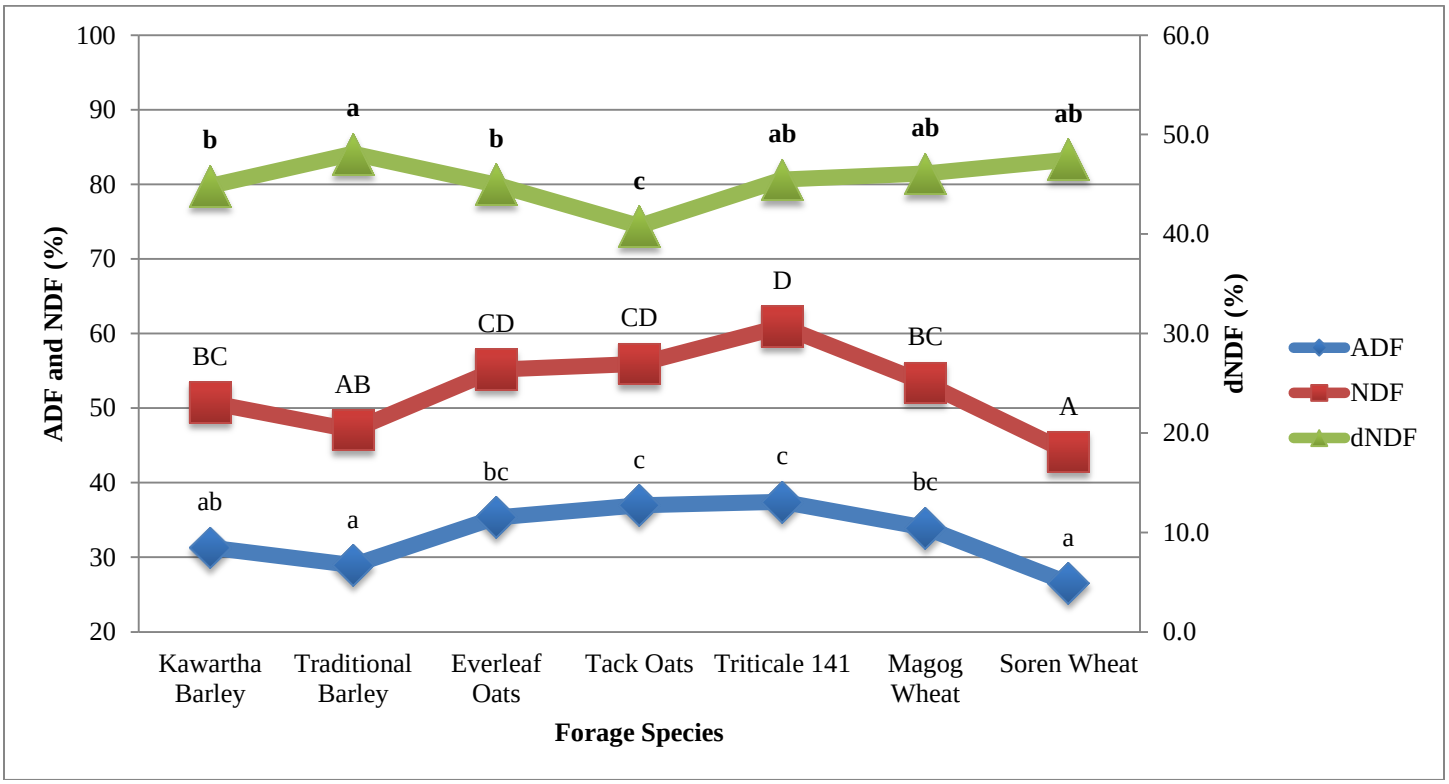

Figure 12. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and digestible neutral detergent fiber (dNDF) of small grain forage harvested in the soft dough stage. Treatments with the same letter did not differ significantly from one another.

During the soft dough stage, total fatty acid concentration for Everleaf oats was almost triple that of wheat and triticale (Table 13). However, the ratio of omega 6 to omega 3 fatty acids was also much higher than the other forages. Magog wheat had the highest omega 3 fatty acid profile of the forage species in the soft dough stage (Figure 13).

Table 13. Average forage fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) of small grain forage harvested in the soft dough stage.

	Everleaf Oats	Magog Wheat	Triticale 141	Soft Dough Mean	LSD
SFA (%)	24.2	26.7	30.5*	27.1	2.4699
SFA (mg g^{-1})	7.0*	3.5	3.0	4.5	0.2895
C16 (%)	18.5	21.1*	21.8*	20.5	0.9332
C16 (mg g^{-1})	5.3*	2.8	2.2	3.4	0.3669
MUFA (%)	32.1*	12.1	12.1	18.8	1.158
MUFA (mg g^{-1})	9.5*	1.6	1.2	4.1	1.1441
PUFA (%)	43.8	61.4*	57.7	54.3	1.9101
PUFA (mg g^{-1})	12.9*	8.3	5.8	9.0	1.4812
C18:2 LA (%)	39.8	45.8*	46.4*	44.0	4.0377
C18:2 LA (mg g^{-1})	11.7*	6.2	4.7	7.5	1.4784
C18:3 LNA (%)	3.8	15.4*	9.7	9.6	2.3211
C18:3 LNA (mg g^{-1})	1.1	2.1*	1.0	1.4	0.2945
Omega 3 FA (%)	4.0	15.5*	9.9	9.8	2.3176
Omega 3 FA (mg g^{-1})	1.2	2.1*	1.0	1.4	0.2932
Omega 6 FA (%)	39.8	45.9*	47.8*	44.5	3.5367
Omega 6 FA (mg g^{-1})	11.8*	6.2	4.8	7.6	1.425
Total FA (mg g^{-1})	29.4*	13.4	10.0	17.6	2.8296
Ratio Omega 6: Omega 3 FA	10.19*	3.11	4.85	6.05	1.1546

SFA Saturated Fatty Acids, MUFA mono-unsaturated fatty acids, PUFA poly-unsaturated fatty acids, LA linoleic acid, LNA linolenic acid.

* Varieties with an asterisk indicate that it was not significantly different than the top performer in row.

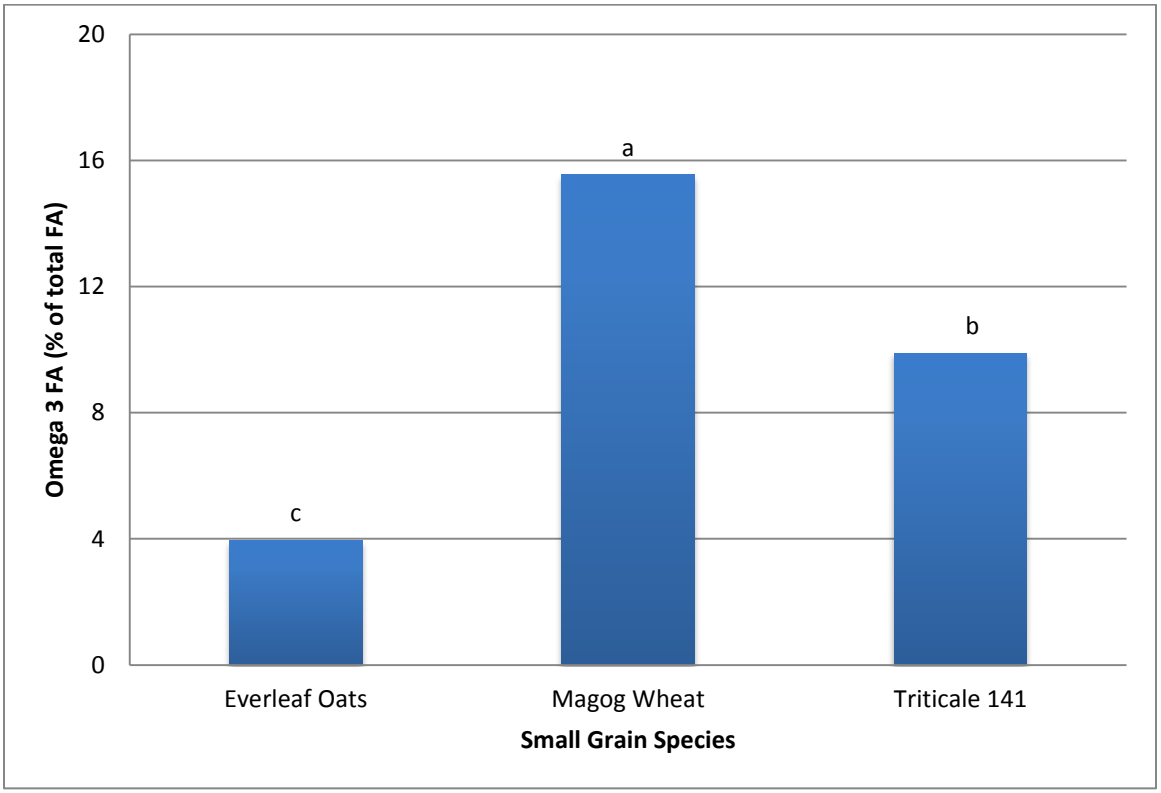

Figure 13. Omega 3 fatty acid profile of small grain forages harvested in the soft dough stage.

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 14, Figure 14). 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 15). 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 14. 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**).

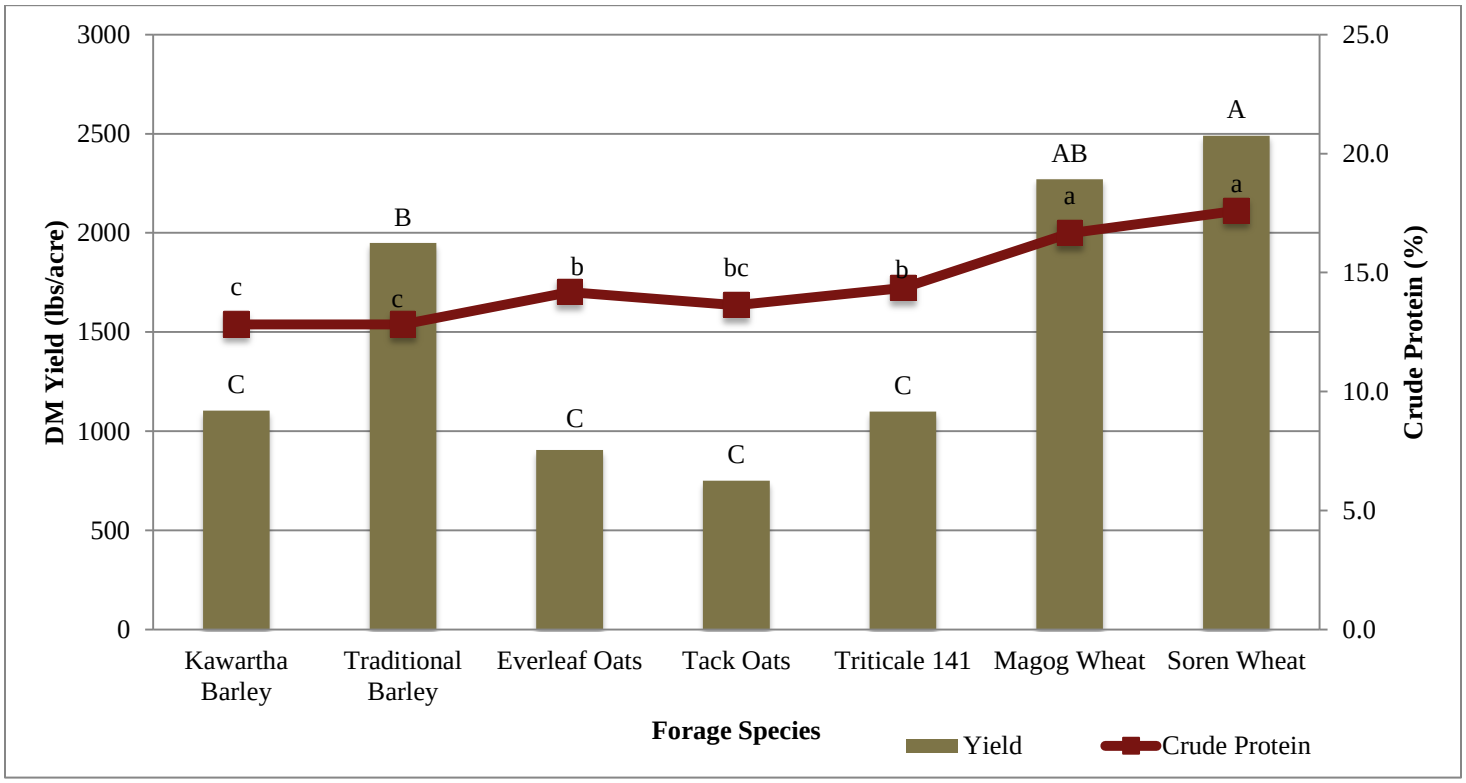

Figure 14. Yield and crude protein of small grain forage harvested as grain.
Treatments with the same letter did not differ significantly from one another.

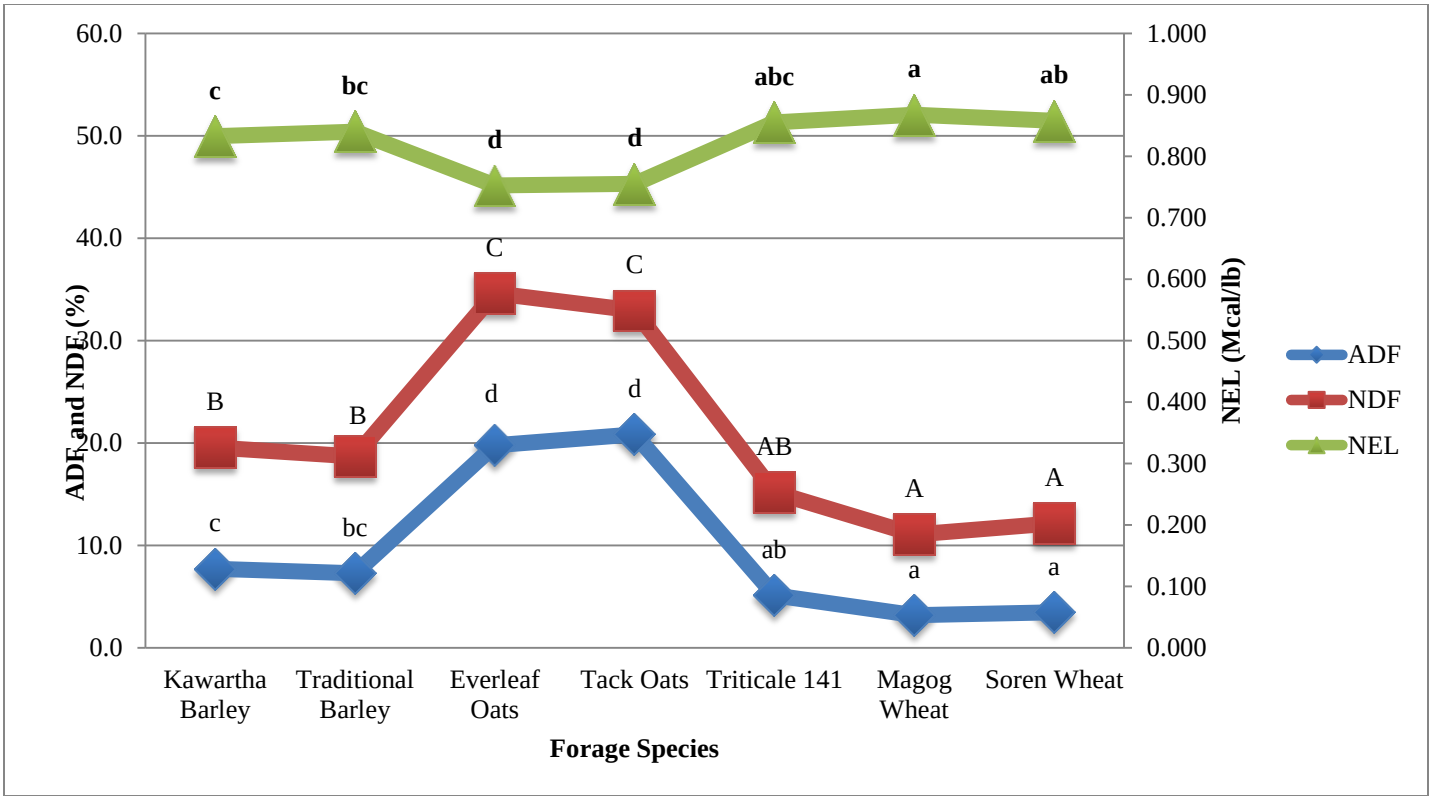

Figure 15. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and net energy for lactation (NEL) of small grain forage harvested as grain. Treatments with the same letter did not differ significantly from one another.

REFERENCE

Sukhija, P. S., and D. L. Palmquist. 1988. Rapid method for determination of total fatty-acid content and composition of feedstuffs and feces. *J. Agric. Food Chem.* 36: 1202-1206.

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