NORTHWEST CROPS & SOILS PROGRAM

2013 Small Grain Forage Trial: Species x Harvest Date

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UNIVERSITY OF VERMONT EXTENSION
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2013 SMALL GRAIN FORAGE TRIAL: SPECIES X HARVEST DATE

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Spring cereal grains such as oats, barley, triticale and wheat 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, milk, 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.

MATERIALS AND METHODS

In 2013, a small grain forage trial was repeated at Borderview Research Farm in Alburgh, VT (Table 1). The previous crop in this location was soybeans, and the seedbed was prepared by conventional tillage methods. The field was disked and spike tooth harrowed in April to prepare for planting. Plots were planted with a six-inch Kincaid cone seeder on 3-May at a seeding rate of 125 lbs acre^{-1}. The varieties and seed source are listed in Table 2. Each treatment was harvested at four development stages: vegetative, boot, milk, and soft dough (Table 3). Subsamples of approximately 2.5 ft^2 were cut 3" from the ground, dried at 40^{o}C, and weighed to determine dry matter yield. Oven dry samples were coarsely ground with a Wiley mill (Thomas Scientific, Swedesboro, NJ), finely ground with a UDY cyclone mill with a 1 mm screen (Seedburo, Des Plaines, IL) and analyzed with an NIRS (Near Infrared Reflectance Spectroscopy) DS2500 Feed and Forage analyzer (Foss, Eden Prairie, MN) at the University of Vermont Cereal Testing Lab (Burlington, VT). Results were analyzed with an analysis of variance method of comparison in SAS (Cary, NC).

Table 1. General plot management.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Covington silty clay loam
Previous crop	Soybeans
Row width (in.)	6
Planting date	3-May
Seeding rate	125 lbs/acre
Tillage methods	Mold board plow, disk, and spike tooth harrow

Table 2. Small grain forage varieties and seed source.

Species	Variety	Source
Barley	McGwire	RDR Grains et Semences
Barley	Robust	Albert Lea Seeds
Forage Barley	Haybet	Albert Lea Seeds
Forage Oat	Everleaf	King's Agriseed
Oat	Tack	Albert Lea Seeds
Triticale	AC Ultima	Oliver Seeds
Hard Wheat	Magog	Semican
Soft Wheat	Kaffe	Semican

Forage quality analysis included crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and various other nutrients. 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 content 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. Acid detergent fiber (ADF) represents the least digestible portion of fiber: the lignin and cellulose. 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 (NDFD) will result in higher energy values, and perhaps more importantly, increased forage intakes. Forage NDF digestibility can range from 20 – 80%. The Total Digestible Nutrients (TDN), Net Energy of Lactation (NE_L), and Relative Feed Value (RFV) were calculated from forage analysis data.

Table 3. Harvest date at each stage of maturity for the spring grain forages.

Variety	Vegetative	Boot	Milk	Soft Dough
McGwire Barley	13-Jun	24 & 27-Jun	9-Jul	22-Jul
Robust Barley	13-Jun	24-Jun	9-Jul	22-Jul
Haybet Barley	13-Jun	24-Jun	9 & 16-Jul	22-Jul
Everleaf Oats	13-Jun	3-Jul	22-Jul	6-Aug
Tack Oats	13-Jun	24-Jun	9-Jul	22-Jul
AC Ultima Triticale	13-Jun	24-Jun	9 &16-Jul	29-Jul
Magog HRSW	13-Jun	24 & 27-Jun	9-Jul	22 & 29-Jul
Kaffe SWSW	13-Jun	1-Jul	16-Jul	29-Jul

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 4. From April to August, there was an accumulation of 4510 Growing Degree Days (GDDs), in Alburgh which is 18 GDDs more than the 30-year average.

Table 4. Seasonal weather data[1] collected in Alburgh, VT, 2013.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	43.6	59.1	64	71.7	67.7
Departure from normal	-1.2	2.7	-1.8	1.1	-1.1
Precipitation (inches)	2.12	4.79	9.23	1.89	2.41
Departure from normal	-0.7	1.34	5.54	-2.26	-1.5
Growing Degree Days (base 32°F)	348.5	847.8	967	1235	1112
Departure from normal	-35.6	91.4	-47.0	36.8	-27.2

[1]Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.
ł June 2013 precipitation data based on National Weather Service data from cooperative stations in South Hero, VT (http://www.nrcc.cornell.edu/page_summaries.html)

Harvest Stage

Forages harvested in the milk stage yielded the highest dry matter averaging 5305 lbs dry matter acre^{-1} (Table 5). Protein levels were highest during the vegetative stage, averaging 24.4%. Additionally, the vegetative stage had the lowest fiber content, highest fiber digestibility, highest total digestible nutrients, highest net energy of lactation and highest relative feed value. Fiber content generally increases as plants mature, but the formation of starch in the soft dough stage dilutes overall fiber content.

Table 5. Cereal grain yield and quality compared across harvest stages.

Harvest	DM %	Yield lb ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Vegetative	**16.0***	1528	**24.4***	**27.8***	**44.2***	**73.5***	**67.1***	**0.70***	**139.3***
Boot	16.6*	3564	18.1	35.4	54.9	66.9	63.3	0.66	103.2
Milk	28.2*	**5305***	12.0	36.7	57.4	49.7	61.3	0.64	96.4
Soft Dough	46.3	4936	10.1	34.8	55.1	39.0	60.7	0.62	105.4
Trial mean	26.8	3833	16.1	33.7	52.9	57.3	63.1	0.65	111.1
LSD (p<0.10)	1.6261	299.61	0.6222	0.6603	0.8483	1.2433	0.4724	0.0058	2.4757

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

Small Grain Varieties

Of the eight forage varieties grown, Everleaf oats and Haybet barley were specifically bred as forage varieties, which means they have been bred to be leafier and stay vegetative longer than other small grains. Averaged across all harvests, Everleaf oats yielded the highest at 5410 lbs acre^{-1}, while McGwire barley had the highest protein, digestible NDF, NE_L and RFV (Table 6). In general, McGwire, Haybet, and Robust barleys had the most desirable forage quality characteristics.

Table 6. Small grain forage yield and quality averaged across four harvest stages (vegetative, boot, milk, and soft dough).

Variety	DM %	Yield lb ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Everleaf	**19.8***	**5410***	15.9	36.3	52.5*	57.7	62.2	0.64	108.3
Haybet	30.0	3806	15.7	32.1*	52.1*	59.6*	63.9*	0.66*	114.4*
Kaffe	31.1	3667	15.4	33.0	53.5	55.3	62.5	0.64	111.7
Magog	29.3	2894	16.6	33.1	53.0	56.0	62.9	0.65	111.9
McGwire	24.6	2549	**17.8***	**31.6***	52.2*	**61.3***	**64.3***	**0.67***	**115.6***
Robust	27.6	4451	15.8	32.0*	**51.7***	57.4	64.0*	0.67*	114.7*
Tack	20.1*	4825	15.5	35.8	53.0	53.9	63.1	0.66	107.2
Triticale	32.0	3062	16.6	35.4	55.4	57.1	61.7	0.64	104.8
Trial mean	26.8	3833	16.1	33.7	52.9	57.3	63.1	0.65	111.1
LSD (p<0.10)	2.29	424	0.879	0.934	1.19	1.76	0.668	0.008	3.50

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

Harvest Stage x Variety Interaction

There was a harvest stage by variety interaction for each parameter studied, which indicates that varieties performed differently at each harvest. For example, Figure 1 shows that DM yields of Everleaf oats increased with each stage of maturity, while yields of McGwire barley peaked at the boot stage and decreased after that. Net energy of lactation generally decreased for each forage with maturity, averaging 0.70 Mcal lb^{-1} in the vegetative stage and 0.62 Mcal lb^{-1} in the soft dough stage (Table 5). However, NE_L of Robust barley did not follow this pattern (Figure 2). Net energy of lactation of Robust barley stayed fairly constant with each harvest, actually increasing from the milk stage to the soft dough stage.

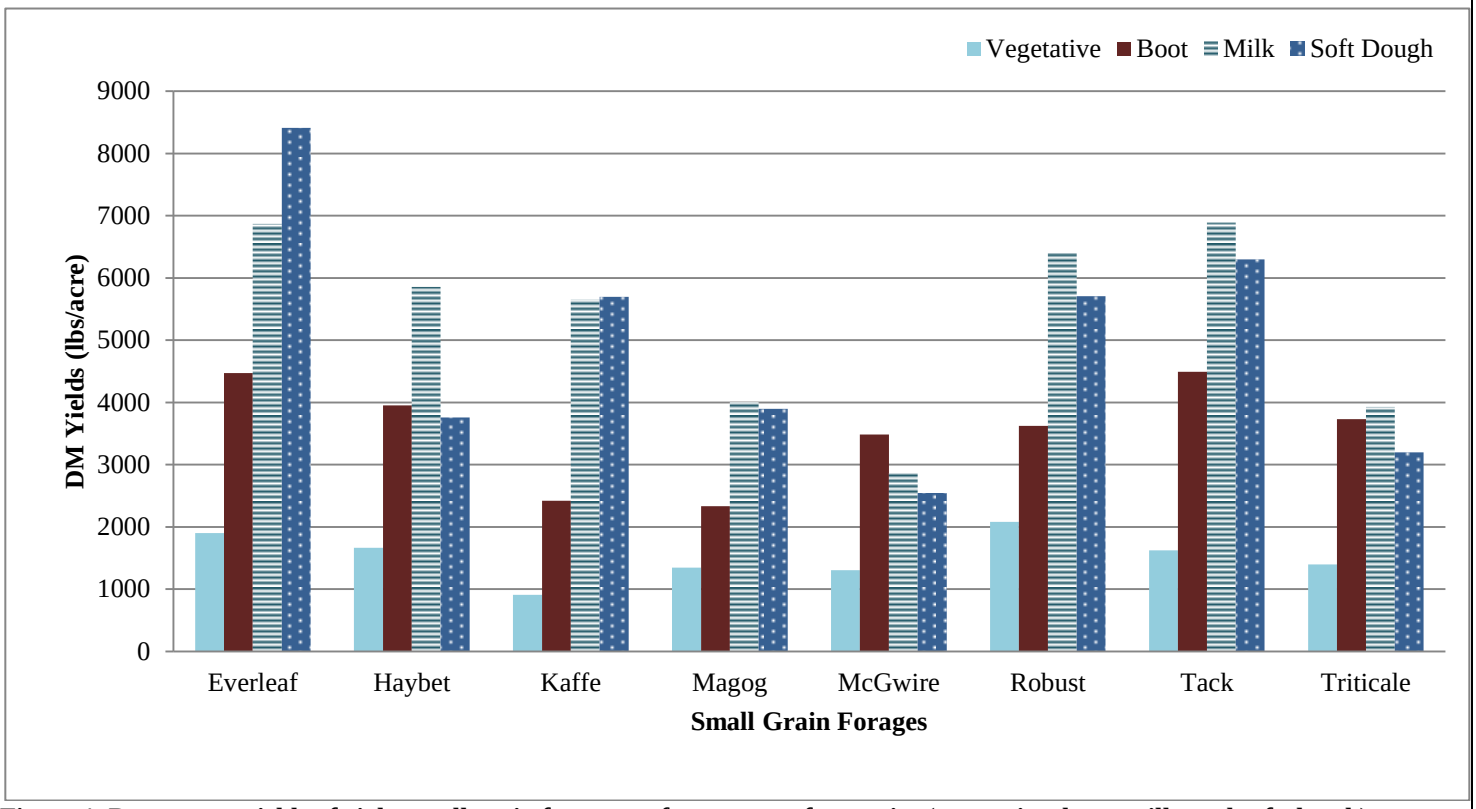

Figure 1. Dry matter yields of eight small grain forages at four stages of maturity (vegetative, boot, milk, and soft dough).

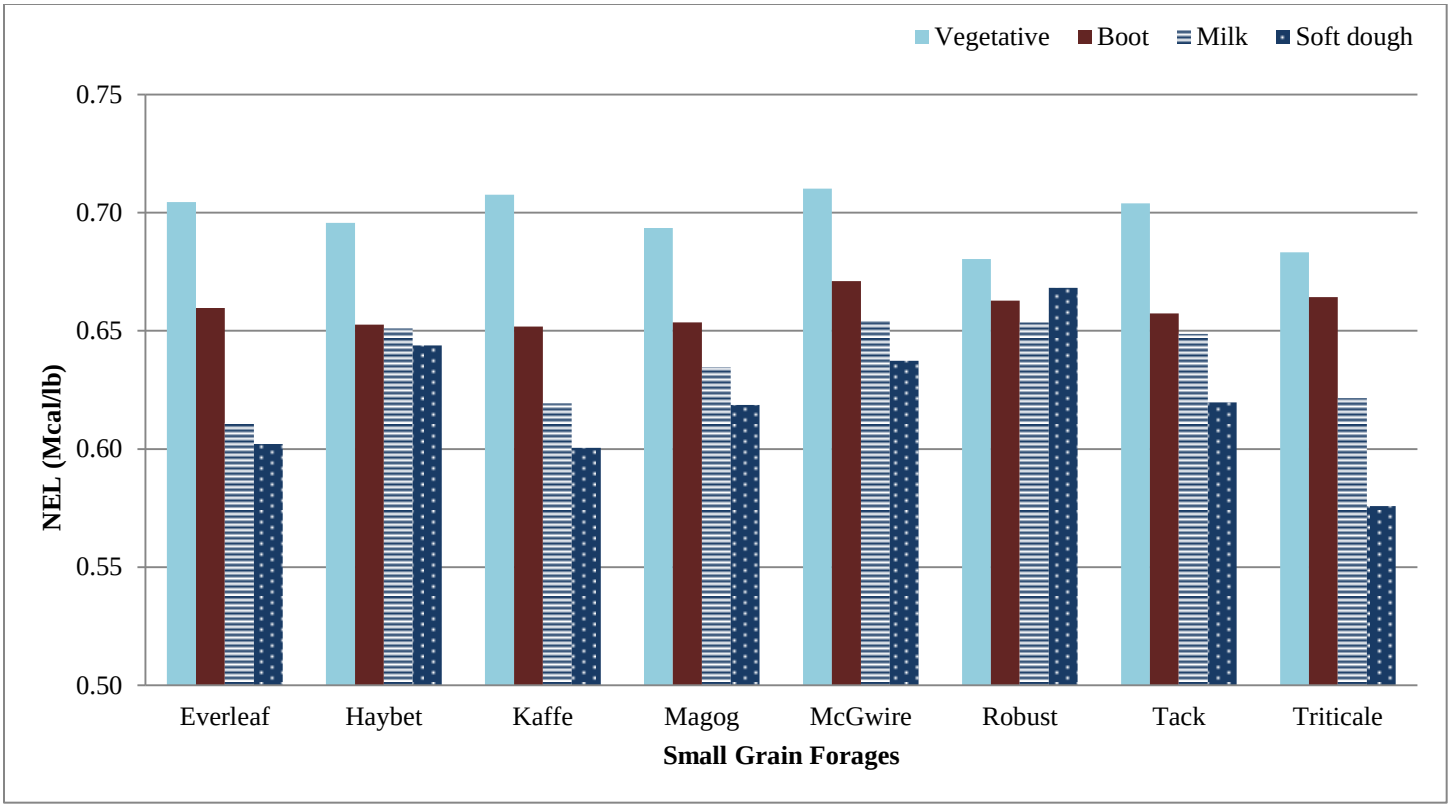

Figure 2. Net energy of lactation (NE_L) of small grain forages at four stages of maturity (vegetative, boot, milk, and soft dough).

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 harvest, the highest yielding treatment was Robust barley, averaging 2079 lbs dry matter $acre^{-1}$ (Table 7). Kaffe wheat had the highest protein levels, over 25% CP (Figure 3). Overall in the vegetative stage, Everleaf forage oats had better quality than the other small grains, with the lowest NDF levels, and highest digestible NDFD, TDN, NE_L, and RFV (Figure 4).

Table 7. Small grain forage yield and quality when harvested in the vegetative stage, June 2013.

Vegetative Stage	DM %	Yield lb ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Everleaf	13.2*	1899*	25.0*	28.2	**41.1***	**76.3***	67.8*	0.70*	145.1*
Haybet	16.5	1665	23.8	27.0	44.6	75.3*	67.1*	0.70	138.5
Kaffe	18.8	907	**25.7***	**25.0***	42.4*	75.0*	68.2*	0.71*	**149.0***
Magog	17.3	1346	23.9	27.8	45.7	71.1	66.8*	0.69*	135.5
McGwire	17.5	1304	25.6*	25.9*	43.1*	73.9	**68.2***	**0.71***	145.3*
Robust	16.9	**2079***	22.5	30.1	47.3	71.7	65.4	0.68	129.1
Tack	**11.6***	1624	23.7	29.6	43.7	73.0	67.3*	0.70*	137.2
Triticale	16.4	1397	25.2*	28.6	46.1	71.6	65.7	0.68	134.4
Trial mean	16.0	1528	24.4	27.8	44.2	73.5	67.1	0.70	139.3
LSD (p<0.10)	1.84	337	1.22	1.86	2.08	2.21	1.70	0.019	7.33

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

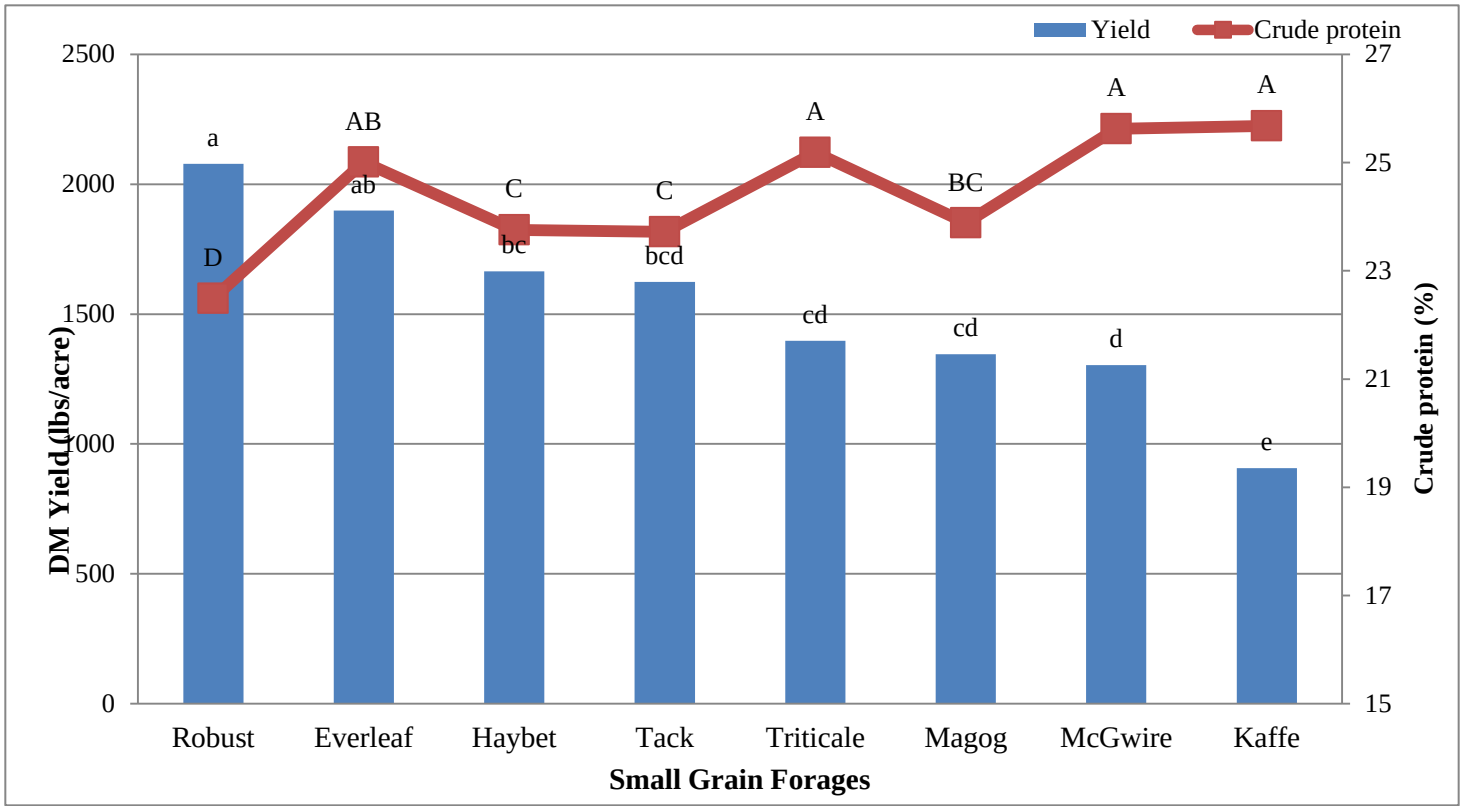

Figure 3. Yield and protein of small grain forage harvested in the vegetative stage.
Treatments with the same letter did not differ significantly from one another.

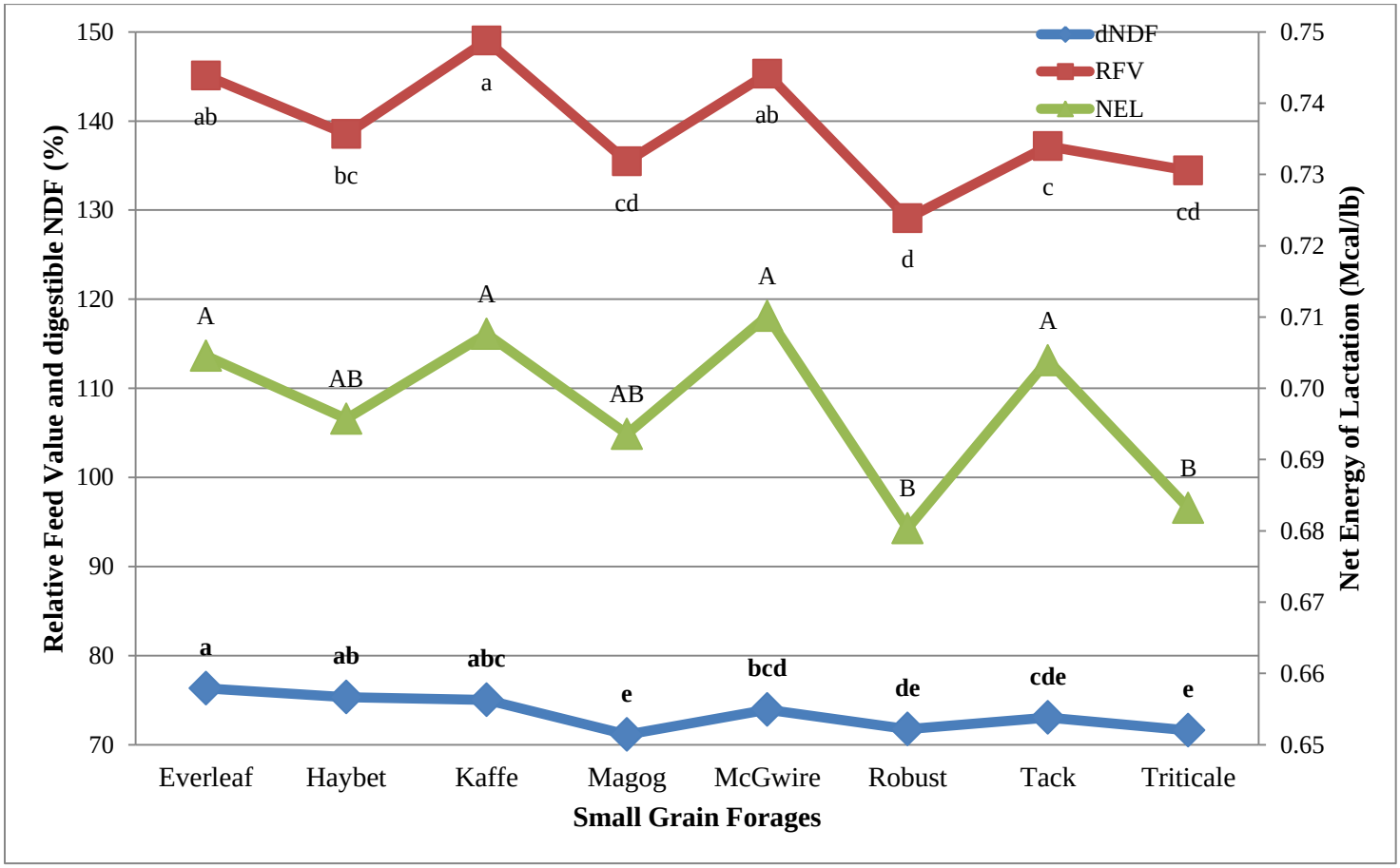

Figure 4. Relative feed value (RFV-squares), net energy of lactation (NE_L-triangles), and digestible neutral detergent fiber (NDFD-diamonds) of small grain forage harvested in the vegetative stage. Treatments with the same letter did not differ significantly from one another.

Boot Stage Harvest

In small grain development, the boot stage occurs when the grain head is just barely visible and about to emerge. Tack oats had the greatest dry matter yields when harvested in the boot stage, 4494 lbs dry matter acre^{-1} (Table 8 and Figure 5). There was no difference in protein levels in the boot stage, which averaged 18.1%. Overall, there were not many differences in forage quality during the boot stage except for ADF and NDF levels (Figure 6). McGwire barley had the lowest ADF while Everleaf oats had the lowest NDF levels.

Table 8. Small grain forage yield and quality harvested in the boot stage, June and July 2013.

Boot Stage	DM %	Yield lb ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Everleaf	**11.5***	4470*	17.6	37.8	**50.8***	68.5	63.1	0.66	106.5
Haybet	17.5	3951*	17.3	36.2	56.2	68.8	62.8	0.65	99.4
Kaffe	19.4	2420	16.7	34.5*	56.4	63.4	62.7	0.65	101.8
Magog	16.7	2334	19.6	33.9*	55.8	68.2	62.9	0.65	105.3
McGwire	17.9	3486	19.3	**33.3***	54.6	67.2	64.5	0.67	107.4
Robust	18.0	3621	18.3	34.9*	55.4	66.6	63.7	0.66	102.4
Tack	14.6	**4494***	16.6	38.2	55.2	63.5	62.9	0.66	97.3
Triticale	17.2	3732	19.2	34.6*	55.0	68.9	63.7	0.66	105.3
Trial mean	16.6	3564	18.1	35.4	54.9	66.9	63.3	0.66	103.2
LSD (p<0.10)	2.216	715.1	NS	1.748	2.591	NS	NS	NS	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.

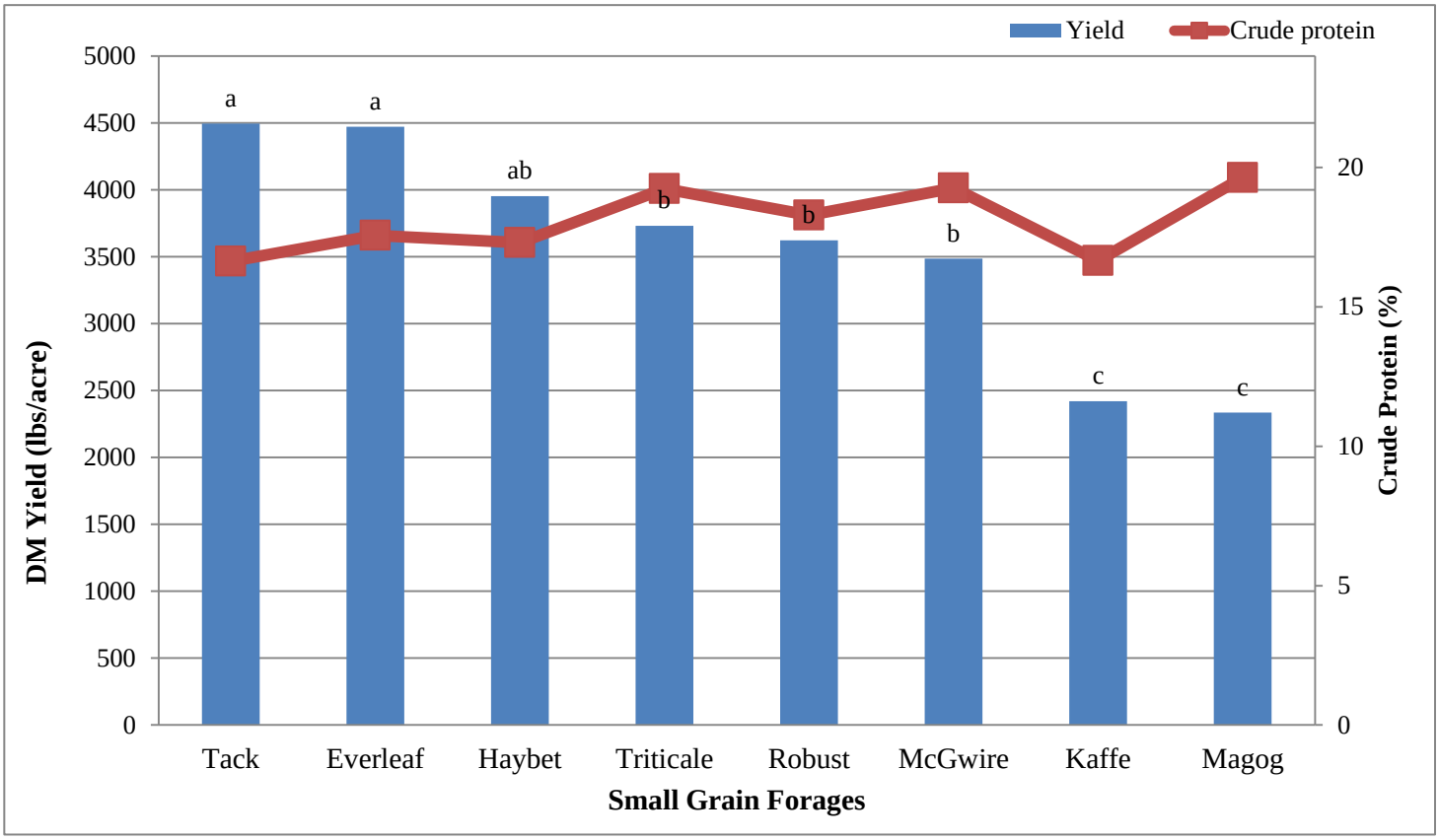

Figure 5. Yield and protein of small grain forage in the boot stage.
Treatments with the same letter did not differ significantly from one another.

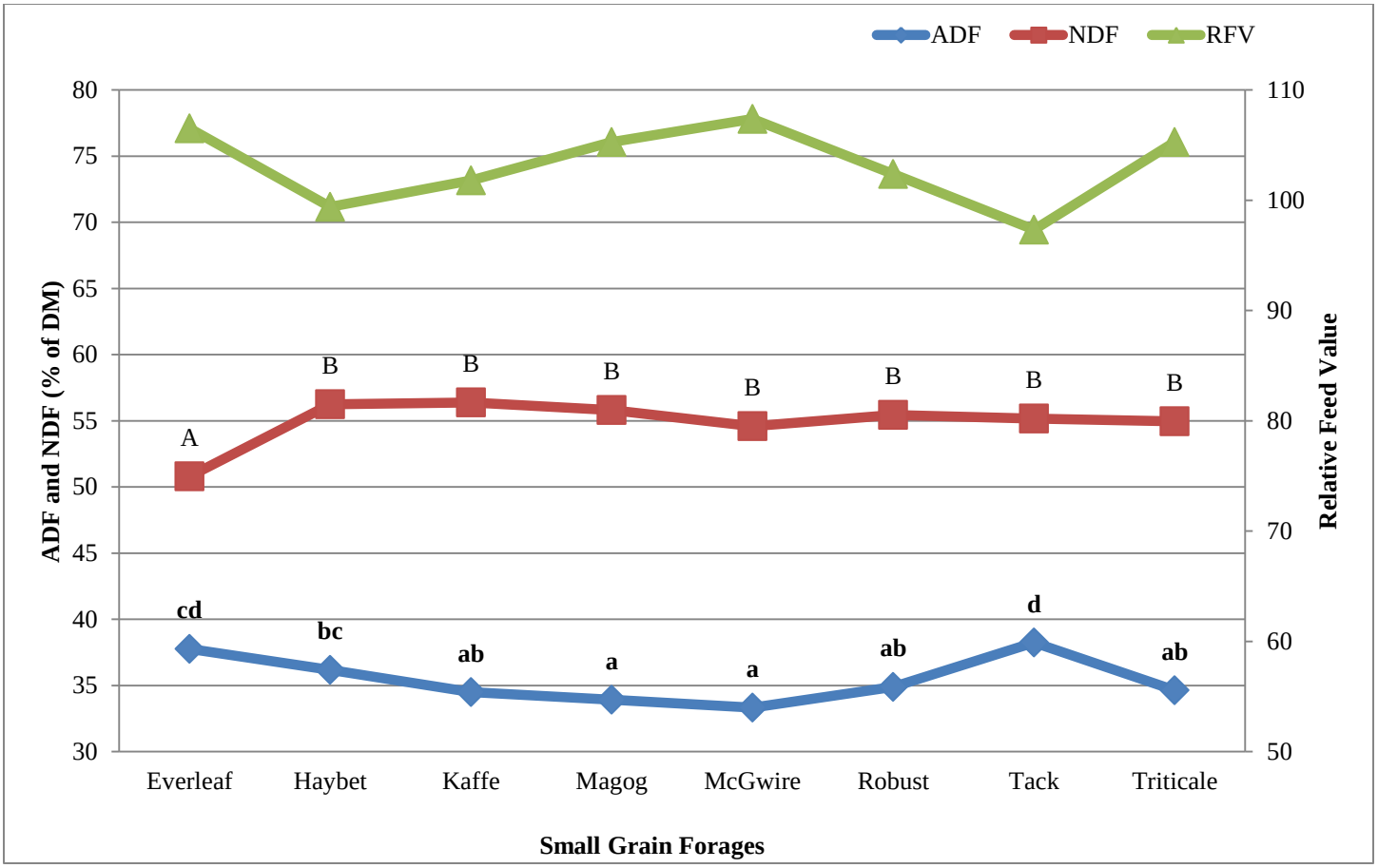

Figure 6. Acid detergent fiber (ADF-diamonds), neutral detergent fiber (NDF-squares), and relative feed value (RFV-triangles) of small grain forage harvested in the boot stage. Treatments with the same letter did not differ significantly from one another.

Milk Stage Harvest

Tack oats were the highest yielding forage when harvested during the milk stage (Table 9 and Figure 7). Tack yielded close to 7000 lbs dry matter acre^{-1}. Other top yielders include Everleaf oats, Robust barley, and Haybet barley. McGwire barley had the highest protein levels of the milk stage at 14.8%. McGwire was also a top performer for all the other quality characteristics with the lowest ADF, and highest NDFD, TDN, and NE_L. The other barley varieties also had similarly low ADF and NDF levels, and high TDN, NE_L, and RFV (Figure 8).

Table 9. Small grain forage yield and quality harvested at the milk stage, July 2013.

Milk Stage	DM %	Yield lb ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Everleaf	**21.9***	6865*	11.7	39.9	60.0	47.6	58.9	0.61	87.3
Haybet	29.4	5852*	11.5	34.2*	55.7*	51.1	62.6*	0.65*	**102.7***
Kaffe	33.8	5648	10.3	36.5	58.3	46.3	59.8	0.62	95.6
Magog	30.4	4003	11.7	37.1	56.7*	46.8	61.1	0.63	97.1*
McGwire	24.8*	2862	**14.8***	**34.1***	56.8*	**59.8***	**62.9***	**0.65***	100.7*
Robust	29.5	6400*	11.3	34.6*	**55.6***	48.9	62.5*	0.65*	101.2*
Tack	22.7*	**6886***	12.9	39.4	56.8*	47.8	62.0*	0.65*	94.0
Triticale	33.3	3926	11.7	37.7	59.3	49.4	60.2	0.62	92.5
Trial mean	28.2	5305	12.0	36.7	57.4	49.7	61.3	0.64	96.4
LSD (p<0.10)	4.68	1181	1.66	1.79	2.07	4.91	1.04	0.013	5.91

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

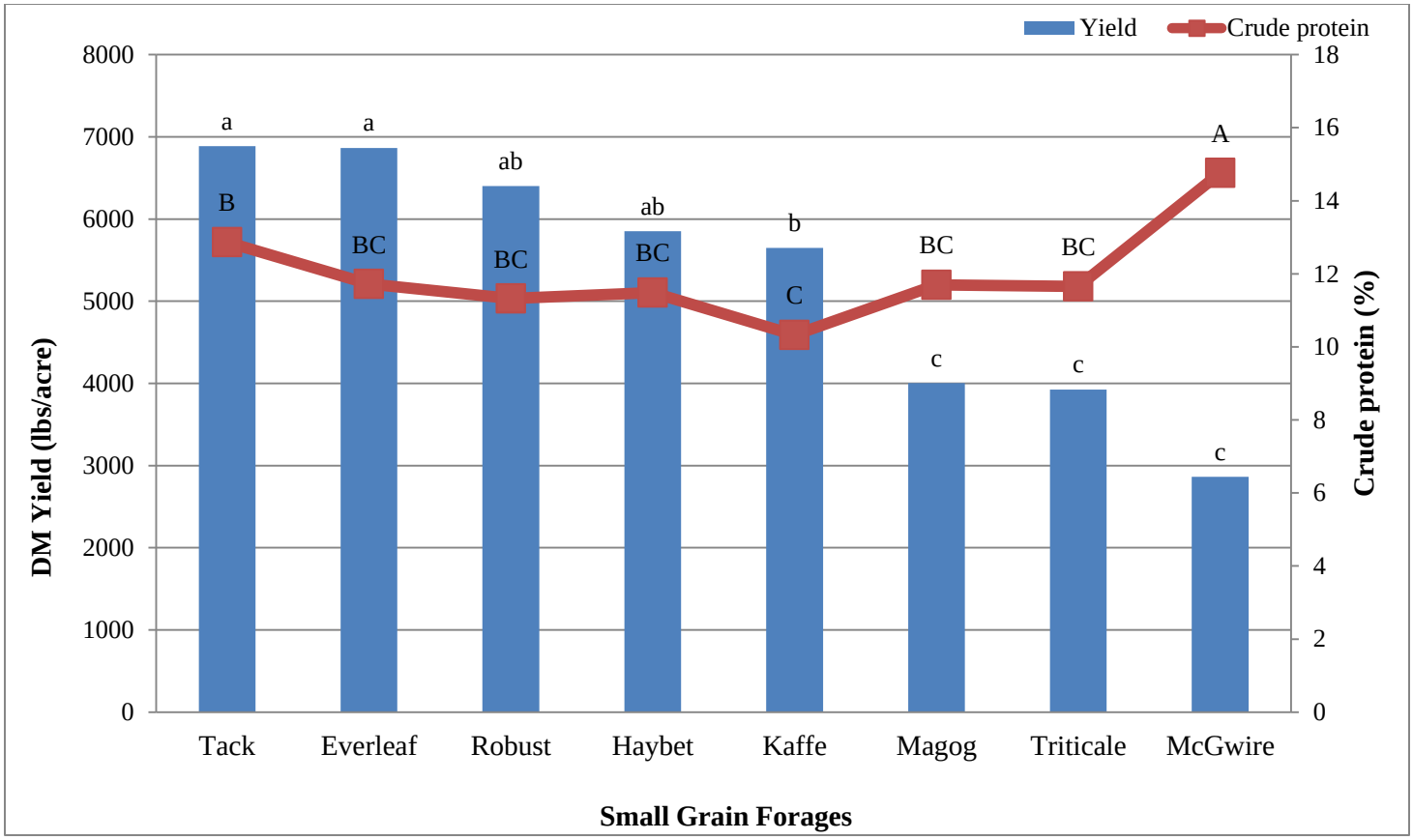

Figure 7. Yield and crude protein (CP) of small grain forages harvested in the milk stage.
Treatments with the same letter did not differ significantly from one another.

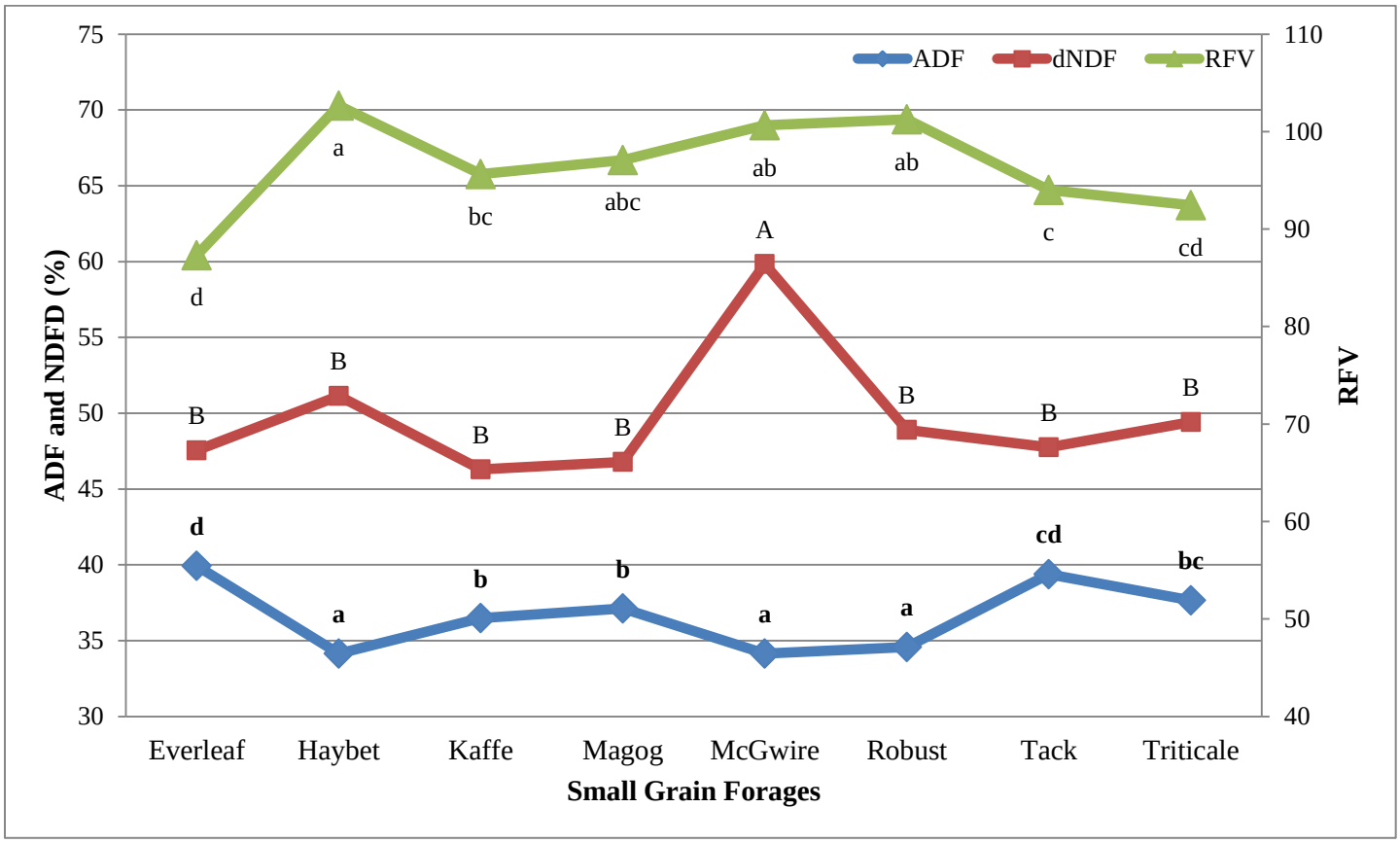

Figure 8. Acid detergent fiber (ADF-diamonds), digestible neutral detergent fiber (NDFD-squares), and relative feed value (RFV-triangles) of small grain forage harvested in milk stage. Treatments with the same letter did not differ significantly from one another.

Soft Dough Harvest

Everleaf oats yielded the highest of all the forage species in the soft dough stage, averaging 8408 lbs acre^{-1} (Table 10, Figure 9). Everleaf oats yielded 2100 lbs more than the next highest yielder, Tack oats. The three barley varieties and triticale had similarly high CP levels—over 10%. Robust barley had the lowest ADF and NDF levels, whereas all three barley varieties had high digestible fiber (NDFD). Overall, Robust barley also had the most favorable quality characteristics—including the lowest fiber levels, high digestible NDF, the highest TDN, NE_L and RFV (Figure 10). Interestingly, yields declined from the milk to the soft dough stage for most of the grains evaluated. This may be partially due to high leaf disease prevalence during the 2013 growing season. Leaf diseases caused premature death of the leaves and hence potentially less overall harvested biomass.

Table 10. Small grain forage yield and quality of soft dough, July and August 2013.

Soft Dough Stage	DM %	Yield lb ac^{-1}	CP %	ADF %	NDF %	NDFD %	TDN %	NE_L Mcal lb^{-1}	RFV
Everleaf	32.5	**8408***	9.5	39.4	57.9	38.5	59.1	0.60	94.2
Haybet	56.4*	3755	10.2*	31.1	52.0	43.1*	62.8	0.64	117.0
Kaffe	52.2	5694	8.8	36.2	56.8	36.4	59.4	0.60	100.5
Magog	53.0	3893	11.0*	33.7	53.9	37.8	60.9	0.62	109.6
McGwire	38.4	2543	**11.5***	33.0	54.3	**44.3***	61.8	0.64	108.9
Robust	45.8	5703	11.1*	**28.3***	**48.4***	42.4*	**64.4***	**0.67***	**126.0***
Tack	31.5	6297	8.7	36.0	56.4	31.3	60.1	0.62	100.2
Triticale	**60.9***	3193	10.2*	40.7	61.3	38.5	57.3	0.58	86.9
Trial mean	46.3	4936	10.1	34.8	55.1	39.0	60.7	0.62	105.4
LSD (p<0.10)	7.8746	957.98	1.5453	2.3801	2.3266	2.6756	1.352	0.0167	7.2375

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

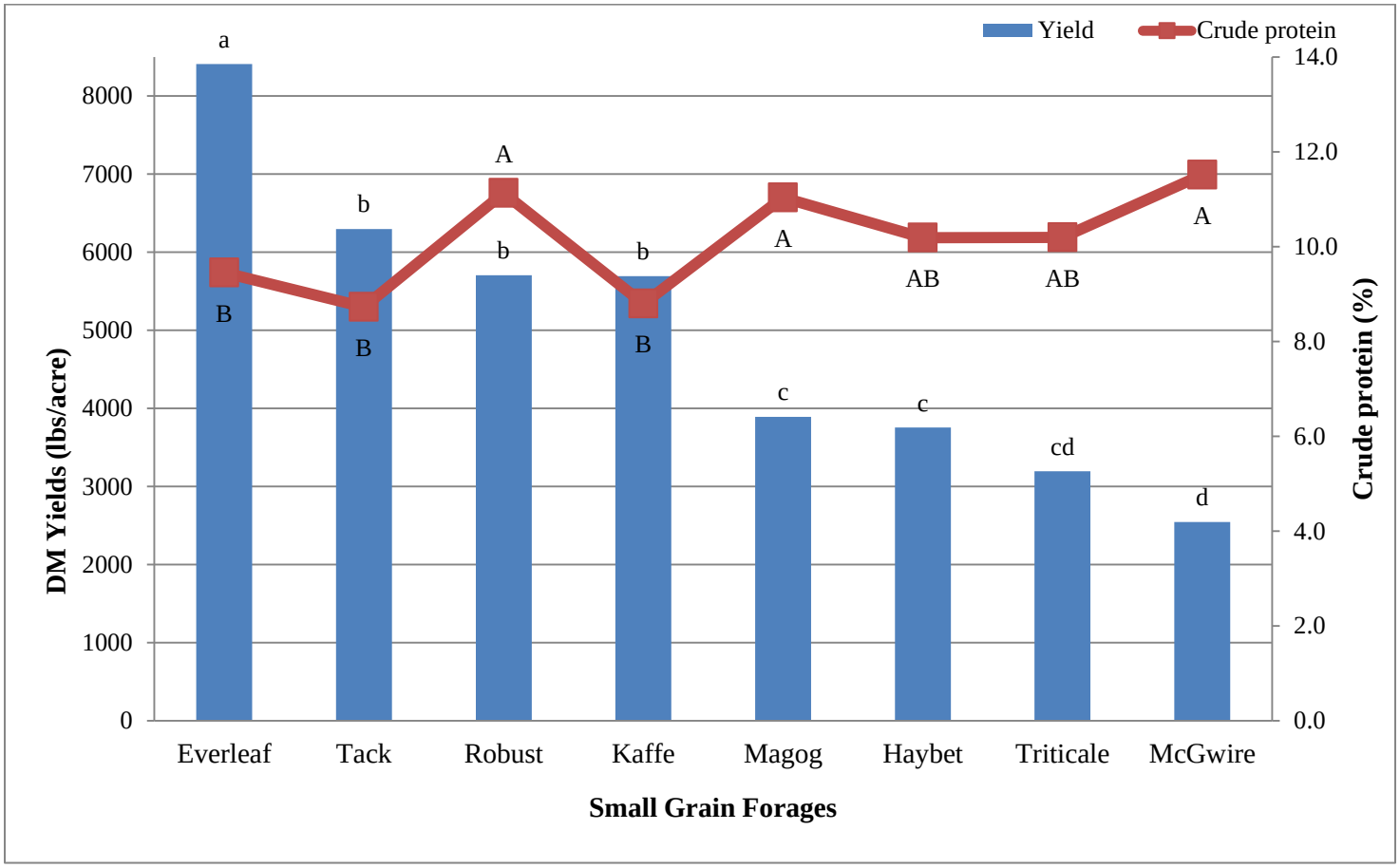

Figure 9. Yield and crude protein of small grain forage harvested in the soft dough stage.
Treatments with the same letter did not differ significantly from one another.

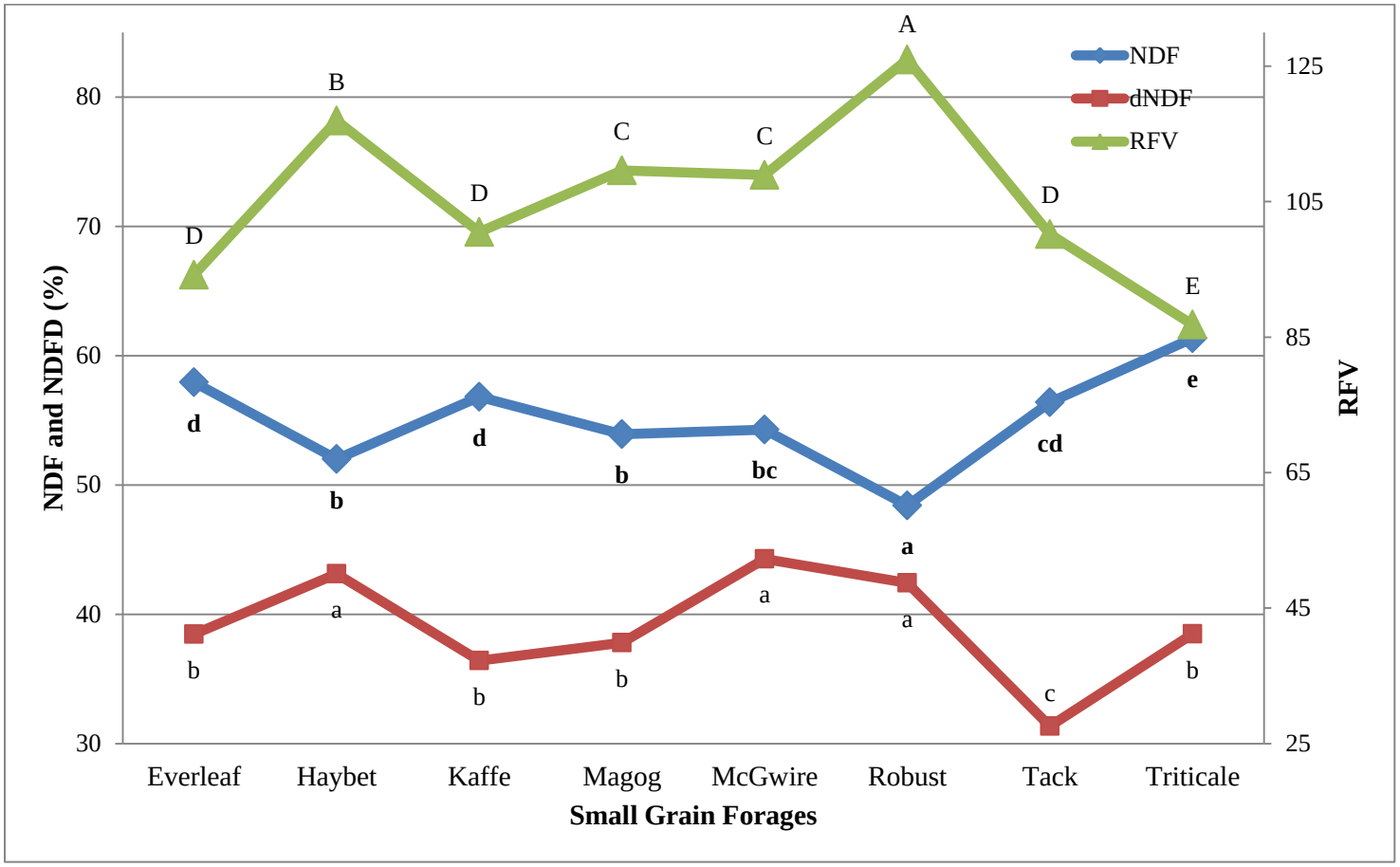

Figure 10. Neutral detergent fiber (NDF-diamonds), digestible neutral detergent fiber (NDFD-squares), and relative feed value (RFV-triangles) of small grain forage harvested in the soft dough stage. Treatments with the same letter did not differ significantly from one another.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank Roger Rainville and the staff at Borderview Research Farm. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

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