NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

2012 Forage Brassica Variety Trial

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The University of Vermont Extension

2012 FORAGE BRASSICA VARIETY TRIAL

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Forage brassicas can provide a near-concentrate type diet late in the season, allow for an extra grazing opportunity after annual row crops are harvested, and establish forage to fill a gap in feed quality and supply. These crops can provide a high quality feed in a short period of time, fitting well into rotations of other crops, extending the grazing season and reducing reliance on expensive commercial feed inputs. The University of Vermont's Northwest Crops & Soils Program conducted a forage brassica variety trial to evaluate yield and quality of this annual crop.

MATERIALS AND METHODS

In 2012, a variety trial was initiated at Borderview Research Farm in Alburgh, VT, in order to evaluate four forage brassica varieties (Table 1, Figure 1).

Figure 1. Appin turnip just before harvest.

Table 1. Forage brassica varieties and their sources, 2012.

Variety	Species	Seed source
Appin	Turnip	King's Agriseed
Barkant	Turnip	Barenbrug
Bonar	Rape	King's Agriseed
Braco	White mustard	Preferred Seed Co.

The seedbed at Borderview Research Farm was prepared using standard local practices, including moldboard plowing the previous winter wheat crop under and finishing with disk and drag harrows (Table 2). The soil was a Benson rocky silt loam. The experimental design was a randomized complete block with three replications. Each plot was 5' by 25,' and a Carter cone seeder was used to plant brassicas at a rate of 6.4 lbs per acre on 23-Aug.

Table 2. Agronomic and trial information for the 2012 forage brassica variety trial.

Location	Borderview Research Farm-Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Winter wheat
Tillage operations	Moldboard plow, disking, drag harrow
Plot size (ft.)	5 x 25
Replicates	3
Planting date	23-Aug
Seeding rate (lbs ac^{-1})	6.4
Harvest date	26-Oct

All plots were hand harvested on 26-Oct. Samples were dried and ground, and a subsample was retained for chemical analysis. Forage quality was analyzed at Cumberland Valley Analytical Services in Hagerstown, Maryland using wet chemistry techniques. Plot subsamples were analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), ash, non-fiber carbohydrates (NFC), non-structural carbohydrates (NSC), total digestible nutrients (TDN) and net energy for lactation (NE_L). The percentage of fat in the sample was determined by ether extraction. The CP content of forages is determined by measuring the amount of nitrogen and multiplying by 6.25. The bulky characteristics of forage come from fiber. High fiber is negatively associated with forage feeding values since the less digestible portions of plants are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, nonprotein 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. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. In addition, the micronutrients calcium, phosphorus, magnesium, potassium, iron, manganese, zinc and copper were quantified in each sample.

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).

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 treatments is real or whether it might have occurred due to other variations in the field. All data was analyzed using a mixed model analysis where replicates were considered random effects. At the bottom of each table, a LSD value is presented for each variable (e.g. yield). Least Significant Differences (LSDs) at the 10% level (0.10) 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 values. Treatments listed in bold had the top performance in a particular column; treatments that did not perform significantly worse than the top-performer in a particular column are indicated with an asterisk. In the example at right, treatment A is significantly different from treatment C, but not from

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

treatment B. The difference between A and B is equal to 400, which is less than the LSD value of 500. This means that these treatments did not differ in yield. The difference between A and C is equal to 650, which is greater than the LSD value of 500. This means that the yields of these treatments were significantly different from one another.

RESULTS

Using an on-site Davis Instruments Vantage Pro2 Weather Station at Borderview Research Farm in Alburgh, VT, weather data are summarized for the 2012 forage brassica growing season (Table 3). The 2012 fall growing season was warmer than average, with the month of October being 4.2°F warmer than the historical (1981-2010) average. August was slightly drier than normal, but September and October each had more rainfall than normal. For this trial, Growing Degree Days (GGDs) are calculated with a base temperature of 32°F and a maximum temperature of 90°F. There were 2717 accumulated GDDs, 218 more than the 30-year average.

Table 3. Temperature, precipitation, and Growing Degree Days (GDDs) data by month for Alburgh, VT.

Alburgh, VT	August	September	October
Average temperature (°F)	71.1	60.8	52.4
Departure from normal	2.3	0.2	4.2
Precipitation (inches)*	2.9	5.4	4.1
Departure from normal	-1.0	1.7	0.5
Growing Degree Days (base 32°F)	1211	866	640
Departure from normal	72	8	138

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).
* Precipitation data from Aug-Sep 2012 are based on Northeast Regional Climate Center data from an observation station in Burlington, VT.

Forage brassicas differed significantly in plant characteristics, yield and quality (Table 4). Plant height varied significantly by variety; the white mustard variety Braco was 29.1 inches tall, significantly taller than all the rest of the varieties (Figure 2). Braco was also the variety with the greatest percentage of dry matter at harvest (13.2%), though the average dry matter content was 10.4% for the trial. Though yields did not differ significantly by variety, the greatest yield observed was in Braco (2594 lbs per acre). Crude protein was not statistically different by variety, and the average CP for the trial was 22.1% of the dry matter yield. There was a significant difference in the ADF of the four trialed varieties; the rape variety Bonar had the lowest ADF content (13.1%), though this was statistically similar to all varieties except Braco. Likewise, the NDF content was lowest in Bonar rape, statistically similar in the turnip varieties Appin and Barkant. The NFC and NSC were highest in Appin turnip, though not statistically better than Barkant. The total digestible nutrients (TDN) content was greatest in Bonar (69.2%), though not statistically greater than Appin and Barkant (Figure 3). Net energy for lactation (NE_L) was greatest in Bonar rape (0.72 Mcal per lb), though not statistically better than Appin turnip. The fat content was also highest in Bonar rape (2.55%), significantly higher than all other varieties. It appears from this one year of data that Bonar rape and Appin Turnip had exceptional forage quality but tended to yield slightly less than the other forage brassicas evaluated in this trial. Braco white mustard had significantly lower quality than the other forage varieties.

Table 4. Crop stand characteristics and dry matter yield of four trialed forage brassicas.

Variety	Plant height	Dry matter (DM)	DM yield	Crude protein	ADF	NDF	Ash	NFC	NSC	TDN	NE_L	Fat
	in	%	lbs ac^{-1}	% of DM	% of DM	% of DM	% of DM	% of DM	% of DM	% of DM	Mcal lb^{-1}	%
Appin	20.5	8.7	1725	21.0	13.3*	17.8*	16.9	**43.4***	**20.9***	67.8*	0.70*	1.49
Barkant	17.7	9.5	2098	21.3	13.7*	18.4*	17.1	42.6*	18.2*	66.1*	0.68	1.53
Bonar	13.1	10.1	1641	**23.5**	**13.1***	**17.6***	14.8*	42.4	18.1	**69.2***	**0.72***	**2.55***
Braco	**29.1***	**13.2***	**2594**	22.4	23.1	32.1	**14.3***	30.8	10.8	61.7	0.64	1.20
LSD (0.10)	5.3	0.8	NS	NS	2.0	3.0	1.4	5.6	4.1	3.3	0.04	0.28
Trial mean	20.1	10.4	2015	22.1	15.8	21.5	15.8	39.8	17.0	66.2	0.68	1.69

Treatments indicated in **bold** had the top observed performance.
* Treatments indicated with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.
NS – No significant difference was determined between treatments.

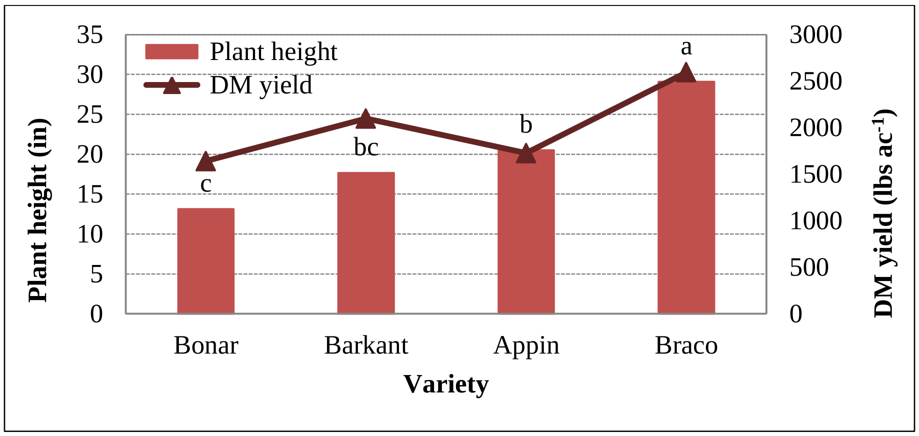

Figure 2. Plant height and dry matter yield by variety. Varieties with the same letter did not vary significantly from one another in plant height (p=0.10). There was no statistical difference in dry matter yield by variety.

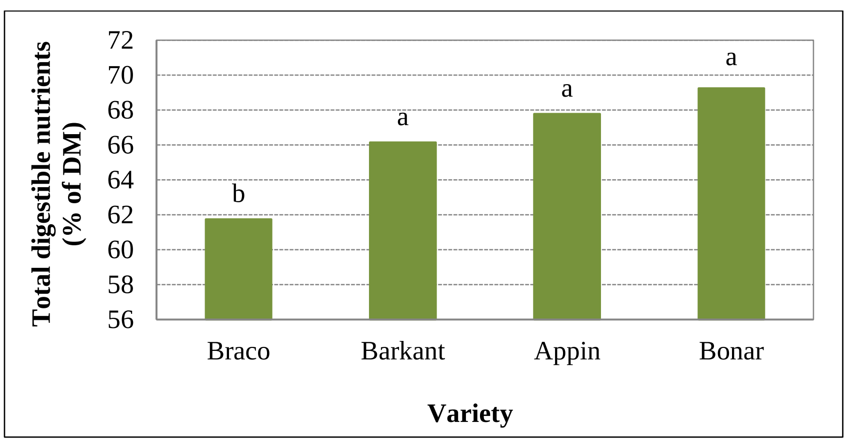

Figure 3. Total digestible nutrients by variety. Varieties with the same letter did not vary significantly from one another (p=0.10).

The four trialed forage brassica varieties varied significantly in their nutrient and micronutrient analyses (Table 5). There were significant differences by variety in calcium (Ca), phosphorus (P), potassium (K), manganese (Mn) and copper (Cu). The greatest Ca content was in Barkant turnip (3.13% of dry matter), though this was not statistically greater than Braco mustard. Phosphorus was highest in Appin turnip (0.53%), significantly greater than all other varieties. Potassium was highest in Appin and Barkant turnips The variety Barkant turnip had the highest level of the micronutrient Mn (31.3 ppm), though this was not statistically greater than Bonar rape. Appin turnip was the top performer in Cu (6.67 ppm). Magnesium (Mg), iron (Fe) and zinc (Zn) were not significantly impacted by variety. The turnip varieties appeared to have the highest levels of macro and micro nutrients.

Table 5. Nutrient and micronutrient analysis of four trialed forage brassicas.

Variety	Ca	P	Mg	K	Fe	Mn	Zn	Cu
	% of DM	% of DM	% of DM	% of DM	ppm	ppm	ppm	ppm
Appin	2.72	**0.53***	0.15	**4.79***	128	23.0	**33.3**	**6.67***
Barkant	**3.13***	0.47	0.16	4.51*	**146**	**31.3***	25.7	6.00
Bonar	2.51	0.44	**0.18**	3.99	131	26.7*	27.7	5.00
Braco	2.93*	0.29	0.16	2.91	98	17.3	32.3	5.00
LSD (0.10)	0.40	0.05	NS	0.56	NS	6.8	NS	0.46
Trial mean	2.82	0.43	0.16	4.05	126	24.6	29.8	5.67

Treatments indicated in **bold** had the top observed performance.
* Treatments indicated with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.
NS – No significant difference was determined between treatments.

Fatty Acid Results

The forage brassica varieties were tested for their fatty acid profile and concentrations. Overall there was not a statistically significant difference in saturated fatty acids (SFA) including C:16 (Table 6). The concentration of monounsaturated fatty acids (MUFAs) was significantly less for Braco white mustard than the other brassicas. Levels of linoleic acid, C18:2, did differ among the brassicas with Bonar rape and Braco white mustard having the highest percentage, while only Bonar rape had a statistically significant higher concentration of linoleic acid than the other brassicas. C18:2 is the main Omega 6 fatty acid found in forages and the same differences seen in C18:2 were also seen in Omega 6 FA results. Bonar rape and Braco white mustard had the highest percent of Omega 6 FA (14.4 and 13.8%, respectively), while only Bonar rape had the highest concentration of Omega 6 FAs (3.18 mg g^{-1}).

A low ratio of Omega 6 to Omega 3 fatty acids is considered beneficial in feed, and Appin turnip and Barkant turnip had statistically significant lower ratios than the other brassicas (Figure 4). However the ratios in this study ranging from 0.16 to 0.29 are much less than a typical grain ratio of close to 10:1.

Table 6. Forage fatty acid profile (%- in grey) and concentration (mg g^{-1}-in white) of forage brassicas.

	Appin turnip	Barkant turnip	Bonar rape	Braco white mustard	Trial Mean	LSD
SFA (%)	34.11	34.60	33.00	33.99	33.92	NS
SFA (mg g^{-1})	7.78	6.54	7.56	5.79	6.92	NS
C16 (%)	26.55	26.14	24.40	25.81	25.72	NS
C16 (mg g^{-1})	6.05	4.94	5.57	4.39	5.24	NS
MUFA (%)	4.76	5.32	5.19	3.09	4.59	NS
MUFA (mg g^{-1})	1.10*	1.02*	1.21*	0.54	0.97	0.4051
PUFA (%)	61.13	60.08	61.81	62.93	61.49	NS
PUFA (mg g^{-1})	14.31	11.60	14.38	10.94	12.81	NS
C18:2 LA (%)	8.34	9.53	13.80*	13.49*	11.29	1.2707
C18:2 LA (mg g^{-1})	1.90	1.84	3.18*	2.35	2.32	0.5934
C18:3 LNA (%)	52.59	50.20	47.15	49.07	49.75	NS
C18:3 LNA (mg g^{-1})	12.36	9.70	11.00	8.53	10.40	NS
Omega 3 FA (%)	52.59	50.20	47.15	49.07	49.75	NS
Omega 3 FA (mg g^{-1})	12.38	9.72	11.05	8.54	10.42	NS
Omega 6 FA (%)	8.48	9.79	14.44*	13.80*	11.63	1.2316
Omega 6 FA (mg g^{-1})	1.91	1.85	3.18*	2.36	2.33	0.5934
Total FA (mg g^{-1})	23.20	19.17	23.14	17.26	20.69	NS
Ratio Omega 6: Omega 3 FA	0.16*	0.19*	0.29	0.28	0.23	0.0395

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.

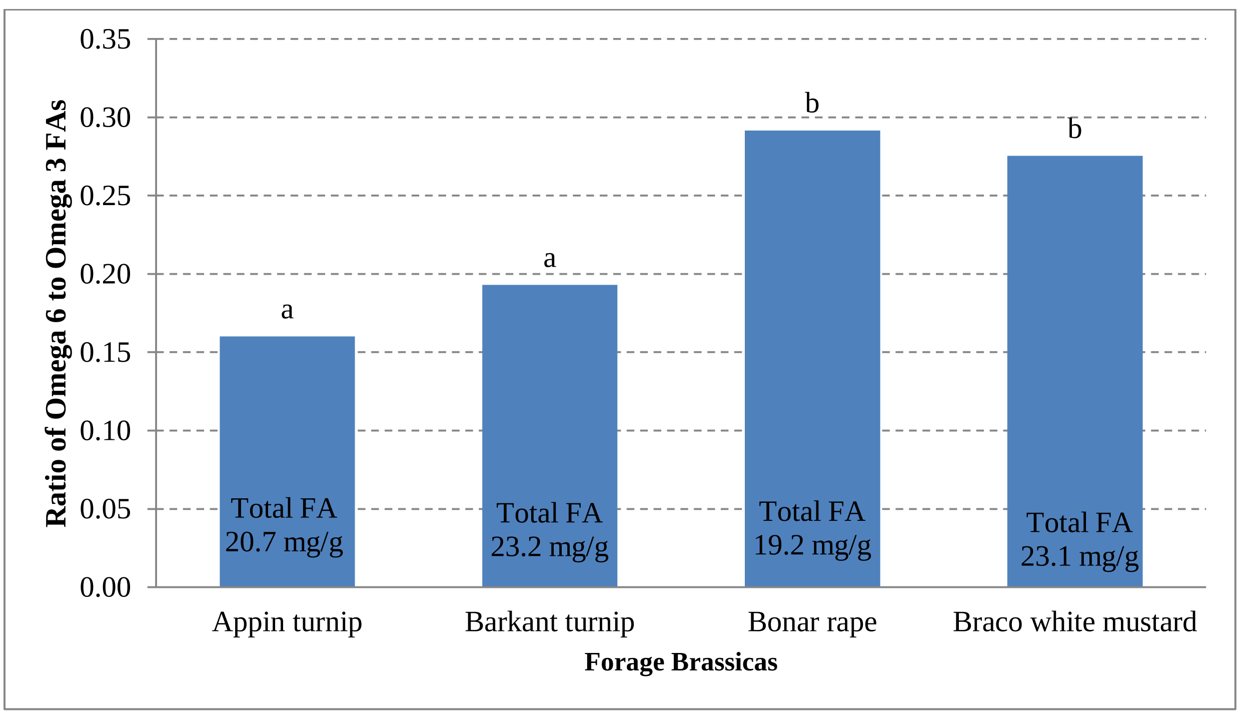

Figure 4. Ratio of omega 6 to omega 3 fatty acids in forage brassicas.

DISCUSSION

Forage brassicas have great potential as an additional grazing crop in the Northeast. With average dry matter yields of over a ton, this study demonstrated that any of the trialed forage brassica varieties could be a strong addition to a feeding plan, providing valuable nutrition during seasonal feed shortages and reducing the need for imported feed. While statistically insignificant, the white mustard Braco had the highest dry matter yield (2594 lbs per acre).

Forage brassicas are known for high CP content, energy and level of digestibility. Crude protein did not differ significantly by variety, but the trial average (22.1% of dry matter) similar to lush spring pasture. Because CP measures the total nitrogen content of forages, including true proteins and non-protein nitrogen, it is also important to evaluate the amount of total nutrients that are digestible by livestock. This is why TDN, a summation of digestible fiber, protein, lipids and carbohydrates, is often more useful as an indicator of feeding value, especially in forages; in this trial, there was a significant difference in TDN by variety. The varieties Bonar (rape), Appin (turnip), and Barkant (turnip) were all significantly higher than Braco (white mustard). This was also the case for both ADF and NDF. This shows that while Braco yielded slightly higher than the other varieties, its fiber content, digestibility and energy were not as desirable as the other three varieties trialed. Because there were three species of forage brassicas included in this variety trial (turnip, rape and white mustard), it is not surprising that most plant characteristics and forage quality indicators varied significantly by variety. The tallest brassica variety, Braco white mustard, was also the top-yielding variety, though dry matter yield did not vary significantly between varieties. This could indicate that the robust vegetation and plant height led to slightly higher yields.

NE_L is a useful measurement of the energy requirements for healthy lactation. Bonar rape and Appin turnip had the highest NE_L (0.72 and 0.70 Mcal per lb, respectively). Bonar also had the highest fat content (2.55%, significantly greater than all other varieties). Yield and quality should both be taken into consideration before selecting a variety. The high overall levels of crude protein and high net energy for lactation show that most forage brassicas have the potential to be a welcome addition to a fall grazing system.

Forage brassicas also have the potential to improve the fatty acid profile of milk by providing season extension of fresh green forages for feed. It is important to note that the data presented here reflect results from only one season and one location. This research should be combined with experience managing dairy animals, research from other regions and across years, as well as recommendations from nutritionists.

ACKNOWLEDGEMENTS

The University of Vermont Extension would like to thank Borderview Research Farm for their generous assistance with the trials. The research was funded in part by the NRCS Conservation Innovation Grant (CIG) and Organic Valley's Farmers Advocating for Organics (FAFO) Fund.