NORTHWEST CROPS & SOILS PROGRAM

2020 Cool Season Annual Forages Trial

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In 2020, the University of Vermont Extension's Northwest Crop and Soils Program evaluated the performance of cool season annual forages planted in monoculture. In the Northeast, cool season perennial grasses dominate pastures and hay meadows that farmers rely on. Often times during the fall months, the perennial pasture will decline in yield and quality. The addition of cool season annual forages into the grazing system during this time may help improve the quality and quantity of forage and potentially extend the grazing season. With the range in species available, it is important to understand the yield potential, quality, and growth characteristics of each in order for farmers to find the best fit for their operation. We compared seventeen varieties of four annual species planted in monoculture to evaluate potential differences in forage yield and quality. While the information presented can begin to describe the yield and quality performance of these forages in this region, it is important to note that the data represent results from only one season and one location.

MATERIALS AND METHODS

The trial was established at Borderview Research Farm in Alburgh, VT, and the plot design was a randomized complete block with four replications (Table 1). The soil type was Benson rocky silt loam. The previous crop in the 2020 field season was oats. Forage species, variety, and seeding rate information are summarized in Table 2.

Table 1. Annual forage trial management, Alburgh, VT, 2020.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Oats
Tillage operations	Pottinger TerraDisc, spike tooth harrow
Planting equipment	Great Plains Cone seeder
Treatments	17 cool season annuals
Replications	4
Plot size (ft)	5 x 20
Planting date	20-Aug
Harvest date	14-Oct

The seedbed was prepared with a Pottinger TerraDisc followed by a spike tooth harrow. The trial was planted with a cone seeder on 20-Aug into 5' x 20' plots. On 14-Oct, plots were harvested from a 3' x 20' area using a Carter flail forage harvester equipped with a scale. Wet yields were recorded and an approximate 1 lb subsample was collected and dried to determine dry matter (DM) content and calculate dry matter yield. The samples were then ground using a Wiley mill to a 2 mm particle size and then to 1 mm using a laboratory cyclone mill from the UDY Corporation.

Table 2. Varieties and seeding rates, 2020.

Species	Variety	Seeding Rate lbs ac^{-1}
Annual ryegrass	Centurion Fria Enhancer kodiak lowboy McKinley	25
Forage brassica	Appin Barkant Barsica Groundhog Pacific gold T-Raptor	12
Oats	Cosaque Everleaf 114 Everleaf 125 Reeves	125

The samples were analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and 48-hour NDF digestibility (NDFD), water soluble carbohydrates (WSC), relative forage quality (RFQ), net energy of lactation (NE_L), and total digestible nutrients (TDN) at the University of Vermont Cereal Testing Lab (Burlington, VT) with a FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the crude protein 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. 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.

Results were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$. 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 varieties 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 this example, 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

Weather data was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). Temperatures and precipitation were slightly below normal in September and approximately normal in October. A total of 855 Growing Degree Days (GDDs) were accumulated during these months which is 28 below the 30-year normal.

Table 3. Weather data for Alburgh, VT, 2020.

	September	October
Average temperature (°F)	59.2	48.3
Departure from normal	-1.33	0.19
Precipitation (inches)	2.75	3.56
Departure from normal	-0.91	0.00
Growing Degree Days (base 41°F)	564	291
Departure from normal	-27	-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.

Impact of Species

The species in this trial differed significantly in yield and forage quality (Table 4). The highest yields were attained in plots with oat and brassica varieties which produced approximately 1.15 tons ac^{-1} on average. Oats and brassica varieties produced significantly higher yields than annual ryegrass varieties which only produced 0.468 tons ac^{-1} on average. Crude protein content was highest in annual ryegrass which averaged 34.6%. Oat and brassica varieties produced similar protein contents of approximately 29%. The NDF content was lowest in brassica lots which averaged 30.2%. In contrast, oat varieties produced forage with an average of 47.2% NDF. However, all these species produced forage with lower NDF content than perennial cool season grasses at this time of year. In addition to NDF content, NDF digestibility varied between species with annual ryegrass and oat varieties having >10% higher NDF digestibility than the brassicas. Taking multiple forage quality parameters into account, oat and annual ryegrass produce approximately 400 lbs of milk per ton of dry matter more than brassicas. However, due to differences in dry matter yield, this translates into approximately 2.5 times more milk per acre from oats and brassicas compared to annual ryegrass.

Table 4. Yield and quality by species.

Species	DM Yield	CP	NDF	48-hr NDFD	Milk yield	
	tons ac^{-1}	% of DM		% of NDF	lbs ton^{-1}	lbs ac^{-1}
Annual ryegrass	0.468b†	34.6a	39.9b	96.3a	4571a	2106b
Brassica	1.14a	28.6b	30.2a	81.5b	4159b	4745a
Oat	1.15a	29.4b	47.2c	93.9a	4635a	5374a
Level of significance‡	***	***	***	***	**	***
Trial mean	0.901	31.0	38.0	90.0	4426	3953

†Treatments that share a letter performed statistically similarly to one another.

‡Level of significance; **0.05< p > 0.001; ***p < 0.0001

By plotting milk yield per acre versus milk yield per ton we can visually compare the species easily in terms of both yield and quality (Figure 1). The dashed vertical line indicates the average milk yield per acre while the dashed horizontal line indicates the average milk yield per ton of dry matter. Therefore, treatments that appear in the top left quadrant, like annual ryegrass here, produced higher than average quality in terms of milk potential per ton of dry matter, but lower than average yield in terms of milk potential per acre. Similarly, treatments appearing in the bottom right quadrant, like the brassicas, produced lower than average quality in terms of milk potential per ton of dry matter, but higher than average yield in terms of milk potential per acre. Treatments in the top right quadrant, however, like the oats here, produced above average yield and quality in terms of predicated milk yields on both a per ton and per acre basis. These visualizations can help understand the pros and cons of each species option when selecting a species that aligns with your farm's goals.

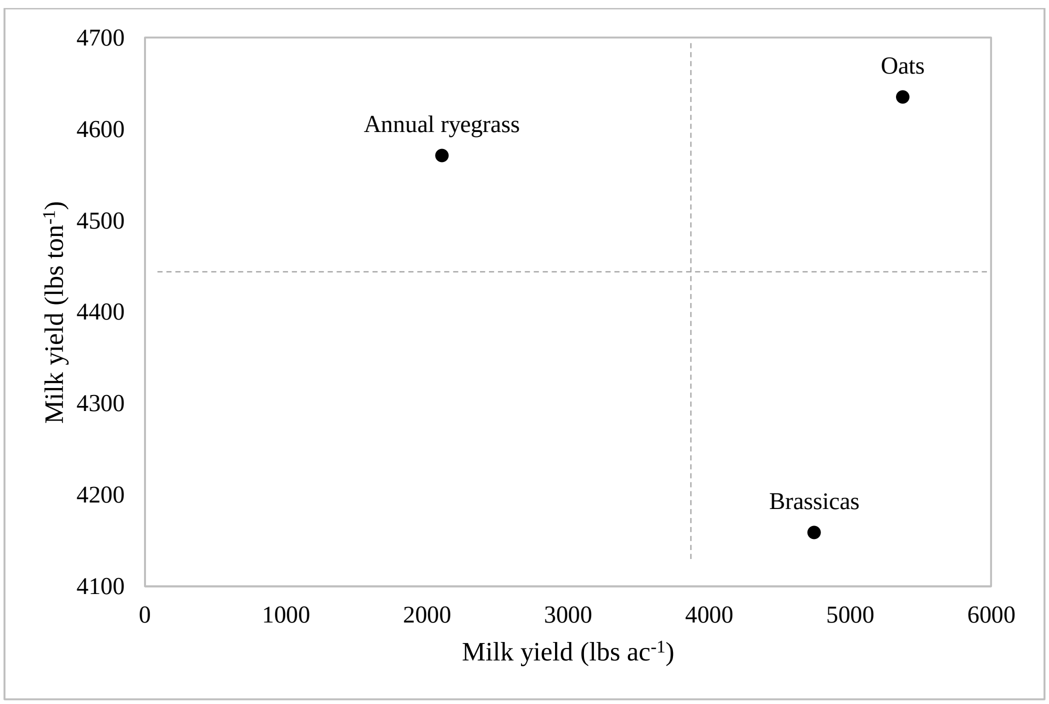

Figure 1. Milk yield per acre vs milk yield per ton of dry matter by species.

Impact of Variety- Annual ryegrass

Annual ryegrass varieties did not differ in height at harvest, dry matter content, or dry matter yield (Table 5). Annual ryegrasses reached an average height of 27.8 cm, approximately 11 inches. The dry matter content averaged 13.9% which is about 10% lower than perennial cool season grasses harvested around the same time. Annual ryegrasses averaged just under 0.50 tons ac^{-1}.

Annual ryegrass varieties did not differ widely in forage quality and were only statistically different in TDN content (Table 6). Crude protein content of all varieties was quite high averaging 34.6%. Fiber contents were relatively low compared to perennial cool season grasses with 25.9% ADF and 39.9% NDF contents. Fiber digestibility (48-hr NDFD) was also exceptionally high averaging 96.3%. The variety Kodiak contained the highest proportion of TDN with 69.0%. This was statistically similar to the varieties Enhancer and Lowboy. Combining several quality parameters into one relative rating, all varieties produced relative forage quality ratings over 230 and predicted milk yields over 4400 lbs ton^{-1}.

Table 5. Harvest characteristics of six varieties of annual ryegrass.

Variety	Height	DM	DM yield
	cm	%	lbs ac^{-1}
Centurion	33.8	13.6	0.561
Fria	23.1	13.8	0.564
Enhancer	24.1	12.4	0.355
Kodiak	28.0	14.5	0.475
Lowboy	27.6	15.5	0.457
McKinley	30.3	13.3	0.396
LSD (p = 0.10) †	NS‡	NS	NS
Species mean	27.8	13.9	0.470

†Least significant difference at the 0.10 level.
‡NS; not statistically significant.

Table 6. Forage quality of six varieties of annual ryegrass.

Variety	CP	ADF	NDF	WSC	TDN	NEL	48-hr NDFD	RFQ	Milk yield
			% of DM			Mcal lb^{-1}	% of NDF		lbs ton^{-1}
Centurion	32.6	28.3	40.9	10.1	64.0c†	0.676	96.0	237	4442
Fria	35.4	25.3	39.3	9.28	65.3bc	0.715	94.8	229	4558
Enhancer	33.6	24.7	40.4	10.5	67.8ab	0.689	98.3	235	4591
Kodiak	35.2	24.3	38.8	9.58	69.0a	0.733	97.3	234	4692
Lowboy	34.8	27.2	41.5	8.28	66.5abc	0.697	95.5	275	4578
McKinley	35.9	25.6	38.6	9.58	64.8c	0.689	95.8	244	4563
LSD (p = 0.10)‡	NS¥	NS	NS	NS	2.52	NS	NS	NS	NS
Species mean	34.6	25.9	39.9	9.55	66.2	0.700	96.3	242	4571

‡Least significant difference at the 0.10 level.
†Treatments that share a letter performed statistically similarly to one another.
¥NS; not statistically significant.

Brassicas

The five brassica varieties differed significantly in height at harvest and dry matter yield (Table 7). The average height was 59.6 cm but the varieties ranged from 44.3 cm to 106 cm with Pacific gold being the tallest. Pacific gold is a mustard variety which grows with a more upright growth habit compared to some of the other brassica types included in the trial. For example, the shortest variety, Groundhog, is a radish variety which grows in a more prostrate or horizontal habit. Dry matter contents did not differ by variety and averaged 8.68%. This is substantially wetter than typical forage crops and can make mechanical harvest particularly challenging and should be mixed with a more fibrous forage if ensiling is desired. Dry matter yields differed substantially between varieties with the highest yielding variety, T-Raptor, yielding 1.41 tons ac^{-1}. T-Raptor is a rape and turnip hybrid that grows more similarly to a turnip and produces a bulb. The lowest yielding variety, Groundhog, produced only 0.852 tons ac^{-1}.

Table 7. Harvest characteristics of six varieties of brassicas.

Variety	Height cm	DM %	DM yield lbs ac^{-1}
Appin	53.0bc†	8.07	0.972de
Barkant	52.1bc	8.50	1.11cd
Barsica	54.9b	8.96	1.20bc
Groundhog	44.3d	7.70	0.852e
Pacific gold	106a	9.91	1.32ab
T-Raptor	47.5cd	8.92	1.41a
LSD (p = 0.10)‡	5.89	NS¥	0.205
Species mean	59.6	8.68	1.14

†Treatments that share a letter performed statistically similarly to one another.
‡Least significant difference at the 0.10 level.
¥NS; not statistically significant.

Brassica varieties also varied significantly in forage quality (Table 8). Crude protein contents averaged 28.6% and did not differ between varieties. Both ADF and NDF fiber fractions differed with the lowest contents being found in Barsica and T-Raptor respectively. Barsica contained only 18.1% ADF which was substantially lower than all other varieties. T-Raptor contained 25.9% NDF, which was statistically similar to all other varieties except for Pacific Gold. The NDF digestibility also differed by variety with Barsica producing the most digestible NDF with 92.8%. This was significantly more digestible than any other variety. Barsica also produced the highest predicted milk yield per ton of dry matter at 4820 lbs ton^{-1}. When yield is considered as well, Barsica also produced the highest milk yield on a per acre basis with 5764 lbs ac^{-1}. However, on a per acre basis, milk yields were statistically similar to T-Raptor and Pacific Gold. Varieties also differed in WSC content with Barkant and T-Raptor producing the highest contents of >11%. Using the net energy system and relative forage quality indexing the varieties did not differ significantly in energy content or overall relative quality.

Table 8. Forage quality of six varieties of brassicas.

Variety	CP	ADF	NDF	WSC	TDN	NEL	48-hr NDFD	RFQ	Milk yield	
			% of DM			Mcal lb^{-1}	% of NDF		lbs ton^{-1}	lbs ac^{-1}
Appin	29.4	24.5b†	26.8a	10.9ab	58.0	0.642	84.0b	327	4188b	4062cd
Barkant	30.2	26.4b	27.5a	11.6a	58.5	0.643	77.5c	306	4093b	4535bc
Barsica	27.1	18.1a	31.8ab	9.85bc	61.8	0.672	92.8a	310	4820a	5764a
Groundhog	30.7	26.1b	31.7ab	8.65cd	53.0	0.576	85.8b	288	4029bc	3424d
Pacific Gold	27.7	32.4c	37.2b	7.73d	57.5	0.610	69.5d	220	3793c	5005ab
T-Raptor	26.9	27.2b	25.9a	11.2ab	56.5	0.628	79.8c	322	4030bc	5682a
LSD (p = 0.1) ‡	NS¥	3.47	6.73	1.42	NS	NS	3.78	NS	237	861
Species mean	28.6	25.8	30.2	9.98	57.5	0.629	81.5	295	4159	4745

†Treatments that share a letter performed statistically similarly to one another.
‡Least significant difference at the 0.10 level.
¥NS; not statistically significant.

Oats

The four oat varieties did not differ in height, dry matter content, or dry matter yield (Table 9). All varieties averaged a height of 52.7 cm and dry matter content of 13.7% at harvest. Yields were all above 1 ton ac^{-1} averaging 1.15 tons ac^{-1} across all varieties.

The varieties also did not differ substantially in forage quality as statistical differences were only found in WSC content and 48-hr NDF digestibility (Table 10). The ADF and NDF fiber fractions did not differ across varieties and averaged 30.1% and 47.2% respectively. However, the variety Reeves had a significantly lower portion of the NDF fraction that would be digestible within 48 hours. While the other three varieties had fiber digestibility over 95.5%, The NDF of Reeves was only 87.3% digestible. This makes sense, as Reeves is a oat variety suited for grain production and the other varieties are more suited for forage. While this is statistically different from the other varieties, all varieties produced highly digestible fiber that rivals perennial cool season grasses at this time of year.

Table 9. Harvest characteristics of four varieties of oats.

Variety	Height	DM	DM yield
	cm	%	lbs ac^{-1}
Cosaque	52.3	14.7	1.29
Everleaf 114	43.3	14.1	1.05
Everleaf 125	54.5	12.9	1.16
Reeves	60.6	13.0	1.10
LSD (p = 0.10) †	NS‡	NS	NS
Trial mean	52.7	13.7	1.15

†Least significant difference at the 0.10 level.
‡NS; not statistically significant.

Table 10. Forage quality of four varieties of oats.

Variety	CP	ADF	NDF	WSC	TDN	NEL	48-hr NDFD	RFQ	Milk yield
			% of DM			Mcal lb^{-1}	% of NDF		lbs ton^{-1}
Cosaque	29.8	29.4	46.0	7.38b†	64.5	0.660	96.5a	169	4486
Everleaf 114	30.1	29.5	47.9	8.08b	62.5	0.634	96.3a	59	4451
Everleaf 125	29.8	31.1	47.0	7.48b	63.0	0.644	95.5a	107	4450
Reeves	28.0	30.2	47.9	9.55a	61.8	0.548	87.3b	72	5151
LSD (p = 0.10) ‡	NS¥	NS	NS	0.968	NS	NS	6.02	NS	NS
Trial mean	29.4	30.1	47.2	8.12	62.9	0.622	93.9	101	4635

†Treatments that share a letter performed statistically similarly to one another.

‡Least significant difference at the 0.10 level.

¥NS; not statistically significant.

DISCUSSION

Annual ryegrass, brassicas, and oats are all potential options in this region to provide forage into the late fall to extend the grazing season and supplement available perennial cool season forages. Oats provided high yield and NDF digestibility, but were lower in protein and higher in NDF than annual ryegrass and brassicas. Conversely, annual ryegrass provided high protein and NDF digestibility but yielded less than half as much as oats and brassicas. While individual varieties of oats and annual ryegrass trialed did not differ from one another very much in yield or quality parameters, brassica varieties varied significantly (Figure 2). These differences are important to consider when selecting a species and variety that fits your farm's needs and goals. It is also important to recognize that feeding brassicas alone as a substantial portion of an animal's overall dry matter intake can pose bloat and milk off-flavor issues. These species should either be grazed for short periods of time, fed in combination with other lower digestibility forages, or grown in mixtures to avoid these potential issues.

ACKNOWLEDGEMENTS

This trial was funded by the Organic Research and Extension Initiative, project no. 2016-51300-25735. UVM Extension would like to thank Roger Rainville and his staff at Borderview Research Farm in Alburgh for their generous help with the trials. We would like to acknowledge Henry Blair, John Bruce, Catherine Davidson, Hillary Emick, Lindsey Ruhl, Mark Sizen, and Laura Sullivan for their assistance with data collection and entry. The information is presented with the understanding that no product discrimination is intended and no endorsement of any product mentioned or criticism of unnamed products is implied.

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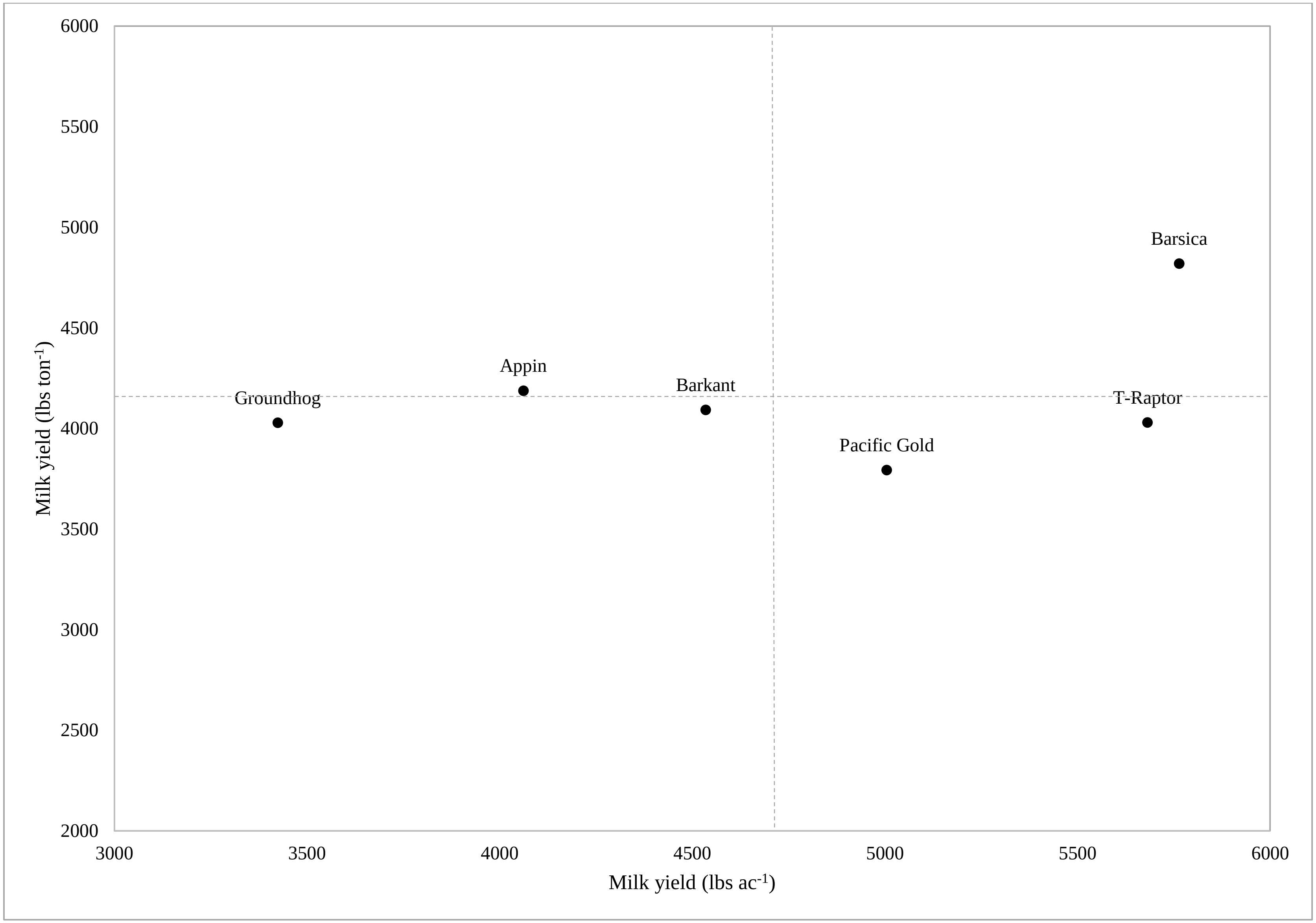

Figure 2. Milk yield per acre vs milk yield per ton of dry matter for six varieties of brassicas.