2019 Cool Season Annual Forage Mixtures Trial

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In 2019, the University of Vermont Extension's Northwest Crop and Soils Program evaluated the performance of cool season annuals for forage planted in mixtures and 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. Recently, there has been a growing interest in utilizing multiple cool season forage species to maximize yield and quality. We compared eleven varieties of eight annual species alone and in two-and-three species mixtures to evaluate potential differences in forage yield and quality. While the information presented can begin to describe the yield and quality performance of these forage mixtures 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 with 5 to 8 percent slopes. Previous crops in the 2019 field season were spring barley and oats. Nine varieties of six species were evaluated in either monoculture or two-and-three species mixtures, for a total of twelve treatments. Forage species and mixture information as well as seeding rates (lbs ac^{-1}) are summarized in Table 2.

Table 1. Annual forage trial management, Alburgh, VT, 2019.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam with 5 to 8% slopes
Previous crop	Spring barley and oats
Tillage operations	Chisel plow, disk and spike tooth harrow
Planting equipment	Great Plains Cone seeder
Treatments (species/mixtures)	12
Replications	4
Plot size (ft)	5 x 20
Planting date	15-Aug
Harvest date	14-Oct

The seedbed was chisel plowed, disked, and finished with a spike tooth harrow. The trial was planted with a cone seeder on 15-Aug into 5' x 20' plots. On the 14-Oct, plots were harvested using a Carter flail forage harvester equipped with a scale in a 3' x 20' area in each plot, and yields were measured at harvest. An approximate 1 lb subsample of the harvested material was collected and dried to determine dry matter 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. Forage mixture composition and seeding rates, 2019.

Species/Mixture	**Variety**	**Seeding Rate** lbs ac^{-1}
Oats	Everleaf	125
Oats + Peas	Everleaf	100
	Arvika	50
Triticale	Trical 815	100
Triticale + Peas	Trical 815	100
	Arvika	50
Triticale + Oats + Peas	Trical 815	75
	Everleaf	50
	Arvika	40
Oats + Peas + Turnip	Everleaf	50
	Arvika	30
	Barkant	3
Annual Ryegrass	Centurion	30
Forage Brassica	Barkant	6
	T-Raptor	6
	Barsica	6
	Purple top	6
	Daikon	6

The samples were analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and 48-hour NDF digestibility (NDFD), non-fiber carbohydrates (NFC), relative feed value (RFV), 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 on 17-Jan 2020. 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. 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).

Table 3. Weather data for Alburgh, VT, 2019.

	August	September	October
Average temperature (°F)	68.3	60.0	50.4
Departure from normal	-0.51	-0.62	2.22
Precipitation (inches)	3.50	3.87	6.32
Departure from normal	-0.41	0.23	2.72
Growing Degree Days (base 41°F)	846	572	320
Departure from normal	-16	-16	97

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.

Temperatures were slightly below average for August and September but rose to 2.22 degrees above average in October, resulting in favorable conditions for forage growth. Rainfall was below average in August, but increased as the season progressed. October saw 2.72 inches above average of precipitation. From August through October there were an accumulated 1738 Growing Degree Days (GDDs) at a base temperature of 41° F, which is 65 more GDDs than the 30-year normal. Conditions continued to be warm and favorable for growth of these species following harvest.

Treatments differed statistically in yield, dry matter, and forage quality parameters (Table 4). Yields ranged from 2267 lbs ac^{-1} (*Trical 815* in monoculture) to 3777 lbs ac^{-1} (*T-raptor* in monoculture). The treatments of *Everleaf* oats in monoculture, Oats + Peas mixture, Triticale + Oats + Peas mixture, and *Purple top* brassica in monoculture all yielded similarly to the top performer, *T-raptor*. Barsica in monoculture was statistically similar to the lowest yielding treatment, *Trical 815* in monoculture. However, it is important to note that triticale will overwinter in this region and has the potential to produce additional forage in the spring, which is beyond the scope of this trial. The annual ryegrass and *Trical 815* in monocultures had significantly higher percent dry matter (16.8, 16.6%, respectively) than the other treatments. Daikon radish had the lowest percent dry matter at harvest, at 8.76%.

Table 4. Yield and forage quality 12 forage species/mixture treatments, 2019.

Treatment	**DM yield**	**DM**	**CP**	**ADF**	**NDF**	**NFC**	**TDN**	**NDFD48**	**NE$_L$**	**RFV**
	lbs ac^{-1}	%	---------------------------% of DM---------------					% of NDF	Mcal lb^{-1}	
T-raptor forage brassica	**3777**	9.72	30.0	25.2*	**21.3**	**35.3**	63.5	78.8	0.71*	**312**
Barkant forage turnip‡	3035	9.62	27.5	29.9	27.6	31.8*	58.3	79.3	0.64	227
Barsica forage rape	2546	11.0	29.3	24.8*	33.9	28.5	62.0	89.3	0.67	191
Daikon radish	2869	8.76	32.3*	25.6*	26.1*	27.2	58.0	81.3	0.65	248
Oats + Peas + Turnip	2932	12.8	29.2	29.6	35.3	25.6	**68.0**	90.5	**0.73**	175
Everleaf oats	3741*†	13.5	29.4	28.5	43.6	18.2	65.5*	95.0*	0.68	145
Oats + Peas	3732*	11.7	29.5	30.5	41.9	19.4	63.8	87.5	0.67	149
Purple top forage brassica	3223*	10.3	**33.4**	**22.8**	25.3*	26.2	56.5	75.5	0.63	265
Centurion annual ryegrass	2895	**16.8**	30.3	24.2*	35.6	23.3	66.8*	95.3*	0.72*	186
Triticale + Oats + Peas	3689*	13.2	28.8	29.5	44.8	17.0	60.3	86.5	0.62	137
Trical 815 triticale	2267	16.6*	29.2	28.4	40.2	21.5	61.0	**96.5**	0.64	155
Triticale + Peas	3095	13.7	30.7	28.4	37.4	23.0	62.8	87.3	0.67	169
LSD (p = 0.10)	588	1.79	2.48	3.42	5.40	4.75	3.56	5.67	0.05	39.1
Trial Mean	3150	12.3	29.9	27.3	34.4	24.7	62.2	86.9	0.67	197

†Treatments with an asterisk* performed similarly to the top performer in **bold**.
‡Varieties in *italics* were used in the mixture treatments.

Treatments differed significantly in quality parameters. Crude protein values ranged from 27.5 to 33.4%. *Purple top* forage brassica had significantly higher CP than all other treatments except for *Daikon* forage radish. *Purple top* also had the lowest ADF value at 22.8%, and was similar to *Centurion* annual ryegrass, *Barsica* forage rape, *T-raptor* forage brassica, and *Daikon* radish. The *T-raptor* forage brassica had the lowest NDF value at 21.3%, similar to the *Purple top* forage brassica and *Daikon* radish. This is to be expected as these plants have growth habits that produce more leaf material low in structural fiber compared to grasses such as oats or annual ryegrass. The treatments with the highest NDF, which indicates lower quality, were the Triticale + Oats + Peas mixture, oats in monoculture, Oats + Peas, and *Trical 815* triticale, with NDF values of 44.8%, 43.6%, 41.9%, and 40.2% respectively. Overall, all treatments had ADF and NDF values that would characterize them as high quality forages. Non-fiber carbohydrates (NFC) ranged from 17.0 to 35.3%. The *T-raptor* brassica was the top performer, and was statistically similar to Barkant forage turnip. The TDN is an estimate of the proportion of the forage that contains digestible nutrients. The Oats + Peas + Turnip mixture, *Centurion* annual ryegrasss, and *Everleaf* oats had the top TDN values, at 68.0%, 66.8%, and 65.5% respectively. The top two performers had significantly higher TDN values than all other treatments except for *Everleaf* oats. *Trical 815* triticale had the highest 48-hour NDF digestibility, 96.5%, and was statistically similar to the annual ryegrass and oats in monoculture.

The NE$_L$ is an estimate of the energy available from the forage for lactation. The NE$_L$ of the cool season annuals ranged from 0.62 to 0.73 Mcal lb^{-1}. The Oats + Peas + Turnip mixture had the highest NE$_L$, and was statistically similar to the annual ryegrass and *T-raptor* forage brassica in monocultures. The *T-raptor* brassica had a significantly higher relative feed value (RFV) than all other treatments, with a RFV of 312. This was likely impacted by ADF, NDF, and NFC. A RFV rating of 150 represents high quality alfalfa. *Everleaf* oats in monoculture, Oats + Peas, and Triticale + Oats + Peas scored under this target, while four treatments scored over 200.

DISCUSSION

In comparing mixtures and their monoculture components, the addition of turnips into oat mixtures decreased yields without significantly increasing quality, despite the turnips having higher quality on their own. This addition of turnips had a greater impact on the oat mixtures than adding peas or triticale, despite triticale in monoculture being the lowest performer in yield. The addition of turnips to the Oats + Peas mixture decreased dry matter yields by 800 lbs ac^{-1}. These data also show increased yields from oats in comparison to the other grasses, without a large difference in quality. Figures 1 and 2 display yield and RFVs for the treatments. Figure 2 is divided into four quadrants by dotted lines signifying the average total yield and relative forage value (RFV). Varieties that land in the top left quadrant are those that produced above average yields but below average quality. Varieties in the bottom right quadrant produced above average quality but below average yields. Varieties in the top right quadrant produced above average yield and quality. While the forage brassicas in monocultures *T-raptor* and *Purple Top* produced both high yields and high quality forage (Figure 2), it is important to recognize that not all of the treatments could be fed and/or grazed in the same capacity. The nutrient dense and highly digestible nature of the forage turnips or peas in monoculture would require additional fiber sources be fed to prevent animal health complications. Furthermore, as mentioned previously, triticale would overwinter in this region potentially providing both fall and early spring forage without reseeding. These additional factors should be considered when selecting annual forages to ensure they meet your farms' needs as well as the nutritional demands of your animals.

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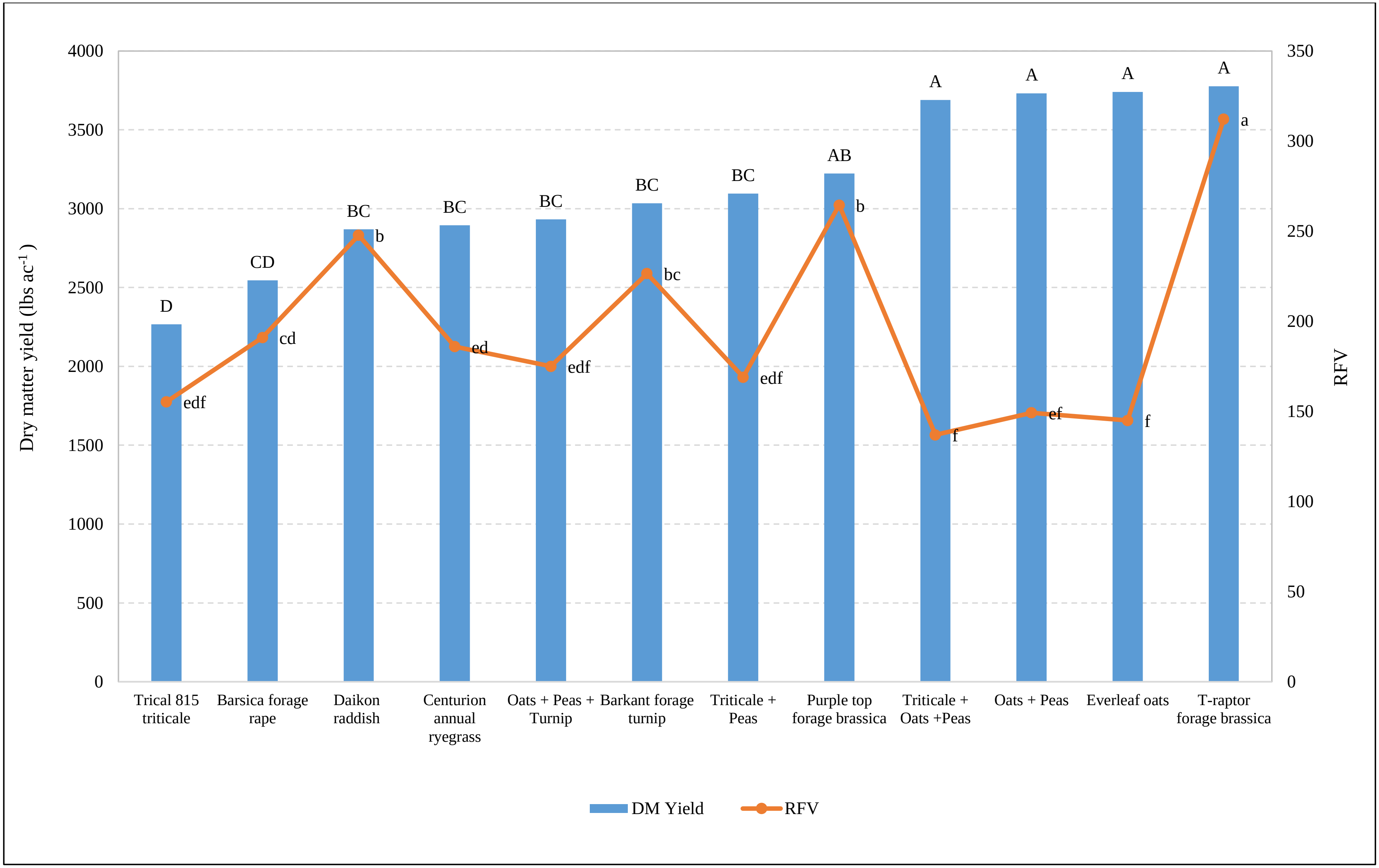

Figure 1. Dry matter yield and RFV of 12 annual forage treatments, Alburgh, VT, 2019.
Treatments that share a letter performed statistically similarly to one another.

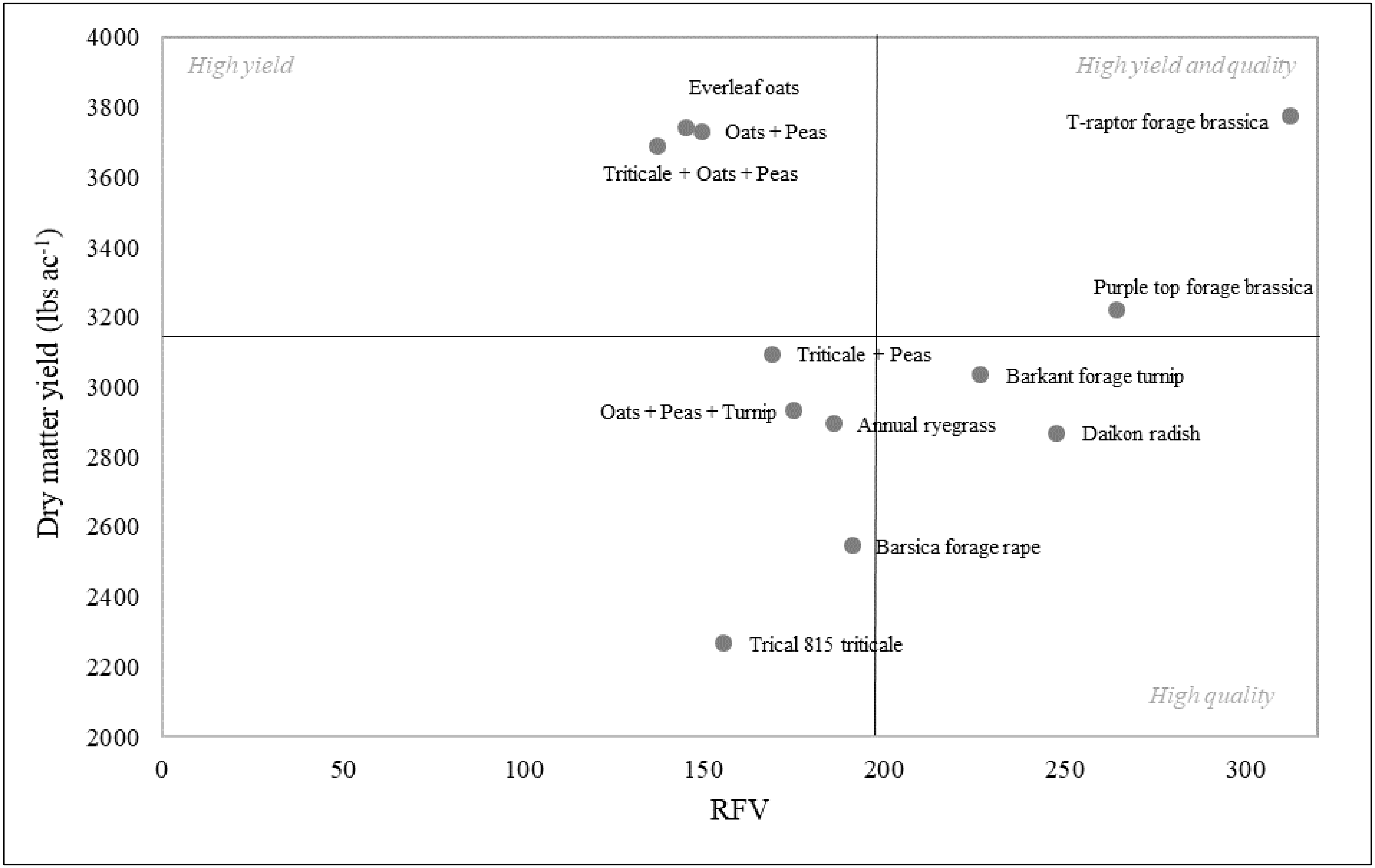

Figure 2. Yield vs. quality of 12 annual forage treatments, Alburgh, VT, 2019.