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2020 Perennial Grass Variety Trial

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NORTHWEST CROPS & SOILS PROGRAM

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THE UNIVERSITY OF VERMONT EXTENSION

2020 PERENNIAL GRASS VARIETY TRIAL

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In 2019, the University of Vermont Extension Northwest Crops and Soils Program initiated a trial evaluating forage yield and quality of an array of cool season perennial grass species and varieties planted in monocultures. The grass species selected were Kentucky bluegrass, meadow brome, meadow fescue, orchardgrass, perennial ryegrass, and timothy. The 2020 growing season was the first full season after establishment for these stands. These stands will continue to be monitored over multiple years to evaluate yield, quality, survivability, pest resistance, persistence, and other characteristics that will help identify the most suitable forage species and varieties in our region over a variety of weather conditions.

MATERIALS AND METHODS

Forage species and variety information for the trial is summarized in Table 1. The plot design was a randomized complete block with five replications. Treatments were grass varieties seeded in monoculture and evaluated for winter survival, forage yield, forage quality, and disease incidence and severity.

Table 1. Perennial grass species information.

Species	Variety
Kentucky bluegrass	Balin
	Ginger
Meadow brome	Fleet
	Macbeth
	Montana
Meadow fescue	Laura
	Liherold
	Preval
	SW Minto
	Tetrax
Orchardgrass	Echelon
	Harvestar
	Husar
	Inavale
	Luxor
	Niva
	Olathe
	Otello

Species	Variety
Perennial ryegrass	Calibra
	Kentaur
	Remington
	Tivoli
	Tomaso
	Toronto
Timothy	Barfleo
	Barpenta
	Climax
	Lischka
	Promesse
	Tuuka

The soil type at the Alburgh location was a Benson rocky silt loam (Table 2). In early April 2020, plots were visually inspected for establishment and survival. Plots with inadequate stands were reseeded on 29-Apr 2020. Plots were harvested with a Carter flail forage harvester in 3’ x 20’ area on 21-May, 23-Jun, 6-

Aug, and 16-Sep. Plots were also rated for disease severity on 6-Sep prior to the third harvest. Plots were rated on a 1-5 scale where 1 was low infection and 5 was high infection for rust (*Puccina sp.)* and for other diseases.

Table 2. Perennial forage trial management, Alburgh, VT.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Soybean
Treatments	30
Replications	5
Plot size (ft.)	5 x 20
Planting date	18-Aug 2019
Harvest dates (2020)	21-May, 23-Jun, 6-Aug, 16-Sep

An approximate 1 lb subsample of the harvested material was collected and dried to calculate dry matter content and yield. The subsamples were then ground to 2mm particle size using a Wiley mill and then to 1mm using a cyclone sample mill (UDY corporation). Ground samples were analyzed for forage quality using near-infrared reflectance spectroscopy (NIR) procedures on a FOSS DS2500 at the University of Vermont.

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 (aNDF) which includes cellulose, hemicellulose, and lignin. This measure indicates the bulky characteristic of the forage and therefore is negatively correlated with animal dry matter intake. The portion of the NDF fraction that is estimated to be digestible after 48 hours of fermentation in rumen fluid is represented by the NDF digestibility (48-hr NDFD). Water soluble carbohydrates (WSC) are a fraction of the overall dry matter (DM) that are utilized for energy. The fraction of dry matter that contains all digestible nutrients is represented by the total digestible nutrients (TDN). The total estimated energy available for bodily maintenance plus lactation by a ruminant consuming the forage is represented by the net energy of lactation (NEL) which is expressed on a per pound of dry matter basis. Several forage quality metrics are combined to estimate the relative forage quality (RFQ) and to predict milk yield produced by feeding the forage to cattle.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and mixtures were treated as fixed. Treatment mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$). 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 hybrids 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 (LSDs) at the 0.10 level of significance 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 that for 9 out of 10 times, there is a real difference between the two hybrids. Treatments that were not significantly lower in performance than the highest treatment in a particular column share a letter. In this example, hybrid C is significantly different from hybrid A but not from hybrid B. This means that these hybrids did not differ in yield.

Hybrid	Yield
A	6.0b
B	7.5ab
C	**9.0a**
LSD	2.0

RESULTS

Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). In general, the fall of 2019 was warmer and wetter than normal however, early cold temperatures and snowfall were experienced in November. Winter precipitation fluctuated with temperatures being warmer than normal. The spring of 2020 generally was cool and dry. Dry conditions persisted through much of 2020, however, temperatures increased to above normal for the middle of the summer. Drought conditions categorized as "Abnormally Dry" (Drought.gov) were experienced for much of the region throughout the summer months. Overall, the grass trial accumulated 3938 Growing Degree Days (GDDs) in 2020, 21 above the 30-year normal.

Table 3. 2019-2020 weather data for Alburgh, VT.

	2019				2020								
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average temperature (°F)	60.0	50.4	31.2	26.0	23.5	21.8	35.0	41.6	56.1	66.9	74.8	68.8	59.2
Departure from normal	-0.51	2.32	-6.76	0.46	4.62	0.41	3.94	-3.19	-0.44	1.08	4.17	0.01	-1.33
Precipitation (inches)	3.87	6.32	2.38	1.29	2.63	1.19	2.79	2.09	2.35	1.86	3.94	6.77	2.75
Departure from normal	0.21	2.76	-0.74	-1.06	0.63	-0.53	0.57	-0.72	-1.04	-1.77	-0.28	2.86	-0.91
Growing Degree Days (base 41°F)	572	320	39	14	5	6	66	144	497	766	1030	860	564
Departure from normal	-19	28	-67	-7	-7	-8	-2	-88	-4	29	123	5	-27

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

Due to poor establishment and drought conditions limiting growth, data for the Kentucky bluegrass and timothy varieties were not collected. The remaining four species differed significantly in yield and all quality parameters (Table 4). Orchardgrass was the highest yielding species averaging 6.03 tons ac^{-1}. This was statistically similar to meadow brome with 5.13 tons ac^{-1}. Meadow fescue was the lowest yielding with 4.38 tons ac^{-1}. The species also differed in average quality over the season. Crude protein content ranged from 18.9% to 22.3% with perennial ryegrass being significantly lower (3-4%) than all other species. Meadow fescue produced the lowest aNDF content and the highest TDN and NEL contents of 49.4%, 60.7%, and 0.613 Mcal lb^{-1} respectively, which outperformed all other species. This also translated into a higher predicted milk yield than all other species of 4224 lbs ton^{-1}. Perennial ryegrass had the highest water soluble carbohydrate (WSC) content of 13.4% which was statistically similar to that of meadow fescue. Fiber digestibility was relatively high for all species but was statistically higher in meadow fescue and

orchardgrass. Factoring together multiple quality measures, meadow fescue and perennial ryegrass had the highest RFQ ratings of 165 and 163 respectively. A rating of 150 is typically used as a benchmark for dairy quality forages.

Table 4. Average yield and quality by species, 2020.

Species	Season yield	CP	aNDF	WSC	TDN	NEL	48-hr NDFD	RFQ	Milk yield
	DM tons ac^{-1}	% of DM				Mcal lb^{-1}	% of NDF		lbs ton^{-1}
Meadow brome	5.13ab†	22.3a	53.2b	10.4b	59.0b	0.578b	81.8b	141b	3928b
Meadow fescue	4.38b	22.1a	49.4a	12.2ab	60.7a	0.613a	86.1a	165a	4224a
Orchardgrass	6.03a	21.7a	57.0c	8.18c	57.5c	0.548c	83.3ab	137b	3975b
Perennial ryegrass	4.87b	18.9b	53.7b	13.4a	58.6bc	0.571b	82.7b	163a	3903b
Level of significance	*	**	**	**	**	**	*	**	**
Trial mean	5.18	21.1	53.7	10.9	58.8	0.574	83.6	151	4007

†Treatments that share a letter performed statistically similarly to one another.
* $0.01 < p > 0.001$
** $p < 0.0001$

The distribution of yield across harvests can also be a helpful tool in species and varietal selection (Figure 1). A significant interaction between species and cutting for yield indicates that these species differed significantly in their dry matter distribution over the four cuttings. Meadow brome and Orchardgrass produced approximately 40% of their season total yield in the 1st cutting while Meadow fescue produced over 50% of its total yield in the 1st cutting. The 2nd cuttings contributed less than 15% of the total yield for all species except for Perennial ryegrass where the 2nd cutting produced over 30% of its total yield.

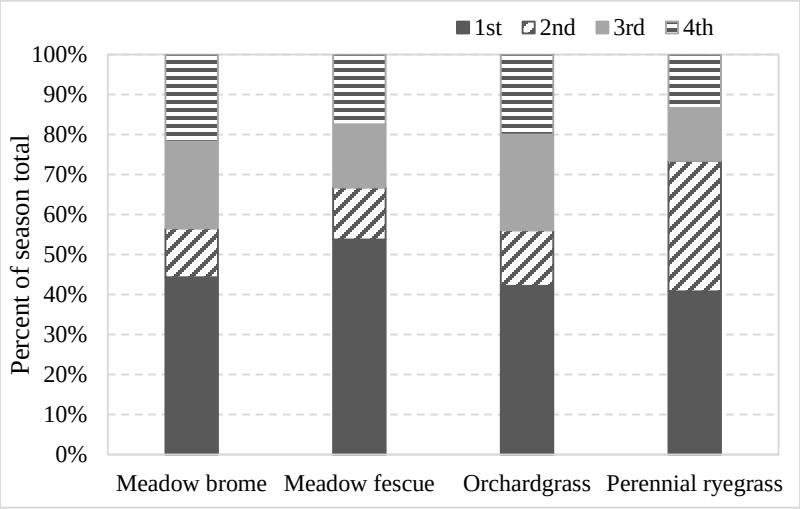

Figure 1. Seasonal distribution of yield by species, 2020.

Impact of Variety- Meadow Brome

Three varieties of meadow brome were included in this evaluation (Table 5). The varieties differed in RFQ but were similar in all other measures. Dry matter yields ranged from 4.16 to 6.67 tons ac^{-1} but did not differ statistically. In terms of quality, the only quality parameter that varied statistically was RFQ in which the variety Fleet produced the highest quality forage with a rating of 163. This was similar to the variety

Montana but not to the variety Macbeth. Disease rating also did not differ statistically between varieties and averaged 2.00 on a scale from 0-5 for the species.

Table 5. Yield and quality of three varieties of meadow brome, 2020.

Variety	DM	Season yield	CP	aNDF	WSC	TDN	NEL	48-hr NDFD	RFQ	Milk yield
	%	DM tons ac^{-1}		% of DM			Mcal lb^{-1}	% of NDF		lbs ton^{-1}
Fleet	27.1	4.16	22.1	52.2	10.8	58.4	0.580	82.5	163a†	3960
Macbeth	26.0	6.67	22.0	55.0	9.74	59.3	0.570	80.6	122b	3869
Montana	25.9	4.56	22.7	52.3	10.6	59.4	0.590	82.2	140ab	3953
LSD (p = 0.10)‡	NS	NS¥	NS	NS	NS	NS	NS	NS	26.6	NS
Species mean	26.4	5.13	22.3	53.2	10.4	59.0	0.580	81.8	141	3928

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

If we look at each cutting separately, however, there is some difference in the distribution of dry matter across the four harvests (Figure 2). In general, as we'd expect, yields are highest in the 1st harvest, lowest in the 2nd, and rebound some for the 3rd and 4th cutting. The yields for the 2nd harvest were approximately 30% of 1st cut yields for all three varieties. However, by third cut the variety Fleet had recovered to approximately 80% of its 1st cut yield, while Macbeth and Montana produced only approximately 45% and 32% respectively. It is important to note that no statistically significant variety x cutting interaction for dry matter yield was observed.

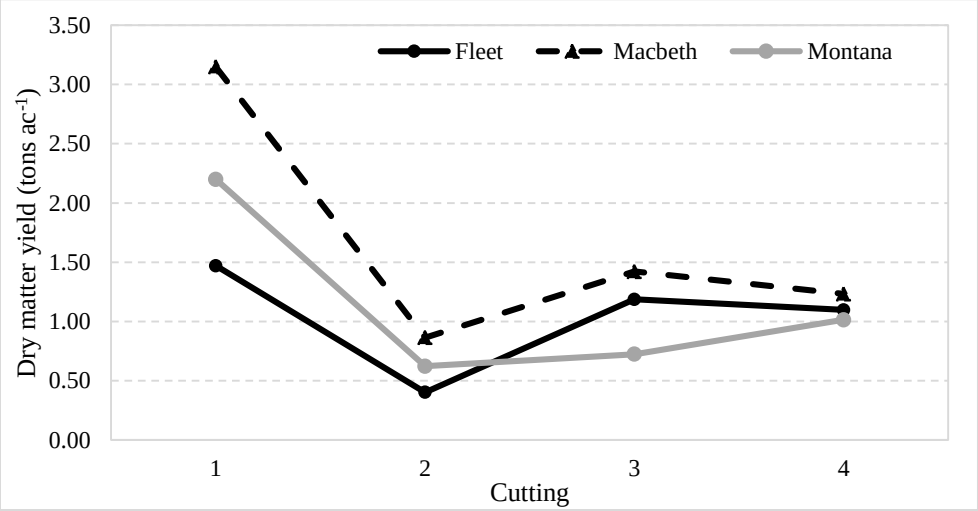

Figure 2. Dry matter yield of three meadow brome varieties over four cuttings, 2020.

Meadow Fescue

Five varieties of meadow fescue were included in this evaluation (Table 6). The varieties did not differ in dry matter yield but did differ in some quality parameters. Dry matter content ranged from 23.9% to 26.7% and differed statistically across varieties. This suggests that these varieties differ in maturation timing with Tetrax and Preval being later maturing varieties, SW Minto and Liherold being earlier maturing varieties, and Laura somewhere in between. Yields ranged from 3.74 to 4.99 tons ac^{-1} but did not differ statistically.

The variety Tetrax was the top performing variety in all quality parameters. Tetrax averaged approximately 4% lower aNDF content than all other varieties and averaged nearly 88% NDF digestibility. The TDN content averaged 62.4% yielding 0.640 Mcal lb^{-1} of dry matter.

Table 6. Yield and quality of five varieties of meadow fescue, 2020.

Variety	DM	Season yield DM tons ac^{-1}	CP	aNDF	WSC	TDN	NEL	48-hr NDFD % of NDF	RFQ	Milk yield lbs ton^{-1}
	%			% of DM			Mcal lb^{-1}			
Laura	25.9bc†	3.74	22.1	50.0b	11.5b	60.3bc	0.600bc	86.8ab	147	4170
Liherold	26.7c	4.11	20.6	50.3b	12.7a	61.8ab	0.620ab	85.7b	165	4252
Preval	24.7ab	4.48	23.1	50.1b	11.5b	59.0c	0.590c	86.8ab	160	4177
SW Minto	26.0bc	4.99	21.6	50.6b	11.4c	59.8bc	0.600bc	83.3c	164	4173
Tetrax	23.9a	4.58	23.0	46.3a	13.7a	62.4a	0.640a	87.9a	188	4347
LSD (p = 0.10) ‡	1.57	NS¥	NS	2.47	1.27	2.03	0.024	1.70	NS	NS
Species mean	25.4	4.38	22.1	49.4	12.2	60.7	0.610	86.1	165	4224

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

Meadow fescue varieties also differed in disease severity (Table 7). Overall, the species averaged a rating of 2.12 on a 0-5 scale, however, individual variety ratings ranged from 1.40 to 3.00. While these ratings do not fully quantify infection, they provide insight into relative differences in disease susceptibility between varieties under the same climatic conditions and can aide in the varietal selection process.

Table 7. Disease rating of five varieties of meadow fescue, 2020.

Variety	**Disease rating** 0-5†
Laura	3.00
Liherold	2.00
Preval	1.40
SW Minto	2.40
Tetrax	1.80
Level of significance	**
Species mean	2.12

†1-5 scale where 1 = low infection and 5 = high disease infection.
** 0.05 < p > 0.01

Similar to the meadow brome varieties, if we look at yield by cutting, we see slight differences in dry matter distribution (Figure 3). For all varieties except for SW Minto, the 2nd harvest produced the lowest yield. The 2nd cut yields ranged from approximately 20% of 1st cut yields for Liherold to 30% of the 1st cut yields for SW Minto. However, following 2nd cut during the hottest part of the summer, SW Minto declined in productivity while other varieties were similar or increased. Finally, between the third and fourth harvests some varieties continued to rebound, increasing in yield while others declined in productivity. While these distributions show some variation in productivity across the season, these differences were not statistically significant.

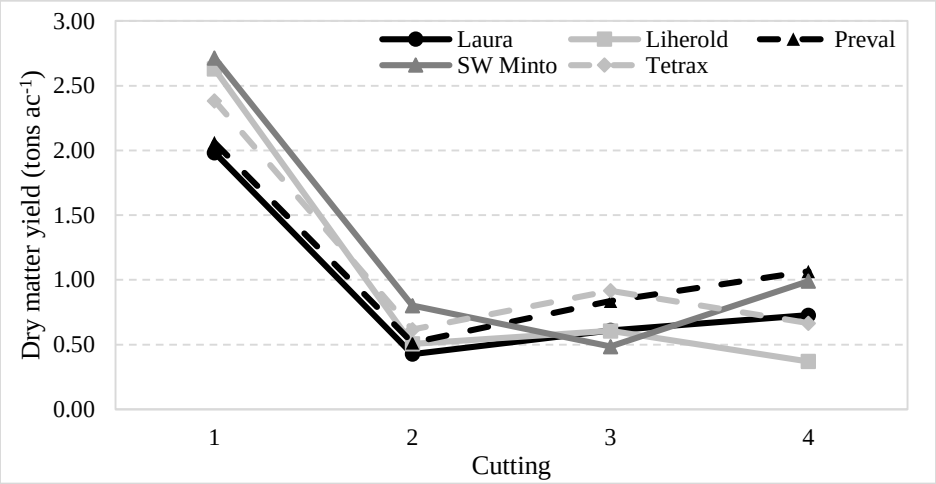

Figure 3. Dry matter yield of five meadow fescue varieties over four cuttings, 2020.

Orchardgrass

The seven varieties of orchardgrass did not differ statistically in terms of yield but did differ in some quality parameters (Table 8). Dry matter content ranged from 23.7% to 25.6% and differed statistically suggesting that the varieties differ in maturation timing. The varieties Echelon and Niva appear to be later maturing varieties while Otello and Luxor are earlier maturing with the other varieties landing somewhere between. Yields ranged from 5.36 to 6.69 tons ac^{-1} but did not differ statistically.

Table 8. Yield and quality of seven varieties of orchardgrass, 2020.

Variety	DM	Season yield DM	CP	aNDF	WSC	TDN	NEL	48-hr NDFD % of NDF	RFQ	Milk yield
	%	tons ac^{-1}		% of DM			Mcal lb^{-1}			lbs ton^{-1}
Echelon	23.7a†	6.25	22.1	58.1c	7.58c	56.4	0.532	83.9a	123	3893d
Harvestar	24.8bcd	6.36	22.4	55.9ab	8.40bc	58.7	0.565	82.5b	132	4057a
Inavale	24.7abcd	5.36	21.3	56.4ab	8.55b	57.8	0.553	82.8b	142	4001ab
Luxor	25.5cd	5.37	21.0	57.6bc	9.47a	57.9	0.549	84.4a	145	4055a
Niva	23.8ab	6.69	22.7	56.9abc	7.60c	56.9	0.544	83.5ab	123	3904cd
Olathe	24.4abc	6.58	21.9	55.8a	7.72bc	57.7	0.556	83.5ab	144	3991abc
Otello	25.6d	5.58	20.9	58.5c	7.93bc	56.9	0.534	82.6b	147	3923bcd
LSD (p = 0.10) ‡	1.15	NS¥	NS	1.71	0.899	NS	NS	1.03	NS	97.3
Species mean	24.6	6.03	21.7	57.0	8.18	57.5	0.550	83.3	137	3975

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

Overall, all varieties produced substantial yields despite the hot and dry conditions. The varieties also differed in quality. In general, aNDF contents were higher than would be ideal to feed to lactating dairy cattle with values ranging from 55.8% to 58.5%. However, NDF digestibility remained high across varieties averaging over 83%. In addition, WSC levels ranged from 7.58% to 9.47% with the variety Luxor outperforming all other varieties. The predicted milk production from these varieties ranged from 3893 lbs

ton^{-1} to 4057 lbs ton^{-1} with the varieties Luxor and Harvestar producing the highest milk yields. Orchardgrass varieties also differed statistically in disease severity rating (Table 9). The species overall averaged a rating of 1.90 on a 0-5 scale. However, individual varieties ranged from 1.40 to 2.60. While these ratings are not perfect, they can compare varietal performance under the same climatic conditions and can aide in the varietal selection process.

Table 9. Disease rating of eight varieties of orchardgrass, 2020.

Variety	Disease rating 0-5†
Echelon	1.80
Harvestar	**1.40**
Husar	2.00
Inavale	1.80
Luxor	2.60
Niva	1.40
Olathe	1.80
Otello	2.40
Level of significance	**
Species mean	1.90

†1-5 scale where 1 = low infection and 5 = high disease infection.
** 0.05 < p > 0.01

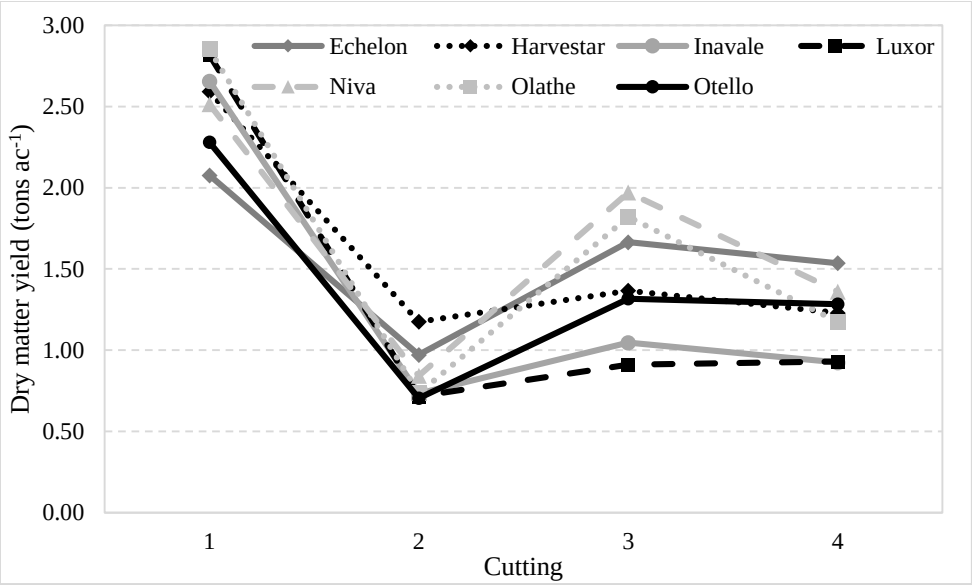

Figure 4. Dry matter yield of seven orchardgrass varieties over four cuttings, 2020.

Looking at dry matter yields by cutting, we also see differences in dry matter distribution across the season (Figure 4). While some varieties, such as Niva and Olathe, produced most of their biomass in the first and third cuttings, other varieties, such as Harvestar, produced biomass more evenly between cuttings. This suggests that these varieties were able to recover from the 1st harvest faster and may not require as long of a recovery period after harvest or grazing. Despite the abnormally hot conditions experienced between the

2nd and 3rd harvests, Niva, Olathe, and Echelon were able to produce over 1.50 tons ac^{-1}, more than double their 2nd cut yields. Conversely, Luxor and Inavale did not recover as quickly and suffered during the hot dry period in the middle of the summer, producing the lowest yields across the 2nd-4th harvests. While these differences in distribution across the cuttings can be helpful in understanding productivity and regrowth curves, it is important to note that these differences were not statistically significant.

Perennial Ryegrass

Six varieties of perennial ryegrass were included in this evaluation (Table 10). Perennial ryegrass is the least cold hardy species included in this trial and therefore may not be recommended for your specific location. Sites with prolonged periods of cold temperatures with little to no insulation from snow cover during the winter can lead to reduced survival and productivity. The winter following establishment was relatively mild allowing for good survivability. Dry matter contents were similar for all varieties except Toronto which was significantly higher. This suggests that Toronto is an earlier maturing variety than the other five varieties. Dry matter yields ranged from 3.24 to 6.08 tons ac^{-1}. While these yields look substantially different, due to high variation within each variety, this was not considered statistically significant. The varieties Calibra and Tomaso were the top performers or statistically similar to the top performer in all quality parameters. They produced the lowest aNDF contents, highest WSC and TDN contents, highest net energy, and ultimately were predicted to produce 3973 and 3954 lbs of milk ton^{-1} respectively. While the variety Toronto also produced a statistically similar milk yield, it is important to remember that the highest quality forage is typically produced in the 1st harvest when made prior to heading out. Since Toronto, as suggested by dry matter content, appears to be an earlier maturing variety, lower quality forage may be produced by this variety in years when the first harvest must be delayed due to unfavorable weather.

Table 10. Yield and quality of six varieties of perennial ryegrass, 2020.

Variety	DM	Season yield DM	CP	aNDF	WSC	TDN	NEL	48-hr NDFD % of NDF	RFQ	Milk yield
	%	tons ac^{-1}		% of DM			Mcal lb^{-1}			lbs ton^{-1}
Calibra	23.2a†	3.24	18.4	53.1ab	14.0ab	60.4a	0.591a	83.0	162	3973a
Kentaur	23.7a	5.97	18.4	54.0b	13.2b	57.5b	0.559c	81.1	154	3809b
Remington	24.1a	6.08	19.3	54.4b	12.1c	57.4b	0.557c	82.8	166	3834b
Tivoli	23.3a	4.97	19.5	54.2b	13.4b	58.4b	0.564c	82.8	163	3891ab
Tomaso	23.4a	5.03	18.9	51.9a	14.6a	58.9ab	0.583ab	84.1	162	3954a
Toronto	27.7b	3.94	19.1	54.4b	13.0bc	58.8b	0.569bc	82.4	171	3960a
LSD (p = 0.10) ‡	2.05	NS	NS¥	1.61	0.989	1.56	0.017	NS	NS	116
Species mean	24.7	4.87	18.9	53.7	13.4	58.6	0.570	82.7	163	3903

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

Perennial ryegrass varieties also differed statistically in disease severity (Table 11). Overall, perennial ryegrass as a species averaged a rating of 3.27 on a 0-5 scale. However, individual varieties ranged from 2.00 to 3.80. These data suggest large differences in disease susceptibility amongst these perennial ryegrass varieties which can be another useful consideration when selecting a variety.

Table 11. Disease rating of six varieties of perennial ryegrass, 2020.

Variety	Disease rating 0-5†
Calibra	3.80
Kentaur	3.40
Remington	2.80
Tivoli	3.80
Tomaso	**2.00**
Toronto	3.80
Level of significance	***
Species mean	3.27

†1-5 scale where 1 = low infection and 5 = high disease infection.
*** $p < 0.0001$

When we look at the dry matter yield by cutting, we see differences in productivity throughout the season across the varieties, however it is important to note that these were not statistically significant. The variety Toronto was the lowest yielding variety at each cutting suggesting that it was less tolerant of the hot and dry weather compared to the other varieties. Interestingly, two varieties, Tivoli and Tomaso, yielded higher in their 2nd harvest than their 1st. In addition, you can see the steep decline in productivity between the 2nd and 3rd harvests for the variety Tivoli, whereas Kentaur produced biomass more evenly across the cuttings (Figure 5).

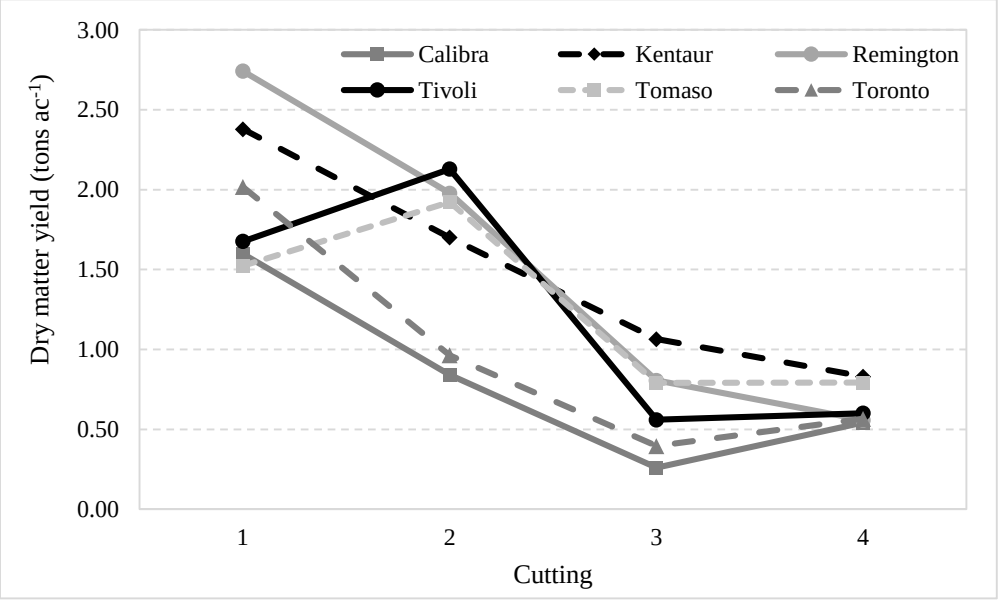

Figure 5. Dry matter yield of six perennial ryegrass varieties over four cuttings, 2020.

DISCUSSION

Overall, performance of these perennial grasses was high despite hot and dry weather conditions throughout much of the season. Yields averaged over 5 tons ac^{-1} over the season with orchardgrass and meadow brome producing the highest yields. While perennial ryegrass is often regarded as the gold standard for producing excellent dairy quality forage, meadow fescue often rivaled its quality and yielded similarly. However, it is also critical to recognize that forage quality is significantly impacted by harvest timing. Within species, varieties differed in maturation timing which can impact the suitability to your operation. Fields that tend to be wetter and more difficult to harvest early in the spring should be planted to later maturing varieties, allowing a longer harvest window prior to declines in quality. Finally, the distribution of dry matter production throughout the season can be important to consider, especially for use in grazing systems. Yield and quality data by variety across each cutting can be found in Tables 12 and 13 and Figure 6. It is important to recognize that these data only represent one year and should not alone be used to make management decisions.

ACKNOWLEDGEMENTS

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Table 12. Dry matter yield for 21 varieties of four perennial grass species, 2020.

Variety	Species	Dry matter yield				
		1st cut 21-May	2nd cut 23-Jun	3rd cut 6-Aug	4th cut 16-Sep	Season total
		tons ac^{-1}				
Fleet	Meadow brome	1.47	0.403	1.19	1.10	4.16
Macbeth	Meadow brome	3.15	0.864	1.42	1.23	6.67
Montana	Meadow brome	2.20	0.622	0.724	1.01	4.56
	Species mean	2.27	0.630	1.11	1.11	5.13
Laura	Meadow fescue	1.98	0.426	0.610	0.728	3.75
Liherold	Meadow fescue	2.63	0.506	0.606	0.370	4.11
Preval	Meadow fescue	2.06	0.514	0.836	1.07	4.48
SW Minto	Meadow fescue	2.71	0.801	0.485	0.991	4.99
Tetrax	Meadow fescue	2.38	0.616	0.916	0.666	4.58
	Species mean	2.35	0.573	0.691	0.764	4.38
Echelon	Orchardgrass	2.08	0.971	1.67	1.54	6.25
Harvestar	Orchardgrass	2.59	1.18	1.37	1.23	6.36
Inavale	Orchardgrass	2.66	0.734	1.05	0.924	5.36
Luxor	Orchardgrass	2.82	0.716	0.911	0.930	5.37
Niva	Orchardgrass	2.52	0.842	1.97	1.36	6.69
Olathe	Orchardgrass	2.85	0.734	1.82	1.18	6.58
Otello	Orchardgrass	2.28	0.704	1.32	1.28	5.58
	Species mean	2.54	0.839	1.44	1.21	6.03
Calibra	Perennial ryegrass	1.60	0.841	0.260	0.542	3.24
Kentaur	Perennial ryegrass	2.38	1.70	1.07	0.830	5.97
Remington	Perennial ryegrass	2.74	1.98	0.806	0.558	6.08
Tivoli	Perennial ryegrass	1.68	2.13	0.560	0.601	4.97
Tomaso	Perennial ryegrass	1.52	1.92	0.791	0.792	5.03
Toronto	Perennial ryegrass	2.02	0.963	0.395	0.566	3.94
	Species mean	1.99	1.59	0.646	0.648	4.87

Table 13. Quality of 21 varieties of four perennial grass species, 2020.

Variety	Species	CP	aNDF	WSC	TDN	NEL	48-hr NDFD	RFQ	Milk yield
		% of DM				Mcal lb^{-1}	% of NDF		lbs ton^{-1}
Fleet	Meadow brome	22.1	52.2	10.8	58.4	0.577	82.5	163	3960
Macbeth	Meadow brome	22.0	55.0	9.74	59.3	0.571	80.6	122	3869
Montana	Meadow brome	22.7	52.3	10.6	59.4	0.587	82.2	140	3953
	Species mean	22.3	53.2	10.4	59.0	0.580	81.8	141	3928
Laura	Meadow fescue	22.1	50.0	11.5	60.3	0.604	86.8	147	4170
Liherold	Meadow fescue	20.6	50.3	12.7	61.8	0.622	85.7	165	4252
Preval	Meadow fescue	23.1	50.1	11.5	59.0	0.594	86.8	160	4177
SW Minto	Meadow fescue	21.6	50.6	11.4	59.8	0.600	83.3	164	4173
Tetrax	Meadow fescue	23.0	46.3	13.7	62.4	0.644	87.9	188	4347
	Species mean	22.1	49.4	12.2	60.7	0.610	86.1	165	4224
Echelon	Orchardgrass	22.1	58.1	7.58	56.4	0.532	83.9	123	3893
Harvestar	Orchardgrass	22.4	55.9	8.40	58.7	0.565	82.5	132	4057
Inavale	Orchardgrass	21.3	56.4	8.55	57.8	0.553	82.8	142	4001
Luxor	Orchardgrass	21.0	57.6	9.47	57.9	0.549	84.4	145	4055
Niva	Orchardgrass	22.7	56.9	7.60	56.9	0.544	83.5	123	3904
Olathe	Orchardgrass	21.9	55.8	7.72	57.7	0.556	83.5	144	3991
Otello	Orchardgrass	20.9	58.5	7.93	56.9	0.534	82.6	147	3923
	Species mean	21.7	57.0	8.18	57.5	0.550	83.3	137	3975
Calibra	Perennial ryegrass	18.4	53.1	14.0	60.4	0.591	83.0	162	3973
Kentaur	Perennial ryegrass	18.4	54.0	13.2	57.5	0.559	81.1	154	3809
Remington	Perennial ryegrass	19.3	54.4	12.1	57.4	0.557	82.8	166	3834
Tivoli	Perennial ryegrass	19.5	54.2	13.4	58.4	0.564	82.8	163	3891
Tomaso	Perennial ryegrass	18.9	51.9	14.6	58.9	0.583	84.1	162	3954
Toronto	Perennial ryegrass	19.1	54.4	13.0	58.8	0.569	82.4	171	3960
	Species mean	18.9	53.7	13.4	58.6	0.570	82.7	163	3903

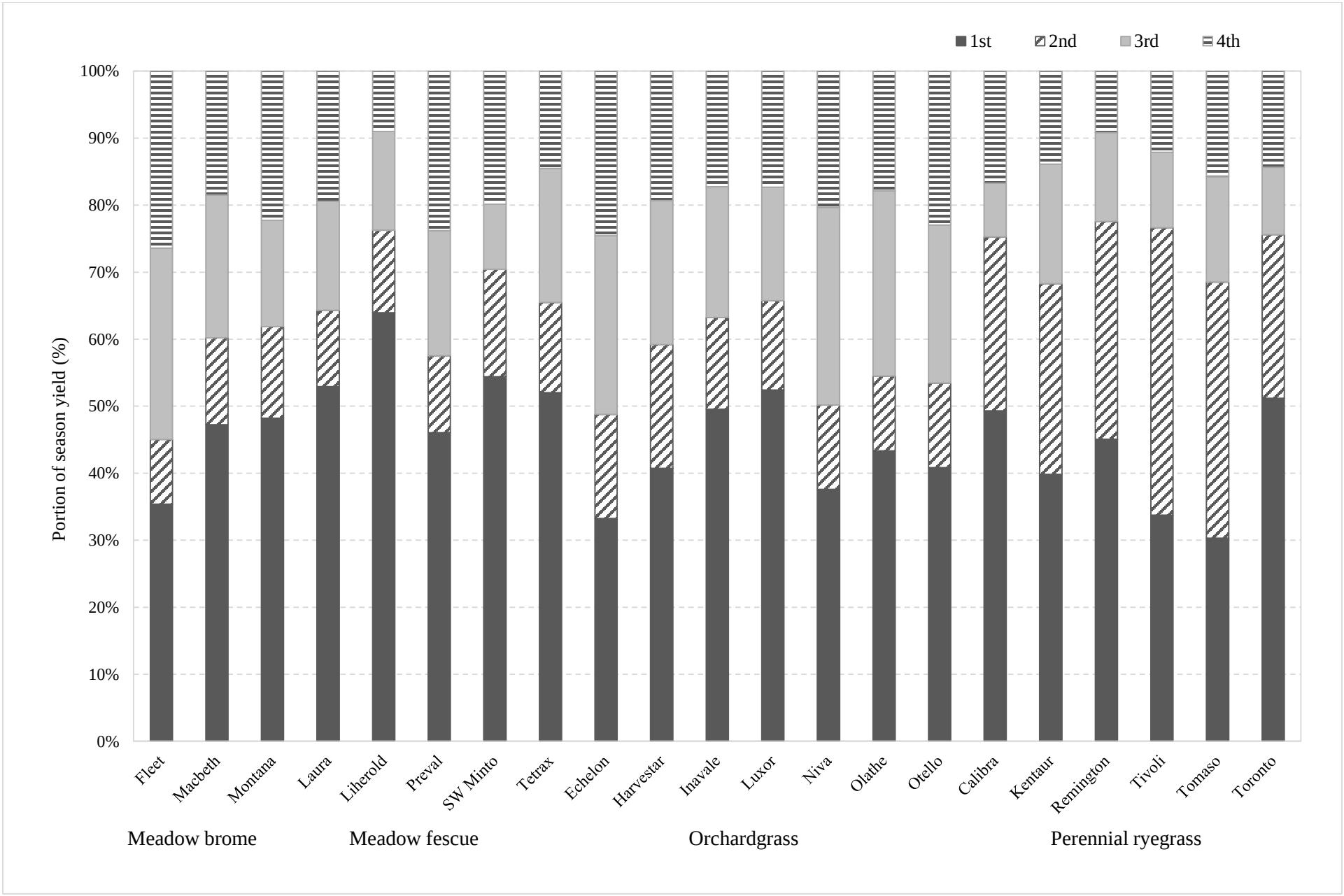

Figure 6. Dry matter yield distribution over four harvests, 2020.