NORTHWEST CROPS & SOILS PROGRAM

2016 Perennial Forage Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 PERENNIAL FORAGE TRIAL

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In 2015, the University of Vermont Extension Northwest Crops and Soils Program initiated a trial investigating forage yield, quality, and nitrogen use efficiency of cool season perennial grasses alone and in combination with red clover. The grass species selected were orchardgrass, timothy, brome, and meadow fescue. These grasses were chosen as they have been shown in previous research to have adequate survivability and forage production in this region compared to other species such as perennial ryegrass or festulolium. The goal of this trial is to evaluate these species not only for forage yield and quality, but also nitrogen use efficiency as this could help determine species and varieties that may be better suited to organic production systems. In addition, we hope to identify any differences in performance when legumes are incorporated. In 2016, with the stands fully established, evaluation of these perennial forage treatments continued.

MATERIALS AND METHODS

Forage species and variety information for the trial initiated in 2015 is summarized in Table 1. Four varieties of four perennial grass species were planted alone and in combination with red clover at Borderview Research Farm in Alburgh, VT. The plot design was a randomized complete block with five replications. Treatments were grass varieties with and without clover evaluated for nitrogen use efficiency, forage yield, and quality.

Table 1. Perennial grass species information.

Species	Variety	Seed Source	Certified Organic
Brome	AC Success	Seedway	No
	Carlton smooth	King's Agriseed	No
	Hakari Alaska	Barenbrug	No
	York smooth	Seedway	No
Meadow Fescue	HDR	Barenbrug	No
	Laura	King's Agriseed	Yes
	Liherold	King's Agriseed	Yes
	Preval	Seedway	No
Orchardgrass	Echelon	King's Agriseed	No
	Endurance	King's Agriseed	No
	Extend	Seedway	No
	Niva	King's Agriseed	Yes
Timothy	Barpenta	Barenbrug	No
	Clair	King's Agriseed	No
	Climax	King's Agriseed	Yes
	Crest	Seedway	No
Red Clover	Freedom	Barenbrug	Yes

The soil type at the Alburgh location was a Benson rocky silt loam (Table 2). The seedbed was moldboard plowed, disked, and finished with a spike tooth harrow. The previous crop was winter wheat. Plots were 5' x 20'and replicated 5 times. Plots were harvested with a carter forage harvester in 3' x 20' area on 2-Jun, 20-Jul, and 7-Sep. Due to equipment issues during the third harvest, the remainder of the trial was harvested on 15-Sep with a small scale sickle bar mower in a 5' x 20' area. At the first harvest, an additional sample was collected from a $0.25m^2$ area from each clover treatment plot. These samples were sorted into grass and clover fractions which were weighed and then dried to determine botanical composition of the treatments. After each harvest, the soil in each plot was analyzed for nitrate content.

Table 2. Perennial forage trial management, Alburgh, VT, 2015 and 2016.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Winter wheat
Tillage operations	Moldboard plow, disk and spike tooth harrow
Planting equipment	Great Plains small plot drill
Treatments	32
Replications	5
Plot size (ft.)	5 x 20
Planting date	1-May, 2015
Harvest dates (2016)	2-Jun, 20-Jul, 7-Sep/15-Sep

An approximate 1 lb subsample of the harvested material was collected and dried to calculate dry matter yield and forage quality. Forage quality was analyzed using the FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Dried and coarsely-ground plot samples were brought to the lab where they were reground using a cyclone sample mill (1mm screen) from the UDY Corporation. The samples were then analyzed using the FOSS NIRS DS2500 for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), 48-hour digestible NDF (NDFD), and total digestible nutrients (TDN).

Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the CP content of forages. 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. Forage feeding values are negatively associated with fiber 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, 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.

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 hybrids 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. Hybrids that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In this example, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Hybrid	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. 2016 weather data for Alburgh, VT.

	2015		2016								
	November	December	January	February	March	April	May	June	July	August	September
Average temperature (°F)	42.2	37.6	22.7	23.2	33.9	39.8	58.1	65.8	70.7	71.6	63.4
Departure from normal	4.0	11.7	4.0	1.6	2.9	-4.9	1.8	0.0	0.1	2.9	2.9
Precipitation (inches)	1.8	3.5	1.3	3.6	2.5	2.6	1.5	2.8	1.8	3.0	2.5
Departure from normal	-1.30	1.13	-0.74	1.81	0.29	-0.26	-1.92	-0.88	-2.37	-0.93	-1.17
Growing Degree Days (base 41°F)	162	78	6	15	88	154	543	745	919	942	681
Departure from normal	93	78	6	15	70	-52	68	1	1	82	95

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.

From November 2015 after the last mowing, through September 2016 after the final harvest, there were an accumulated 4333 Growing Degree Days (GDDs), at a base temperature of 41° F. This is 526 more than the long term average. Temperatures through the winter months were above normal, especially in December which was 11.7 degrees above the normal. Following a dry summer, precipitation finally returned in December with 1.13 inches above normal. February also saw above normal precipitation. Late spring and early summer started another stretch of droughty conditions although less severe than 2015. Precipitation remained below normal through the rest of the growing season with 7.5 inches fewer inches of rain from April-September.

Impact of Species

The four grass species trialed differed significantly in terms of yield and their ability to grow with red clover in a balanced mixture (Table 4). Brome, orchardgrass, and timothy all had similar grass and clover quantities to one another and were very close to a 50:50 mixture of grass and clover. Meadow fescue, however, had a significantly higher proportion of grass when mixed with clover with an average of 62.4%. This indicates that the meadow fescue was more dominant over the clover while establishing than the other grass species.

Table 4. Composition of grass/clover mixtures by species, 1st cut 2016.

Species	Grass %	Clover %
Brome	**46.2**	**53.8**
Meadow Fescue	62.4	37.6
Orchardgrass	52.9*	47.1*
Timothy	51.0*	49.0*
LSD (*p*=0.10)	8.13	8.13
Trial Mean	53.1	46.9

Treatments with an asterisk* performed similarly to the top performer in **bold.**

Overall, the species all performed very well in this second year all producing over 3 tons of dry matter per acre across three harvests (Table 5).

Table 5. Yield over three harvests by species, 2016.

Species	Dry matter yield			
	1st Cut	2nd Cut	3rd Cut	Total
	tons ac^{-1}			
Brome	1.04	**1.13***	**1.44**	3.61*
Meadow Fescue	1.05	0.877	1.31	3.23
Orchardgrass	0.935	0.916	1.30	3.15
Timothy	**1.20***	1.09*	1.37	**3.66***
LSD (*p*=0.10)	0.133	0.196	NS	0.333
Trial Mean	1.05	1.00	1.36	3.41

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Yields differed the most in the second harvest where brome and timothy produced slightly more dry matter per acre than their first harvest whereas meadow fescue and orchardgrass produced less. Timothy produced the highest overall yield of 3.66 tons of dry matter per acre with brome slightly below that at 3.61 tons. Orchardgrass produced the least with 3.15 tons of dry matter per acre.

Quality parameters also varied across species for the three harvests (Tables 6-8). At the first harvest, protein levels ranged from 17.1 to 17.9 with the highest level produced by brome. ADF, NDF, and ash content were also lowest (for ADF and NDF) and highest (for fat) in the brome although NDF did not statistically vary across species in this harvest. NDF digestibility averaged 31.8% but did not differ across species in this harvest.

Table 6. Quality by species 1st cut, 2016.

Species	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Brome	**17.9**	**30.3**	**51.6**	31.0	**6.67**	2.68
Meadow Fescue	17.1	31.0	52.1	32.0	7.02	2.68
Orchardgrass	17.2	30.7*	52.4	**32.6**	6.92	**2.98**
Timothy	17.1	31.3	53.1	31.8	6.91	2.64
LSD (*p*=0.10)	0.513	0.638	NS	NS	0.176	0.094
Cut Mean	17.3	30.9	52.3	31.8	6.88	2.75

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Protein levels increased by about 1% in the second harvest to range from 18.2 to 19.2% with the highest levels in the meadow fescue although not statistically different from the other species (Table 7). ADF and NDF content were also lowest in the meadow fescue, however NDF did not statistically differ across the species in this cut. NDF digestibility was highest in the orchardgrass with 32.4%.

Table 7. Quality by species 2nd cut, 2016.

Species	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Brome	18.8	29.8	50.6	29.2	7.44	2.80
Meadow Fescue	**19.2**	**28.8**	**49.3**	30.4	**7.71**	2.91
Orchardgrass	18.2	29.5*	51.0	**32.4**	7.54*	**3.29**
Timothy	18.2	30.2	50.8	29.0	7.35	2.77
LSD (*p*=0.10)	NS	0.743	NS	0.995	0.242	0.101
Cut Mean	18.6	29.6	50.4	30.2	7.51	2.93

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Species also differed in quality at the third harvest (Table 8). Protein ranged from 17.9% to 19.7% with the highest level produced by meadow fescue and the lowest by orchardgrass. ADF and NDF were also lowest in meadow fescue with 31.3% and 48.8% respectively. NDF digestibility and fat were highest in the orchardgrass with 32.0% and 3.15% respectively.

Table 8. Quality by species 3rd cut, 2016.

Species	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Brome	18.4	32.7	51.3	28.3	**8.80**	2.82
Meadow Fescue	**19.7**	**31.3**	**48.8**	29.4	8.98	2.86
Orchardgrass	17.9	33.4	53.1	**32.0**	8.84	**3.15**
Timothy	18.7	32.2	50.1	28.1	8.86	2.87
LSD (p=0.10)	0.660	0.601	1.11	0.844	NS	0.080
Cut Mean	18.7	32.4	50.8	29.4	8.87	2.93

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Impact of Variety

Varieties also performed differently in terms of yield across the three harvests (Table 9). Across the three harvests, AC Success brome performed the best compared to the other brome varieties producing almost 4 tons of dry matter per acre although not statistically different from the other varieties. Similarly, Preval meadow fescue and Endurance orchardgrass produced the highest yields of 3.40 and 3.29 tons per acre respectively but were not statistically different from the other varieties of their species. Timothy varieties varied much more. The highest yielding timothy variety was Clair with 4.37 tons of dry matter per acre, approximately 0.75 tons per acre more than the next highest variety Crest. It is interesting to note that Climax timothy and York smooth brome are varieties that have been widely used for many years yet both performed significantly worse than the other varieties of their species.

Table 9. Yield by variety at 1st, 2nd, and 3rd cuts, 2016.

Species	Variety	DM Yield tons ac^{-1} 1st cut	2nd cut	3rd cut	Overall
Brome	AC Success	**1.10**	1.05	**1.76**	**3.91**
	Carlton smooth	1.02	1.08	1.46*	3.57
	Hakari Alaska	1.05	**1.40**	1.35	3.79
	York smooth	0.982	0.969	1.21	3.16
	LSD (*p*=0.10)	NS	0.300	0.300	NS
	Species Mean	1.03	1.13	1.44	3.61
Meadow Fescue	HDR	0.875	0.813	**1.58**	3.27
	Laura	1.00*	**0.940**	1.14	3.08
	Liherold	1.13*	0.829	1.23	3.18
	Preval	**1.18**	0.926	1.30	**3.40**
	LSD (*p*=0.10)	0.209	NS	NS	NS
	Species Mean	1.05	0.877	1.31	3.23
Orchardgrass	Echelon	0.821	0.857	1.41	3.08
	Endurance	0.929	0.904	**1.46**	**3.29**
	Extend	0.905	0.896	1.28	3.08
	Niva	**1.08**	**1.01**	1.07	3.16
	LSD (*p*=0.10)	NS	NS	NS	NS
	Species Mean	0.935	0.916	1.30	3.15
Timothy	Barpenta	1.01	0.999	**1.48**	3.50
	Clair	**1.53**	**1.47**	1.37	**4.37**
	Climax	1.07	0.840	1.23	3.14
	Crest	1.18	1.06*	1.39	3.64
	LSD (*p*=0.10)	0.240	0.411	NS	0.556
	Species Mean	1.20	1.09	1.37	3.66

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Impact of clover

In every cut, regardless of species, the addition of clover (Image 1) always increased the dry matter yield (Table 10). Clover added on average .25 to .50 tons per acre dry matter to each cutting. The largest differences were observed in the second harvest where increases over 0.50 tons per acre were seen for three of the four species.

Table 10. Yield by species and clover across three cuts, 2016.

Species	1st Cut		2nd Cut		3rd Cut	
	Grass only tons ac^{-1}	Grass with clover tons ac^{-1}	Grass only tons ac^{-1}	Grass with clover tons ac^{-1}	Grass only tons ac^{-1}	Grass with clover tons ac^{-1}
Brome	0.978	1.10	0.863	1.39	1.40	1.49
Meadow Fescue	0.792	1.30	0.543	1.21	1.13	1.50
Orchardgrass	0.821	1.05	0.719	1.11	1.28	1.33
Timothy	1.11	1.29	0.787	1.40	1.22	1.52
LSD (*p*=0.10)	0.165	0.182	0.199	NS	NS	NS
Trial Mean	0.924	1.18	0.728	1.28	1.26	1.46

NS - No significant difference.

Across all three harvests significant increases in dry matter yield due to the addition of clover were observed (Table 11). Yields increased by over 1 ton for timothy and meadow fescue with meadow fescue seeing the highest increase of 1.5 tons per acre.

Table 11. Yield across all cuts by species with and without clover.

Species	**DM Yield** tons ac^{-1}
Brome	3.2
with clover	**4.0**
LSD (*p*=0.10)	0.436
Species Mean	3.6
Meadow Fescue	2.5
with clover	**4.0**
LSD (*p*=0.10)	0.342
Species Mean	3.2
Orchardgrass	2.8
with clover	**3.5**
LSD (*p*=0.10)	0.305
Species Mean	3.2
Timothy	3.1
with clover	**4.2**
LSD (*p*=0.10)	0.438
Species Mean	3.66

Image 1. Visual difference between grass-only (left) and grass-clover plots

The addition of clover also influenced the quality of the feed harvested across the three harvests (Tables 12-14). Statistical analyses have not fully been completed and will be updated as soon as possible.

Table 12. Quality by species and clover treatment 1st cut, 2016.

Species	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Brome	16.1	31.8	57.4	36.1*	**6.34***	2.97
with clover	**19.7***	**28.8***	**46.1***	25.9	6.99	2.39
Meadow Fescue	15.4	31.8	55.5	35.4*	6.77	2.94
with clover	18.9	30.3	48.8*	28.6	7.28	2.43
Orchardgrass	16.3	31.5	56.0	**36.1***	6.81	**3.28***
with clover	18.0	30.0	48.9*	28.7	7.04	2.69
Timothy	15.8	32.2	56.9	35.4*	6.75	2.89
with clover	18.4	30.4	49.3*	28.2	7.07	2.39
LSD (p=0.10)	0.725	0.902	1.92	1.56	0.248	0.133
Cut Mean	17.3	30.9	52.3	31.8	6.88	2.75

Treatments with an asterisk* performed similarly to the top performer in **bold.**

Table 13. Quality by species and clover treatment 2nd cut, 2016.

Species	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Brome	**19.7**	29.1	52.2	32.1	7.58	3.11
with clover	17.9	30.6	49.1	26.2	7.31	2.49
Meadow Fescue	19.8	**27.9***	49.8	32.6	7.82	3.15
with clover	18.6	29.8	48.9*	28.2	7.61	2.67
Orchardgrass	18.7	29.0	52.8	**35.3***	7.58	**3.54***
with clover	17.7	29.9	49.2	29.4	7.51	3.05
Timothy	18.4	29.6	53.3	33.0	**7.24**	3.13
with clover	18.0	30.8	**48.3***	25.1	7.46	2.41
LSD (p=0.10)	NS	1.05	1.77	1.41	NS	0.143
Cut Mean	18.6	29.6	50.2	30.2	7.51	2.94

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Table 14. Quality by species and clover treatment 3rd cut, 2016.

Species	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Brome	18.3	33.0	54.0	31.6	8.96	3.10
with clover	18.5	32.5	48.6*	25.1	**8.63***	2.55
Meadow Fescue	**20.5***	**30.6***	49.8	32.2	9.15	3.17
with clover	19.0	32.0	47.7*	26.6	8.80*	2.56
Orchardgrass	18.3	33.4	54.9	**34.6***	9.00	**3.35***

with clover	17.5	33.4	51.3	29.4	8.67*	2.96
Timothy	18.7	32.0	52.5	31.5	8.90	3.17
with clover	18.7	32.4	**47.6***	24.6	8.82*	2.56
LSD (p=0.10)	0.934	0.850	1.56	1.19	0.265	0.114
Cut Mean	18.7	32.4	50.8	29.4	8.86	2.93

Treatments with an asterisk* performed similarly to the top performer in **bold.**

In the first cutting, protein was significantly increased by the addition of clover (Table 15). This also contributed to lower ADF and NDF values, however NDF digestibility, ash and fat content were all better in grass only treatments for this cutting.

Table 15. Quality by clover treatment 1st cut, 2016.

Clover	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Yes	**18.8**	**29.9**	**48.3**	27.8	7.10	2.48
No	15.9	31.8	56.4	**35.7**	**6.67**	**3.02**
LSD (*p*=0.10)	0.363	0.451	0.957	0.778	0.124	0.067
Cut Mean	17.3	30.9	52.3	31.8	6.88	2.75

Treatments with an asterisk* performed similarly to the top performer in **bold.**

In the second cutting, the grass-only treatment outperformed the mixed treatment except for NDF content (Table 16). The mixed treatment produced forage with 3.2% lower NDF than the grass only treatment.

Table 16. Quality by clover treatment 2nd cut, 2016.

Clover	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Yes	18.0	30.3	**48.8**	27.2	7.47	2.65
No	**19.1**	**28.9**	52.0	**33.2**	**7.55**	**3.23**
LSD (*p*=0.10)	0.706	0.526	0.884	0.704	NS	0.071
Cut Mean	18.6	29.6	50.4	30.2	7.51	2.94

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Similarly, in the third cutting the grass-only treatment outperformed the mixed treatment with the exception of NDF and ash content which were significantly lower in the mixed treatment (Table 17).

Table 17. Quality by clover treatment 3rd cut, 2016.

Clover	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Yes	18.4	32.6	**48.8**	26.4	**8.73**	2.66
No	**18.9**	**32.2**	52.8	**32.5**	9.00	**3.20**
LSD (*p*=0.10)	0.467	NS	0.782	0.597	0.132	0.057
Cut Mean	18.7	32.4	50.8	29.4	8.87	2.93

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

Overall across the three harvests, the mixed treatment produced forage with higher protein and lower ADF and NDF while the grass-only treatments had higher NDF digestibility and fat (Table 18). The ash content was similar between the treatments.

Table 18. Quality by clover treatment across all cuts, 2016.

Clover	Crude protein	ADF	NDF	NDFD	Ash	Fat
	% of DM	% of DM	% of DM	% of NDF	% of DM	% of DM
Yes	**18.4**	**30.9**	**48.6**	27.1	7.77	2.60
No	18.0	31.0	53.7	**33.8**	**7.74**	**3.15**
LSD (*p*=0.10)	0.348	NS	0.551	0.437	NS	0.040
Trial Mean	18.2	30.9	51.2	30.5	7.75	2.87

Treatments with an asterisk* performed similarly to the top performer in **bold.**
NS - No significant difference.

DISCUSSION

Overall, timothy and brome yielded the highest producing over 3.66 and 3.60 tons of dry matter per acre respectively. Brome produced the highest quality forage in the first cut while meadow fescue outperformed the others in the second and third cuts. Minor differences in yield were observed across varieties within a species for all species except for timothy where Clair produced about 0.75 tons per acre more dry matter than the next best timothy variety. Interestingly, this was similar to the performance of AC Success and York smooth brome; both Clair and York smooth brome are varieties that have been widely used for years whereas these other varieties, Clair and AC Success, are newer improved forage varieties of these grass species. These observations demonstrate the importance of this and other related works. This report will be updated as statistical analyses are completed.

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