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Feeding Legumes to Organic Dairy Cows

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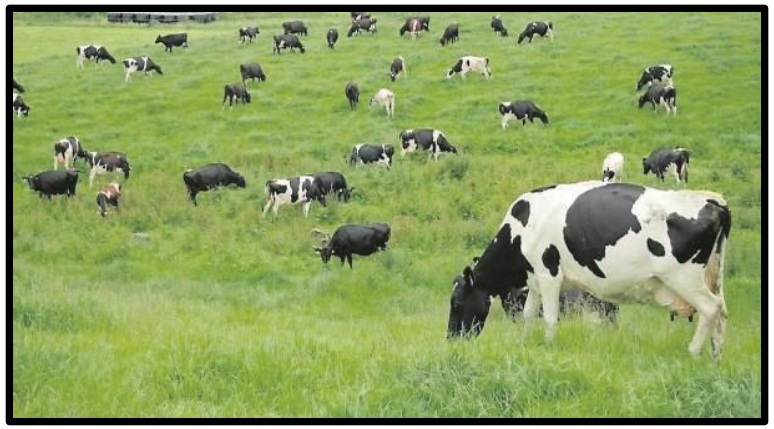
Pasture net energy of lactation (NE_L) in northeastern organic dairies

Table 2. Summary statistics (n = 380) of forage quality parameters and macro minerals and the effect of year, month, and farm on forage quality and macro mineral concentration of pastures in 2012, 2013, and 2014

					P-value		
Item	Mean[1]	SD[1]	Min[1]	Max[1]	Year	Month	Farm
Forage quality							
CP, %	19.5	4.10	6.60	32.4	0.25	<0.01	<0.01
ADF, %	31.4	4.79	18.0	73.0	0.75	<0.01	<0.01
NDF, %	51.0	8.67	24.2	71.0	<0.01	<0.01	<0.01
NE_L, Mcal/kg	1.39	0.15	0.77	1.76	0.03	<0.01	<0.01
Macro minerals[2]							
Ca, %	0.76	0.25	0.19	1.66	<0.01	<0.01	<0.01
P, %	0.36	0.08	0.07	1.04	0.23	<0.01	<0.01
Mg, %	0.28	0.06	0.10	0.46	<0.01	<0.01	<0.01
K, %	2.68	0.60	0.26	4.69	0.02	0.03	<0.01
S, %	0.28	0.05	0.09	0.44	0.14	<0.01	<0.01

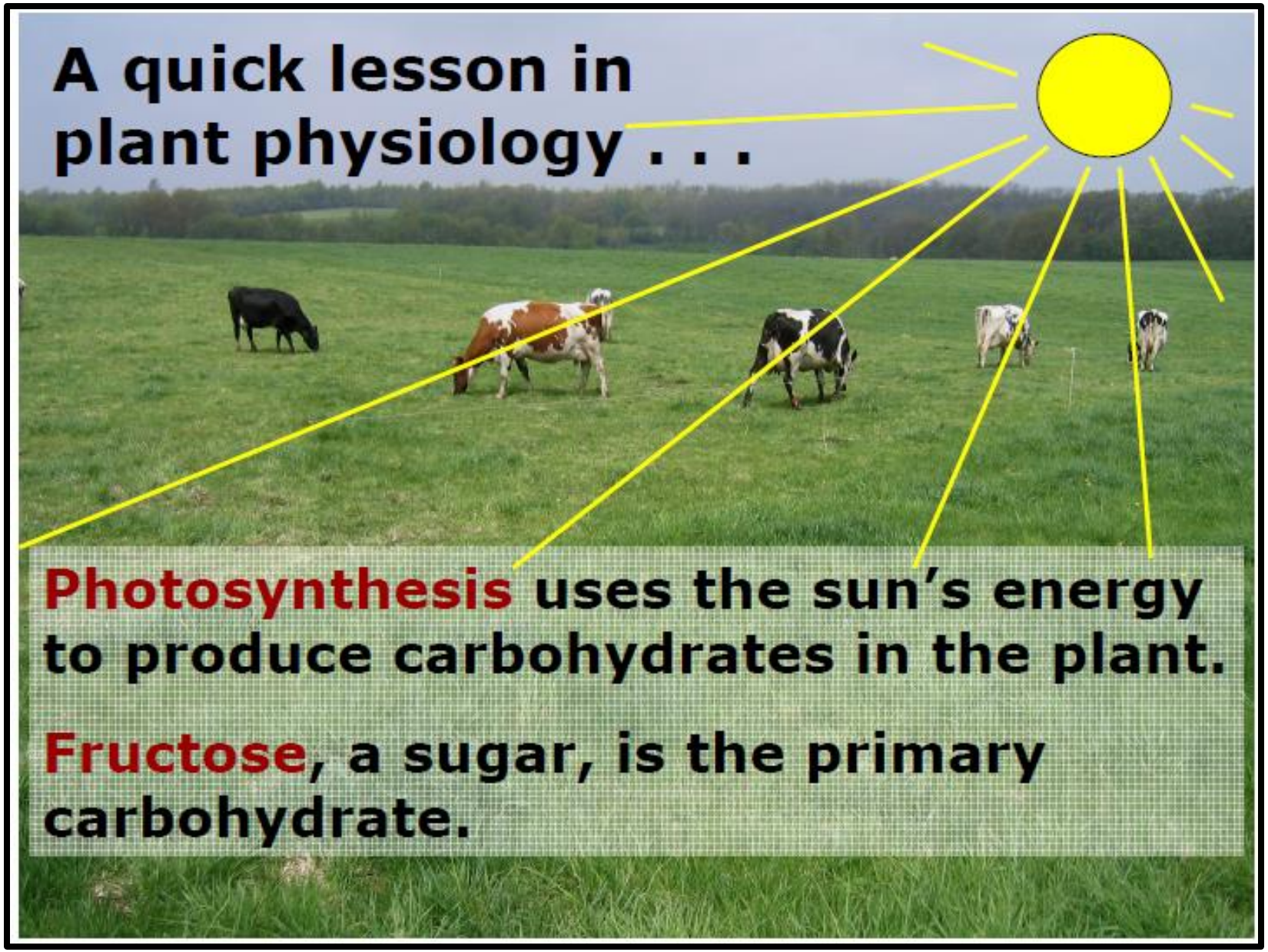
[1]Mean, SD, minimum (Min), and maximum (Max) values across all farms and all months sampled in 2012, 2013, and 2014.

[2]Near-infrared reflectance spectroscopy analysis for sodium was missing on many samples; therefore, it is not included.



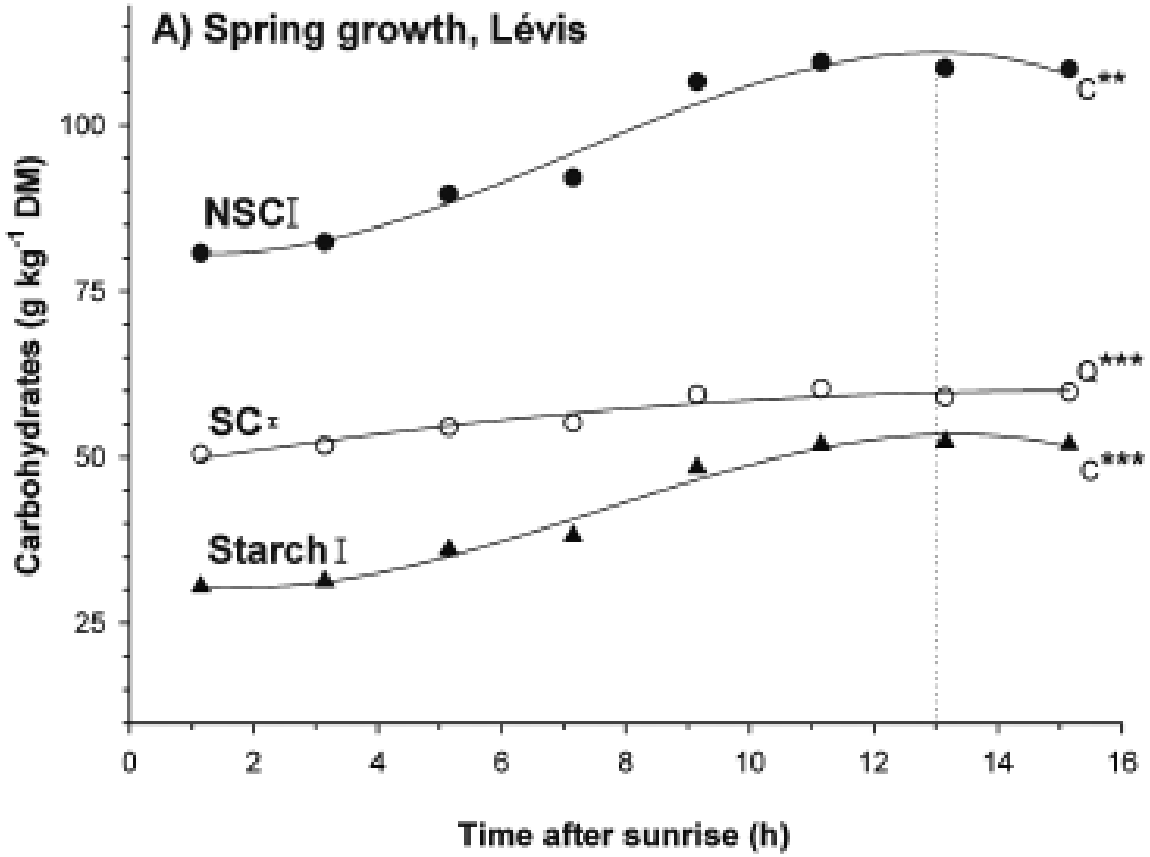
NE_L
Mean = 0.63 Mcal/lb
Minimum = 0.35 Mcal/lb
Maximum = 0.80 Mcal/lb

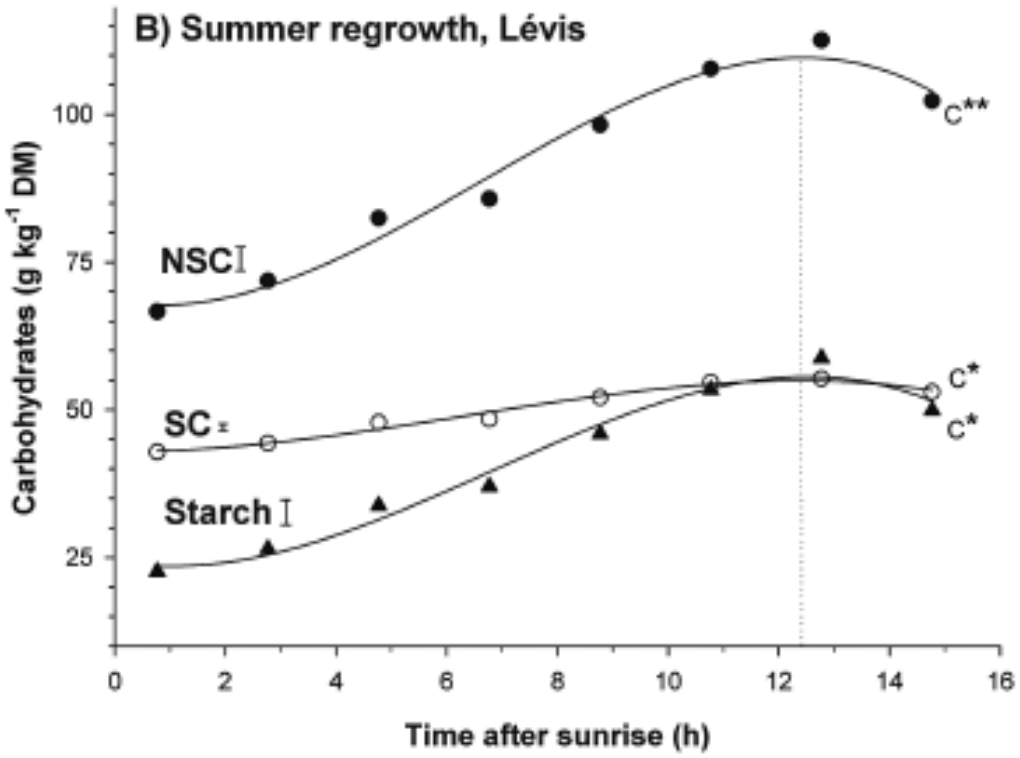
Source: Hafla et al. (2016)



Source: Brink

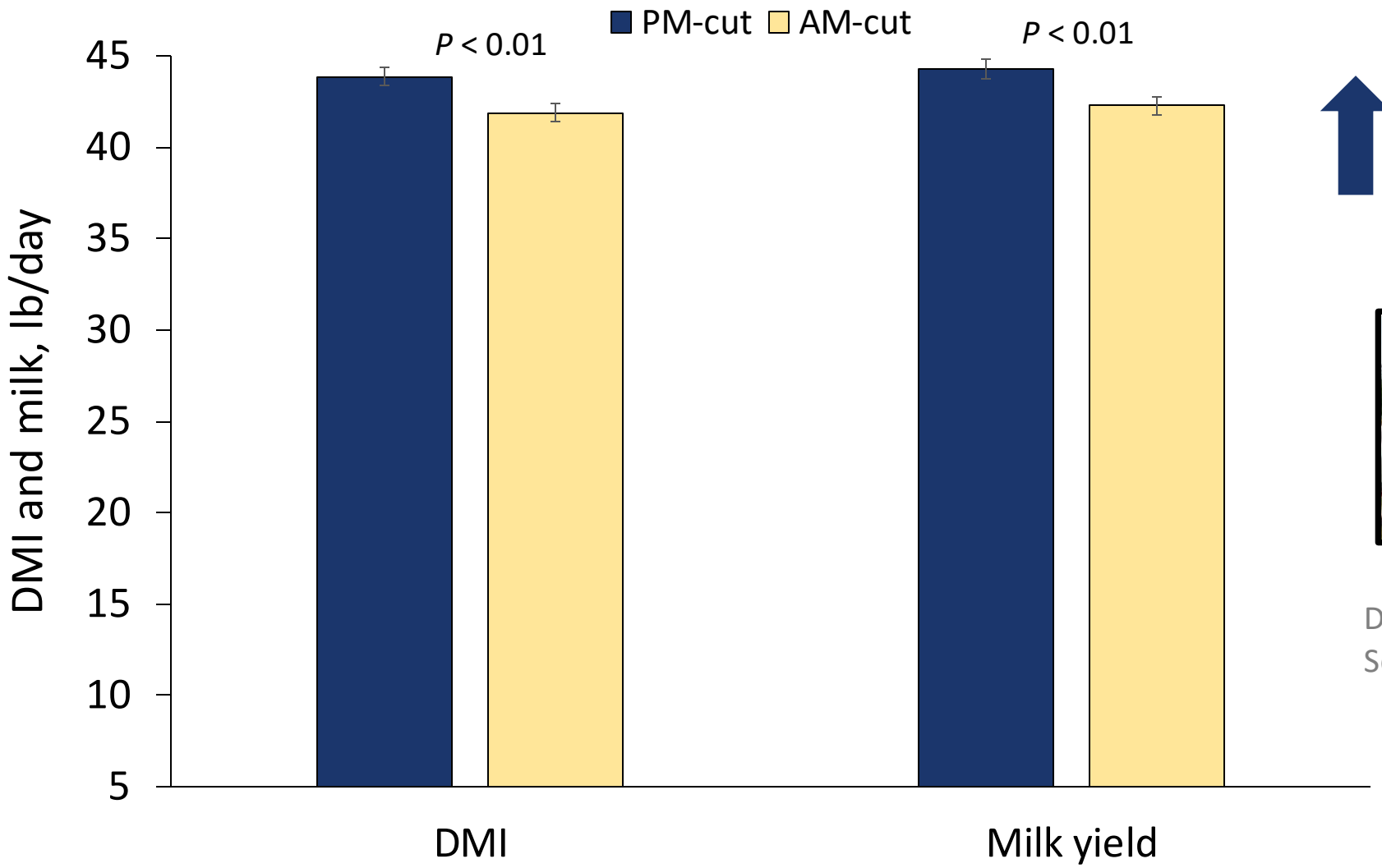
Diurnal variation in sugars and starch in alfalfa





NSC = non-structural carbohydrates
SC = soluble carbohydrates
Source: Pelletier et al. (2010)

Increased intake and milk production in cows fed PM-cut alfalfa baleage

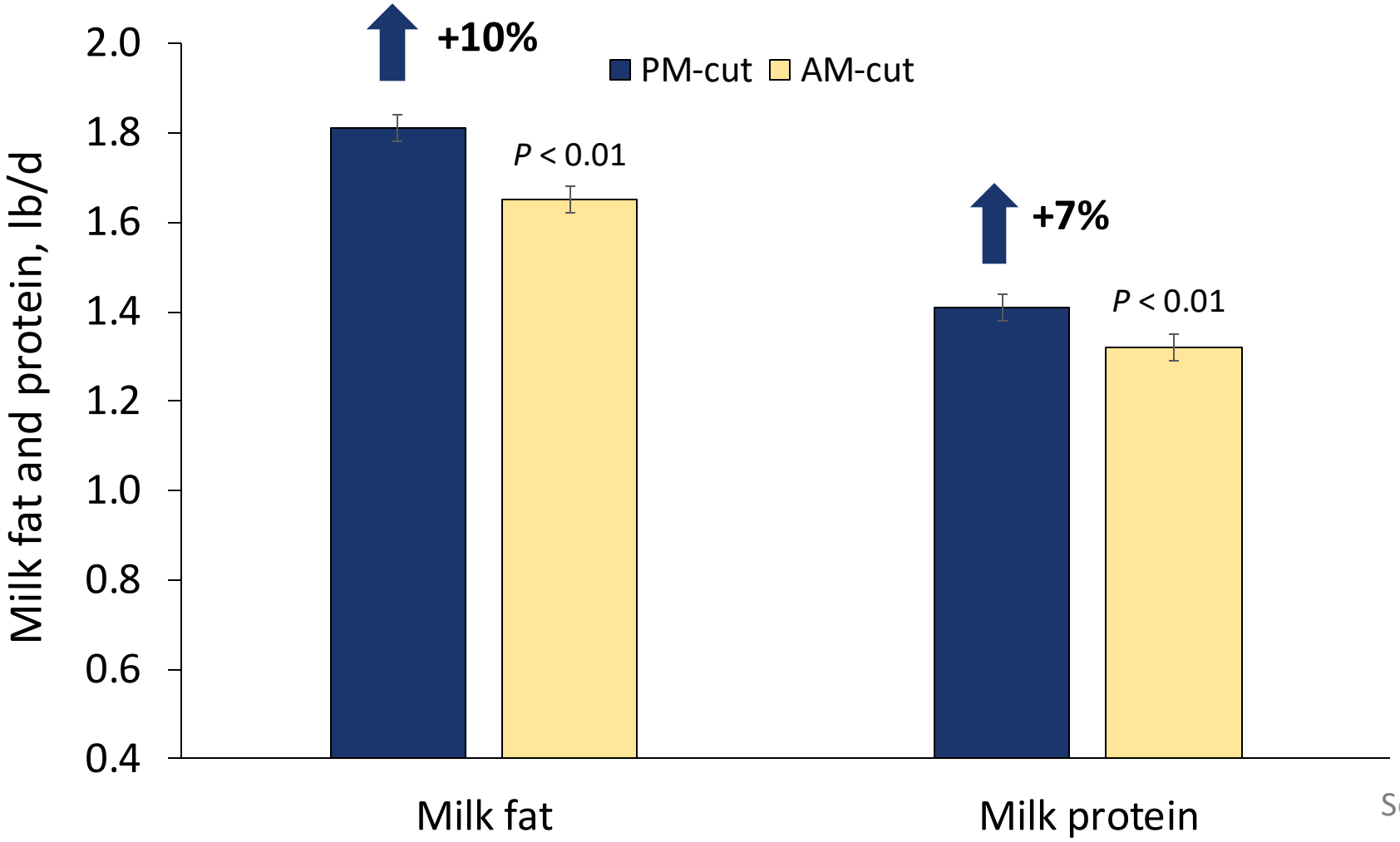


+5% overall

DMI = dry matter intake

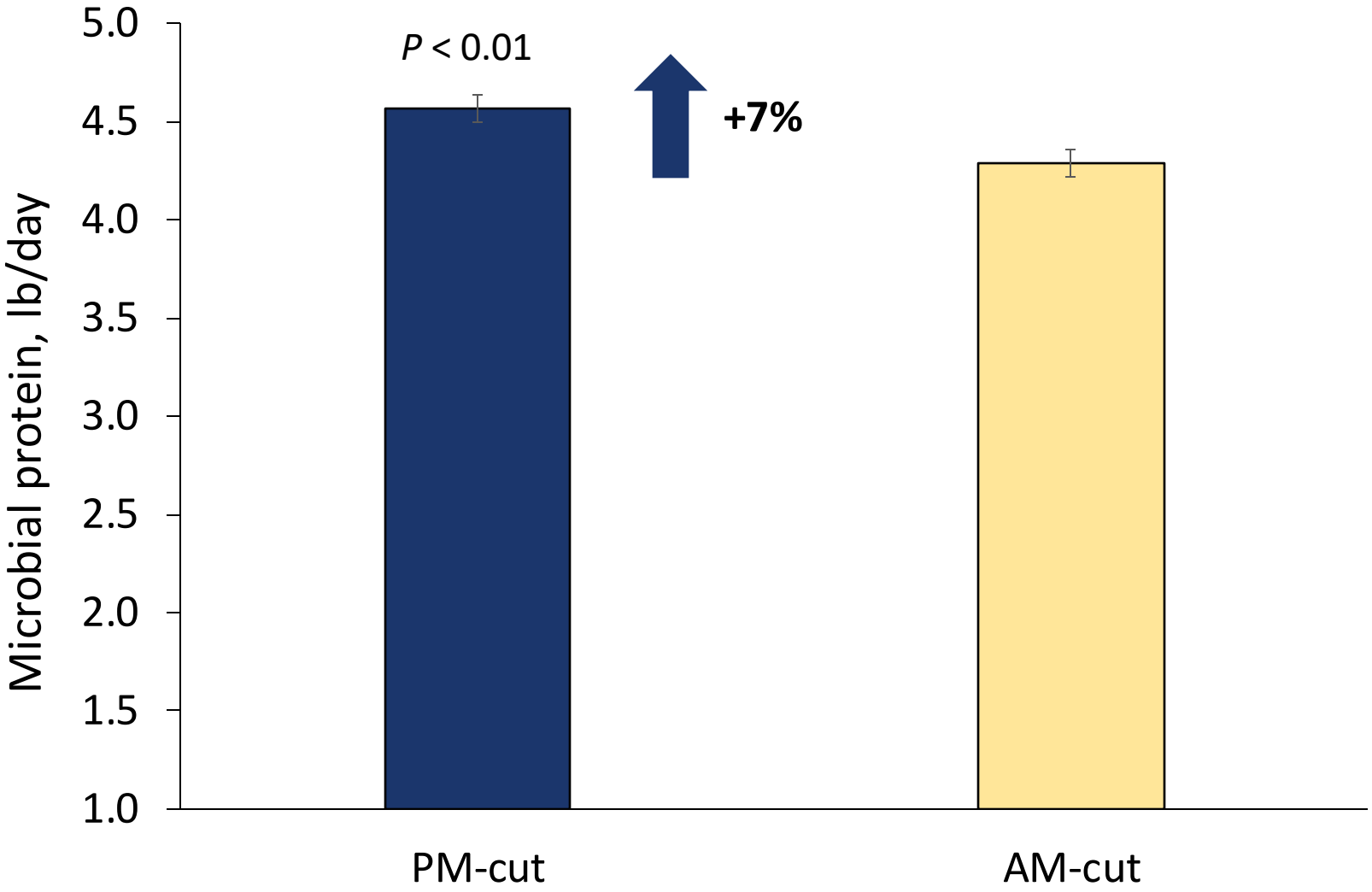
Source: Brito et al. (2008)

Increased milk fat and protein production in cows fed PM-cut alfalfa baleage



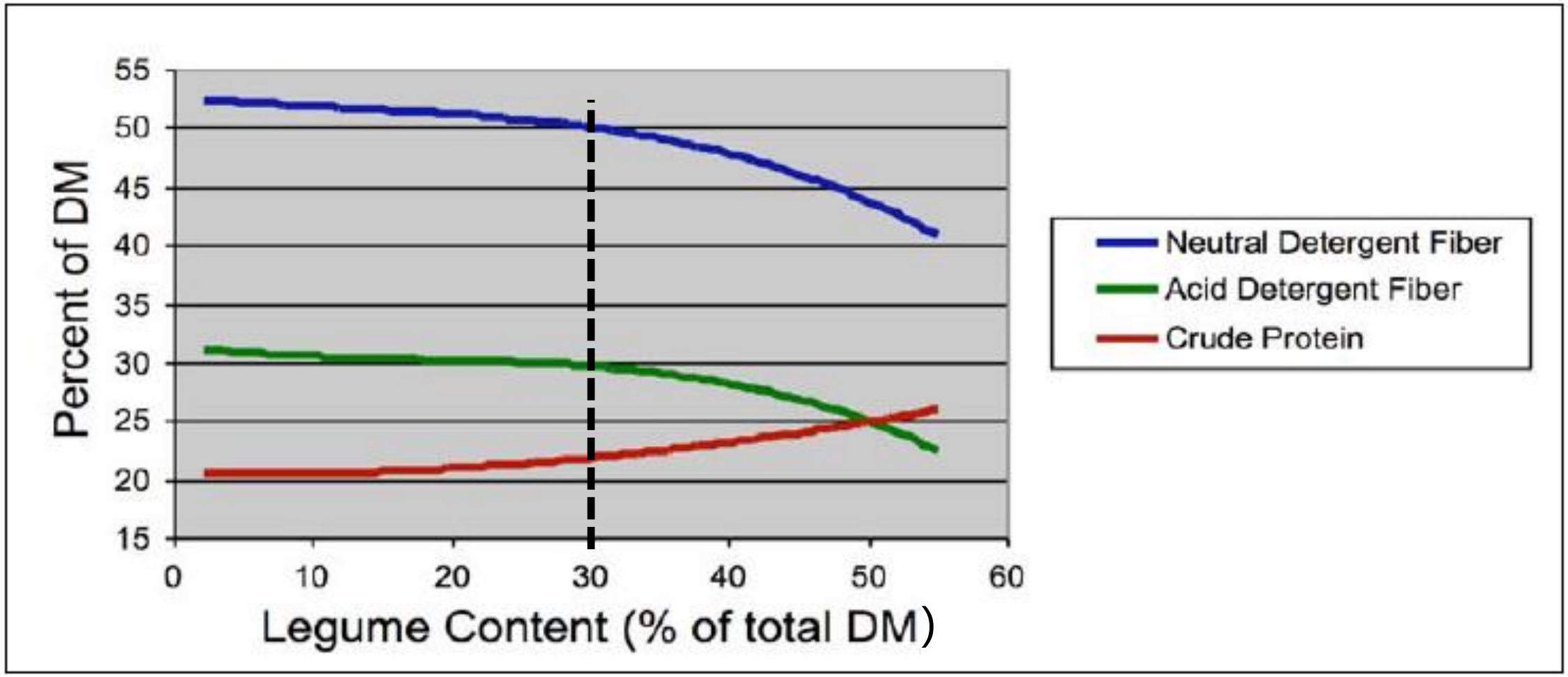
Source: Brito et al. (2008)

Increase microbial protein in cows fed PM-cut alfalfa baleage



Source: Brito et al. (2008)

Relationship between legume proportion in pasture and forage quality traits



Source: Bosworth and Cannella (2007)

Pasture botanical composition in northeastern organic dairies

Table 3. Pasture availability and botanical composition of participating farms in the northeastern United States during the 2012, 2013, and 2014 grazing seasons

				P-value	
Item	**2012 (SEM)**	**2013 (SEM)**	**2014 (SEM)**	**Year**	**Month × year**
Pasture availability, kg/ha	1,320 (185)	1,048 (151)	871 (161)	<0.01	0.01
Botanical composition, %					
Grasses	61 (6)	54 (6)	50 (6)	0.04	0.16
Legumes	22 (5)	29 (4)	37 (5)	<0.01	0.07
Weeds	13 (3)	13 (2)	15 (3)	0.68	0.49

Source: Hafla et al. (2018)

Effect of forage type on feed intake and milk production

	Forage type					
Item	Grasses	White clover	Red clover	Alfalfa	Birdsfoot	*P*-value
Dry matter intake, lb/d	41.7^{b}	44.1^{ab}	44.1^{a}	46.3^{a}	48.1^{ab}	<0.001
Milk production, lb/d	57.8^{c}	65.3^{a}	60.2^{b}	61.1^{b}	69.2^{a}	<0.001
Energy-corrected milk, lb/d	56.7^{d}	61.9^{ab}	57.5^{cd}	59.5^{bc}	67.0^{a}	<0.001
Feed efficiency[1], lb/lb	1.35	1.39	1.31	1.30	1.43	0.07
OM digestibility[2], %	71.5^{ab}	73.6^{a}	69.4^{b}	66.0^{c}	67.2^{abc}	<0.001

^{a,b,c,d}Values in same line with different letters differ at $P < 0.05$

[1]Feed efficiency = energy-corrected milk/dry matter intake

[2]OM = organic matter

Source: Johansen et al. (2018)

Developing advanced perennial legume-grass mixtures harvested as stored feeds to improve herd productivity and mitigate greenhouse gas emissions in organic dairies in the Northeast

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National Institute of Food and Agriculture

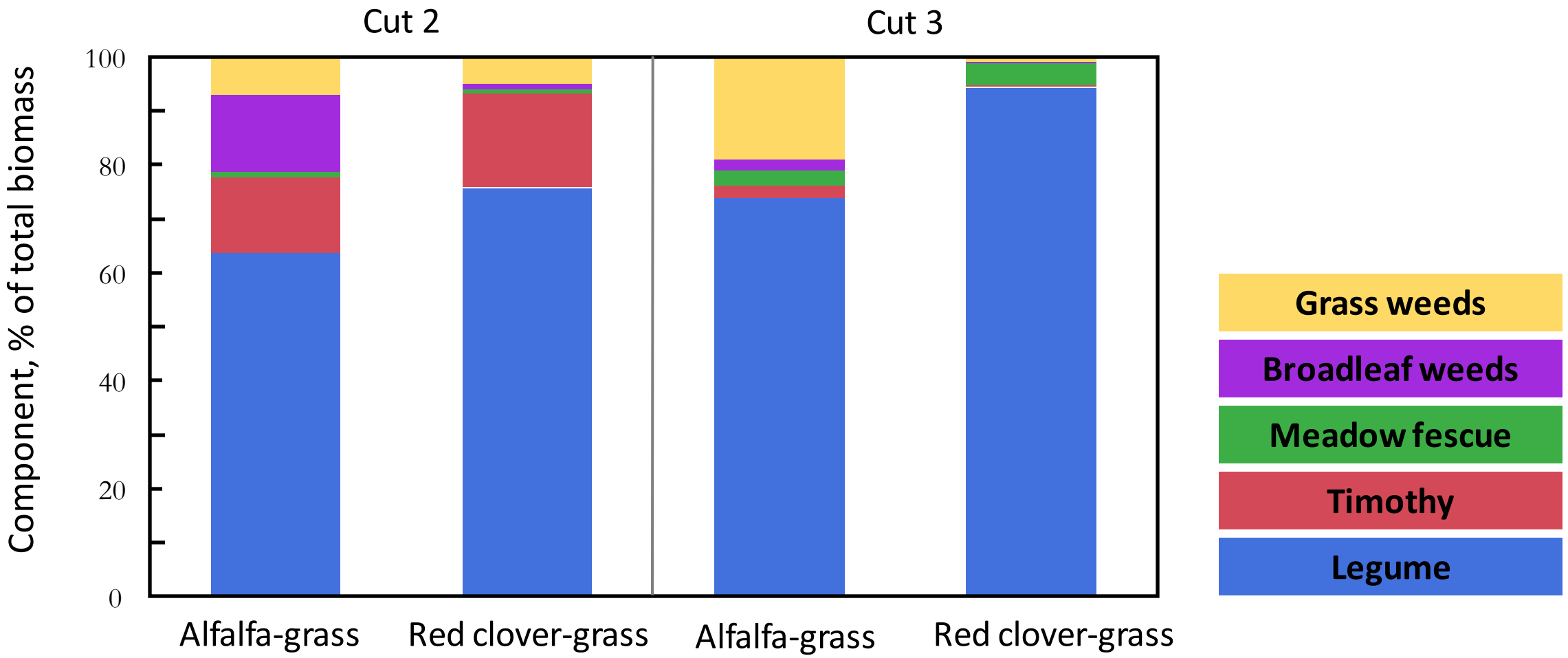
University of New Hampshire Organic Dairy Research Farm

- Area (111.3 ha): **48.6 ha (woodland), 40.5 ha (hayfields), and 22.3 ha (pasture)**
- ~45 lactating cows: **pure-bred Jerseys**
- Rolling herd average: **6,473 ± 503 kg**
- Milk fat: **4.88 ± 0.09**
- Milk protein: **3.63 ± 0.06**
- Milk SCC: **135,000**
- MUN: **11.1 ± 2.9 mg/dL**
- Grazing season: **40% pasture + 60% TMR**
- Winter season: **TMR (60% baleage + 40% concentrate)**

Feeding trial 1 methods

- Twenty organic-certified mid-lactation Jersey cows were used
- Cows (n = 10/treatment) were randomly assigned to 1 out 2 diets fed as TMR: **(1) alfalfa- or (2) red clover-grass mix**
- Completely randomized block design with a 2-week covariate/baseline period and 7 weeks of measurements including daily intake (Calan gates) and milk production
- Samples were taken during weeks 4 and 7
- Methane emissions were measured throughout the 9-week study using the GreenFeed system

Botanical composition of alfalfa- and red clover-grass fields by cutting



Nutritional composition of baleages

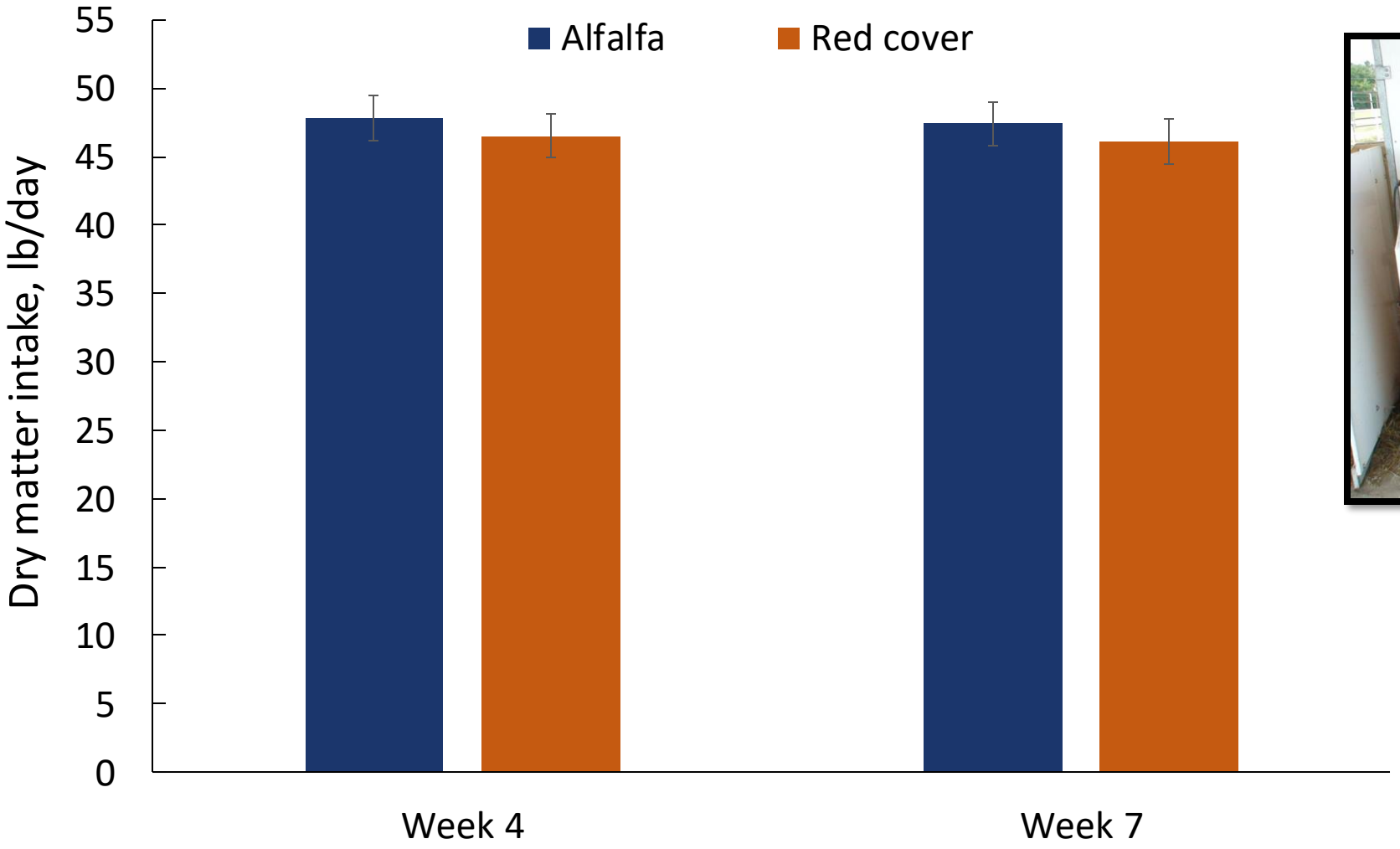
Item	Baleage[1]			
	ALF-GR, 2nd cut	ALF-GR, 3rd cut	RC-GR, 2nd cut	RC-GR, 3rd cut
Dry matter (DM), % as fed	42.7	48.9	75.7	32.3
Crude protein (CP), % DM	20.9	21.8	20.1	20.5
Soluble CP, % CP	63.0	62.0	25.5	40.5
aNDFom, % DM	41.0	41.3	41.6	42.1
ADF, % DM	31.7	33.1	29.9	33.7
Lignin, % DM	6.05	7.25	5.05	7.95
Starch, % DM	2.60	1.75	1.40	0.85
Sugars, % DM	4.95	3.05	6.90	4.05
Crude fat, % DM	3.20	3.65	3.75	3.35
NE_L, Mcal/lb	0.63	0.60	0.68	0.57

[1]ALF-GR = alfalfa-grass mix; RC-GR = red clover-grass mix

Experimental diets

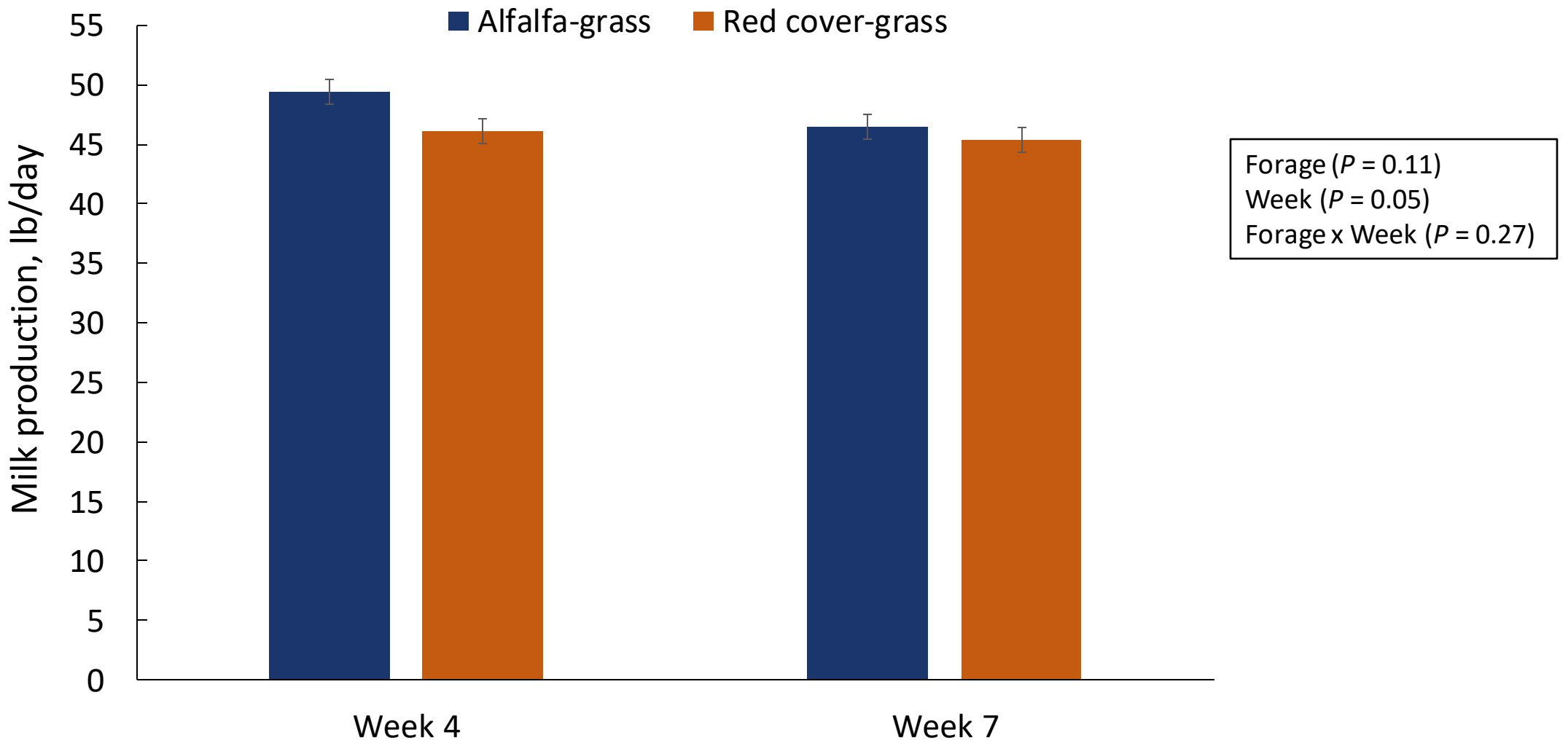
Item	Diets	
	Alfalfa-grass mix	Red clover-grass mix
	----------% of diet dry matter (DM)----------	
Alfalfa-grass mix, 2nd cut baleage	32.5	-
Red clover-grass mix, 2nd cut baleage	-	32.5
Alfalfa-grass mix, 3rd cut baleage	32.5	
Red clover mix, 3rd cut baleage	-	32.5
Grain mash	35.0	35.0
Crude protein, % DM	18.8	18.1
aNDFom, % DM	30.1	30.5

Dry matter intake in cows fed alfalfa- or red clover-grass mix



Forage (P = 0.21)
Week (P = 0.66)
Forage x Week (P = 0.93)

Milk production in cows fed alfalfa- or red clover-grass mix



Milk composition in cows fed alfalfa- or red clover-grass mix

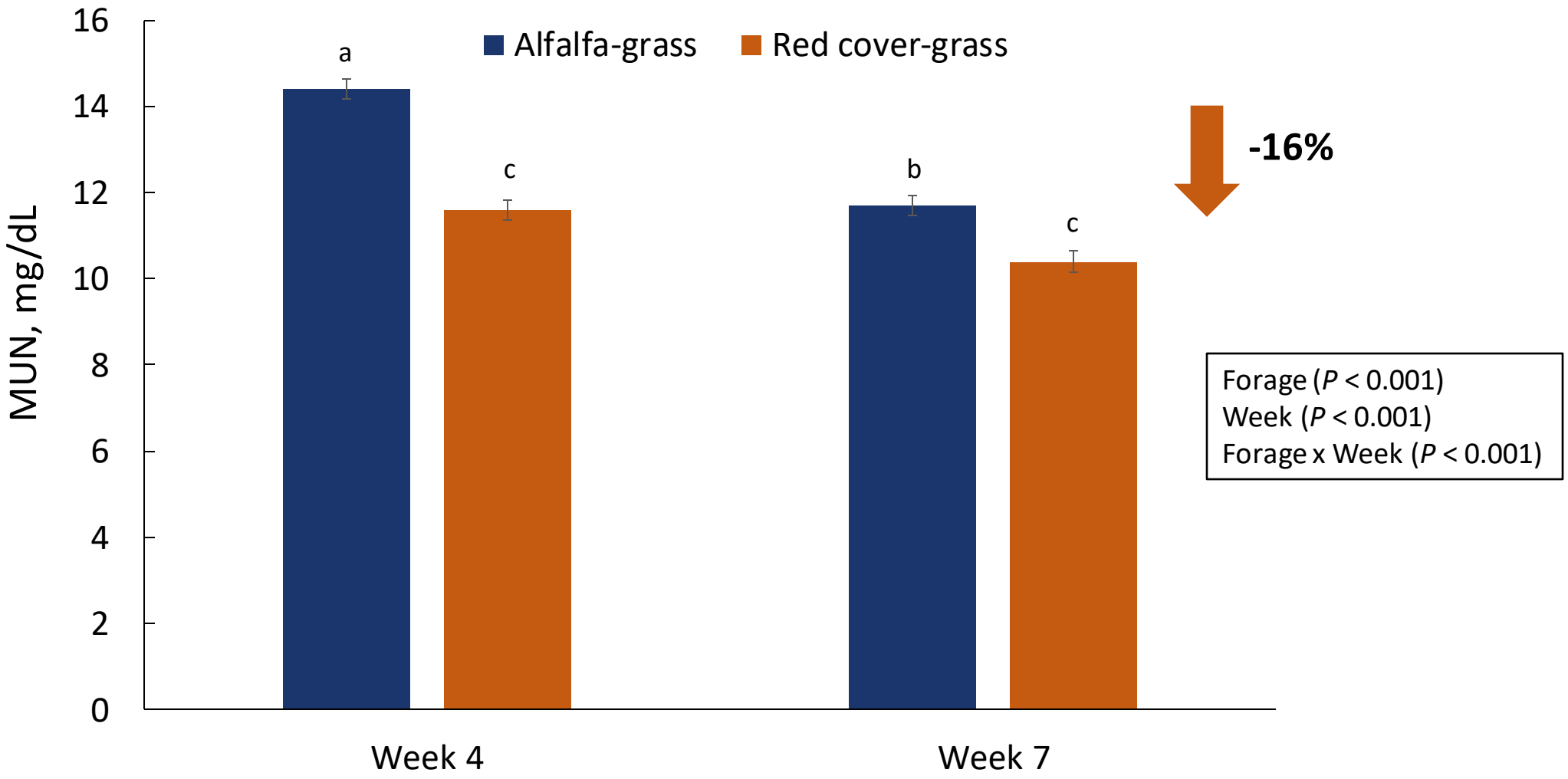
	Week 4		Week 7			*P*-value		
Item	ALF-GR[1]	RC-GR[1]	ALF-GR[1]	RC-GR[1]	SEM[2]	Forage	Week	Forage × Week
Milk fat, %	5.61	5.32	5.36	5.27	0.10	0.18	0.03	0.13
Milk fat, lb/day	2.78	2.45	2.49	2.38	0.09	0.05	0.02	0.13
Milk protein, %	3.64	3.57	3.73	3.60	0.10	0.48	0.19	0.44
Milk protein, lb/day	1.79	1.65	1.72	1.63	0.07	0.21	0.18	0.40
Milk lactose, %	4.72	4.73	4.66	4.71	0.02	0.23	0.10	0.55
Milk lactose, lb/day	2.31	2.18	2.16	2.14	0.04	0.21	0.03	0.23

+9.1%

[1]ALF-GR = alfalfa-grass mix; RC-GR = red clover-grass mix

[2]SEM = standard error of the mean

Milk urea nitrogen (MUN) in cows fed alfalfa- or red clover-grass mix

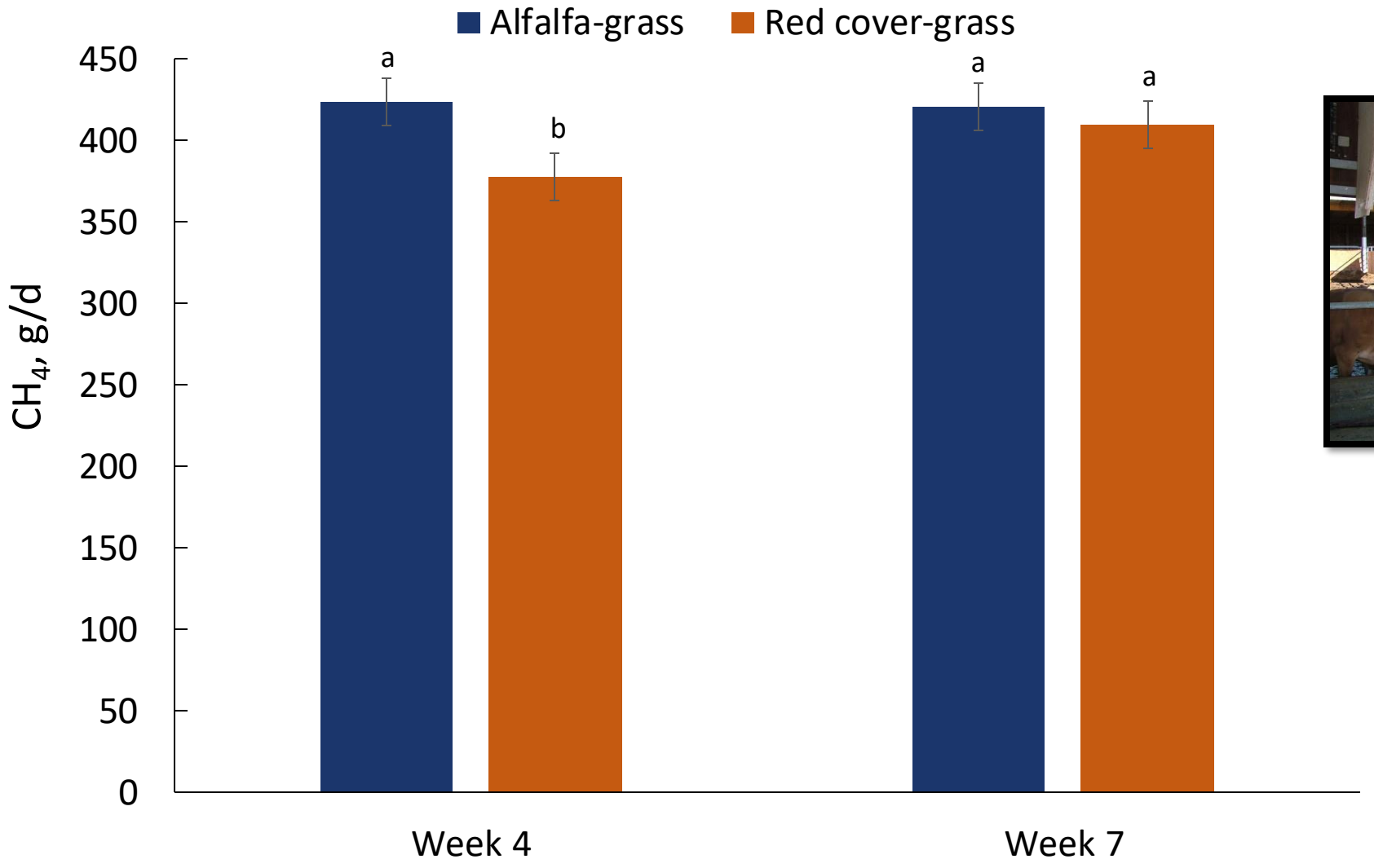


Milk fatty acids (FA) in cows fed alfalfa- or red clover-grass mix

FA, g/100 g	Week 4		Week 7			*P*-value		
	ALF-GR[1]	RC-GR[1]	ALF-GR[1]	RC-GR[1]	SEM[2]	Forage	Week	Forage × Week
trans-10 18:1	0.15	0.19	0.19	0.21	0.01	0.01	<0.01	0.38
trans-11 18:1	1.12	1.15	1.20	1.20	0.07	0.92	0.02	0.58
cis-9, *trans*-11 18:2 CLA	0.42	0.39	0.46	0.42	0.03	0.37	<0.01	0.67
α-Linolenic acid (ω-3)	0.67^{c}	0.85^{a}	0.61^{b}	0.87^{a}	0.03	<0.01	0.05	<0.01
Σ ω-6 FA	2.20	2.43	2.14	2.48	0.07	0.02	0.85	0.09
Σ ω-3 FA	0.73^{c}	0.93^{a}	0.67^{b}	0.95^{a}	0.03	<0.01	0.08	<0.01
ω-6/ω-3 ratio	3.04^{a}	2.62^{c}	3.22^{b}	2.62^{c}	0.03	<0.01	<0.01	<0.01

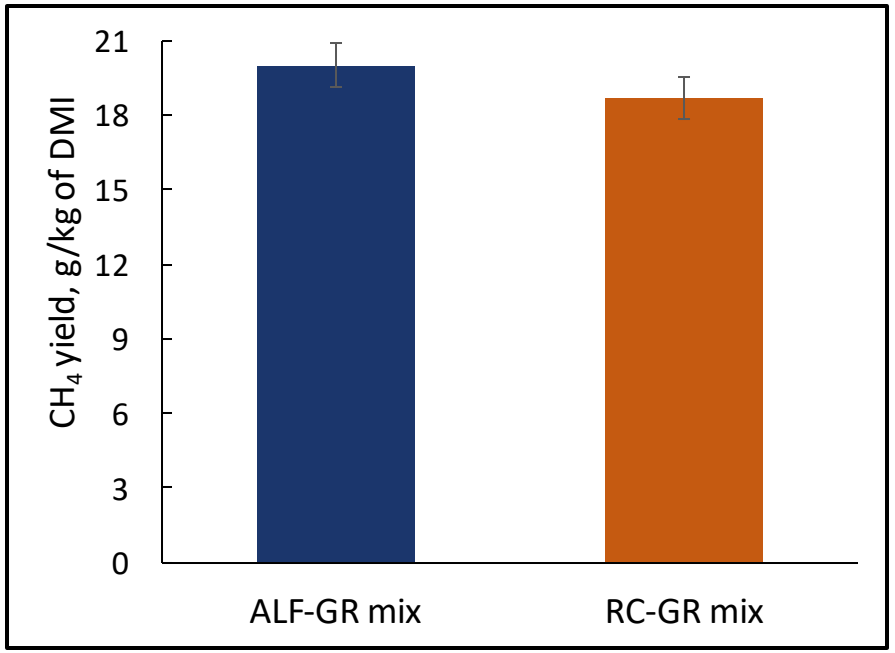
[1]ALF-GR = alfalfa-grass mix; RC-GR = red clover-grass mix
[2]SEM = standard error of the mean

Enteric methane (CH_4) emissions in cows fed alfalfa- or red clover-grass mix

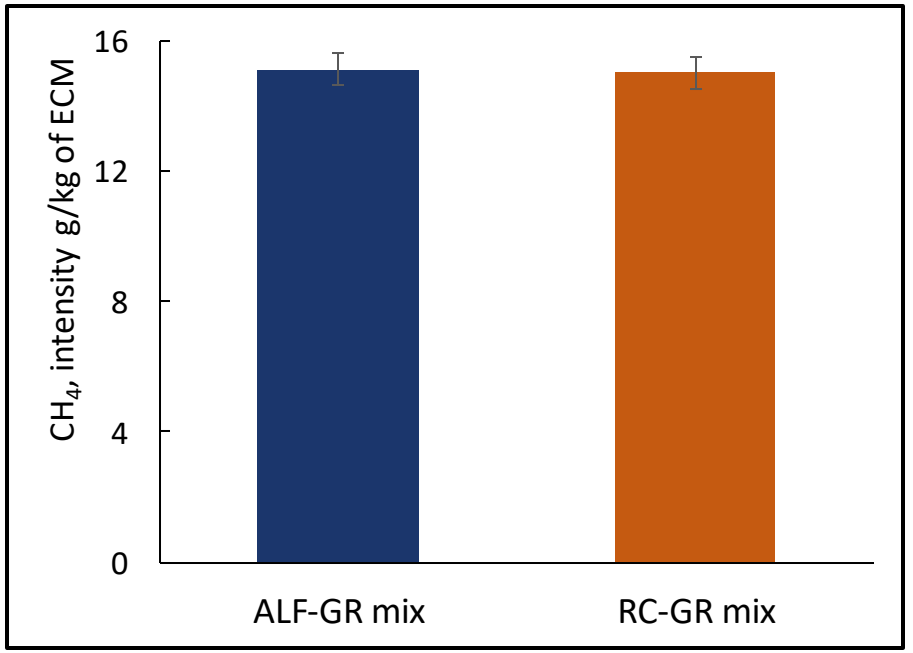


Forage (P = 0.17)
Week (P = 0.05)
Forage x Week (P = 0.02)

Enteric methane (CH_4) emissions in cows fed alfalfa- or red clover-grass mix



Forage: *P* = 0.33
Week: P = 0.17
Forage × week: 0.12



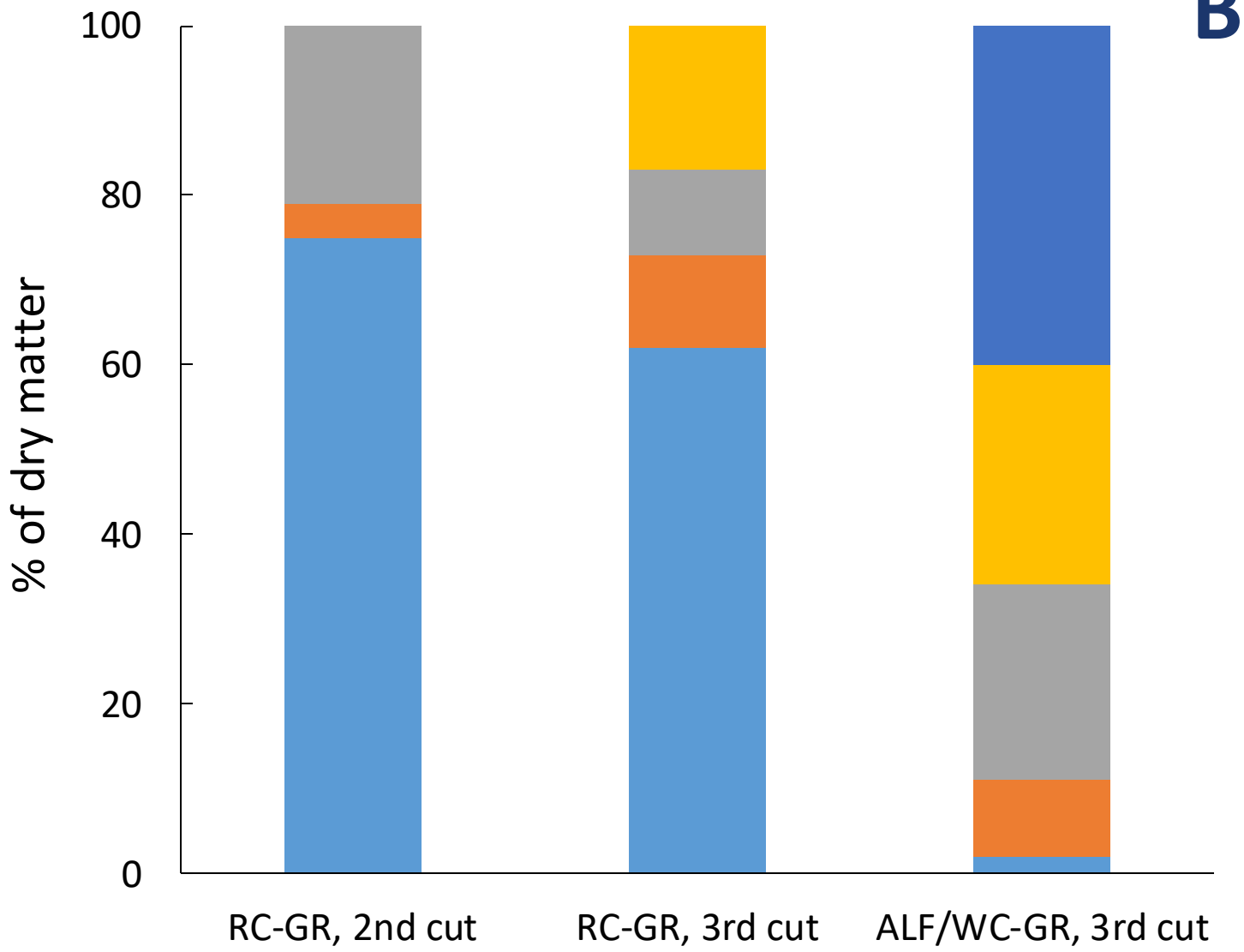
Forage: *P* = 0.88
Week: *P* = 0.01
Forage × week: *P* = 0.68

ALF-GR mix = alfalfa-grass mix; RC-GR mix = red clover-grass mix
DMI = dry matter intake
ECM = energy-corrected milk

Feeding trial 2 methods

- Twenty organic-certified mid-lactation Jersey cows were used
- Cows (n = 10/treatment) were randomly assigned to 1 out 2 diets fed as TMR: **(1) Red clover-grass mix or (2) Alfalfa/white clover-grass mix**
- Crossover design with two, 24-d periods: **14 d for diets adaptation and 10 d for sample collection**
- Methane emissions were measured throughout the 48-d study using the GreenFeed system

Botanical composition



RC-GR = red-grass mix
ALF/WC-GR = alfalfa/white clover-grass mix

University of New Hampshire

Nutritional composition of baleages

Item	Baleage[1]		
	RC-GR, 2nd cut	RC-GR, 3rd cut	ALF/WC-GR, 2nd cut
Dry matter (DM), % as fed	60.0	58.5	49.5
Crude protein (CP), % DM	16.9	19.5	18.1
Soluble CP, % CP	37.5	41.0	58.5
aNDFom, % DM	43.7	38.9	44.3
ADF, % DM	37.9	31.7	40.1
Lignin, % DM	8.60	7.40	9.40
Starch, % DM	1.33	1.00	1.75
Sugars, % DM	5.85	5.05	3.70
Crude fat, % DM	4.51	4.10	3.85
NE_L, Mcal/lb	0.64	0.67	0.61

[1]RC-GR = red-grass mix; ALF/WC-GR = alfalfa/white clover-grass mix

Experimental diets

Item	Experimental diets	
	Red clover-grass mix	3Legume-grass mix[1]
	----------% of diet dry matter----------	
Red clover-grass mix, 2nd cut baleage	30.0	15.0
Red clover-grass mix, 3rd cut baleage	30.0	15.0
Alfalfa/white clover-grass mix, 2nd cut baleage	-	30.0
Grain mash	40.0	40.0
Crude protein	17.7	17.2
aNDFom	31.7	31.3

[1]3Legume-grass = red clover/alfalfa-white clover-grass mix

Intake and milk production in cows fed different legume-grass mixes

	Experimental diets[1]			
Item	RC-GR mix	3LG-GR mix	SEM	*P*-value
DMI, lb/d	46.3	45.0	0.86	0.02
Milk, lb/d	47.0	46.1	1.69	0.33
Milk fat, %	5.31	5.50	0.14	0.14
Milk fat, lb/d	2.49	2.54	0.15	0.34
Milk protein, %	3.66	3.71	0.06	0.06
Milk protein, lb/d	1.70	1.70	0.09	0.77
MUN, mg/dL	11.7	12.3	0.49	0.16
PUN, mg/dL	15.6	17.0	0.48	0.06

[1]RC-GR = red clover-grass mix; 3LG-GR mix = red clover/alfalfa-white clover-grass mix

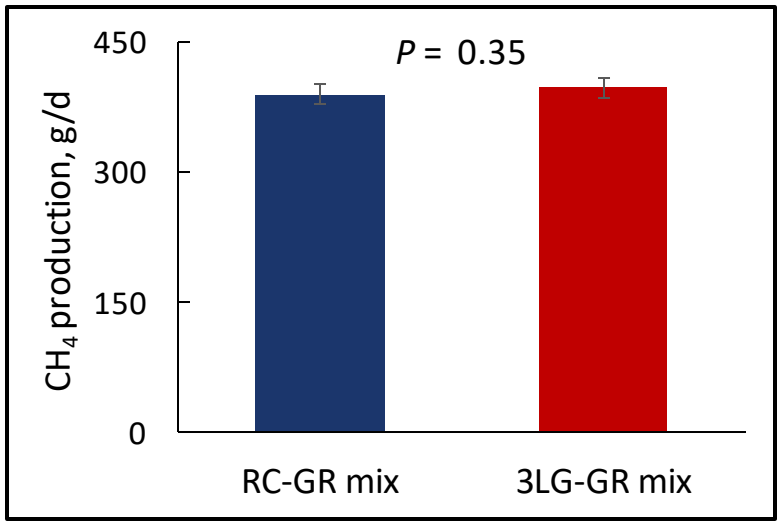
Digestibility of nutrients in cows fed different legume-grass mixes

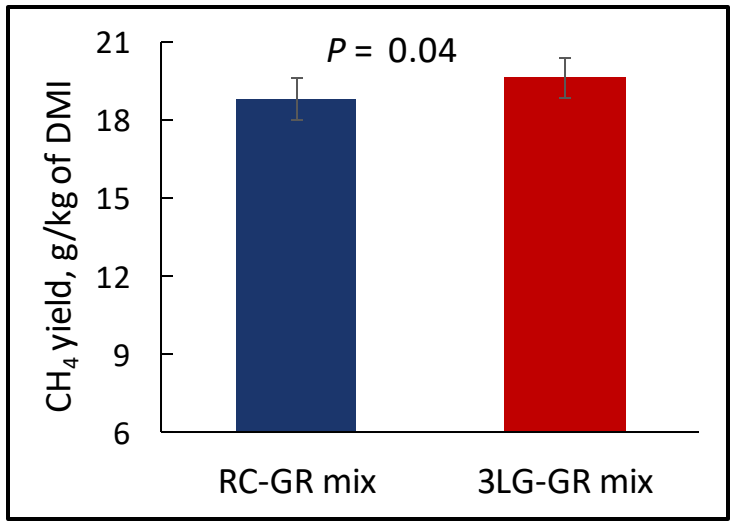
	Experimental diets[1]			
Item[2]	RC-GR mix	3LG-GR mix	SEM	*P*-value
DM, % of DMI	68.4	64.0	0.87	<0.01
OM, % of OM intake	70.4	66.0	0.81	<0.01
NDF, % of NDF intake	47.9	39.7	1.00	<0.001
ADF, % of ADF intake	51.8	48.6	0.81	0.02
CP, % of CP intake	60.9	57.8	1.44	0.16

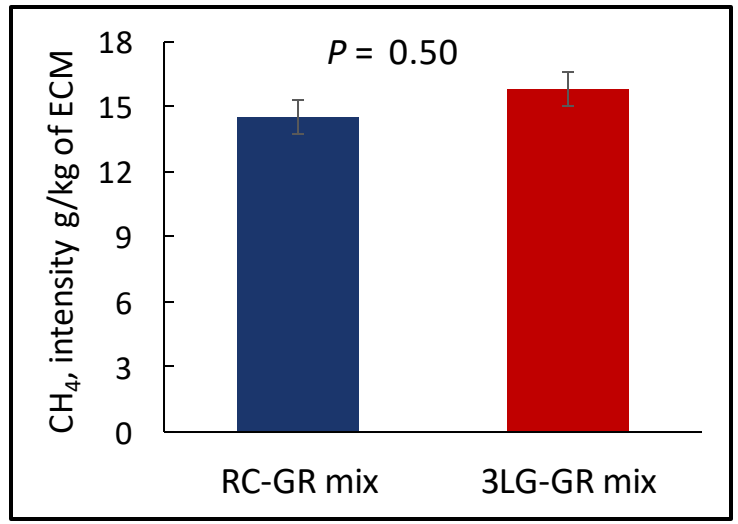
[1]RC-GR = red clover-grass mix; 3LG-GR = red clover/alfalfa-white clover-grass mix

[2]DM = dry matter; DMI = dry matter intake; OM = organic matter; NDF = neutral detergent fiber; ADF = acid detergent fiber; CP = crude protein

Enteric methane (CH_4) emissions in cows fed different legume-grass mixes







RC-GR = red clover-grass mix; 3LG-GR mix = red clover/alfalfa-white clover-grass mix
DMI = dry matter intake
ECM = energy-corrected milk

Take home message

- Increased proportion of legumes in dairy diets improves NE_L concentration, as well as dry matter intake and milk production
- Based on UNH feeding trial 1, alfalfa increased milk fat production while red clover reduced MUN and improved ω-3 fatty acids
- Based on UNH feeding trial 2, red clover-grass mix increased dry matter intake and digestibility, but these changes did not result in more milk and milk components

Acknowledgments

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Questions??

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