Herbage Characteristics Affecting Intake By Dairy Heifers Grazing Grass-Monoculture And Grass-Birdsfoot Trefoil Pastures

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UTAH AGRICULTURAL EXPERIMENT STATION

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WESTERN SARE Sustainable Agriculture Research & Education

USDA

Organic Agriculture: A Large Industry

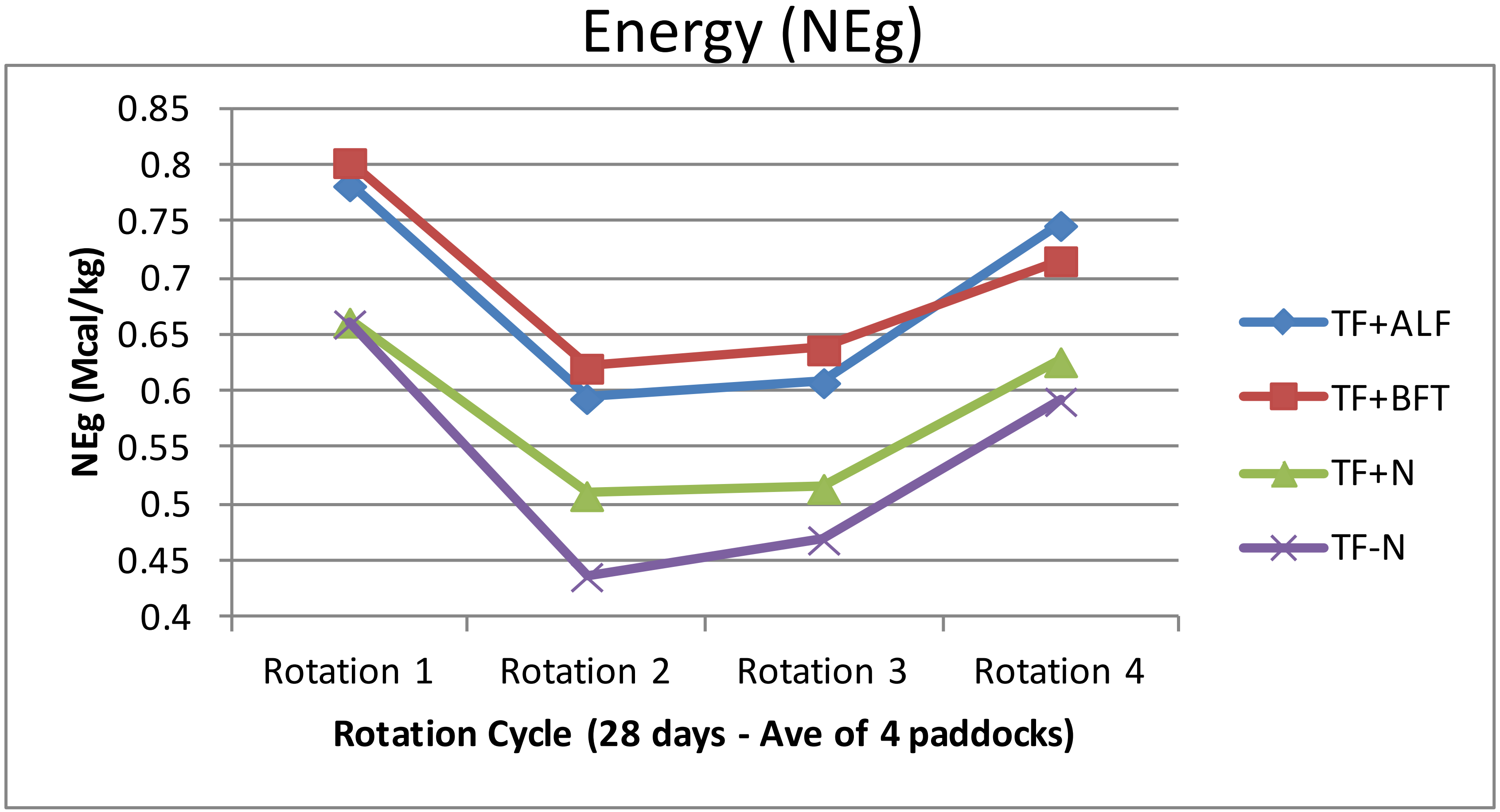
- Over 3.5 million milk cows in western U.S
- Consistent growth
- Increased producer interest in organic/pasture-based dairies

Organic/Pasture-Based Dairy Challenges

- Intake on pasture-based dairies
  - 32% decrease in milk production for dairies where 75-100% of forage is pasture-based (McBride and Greene, 2009)
  - Reduced dry matter intake (DMI) (Bargo et al., (2003) J. Dairy Sci. 86: 1-42)
- Energy is a major limiting factor in growth and production
- Dairy breeds can be finicky grazers-may not eat tall fescue

progressivedairy.com

Previous Research-Beef Steers



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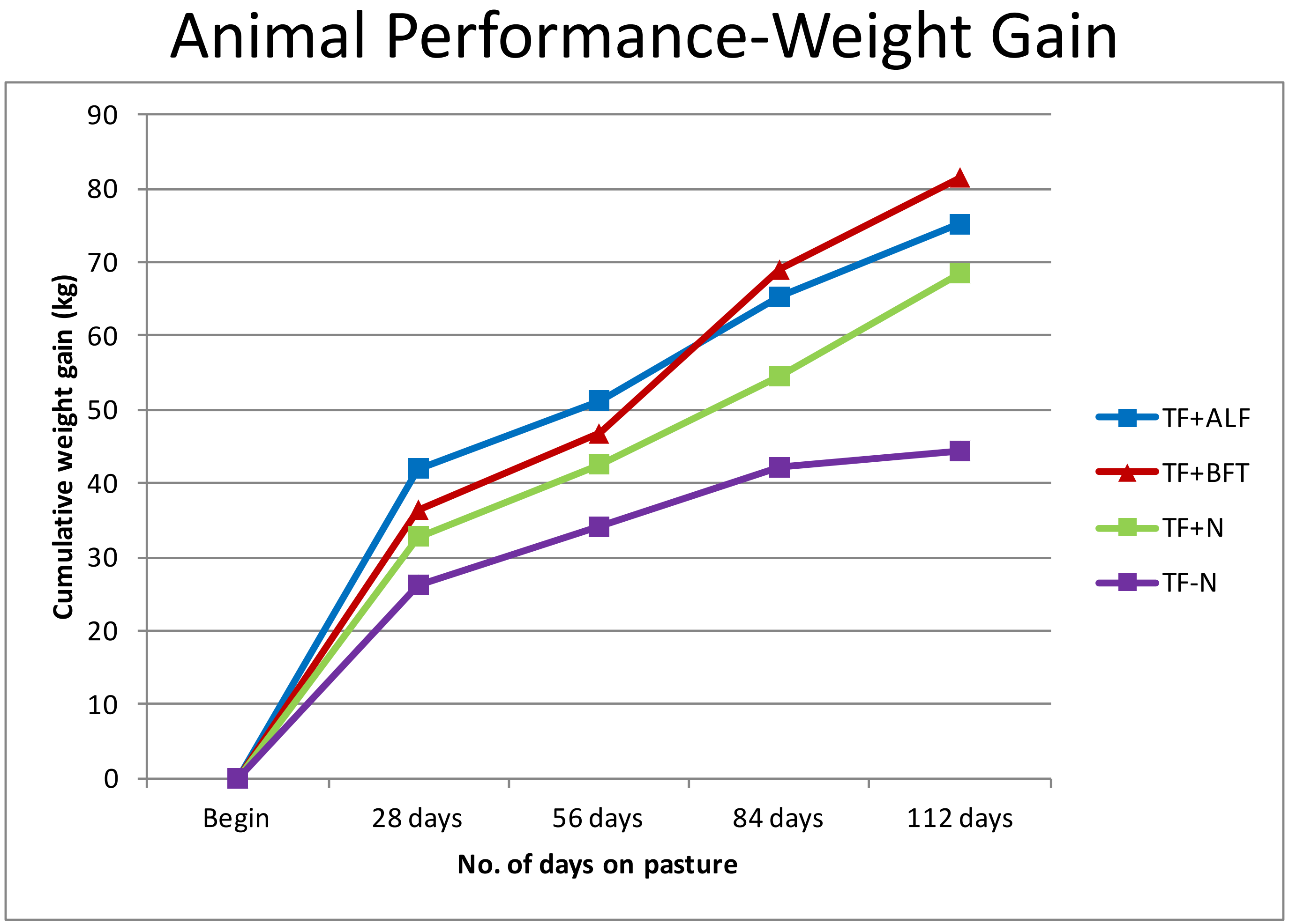


Possible Solution

Hypothesis:

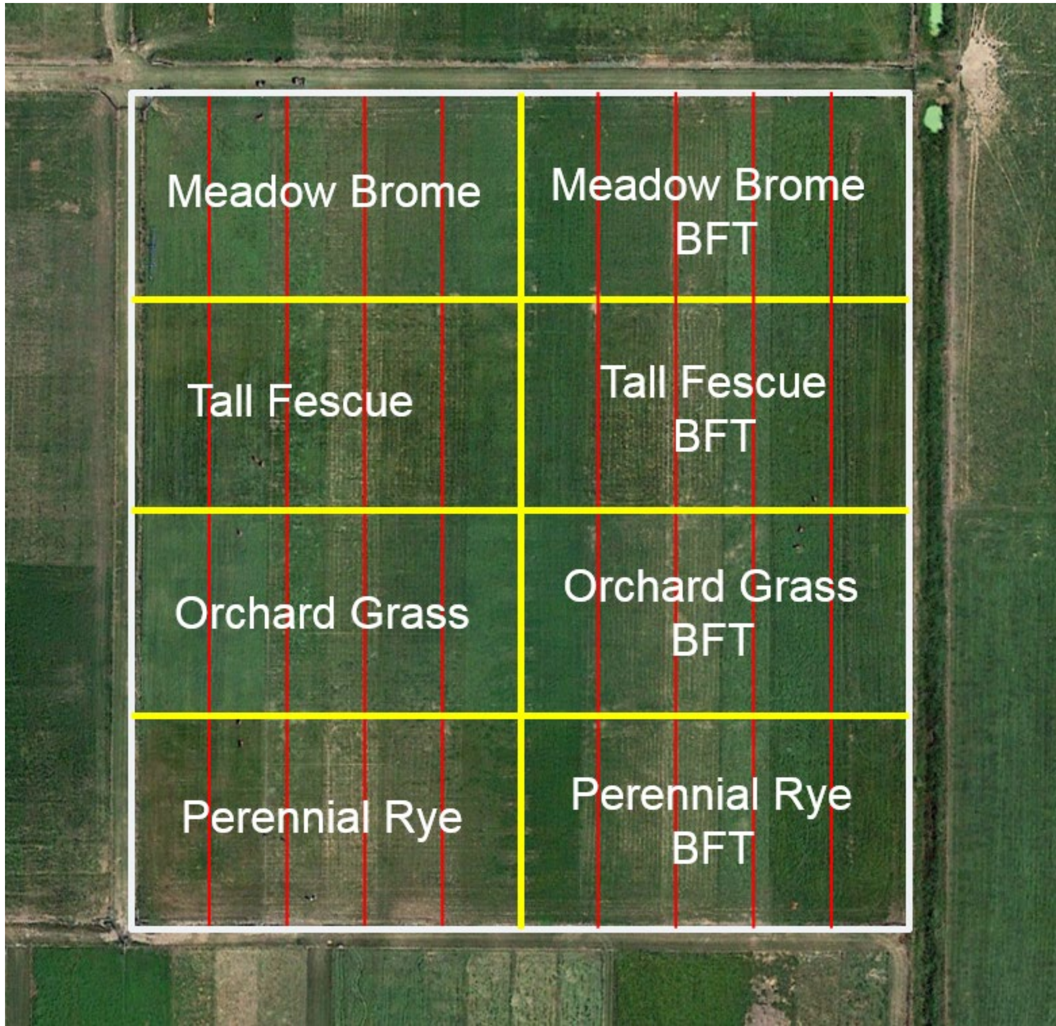
High energy grasses + Condensed tannins in birdsfoot trefoil = Complimentary effect to improve dairy heifer intake

Study Objectives

- Compare grass-BFT mixtures with grass monocultures in a dairy grazing system
  - Measure herbage mass and nutritive value (energy)
  - Measure livestock DMI
  - Identify which herbage characteristics affect intake

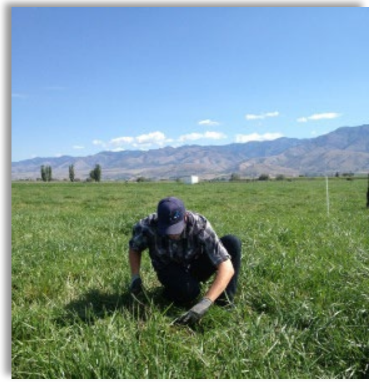
Pasture Configuration and Plant Materials

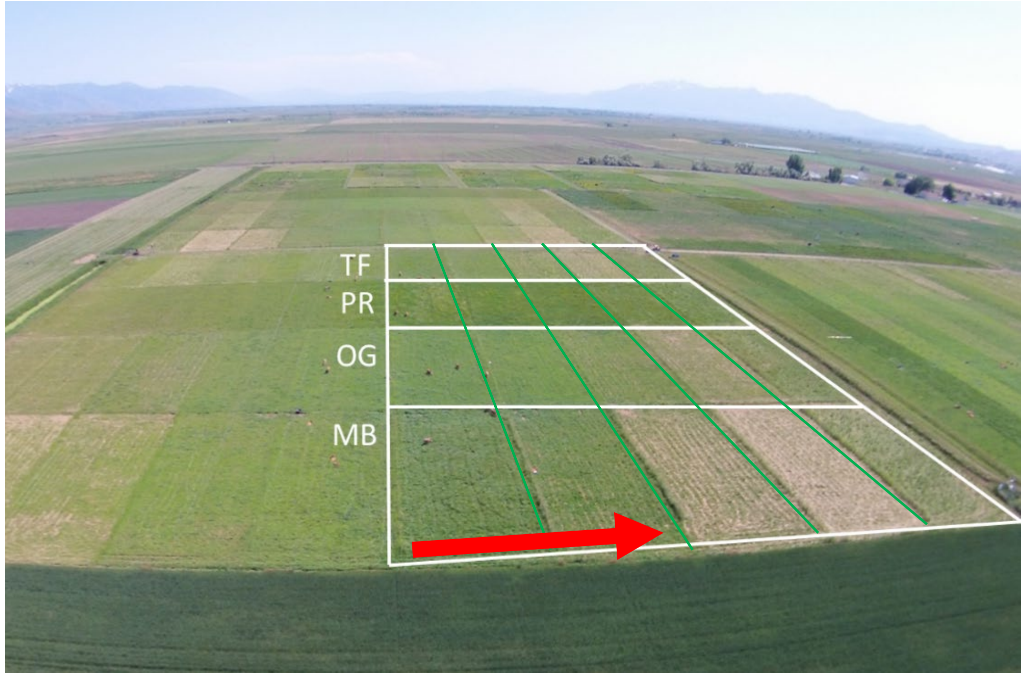
- Nine acre pasture divided into 8 treatments
  - Four grass monocultures:
    - Amazon Perennial Ryegrass (PR)-High sugar
    - Quickdraw Orchardgrass (OG)-High sugar
    - Cache Meadow Bromegrass (MB)
    - Fawn Tall Fescue (TF)
  - Four grass+ Birdsfoot trefoil (BFT) mixtures
- Rotational grazing within a treatment
- Three replications



Rotations

- Grazed for 105 days/year (May to August) 2017 and 2018.
- 7-day grazing period per paddock, 35-day rotation cycle.
- Three 202 kg Jersey heifers per paddock
- Heifers weighed every 35-days.
- Four 0.25-m^{-2} clipped samples before and after grazing
  - Nutritive value
  - Rising plate meter calibration (intake and herbage mass)
- Analyzed with NIRS





Herbage traits

- Nutritive value
  - NDF
  - ADF
  - DNDF
  - ASH
  - FAT
  - NDFD
  - Fructan
  - Lignin
  - CP
  - IVTD48
  - WSC
  - ESC
  - ME
  - NFC
  - Forage Tannins
- Physical traits
  - Leaf softness (1-5 least to most soft)
  - Leaf pubescence (0 or 1)
- Herbage production traits
  - Herbage mass
  - Herbage height
  - Herbage allowance
  - Bulk density
  - BFT proportion

Statistical Analysis

- Analyzed as RCB (PROC MIXED procedure in SAS)
  - Pastures were experimental units
  - Paddocks and heifers were observational/sampling units
    - Means of four herbage samples and three heifers used for analysis
  - Pasture treatment type (mix vs. mono), treatment within type, and rotation considered fixed effects
  - Year and replication considered random
  - Rotation cycle considered a repeated measure
  - Fisher's least significant difference test used for mean comparisons *(p=0.05)*
- Principal component analysis (PCA)(PRINCOMP procedure of SAS)
- Stepwise multiple regression (SAS regression procedure with 'stepwise option of SAS)
- Canonical Discriminant Analysis (CDA)(DISCRIM procedure of SAS)

Results and Discussion

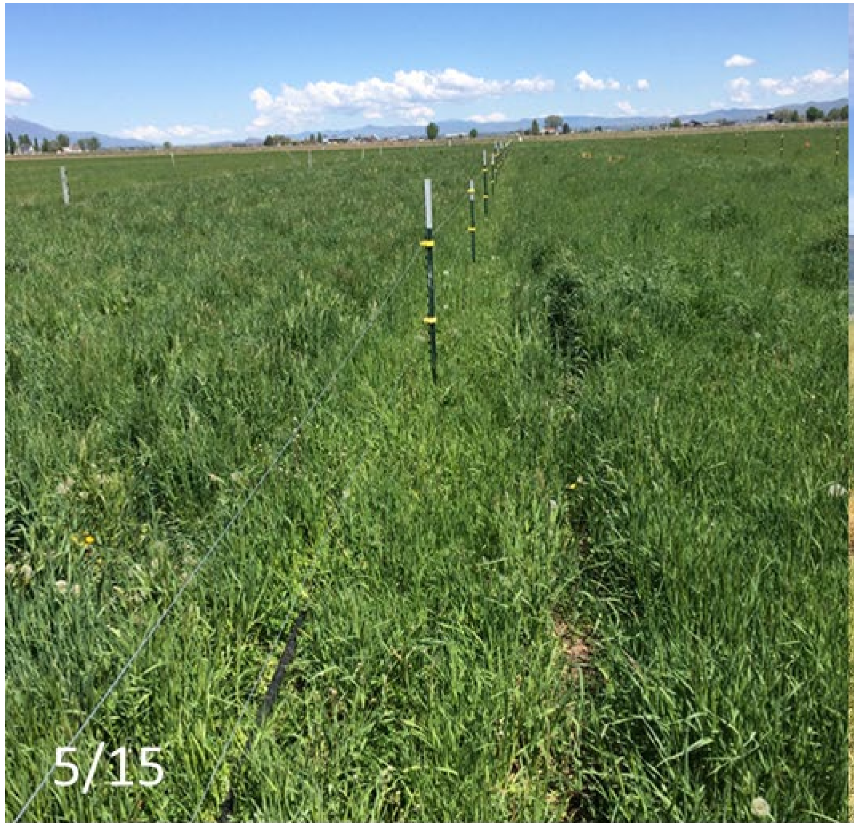
Herbage mass- Rising Plate Meter

- Rising plate meter was used to figure herbage mass and intake:
  - Separate regression equations developed for each treatment within each year
  - Intercept forced to zero (Dillard et al., 2016)
  - R^2 ranging from 0.78 to 0.97

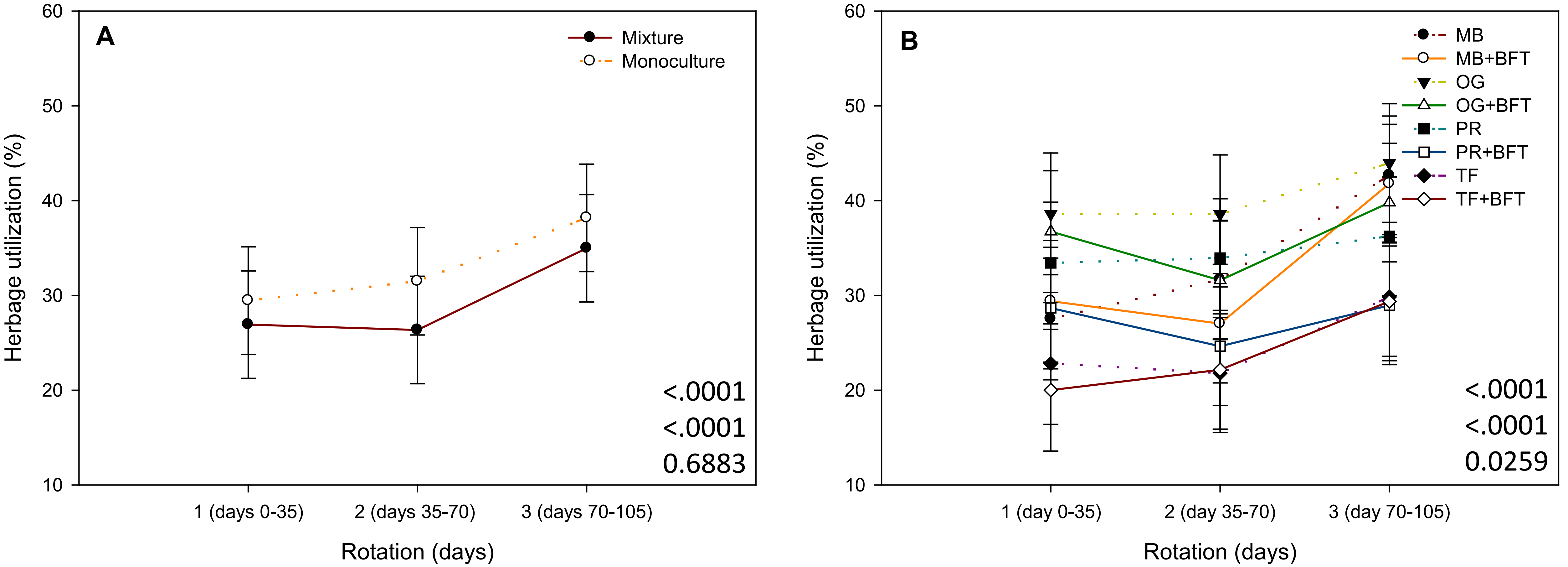
Herbage Growth

- All treatments reached a reproductive growth stage in rotation one:

MB and MB+BFT, OG and OG+BFT, TF and TF+BFT, PR and PR+BFT



Herbage Utilization



Herbage Intake

Treatment type	------------Intake------------			
	kg AU^{-1} day^{-1}		kg ha^{-1}	
Mixture	5.0	a	1031	a
Mono	4.3	b	870	b
Mean S.E	0.3		75	
Rotation				
1, 0-35 days	5.2	x	1018	x
2, 35-70 days	3.7	z	775	y
3, 70-105 days	4.8	y	1059	x
Mean S.E	0.2		73	

Treatment	------------Intake------------			
	kg AU^{-1} day^{-1}		kg ha^{-1}	
MB+BFT	5.9	a	1241	a
OG+BFT	5.7	a	1191	ab
OG	5.6	a	1126	ab
MB	5.0	ab	1022	bc
PR+BFT	4.3	bc	813	cd
TF+BFT	3.7	cd	780	de
TF	3.2	d	668	e
PR	3.3	d	664	e
Mean S.E	0.3		90	

Herbage Intake

- PR+BFT and MB+BFT had the most BFT content (41.0 and 20.7% respectively)
- Others have found that legumes increase intake
  - Fresh BFT in feed bunk (Woodward et al., 2000)
  - Grazing BFT monocultures (Macadam et al., 2015)
  - Grass-clover mixes with 42% increased intake but not 27% (Ribeiro-Filho et al., 2003, 2005)
- Mixtures with over 20% BFT had Increased intake
- Heifers grazed TF same as PR but other grasses more utilized
  - TF+BFT intake less than PR+BFT

Principal Component Analysis (PCA)

Herbage Trait	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
NDF	-0.354					
ADF	-0.325				-0.210	
DNDF	-0.306					
ASH			-0.288	-0.353	0.433	
FAT		0.276	-0.236	0.266	0.290	-0.291
Leaf pubescence			0.211	0.444		0.337
Herbage height			0.459	-0.214		-0.459
Herbage allowance			0.515		0.272	
NDFD		0.415			0.256	
Bulk density			0.224	0.246	0.308	0.496
Leaf softness				0.578		-0.304
Fructan			-0.456			
Lignin		-0.383				
Forage Tannins		-0.293				
BFT percent		-0.311				-0.229
CP	0.252				0.369	
IVTD48	0.254	0.271				
WSC	0.263	0.287				
ESC	0.274	0.249				
ME	0.290					
NFC	0.323				-0.266	
Eigenvalue	7.336	4.677	2.944	1.970	1.352	0.844
Proportion of variance	0.349	0.223	0.140	0.094	0.064	0.040
Cumulative proportion of variance	0.349	0.572	0.712	0.806	0.870	0.911

Discriminant Analysis

TRMT	MB	MB+BFT	OG	OG+BFT	PR	PR+BFT	TF	TF+BFT	Total
MB	70	3	2	0	0	0	0	0	75
	93.33	4	2.67	0	0	0	0	0	100
MB+BFT	8	58	0	0	0	9	0	0	75
	10.67	77.33	0	0	0	12	0	0	100
OG	5	0	62	7	1	0	0	0	75
	6.67	0	82.67	9.33	1.33	0	0	0	100
OG+BFT	2	0	2	71	0	0	0	0	75
	2.67	0	2.67	94.67	0	0	0	0	100
PR	0	0	1	0	74	0	0	0	75
	0	0	1.33	0	98.67	0	0	0	100
PR+BFT	0	3	0	0	0	72	0	0	75
	0	4	0	0	0	96	0	0	100
TF	0	0	0	0	0	0	68	7	75
	0	0	0	0	0	0	90.67	9.33	100
TF+BFT	0	0	0	0	0	0	6	69	75
	0	0	0	0	0	0	8	92.0	100
Total	85	64	67	78	75	81	74	76	600
	14.17	10.67	11.17	13	12.5	13.5	12.33	12.67	100
Priors	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	
Error Rate	0.067	0.2267	0.173	0.053	0.013	0.04	0.093	0.08	0.093

Discriminant Analysis

Variable	Herbage Trait	Canonical 1	Canonical 2	Canonical 3	Canonical 4	Canonical 5	Canonical 6
PC 1	(NDF, ADF, NFC, WSC, ESC, ME)	0.122	0.444	0.315	-0.625	0.215	0.501
PC 2	(NDFD, lignin, tannins, BFT%)	-0.028	-0.344	0.340	-0.350	0.710	0.372
PC 3	(Herbage allowance, height)	0.034	0.053	-0.160	0.428	0.403	0.790
PC 4	(leaf softness, pubescence)	0.655	-0.171	0.161	0.278	0.188	-0.635
PC 5	(CP, Ash)	-0.028	0.091	-0.282	-0.057	0.791	-0.531
PC 6	(Bulk Density)	-0.086	0.131	0.700	0.502	0.277	-0.395
R^2		0.583	0.284	0.073	0.056	0.003	0.000
Cum. R^2		0.583	0.867	0.941	0.997	1.000	1.000

PC 4-Leaf Softness and Leaf Pubescence

- Positive correlations to PC 4
- Leaf Pubescence
  - Often considered plant defense mechanism but less so for herbivore vertebrates (Briske, 1996)
    - Likely more associated with herbage differentiation than intake
- Leaf Softness
  - Leaf ‘harshness’ negatively correlated with sheep preference (Cougnan et al., 2014)
  - ‘Fawn’ tall fescue is an old variety with course leaves

PC 1-Fiber, Carbohydrates and Energy

Variable	Herbage Trait	Canonical 1	Canonical 2	Canonical 3	Canonical 4	Canonical 5	Canonical 6
PC 1	(NDF, ADF, NFC, WSC, ESC, ME)	0.122	0.444	0.315	-0.625	0.215	0.501
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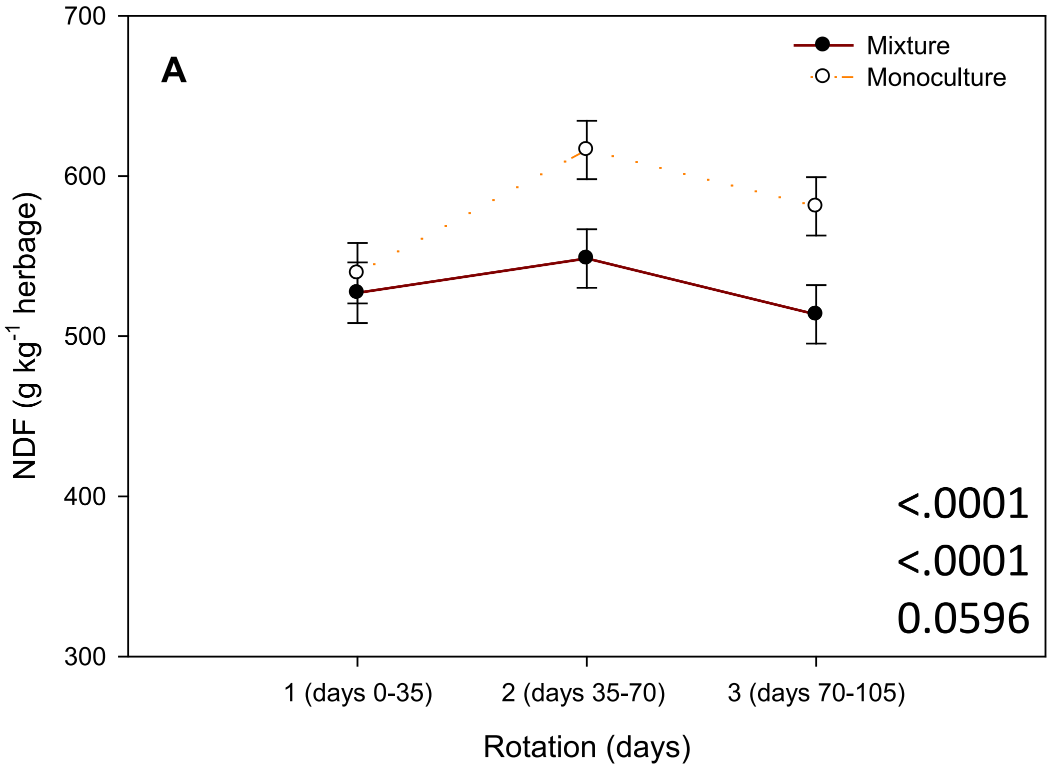
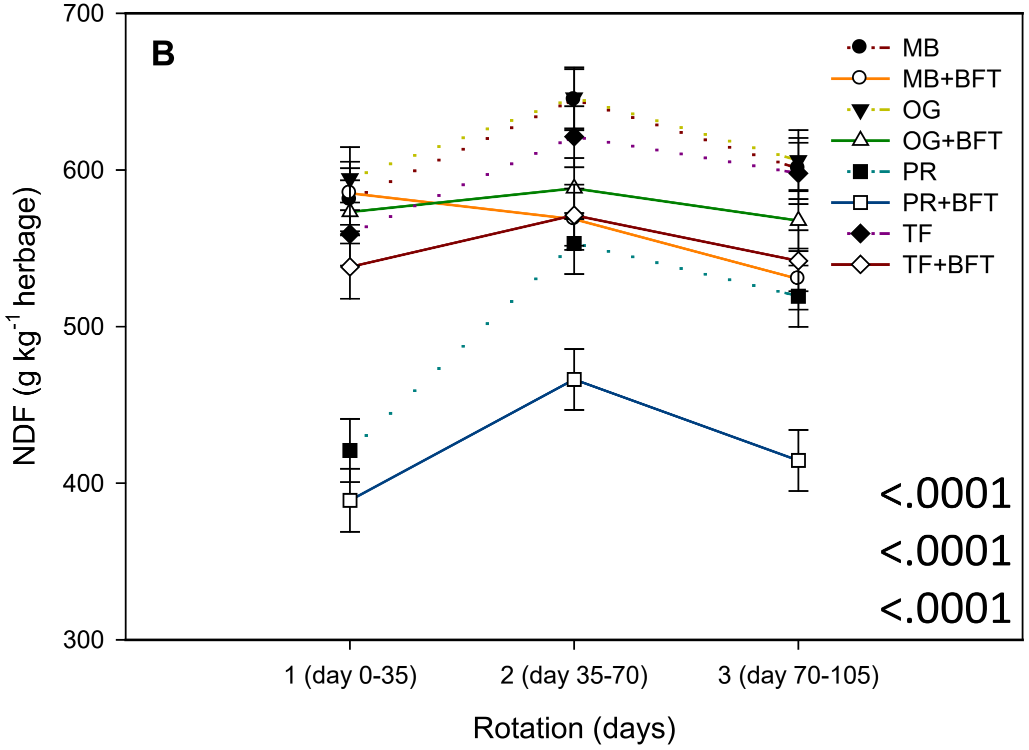
PC 1-Neutral Detergent Fiber

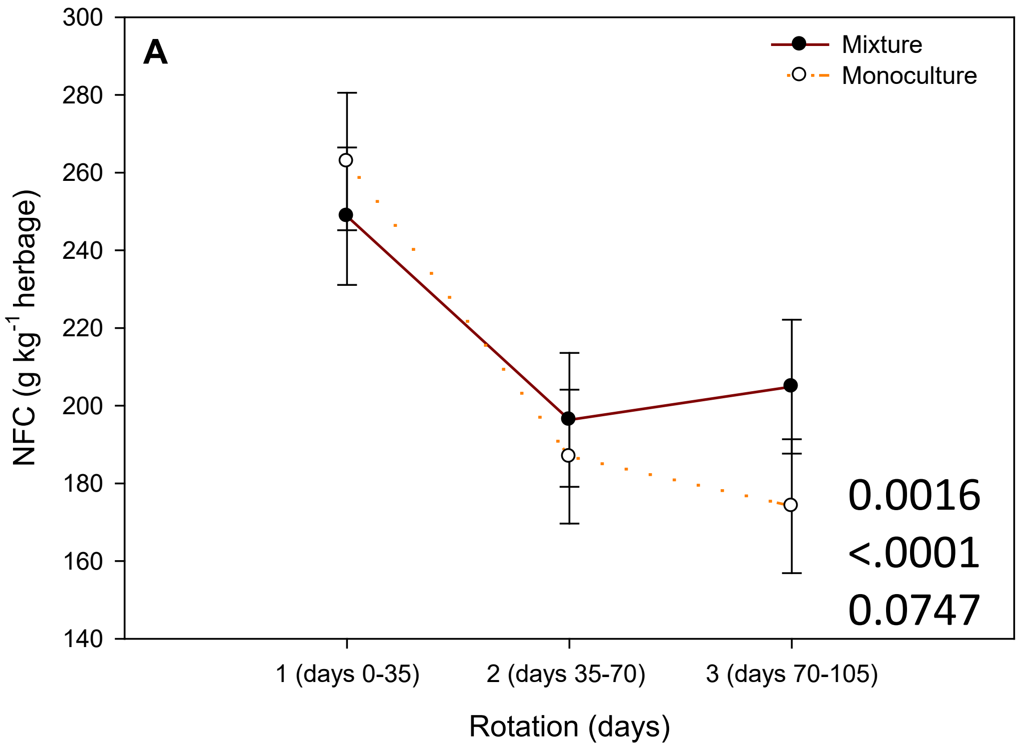


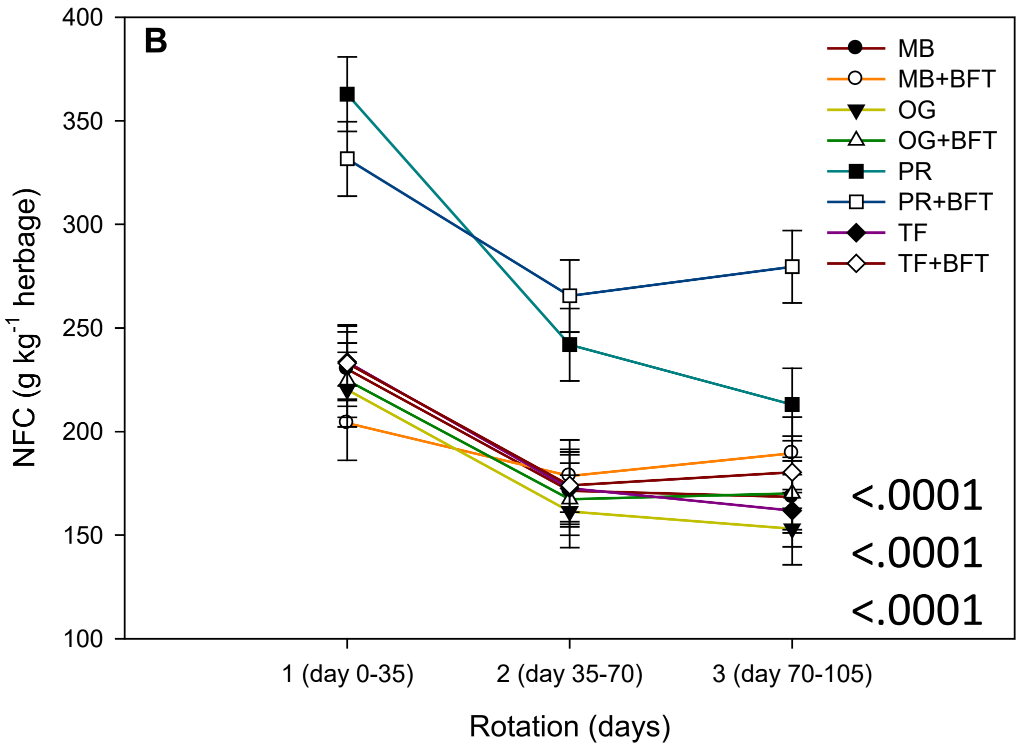


PC 1-Neutral Detergent Fiber discussion

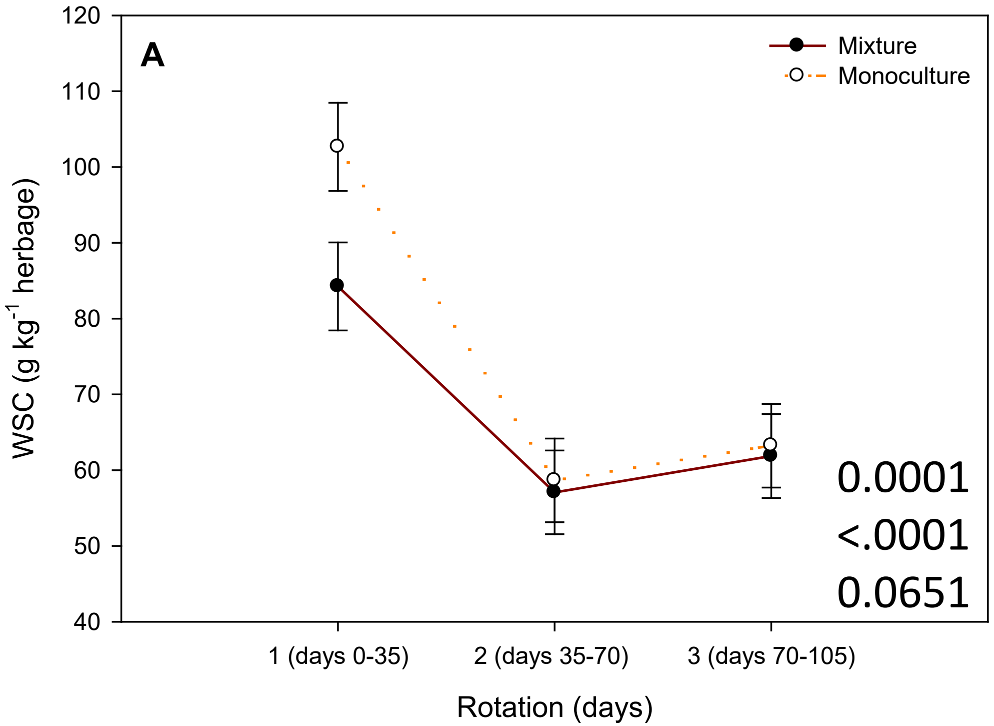
- Negatively correlated with PC 1
- NDF of orchardgrass was similar to other studies in the region (51-61%) (Robins et al., 2015, 2016)
- Tall fescue NDF was greater than previous beef steer study in Lewiston (Waldron et al., 2019)
    - Due to difference in rotation cycle length
- Overall mean NDF was greater than other mechanically harvested studies (Jensen et al., 2016)
    - Likely due to harvest frequency

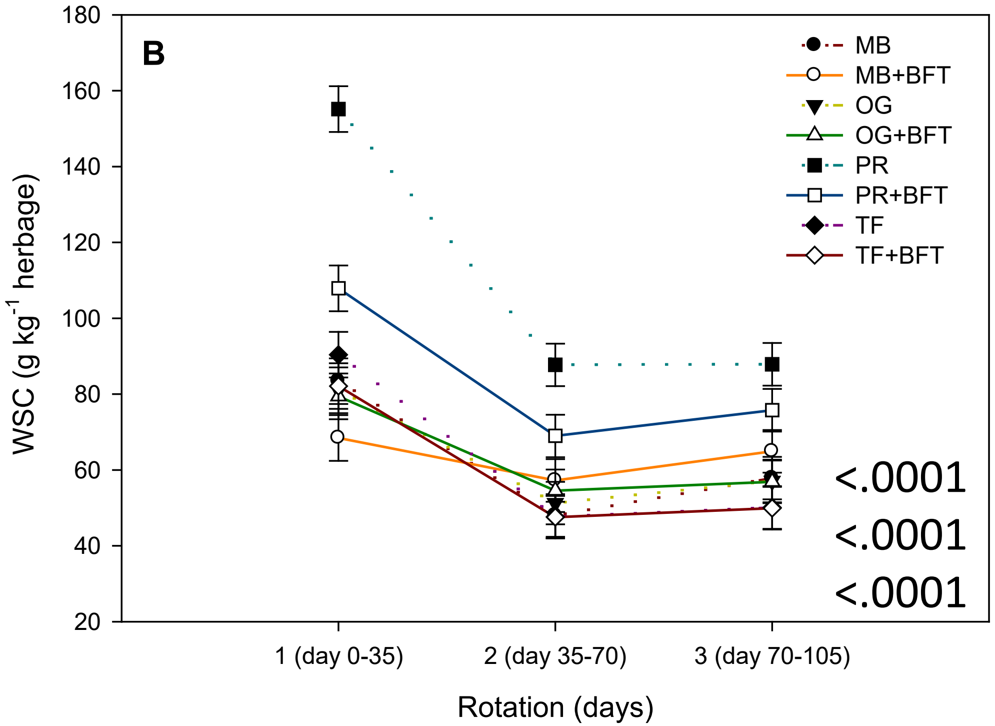
PC 1-Non-Fibrous Carbohydrates





PC 1-Water Soluble Carbohydrates

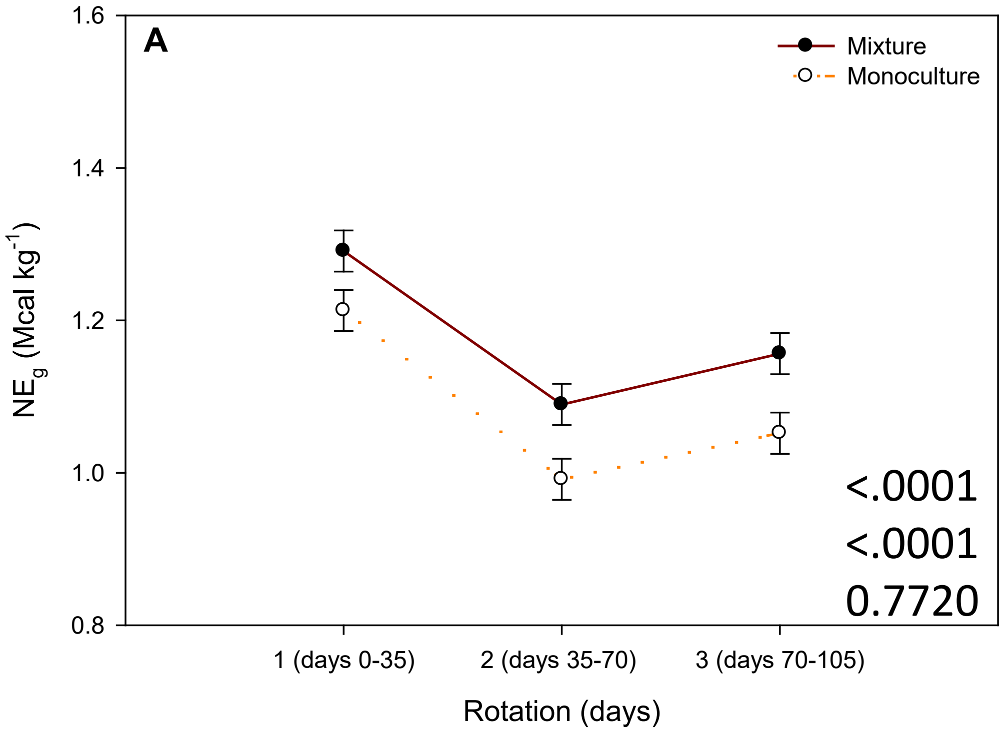


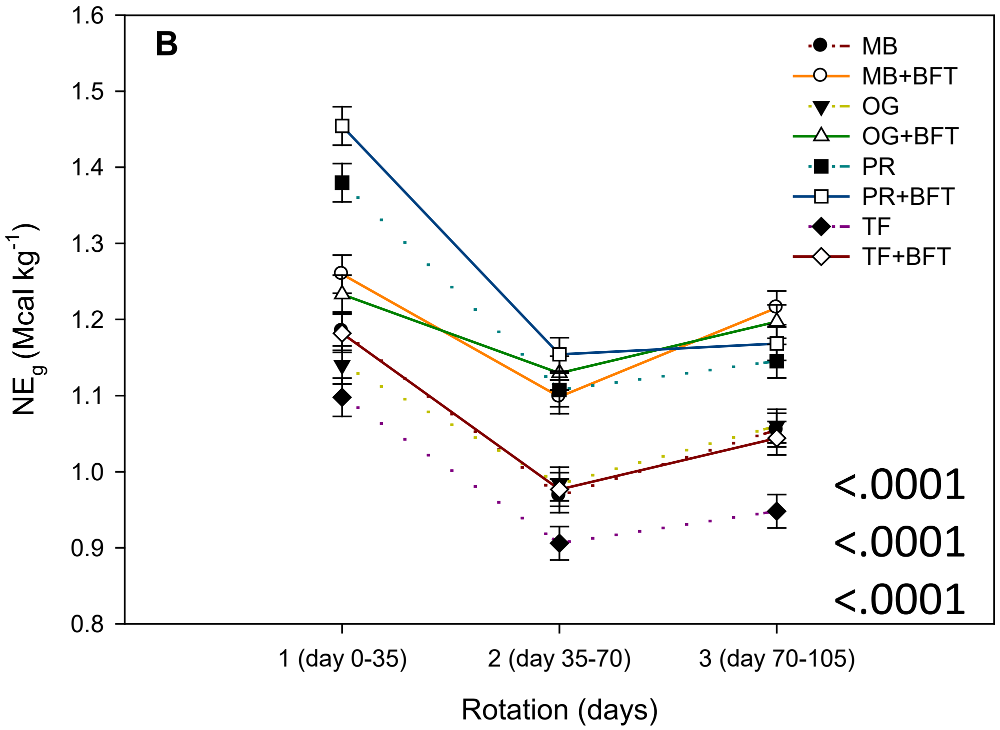


PC 1-Carbohydrates discussion

- Positive correlation to PC 1
- Perennial ryegrass treatments were consistently greater in NFC and WSC
  - Validation of ‘high sugar’ claim for PR
  - Orchardgrass WSC levels were similar to other treatments

PC 1-Energy


A
Mixture
Monoculture
1.6
1.4
1.2
1.0
0.8
NE_g (Mcal kg^{-1})
1 (days 0-35)
2 (days 35-70)
3 (days 70-105)
Rotation (days)
<.0001
<.0001
0.7720


B
MB
MB+BFT
OG
OG+BFT
PR
PR+BFT
TF
TF+BFT
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
NE_g (Mcal kg^{-1})
1 (day 0-35)
2 (day 35-70)
3 (day 70-105)
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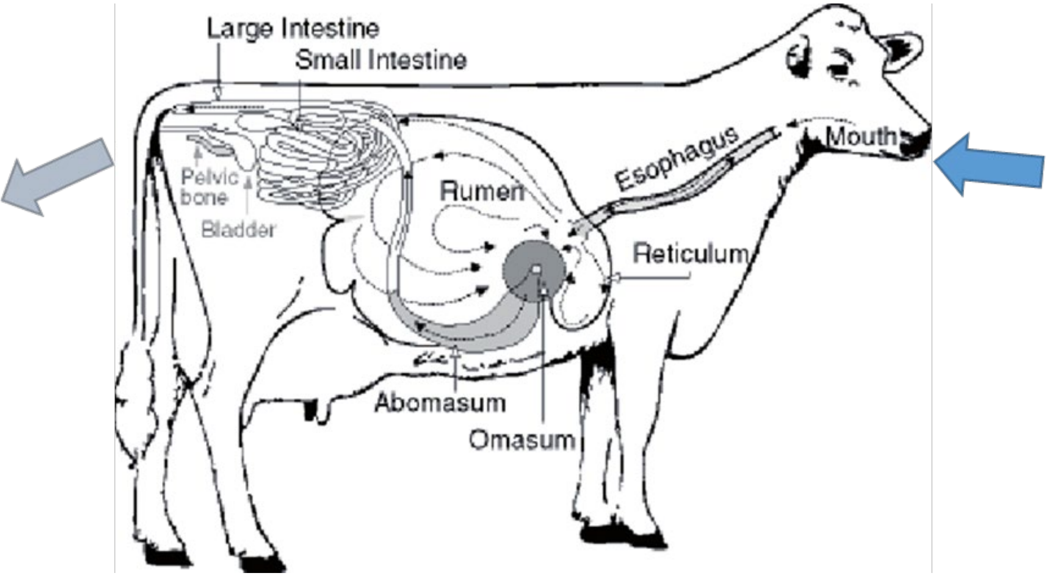
<.0001
<.0001
<.0001

PC 1-Energy discussion



- Positive correlation to PC 1
- Energy most limiting factor on pasture (Bargo et al., 2003, Kolver and Muller, 1998)
- Grasses differed in energy content (objective)
- BFT increased energy

PC 2-Tannins and BFT%

Variable	Herbage Trait	Canonical 1	Canonical 2	Canonical 3	Canonical 4	Canonical 5	Canonical 6
PC 1	(NDF, ADF, NFC, WSC, ESC, ME)	0.122	0.444	0.315	-0.625	0.215	0.501
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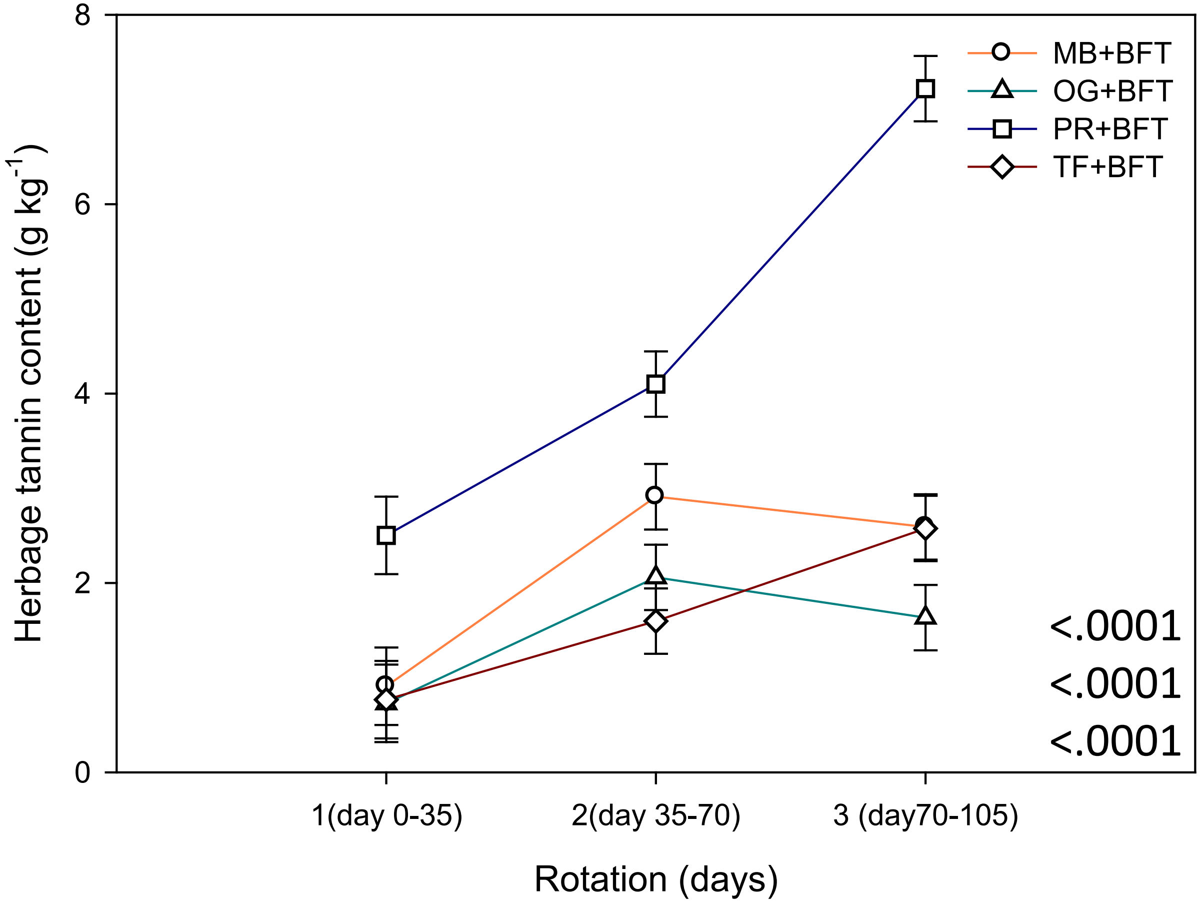

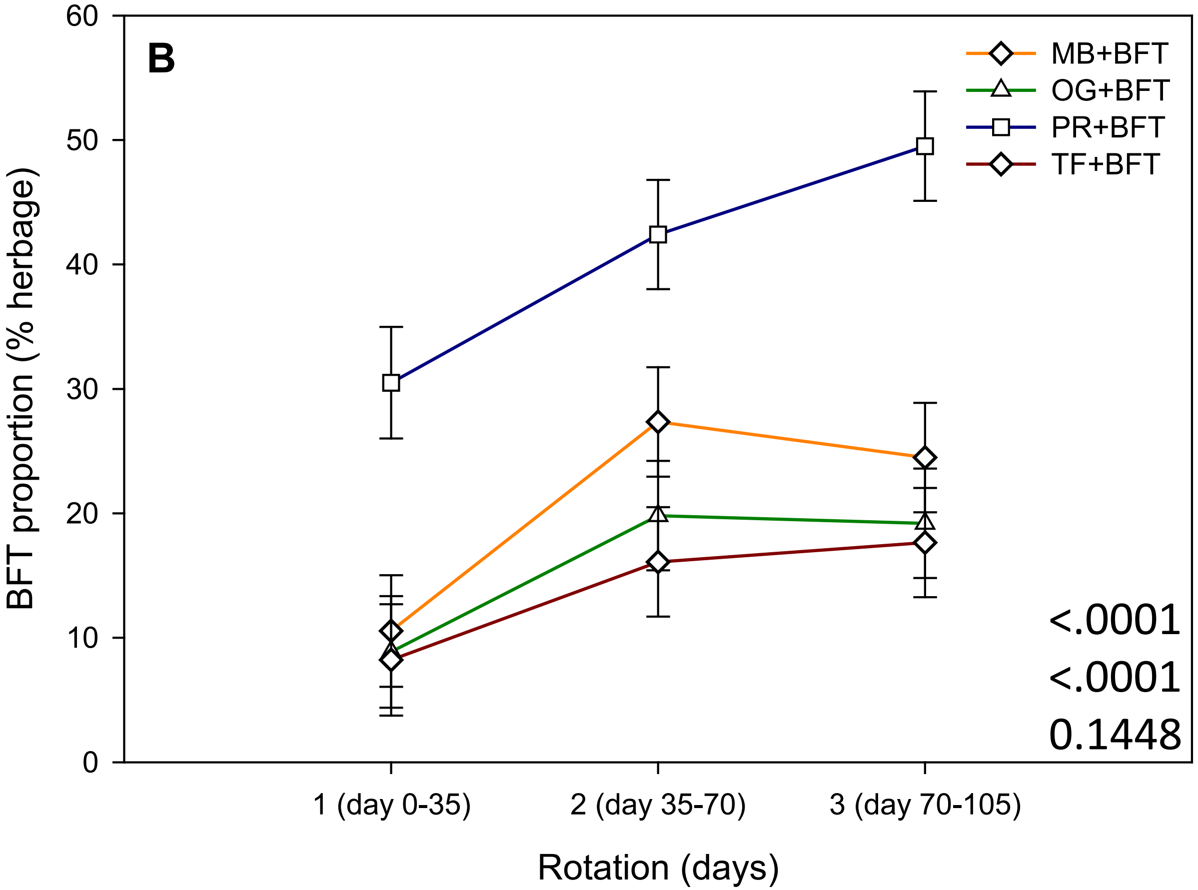

PC 2- Tannins and BFT%

- Total Tannins closely associated with BFT%
- Low tannin content in most mixtures (<1%)
- PR+BFT
  - Greatest tannin content
  - Greatest energy content
    - Increased intake over PR monoculture

PC 6-Bulk Density

Variable	Herbage Trait	Canonical 1	Canonical 2	Canonical 3	Canonical 4	Canonical 5	Canonical 6
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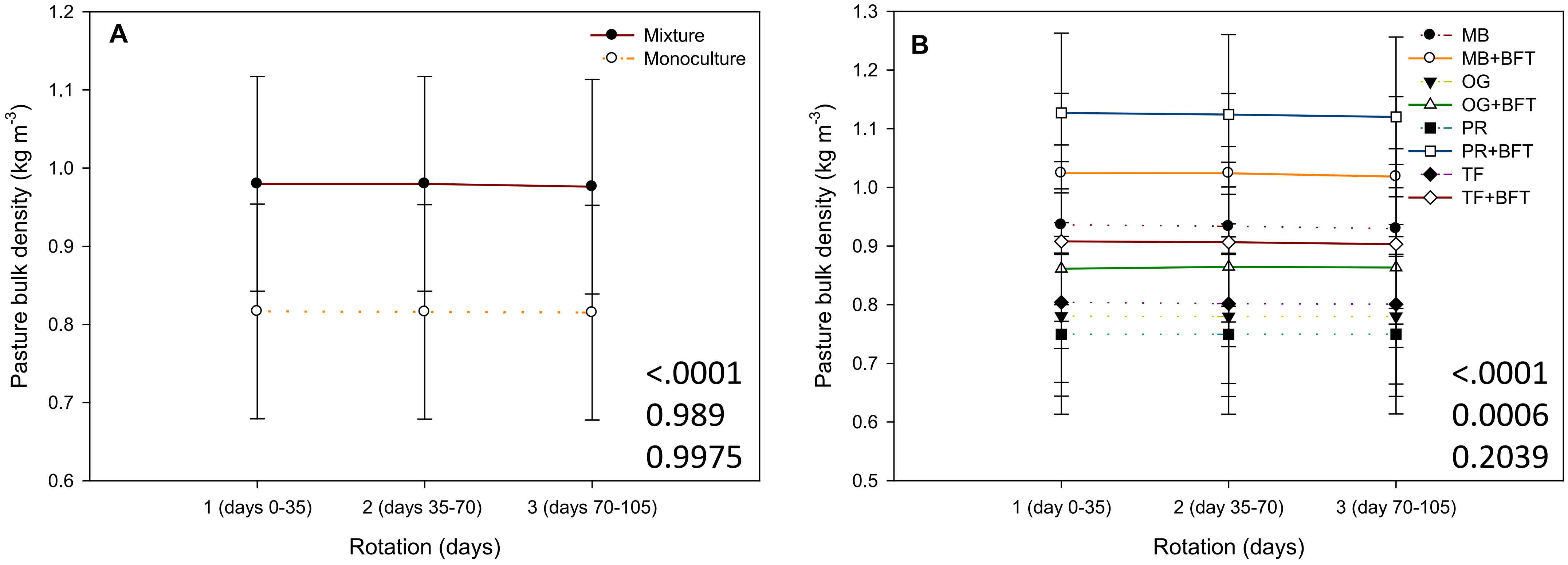
PC 6- Bulk Density



PC 6- Bulk Density discussion

- Positively correlated to PC 6
- Very influential on intake
- Cited as important in other studies
  - Bite mass increased as bulk density increased under uniform grazing height (Casey et al., 2004)
  - Bulk density becomes increasingly important as herbage height is reduced McGilloway et al., (1999)

Conclusions

- Was intake increased?
  - BFT increased intake for meadow brome and perennial ryegrass (kg ha^{-1})
  - Over 20% BFT
  - Affected by nutritive value and physical traits
- Energy and WSC
  - BFT mixtures had more energy than monocultures
  - Orchardgrass did not show same high sugar characteristics as perennial ryegrass
- Tannins
  - Tannins were low (0.5-1%)
  - Tannins likely had a complimentary effect with non fibrous energy on intake in PR+BFT

On-Farm Trial: Bingham Dairy

- Planted in 2015 in Weston, Idaho
- Rotationally grazed by lactating, cross-bred dairy cows
  - 24 hour grazing period
  - 21-45 day rotation cycle
- Data taken in 2017 and 2018
  - Four 0.25m^2 samples taken per treatment (two per rep)
- Herbage mass and nutritive value measured
  - Milk production predicted

Border-TF		Border-TF
TF		TF+BFT
TF+BFT		PR
PR		OG+BFT
PR+BFT	Border-TF	TF
OG		MB+BFT
OG+BFT		PR+BFT
MB		MB
MB+BFT		OG
Border-TF		Border-TF

On-Farm Trial: Bingham Dairy

							2017				2018			
Trmt.	production		WSC		NE_L		milk/day†		milk/acre†		milk/day†		milk/acre†	
	lb acre^{-1}		%		Mcal kg^{-1}		------------lb------------				------------lb------------			
TF+BFT	2640	A	6.2	E	0.64	E	58	CD	2638	AB	50	D	5281	A
TF+N	2629	A	6.3	E	0.58	F	45	E	2704	A	39	E	3997	B
OG+BFT	1774	B	7.4	DE	0.70	B	67	C	2439	ABC	59	C	3949	B
OG+N	1445	BC	8.2	CD	0.65	DE	54	DE	1919	C	56	CD	2763	C
MB+N	1262	BC	8.9	BC	0.67	C	60	CD	1961	C	59	C	2526	C
MB+BFT	1144	C	9.6	AB	0.74	A	90	B	2023	BC	76	B	2827	C
PR+BFT	579	D	10.8	A	0.75	A	141	A	1129	D	110	A	1557	D
PR+N	454	D	10.2	AB	0.67	CD	61	CD	576	D	59	C	1071	D
Mean S.E	565		0.5		0.02		4		232		3		329	

Pasture treatments followed by different letters (a,b,c,d,e) are significantly different ($p = 0.05$).

†Milk predicted via MILK equation

On-Farm Trial: Wangsgard Willow Dairy

- Existing pastures-meadow brome, clover, and garrison creeping foxtail
  - Young Ward, Utah
  - Cornish, Utah (mechanically harvested sorghum-sudan)
- Certified organic soil amendments
  - Chilean nitrate (100 lb. $acre^{-1}$)
  - High-sulfur gypsum (300 lb. $acre^{-1}$)
  - Elemental sulfur (125 lb. $acre^{-1}$)
  - Nitrate+Gypsum
  - Gypsum+Sulfur
- Rotationally grazed in 2018 by lactating Holstein dairy cows
  - 24 hour grazing period
  - 21-45 day rotation cycle
- Four 0.25 m^2 herbage samples per treatment taken before grazing

On-Farm Trial: Wangsgard Willow Dairy

Trmt.	Herbage production		IVTD		TDN		RFQ		Milk/day		Milk/acre	
	lb $acre^{-1}$								------------lb------------			
Nit+Gyp	4740	A	77.4	AB	62.5	D	141.2	B	53.1	B	7353.8	A
Nitrate	4244	AB	77.4	AB	65.5	ABC	150.4	AB	57.9	AB	6987.2	A
Nothing	3765	B	79.8	A	67.1	AB	163.9	A	64.7	A	6455.3	AB
Gypsum	3667	BC	75.9	B	63.5	CD	140.3	B	52.8	B	5853.7	BC
Gyp+Sulf	3595	BC	78.2	AB	65.0	BCD	158.4	AB	61.9	AB	5642.2	BC
Sulfur	2983	C	78.6	A	67.9	A	165.6	A	65.6	A	5194.0	C
Mean S.E	265		0.9		1.1		6.6		3.3		399.1	

Pasture treatments followed by different letters (a,b,c,d,e) are significantly different ($p = 0.05$).

†Milk predicted via MILK equation

What I Have Learned about On-Farm Trials

Photo by David Nevala, Organic Valley Coop

- Producers generally want to improve and participate in research
- Successful producers are always learning
- Producers have large amounts of real-life experience and knowledge to offer in research settings
- Controlling variables is more difficult in on-farm trials

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