Effect of silage from short corn hybrids on milk production of dairy cows.

Michael VandeHaar
Efstathios Sarmikasoglou
Riley Barber
Michigan State University

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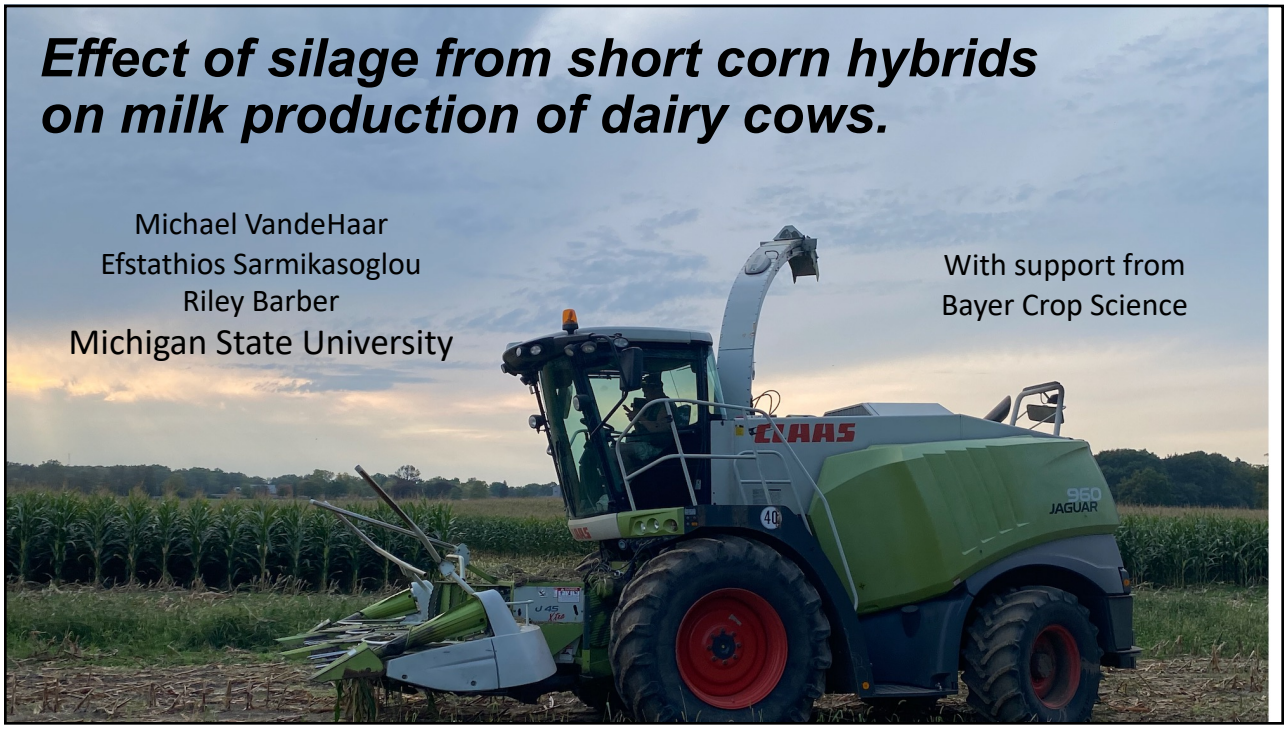

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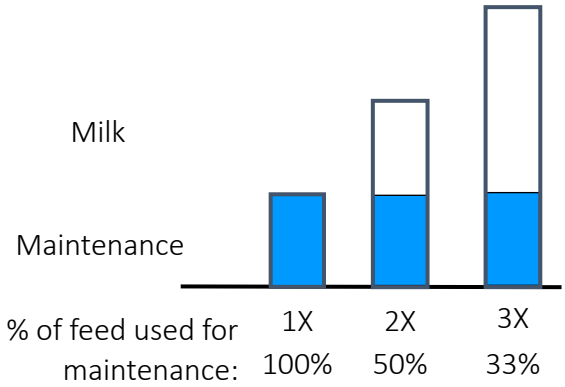
Increased milk per cow means greater efficiency and profitabilty



As cows eat more and produce more per day, the proportion of their feed used for maintenance is diluted out by the proportion converted to product.

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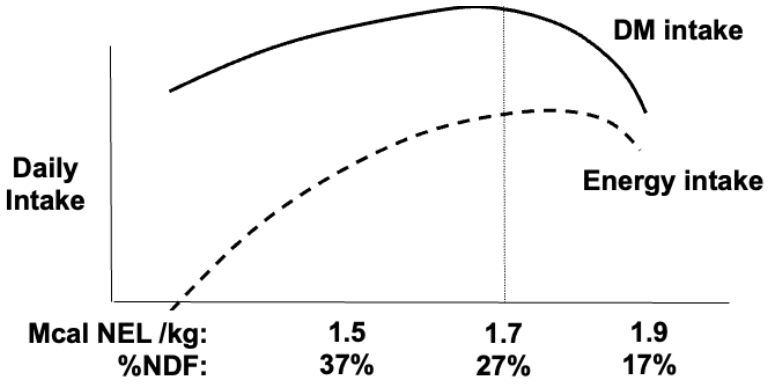
Energy and fiber nutrition for high production

The balance of fiber and starch is key to maximizing milk production.

- ***Fiber is needed for rumen health but too much fiber increases rumen fill and decreases feed intake and milk production.***
- ***Forage fiber is more filling than non-forage fiber.***
- ***Forages with greater fiber digestibility enable greater intake and milk production with less risk of ruminal acidosis than high starch diets.***



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The optimal balance of fiber and starch

TABLE 5-1 Recommended Minimum Forage and Total NDF and Maximum Starch Concentration of Diets for Lactating Cows When a Diet Is Fed as a TMR, the Forage Has Adequate Particle Size, and Dry Ground Corn Is the Predominant Starch Source

Minimum fNDF	Minimum Total NDF	Maximum Starch
19	25	30
18	27	28
17	29	26
16	31	24
15	33	22

NASEM, 2021

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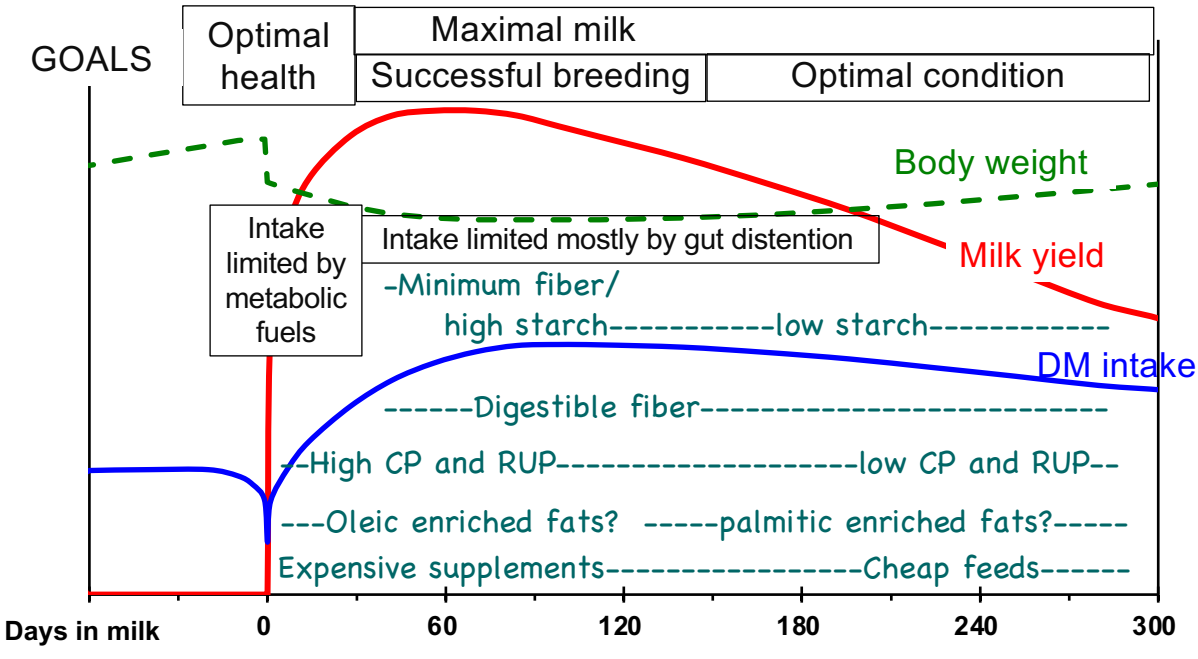
Feeding through the lactation cycle



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Effect of BMR corn silage on intake and milk production

Oba and Allen, 2000 JDS	~29% NDF ~37% starch		~38% NDF 26% starch		*P*-values		
Variable*	**BMR**	**Control**	**BMR**	**Control**	**NDF**	**CS**	**NDF x CS**
Intake, kg/d	**24.7**	**23.9**	**22.9**	**21.5**	<0.01	0.02	NS
Yield, kg/d							
Milk	36.9	33.5	33.7	30.4	<0.01	<0.01	NS
3.5% fat-corrected milk	**35.6**	**34.3**	**35.8**	**32.6**	NS	0.06	NS
Fat	1.22	1.23	1.32	1.20	NS	NS	NS
Protein	1.15	1.05	1.04	0.93	<0.01	<0.01	NS
Body weight change, kg/21 d	**1.10**	**0.79**	**0.00**	**-0.02**	<0.01	NS	NS
Condition score change/21 d	0.17	0.22	0.10	0.04	0.07	NS	NS

*Cows were 70 ± 7 days in milk at the start of the experiment (n = 8). Dry ground corn replaced corn silage to decrease NDF.

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The basic question

- Is short corn a cost-effective alternative for making silage for lactating dairy cows?

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Hybrid plots

Five corn hybrids:
- 3 short corn varieties
- 1 tall corn
- 1 BMR.

- Hybrids were grown on a small field of mostly Marlette fine sandy loam soils with 2 to 6% grade next to the MSU Dairy that had been heavily fertilized with cow manure for years.

- Plots for each hybrid were 2.19 hectares (5.4 A), so there were ~80 rows of each hybrid x 340 m.

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Management during growth

- 2023 was exceptionally dry, especially in the spring; however, the field was one of our best.
- Each hybrid was planted at 86,500 seeds/ha (35,000/A)
- Seeds germinated well and grew reasonably well for a dry year.
- The corn was sprayed with a broadleaf herbicide (Syngenta Explorer) on June 28 and with a fungicide on August 8.

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Harvest and ensiling

- Short varieties were harvested on September 21; tall and BMR on September 22.
- Each was packed in a separate bag after inoculation with Vita Plus Titanium.
- In December, samples were taken from the front, and at two 20-ft intervals on the sides of each bag and sent to Cumberland Valley Analytical Services, Inc. Samples within a hybrid were consistent with CV less than 3% for NDF and CP. The first two samples of each bag were used to develop diets.

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Yield and initial analyses of hybrids

	Tall	BMR	Short 1	Short 2	Short 3
Bag (order filled)	4	5	1	2	3
DM yield, tons/A	8.7	7.6	9.3	7.5	8.6
Total tons DM	47	41	50	41	46
%DM	35	35	33	34	34
Neutral Detergent Fiber, %DM	36	34	37	33	33
Crude Protein, %DM	7.1	7.7	8.1	7.4	7.7
Starch, %DM	40	40	35	40	41
pH	3.9	3.8	3.8	3.8	3.8
Starch yield, tons/A	3.51	3.04	3.27	3.01	3.48
Predicted grain yield, bu/A	198	171	184	169	196
Total VFA, %DM	5.4	5.7	6.0	5.8	5.1
Lactic acid, %DM	3.9	4.5	5.0	4.7	4.6

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Composition based on pre, mid, and post samples

Composite of pre, mid, and post	Tall	BMR	Short1	Short2	Short3
Bag (order filled)	4	5	1	2	3
%DM	35	35	33	34	34
aNDFom, %DM	36	36	38	33	34
Crude Protein, %DM	7.2	7.5	8.0	7.7	7.6
Rumen Degraded Protein, %CP	77	75	77	75	75
Starch, %DM	37	37	35	40	39
Lignin, % NDF	7.3	5.9	6.3	6.6	6.8
30h IV NDF Digestibility, %NDF	56	65	61	60	59

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NDF digestibility

	In vitro NDFD (% of NDF)				
Time (h)	Tall	BMR	Short1	Short2	Short3
12	36	38	40	36	34
30	57	64	60	61	58
120	68	75	74	72	68
240	71	78	77	75	71

	In situ NDFD (% of NDF)				
	Tall	BMR	Short1	Short2	Short3
NDFD24_NDF	13	10	11	11	11
NDFD48_NDF	35	41	46	40	45

In vivo total tract diet NDF digestibility (% of NDF)	47.2	45.4	45.2	46.1	44.2

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Approach

Study 1: Determine if 1 of the 3 short corns is superior.

Hypothesis: Short stature corn results in more milk per cow and per pound of silage compared to tall corn and/or BMR in diets formulated to limit milk production in the tall corn diet. One of the short corns will be best.

Study 2: Determine value of the superior short hybrid at 2 levels of NDF.

Hypothesis: Short stature corn results in more milk per cow and per pound of silage compared to tall corn in diets with high and/or low fiber.

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Study 1 Protocol

40 Holstein cows (20 primi, 20 multip; 150 ± 42 DIM, 35 ± 6.4 kg milk/d, 674 ± 103 kg BW).

- due to clinical mastitis one cow was removed from the study.
- blocked by parity (primi vs multip). Within block, diets were randomly assigned.
- fed a blend of all 5 silages for a 2 wk preliminary period.
- fed 5 treatments in a replicated incomplete Latin square design with 3 periods of 3 wk each. Carryover effects were not completely balanced but could be evaluated.

Cows were milked 3X/d. Diets were fed 1X/d as TMR ad libitum at 110% of expected intake.

- Milk and feed intake were measured daily
- Body wt from 3 d and condition scores were measured at beginning and end of periods.
- Milk composition analyzed 2 d /wk
- Samples of all diet ingredients and TMRs were collected once weekly.
- Orts and feces were collected every 15 h over the last 5 d of period 2. Composited samples on an equal DM basis for feces and on a proportional basis for orts for each cow were used to determine the apparent total-tract digestibility using UNDF240 as an internal marker.

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Diets in study 1

% DM	Tall	BMR	Short1	Short2	Short3
Corn silage	**55**	**58**	**54**	**60**	**59**
Alfalfa silage	10.0	10.0	10.0	10.0	10.0
Soybean meal, solvent-extracted	13.8	13.5	12.7	13.9	13.6
Soybean hulls	5.6	4.6	3.5	3.8	4.5
Corn Grain, Ground finely	3.8	2.1	8.0	0.5	1.1
Protein (8.0) + MinVit (3.8) premix	11.8	11.8	11.8	11.8	11.8
NDF, % of DM	29.6	29.5	29.3	28.2	28.6
forNDF, % of DM	**23.9**	**24.6**	**24.5**	**23.8**	**.7**
CP, % of DM	18.1	18.1	18.1	18.3	18.1
Starch, % of DM	25.2	25.0	26.6	26.5	25.9
RUP, % of CP (calculated)	34	34	34	34	34

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Statistical Analyses – Study 1

Statistical analyses were performed using the GLIMMIX procedure of SAS 9.4 (SAS Institute Inc., Cary, NC).

The statistical models to analyze responses only from week 3 of each period:

$Y = \mu$ + diet + parity + d1-days-in-milk + period
+ diet x parity + period x diet + period x parity + period x diet x parity

Normality of residuals and homoscedacity of variance was assessed. Outliers were removed. For daily variables, we also included week and respective interactions. None were important. All results are reported as LSMeans for averages of week 3 within periods.

Orthogonal contrasts within Diet were:

1) BMR vs all other hybrids
2) Tall vs shorts
3) Short 1 vs average of short 2 and short 3
4 Short 2 vs short 3

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RESULTS	Tall	BMR	Sh 1	Sh 2	Sh 3	BMR vs. others	Tall vs. Shorts	S1 vs. S2,3	S2 vs. S3
DMI (kg)	26.2	24.5	27.8	25.8	25.9	<0.01	0.35	<0.01	0.24
Milk (kg/d)	32.5	32.0	33.7	33.2	32.7	<0.01	0.02	0.01	0.20
0.7ECM (kg/d)	37.0	36.5	38.7	37.3	36.9	0.02	0.11	<0.01	
Fat (%)	4.43	4.45	4.34	4.30	4.33	<0.01	<0.01		
Fat (kg/d)	1.41	1.40	1.46	1.41	1.41	0.15	0.39	<0.01	
Protein (%)	3.48	3.46	3.52	3.43	3.46			<0.01	0.17
Protein (kg/d)	1.12	1.10	1.20	1.14	1.14	<0.01	<0.01	<0.01	
Feed Efficiency (0.7ECM/DMI)	1.44	1.51	1.39	1.45	1.45	<0.01		0.02	
BW (kg)	691	690	693	690	696	0.35	0.34		0.03
BW gain (kg/d)	0.93	0.87	0.93	0.80	1.12	0.50			0.02
BCS	3.25	3.38	3.31	3.23	3.18	0.01		0.18	

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Total tract nutrient digestibilities

Variable	Tall	BMR	Sh 1	Sh 2	Sh 3	BMR vs. others	Tall vs. Shorts	S1 vs. S2,3	S2 vs. S3
OM digestibility (%)	62.4	52.2	61.3	58.0	60.3	<0.01	0.19	0.29	
NDF digestibility (%)	47.2	45.4	45.2	46.1	44.2		0.15		0.25
Starch digestibility (%)	99.0	98.1	99.1	99.3	99.4	<0.01	0.12	0.17	
CP digestibility (%)	71.0	67.2	71.1	72.1	70.0	<0.01			0.05

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Summary and conclusion from Study 1

- BMR improved feed efficiency but decreased intake and milk production
- Short hybrids increased intake and milk production relative to tall corn but did not alter feed efficiency
- Short 1 had greater intake and milk production than Short 2 and 3, but lower feed efficiency.
- Short 2 and 3 were similar

Short 1 seems the best based on DM yield/acre and results of study 1.

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Study 2 Protocol

40 Holstein cows (20 primi, 20 multip; 76 ± 31 DIM, 46 ± 9 kg milk/d, 658 ± 83 kg body wt).

- blocked by parity and ECM/mBW. Diets were randomly assigned within block.
- fed a common diet (blend of tall and short 1) with high starch for a 2 wk preliminary period.
- Fed 1 of 4 treatment diets for 6 wk.

Cows were milked 3X/d. Diets were fed 1X/d as TMR ad libitum at 110% of expected intake.

- Milk and feed intake were measured daily
- Body wt from 3 d and condition scores were measured at 0, 3, and 6 wk.
- Milk composition analyzed 2 d /wk
- Samples of all diet ingredients and TMRs were collected once weekly.
- Orts and feces were collected every 15 h for 5 d in wk 6. Composited samples on an equal DM basis for feces and on a proportional basis for orts for each cow were used to determine the apparent total-tract digestibility using UNDF240 as an internal marker.
- Methane was measured every 9 h over 3 d in weeks 3 and 6 using GreenFeed unit.

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Statistical Analyses – Study 2

Statistical analyses were performed on data from wk 3 of each period using the GLIMMIX procedure of SAS 9.4 (SAS Institute Inc., Cary, NC) to

- Fixed effects
  - Hybrid, starch level, parity class, and 2-way and 3-way interactions
- Random effects
  - Block nested with parity
  - Cow nested with block and hybrid
  - Cow nested with block and fiber
- Covariates
  - DIM on the start of the study and the pre-treatment covariate values

All results are reported as LSMeans based on all 6 weeks of study.

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Composition based on pre, mid, and post samples

Composite of pre, mid, and post	Tall	BMR	Short1	Short2	Short3
Bag (order filled)	4	5	1	2	3
%DM	35	35	33	34	34
aNDFom, %DM	36	36	38	33	34
Crude Protein, %DM	7.2	7.5	8.0	7.7	7.6
Rumen Degraded Protein, %CP	77	75	77	75	75
Starch, %DM	37	37	35	40	39
Lignin, % NDF	7.3	5.9	6.3	6.6	6.8
30h IV NDF Digestibility, %NDF	53	63	60	57	57

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Experimental diets

% DM	Short		Tall	
	HiSta	LoSta	HiSta	LoSta
Corn silage	35.5	55.7	36.0	56.5
Alflafa haylage	14.0	14.0	14.0	14.0
Corn Grain Dry Ground	23.0	1.60	22.0	0
Soybean meal	10.0	11.2	10.5	12.0
Cottonseed	7	7	7	7
Protein, Mineral, and Vitamin Premix	10.5	10.5	10.5	10.5
Nutrient Composition (%DM)				
aNDFom, % of DM	24.7	29.9	25.0	30.3
forNDF, % of DM	16.8	23.9	17.2	24.5
EfNDF, % of DM	21.9	28.9	21.9	28.9
CP, % of DM	17.7	18.1	17.7	18.2
Starch, % of DM	31.6	22.7	31.6	22.7

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RESULTS	Short		Tall		P>F		
Variable	HiSta	LoSta	HiSta	LoSta	Hybrid	%Starch	H x S
DMI (kg)	28.1	26.7	28.0	24.9	0.04	<0.01	0.08
Milk (kg/d)	46.2	43.8	45.5	42.1	0.15	<0.01	
0.7ECM (kg/d)	45.2	44.1	43.3	42.5	0.05	0.29	0.84
Fat (%)	3.46	3.79	3.37	3.82		<0.01	
Fat (kg/d)	1.58	1.62	1.49	1.57	0.11	0.17	
Protein (%)	3.13	3.07	3.10	3.01	0.06	<0.01	
Protein (kg/d)	1.44	1.33	1.39	1.27	0.01	<0.01	
MUN (mg/dL)	6.32	7.14	6.39	7.58	0.17	<0.01	
0.7ECM / DMI	1.67	1.71	1.60	1.75		0.01	0.19
BW (av), kg	681	670	677	672		0.02	
BW Gain, kg/d	0.54	0.27	0.42	0.33		0.01	0.17
BCS Gain (Wk6)	0.003	0.003	0.001	-0.002	0.24	0.07	

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Study 2 results for gas emissions

	Short		Tall		P>F		
	HiSta	LoSta	HiSta	LoSta	Hybrid	%Starch	H x S
CO2 (kg/d)	17.0	16.8	16.8	16.4			
CH4 (g/d)	444	527	478	513		0.03	
H2 (g/d)	2.49	2.23	2.31	1.95		0.16	
CH4/DMI	16.5	19.9	17.6	20.3		< 0.01	
CH4/ECM	9.76	11.5	10.6	11.5		0.01	

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Summary and conclusion from Study 2

- As expected, high starch diets increased intake, milk yield, milk protein content and yield, body weight gain, and body condition gain, but decreased milk fat content.
- The short hybrid increased intake, energy-corrected milk yield, and milk protein content and yield.
- No interaction between hybrid and dietary starch level was detected.
- As expected, high starch diets decreased methane per unit EC-milk and per unit feed intake. Hybrid had no effect on methane emissions.

The short 1 hybrid in this study outperformed the tall control as a forage corn for cows in peak lactation.

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Shortfalls

- The perfect study for corn silage comparisons is nearly impossible.
  - Small plots of each hybrid, each stored in a separate bag.
  - Should treatments be equal amounts of corn silage? Or equal ForNDF? Or equal starch? Or something else?

- The perfect corn silage for all farms is impossible.
  - What other feeds are readily available? Corn grain? Non-forage fiber sources?
  - Is minimizing off farm feed costs a goal?
  - Is land availability a concern?
  - Is wind a concern?

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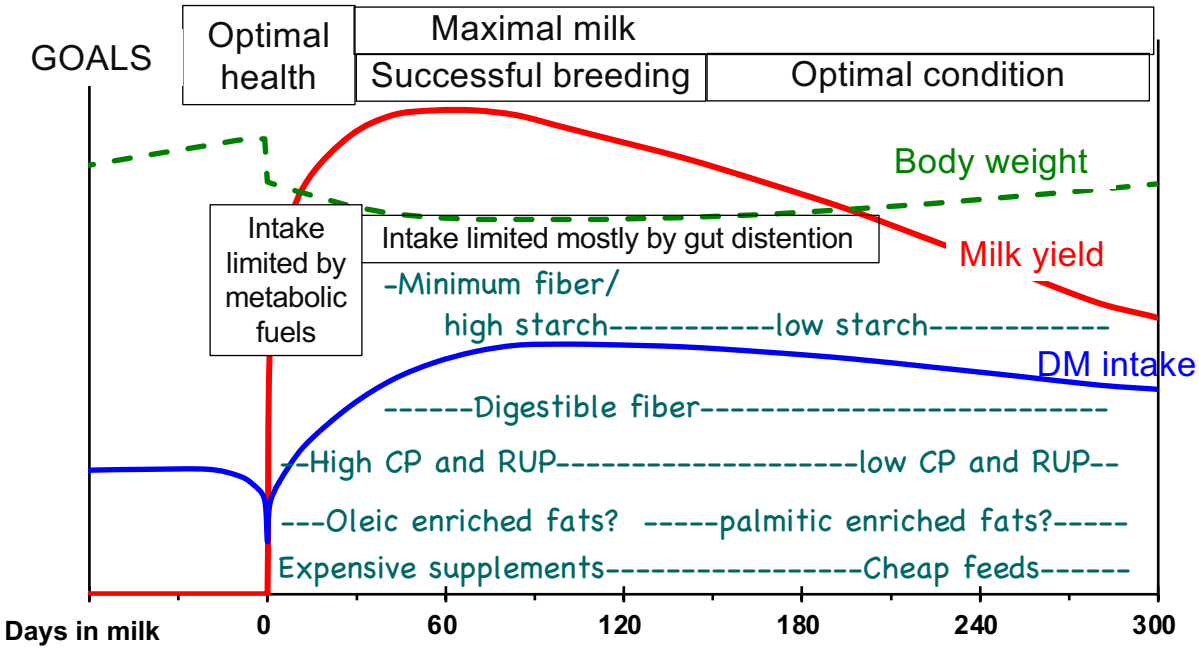
Feeding through the lactation cycle



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Questions?

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