This is a final project report submitted to The Ceres Trust.

Project Title:

Effect of organic grain supplementation on economic, behavior, and pest management strategies of organic dairy cows.

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Project Period: 2012-2013

Problem addressed

The number of organic dairies has been steadily growing during the past decade in the United States and the Midwest. However, current research and extension programs do not adequately support the needs of the increasing number of organic dairies, and scientific research on feeding organic dairy cattle is lacking. Science-based information is needed to better inform farmers on how to supplement dairy cows during the grazing season, especially during high grain prices. Some dairy producers are moving towards 100% pasture because of increased feed costs, their personal philosophy to use less grain, or they may have a specific market demand for grass-fed products.

Project Objective

The objectives of the study were to develop practical strategies for organic dairy producers to enhance the profitability of their farm by evaluating organic grain supplementation levels, and its effect on economics, behavior, and pest management of organic dairy cows. We will deliver organic best management practices for organic grain supplementation to organic dairy cows through learning opportunities via workshops, field days, conferences, and scholarly articles.

Methodology

The study was conducted at the University of Minnesota West Central Research and Outreach Center (**WCROC**; Morris, Minnesota) and all animal care and management was approved by the University of Minnesota Institutional Animal Care and Use Committee recommendations (Animal Subjects Code no. 1201B09304). The University of Minnesota WCROC organic dairy has been certified organic since June 2010 through Midwest Organic Service Association (MOSA).

Organic dairy cows at the WCROC organic dairy that calved during fall and spring calving seasons over 2 consecutive years (96 cows during 2012 and 57 cows during 2013) were used to evaluate production, grazing behavior, pest management, and profitability of organic dairy cattle supplemented with three levels (none, low, and high) of organic grain. Lactating Holstein and crossbred organic dairy cows were assigned to one of three supplementation levels and were blocked by lactation number, breed, and previous lactation milk production. Breed groups of cows included pure Holsteins and various crossbreds of Jersey, Normande, Holstein, Montbéliarde, and Scandinavian Red.

Cows were fed the following dietary supplementation levels, 1) no grain supplementation (100% pasture, **GRASS**), 2) low grain (6 lb of grain supplementation per day, **LO**), or 3) high grain (12 lb per day, **HI**). Supplement was fed with a total mixed ration of an organic grain mix (corn and minerals). Cows supplemented were fed a TMR that includes corn silage, alfalfa silage, and a corn-grain mix. On a per cow per day basis, the TMR was 25 pounds of organic corn silage, 16 pounds of organic alfalfa silage, and 1.45 pounds of organic minerals. The TMR was fed in a compost barn after the morning milking, but LO and HI Grain cows were allowed to graze during the afternoon and overnight. The GRASS cows were continually on pasture except during milking.

Furthermore, at least 30% of their diet consisted of high-quality organic pasture during the grazing season. All feed consumption was recorded daily with Feed Supervisor software utilized by the WCROC dairy. All three groups grazed alongside each other in the same pasture, consisting mainly of smooth bromegrass, orchardgrass, timothy, alfalfa, and red and kura clover.

Pasture herbage production was assessed for each group of supplemented cows during the grazing season with an electronic rising plate meter. Pasture herbage samples were analyzed for dry matter, ash, crude protein, neutral detergent fiber, acid detergent fiber, starch, and minerals using wet chemistry by Rock River Laboratories, Watertown, WI. For the pest management evaluation aspect of the project, effects of grain supplementation on pasture pest flies was determined by comparing the numbers of horn flies and face flies produced from the dung of herds on the three supplementation regimes during each gazing season.

Production, Body, and Fatty Acid Measurements

Body weights and body condition score were measured every two weeks from June to September as cows exited the milking parlor during the morning milking. Milk production was collected daily from the Boumatic SmartDairy system at the WCROC dairy, and milk samples were collected every two weeks and analyzed for milk components with mid-infrared spectrophotometry.

Milk for fatty acid profiles was collected every 2 weeks, and samples were analyzed at Minnesota Valley Testing Laboratories in New Ulm, Minnesota. Fatty acids from the supplementation groups were determined according to the AOAC International method (AOAC International, 2002; method 996.06). Briefly, lipids were extracted from a 3-g sample, saponified, derivatized, and then run on a gas chromatograph to determine which FA were contained in the sample. Results were reported as a percentage of a specific FA in the total fat and the value of all FA added up to 100%.

Profitability

Profit was estimated as a function of the revenue and expense for TMR cost, pasture cost, and organic mineral cost for a pen of cows during both years of the study. Profit per cow per day was the profit for a cow for the 125 days of the study. Milk price was $0.5853/kg of milk ($0.023/kg for milk volume, $4.617/kg for fat solids and $4.617/kg for protein solids), which was the mean milk price from 2012 to 2013 from component prices of the CROPP Cooperative. The average organic TMR price for the low grain and high-grain cows was mix was $0.1569/kg and $0.2213/kg, respectively. The average organic corn price included in the TMR price was $13.72/bushel, which was the average organic corn price from USDA during both years of the study. Pasture was valued at $0.09/kg of dry matter. Sensitivity analyses were performed to evaluate the effects of changes in organic corn price on total feed cost and profit per cow per day for organic dairy cows. Alternative corn prices were used for sensitivity analysis. The organic corn cost was decreased from $0.54 to $0.41/kg (25% lower) and $0.27 kg (50% lower), and increased to $0.68/kg (25% higher), which reflect potential market conditions for organic corn. An alternative milk price and corn price was evaluated that may reflect conditions on a conventional grazing dairy.

Pest Management

For the three treatments, fresh dung was collected from 3-4 cows per herd on three dates in 2012 and four in 2013. Samples were frozen for 4–12 d, and then thawed for bioassays with face flies in 2012, and with face flies and horn flies in 2013. Aliquot samples (50 g) on 9-cm diam plastic plates were inoculated with 25, 50 or 100 neonate face fly larvae, or 50, 100 or 200 horn fly eggs, and incubated on dry sand in ventilated containers at ~27 °C until all adult flies had emerged and died. Dead flies were sorted by sex, counted, and weighed (± 0.01 mg). Dung quality was indexed by survival to adult, average fly mass, and dry matter biomass. Each response was analyzed in a repeated measures design, with fixed effects of supplement level, date(repeats), and a 2nd order polynomial for dung supply (gm dung per egg or larva). Fitted treatment means were compared graphically with LSDs, using $\alpha = 0.05$.

Animal Behavior

We installed Heatime® HR Tags from SCR Dairy (SCR Engineers, Ltd., Netanya, Israel) around the neck of each cow in the study. This system allows us to track rumination (chewing) in addition to monitoring activity levels of cows. Due to manufacturer's settings, the monitors collect data for 7 days before registering activity and rumination index data. The monitors hold 24-hours of data and correspond with a long distance (LD) antenna placed atop the milking center. The antenna had a range of several hundred meters depending on the weather and other environmental factors. Each time the cattle returned to the milking center, and if they were in paddocks nearby the milking center, the antenna would download data as often as every 20 minutes. Unique to the HR Tag, we are also able to monitor rumination through a microphone installed around the neck. This microphone is actually picking up jaw movements as bones rub together during rumination. Rumination is measured in minutes per day.

Statistical analysis

For statistical analysis of production, body weight, and body condition score, independent variables were fixed effects of year of study (2012 or 2013), season of calving (fall or spring) nested within year of study, lactation number (1,2,3+) nested within year of study, supplementation group, supplementation group nested within year of study, breed group nested within supplementation group; breed group nested within year of study, and supplementation group nested within breed group and year of study. Cow within breed group and supplementation group and replicate within year of study were random effects with repeated measures.

For fatty acid analysis, the fixed effects were year of study, supplementation group, and the interaction of supplementation group and year of study, with collection date as a random effect with repeated measures.

For pasture herbage mass, the fixed effects were year of study, month of grazing (June, July, August, September), and the interaction of year of study and month of grazing, with paddock and collection date was a random effect.

For economics, fixed effects were year of study, supplementation group, and supplementation group nested year of study, with replicate nested within supplementation group as a random effect. The MIXED procedure of SAS (SAS Institute, 2013) was used to obtain solutions and conduct the ANOVA. All treatment results are reported as least squares means and significance was declared at $P < 0.05$.

Independent variables for statistical analysis of daily activity, daily rumination, activity at 2-hr intervals, and rumination at 2-hr intervals were effects of month of grazing, lactation number, breed group, supplementation group, and the interactions of month of grazing and supplementation group, breed group and supplementation group, and lactation number and supplementation group. Additionally, cow nested within breed group and replicate were random effects with measurement date as repeated measures. For activity and rumination at 2-hr intervals, 2-hr time block and the interactions of 2-hr time block and supplementation group, and 2-hr time block and month of grazing and supplementation group were added to the model. The

HPMIXED procedure of SAS (SAS Institute, 2013) was used to obtain solutions and conduct the ANOVA.

Results

The distribution of cows by breed group and supplementation group is in Table 1. Breed groups of cows were Holsteins (n = 50) maintained at 1964 breed average level (**H64**), Holstein-sired crossbreds (n = 40), Jersey-sired crossbreds (n = 42), and Scandinavian Red-sired crossbreds (n = 21).

Table 1. Distribution of organic dairy cows by breed group and supplementation group across both years of the study (2012 and 2013).

Breed group	Grass (N)	Low supplement (N)	High supplement (N)
1964 Holstein	16	17	17
Holstein-sired crossbreds	14	13	13
Jersey-sired crossbreds	15	14	13
Scandinavian Red-sired crossbreds	6	7	8
Total cows for the 2 years[1,2]	51	51	51

[1]32 cows for each group during 2012
[2]19 cows for each group during 2013

The GRASS cows had lower ($P < 0.05$) milk, fat, and protein production than the LO and HI cows (Table 2). However, LO and HI cows were not different for milk, fat, and protein production. Surprisingly, there were no differences in production between the two supplemented groups of organic cows, but the HI cows could have been partitioning the extra 6 lbs. of grain into body condition, and these results are presented in Table 5.

As expected, the GRASS cows had higher milk urea nitrogen (MUN) than the LO and HI groups of cows. The concentration of MUN in milk provides an idea of how cows utilize crude protein from the feedstuffs they consume. Typical dairy cow MUN ranges from 10 to 12 mg/dl, but values are higher when excess rumen degradable and undegradable protein is fed. The interpretation of MUN values may be influenced by many different variables, i.e. season, breed, level of production, and feedstuffs. When correcting for the fat and protein content in milk, the difference between the GRASS and LOW and HI cows was reduced, but the GRASS cows were still lower for energy-corrected milk.

Breed groups (Table 3) were variable for energy-corrected milk production within each supplementation group. The H64 cows had similar production for all three supplementation groups. The Holstein-sired crossbreds had higher energy-corrected milk in the HI group than the GRASS and LO groups. The LO and HI Jersey- and Scandinavian Red-sired crossbreds had more energy-corrected milk than the GRASS crossbreds.

Table 2. Least squares means and SE for production, SCS, and MUN by supplementation group across 2012 and 2013 during the grazing season for organic dairy cows.

	Grass		Low supplement		High supplement	
Measurement	Mean	SE	Mean	SE	Mean	SE
Milk (kg/d)	14.3[a]	0.6	17.4[b]	0.7	18.6[b]	0.7
Fat (kg/d)	0.50 [a]	0.02	0.63[b]	0.02	0.66[b]	0.02
Fat (%)	3.57	0.07	3.64	0.07	3.61	0.07
Protein (kg/d)	0.45a	0.02	0.56[b]	0.02	0.60[b]	0.02
Protein (%)	3.24	0.05	3.26	0.07	3.28	0.06
Somatic cell score	3.30	0.3	3.34	0.2	3.05	0.3
Milk urea nitrogen (mg/dl)	14.7[a]	0.2	10.9[b]	0.2	8.7[c]	0.2
Fat-corrected milk (lb)	13.3[a]	0.6	16.4[b]	0.6	17.4[b]	0.6
Energy-corrected milk(lb)	14.4[a]	0.4	16.2[b]	0.4	17.0[b]	0.4

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

Table 3. Least squares means and SE for milk volume and energy-corrected milk by supplementation group and breed group for organic dairy cows.

	Grass		Low supplement		High supplement	
Breed group	Mean	SE	Mean	SE	Mean	SE
Milk volume						
1964 Holstein	15.5	1.0	15.9	1.0	16.1	1.0
Holstein-sired crossbreds	14.0[a]	1.0	16.9[b]	1.1	20.8[c]	1.1
Jersey-sired crossbreds	14.3[a]	1.0	18.3[b]	1.1	17.4[b]	1.1
Scandinavian Red-sired crossbreds	13.4[a]	1.5	18.5[b]	1.5	20.3[b]	1.5
Energy-corrected milk						
1964 Holstein	14.8	0.5	15.2	0.6	15.3	0.5
Holstein-sired crossbreds	14.2[a]	0.6	16.0[b]	0.6	18.2[c]	0.6
Jersey-sired crossbreds	14.5[a]	0.6	16.9[b]	0.6	16.4[b]	0.6
Scandinavian Red-sired crossbreds	13.9[a]	0.8	16.8[b]	0.8	17.9[b]	0.8

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

Means for body weight for cows by 14-d period and across the grazing season are in Table 4. Across the grazing season, there were no differences for body weight for the GRASS (491 kg), LO (498 kg), and HI (498 kg) organic cows. Towards the end of the grazing season, the GRASS cows were not gaining as much weight as the LO and HI cows, and therefore, the GRASS cows were significantly lower in body weight during the last 2 weeks of the grazing season (September) than the LO and HI cows.

Table 4. Least squares means and SE for body weight by supplementation group during the grazing season for organic dairy cows.

	Grass		Low supplement		High supplement	
Measurement for 14-d period	Mean	SE	Mean	SE	Mean	SE
1	475.7	7.4	483.6	7.6	482.8	7.6
2	491.4	7.4	489.4	7.6	488.2	7.6
3	481.4	7.4	486.7	7.6	488.3	7.6
4	482.0	7.4	482.9	7.6	481.6	7.6
5	485.7	7.4	495.5	7.6	487.8	7.6
6	486.7	7.4	496.9	7.6	501.9	7.6
7	504.3	7.4	501.8	7.7	501.5	7.6
8	492.0	7.5	498.8	7.7	502.6	7.7
9	504.4^{a}	7.6	522.2^{b}	7.7	$516.2^{a,b}$	7.7
10	502.6^{a}	7.8	520.0^{b}	7.8	529.6^{b}	7.9
Mean of 14-d periods	490.6	6.9	497.8	7.2	498.0	7.1

^{a,b} = Means within a row without common superscripts are different at $P < 0.05$

Means for body condition score for cows by 14-d period and across the grazing season are in Table 5. Across the grazing season the GRASS (3.05) cows had lower ($P < 0.05$) body condition scores than the LO (3.14) and HI (3.15) cows. During the early period of the grazing season (June), GRASS cows were not different from the supplemented cows for body condition score. These results may be attributed to fact that there was an adjustment period for the GRASS cows moving from TMR to 100% pasture. However, during the latter period of the grazing season, the GRASS cows were lower ($P < 0.05$) for body condition score than the LO and HI cows. Although not significantly different, the HI cows had numerical higher body condition scores than the LO cows. Potentially, the LO and HI cows in this study devoted more of the energy they consumed to maintain and restore BCS compared than no grain cows and this, in turn, may have resulted in the enhanced reproductive cyclicity of the low and high grain cows.

Table 5. Least squares means and SE for body condition score by supplementation group during the grazing season for organic dairy cows.

Measurement for 14-d period	Grass		Low supplement		High supplement	
	Mean	SE	Mean	SE	Mean	SE
1	3.08	0.05	3.06	0.05	3.12	0.05
2	3.14	0.05	3.17	0.05	3.10	0.05
3	3.19	0.05	3.27	0.05	3.22	0.05
4	2.98[a]	0.05	3.13[b]	0.05	3.12[b]	0.05
5	2.98[a]	0.05	3.12[b]	0.05	3.14[b]	0.05
6	2.99[a]	0.05	3.13[b]	0.05	3.11[b]	0.05
7	3.08	0.05	3.19	0.05	3.17	0.05
8	2.94[a]	0.05	3.03[a,b]	0.05	3.10[b]	0.05
9	3.09	0.05	3.17	0.05	3.21	0.05
10	3.02[a]	0.06	3.17[b]	0.06	3.20[b]	0.06
Mean of 14-d periods	3.05[a]	0.04	3.14[b]	0.04	3.15[b]	0.04

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

Pasture herbage mass results (Table 6) for cows report the GRASS (1,716 kg/DM) cows consumed more dry matter intake per hectare per day than the LO (1,560 kg/DM) or HI (1,476 kg/DM) cows on pasture, as expected. The GRASS cows may have had higher dry matter intake on pasture, if the digestibility of the grass would have remained constant throughout the grazing season. The digestibility (NDFD, Table 7) was high during June decreased during July and August, and was the lowest in September even though crude protein was fairly constant from June to September (Table 7). The GRASS cows were simply not consuming enough quality dry matter intake during the latter part of the grazing season, and this may be one of the reasons for the lower milk production that was observed for the GRASS cows compared to the LO and HI cows.

Table 6. Means of pasture herbage mass by supplementation group during the grazing season for organic dairy cows.

	Grass		Low supplement		High supplement	
Grazing measurement	Mean	SE	Mean	SE	Mean	SE
Pre-grazing herbage mass (kg/DM/ha)	4,504	544	4,558	545	4,569	545
Post-grazing herbage mass (kg/DM/ha)	2,739[a]	305	2,943[b]	306	3,038[b]	306
Forage intake (kg/DM/ha)	1,716[a]	231	1,560[b]	232	1,476[b]	232
Dry matter/hectare/day	625[a]	53	536[b]	53	490[b]	53

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

Total mixed ration costs were lower ($0.00 versus $3.24 versus $4.81), pasture cost were higher ($2.64 versus $1.70 versus $1.73), and production revenue from milk were lower ($4.70 versus $5.85 versus $5.98) for GRASS, LOW, and HI cows, respectively. Although the LOW cows consumed lower amounts of concentrate, they had similar production to the HI cows, and therefore, similar revenue at organic milk price. Profit per day (income over feed cost, $/cow/day) was higher for the GRASS and LOW cows compared to the HI cows ($1.76 versus $0.85 versus -$0.61, respectively). For profitability, grain costs were substantially higher for the HI cows, and therefore, resulted in a reduced and negative income over feed cost for HI cows. The higher cost of production for the HI cows is due to the extremely high value of organic corn ($13.72/bushel average for the current study). The GRASS cows had the highest income over feed costs compared to the other supplementation groups because of lower feed costs, mainly pasture. Therefore, a low grain ration may reduce feed costs without sacrificing profit in an organic dairy system.

At the lowest organic corn price, there were no differences in profit per cow per day for the GRASS cows compared to the LO or HI cows. However, at the highest corn price, the GRASS cows continued to have advantage in profit per cow compared to the LO and HI cows, and the differences were greater.

Table 7. Forage quality results across 2012 and 2013 during the grazing season for organic dairy cows.

	June		July		August		September	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Dry matter	23.2	2.0	24.1	1.7	29.5	1.8	26.7	2.3
Crude protein	23.3	1.4	21.5	1.0	21.5	1.0	22.9	1.4
ADF	32.2	1.5	31.8	1.4	30.2	1.4	26.7	1.8
NDF	48.4	2.8	47.7	2.6	46.2	2.7	41.8	3.3
Lignin	5.0	0.4	6.3	0.4	6.0	0.4	5.4	0.5
NDFD[1]	67.5a	3.0	57.7b	2.9	57.7b	2.8	52.7b	3.5
TTNDFD[2]	57.3	3.2	51.3	2.6	49.6	2.3	52.5	3.6
Sugar	8.9	0.6	9.4	0.6	8.9	0.6	9.7	0.7
Fat	2.1	0.2	2.0	0.2	2.0	0.2	2.3	0.3
Ash	11.4	0.4	10.5	0.4	10.5	0.4	10.6	0.5
NFC	15.6a	2.7	19.9ab	2.6	20.9ab	2.6	23.7b	3.9
NE_L	0.61	0.02	0.61	0.01	0.63	0.01	0.64	0.02

[1] NDF digestibility
[2] Total-tract NDF digestibility
[a,b]= Means within a row without common superscripts are different at $P < 0.05$

Table 8. Least squares means and SE for profit per cow per day by supplementation group during the grazing season for organic dairy cows across 2012 and 2013.

	Grass		Low supplement		High supplement	
Measurement	Mean	SE	Mean	SE	Mean	SE
Production revenue ($/cow)	4.70	0.48	5.85	0.48	5.98	0.48
Pasture cost ($/cow)	2.64[a]	0.11	1.70[b]	0.11	1.73[b]	0.11
TMR cost($/cow)	0a	--	3.24[b]	0.12	4.81[c]	0.12
Mineral cost ($/cow)	0.20[a]	.01	0[b]	--	0[b]	--
Profit per day ($/cow)	1.76[a]	0.38	0.85[a]	0.38	-0.61[b]	0.38
Sensitivity analysis for profit per day ($/cow)						
Lowest corn price	1.76	0.40	1.54	0.40	1.20	0.40
Lower corn price	1.93[a]	0.39	1.19[a,b]	0.39	0.54[b]	0.39
Highest corn price	1.93[a]	0.38	0.51[b]	0.38	-0.72[c]	0.38
Conventional milk price	1.09[a]	0.32	0.0[b]	0.32	-1.44[c]	0.32
Lowest corn price and conventional milk price	1.09	0.34	0.68	0.34	0.37	0.34

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

The results for fatty acid profile analysis across the grazing season are in Table 9 and 10. The most beneficial fatty acids to human health are Stearic (18:0), Oleic (18:1), Linoleic (18:2), and Linolenic (18:3), and those fatty acids were all higher ($P < 0.05$) in milk from the GRASS cows compared to milk from the LO or HI cows. Furthermore, the GRASS cows had milk that was lower in Lauric (12:0), Myristic (14:0), and Palmitic (16:0) acid than the LO and HI cows. Lauric, Myristic, and Palmitic acid have been shown to be of greater risk to human health.

The GRASS cows had milk that was higher ($P < 0.05$) for mono-unsaturated fat and Omega-3 fatty acid (Table 10) than milk from LO and HI cows. No difference was found for supplementation groups for Omega-6 fatty acid. Furthermore, omega-6/omega-3 ratio was lower for GRASS cows compared to LO and HI cows. These fatty acid profile results may indicate that milk from cows that consume 100% grass compared to pasture and TMR may provide human health benefits.

Table 9. Least squares means and standard errors for specific fatty acids for supplementation groups during the 2012 and 2013 grazing season for organic dairy cows.

	Grass		Low supplement		High supplement	
Fatty acid	Mean	SE	Mean	SE	Mean	SE
	----------------------- (%) weight of total fat ------------------------					
4:0, butryic	3.24	0.16	3.59	0.16	3.37	0.16
6:0, caproic	1.64[a]	0.04	1.94[b]	0.04	1.97[b]	0.04
8:0, caprylic	0.87[a]	0.03	1.09[b]	0.03	1.15[b]	0.03
10:0, capric	1.88[a]	0.08	2.54[b]	0.08	2.73[c]	0.08
12:0, lauric	2.31[a]	0.15	2.99[b]	0.15	3.28[c]	0.15
13:0, tridecanoic	0.11[a]	0.01	0.12[a,b]	0.01	0.14[b]	0.01
14:0, myristic	8.13[a]	0.28	9.99[b]	0.28	10.36[b]	0.28
14:1, myristoleic	0.63[a]	0.05	0.73[b]	0.05	0.84[c]	0.05
15:0, pentadecanoic	1.38	0.44	1.73	0.44	1.16	0.44
16:0, palmitic	22.83[a]	1.48	27.23[b]	1.48	26.01[a,b]	1.48
16:1, palmitoleic	1.29[a]	0.06	1.40[a,b]	0.06	1.42[b]	0.06
16:1T, palmitelaidic	1.04	0.36	0.47	0.36	0.64	0.36
17:0, margaric	0.79[a]	0.02	0.73[b]	0.02	0.67[c]	0.02
17:1, margaroleic	0.25	0.02	0.23	0.02	0.20	0.02
18:0, stearic	12.07[a]	0.40	10.82[b]	0.40	9.93[b]	0.40
18:1, oleic	21.43[a]	0.60	19.05[b]	0.60	18.36[b]	0.60
18:1T, elaidic	5.38[a]	0.15	3.24[b]	0.15	2.98[b]	0.15
18:2, linoleic	1.35[a]	0.05	1.48[b]	0.15	1.67[c]	0.15
18:2T, linoelaidic	1.65[a]	0.08	1.30[b]	0.08	1.15[b]	0.08
18:3, linolenic	0.90[a]	0.04	0.65[b]	0.04	0.58[c]	0.04
cis-9, trans-11 CLA	0.03[a]	0.002	0.02[b]	0.002	0.01[c]	0.002
20:0, arachidic	0.20[a]	0.01	0.19[a]	0.01	0.15[b]	0.01
21:0, heneicosanoic	0.90[a]	0.03	0.46[b]	0.03	0.40[b]	0.03

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

Table 10. Least squares means and standard errors for fatty acids and their ratios for supplementation groups during the 2012 and 2013 grazing season for organic dairy cows.

	Grass		Low supplement		High supplement	
Fatty acid	Mean	SE	Mean	SE	Mean	SE
	------------------------ (%) in sample of fat ------------------------					
cis-Monounsaturated Fat	1.01[a]	0.06	0.90[a,b]	0.06	0.79[b]	0.06
cis-Polyunsaturated Fat	0.12	0.01	0.11	0.01	0.10	0.01
Omega-3 fat	0.054[a]	0.01	0.037[b]	0.01	0.031[b]	0.01
Omega-6 fat	0.073	0.01	0.074	0.01	0.074	0.01
Saturated fat	2.42	0.18	2.65	0.18	2.40	0.18
Total fat triglycerides	4.41	0.31	4.37	0.31	3.91	0.31
trans fat	0.33[a]	0.01	0.21[b]	0.01	0.18[b]	0.01
Saturated fat (%)	62.38[a]	0.86	68.47[b]	0.86	69.30[b]	0.86
Mono-unsaturated fat (%)	26.02[a]	0.71	23.28[b]	0.71	22.78[b]	0.71
Poly-unsaturated fat (%)	3.09a	0.10	2.76[b]	0.10	2.91[a,b]	0.10
Trans-fat (%)	8.51[a]	0.21	5.49[b]	0.21	5.01[b]	0.21
Omega-6/Omega-3 ratio	1.40[a]	0.09	1.98[b]	0.09	2.44[c]	0.09
Omega-3/Omega-6 ratio	0.74[a]	0.03	0.51[b]	0.03	0.42[c]	0.03
ALA	0.90[a]	0.04	0.65[b]	0.04	0.57[b]	0.04
Sum ALA + CLA	1.23[a]	0.06	0.83[b]	0.06	0.72[b]	0.06
LA/ALA ratio	1.54[a]	0.15	2.32[b]	0.15	3.06[c]	0.15

[a,b,c] = Means within a row without common superscripts are different at $P < 0.05$

Pest Management Results

Dung pat samples showed that more face flies, horn flies and non-pest flies emerged from dung pats produced by herds on HI supplement than on LOW or GRASS (Table 11), but differences were not significant ($F_{2,3\ df} < 4.2$, $P > 0.16$) in either year. Non-pest flies included a wide variety of species whose adults cause no harm to cattle or people, but whose larvae aid in dung recycling. Dung beetles included burrowers and tunnelers; none seemed to be affected by grain supplements either way.

Table 11. Average numbers of three different pest flies on cattle in herds fed no TMR supplement, or ones fed supplements with low and high amounts of grain, Morris, MN, 2012 and 2013. Grain supplements did not significantly change numbers of flies per animal.

	Horn flies		Face flies		Stable flies	
Treatment	2012	2013	2012	2013	2012	2013
Grass	21.3	17.7	5.8	2.9	9.8	9.8
Low supplement	15.5	13.4	3.6	2.3	7.8	7.0
High supplement	13.5	13.1	2.9	2.1	7.9	6.5
Average	16.8	14.8	4.1	2.5	8.5	7.8

For given type of fly and year, means among different treatment groups (in columns) were not significantly different (6 tests, $F_{2,3} < 3.4$, $P > 0.17$)

Laboratory bioassays indicated grain supplements roughly doubled the nutritional value of the supplemented cows' dung for face fly maggots on most dates in 2012 and 2013 (Figure 1). Increases in survival and size of face flies were greater in dung from grass vs. low grain supplements cows, than in dung from low grain vs. high grain supplement cows. Six lbs of grain per day was enough to make a difference. Differences with horn flies in 2013 were smaller and significant less frequently (Figure 1), but the pattern of increase with grain supplementation was similar to what occurred with face flies in both years.

The biological basis for the increase in dung quality may involve nitrogen content and bacterial composition, and is likely to be complex. Assuming other mechanisms do not compensate for changes in dung quality, it appears that grain supplements may increase numbers of face flies and horn flies on grazing cattle herds. Net benefits of grain supplements for dairy cows are under analysis.

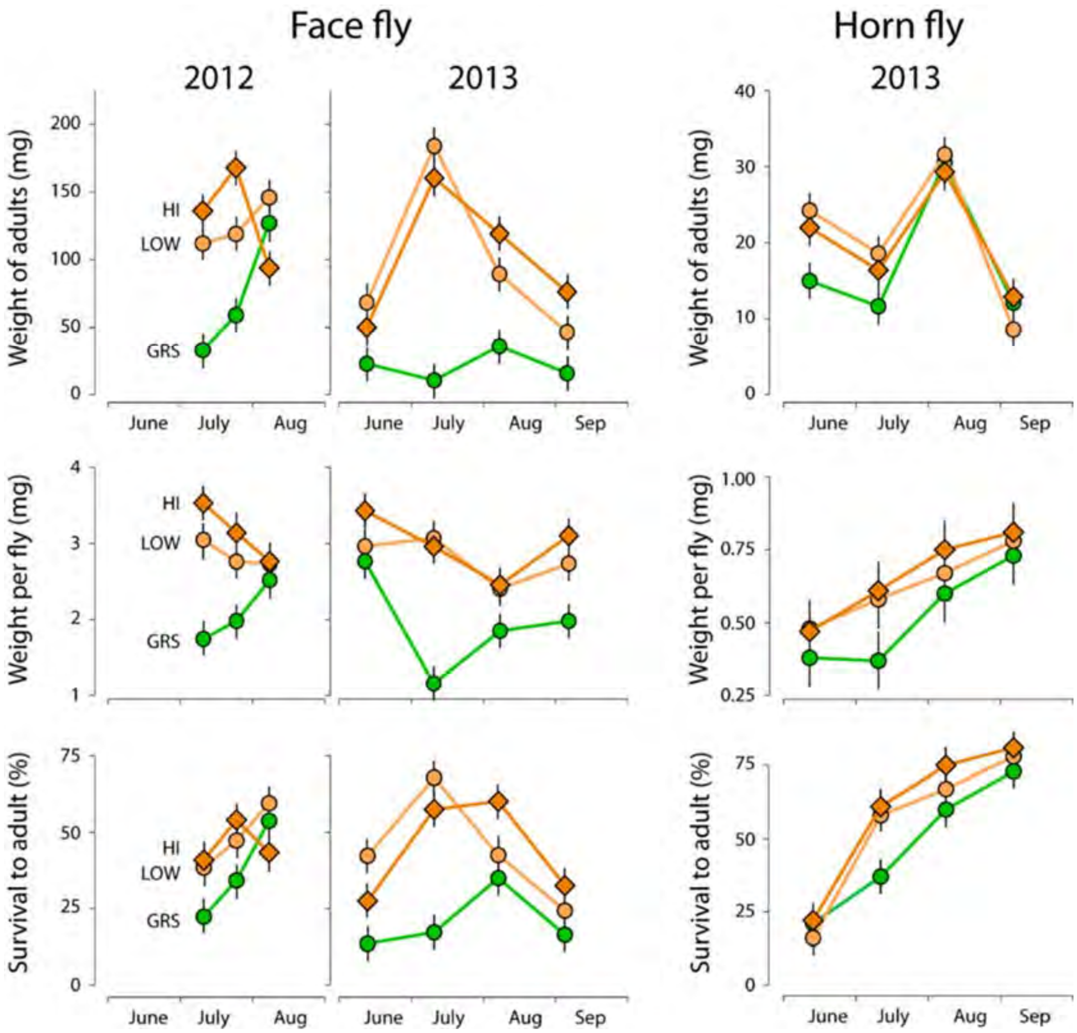

Figure 1. Fitness measures for face fly and horn fly larvae developing in dung collected from replicate, pasture based dairy cow herds receiving no grain, or low or high levels of grain supplement. Points are fitted means for date*treatment combinations, with supply set at 1 g dung per initial specimen. Bars are least significant differences (LSDs) between arbitrary means for each species' response. Bars that overlap are not different at $\alpha = 0.05$.

Animal Behavior and Activity

Supplementation groups did not differ for daily activity for the months during the grazing season; however, activity was the highest in July and lowest in September. Possible reasons for the high activity in July include hot, humid weather and an increase in horn fly numbers on pasture. While it was expected that GRASS cows would have higher activity, with longer walks to the milking parlor and the ability to run long distances within the paddock, the GRASS cows had numerically higher rumination than both the HI and LOW groups for each month. Furthermore, the HI cows, those with the least need to graze, had the lowest average daily rumination. Daily rumination for the organic cows averaged from 344 to 417 minutes per day.

All of the supplementation groups ruminate during the night and remain active during the day (Figure 2 and 3), possibly reversing the notion that the GRASS cows would rest during the hot part of the day and consume the most dry matter at night.

The reason for the varying daily activity and rumination levels among months could be due to feed availability, ambient temperature, weather events, insect pressure, or other factors. The reason for the difference among supplementation groups is likely the time spent grazing and percent of ration coming from pasture.

Table 12. Least squares means and standard errors for daily activity and rumination for grazing month and supplementation group.

	Grass		Low supplement		High supplement	
	Mean	SE	Mean	SE	Mean	SE
Daily activity						
June	1175	46.1	985	67.8	935	43.5
July	1280	46.1	1264	67.9	1230	43.6
August	1189	46.3	1053	68.5	1063	43.9
September	907	47.4	777	69.0	775	45.1
Daily rumination						
June	380	24.8	373	36.9	378	23.3
July	380	24.8	357	36.9	344	23.3
August	412	24.8	396	37.1	376	23.4
September	417	25.0	408	37.2	382	23.7

[a-c]Means within a row without common superscripts are different at $P < 0.05$.

Farmers in a limited labor or organic situation can evaluate whether precision technologies that include activity and rumination monitoring are right for their herd. Knowing the daily pattern of cows on pasture versus those fed concentrate indoors will help find health events and fertility events faster, leading to more profitability and more precise herd-level and cow-level management.

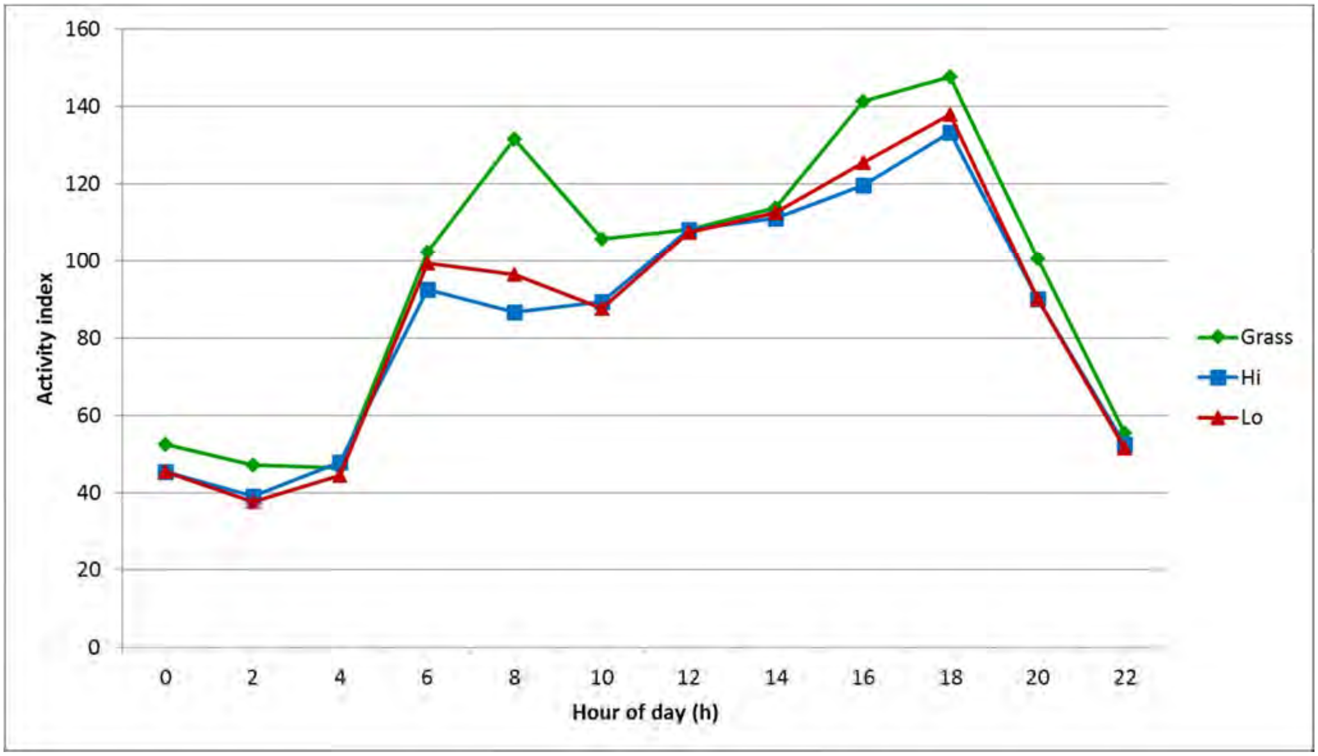

Figure 2. Average activity for supplementation groups for 2 hours blocks during a 24 hour day.

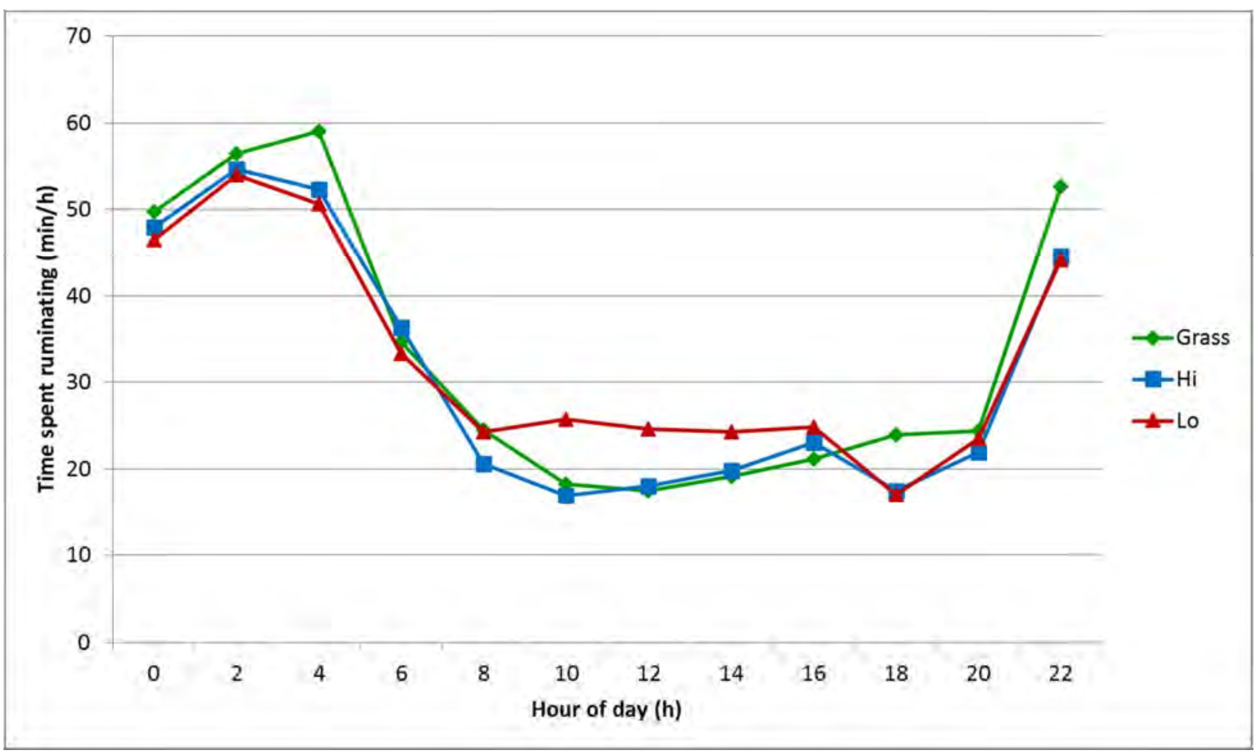

Figure 3. Average rumination for supplementation groups for 2 hours blocks during a 24 hour day.

Conclusion

During the study of this organic grain supplementation project, cows that consumed 100% pasture had lower milk production, lower body condition scores, but had milk that was higher in beneficial fatty acids. Profitability was higher for cows that consumed greater amounts of pastures, because organic corn price was high.

It is not clear how addition of grain supplements to diets of grazing cattle could lead to increases in dung quality for the pest flies. It is likely to involve complex changes in nitrogen content and bacterial composition. Assuming other mechanisms do not compensate for changes in dung quality, it appears that grain supplements may increase modestly the numbers of face flies and horn flies on grazing cattle herds.

The information from this study can be significant to organic dairy producers, as well as conventional producers, who are looking to reduce input costs during high grain prices. Producers who have a handle on their feed costs in an organic dairy production system can make informed decisions that reduce financial loss. The most important point for reducing inputs and increasing profits in organic dairy systems is to produce high quality forages and maximize dry matter intake on pasture.

This CERES Trust project was very instrumental and leveraged to receive a $1.93 million grant from the USDA-NIFA-OREI program to research strategies to improve the profitability of organic dairy production in the Upper Midwest.

Outreach and Extension

Investigators published numerous articles from the results of the first year of this study. Numerous presentations were made an organic farmer conferences, as well as scientific meetings from the results. Continued outreach will include seminars at conferences and publication in the Journal of Dairy Science and Journal of Veterinary Entomology.

The West Central Research and Outreach Center hosted its annual Organic Dairy Day in Morris in 2012 and 2013. More than 80 people, mostly dairy producers, from three states attended the event. Three seminars were presented during the morning session, and the afternoon concluded with three field tour stops at the WCROC dairy. The field tour provided opportunities for producers to view several research projects at WCROC. The pasture tour focused organic grain supplementation and forage intake on pasture. This current project was also an important part of the organic dairy day at WCROC and received much interest from the participants.

Publications authored by Investigators

Heins, Brad. 2013. Supplementation for the grazing cow. http://www1.extension.umn.edu/agriculture/dairy/organic/supplementation-for-the-grazing-cow/index.html December 7, 2013.

Heins, Brad. 2013. Estimating pasture forage mass for pasture-based dairies. http://www1.extension.umn.edu/agriculture/dairy/grazing-systems/estimating-pasture-forage-mass-for-pasture-based-dairies/index.html July 27, 2013

Heins, Brad. 2013. Supplementation strategies for organic dairy herds. Graze. October 1, 2013.

Heins, Brad. 2013. Estimating pasture forage mass for pasture-based dairy production systems. University of Minnesota, West Central News, May 29, 2013.

Heins, Brad. 2013. Nutrition for grazing dairy cattle in Minnesota. 2013 Morris SunTribune Farm Progress Supplement, March 9, 2013, pp. 8C

Heins, Brad and E. Bjorklund. 2012. To feed grain or not to feed grain?. University of Minnesota, West Central News, August 1, 2012.

Heins, Brad. 2012. University of Minnesota Organic Dairy Research Update. Northeast Organic Dairy Producers Alliance News, May 2012, Vol. 12, Issue 3. p. 8, 9, 37.

Heins, B. J. 2013. Organic dairy cattle management and nutrition. *In:* Proc. 74th Minnesota Nutrition Conference. Prior Lake, Minnesota, September 17-18, 2013, p. 178-179

Heins, B. J. 2013. Feeding the organic dairy herd during 2013 and beyond. *In:* Proc. Four-State Dairy Nutrition and Management Conference. Dubuque, Iowa, June 12-13, 2013, p. 44-50.

Heins, B. J. and J. C. Paulson. 2013. Estimating pasture forage mass for pasture-based dairy production systems with precision dairy technology. *In:* Proc. Precision Dairy Conference and Exp. Rochester, Minnesota, June 26-27, 2013, p. 139-140

Heins, B. J. 2012. Nutrition for grazing dairy cattle in Minnesota. *In:* Proc. 73rd Minnesota Nutrition Conference. Owatonna, Minnesota, September 18-19, 2012, p. 33-34.

Moon, R. D., M. I. Endres, and B. J. Heins. 2013. Do grain supplements for grazing cattle affect face fly and horn fly populations? Entomological Society of America, 10-13, November, Austin, TX

Heins, B. J., J. C. Paulson, M. I. Endres, and R. D. Moon. 2013. Effect of organic grain supplementation on production, body weight, body condition score, and profitability of organic dairy cows. J. Dairy Sci. Vol. 96 (E-Suppl. 2): 662

Heins, B. J., J. C. Paulson, M. I. Endres, and R. D. Moon. 2013. Effect of organic grain supplementation on pasture and total mixed ration, dry matter intake, and fatty acid profiles of organic dairy cows. J. Dairy Sci. Vol. 96 (E-Suppl. 2): 662

Heins, B. J. 2012. Nutrition for Grazing Cattle in Minnesota. *In:* Proc. 73rd Minnesota Nutrition Conference. Owatonna, Minnesota, September 18-19, 2012, p. 33-34.

Presentations by Investigators related to Grain Supplementation of Organic Dairy Cows

World Dairy Expo, Madison, Wisconsin, October 4, 2013, Title: Supplementation for the grazing cow: Corn and alternatives

74th Minnesota Nutrition Conference, Prior Lake, Minnesota, September 18, 2013, Title: Organic Dairy Cattle Nutrition and Management

2013 WCROC Organic Dairy Day, Morris, MN, August 13, 2013, Title: U of MN Organic Dairy Research Update

Four-State Dairy Nutrition and Management Conference Dubuque, Iowa, June 12, 2013
Title: Feeding the Organic Dairy Herd During 2013 and Beyond

Organic Valley Annual Meeting, LaCrosse, WI, April 10, 2013, Title: Organic Grazing Management

McIntosh Dairy Days, McIntosh, Minnesota, March 21, 2013, Title: Economics of Grain Supplementation for Organic Dairy Cows and Steers

Midwest Organic and Sustainable Education Service (MOSES) Organic Conference, LaCrosse, Wisconsin, February 21-23, 2013, Title: Production, Economics, and Pest Management Strategies of Organic Grain Supplementation for Organic Dairy Cows

World Dairy Expo Grazing Seminars, Madison, Wisconsin, October 5, 2012, Title: Dealing with high feeds costs: supplementation on pasture

73rd Minnesota Nutrition Conference, Owatonna, Minnesota, September, 2012, Title: Nutrition for grazing cattle in Minnesota

Photos

Organic dairy cows grazing during the month of August at WCROC, Morris

Discussion of the organic supplementation study with dairy producers at the WCROC Organic Dairy Day

Brad Heins and Jim Paulson discussing forage intake from pasture at the Organic Dairy Day

Roger Moon discusses fly management for organic dairies during a pasture walk

Electronic rising plate meter used to collect pasture herbage mass during the grazing season

Collection of dung pats for transfer to a greenhouse to rear out dung breeding pests