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To the Graduate Council:

I am submitting herewith a thesis written by Sarah Rebecca Edwards entitled "Impact of milk production level on beef cow-calf productivity in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

John T. Mulliniks, Major Professor

We have read this thesis and recommend its acceptance:

Arnold M. Saxton, Renata Nave, Justin Rhinehart

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Impact of milk production level on beef cow-calf productivity in Tennessee

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Sarah Rebecca Edwards
December 2015

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ABSTRACT

The beef cattle industry tends to focus on selecting production traits with the purpose of maximizing cow-calf performance. One such trait is milking ability, which is considered the primary influence on weaning weight of the calf. But, it can also have a negative effect on cow reproductive efficiency and cost of production. Therefore, the objective of this study was to determine the effect of actual milk yield on reproductive performance, circulating blood metabolites, and calf performance in beef cows in Tennessee. Data were collected from 239, 3- to 9-yr-old Angus sired beef cows from 3 research centers across Tennessee. On approximately d 58 and 129 postpartum, 24-hr milk production was measured with a modified weigh-suckle-weigh technique using a milking machine. Subsamples of milk were collected for analysis of milk components. Milk yield data were used to classify cows on actual milk yield as High (≥ 10 kg/d), Moderate (8-9 kg/d), or Low (<8 kg/d). Cow BW and BCS were collected weekly at each location through breeding. Calf BW was recorded at birth, mid-weight for an adjusted 58-d, and weaning BW for an adjusted 205-d. At d 58 and 129 of postpartum, milk yields were different ($P < 0.001$) among the treatment groups. Milk fat, protein, and solids-non-fat (g/d) were influenced ($P < 0.001$) by milk yield. However, milk lactose was not influenced ($P = 0.82$) by milk yield. Cow BW at the beginning of the study and at the end of breeding were different ($P \leq 0.05$) among milk production groups. Cow BCS were different after parturition, and pre- breeding ($P \leq 0.05$). AI pregnancy rates and overall pregnancy rates were not different ($P \geq 0.21$) across the individual milk groups. Calf BW at 58-d and 205-d of age ($P \leq 0.001$) was influenced by milk production

level of their dams. Results indicate that increased milk production in beef cows has the potential to increase calf weights at weaning. However, selection for milk production in this management environment could be discounted to decrease to nutrient demands of lactation and maintain productivity.

Key Words: beef cattle, calf performance, milk production

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

LITERATURE REVIEW

Introduction

To increase sustainability and profitability in the beef industry, production efficiency is a necessary objective for producers. To achieve production efficiency, beef producers may need to focus on long-term trait selection and optimizing genetic potential for traits like growth, and milk production for their distinct environments and operations. However, trends in genetic selection over the last 20 years have indicated a trend for increased mature cow size (Lalman et al. 2013). Milk production is often believed to positively influence weaning weights and profitability of cow/calf. However, weaning weight has only a 5% influence on profitability for commercial cow-calf producers (Miller et al., 2001). Conversely, this increase in selection for growth traits has been associated with an increase in maintenance requirements of the cowherd (Ferrell and Jenkins, 1985). This increase for energy cost and maintenance can account for 50% of energy required for beef production (Neville and McCullough, 1969; Ferrell and Jenkins, 1985; Montaño-Bermudez et al., 1990). Therefore, selection of increased genetic potential for traits like milk production will lead to higher maintenance cost. With feed costs accounting for 63% of annual cow cost (Miller et al., 2001), selecting cows that have higher milk production and wean heavier calves may not be more economically efficient due to increased input feed cost associated with the higher maintenance requirements. With that in mind, research conducted in this thesis was performed to determine the effects of milk production on performance of cows and calves in Tennessee.

Effects of Energy Requirements & Environmental Factors on Lactation

Environmental and nutritional constraints influence milk production and can prevent cows from reaching their peak milking potential (Brown et al., 2005). For example, cows grazing poor quality forage, or not meeting their nutrition requirements will either mobilize fat reserves to offset the nutrient deficiency or decrease milk production (Lalman et al., 2000). High-quality forages or supplemental feed can support increased levels of milk. Increased lactation, results in a 12-14% increase in energy requirements (van Oijen et al., 1993). Ferrell and Jenkins (1985) indicated maintenance requirements of a beef cow represents 70-75% of the total energy consumed annually by a cow and its calf. Comparing the predicted performance (using the 1996 NRC nutrient requirements of beef cattle; NRC, 2000) to actual cow performance, Petersen et al. (2014) indicated that the NRC underestimates the nutrient demands of a lactating beef cows in Tennessee. Cows with greater milk yield require a greater amount of feed energy and forage to support an increase in milk production (Arnett et al., 1971; Baker et al., 2003). In addition, increasing dietary energy intake during lactation increases 24-h milk yield and delays the days to peak lactation (Lalman et al., 2000). Montaño-Bermudez et al. (1990) compared energy requirements for cows varying in milk yield and concluded that the cows with a high (10.5 ± .30 kg) and medium (9.6 ± .20 kg) milk yield required 11% more energy to support an increased level of milk production as compared to the low (8.5 ± .27 kg) milk cows. Thus, the scientific literature clearly shows the increasing need for selecting cows to fit their nutritional environment (Baker and Boyd, 2003) rather than altering the environment with high energy diets to meet the demand of larger cows with increased milk yield.

Effects of Lactation on Cow Reproductive Performance

Beef cows should produce and wean one calf per year to remain profitable (Bond and Wiltbank, 1970; Short et al., 1990). Therefore, careful consideration must be taken to ensure that the nutritional requirements for key physiological periods are met. As previously stated, milk production has a large influence on nutrient requirements. The review by Short et al. (2000), explains that nutrients are partitioned in the order of: (1) basal metabolism, (2) activity, (3) growth, (4) basic energy reserves, (5) maintenance of pregnancy, (6) lactation, (7) additional energy reserves, (8) estrous cycles and initiation of pregnancy, and (9) excess body energy reserves. Thus, reproduction is considered a luxury event if sufficient nutrients are supplied to meet the higher ranking priorities. In agreement, Butler (2000) concluded that there is an inverse relationship between milk production and fertility in dairy cows. This might be explained by the high levels of energy required for lactation competing with metabolic necessities for reproduction.

Due to the high nutrient demand of lactation, cows often experience extended negative energy balance after parturition, which can have a negative impact on reproductive performance (Minick et al., 2001). Body condition score can be used to monitor cows' energy balance and has been suggested as a main factor in determining length of postpartum anestrus (Short et al., 1990). Cows that experience a negative energy balance during late gestation also have poor body condition scores at parturition and an extended period of postpartum anestrus (Hess et al., 2005). Therefore, heavier milking cows with a dramatically lower BCS at breeding due to energy partitioning (because of the demands of lactation) may have a decreased pregnancy rate in a defined breeding season depending on environmental conditions. To reduce the negative effects of nutrient restricted diets, higher energy diets can be fed to increase energy reserves and body condition (Lalman et al., 2000). Thus, with an increase in milk production, and the possibility of negative effects on cow reproductive performance, there may be an increase in cost of production (Ferrell and Jenkins, 1985). Therefore, cows with greater milk potential may require increased energy supply or an expensive feed modification of their environment to maintain their body reserves.

Effects of Lactation on Calf Performance

Beef breed associations use genetic selection tools such as expected progeny differences (EPD) to show the expectation of how progeny of an individual animal are expected to preform compared to the progeny of other animals (Brown et al., 2005). Maternal milk EPD is a prediction of relative genetic merit for the maternal component of weaning weight. Daughters of high-milk EPD sires are expected to produce more milk and wean heavier calves than cows with low-milk EPD sires (Minick et al., 2001). In addition, several studies have reported a positive relationship between sire milk EPD, and their crossbred daughter's actual milk production in relation to calves weaning weights (Diaz et al., 1992; Marston et al., 1992; Marshall and Long, 1993). Milk production has been found to be positively correlated with calf weaning weight and accounts for pre-weaning gains similar or greater than differences predicted by milk EPD in beef calves (Mallinckrodt et al., 1993; Baker et al., 2003).

As milk production increases, there is expected to be an increase in calf weight gain. Offspring from cows that produced a greater level of milk resulted in larger gains from birth to 6-mo-old (Drewry et al., 1959). However, those calves required more total milk per pound of live weight in order to achieve gains, which points out another important factor to consider is the efficiency of the conversion of milk intake to calf gain. The efficiency of conversion of additional milk to additional calf gain is improved (approximately 20:1) with lower milk yielding cows and considerably compounded (approximately 40:1) with higher milk yielding cows (Clutter and Nielson, 1987; Fox et al., 1988; Mallinckrodt, 1993). Thus, the declining efficiency of selecting for increased genetic potential of calf gain and milk production has been clearly illustrated in the literature.

Calf BW at weaning may be affected by the amount of available forage or milk consumed pre-weaning. Forage intake of calves is inversely affected by milk consumption and availability of forage (Abdelsamei et al., 2005). Calves with greater milk intake have a decreased forage intake, conversely with a decrease in milk intake calves tend to graze more and have a greater forage intake (Fox et al., 1988). Likewise, Tedeschi and Fox (2009) indicated calves were more dependent on forage after 60-90 d depending on the amount of milk available. In addition, calves with increased milk intake consumed less forage in the first 60 d of age than calves of the same BW that consumed less milk. Thus, any differences in weaning weight of the calf may only be associated with calf gain up to 60 d of age as reported by Ansotegui et al. (1991) that reported no differences in ADG for high- and low-milk-consuming calves after d 60 due to forage intake differences.

The efficiency of raising a calf from birth to slaughter in relation to optimum milk yield is not well quantified in grazing situations (Miller, 1999). Studies show that milk production can either negatively (Brown and Dinkel, 1982) or positively (Ferrell and Jenkins, 1985; Montaño-Bermudez and Nielsen, 1990) affect efficiency from birth to slaughter of calves. Brown and Dinkel (1982) found a positive relationship between milk production and weaning weights, slaughter weights, and slaughter age. However, this may not be economically or biologically efficient. Contrarily, Montaño-Bermudez and Nielsen (1990) and Ferrell and Jenkins (1985), indicated that lower calves from lower milking cows were more biological efficient at weaning and slaughter when compared to calves of similar size and growth potential. A study conducted by Lewis et al. (1990) reported that as the dam's milk level increases, there is an increase in DMI during post-weaning. Increased feed intake and gut capacity is related to increased visceral organ mass relative to live body weight (Wang et al., 2009). In addition, visceral organ mass of calves that come from dams that produce a larger amount of milk have an increased maintenance requirement (Ferrell and Jenkins, 1985). Likewise, Abdelsamei et al. (2005) compared Holstein bull calf performance from birth to slaughter using controlled amounts of milk and forage and concluded that calves consuming more milk had heavier BW at weaning than those consuming less milk. However, calves consuming less milk were more feed efficient from birth to slaughter than calves fed greater amounts of milk.

Conclusion

Livestock producers have emphasized improving output-related growth traits through a focus on genetic selection for increased milk production, greater calf weights, and larger cow size. These growth and milk traits have been selected with less regard for input costs to achieve certain production goals. Although these selection traits may increase production in the short-term by increasing calf weaning weight, it may not be profitable because of the additional cost of feed for increased genetic potential. Therefore, cows should be carefully selected to genetically match their environment to maximize biological and economic efficiency.

CHAPTER II

IMPACT OF MILK PRODUCTION LEVEL ON BEEF COW-CALF PRODUCTIVITY IN TENNESSEE

Introduction

Focus in the beef industry has been to maximize profit by using trait selection. In doing so, cow-calf producers have tended to select for short-term traits such as growth and milk yield to increase weaning weights of calves for the potential to increase profitability (Lewis et al., 1990). These selection traits do play a role in profitability for cow-calf producers; however, calf BW at weaning, for instance, only accounts for 5% of profitability for the producer in a profit model (Miller et al., 2001). Therefore, selection and management practices should be more focused on variables that play a large role in profitability.

Selection for increased milk yield also results in an increase in cow maintenance energy requirements (Neville and McCullough, 1969; Ferrell and Jenkins, 1985; Montaño-Bermudez et al., 1990). Therefore, there is a higher input cost of feed to maintain cows with a greater milk yield (van Oijen et al., 1993). With feed costs accounting for 63% of annual cow cost (Miller et al., 2001), producers may instead focus on decreasing the high-input cost that is associated with high maintenance beef cows. Although growth and milk selection traits may increase production by increasing calf weight at weaning, the additional cost to maintain production goals with increased milk production may decrease profitability. Therefore, the objective of this study was to evaluate the effects of actual milk yield in mature beefs cows on pregnancy rates, cow BW, cow BCS, calf BW and calf gain. The hypothesis is that cows with high milk yield will not have an increased calf weaning weight in Tennessee.

Materials and Methods

The Institutional Animal Care and Use Committee of University of Tennessee, Knoxville approved all described animal handling and experimental procedures.

In a 2-year study, 237 spring-calving Angus and Angus crossbred, cows (620.38 ± 9.54 kg) were used to determine the influence of milking potential on reproduction and calf performance at 3 research stations across the state of Tennessee (Plateau Research and Education Center, Crossville, TN (**PREC**); Middle Tennessee Research and Education Center, Spring Hill, TN (**MTREC**); Highland Rim Research and Education Center, Springfield, TN (**HRREC**)). Predominate forage of the pastures were endophyte-infected tall fescue (*Festuca arundinacea* Screb). Tennessee has a moderate climate environment with an average of 1,397 mm annual precipitation and an estimate of 6,734 kg/ha of standing forage (G.E. Bates, University of Tennessee, Knoxville, personal communication).

On approximately d 58 and 129 postpartum, cow milk yield was measured using a modified version of weigh-suckle-weigh method described by Waterman et al. (2006). Cows were milked using a portable milking machine (Porta-Milker, Coburn Company Inc., Whitewater, WI). Milk weights were recorded to calculate 24-h milk production. An aliquot was collected to analyze for milk protein, butterfat, lactose, and solids non-fat (SNF) by Dairy Herd Lab of Tennessee (DHIA), Knoxville TN. After milking, cows were retrospectively classified as 1 of 3 milk yield groups: LOW (6.57 ± 1.21 kg; range = 3.03 to 7.97 kg), MODERATE (9.02 ± 0.60 kg; range = 8.02 to 9.98 kg), or HIGH (11.97 ± 1.46 kg; range = 10.05 to 16.57 kg).

Depending on location, management practices varied. At the MTREC and HRREC locations, cows were managed as one group in a single pasture. Cows at PREC were managed in two groups in 2014 and three groups in 2015, in adjacent pastures with treatments evenly distributed. From December to May in each year, cows were fed ad libitum corn silage (6 % CP, 37% NDF) at PREC, rye haylage (8% CP, 61% NDF) with 5% corn distillers grain (30% CP) at HRREC, and orchard grass hay (17% CP, 48% NDF) at MTREC. Forage samples were ground with a Wiley mill (Thomas Scientific, Swedesboro, NJ) before analysis was performed. Crude protein analysis was determined by combustion (Leco-NS2000, Leco Corp., St. Joseph, MI). Neutral detergent fiber concentrations were determined using by a fiber analyzer vessel using methods described by ANKOM Technology (ANKOM A200, ANCOM Technology, Macedon, NY).

Calves were born in January and early February (avg. January 26th ± 28d). Approximately 30-d after calving, cows were weighed weekly until the termination of the breeding season and at weaning. Body condition scores were assigned to each cow (1= emaciated, 9= obese; Wagner et al., 1988) based on visualization and palpation by a trained technician once weekly. Calf BW was determined at birth, adjusted 55-d weight, and adjusted 205-d weight with no adjustment for sex of calf or age of dam.

Starting at approximately 35 d postpartum until the end of the breeding season, blood samples (~9 mL) were collected weekly via coccygeal venipuncture into serum separator tube (Corvac, Kendall Health Care, St. Louis, MO). After collection, blood was cooled and centrifuged at 2,000 x g at 4 ℃ for 30 min. Serum was harvested and stored in plastic vials at -4℃ for later analysis. To evaluate nutrient status, serum samples were then composited by cow within 2 physiological periods: 1) pre-breeding and 2) AI to end of breeding. Composite samples were analyzed using commercial kits for glucose (Infinity, Thermo Fischer Scientific, Waltham, MA), BUN (Infinity, Thermo Fischer Scientific, Waltham, MA) and NEFA (Wako Chemicals, Richmond, VA). Inter- and intra-assay CV were <10% for all serum metabolites.

In April of each year, cows were synchronized using a controlled internal drug-releasing (CIDR) device (Eazi-Breed CIDR, Zoetis Inc., Kalamazoo, MI) with 7-d CO-Synch protocol. Cows were administered a single 2-mL intramuscular (i.m.) injection of GnRH (Cystorelin, Merial LTD., Duluth, GA) and CIDR on -7 d. On 0 d, CIDR was removed and cows were injected with 5-mL i.m. injection of PGF (Lutelyse, Zoetis INC., Kalamazoo, MI). Approximately 66 h after CIDR removal, all cows were given an i.m. injection of 2 mL GnRH (Cystorelin, Merial) and artificially inseminated. After timed AI cows were managed together by location in a 60 ± 5 d breeding season. Pregnancy diagnosis was determined 30 d after timed AI and an overall pregnancy diagnosis was determined in September. Pregnancy diagnosis was determined at PREC by blood analysis (Golden Standard Labs, Bowling Green, KY) and by transrectal ultrasonography at HRREC and MTREC.

Data were analyzed as a complete randomized design, using a mixed procedure of SAS 9.4 (SAS Inst., Inc., Cary, NC). Cow was used as the experimental unit with the Kenward-Roger degrees of freedom method. The model included fixed effects of milk treatment, location, age of dam, sex of calf, year and their interactions. Differences in pregnancy rates were analyzed using logistic regression (PROC GLIMMIX) utilizing a model that included the fixed effects of treatment, location, age of dam, year and their interactions. Serum metabolite concentrations were analyzed with productive period as the repeated factor and cow as the subject with compound symmetry as the covariance structure. The model included treatment, location, period of measurement, age of dam, and their interactions. Significance was determined at $P \leq 0.05$ using LSD mean separation.

Results and Discussion

Milk yield and milk components

Due to retrospective-designed treatments, 24-hr milk yield was different ($P < 0.001$) among treatment groups. Milk components (fat, protein, and solids) increased as milk level increased ($P < 0.001$; Table 1). However, milk lactose was not different ($P = 0.38$) among milk treatment groups. In contrast, Marston et al. (1992) reported that with an increase in milk yield there was and increase in lactose, and a decrease in milk fat. In addition, Rutledge et al. (1971) also reported that fat decreases when milk level increases. With an increase in fat, protein, and solids in Moderate and High milk cows, calves from this study receiving an increase in milk may have an advantage in pre-weaning gain. In agreement, milk with higher fat and protein has been associated with improved pre-weaning weight gain of calves (Brown et al., 2001). In contrast, Rutledge et al. (1971) found that milk quantity was more in important that milk quality on 205-d BW in calves.

Effects of milk yield on cow and calf performance

Cow BW at the initiation of the study, and end of breeding were lower ($P \leq 0.05$) with an increase in milk yield. In contrast, Minick et al. (2001) reported no significant differences in cow BW between levels of milk production.

Table 1. Effects of milk yield on milk components.

Measurements	Milk Group[1]			SEM	*P*-Value
	Low	Moderate	High		
n =	74	72	93	--	--
24-hr Milk, kg/d	6.69[a]	9.11[b]	11.96[c]	0.21	< 0.001
Milk Components, g/d					
Fat	158.94[a]	245.42[b]	354.88[c]	17.44	< 0.001
Protein	198.11[a]	263.27[b]	354.09[c]	8.60	< 0.001
Lactose	329.79	360.11	477.36	121.76	0.38
Solids	737.17[a]	1,046.17[b]	1,422.96[c]	35.92	< 0.001

[1] Low = 6.69 kg (3.03 - 7.97 kg/d); Moderate = 9.11 kg (8.03 – 9.98 kg/d); High = 11.96 kg (10.05 – 16.57 kg/d).
[a,b,c] Means in rows with different superscripts differ ($P < 0.05$).

However, cow BW at pre-breeding and BW change during the course of the study was not different ($P \geq 0.09$) among milk groups. In addition, cow BCS was lower ($P \leq 0.05$) in High milk cows at the initiation of the study and at breeding. The decrease in cow BW and BCS could be explained by the increase in nutrient demand due to the increase in lactation (Belcher and Frahm, 1979; Mondragon et al., 1983; Minick et al., 2001; Lake et al., 2005).

Artificial insemination (AI) pregnancy rate ($P = 0.21$; Table 2), and overall pregnancy rate ($P = 0.81$) was not influenced by milk yield. In opposition, Butler (2000) reported an inverse relationship between milk yield and fertility in dairy cows. This inverse relationship is due to increased demand of energy competing with nutrient demands for reproduction. However, in an environment where energy levels are met or exceeded, increased milk production may not have an effect on reproductive performance.

Dam's milk yield did not alter calf BW at birth (*P* = 0.63). Contradictory, Minick et al. (2001), Pope (1963), and Jeffery et al. (1971) found a slight positive correlation between calf BW at birth and milk production. However, calf 58-d BW was increased (*P* < 0.001) with increasing dam milk production. Ansotegui et al. (1991) reported that milk production influenced calf growth up to 60 d postpartum. However, Ansotegui et al. (1991) reported no differences in ADG of calves from low milk producing cows versus high milk producing cows after d 60, due to forage intake differences, indicating that milk yield may be influencing calf growth up to 60 d of age. This agrees with the findings of Jenkins and Ferrell (1984), Marshall et al. (1976), Freking and Marshall (1992), Minick et al. (2001).

Calf 205-d weaning BW exhibited (*P* < 0.001; Table 3) a milk yield, location, and year interaction. In 2014, milk yield classification did not influence calf 205-d BW at all locations. In 2015 at the PREC and HRREC locations, Moderate and High milk cows had greater calf 205-d weights. However, at the MTREC location, no differences were found in 205-d weights among milk groups. Overall, across 2 yr and 3 locations, milk yield only influenced calf 205-d weaning BW 33% of the time. In agreement, milk yield has been suggested to be responsible for 40% of variance in weaning weights (Robison et al., 1978). Buskirk et al. (1995) also reported that milk production had no influence on calf BW at weaning. In addition, Buskirk et al. (1995) indicated that milk consumption was inversely related to forage intake. As milk consumption decreased, forage intake increased. Likewise, Tedeschi and Fox (2009), indicated that there is an inverse relationship between milk consumption and forage intake, but milk was prioritized over forage intake if both are readily available. In environments that are artificially modified with harvested feedstuffs and nutrient availability is not limited, calf performance may be increased without negatively impacting cow production.

Cow metabolite analysis

Milk yield had no effect on glucose ($P \geq 0.85$; Table 4) or serum urea N (SUN; $P \geq 0.56$) during pre- and post-breeding. In contrast, Morbeck et al. (1991) reported low circulating plasma glucose concentrations were positively related to increased milk production during d 30 to100 postpartum in dairy cows. A decrease in circulating glucose concentration may be due to glucose being a main precursor in milk production (Zhao et al., 2007). Gustafsson and Palmquist (1993) reported that SUN is positively correlated with milk. However, these authors indicated that the positive relationship could be confounded with sampling time versus time of feeding.

Serum NEFA concentrations exhibited a milk yield and time interaction ($P \leq 0.04$; Table 5). Serum NEFA concentrations increased with increasing level of milk production during the pre-breeding phase. Overall, serum NEFA concentrations decreased from pre-breeding to post-breeding in all milk groups. Although BW changes were not different, the increase in NEFA with an increase in milk yield during early lactation of the pre-breeding phase may be due to the mobilization of fat stores to support a greater amount of milk produced. In agreement, Ospina et al. (2010) also found that

Table 2. Effects of milk yield on Cow and Calf Performance.

Measurement	Milk Group[1] Low	Moderate	High	SEM	*P*-Value
Cow BW[2], kg					
Initial	634[a]	610[b]	608[b]	12	0.05
Pre-Breeding	607	599	584	13	0.17
End of breeding	645[a]	619[b]	612[b]	12	0.01
BW Change, kg					
Calving to Pre-breeding	-27	-12	-23	8	0.09
Pre-breeding to end of breeding	38	20	26	9	0.12
Calving to end of breeding	11	9	3	5	0.26
Cow BCS					
Initial	5.20[ab]	5.41[a]	5.09[b]	0.15	0.05
Pre-Breeding	5.19[ab]	5.31[a]	5.00[b]	0.13	0.03
End of breeding	5.34	5.47	5.24	0.13	0.15
Reproductive performance, %					
AI Pregnancy rate	48	59	62	6	0.21
Overall Pregnancy rate	85	87	88	4	0.81
Calf BW, kg					
Birth	36	36	37	1	0.63
Adjusted 58d	61[a]	68[b]	70[b]	2	0.0002

[1] Low = 6.57 kg (3.03 - 7.97 kg/d); Moderate = 9.02 kg (8.03 – 9.98 kg/d); High = 11.86 kg (10.05 – 16.57 kg/d).
[2] Initial date = February – March; Pre-Breeding = April; End of Breeding = June
[a,b,c] Means in each row with different superscripts differ ($P < 0.05$).

NEFA concentrations increased as milk yield increased in dairy heifers postpartum. Differences in NEFA concentration could also explain the decrease in cow BW and BCS across milk treatments (McArt et al., 2013).

Table 3. Effects of milk yield, location, and year interaction on 205 d weight (kg).

	Milk Group			
Measurement	Low	Moderate	High	SEM
2014				
HRREC	285^{ax}	294^{ax}	294^{ax}	12
MTREC	273^{ax}	284^{ax}	292^{axy}	8
PREC	276^{ax}	280^{ax}	274^{ay}	7
2015				
HRREC	249^{ax}	285^{bx}	279^{bxy}	11
MTREC	273^{ay}	267^{ax}	269^{ay}	9
PREC	251^{ax}	281^{bx}	292^{bx}	6

[a,b,c] For each interaction within timing of sample, means in a row with different superscripts differ ($P < 0.05$).
[x,y,z] For each interaction within timing of sample, means in columns within year with different superscripts differ ($P < 0.05$).

Table 4. Effects of milk yield on circulating glucose and serum urea N concentrations.

	Milk group[1]				
Measurements	Low	Moderate	High	SEM	*P* - Value
Glucose, mg/dL	64.77	62.6	67.38	6.63	0.85
SUN[2], mg/dL	20.05	21.89	13.18	6.86	0.56

[1] Low = 6.69 kg (3.03 - 7.97 kg/d); Moderate = 9.11 kg (8.03 – 9.98 kg/d); High = 11.96 kg (10.05 – 16.57 kg/d).
[2] Serum urea N

Table 5. Effect of milk yield on NEFA concentrations during pre- and post-breeding.

	Milk Group[1]			
Measurement	Low	Moderate	High	SEM
NEFA, mmol/L				
Pre-breeding[2]	571.47^{ax}	679.34^{bx}	744.35^{cx}	24.42
Post-breeding[3]	396.80^{ay}	404.72^{ay}	439.40^{ay}	24.04

[1] Low = 6.69 kg (3.03 - 7.97 kg/d); Moderate = 9.11 kg (8.03 – 9.98 kg/d); High = 11.96 kg (10.05 – 16.57 kg/d).
[a,b,c] For each interaction within timing of sample, means in a row with different superscripts differ ($P < 0.05$).
[x,y,z] For each interaction within timing of sample, means in a column with different superscripts differ ($P < 0.05$).

Implications

Results from this study suggest that an environment modified with harvested feedstuffs can effectively support cows with higher potential for increased milk yield. However, calf performance did not consistently respond to the increase in milk production. Therefore, potentially increasing weaning weight with higher-milk producing cows may not offset the cost of supplemental nutrition necessary to maintain the increase in milk yield and cow performance. Therefore, producers might discount high milk producing cows and take into account the requirements for maintaining a greater amount of milk, and the negative influences associated with a greater milk yield. Before placing more emphasis on increasing milk production, concerns about milk intake of the calf and energy utilization efficiency need to be addressed.

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