1-1-2007

# Use of corn forage for grazing lactating dairy cows

Brandon Jermaine McClenton

# USE OF CORN FORAGE FOR GRAZING LACTATING DAIRY COWS: AN ALTERNATIVE MANAGEMENT TOOL FOR DAIRY FARMS

By

Brandon Jermaine McClenton

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Animal Physiology
in the Department of Animal and Dairy Sciences

Mississippi State, Mississippi

December 2007

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By

Brandon Jermaine McClenton

Approved:

Terry R. Smith
Assistant Professor of Animal and Dairy Sciences
(Major Professor and Director of Thesis)

Peter L. Ryan
Associate Professor of Animal and Dairy Sciences
Graduate Coordinator of Animal Physiology
(Committee Member)

Brian J. Rude
Associate Professor of Animal and Dairy Sciences
(Committee Member)

Glover Triplett
Professor of Soil and Plant Sciences
(Committee Member)

Vance Watson
Dean of the College of Agriculture and Life Sciences

Name: Brandon Jermaine McClenton

Date of Degree: December 14, 2007

Institution: Mississippi State University

Major Field: Animal Physiology

Major Professor: Dr. Terry R. Smith

Title of Study: USE OF CORN FORAGE FOR GRAZING LACTATING DAIRY COWS: AN ALTERNATIVE MANAGEMENT TOOL FOR DAIRY FARMS

Pages in Study: 76

Candidate for Degree of Masters of Science

Two lactation trials were used to investigate corn grazing as a management tool for dairies. Control (n = 18) cows, housed in free-stall barns were allowed *ad libitum* access to TMR while Grazing (n = 18 to 36) cows were limit-fed TMR down to 70% of that in Controls and allowed 24-h access to corn plots. By wk 3, Grazing cows consumed 7.9 ± 1.5 kg/hd/d of standing corn. By wk 7, the crop had matured and Grazing cows consumed 11.42 kg/hd/d of corn grain. Intake of TMR by Controls was 20.07 ± 0.46 kg DM/hd/d, 19.78% greater than Grazing groups. Corn grazing had no impact on body weight, condition score, or ruminal pH, but significantly increased milk production in the Grazing group. Corn grazing reduced the need for purchased commodities, while improving milk production and performance. The value of saved commodities and increased milk production was $0.71 per cow/d.

Key Words: Corn Grazing, Dairy Nutrition, Dairy Management, Alternative Crop

DEDICATION

I would like to dedicate this work to my parents, Henry and Thelma McClenton, who gave me the encouragement to follow in what I believe, to be persistent in what I start, and guided me through my accomplishments.

## ACKNOWLEDGEMENTS

This research was supported by Alternative Crops grant No. 172050. The author would like to give thanks and glory to God who through him all things are possible. I would like to thank all those who helped me along the way and stood behind me, so that I might see this through. I would also like to express his sincerest gratitude to Dr. Terry Smith for approaching me with this opportunity and making this research opportunity and opening the door. Also, special thanks go out to Dr. Peter Ryan for having a very open door policy and helping to guide me through my graduate studies. The author would also like to thank the Mississippi Agricultural and Forestry Experiment Station (MAFES), the Mississippi State University Department of Animal and Dairy Sciences for their generous support of the research, the Alliance for Graduate Education in Mississippi (AGEM) program for their sponsorship and funding, and the staff and crew at the Coastal Plains Experiment Branch Station in Newton, Mississippi for all of their help.

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# CHAPTER I

# INTRODUCTION

The idea of grazing is an age-old process and the use of corn as a very concentrated feed source is widespread. The theory of combining the two into one is relatively new. As an annual grass, corn is a very flexible feed that can be used for dairy cows: in addition to a source of grain, corn can be used as forage that matures in the summer months when the availability of other quality forages may be limited. In fact, corn silage is a significant forage crop in most states except in the arid southwest, Alaska and Hawaii, but its use has limitations, particularly for small dairy producers. Specialized equipment is needed to harvest and store corn silage, and along with the intense labor required and expense for fuel and fertilizer, its production can be costly. Most producers overlook the possibility of grazing corn as a means to reduce input costs.

Allowing cows to graze corn has the potential to overcome many of the limitations associated with producing corn silage. Grazing corn eliminates the harvesting, drying, storage, and transportation costs associated with marketing the grain. Similarly, grazing corn reduces the costs associated with harvesting, storing and feeding corn silage. Because fewer inputs are required in the production of the crop and there is no need for marketing, grazing corn reduces the costs per acre. Additionally, when corn is used for grazing, the development stage at harvest is less of a concern because the crop is not required to reach physiological maturity. The moisture content is also of less concern than when the crop is used for silage because storage losses are not an issue (Erickson et al., 2005). Erickson et al. (2005) found that when grazed, the impact of reduced yield on the cost per ton of feed produced is reduced. Yet, corn grazing is a novel approach for most dairy producers and there is limited scientific research on the issue. Further, little information is currently available on the impact of integrating the practice into standard dairy management procedures.

Grazing corn has other potential advantages to the producer such as leaving the majority of the surplus or waste nutrients in the field (Kilmer et al., 2000). Producers that are subject to strict waste regulations or wish to improve environmental quality can reduce the amount of waste accumulation in lagoons and decrease the need for lagoon capacity and wastewater removal. Utilizing no-till practices in planting also reduces the loss of topsoil and permits the use of more marginal land such as hills and terrain subject to increased stages of erosion. As an additional benefit, corn grazing can open fields for double cropping, allowing time for pastures to be replanted in time to grow ryegrass or other winter annuals.

When grazed as forage, from the vegetative to early milk stage (R-3), corn is an extremely palatable forage, with good energy and protein content (Ritche et al., 1997). Furthermore, in the vegetative stage the corn plant has less fiber and is more digestible by ruminants (Hoorman et al., 2002). As the crop matures the intake pattern changes and when grazed after senescence the consumed portion is predominantly corn grain. Corn can potentially produce more digestible energy per acre than most other warm season crops (Wiedmeier et al., 2005). Thus, the increased-energy content makes corn a good nutrient source for lactating dairy cows, but the nutrient profile of the forage depends on its stage of development. At the early milk stage (R-3), just after the ear has formed, the whole plant averages 21% DM, 11.7% CP and 68.2% digestible on a DM basis (Johnson & McClure, 1968). Once the plant reaches mid-dent (R-5) the grain averages 55% DM and 10.7% CP on a DM basis (Gregoire, 2005). While the DM yield continues to climb as the plant matures, the nutrient composition does not change dramatically until the plant becomes senescent at this point much of the nutrients have been transferred to the ears, and "whole ear corn" averages 44% DM, 8.9% CP and 74% digestible on a DM basis (National Research Council 2001; Hunt et al., 2001). The intake patterns of beef cattle change with the plants development stage and shows that grazing follows nutrient composition: as the corn matures steers consume less of the stalks, and more of the ears (Boyd, 2003).

The objective of this research was to evaluate the impact of corn grazing on milk production, animal well being, and nutritional requirements as well as dairy productivity and resource management. In addition, research was conducted to study the effectiveness of using global positioning systems (GPS) to observe cows' grazing behavior on a forage based system, in order to better understand time utilization and scheduling in relation to milking, grazing, and other management practices, as well as to develop a model for patterning cow movement. It was our hypothesis that a corn grazing system could be integrated into normal dairy production practices to add value to the corn crop, provide alternative forage during periods of limited summer grazing, increase the productivity of the grazed land, while reducing producer costs and maintain production and performance.

# CHAPTER II

# LITERATURE REVIEW

## Grazing

Cows grazing standing forages is the most widely used system of production in the livestock industry, mainly because of the many potential advantages, including improved herd health, reduced capital requirements, reduced time spent row crop farming, environmental conservation, and lifestyle benefits to the farmer. Grazing is the feeding of livestock on growing grass and/or herbage. Dartt et al. (1999) defines grazing as herds consuming at least 25% of annual forage from pasture. By comparison non-grazing herds, typically have greater than 95% of forage mechanically harvested and stored before feeding. In most countries, grazing cows on pasture is an integral part of the milk production system. Properly managed pastures offer cows a superior-quality feed at lesser cost. Furthermore, grazing may improve the health of the cow with regard to leg and hoof disorders and decrease the number of veterinary treatments (Spörndly and Wredle, 2004; Gustafson, 1993). Milk production based on intensively managed pastures is a rapidly growing system in the United States (Hanson et al., 1998b).

Grazing allows cows to spend much of their time outside and harvest forage while on pasture (Gloy et al., 2002), as compared to confinement based operations where cows remain in free stall or tie stall barns. In confinement operations pasture access is limited and cows are fed a ration elevated in concentrates and energy and contain the roughage required by the animal. Efficient pasture based systems are characterized by increased milk output per unit of land, while efficient confinement systems are characterized by increased milk output per cow (Clark and Kanneganti, 1998).

There are several different types of grazing methods or management procedures designed to achieve specific objectives: continuous stocking, rotational stocking, buffer grazing, strip grazing, creep grazing, first-last grazing, mixed grazing, sequence grazing, and frontal grazing. The more common of these is continuous stocking which allows livestock unrestricted and uninterrupted access to a specific area for a specific time, and rotational stocking, which implies recurring periods of grazing among two or more paddocks with periods of rest and regrowth of forage between defoliation events (Barnes et al., 2003). Both systems are used extensively in the dairy industry, but are not the only source of nutrients for lactating cows, meaning the nutrients grazed from pastures are supplemented with a concentrate or a total mixed ration (TMR).

Pastures for dairy cows are commonly planted with temperate species and described as premium-quality or young and leafy pastures with 18 to 24% DM, 18 to 25% CP, 40 to 50% NDF, and 1.53 to 1.67 Mcal/kg DM of $NE_L$ (Clark and

Kanneganti, 1998). Muller and Fales (1998) reported a range of 18 to 25% CP, 40 to 55% NDF, and 1.55 to 1.70 Mcal/kg DM of $NE_L$ for well-managed pastures typically grazed in the Northeastern United States. Environment and climatic conditions do not always permit year-around grazing of premium-quality pasture, especially in dairy areas of the Midwest and northern United States; where cold temperatures and snow cover exist 4 to 5 mo/yr. Therefore, the use of feeding systems combining pastures plus additional feed supplementation of concentrates and conserved forage are required (Clark and Kanneganti, 1998).

Grazing dairy cows has been advocated, abandoned, and now beginning to reemerge as an alternative feeding system for dairy producers (Fontaneli et al., 2005). Staples et al. (1994) reported several reasons for a greater interest in dairy grazing operations, including: 1) decreased feed expenses, equipment, and buildings potentially leading to greater income per cow, 2) improvements in animal health and reproduction (less culling), 3) growing pressure from regulatory agencies and environmental interest to reduce centralized accumulation of cattle wastes, and 4) improved quality of life for managers (less stress, more leisure time, etc.).

### *Grazing and Dry Matter Intake*

Dry matter intake (DMI), is fundamentally important for nutrition because it establishes the amount of nutrients available to an animal for health, production, and maintenance. Dry matter intake is a function of meal size and intermeal interval, which are determined by satiety and hunger. Fully functioning ruminants commonly consume 2.5 to 3.0% DM of their body weight per day. For lactating dairy cows, DMI ranges from 2 to 4% of body weight (NRC, 2001). Decreased DMI on pastures has been identified as a major factor limiting milk production of greater-producing cows on a grazing system (Bargo et al., 2003; Leaver, 1985; Kolver and Muller, 1998; McGilloway and Mayne, 1996). Hodgson and Brookes (1999) describes three factors affecting pasture DMI of grazing cows: 1) "feeding drive" or nutrient requirements of the cow; 2) "physical satiety" or factors associated with the distension of the alimentary tract; and 3) "behavioral constraints" or limits to potential pasture DMI resulting from the combination of pasture and animal factors affecting grazing behavior.

Voluntary DMI is under the control of the animal and part of the dietary response of the animal (Van der Honing, 1998). Leaver (1985) suggested that greater-producing dairy cows consuming pasture only diets could reach a total DMI of 3.25% of body weight. Mayne and Wright (1988) estimated that with no pasture quantity and quality restrictions, pasture DMI of greater yielding dairy cows could reach up to 3.5% of body weight. Research conducted in New Zealand, recorded that the DMI of cows consuming pasture has been as much as 4.5% of live weight of cows averaging 450 to 500 kg (Holmes, 1987). Beaver and Thorp (1997) proposed that total DMI of dairy cows fed pasture only diets is less than in cows fed pasture plus concentrates, and that this may be due to physical constraints, the rate of forage removal from the rumen, and the additional water intake associated with fresh forage.

According to Fontaneli et al. (2005), grazing cows typically receive 55% of their DMI from the pasture. According to Combs (2001) the intake of pasture by cows is the product of the time spent grazing, the rate of biting during grazing and the weight of pasture per bite. Forages with a greater energy concentration ($NE_L$/DM) are consumed in larger amounts than poor-quality forage, and greater quality forage is essential to increased milk yields (Holter et al., 1997). Vazquez and Smith (2000) conducted a study to identify factors affecting pasture intake and total DMI in grazing cows. They sought to determine the most relevant variables for estimating pasture DMI and DMI and found those to be: pasture allowance, amount of supplementation, 4% fat corrected milk (FCM), body weight, change in body weight, and pasture NDF content. They also found that average DMI was 13.4 kg/d, with a maximum DMI of 21.3 kg reported and concluded that accurate estimates of DMI and pasture DMI are crucial in the management of a dairy grazing system.

### *Grazing with Supplementation: Corn/Protein*

The main objective of feeding supplements to grazing dairy cows is to increase total DMI and energy intake relative to what is achieved with pasture only diets (Peyraud and Delaby, 2001; Stockdale, 2000b). This is an important goal in dairy cow management, because cows in early lactation often experience a negative energy balance, and energy status affects milk yield and persistency of milk production. By feeding more fermentable grains one can increase the energy density of diets, therefore increasing energy intake (Oba and Allen, 2003). According to

Kellaway and Porta (1993), the objectives of supplementation include: 1) increasing milk production per cow, 2) increasing stocking rate and milk production per unit of land, 3) improving the use of pasture with superior stocking rates, 4) maintaining or improving body condition scores (BCS) to improve reproduction during pasture shortage, 5) increasing the length of lactation during periods of pasture shortage, and 6) to increase milk protein content by supplementing energy. Supplementation also optimizes profit per cow and per unit of land (Fales et al., 1995; Kellaway and Porta, 1993). However, over-feeding of concentrates increases feed costs and may cause cows to become overtly obese, resulting in reproductive and health problems (Holter et al., 1997).

Increasing the amount of concentrate fed to grazing cows can reduce grazing time (Rook et al., 1994), as well as pasture DMI. This is known as the substitution rate, which is one of the main factors explaining the variation observed in milk response (increase or decrease in production) to supplementation (Stockdale, 2000a). Forage supplementation decreases pasture DMI more than concentrate supplementation (Mayne and Wright, 1988). It is hypothesized that substitution rate is caused by negative associative effects in the rumen (Dixon and Stockdale, 1999), or a reduction in grazing time (McGilloway and Mayne, 1996). The energy provided by concentrates (fermentable carbohydrates) might also lead to reductions in ruminal pH, which may reduce the rate of fiber digestion from the pasture and therefore reduce pasture DMI (Dixon and Stockdale, 1999). Stockdale (1994) found that corn silage supplementation had positive effects on milk production when the amount of pasture offered was less, but when offered to cows on *ad libitum* pasture; supplemental corn silage either does not change or decreases milk production (Philips, 1988).

### ***Production/Performance Maximization (compared to TMR)***

Using premium-quality pasture in conjunction with a TMR during the grazing season can reduce feed costs and benefit herd health. Results from Soriano et al. (2001) shows that grazing of premium-quality pasture can maintain cow performance without decreasing milk composition and body weight, compared to cows fed a TMR in total confinement. In a review by Bargo et al. (2003) the total DMI of dairy cows on pasture only (traditional grass pastures) diets is less than dairy cows consuming a TMR or pasture plus supplements, indicating that greater-producing cows on grass pastures need to be supplemented to achieve there genetic potential for DMI. Supplementing dairy cows on a complete TMR diet with pasture in the afternoon, after the a.m. milking, had an economical advantage over feeding TMR alone (Soriano, 2001).

### ***Herd Health and Performance***

Grazing has many other beneficial effects in relation to the health and performance of dairy cows. Mastitis is a major cost to producers with the majority of the cost attributed to decreased milk production (White et al., 2002). Mastitis is an inflammation of the mammary gland often resulting from an intramammary infection that occurs when microorganisms penetrate the teat canal, multiply in the milk-producing tissue, and release toxins. Infections can be classified as clinical or sub-clinical depending on the degree of infection. According to Washburn et al. (2002a) there is a lesser incidence of mastitis in cows grazing pasture than those in confinement. Cows in confinement had 1.8 times more cases of clinical mastitis and eight times the culling rate due to mastitis and than did cows on pasture. A 4 yr pasture trial by Smith and Hogan (1994) reported decreased incidences of mastitis and speculated that pastured cows were exposed to fewer environmental pathogens compared to those in more traditional confinement-based systems.

Goldberg et al. (1992) examined clinical mastitis, udder edema, and bulk milk quality of grazing and non-grazing dairy farms in Vermont. Bulk tank milk samples were evaluated for standard plate count, bacterial type counts on tryptose-blood-esculin agar and somatic cell count (SCC). Mean standard plate counts were lesser in rotationally grazed herds than counts of confined herds during the grazing season. Mean bulk tank counts of streptococci (other than *Streptococcus agalactiae)* during the grazing season were the least in rotationally grazed herds. Among herds using recognized efficacious pre-dip products, fewer streptococci other than (*S. agalactiae)* were isolated from the bulk tank milk of rotationally grazed herds than confined herds.

Fontaneli et al. (2005) compared the productive and metabolic responses of lactating dairy cows managed on two pasture-based systems using a concentrate supplement, with cows in a traditional freestall housing system. They reported that plasma nonesterified fatty acid (NEFA) concentrations during the first four wk postpartum were greater for cows grazing pasture systems compared to those in free-stalls. Milk yield did not differ, but body weight loss was greater for grazing cows. Plasma glucose concentrations in grazing cows gradually increased in the first 10-wk post partum, following increases of forage intake. In addition grazing cows had decreased concentrations of plasma-glucose, than cows housed in freestall barns, during the 12-wk summer period that coincided with the loss in body weight. Thus, most studies agree that grazing has a positive influence on the health of lactating dairy cows.

***Cost/Economics/Profitability***

Over the past 50 years the dairy industry has been characterized by a favorable milk price to feed cost ratio, therefore dairy systems have tended to focus on the maximum milk production per cow possible (Clark and Kanneganti, 1998; Muller and Fales, 1998) and less use of pasture based systems until recent years (Muller and Fales, 1998). There has been a steady rise of the cost of production, pressuring producers to find cheaper means of production. Grazed forage is a less expensive source of nutrients, so the use of pasture for dairy cows results in less-costly feeding system (Bargo et al., 2003; Clark and Kanneganti, 1998; Peyaud and Delaby, 2001).

Ruminant digestive systems are uniquely designed to utilize forage. Energy from forages is generally cheaper than that from concentrates; hence the economic incentive to maximize the proportion of forage in the ration of dairy cows (Holter et al., 1997). Well-managed pastures can produce forages that are comparable or better than those produced with mechanical harvesting systems (Combs, 2001). Traditionally, producers starting farms would need to construct barns, facilities, and purchase machinery, which requires substantial capital investment. Staples et al. (1994) listed the benefits of grazing-based dairy systems: 1) decreased expenses for feed, equipment, and buildings potentially leading to greater income per cow, 2) important improvements in animal health and reproduction, 3) growing pressure from regulatory agencies and environmental interests to reduce centralized accumulation of cattle waste, and 4) improved quality of life for managers (less stress, more leisure time).

Feed costs are commonly the largest cash expenditure for producing milk. There is considerable interest in pasture-based systems in which grazed forage from fresh pasture can replace much of the stored forage in the ration (White et al., 2002). Data from the New York Dairy Farm Business Summary (Conneman et al., 1997) suggests that total costs of producing milk from grazing farms was lesser than the confinement systems, net income per cow was greater, and while labor efficiency was similar, the grazing farms had a smaller investment per cow (Conneman et al., 1997; Knoblauch et al., 1999). Intensively managed pasture-based systems can reduce input costs and increase net returns on small to medium sized farms in the United States by as much as $150/cow when compared to conventional confinement dairy systems (Tranel and Frank, 1991, Parker et al., 1992). The major economic advantage of a pasture based dairy system is associated with reductions in the cost of forage production; however, if producers are adept at pasture management, they must be aware that the potential savings in production costs are quickly lost if milk production declines (Combs, 2001).

Herd size, milk production per cow, and milk quality has a strong impact on dairy profitability. When similar dairy operations are compared, producers utilizing a grazing system are at least, if not more, profitable than producers not using grazing systems (Gloy et al., 2002). Researchers surveying New York dairy farms found that producers who used grazing for more than 15% of their forage needs had greater returns per cow and greater net farm income than producers that received less than 15% of forage needs from grazing. They also indicated that farms adopting a grazing system are less likely to incur added expenses while maintaining the amount of profitability that would likely be generated with a mechanical forage harvesting system (Gloy et al., 2002).

***Time for Grazing/Grazing Patterns***

According to the Dairy NRC (2001), maximal DMI can only be achieved when cows have adequate time for grazing. Data from Dado and Allen (1994) indicate cows during early lactation, producing 23 to 44 kg/d and allowed access to an *ad libitum* TMR, ate an average of 5 h/d. In order to maximize pasture DMI, the management system must also ensure unrestricted pasture quality and quantities (Bargo et al., 2003). Soriano et al. (2001) compared the TMR intake of cows fed a combination of TMR and pasture on dairy operations. Lactating Holsteins were fed a TMR diet alone, a TMR in the afternoon and pasture in the morning, or a TMR in the morning and pasture in the afternoon. Intake of the TMR was greatest for cows fed TMR alone, followed by those grazed in the a.m., and least for cows grazing after the p.m. milking; 26.6, 20.3, and 17.5 kg/d of DM, respectively.

Data from Schmidt and Pritchard (1987) suggests that lactating dairy cows spend more time grazing in the afternoon at least 4.1 h/d and only 2.3 h/d grazing in the morning. Soriano et al. (2000) also reported that when allowed *ad libitum* access to TMR throughout half the day, between 65.8 to 76.3% of the total DMI was consumed from the TMR and the rest from pasture. Additional results from this same study suggest that the most economical returns came from feeding a TMR diet after the a.m. milking and by allowing cows to graze good quality and abundant pasture in the afternoon, but this could vary depending on the environment.

Grazing generally occurs in three to four periods during the day, with the most intensive being 2 to 3 h at dawn and 4 to 5 h prior to dusk, with less intensive periods during the day or night depending on environmental conditions and rarely exceeds 12 to 13 h/d (Combs, 2001). Variation of these grazing times may be explained from forage mass and height, the number of leaves per unit of area, and the forage digestibility (Arnold, 1987). The upper limit of grazing time, to compensate for a reduction in bite mass (decreased forage availability), is determined by the time required for other activities such as ruminating (Rook, 2000).

Distance to pasture of grazing systems is an important factor in setting up a grazing system. Research by Spörndly and Wredle (2004) states that cows housed near the pasture spent 68% of their time outdoors, whereas cows housed further from the pasture spent only 44% of time outside. All cows spent 42 to 46% of their time lying down (lounging), while cows housed near the pasture spent 80% of that total time lying down in the pasture and cows on distant pasture preferred to lie down indoors. The distance that cows have to travel per day between, the milking parlor, pasture, and housing is an important factor that must be kept in consideration. According to the NRC (2001), the increase in energy requirement for walking 2km/d is around 5% of maintenance, corresponding to approximately 0.5 to 1 kg of milk. Cows having to walk greater distances (over 260 m) to pasture had a decreased milk yield, possibly due to the increased energy expended by walking (Spörndly and Wredle, 2004).

***Producer Benefits***

In past years, grazing provided some forage to dairy cows, but pastures were not managed to provide greater-quality forage. Management was extremely variable among many farms utilizing grazing systems, with pastures managed primarily to provide cheap forage in which milk production quality is not the top priority (Parsons, et al., 2004). According to the study by Parsons et al. (2004) farmers using confinement management had significantly more cows, greater milk production, more crop acreage, increased debt, fed TMR and were more satisfied with their current management system.

Dairy producers who grazed their milking cows had smaller herds, fewer acres, but had more acres per cow and used less technology. Additionally they reported that producers practicing intensive grazing were significantly younger, more educated, with less experience, more likely to use computers, and farmed less acreage than other grazers or producers on confinement farms. Grazers were more likely to have completed high school and had significantly less debt. According to Hanson et al. (1998b) it has been suggested that constraints on available credit have influenced farmers to adopt grazing systems.

As stated by White et al. (2002), mastitis is a major cost to producers, but producers grazing cows have witnessed reductions in mastitis resulting in fewer losses due to culling and death. Research has also shown that cows kept in free-stall barns had significantly decreased milk production due to lameness from sole ulcers, foot abscesses, and foot rot or foot warts (Warnick et al., 1997). Grazing reduces these risks, thereby reducing the number of veterinary treatments and culling rates. There are also advantages to grazing herds in conjunction with marketing, savings in labor etc. The potential for improved milk quality and related bonus programs that exist in many regions is also an advantage, as well being more appealing to consumer markets.

## Zea mays L.

*Zea mays L.*, commonly referred to as corn, is the number one field crop in the United States. It leads all other row crops in value and volume of production. In 2005, producers in Mississippi alone, planted an estimated 157,677 ha of corn, yielded an estimated 310 bu/ha, and 47.1 million bushels of corn grain (MAFES, 2006). As one of the most important row crop grown in North America, corn is planted on more land than any other U.S. crop, and is grown in almost every state; however, the main production region lies in the north central states. Corn originated in Southern Mexico, it is an annual grass that stands erect, is thick stemmed, leafy and grows from three to four meters tall.

Corn is typically grown and harvested by livestock producers for either grain or silage due to its increased yield and forage digestibility, but not as a forage crop. Although, corn stover, which is the crop residue of corn grain production that consists of stalks, leaves, and husks, is used to extend the grazing season or as a roughage source for gestating beef cows (Barnes et al., 2003). One of the most common means of wintering beef cows in Iowa, Nebraska, and Kansas are by grazing corn residues (Clanton, 1989; Russell, 1990; and Russell et al., 1993). While grazing corn stover is a common practice currently, grazing standing corn is not, but during an emergency, corn can be used as a pasture crop.

### *Production and Establishment*

As a warm season crop, corn has growth characteristics that allow it to produce greater yields along with better nutrient values if intensively managed (Erickson et al., 2005). Corn is productive and is very responsive to nitrogen, phosphorous and potassium. It has the potential to produce up to 9.07 tonne of premium-quality forage per hectare. Few other crops can compare to the DM yield/ha and cost per kilogram of gain of corn. As a production crop, corn should be harvested from July to October, and when used for silage the kernels should be in the early dent stage (Ball et al., 2002 and Barnes et al., 2003). As silage (at the hard dough stage), corn is capable of producing 13 tonne/ha of DM annually. At 35% DM, yields can increase to 37 tonne/ha annually (Ball et al., 2002 and Barnes et al., 2003). For optimum production in the South corn should be drilled in 75 to 100 cm wide rows at 12 to 22 kg/ha in the spring (March to May) once soil temperatures exceed 10º C at densities between 60,000 to 72,000 plants/ha (Ball et al., 2002; Barnes et al., 2003).

### *Nutritional Properties of Corn*

Superior-producing dairy cows require a tremendous amount of energy in order to sustain milk production and parturition. The most economical source of providing these nutrients is through quality forages. Corn has the potential to produce more digestible energy per acre than other silage crops, (Ball et al., 2002 and Wiedmeier et al., 2003) which is the reason that corn remains a staple component in most dairy rations on Southern dairy farms. Corn grain is the major source of dietary starch for lactating dairy cows in the United States. Ground corn grain typically contains 3.85 Mcal/kg of digestible energy (DE), is 9.4% CP, 9.5% NDF, and is 88.7% TDN (NRC, 2001). Ruminal starch digestibility of corn grain can be altered by grinding fineness and by the method of preservation (Oba and Allen, 2003).

Corn silage, which is the forage preserved at a lesser pH, is an excellent crop due to the production of organic acids by partial anaerobic fermentation of sugars in the forage (Barnes et al., 2003). According to the NRC (2001) normal corn silage, harvested at 32 to 38% DM is 8.8% CP, 68.8% total digestible nutrients (TDN), and 45% NDF Corncobs alone are 90% DM, 3% CP 54.2% TDN and 86.2 % NDF. Although, increased-moisture forages that are fermented (silages) result in greater declines of intake compared to those fed without fermentation (Barnes et al., 1995 and NRC, 1989). Barnes et al., (1995) reported that fresh (unfermented) corn plant material fed without drying or with variable amounts of heat drying resulted in equal intakes when fed as the sole source of nutrients (Barnes et al., 1995).

In the vegetative stage corn makes a good quality forage. When harvested for silage (<25% moisture), DE is 2.87 Mcal/kg, CP is 9.7%, NDF is 54.1%, and TDN is 65.6% (NRC, 2001). At physiological maturity, the quality decreases as the grain dries, but at 25% to 30% grain moisture, the whole plant is still considered to be a good quality. At this stage, digestible energy measures 2.84 Mcal/kg, CP is 8.5%, and NDF measures 44.5%, and TDN are 65.4%. The feed value of corn varies as the plant matures (Table 2.1). Crude protein, fiber and ash are greater in immature corn as it produces a lesser yield (test weight), but the gross energy of corn does not change with yield. Although, by the time the dry grain is harvested the feed value of corn stalks has decreased considerably, but the nutrient value of corn stover at 85.2% DM is 2.26 Mcal/kg, DE, 5.4% CP, 57% NDF, and 51.3% TDN (Jurgens, 2002). Nevertheless, the cornhusk is also extremely digestible, often above 60% in DM digestibility (Barnes, 1995).

Table 2.1 Feed Value of the Whole Corn Plant at Various Maturity Stages[1].

| | **Stage of Maturity** | | | |
|---|---|---|---|---|
| **Nutrient** | **Early Milk** | **Early Dough** | **Mid Dent** | **Physiological Maturity** |
| | **Concentration in Dry Matter** | | | |
| **Dry Matter, %** | 20.9 | 35.7 | 55.5 | 76.6 |
| **Crude Protein, %** | 16.6 | 12.5 | 10.7 | 10.9 |
| **Crude Fiber, %** | 5.4 | 3.3 | 2.5 | 2.1 |
| **Crude Fat, %** | 3.0 | 4.0 | 4.8 | 4.9 |
| **Ash, %** | 2.8 | 2.3 | 1.7 | 1.5 |
| **Starch, %** | 47.4 | 55.0 | 58.7 | 63.7 |
| **Gross Energy (kcal/kg)** | 4650 | 4540 | 4590 | 4580 |

[1]Data on the composition of corn was taken from NDSU Extension Service (Gregoire, 1999).

## Corn Grazing

To maintain profitability and optimum milk production, dairy cows must consume large quantities of quality feed (Barnes et al., 2003). As previously stated the cheapest way for producers to provide this feed is by grazing quality forage. A quality forage is one that results in greater intakes, increases digestibility, and contains the proper balance of needed nutrients (Ball et al., 2002). The key concept of corn grazing is to replace expensive machinery needed for the harvest and storage of the forage, by substituting the cow (Fontaneli, 2005). Feeding quality forages reduces feed costs; stimulates greater milk production; increases DMI; and contributes to the health, thriftiness, and productive life of the cow. As previously mentioned, feeding fermentable carbohydrates (silages) decreases DMI, therefore concentrates or TMR should be limited, which makes corn forage a good substitute.

Standing corn has the nutritive composition to meet the requirements for many categories of livestock (Hoorman et al., 2002) and corn grazing has been used for a variety of farm animal species. Sheep have been rotationally grazed on corn when the plants are 18 inches tall or less. Standing mature corn has been successfully utilized for finishing hogs and market steers (Hoorman et al., 2002). It has also been used for beef cows under maintenance conditions and to winter fall-calving cow pairs instead of feeding hay or straw (Wiedmeier et al., 2003; 2005) and dairy producers have utilized corn for grazing dairy cows and dairy heifers (Hoorman et al., 2002).

*Need for Corn Grazing*

Feed costs have been identified as the largest single cost of livestock production making up 50 to 70% of the total cost of production (Hoorman et al., 2002). To reduce feed costs, producers are seeking alternative options to extend the grazing season. Corn is potentially available for grazing from May through January, and while its composition varies as the season progresses, this quality forage is available when other, more traditional, forages are lacking or of marginal nutritional value. Traditionally the harvest and storage of a corn crop involves a substantial capital investment, and because of the increased costs, some producers may not be able to take full advantage of the potential of corn. Allowing livestock to graze corn reduces the investment required for harvest, storage, and feeding equipment (Hoorman et al., 2002). Thus, corn grazing gives small to medium scale farmers the potential to utilize and/or add value to their corn crop. Other potential value-added aspects of grazing corn include: increases the manure spread by cattle in the field and thereby reduces or eliminates the need for manure storage and handling facilities as well as groundwater contamination; reduces the energy costs associated with harvest and transportation of the grain and spreading manure; maintains soil fertility; and reduces the cost of fertilization by capturing the nutrients lost when cattle are confined (Dingels and Dingels, 2000).

***Crop Availability***

From a nutritional standpoint, grazing immature corn is similar to grazing other summer annuals. It is a warm season, annual grass, moderate in protein and extremely digestible (Ball et al., 2002; Barnes et al., 2003). But unlike other forages, once the corn plant reaches maturity, the nutritional value of the plant is transferred into the ear and the grain produced compensates for the loss of the feed value the forage. The biggest decision for producers planning to graze corn is deciding when additional forage is needed. Corn is planted throughout March, April, May, and June, depending on region and is normally harvested from July to October. Corn can be grazed during mid summer months (late June and early August) when temperatures are hot, allowing producers to stockpile their perennial pastures for fall or early winter grazing.

Alternatively, the corn can be grazed extremely late in the season, having the ability to provide energy and shelter during the fall and winter months (Hoorman et al., 2002). As an annual crop, it is extremely flexible as to when it can be grazed. The forage can be consumed from 30 to 100 d after planting; this offers the potential for producers to integrate corn grazing with a variety of secondary crops to maximize productivity of the plot (Hoorman et al., 2002). Additionally, corn has an advantage as a winter grazing crop, because its stem cures well, it stands above the snow, and it stands up in windy conditions, which has the added advantage of providing a windbreak for cattle grazing it (Wiedmeier et al., 2003).

### *Grazing Dynamic*

There are a variety of ways that a corn-grazing plot can be adapted to work for each producer's individual situation, but the efficient utilization of the crop becomes a key issue to being profitable. Typically animals will waste or trample some feed, so with typical forage only 60 to 90% grazing efficiency will be achieved (Hoorman et al., 2002). Feeder heifers grazing corn consumed 99% of corn grain, leaves, husks and cob and about 20% of the stalk (Dingels and Dingels, 2000). To achieve maximum efficiency the pasture has to be carefully monitored and allocated to the amount of DM needed at that time. To calculate the effective amount of DM needed daily, the pounds of DM required can be divided by the grazing efficiency (Hoorman et al., 2002). Dingels and Dingels (2000) determined the amount of corn or grazing area allocated to the cows, simply by monitoring how much forage was left from the previous day.

Hoorman et al. (2002) used an electric fence to strip graze corn, allowing livestock access to only enough of the plot for two to three days of grazing. By limiting the cattle's access to a portion of the plot, strip grazing prevents significant trampling and/or wasting of the corn (Dingels and Dingels, 2000); however it requires more intensive management. Strip grazing confines an increased density of animals to a specific area in order to utilize the forage in a short period of time (0.5 to 7.0 days; Barnes et al., 2003). To partition the plot using a portable electric fence, a cornrow is typically knocked down and the fence is placed in this path, since a normal cornrow is generally not wide enough for this. The electric fence should have a minimum of two strands to keep cows from reaching through or over it and to prevent the fence from grounding out should a stalk fall on it. The livestock should be given a grazing area that allows them to efficiently clean up the grazing area without excessive trampling. The size or area provided for grazing can be adjusted depending on the time of grazing. As corn matures forage consumption patterns shift, there will be more DM per unit area each day, so the grazed area can be reduced slightly as the forage matures (Hoorman, 2002).

When grazed as immature forage (vegetative stage), mature dairy cows will consume the entire corn plant, eating the leaves, ears, and most of the stalk (Smith et al., 2005). As the plant begins to mature cows will consume less of the lower stalk and focus more on eating just the ears, leaves, and upper third of the stalk, which is mostly fiber. By physiological maturity (senescence or dent), most of the nutrients are transferred to the ears and grain. At this time cows will consume the grain from the ears leaving just the cob (Smith et al., 2005). The grazing dynamic that cows follow when grazing the corn plant clearly follows the deposition pattern of nutrients throughout plant growth. As mentioned, the availability of the corn crop and when it can be grazed is variable. Planting corn at greater densities can increase the yield of the forage for early grazing systems making more forage available during the earlier part of the season. However, the yield and quality of mature ears may be reduced. This alternative can be used if the crop is strictly for forage purposes (McClenton et al., 2006).

### *Cost of Corn Grazing*

The biggest incentive for producers to graze corn is the reduced feed cost and increased profitability. The use of corn grazing can be adapted in a variety of different ways therefore the cost of grazing corn can be viewed several different ways. According to Hoorman et al. (2002) the most common way is the direct expense needed to grow and graze the corn, but as with all grazing programs, determining the true value of the crop must be done on a case-by-case basis. For commercial beef operations the cost of feed is second only to the fixed costs of operating (facilities, equipment, labor etc.), in relation to profitability (Bassarab, 2005).

In a study by Wiedmeier et al. (2003), grazing beef cows under maintenance conditions had a total variable cost of $540.13/ha, which included land preparation, seeding, cultivation, fertilization, pesticides/herbicides, irrigation, and interest on operating capital at 9.75% for 5.8 ha. The total ownership cost (insurance, machinery, irrigation equipment, land ownership) was $199.11/ha, which included insurance, machinery, irrigation equipment, and land ownership. In this study the total cost of to graze 16 dry, pregnant beef cows (644 kg) on a corn plot from November 1 to February 15 was $739.24/ha. These researchers found that compared to feeding mechanically harvested forages, the grazing of standing corn was more cost effective; costing only $0.51/cow per d to graze versus $0.84/cow per d feeding harvested forage. In a second study by Wiedmeier et al. (2005), wintering fall-calving cows with calves on standing whole corn yielded profits of $142.47/calf from

August to September, compared to the $81.36 in profits when fed ammoniated wheat straw/wheat middling or $71.69 when fed grass hay. Dingels and Dingels (2000) proposed that by grazing feeder heifers on standing corn, grazed corn had a net return of $630.07/ha, compared to $68.66/ha on mechanically harvested corn. According to Erickson et al. (2005), when compared to growing cereal grains or corn grown for silage, using corn for winter grazing quickly becomes more competitive for use as winter forage if the harvest, transportation, and feeding costs are eliminated. Although the cost of growing corn is greater than the cost of growing cereal grains, because its productivity (yield/ha) is much greater than cereal grains and the use of corn for grazing is more flexible than harvesting grains. Therefore, corn is much more economical to be grazed than ensiled.

The reduced need for labor associated with manure management is one significant advantage of pasture based dairy systems. On grazing operations, approximately 85% of daily defecations and urinations take place on the pasture and, therefore, incurred no storage or handling costs (White et al., 2001b). Dingels and Dingels (2000) found that since cattle excrete 60 to 70% of the nutrients consumed, the recycled nutrients from manure left on the field, during grazing had a commercial fertilizer value of approximately $48.19 to $60.25/ha.

### *Potential Management Problems with Corn Grazing*

Corn grazing is not always the best alternative and precautions have to be taken in order to reduce the associated risks. Grazing during the dry period could result in over-conditioned cows. Another problem associated with corn grazing is founder, although not evidenced in lactating dairy cows; it can be prevented by gradually adapting animals to the new diet. Initially feeding hay, limiting the amount of corn grazed or offering alternative pasture can be used to adapt animals to their new diet. As the plant develops, nitrogen is concentrated in the lower portions of the stalk and less in the ears and grain. Increased nitrate concentrations are found in drought-stressed corn. Nitrate concentrations should be determined before grazing stressed corn. The rumen of beef and dairy animals develops when the animal is around 180 to 225 kg (Hoorman et al., 2002), therefore cattle smaller than 180 kg should not be fed grazing corn extensively until their rumen is fully developed. Furthermore, Boyd et al. (2003) found that cows weighing less than 340 kg were unable to get their mouths around mature corn ears in order to consume it; however they could still consume the immature plant. Planting at greater densities will reduce ear size and therefore increase the plants utilization by smaller animals.

***Animal Health and Production***

While the area of milk production and milk composition of lactating dairy cows utilizing corn grazing has not been thoroughly explored, information has been published on growing dairy heifers and beef cattle on corn. In research done by Kilmer et al. (2000), gestating dairy heifers, with an average body weight of 439 kg (range of 315 to 573 kg), grazed on corn (dough stage) for 40.8 days gained 1.08 kg/d while grazing corn. This was greater than the 0.61 kg/d gained by open heifers grazing grass. Heifers grazing corn also gained an average of 4.27 cm in wither height and had a 0.21-point improvement in body condition score (BCS). Heifers grazing grass gained 8.36, cm in wither height, and only 0.07 of a point in BCS. Because the heifers grazing corn exceeded the target of 0.82 kg for average daily gain, the researchers suggested that gestating dairy heifers should be monitored for growth and performance and access to grazing corn should be limited in these animals. Wiedmeier's (2003) dry pregnant beef cows gained 54 kg of body weight and improved body condition by one full BCS. However, corn silage is considered to be too energetically dense for non-lactating cows and is therefore limited in their ration to avoid over-conditioning. They also concluded that heifers grazing grass before given access to corn, gained more rapidly, than those fed in a dry lot.

***Corn Varieties***

There are several of corn varieties available for use in grazing programs, from conventional hybrids to specialty grazing hybrids. In research conducted by Dingels & Dingels and Dingels (2000), conventional hybrids were chosen because Nebraska field trials suggested they produce more grain per acre when grazed at maturity. Also, conventional hybrids allow greater flexibility if the producer changes his/her mind and want to harvest the corn for grain instead of grazing it. According to Dingels and Dingels (2000), there are many corn hybrids on the market and all could be grazed, however the field must be intended for grazing and not grain production. Corn varieties ideal for grazing are bred for increased forage yields, increased digestibility, decreased fiber concentration, and increased fiber digestibility. There are several corn varieties (Table 2.2) grown in Mississippi that exemplifies exceptional forage yield, composition and/or digestibility.

Table 2.2 Silage yield, crude protein, acid detergent fiber content, and total digestible nutrients of 27 corn hybrids grown at Newton, Mississippi, 2005[1].

| Hybrid | Brand | Silage Yield[2] | Crude Protein | Acid Detergent Fiber | Total Digestible Nutrients |
|---|---|---|---|---|---|
| | | ***tonne/ha*** | ***pct*** | ***pct*** | ***pct*** |
| DG58P59 | Dyna-Gro | 40.9 | 7.9 | 29.5 | 65.7 |
| 746RRBT | FFR | 39.4 | 7.6 | 31.1 | 64.5 |
| DKC69-72 | DEKALB | 39.4 | 6.8 | 36.2 | 60.7 |
| 2841RRB | Golden Acres | 38.7 | 7.8 | 28.8 | 66.2 |
| 2995RR | Golden Acres | 38.7 | 7.7 | 30.1 | 65.2 |
| 2011RR | Triumph | 38.5 | 7.0 | 33.7 | 62.6 |
| DKC69-71 | DEKALB | 38.5 | 7.0 | 34.7 | 61.8 |
| 1536CBRR | Triumph | 38.5 | 8.5 | 28.8 | 66.3 |
| TV26B82 | Terral | 38.0 | 8.3 | 30.8 | 64.7 |
| DKC61-45 | DEKALB | 37.6 | 8.6 | 28.5 | 66.5 |
| 1866BT | Triumph | 37.6 | 8.0 | 30.8 | 64.7 |
| 851RR/BT | Croplan Genetics | 37.6 | 8.4 | 28.3 | 66.6 |
| V62R66 | Vigoro | 37.4 | 7.3 | 32.3 | 63.6 |
| TV25R31 | Terral | 37.4 | 8.0 | 32.8 | 63.2 |
| X-6501BT | Golden Acres | 37.2 | 7.1 | 32.8 | 63.2 |
| 8204RR | Garst | 37.2 | 8.0 | 32.3 | 63.6 |
| 822RR/BT | Croplan Genetics | 36.7 | 7.7 | 30.5 | 65.0 |
| 8213RR | Garst | 36.1 | 8.1 | 31.2 | 64.5 |
| TV27C48 | Terral | 35.9 | 8.8 | 32.9 | 63.1 |
| 33V15 | Pioneer | 35.2 | 8.5 | 31.1 | 64.5 |
| 31R87 | Pioneer | 35.0 | 7.1 | 31.8 | 64.0 |
| V58YR2 | Vigoro | 34.8 | 8.7 | 29.6 | 65.7 |
| 33D63 | Pioneer | 34.5 | 9.0 | 29.4 | 65.8 |
| 900BT | FFR | 34.5 | 8.1 | 33.1 | 63.0 |
| 886RR | FFR | 34.5 | 8.1 | 32.4 | 63.6 |
| 818RR/BT | Croplan Genetics | 33.5 | 8.4 | 31.3 | 64.4 |
| 8200YG1 | Garst | 32.1 | 8.1 | 30.7 | 64.8 |
| | | | | | |
| **Overall Mean** | | 36.9 | 7.9 | 31.3 | 64.4 |
| **LSD** | | 5.47 | 1.0 | 3.5 | 2.6 |
| **CV** | | 26.2 | 7.1 | 6.3 | 2.3 |
| **$R^2$** | | 26.5 | 71.3 | 66.2 | 66.2 |

[1]Data on the yield and composition of corn was taken from the MSU Agricultural and Forestry Experiment Station, (Vaughan et al., 2006).

[2]At 35 percent DM.

[3]LSD=Least significant difference; CV=Confidence interval; $R^2$=Root mean square deviation.

## Global Positioning Systems (GPS)

There is little published data on the use of GPS receivers in production animal research; most studies are limited to wildlife. To better understand movement, grazing, defecation and behavior patterns, one has to understand the affects of water, feed, shade placement, fence design, and stream layout within pasture. Researchers at the University of Kentucky conducted a preliminary study using GPS tracking collars to record cow-grazing patterns and test the usage of these collars (Udal, 1998). They found that over a 24-h period location fixes were accurate to approximately 8 m, 95% of the time. In addition, they reported that increasing the tracking interval from 5 to 30 min introduced more errors in data, suggesting that any interval over 5 min may overlook data apart from pasture utilization, such as discrete watering events.

A single GPS unit can be very accurate and reliable when used to monitor one animal, but when tracking groups it is helpful to attach units to multiple animals. Udal (1998) reported significantly more errors when a decreased number of collars were used to model a larger number of animals. Errors in precisely locating animals in a group ranged from 10% when four of five cows were collared compared to 40% when one of five cows was collared, indicating individual animal variation in grazing patterns. Activity patterns were classified, as grazing or non-grazing, by recorded location. Use of GPS collars accurately classified 94.8% of active grazing data records, and 91.2% inactive or non-grazing data record for an overall performance 91.7% of records correctly classified. Global positioning systems can also be useful in correlating grazing activity with environmental factors, such as in the research done by Turner et al. (2000). When cow movement was analyzed from 1500 h to 0000h it revealed that cows were initially inactive and located near a watering point, ambient temperature being 30 to 35°C. The temperature began to drop at approximately 1800 h and cows sequentially moved from water into the grazing area. The cows continued to graze as the temperature decreased to 17°C at 2145 h. This pattern reveals that cow movement may be influenced by ambient temperature (Turner et al., 2000).

Traditionally grazing time measurements were based on visually recording grazing activity at different intervals (e.g., 5 to 10 min) with the disadvantage being labor intensive and limited by daylight (Rook, 2000). Recent advances in GPS have allowed for smaller, lightweight recorders that can monitor the position, time, elevation, distance traveled, and speed of animals almost continually. With additional sensors, some units can also measure tympanic temperatures and atmospheric pressures and this data can be imported into a Global Information System (GIS) to assess animal behavior characteristics and pasture utilization. Precision animal location recording allows researchers to evaluate pasture utilization as well as animal performance and behavior. Using the GPS data, researchers may assess the merits of pasture or paddock shapes and sizes, fence designs, grazing systems, forage composition and availability, location of shade, water, supplements, and other variables (Turner et al., 2000).

The US Department of Defense (DOD) operates global positioning systems. Users obtain position fixes via a constellation of carefully monitored earth orbiting satellites. Units may have an inherent accuracy from 15 to 100 m dependent on the receiver. Receivers can be corrected differentially, by placing two collars on a known benchmark and collecting readings for a known period of time, then comparing and computing an error term (Udal, 1998). The GPS system consists of three components: 1) space segment –24 satellites arranged in orbits where five to eight satellites are visible from any point on earth at any time and generate/transmit precisely timed radio signals (Dana, 1997); 2) control segment – network of ground based stations to monitor satellite information (health status and time, and satellite location) to ensure correct operation of the system; 3) user segment – user community receivers convert satellite signals into location estimates. Although GPS is extremely accurate, it is subject to errors, such as: satellite clock errors, satellite position errors, receiver errors, atmospheric errors, multi path errors (the difference in arrival time of the same signal, due to interference of nearby objects and that signal taking a longer path), and selective availability errors. There are software and programs available that are capable of filtering out and correcting for these types of errors, depending on the type of unit, make, and manufacturer. Some errors are corrected by satellite, which is controlled from base stations, through the DOD. Therefore, units should be evaluated to test performance for individual species due to factors affecting accuracy, like cover, and to insure user confidence and success rate.

Regardless of the unit used, data received may have to be interpreted into a form of analysis to fit the user. In addition, individual units may have to be calibrated. Using GPS to track grazing patterns or cattle movement matches or exceeds the benefits of any other methods, such as radio signal tracking or human observation, with few disadvantages (Turner et al., 2000). Using GPS units allows for 24 h observation, a reduction in labor, and results in less human error. With some smaller or less expensive GPS units, battery life can be an issue with animals that are not frequently handled, such as wildlife and beef cattle, but is much less of a limitation with dairy research, because the animals are commonly handled every 12 h (McClenton et al., 2006). Extensive rangeland grazing systems compared to cattle in small intensively managed systems may require different monitoring protocols, such as monitoring dominant or social cows (Turner et al., 2000).

# CHAPTER III

# MATERIALS AND METHODS

## Experiment Design

Two corn-grazing trials were conducted during the summers of 2004 and 2005 at the Coastal Plains Research and Experiment Station in Newton, MS. In 2004, thirty-six lactating Holsteins were randomly allocated to one of two treatments; Control cows were housed in a traditional freestall barn and given access to a dry lot, while Grazing cows were given 24 h access to a standing corn plot. In the first year of the trial, Grazing cows were allowed a 2-wk adaptation period to become accustomed to consuming the forage, which was followed by a 10-wk lactation trial, conducted from July 21, 2004 through September 30, 2004.

During the 2005 trial, fifty-four lactating Holsteins were randomly assigned to either the Control group or one of two Grazing groups. An 8-wk lactation trial was conducted from June 28, 2005 through August 16, 2005. Cows were fed and housed as in 2004, but to more closely mimic what might happen on producer facilities, in the 2005 study Grazing cows had no adaptation period. Groups were balanced for parity and production in both years of the study. Standard herd management and milking practices were used throughout the trial.

At the onset of the trial in 2004 (prior to the adaptation period) the mean ± S.E. for cow parity was 2.09 ± 0.21 yr, DIM was 218 ± 15, test day milk was 34.7 ± 1.6 kg, fat percent was 3.5 ± 0.18 and 305d ME ECM was 11,014 ± 293 (Table 3.1).

Table 3.1 Pretrial characteristics of lactating Holstein cows grazing corn (Grazing) and matched herdmates (Controls) at the onset of the grazing trials in 2004 and 2005.

| **Parameter** | **Experimental Group** | | | |
|---|---|---|---|---|
| | **2004** | | **2005** | |
| | **Control** | **Grazing** | **Control** | **Grazing** |
| N | 18 | 18 | 18 | 36 |
| Parity | 2.06 ± 0.21 | 2.11 ± 0.21 | 2.39 ± 0.33 | 2.22 ± 0.28 |
| DIM | 221 ± 16 | 215 ± 14 | 233 ± 10 | 220 ± 12 |
| Test Day Milk, [A] (kg) | 34.7 ± 1.5 | 34.9 ± 1.7 | 35.9 ± 1.1 | 36.6 ± 1.7 |
| Test Day Fat, [A] % | 3.49 ± 0.15 | 3.47 ± 0.22 | 3.31 ± 0.16 | 3.14 ± 0.11 |
| 305 D ME ECM, [A, B] (kg) | 10,909 ± 256 | 11,118 ± 330 | 11,889 ± 340 | 11,398 ± 292 |
| Body Weight, (kg) | 602 ± 14 | 623 ± 18 | 615 ± 17 | 602 ± 13 |
| Body Condition Score, [C] (units) | 2.79 ± 0.09 | 2.92 ± 0.09 | 3.42 ± 0.11 | 3.34 ± 0.09 |

[A]Pretrial milk production and composition data was from the preceding DHI test records.
[B]ME ECM = Mature Equivalent Energy Corrected Milk was calculated as 0.3246 x 30: dME milk + 12.86 x 305-d ME fat + 7.04 x 305-d ME protein (Tyrrell and Reid, 1965).
[C]Based on the 5-point scale of Wildman et al. (1982).

Similarly, cows in the 2005 study were 2.3 ± 0.31 for parity and 227 ± 11 DIM, test day milk was 36.3 ± 1.4 kg, fat percent was 3.2 ± 0.13 and the 305d ME ECM was 11,743 ± 317. There were no significant differences in the initial parameters between groups in either year studied.

## Corn Plots

For the trial in 2004, a 1.8-ha ryegrass plot was sprayed with glyphosate herbicide to kill residual vegetation and was fertilized with nitrogen at 450 U/ha. A Roundup-ready™ corn variety (Terral TV2140RR; Terral Seed, Inc., Lake Providence, LA.) was planted on March 23, 2004 at 64,000 seeds/ha into an unprepared bed (no-till). Sections of 6 rows were planted with 76 cm spacing and an empty row between sections. The plot was sprayed with glyphosate 7 to 10 d after planting and again 40 d after planting.

Following a similar protocol, the 2005 study utilized two 1.8-ha plots that were sprayed with glyphosate herbicide two-wk prior to planting to kill pre-existing vegetation and ammonium nitrate was applied at 227 kg/ha. A Roundup™ Ready corn hybrid (Terral TV2140RR ECOB; Terral Seed, Inc., Lake Providence, LA) was planted on April 19 into an unprepared seedbed (no-till) at 79,000 seeds/ha in sections of 6 rows (76 cm row spacing), with an empty row between sections. Additionally, Plot 2 was inter-seeded with reseeding soybeans (*Glycine soja*; USDA, Natural Resources Conservation Service, Coffeeville, MS) planted on May 9, 2005 using a no-till drill. The soybeans were to be used as a supplemental protein source, but the crop failed due to a lack of moisture. Therefore, Plot 2 was considered as a replicate “corn-only” plot and the soybeans were not factored into the data analysis. Thus, the 2005 trial utilized a Control group and two corn Grazing groups.

## Feeds and Feeding Management

Control cows received *ad-libitum* access to the standard herd ration (a corn silage-based total mixed ration [TMR]) throughout the trial in both years (Table 3.2). During the adaptation in 2004, cows in the grazing group were offered the same TMR as Controls. Beginning in wk 1, Grazing cows were progressively limit fed to 70% of the TMR consumed by the Control cows. In addition, in an effort to balance dietary protein and fiber intake, during wk 1 to 3 of the trial the ration was adjusted for Grazing cows by removing 2.67 kg DM per hd/d of corn silage (5.34 kg/hd per d as fed) and 1 kg DM per hd/d of corn grain (2 kg/hd per d as fed) from the TMR offered (Table 3.2). The amount of TMR offered to Grazing cows was adjusted weekly based on the intake of Controls. As a result, during this 3-wk period corn silage fed to the Grazing cows was 10.08 kg per hd/d (as fed) less than Control cows.

By wk 4, the grazing pattern had changed; Grazing cows were now eating leaves and stripping the grain from the ears, but were no longer consuming the whole plant. To maintain fiber intake, corn silage was added back into the TMR of Grazing cows for the remainder of the trial and all 4.69 kg DM per hd/d of corn grain (11.73 kg/hd per d as fed) was removed from their TMR.

Table 3.2 Composition of the total mixed ration (TMR; as fed) fed to lactating Holstein cows consuming TMR alone (Controls) and those supplemented by grazing corn (Grazing) during the 2004 and 2005 trials[1, 2].

| Component | 2004 | | | 2005 | | |
|---|---|---|---|---|---|---|
| | Control | WK 1 to 3 | WK 4 to 10 | Control | WK 1 to 5 | WK 6 to 8 |
| Corn Silage, % | 63.9 | 59.8 | 73.6 | 65.9 | 64.60 | 71.2 |
| Bermudagrass Hay, % | 9.37 | 11.7 | 10.8 | 8.48 | 8.31 | 9.15 |
| Corn Grain, % | 13.2 | 11.7 | 0.00 | 10.9 | 10.69 | 0.00 |
| Soybean Meal, % | 4.69 | 5.79 | 5.39 | 5.75 | 7.25 | 7.75 |
| Vitamin /Mineral Premix, % | 1.52 | 1.84 | 1.75 | 1.55 | 2.02 | 2.08 |
| ProLak [3], % | 1.16 | 1.47 | 1.36 | 1.18 | 1.14 | 1.61 |
| MegaLac [4], % | 0.61 | 0.74 | 0.71 | 0.47 | 0.46 | 0.64 |
| Cottonseed, % | 5.54 | 6.99 | 6.38 | 5.66 | 5.54 | 7.62 |
| **Composition** | | | | | | |
| CP, % | 16.4 | 16.7 | 17.8 | 16.8 | 17.8 | 20.1 |
| $NE_L$, Mcal/kg | 1.58 | 1.62 | 1.54 | 1.61 | 1.64 | 1.57 |
| NDF, % | 31.6 | 33.9 | 40.9 | 33.8 | 32.3 | 38.7 |
| ADF, % | 16.8 | 18.9 | 25.7 | 20.8 | 19.8 | 24.6 |
| Ash, % | 4.78 | 6.02 | 5.07 | 4.31 | 4.31 | 5.09 |

[1]40% of TMR was fed in the mornings, and 60% was fed in the evenings.
[2]Water was added to the rations as needed to maintain approximately 50% DM.
[3]H.J. Baker and Bro., Inc. West Port, CT
[4] Church and Dwight Company, Inc., Princeton, NJ

In 2005, cows in all groups began with the same TMR and the goal was again to restrict Grazing cows to 70% of the intake in Controls. In wk 2 to 5, Grazing cows were fed 7.94 kg/hd per d less corn silage (as fed) and 1.34 kg/hd per d less corn grain than Control cows. By wk 6 the intake pattern had changed, to maintain fiber intake similar to that in Control cows, corn silage was added back into the ration and all corn grain (5.27 kg DM per hd/d) was removed in wk 6 to 8 of the trial.

Cows were fed TMR twice daily after milking (0300 h and 1530 h) and fresh water was available at all times. Feed offered and refusals were measured daily in both groups to calculate TMR intake and samples were collected weekly for analysis of composition.

## Environmental Measures

Both trials were conducted during the summer months. In both years, environmental temperature and humidity were recorded every 10 minutes inside the freestall barn and outside near the corn plots using Hobo™ (Onset Computer Corp., Pocasset, MA) monitors. One monitor was placed in the center of the free-stall barn at an elevation of 2.7 m and the outside monitor was hung in the shade at an elevation of 2.1 m. The data obtained was used to compare environmental conditions by year and by week within trials to quantify the amount of heat stress exposure for cows in both treatment groups. The combined effects of temperature and humidity were characterized using the Temperature Humidity Index (**THI,** NOAA, 1967; Igono, 1992; Ravagnolo et al., 2000). All grazing plots were located in proximity to shade and water to reduce heat stress and to promote grazing, but were also located 0.5 km from the milking parlor and the control barn.

### Cow Measures

Body weight and body condition scores were recorded at the start of both trials and every 2 wk thereafter. Body condition scores were based on the modified scale of 1 to 5 (Wildman, 1982) with 0.25-point increments. Venous blood was collected every 2 wk throughout both trials to measure blood glucose and nonesterified fatty acid (NEFA) concentrations. Blood samples were collected via jugular vein puncture using 1.5 in. 20 ga. needles into 10 ml Vacutainer brand collection tubes. Blood samples were centrifuged at 4 ºC and 1500 x $G_{max}$, for 10 min, and plasma was separated into replicate vials and frozen before analysis.

In the second year of the study, ruminal fluid samples were also collected to characterize the effect of corn grazing on ruminal pH. The samples were collected during wk 3 and 6 from three cows per group, selected randomly. The fluid samples were collected 3 to 4 h following the morning feeding using an esophageal tube fitted with a particle strainer. The ruminal fluid pH was measured immediately using a portable pH meter (Corning Inc., Corning, NY).

Cows were milked twice daily and daily milk production was recorded at each milking. Monthly DHI records were used to determine milk protein, fat content and the somatic cell count (SCC). To avoid exposing the cows to any additional heat stress, minimize distance traveled, and avoid interruption of the cow's normal grazing routine, all measurements and collections were taken between 0700 to 0900 h or in the afternoon as cows left the parlor.  All animal protocols were approved by the Institutional Animal Care and Use Committee (IACUC approval # 05-044).

**Forage Yield Measurements and Intake Analysis**

Portable electric fences were set between 6-row sections to allow Grazing cows progressively more access to the corn plots and to minimize trampling losses. The area of each section was determined by using a handheld GPS unit (Garmin® eTrex Legend C). Cows were allowed access to a new section of corn every 7 to 8 days based on forage availability and also had access to the residuals from previously grazed sections.  Whole plant collections from $1m^2$, taken before grazing each section, were used to estimate forage yield and composition.  Similar collections taken after grazing each section were used to estimate forage intake and utilization. Forage DM was determined after chopping and weighing the samples by drying samples at 65 °C until reaching a stable weight.  The samples were ground in a Wiley Mill using a 0.1 mm screen and the composition analyzed for DM, CP, NDF and ADF by Louisiana State Universities, Southeast Research Station (Franklinton, LA.) using wet chemistry techniques.

## Monitoring Cow Behavior and Grazing Patterns

During each week of the 2005 study, two cows from the Controls and two cows from the Grazing groups were randomly selected and fitted with handheld GPS units (Garmin® eTrex Legend C). The units were calibrated to take position readings every 1 min for up to 32 h. These readings produced "tracks" which in turn were used for analysis. The "tracks" were read and processed using MapSource™ Trip and Waypoint Manager, a GIS system. The analysis included calculating time and duration of grazing, milking, and lounging; the distance traveled during the day; and the time spent feeding (grazing or at the feed bunk). The environmental data was also correlated with GPS data to determine the specific environmental conditions present during each of these events. For the GPS analysis, the geographical coordinates of each area the cows had access, to was defined as: shade, feed bunks, grazing area, and the milking parlor. These areas were defined using Latitudinal and Longitudinal readings, and the perimeter of each plotted on a map using these coordinates. Extraneous variation due to loss of satellite signal or change of satellite was smoothed to reduce "jumps" in the track.

## Statistical Analysis

Data were analyzed as an incomplete randomized design with two treatments (Control and Grazing) and repeated measures using the means and mixed procedure of SAS (SAS Institute, Cary, NC 1999). The experimental unit considered being the group of cows, so the statistical design included the fixed effects of treatment and year as well as the random effects of week. A *P*-value of $< 0.05$ was considered statistically significant. In wk 7 of the 2005 trial one cow from the corn-grazing group died due to chronic mastitis, but data was included in the analysis up until the point she left the study.

# CHAPTER IV

# RESULTS AND DISCUSSION

## Environmental Conditions

Environmental temperatures during both years of the study are shown in Figure 4.1. During the experimental period in 2004, the 24-h outside temperature was 24.9 ± 0.11 °C and the relative humidity (RH) was 77.5 ± 0.44 %, thus the THI averaged 73.9 ± 0.13 units throughout the trial. The environmental conditions during the 2005 trial were hotter than in 2004, but the majority of the difference between years was the result of a cooling trend that occurred in wk 5 of the 2004 trial. As a result, in 2005 the outside temperature was 26.5 ± 0.12 °C and with a RH of 81.2 ± 0.46%, the THI was 76.9 ± 0.14 units during the trial period. There were no significant differences between the inside and outside temperatures in either year of the trial.

## Corn Yield, Composition and Intake

In the 2004 study, cows were given access to the plot (adaptation period) when the corn was immature (R-3; milk stage). The grazing group quickly learned to eat the immature forage and consumed the leaves, ears and the top of the stalk. Early in the 2004 trial (wk 2), forage DM yield was 16.2 tonne/ha. The composition of

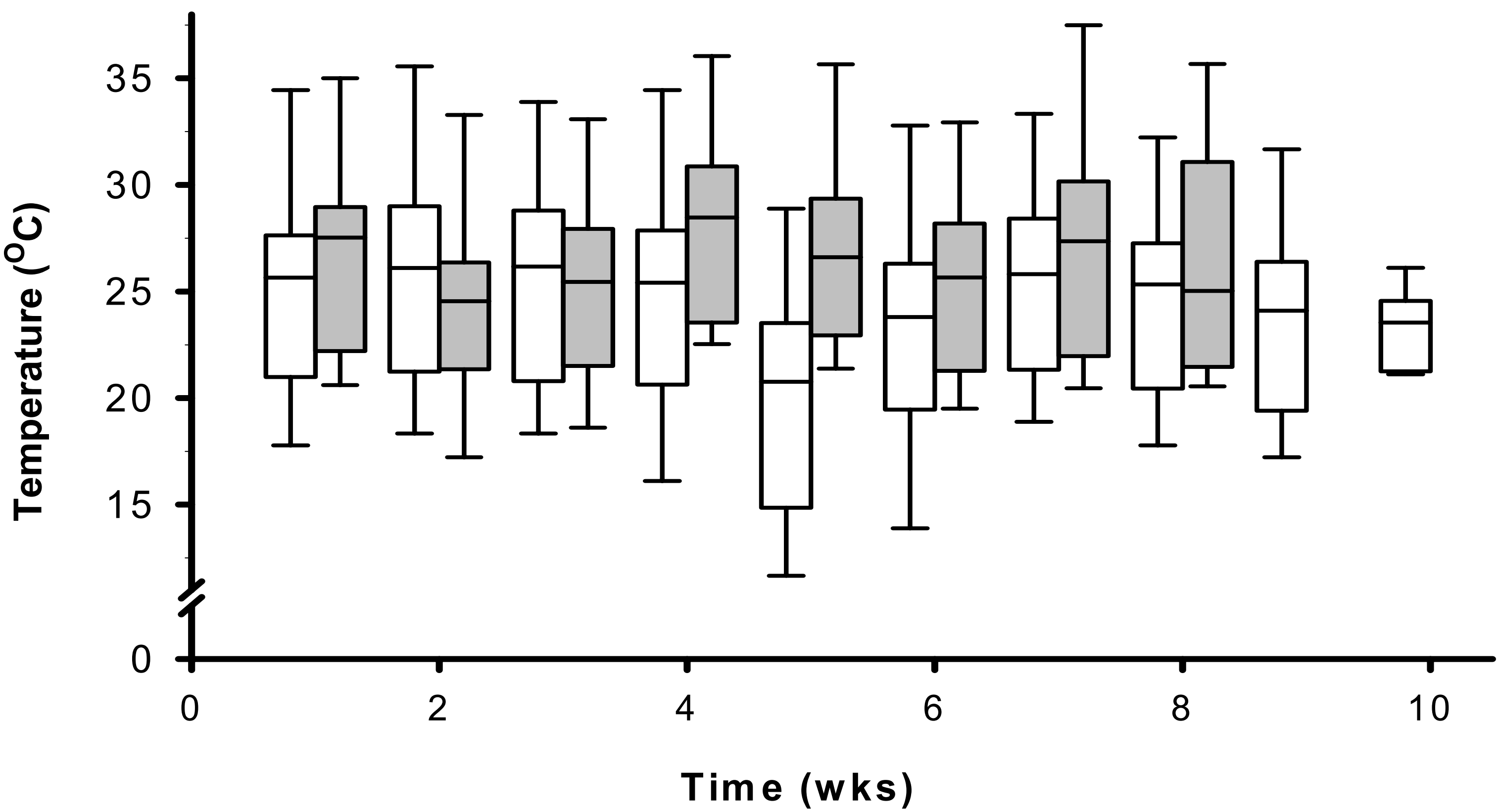


Figure 4.1 Temperature profile during the dairy corn grazing trials in 2004 (open boxes) and 2005 (gray boxes). Data represents the weekly average of daily high and low temperatures (box), 24-h average temperature (center bar) and the weekly temperature extremes (whiskers). Environmental data was summarized from observations collected at 10-min intervals, using Hobo (Onset Computer Corp.; Pocasset, MA) data recorders. Recorders were mounted in the shade adjacent to the corn plots at an elevation of 2.1 m

Table 4.1 Nutrient composition of corn forage at various physiological stages during the dairy corn-grazing trials (DM basis).

| Stage[1] | DM (%) | CP (%) | NDF (%) | ADF (%) |
|---|---|---|---|---|
| **R-2 (Blister)** | 16.6 | 10.9 | 67.9 | 39.3 |
| **R-3 (Milk)** | 28.5 | 9.9 | 54.8 | 32.2 |
| **R-5 (Dent)** | 36.4 | 6.6 | 42.0 | 21.6 |
| **R-6 (Physiological Maturity)** | 41.0 | 6.0 | 38.3 | 20.9 |

[1]The R-unit refers to the kernel's developmental stage (Ritche et al., 1997).

whole plant at this stage is shown in Table 4.1. In wk 1 to 3 of the trial, forage intake was 7.4 ± 1.5 kg DM/hd per d.

As the season and the forage maturity progressed, the intake pattern of the cows gradually changed from eating the whole plants to stripping just the grain off the ears. Samples taken from each section before grazing showed the grain production averaged 9.65 ± 0.41 tonne DM/ha. Similar samples taken post-grazing suggest that cows consumed 78.8% of the available grain after just 1 wk of grazing a section during the R-5 or dent stage. While more of the plot was made available each week, cows were able to graze the older sections and after 3 wk had consumed 95% of the grain available on a section. Using this data, the consumption of corn grain averaged 7.6 ± 0.21 kg DM/hd per d in wk 7 to 10 of the trial period.

In the 2005 trial, cows were given access to the corn at the R-2 (blister) stage with no adaptation period to more closely reflect what might occur in the industry. After 1 to 2 days of acclimation, cows were consuming most of the plant and stalks. In wk 3 of the trial, DM yield of the plot was estimated at 10.7 tonne/ha. Forage samples taken in wk 4 after grazing suggest cows consumed 11.1 ± 1.04 kg DM/hd per d, or 81.5% of the available forage within the first week of access to a section. The corn never reached senescence during the 8 wk trial in 2005, so at the end of the trial Grazing cows were still consuming leaves and most of the cob along with the corn grain, but leaving behind the fibrous stalks. Over the entire 8-wk trial forage intake averaged 9.3 ± 1.55 kg DM/hd per day.

Corn grazing can provide additional forage management options for dairy producers. Corn can be planted for greater-density growth, making the forage more digestible and more palatable for the cows if grazed early rather than later in the season. The crop may even be rotationally grazed at different stages of maturity, depending on the needs and time frame of the producer. Furthermore, there are several corn varieties or hybrids available to meet the needs of producers for some of these more specific grazing purposes (Dingels, 2000). Under the management program used in the current study, grazing days per hectare was estimated at 120 d in order to achieve maximum grazing efficiency.

## TMR Intake

During the grazing trials, TMR intake in controls was 20.08 ± 0.26 kg DM/hd per d (Figure 4.2). The feed restriction protocol, which began in wk 1 to 3 of the trials reduced TMR intake in Grazing cows to 25.7% below that in Controls by wk 6 of the study ($P < 0.001$). Over the entire trial period, Grazing cows consumed 16.08 ± 0.26 kg DM/hd per d, which was 20% less than Controls ($P < 0.001$).

Corn grazing accounted for 23% of the total DMI in Grazing cows in the first week of the trials, but increased as the trial progressed and over the entire trial period, intake from grazing accounted for 35% of their total DMI. Total DMI during the 2004 and 2005 trials were 25.02 ± 0.67 kg/hd per d for the Grazing cows, which was 20% greater than in Controls ($P < 0.001$; Figure 4.3). Intake of corn from the plot was 35.3 ± 2.15% (9.07 kg/hd per d) of the total DMI over the 10-wk trial period. Thus, Grazing cows had a decreased TMR intake, but a greater total DMI than Controls.

Although, grazing cows at a distance from the barn or milking parlor requires additional travel by the cows, having corn plots within reasonable distances is a concern for lactating cows. According to Spörndly and Wredle (2004) the longer distance cows have to travel to pasture may lead to decreased milk yield and pasture intake, since longer walking distances can increase the cows energy requirements. In this study it seems that for cows supplemented with a TMR, walking had no impact on production, but increased DMI. Alternatively, the difference in DMI between

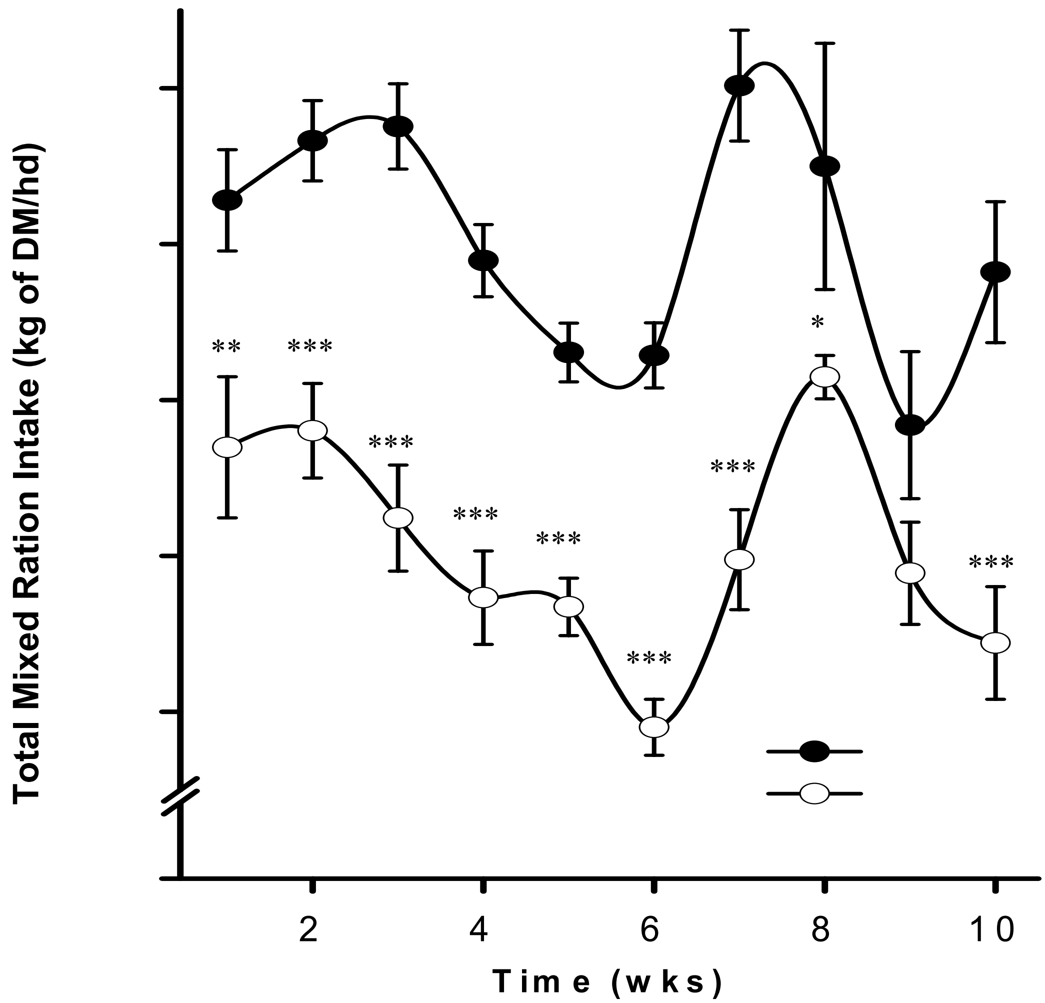


Figure 4.2 Intake of total mixed ration (TMR; kg of DM/hd per d) by lactating Holstein cows fed the control ration (●) and in those supplemented by grazing corn (○) during the trials in 2004 and 2005. Data represents the means ± SE of daily observations of TMR fed minus refusals for 18 cows per group in all but the 2005 grazing group, which represents 36 cows. Significant differences between treatment groups are indicated; * $P < 0.05$, ** $P < 0.01$, and *** $P < 0.001$

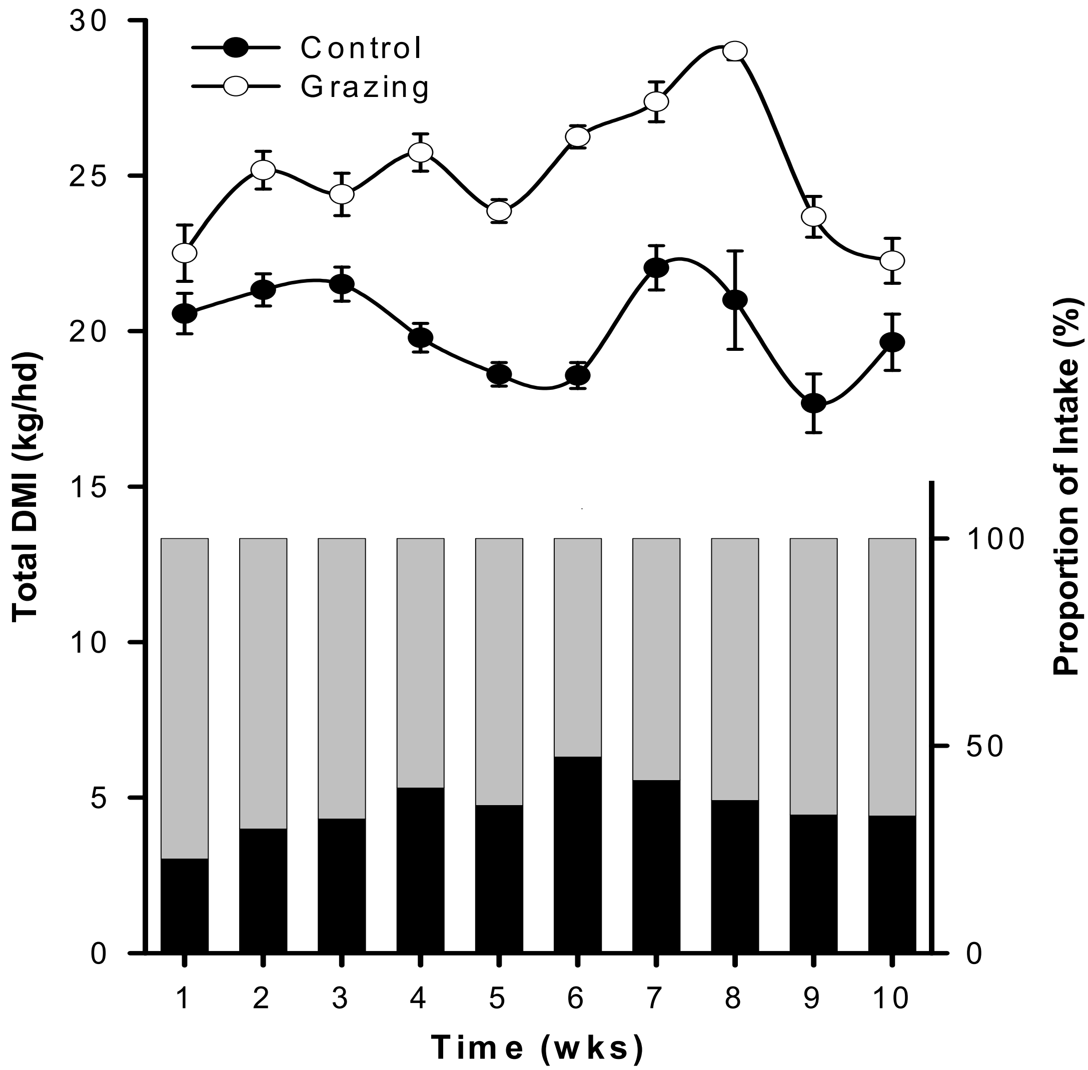


Figure 4.3 Total dry DMI in lactating Holstein cows fed the control ration (●) and herdmates supplemented by grazing corn (○) during the trials in 2004 and 2005. Data represents the means ± SE of daily observations of TMR fed minus refusals for 18 cows per group in all but the 2005 grazing group, which represents 36 cows. Data for the grazing cows includes weekly estimates of DM disappearance from the grazing plots. Bars represent the proportion of DMI from corn grazing (black bar) and the TMR (gray bar) in the grazing groups

groups may be attributed to the difficulty in measuring intake from field disappearance data.

According to NRC (2001), the increase in energy requirement for walking 2 km/d is approximately 5% of maintenance for lactating dairy cows and corresponds to approximately 0.5 to 1 kg of milk/d. In the present study, cows had to travel approximately 1.09 km round-trip from the corn plots to the parlor twice daily, but over the course of two years summer grazing, there was no negative impact on the milk production or overall well being of the cows. The increased energy expenditure may, however, have attributed to the greater DMI consumed by grazing cows.

## Lactation Performance

During the study periods milk production averaged 25.6 ± 0.08 kg/d in all cows (Figure 4.4). Milk production was similar during wk 1 and 2 of the trial, averaging 27.38 ± 0.19 and again during wk 4 and 5. By wk 6 the milk production of Grazing cows was significantly greater than Controls ($P < 0.05$). Milk production averaged 23.87 kg/d compared to 22.37 kg/d for Controls for the remainder of the trial period. At the beginning of the trials, fat content averaged 3.26 ± 0.02% and protein content averaged 2.89 ± 0.01%. Milk composition was not affected by treatment and remained constant throughout the trial. Fat content averaged 3.67 ± 0.21% for both the Control and Grazing cows, while protein content averaged 2.89 ± 0.08% for both groups and SCC was 575.8 ± 128.7 x $10^3$ cells/ml. There was no significant difference in the fat, protein, and SCC content of the two groups.

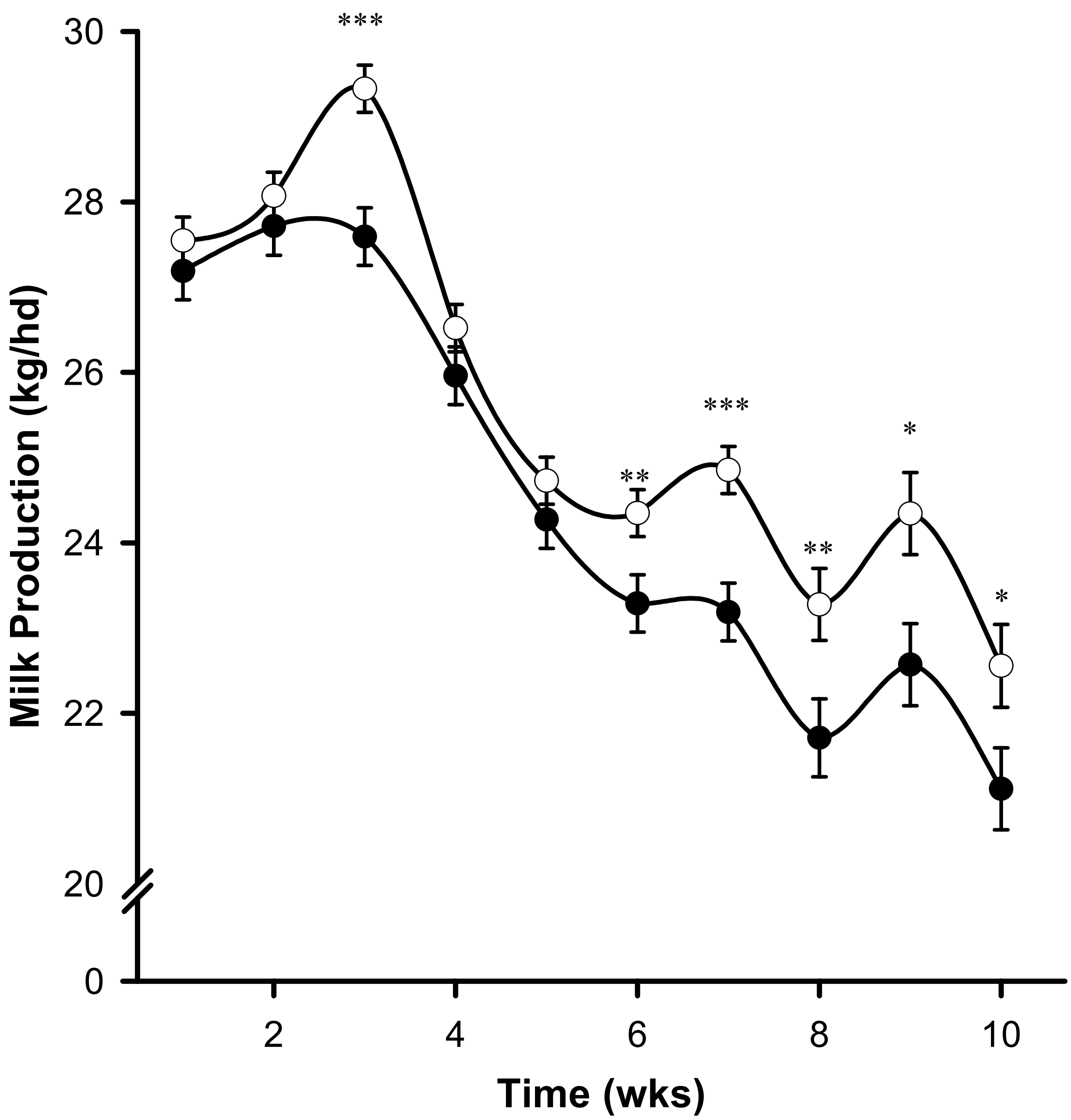


Figure 4.4 Milk production (kg/hd per d) in lactating Holstein cows fed the control ration (●) and those supplemented by grazing corn (○) during the trials in 2004 and 2005. Data represents the means ± SE of daily observations of 18 cows per group in all but the 2005 grazing group, which represents 36 cows. Significant differences between treatment groups are indicated; * $P < 0.05$, ** $P < 0.01$, and *** $P < 0.001$

## Body Weights and Condition Scores

At the onset of the grazing trials cows body weights and body condition scores were similar ($P > 0.05$) between groups, averaging 615 ± 17.5 kg and 3.4 ± 0.06 units for Controls, and 602 ± 4.69 kg and 3.4 ± 0.07 units for Grazing cows, respectively, (Table 4.2). During the trial period Control cows gained 20.28 ± 17.49 kg (Figure 4.5) but, lost 0.6 ± 0.1 units in body condition. Grazing cows gained 44.59 ± 14.8 kg, but only lost 0.3 ± 0.1 units of body condition. There was significant difference in body weight or condition score between groups at the beginning or end of the trial period ($P < 0.05$). However, body weight gain was significantly greater in Grazing cows when compared to Controls ($P < 0.05$).

Table 4.2 Mean body weight, weight gain and body condition score of lactating Holstein cows fed a control ration (Controls) and grazing corn (Grazing) during the 2004 and 2005 trials.

| | **Groups** | |
|---|---|---|
| | **Control** | **Grazing** |
| **Initial BW, kg** | **615 ± 18** | **602 ± 10** |
| **Final BW, kg** | **635 ± 14** | **660 ± 15** |
| **Δ in BW, kg** | **+ 20[1]** | **+ 58[2]** |
| **Initial BCS, units** | **3.4 ± 0.11** | **3.3 ± 0.07** |
| **Final BCS, units** | **2.8 ± 0.12** | **3.0 ± 0.11** |
| **Δ in BCS. units** | **- 0.6** | **- 0.3** |

[1,2] Means in the same row with different superscript are significantly different at $P < 0.05$.

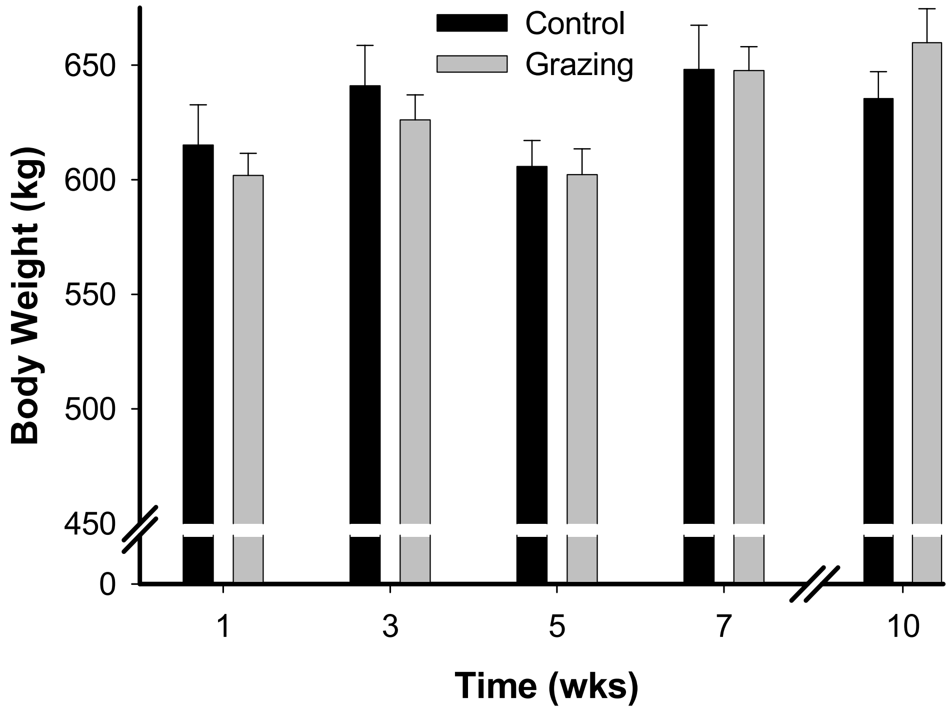


Figure 4.5 Body weight of lactating Holstein cows fed a control ration (Controls) and grazing corn (Grazing) during the 2004 and 2005 trials. Data represents the means ± SE of bi-weekly observations. Bars represent the differences in body weight of Controls (black bar) and the grazing groups (gray bar)

The simultaneous increase in weight and loss of body condition is not unheard of; it is a common sign of heat stress exposure, which increases water intake, but decreases feed intake in dairy cows.

## Blood and Rumen Measures

The glucose concentrations were 83.8 ± 5.02 mg/dl at the start of the trial in 2005, and declined ($P < 0.05$) to 65.04 ± 0.7 mg/dl by wk 8. While plasma glucose concentrations declined as the experiment progressed, there were no significant differences due to treatment or treatment by week interactions. Similarly, both declined as the experiment progressed. At the start of the 2005 trial plasma NEFA concentrations averaged 1,336 ± 103.8 mEqu/L and by wk 8 NEFA concentrations averaged 239 ± 9.9 mEqu/L. Over the entire 8-wk trial period NEFA concentrations in Control cows averaged 564.4 ± 86.5 mEqu/L, while that in Grazing cows averaged 12% greater ($P < 0.05$), at 700.0 ± 131.4 mEqu/L. While plasma NEFA concentrations were greater in grazing cows, the majority of the difference was in wk 1 to 3 and there was no difference at the end of the trial. Thus, the elevated NEFA concentrations may be relative to the stress of adapting to grazing environment or feed restriction protocol, but was not a result of corn grazing. The rumen samples had an average pH of 6.71± 0.07, and were not significantly affected by dietary treatment or week of the trial ($P < 0.01$). Blood samples were not collected as part of the 2004 trial.

## Cow Behavior and Grazing Dynamic

Inexpensive hand-held GPS units can be used to track grazing patterns and cow movement. Grazing time for Control cows on the dry lot was greater than grazing times for Grazing cows (Table 4.3). Controls spent 357 ± 75 min/d grazing whereas Grazing cows only spent half that time, grazing for 179 ± 19 min/d (3 h/d). Although the Controls only had access to a dry-lot, these cows spent more outside to get off the hard, concrete floors and to escape the heat of the control barn. The distance traveled by Grazing cows to and from the parlor, as well as moving through the pasture was 4.3 km/d. This was three times greater than the distance traveled by the Control cows. Lounging and milking times were similar between both groups.

There was also correlation between grazing times and environmental temperatures (Table 4.4). In the mornings, cows began grazing at 0600 h (3 to 4 h after the a.m. milking) when temperatures were 22.2°C and stopped when temperatures rose above of 23.9 °C. During the evenings cows began grazing in the corn plot at 1800 h (2 to 3 h after the p.m. milking) when temperatures dropped below 30°C. Elapsed grazing times for both periods was from 1h 30 min /d to 2 h 30 min/d.

Table 4.3 Average daily activity of lactating Holstein cows housed in confinement (Controls) and grazing corn (Grazing) during the 2005 trial.

| Parameters | Experimental Groups | |
|---|---|---|
| | Control | Grazing |
| Cows (n) | 5 | 8 |
| Grazing Time (min/d) | 357 ± 75[1] | 179 ± 19[2] |
| Lounging Time (min/d) | 551 ± 65 | 500 ± 41 |
| Feeding Time (min/d) | [a]N.D. | 352 ± 58 |
| Milking Time (min/d) | 245 ± 60 | 182 ± 7.6 |
| Distance Traveled (km/d) | 1.45 ± 0.33[1] | 4.38 ± 0.38[2] |

[a] For Controls, the feed bunks and lounging area were both under barn roof and could not be distinguished by the GPS units used.
[1,2] Means in the same row with different superscript are significantly different at $P < 0.01$.

Table 4.4 Average grazing times and temperatures of lactating Holstein cows grazing corn (Grazing) during the 2005 trial.

| | Morning Period | | Evening Period | |
|---|---|---|---|---|
| | Time | Temperature (°C) | Time | Temperature (°C) |
| Stop | 0616 | 22.75 ± 0.25 | 1833 | 29.97 ± 1.65 |
| Start | 0803 | 24.32 ± 0.42 | 2046 | 22.46 ± 1.14 |

## Economic Analysis

Since corn grazing had a significant impact on milk production, the value of the corn crop can be based on the value of the TMR saved and the additional kilograms of milk produced. During wk 1 to 3 (the first 21 d) of the trial period, Grazing cows were limit-fed the same ration as Controls. The savings in feed costs was 4.0 kg/hd per d (DM) and at $8.50/100 kg, this equates to a savings in feed costs of $0.34/d for each or $128.52 over the 3 wk interval for the Grazing cows. During the next 21 d, the change in ration composition, made to compensate for the change in intake (see Methods and Materials), increased the cost to $9.85/100 kg. However, during this period the savings in feed costs were 4 kg/hd per d (DM), which equates to a savings in feed costs of $0.39/d for each cow or $147.93 during this interval. In the final 4 wk of the study, the change in ration composition reduced the feed cost to $8.33/100 kg, and during this period the savings in feed costs were 4 kg/hd per d (DM) and this equates to a savings in feed costs of $0.33/d for each cow or $167.93 over the 28-d interval for the Grazing cows. During wk 3 and wk 6 to 10 of the trial period, Grazing cows had significantly greater milk production than Controls. The increase in milk production averaged 1.54 kg/hd per d. Average milk prices during this phase of the study were $38.59/100 kg (NASS, 2007), and equates to a profit increase of $449.27 over the 42 d period. Combined with total savings in feed costs for the Grazing cows, total profits were $893.65 or $0.71 per cow/d over the 10-wk study.

# CHAPTER V

# CONCLUSIONS

With the greatest DM yield of traditional summer crops in the southeast, corn is the "King" of forages, but its superior productivity can be out of reach for smaller producers who do not have the capability to harvest and store corn silage. Corn grazing provides a viable option for smaller dairy producers to take advantage of this productive crop and, while grazing corn is not a traditional practice, the present study demonstrates it can be readily integrated into normal dairy management routines. Corn for grazing can be planted similarly as for the production of corn silage, in May or early June, and grazed as a forage in the summer to substitute or compliment other summer forages, which are often of marginal nutritional value in the Southeast. While summer grazing of corn may not maximize the crop's yield potential, the flexible grazing schedule (from 30 to 100 d after planting) offers the potential for producers to integrate corn grazing with a variety of secondary crops to maximize productivity of the plot (Hoorman et al., 2002). Alternatively, the corn crop can be retained for winter grazing as a grain to reduce the need for purchased commodities.

As with grazing traditional forages, corn grazing has the potential to provide producers with additional land management options. Waste management is an emerging issue for farmers with strict environmental regulations. Grazing reduces waste accumulation in lagoons and the cost of pumping effluent. Even producers with marginal lands for planting and harvesting corn in the traditional sense can benefit by using no-till planting and grazing, which reduces soil erosion and compaction. Thus, a corn grazing system could expand the available land to sloped terrain or bottomlands otherwise not suited for planting. Also, the residue from grazed corn can make an ideal wildlife habitat for dove, deer, and turkeys that may forage and seek shelter in fields after grazing (Ball et al., 2002 and Manning, 2005). This more favorable wildlife habitat can provide a source of supplemental income for landowners willing to provide hunting leases, during the months when the field is not being grazed.

Lactating dairy cows easily transitioned to this corn grazing system and the practice can spare the need for purchased commodities. In the present study, corn grazing replaced up to 47% of the total DMI with no change in milk production or composition. Furthermore, grazing cows exhibited no indications of digestive upset or other health consequences from grazing corn. Corn grazing had no significant differences in rumen pH when measured 4 h after the morning feeding. The present study also demonstrated that cows accustomed to grazing vegetative corn can easily transition to grazing whole ears and mature corn grain. But, as with other grazing programs, corn grazing can provide additional benefits over feeding in the barn. Other advantages to utilizing a corn grazing system include removing cows from concrete floors to promote cow health, increasing feet and leg soundness, and reducing the time spent lying in bacteria infested sand stalls, minimizing production losses due to mastitis and money spent on the related treatments.

While signal acquisition can be a problem in barns, GPS tracking of grazing cows can be a useful tool in the study of grazing management. Pasture location is critical to successful corn grazing, particularly for dairies. Walking to pastures dramatically increases the distance cows must travel, which can in turn reduce performance. Providing shade and water near the grazing site is important to maximize forager use, particularly during periods of hot weather. The cows' "daily schedule" is an important factor in the success of a grazing program. Regardless of forage abundance and quality, the forage program cannot be successful, unless cows are provided with access to pasture when they will graze. Global Positioning Systems can be a useful tool in pasture selection and management when setting up a forage grazing operation.

By reducing the use of stored forages and concentrates, corn grazing can be a profitable practice for dairy producers. Grazing corn provides an alternative to harvesting corn silage, as it cuts the costs of inputs, machinery and labor. In addition, the fixed costs of facilities and equipment operating costs are lessened with the use of corn grazing. By reducing the stress associated with more intensive management practices, grazing may also increase quality of life for dairy producers.

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# APPENDIX

# EQUATIONS AND CALCULATIONS FOR FORAGE SAMPLING

**Equations for Calculating Forage DMI**

Net Wet Wt. (kg) = Gross Wet Wt. (kg) – Container Wt. (kg)

Net Dry Wt. (kg) = Gross Dry Wt. (kg) – Container Wt. (kg)

% DM = Net Dry Wt./ Net Wt. X 100

Tons/Acre of DM = Net Dry Wt. (kg/$m^2$) (2.205) / 2000 / 0.000247

*1$m^2$ = 0.000247 Acres

Consumed from Field (Tons/Acre) = Pre-grazing Sample (Tons/Acre) – Residual Sample (Tons/Acre)

Actual DM Forage Intake = Consumed (Tons/Acre) (Actual Acreage) (2000) / # Cows/ # Days/ 2.205

Actual Acres = GPS Acres – Row Area (Acres)

Row Area = Width (ft.) X Length (ft.) X 0.00002229567

*1ft.$^2$ = 0.00002229567 Acres

*Example Numerical Calculation*:

**Pre-grazing Forage Sample**:

Net Wet Wt. (kg) = 4.6205 kg -0.0555 kg = **4.565 kg**

Net Dry Wt. (kg) = 1.0022 kg -0.0555 kg = **0.9467 kg**

% DM = (0.9467 kg / 4.565 kg) X 100 = **20.73823%**

Tons/Acre of DM = 0.9467 kg/$m^2$ (2.205) / 2000 / 0.000247 = **4.2257 Tons/Acre**

**1st Residual:**

Net Wet Wt. (kg) = 1.5988 kg -0.0555 kg = **1.5433 kg**

Net Dry Wt. (kg) = 0.6056 kg -0.0555 kg = **0.5501 kg**

% DM = (**0.5501** kg / **1.5433** kg) X 100 = **35.6444%**

Tons/Acre of DM = 0.5501 kg/$m^2$ (2.205) / 2000 / 0.000247 = **2.4554 Tons/Acre**

**Actual DMI:**

Consumed from Field = 4.2257 Tons/Acre – 2.4554 Tons/Acre = **1.7702 Tons/Acre**

Row Area = (5 ft X 489 ft) 0.00002229567 = **0.0545 Acres**

Actual Acres = 0.511 Acres – 0.0545 Acres = **0.456 Acres**

Actual DM Forage Intake = 1.7702 Tons/Acre (0.456 Actual Acres) (2000) / 18 Cows / 7 Days / 2.205 = **5.8109 kg/hd/d**

**Intake for 1 week of grazing beginning on Plot B.**