Proceedings of the Organic Agriculture Research Symposium
LaCrosse, WI February 25-26, 2015

Enhanced Forage Intake and Milk Production on Birdsfoot Trefoil Pastures in the Western US

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Abstract

Milk production on side-by-side irrigated birdsfoot trefoil (*Lotus corniculatus* L.) and grass pastures was assessed on a southern Idaho organic dairy farm. Greater production on birdsfoot trefoil was expected because perennial legume forages have greater nutritive value than grasses and can be digested more rapidly. The nitrogen they require for growth is fixed as needed, and birdsfoot trefoil is deep-rooted and grows well under irrigation in mid-summer. Birdsfoot trefoil is non-bloating because it contains a low concentration of condensed tannins that do not interfere significantly with intake or digestion. Both intake and milk production were elevated on birdsfoot trefoil relative to grass pastures in 2012 and 2013. The concentration of conjugated linoleic acid was similarly elevated in cheese made from the milk of both birdsfoot trefoil- and grass-fed cows compared with cheese from the milk of conventionally fed cows. The omega-3 fatty acid concentration of cheese from the milk of birdsfoot trefoil-fed cows, however, was significantly greater than in cheese from grass-fed cows, and significantly greater in cheese from the milk of grass-fed than conventionally fed cows.

Introduction

In the USA, organic ruminant production requires access to pasture for a minimum of 120 days during the grazing season, and the provision of at least 30% of dry matter intake from pasture during the grazing season. (Rinehart and Baier 2011). McBride and Greene (2009) determined that the quartile of organic dairies using the most pasture had feed costs that were 25% less than the quartile of organic dairies using the least pasture, but milk yields were 30% less for the pasture-based dairies. The goal of our study was to address this deficit in milk production on grazing-based organic dairies. Research on grazing-based dairy production from New Zealand had demonstrated that dairy cows fed pastures comprised of mixtures of perennial ryegrass (*Lolium perenne* L.) and birdsfoot trefoil had greater milk production than cows fed perennial ryegrass pastures without birdsfoot trefoil (Woodward et al. 2009).

Objectives

Our objectives were to quantify the forage dry matter production, milk production and composition of cheese from the milk of organic dairy cows grazing irrigated grass or birdsfoot trefoil pastures on a grazing-based commercial organic dairy farm in the Mountain West. Data for other aspects of this study have been or will be reported in other publications.

Methods

An existing 20-acre (8 ha) grass pasture was subdivided, and half was cultivated and planted to birdsfoot trefoil in the early autumn of 2011. In the spring of 2012, walkways, a stock watering system and paddocks were developed using temporary electric fencing to enable two herds of 9 cows matched for milk production and number of lactations to be rotationally stocked on adjacent grass or birdsfoot trefoil pastures from mid-June until late August. The study was repeated between mid-May and early July of 2013. Pre- and post-grazing forage dry matter in pastures was assessed using a rising plate meter

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calibrated for grass or birdsfoot trefoil, and intake was estimated as the disappearance of pasture dry matter. Milk production was measured at four successive milkings every two weeks and is reported as mean daily milk production. Cheese was made from milk collected at a morning milking in mid-July 2012 from cows on grass or birdsfoot trefoil pastures or from milk produced by the Utah State University dairy herd, which is fed a total mixed ration (TMR) year-round. Milk was used to make medium cheddar cheeses that were aged for six months.

Results and discussion

Forage intake and milk production were significantly greater on birdsfoot trefoil in 2012 and 2013 (Table 1). The condensed tannins in birdsfoot trefoil are a key to improved ruminant production because this forage can be grazed in enriched or pure stands. Another contributing factor is elevated stem digestibility due to fiber cell wall structure and lignification pattern, which differentiate birdsfoot trefoil from alfalfa. Cheese made from the milk of cows grazing grass was significantly greater in omega-3 fatty acids than cheese made from the milk of TMR-fed cows, while the omega-3 fatty acid concentration of cheese made from the milk of birdsfoot trefoil-fed cows was significantly greater than in cheese made from the milk of grass-fed cows (Fig. 1A). The conjugated linoleic acid (CLA) concentration of cheese made from the milk of both grass- and birdsfoot trefoil-fed cows was significantly greater than the CLA concentration of cheese made from the milk of TMR-fed cows, but grass- and birdsfoot trefoil cheese CLA concentrations did not differ (Fig. 1B).

There are several reasons milk production will be elevated on birdsfoot trefoil relative to grass pastures. Legumes typically have more crude protein and less neutral detergent fiber (NDF) than grasses (Smith et al.,1972), increasing the rate of forage digestion and resulting in greater intake (Crampton et al. 1960). Tap-rooted perennial legumes such as alfalfa (*Medicago sativa* L.) and birdsfoot trefoil are more productive than grasses in mid-summer because they are more tolerant of high daytime temperatures and dry soil conditions (Berdahl et al. 2001). Legume forages are inoculated at planting with non-pathogenic soil bacteria that form root nodules in which atmospheric nitrogen is fixed into the nitrogen needed for legume growth, while grasses must rely on manure deposition in organic systems. While alfalfa and most clovers (*Trifolium* spp.) are bloat-causing, birdsfoot trefoil produces condensed tannins that prevent bloat. Birdsfoot trefoil tannins bind excess plant proteins in the rumen, and release these proteins for digestion in the abomasum, while most forage tannins do not release bound proteins as readily (Waghorn, 2008).

The proportion of leaf to stem dry matter is greater in birdsfoot trefoil than in alfalfa (Mowat et al. 1969) because birdsfoot trefoil has finer stems than alfalfa (Undersander et al. 1993). Relative to the proportion of cell wall present, birdsfoot trefoil also has greater voluntary intake than alfalfa (van Soest 1995), probably because stem cell wall digestibility is greater in birdsfoot trefoil than in alfalfa (Mowat et al. 1969). A variety trial was carried out in Utah comparing14 cultivars of birdsfoot trefoil with two check cultivars of alfalfa (MacAdam and Griggs 2013b). A comparison of forage nutritive value at three harvests in the third year after planting determined that the NDF concentration of alfalfa was greater than that of birdsfoot trefoil (Fig. 2A), but the non-fibrous carbohydrate (NFC) concentration of birdsfoot trefoil was greater at each harvest than that of alfalfa (Fig. 2B) (MacAdam and Griggs 2013a). This could explain the relatively high stem cell wall digestibility of birdsfoot trefoil reported by Mowat et al. (1969) and the greater voluntary intake reported by van Soest (1965). These NFC data are further supported by the less complete lignification observed in the inner layer of fiber cell walls in the xylem of 10-week-old birdsfoot trefoil stems compared with xylem fiber cells in alfalfa stems of the same age (Hunt et al., 2014).

Conclusions

This study compared intake and milk production of organic dairy cows on grass or birdsfoot trefoil pastures on a commercial dairy farm between late May and late August, and demonstrated that cows grazing birdsfoot trefoil pasture consistently produced more milk than cows grazing grass pasture. When

the milk was used to make cheese, the cheese of birdsfoot trefoil-fed cows was significantly greater in omega-3 fatty acids than the cheese of grass-fed cows.

Acknowledgements

This research was supported by the Utah Agricultural Experiment Station, Utah State University. Funding was provided by the United States Department of Agriculture National Institute of Food and Agriculture Organic Agriculture Research and Extension Initiative Grant Number 2010-51300-21283.

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Appendix

Table 1. Mean intake and milk production on pastures in 2012 and 2013.

Year	BFT Intake, kg/ha	Grass Intake, kg/ha	BFT Milk Production, kg/cow/d	Grass Milk Production, kg/cow/d
2012	1603	773	30	25
2013	2183	1301	35	30

BFT: birdsfoot trefoil

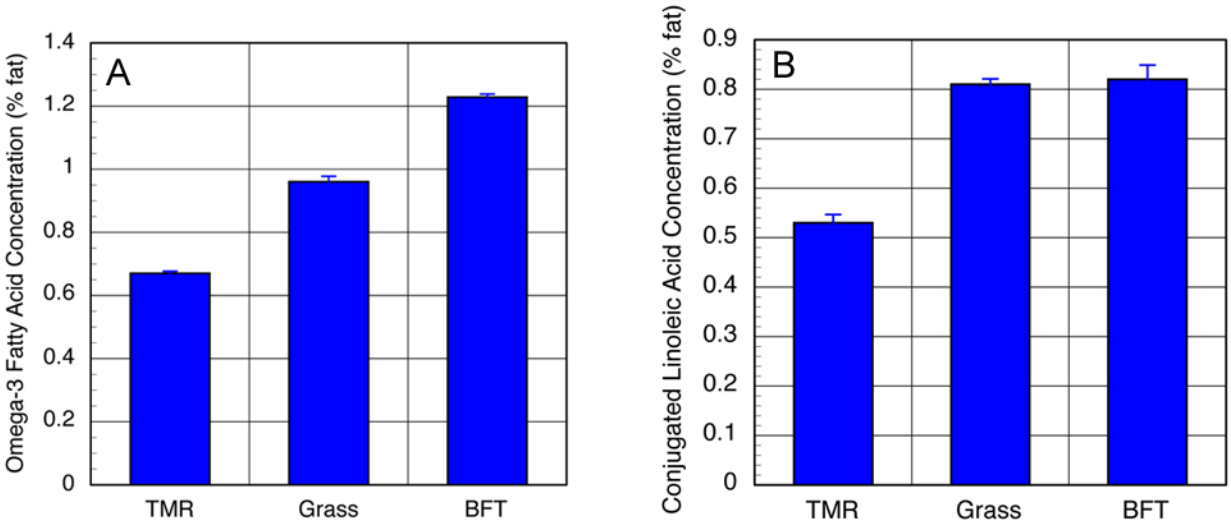

Figure 1. The omega-3 fatty acid concentration (left) of cheese made from the milk of grass-fed cows was significantly greater than that of total mixed ration- (TMR) fed cows, and the omega-3 fatty acid concentration of cheese from the milk of birdsfoot trefoil-fed (BFT) cows was a further increment greater than cheese from the milk of grass-fed cows. The conjugated linoleic acid (CLA) concentration (right) of cheese from the milk of grass- and BFT-fed cows was similar and significantly greater than that of cheese made from the milk of TMR-fed cows.

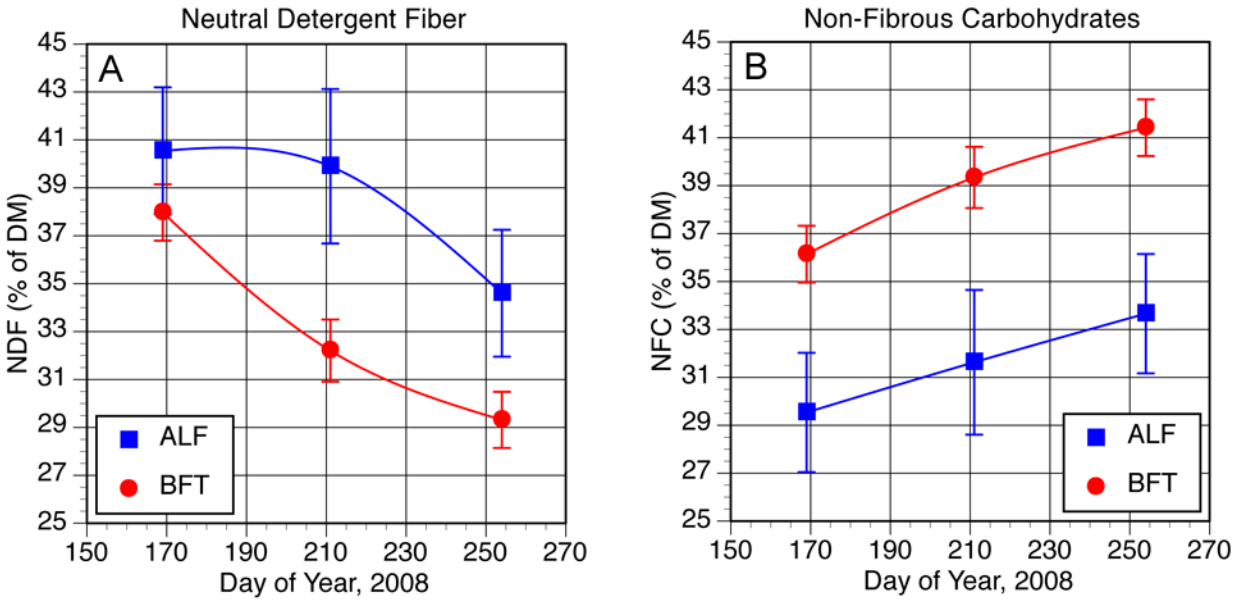

Figure 1. When 14 cultivars of birdsfoot trefoil (BFT) were compared with two check cultivars of alfalfa (ALF) during the third year of a variety trial, the neutral detergent fiber concentration (NDF, left) of birdsfoot trefoil was lower than that of alfalfa, but the non-fibrous carbohydrate concentration (NFC, right) of birdsfoot trefoil was greater than the NFC concentration of alfalfa (MacAdam and Griggs, 2013a).