The Effects of Organic Grass and Grass-Birdsfoot Trefoil Pastures on Jersey Heifer Development: Heifer Growth, Performance and Economic Impact

Journal:	*Journal of Dairy Science*
Manuscript ID	JDS.2020-19524.R2
Article Type:	Research
Date Submitted by the Author:	09-Apr-2021
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Key Words:	dairy hiefer, organic, pasture

Running title: Heifer Performance on Pasture

The Effects of Organic Grass and Grass-Birdsfoot Trefoil Pastures on Jersey Heifer Development: Heifer Growth, Performance and Economic Impact

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ABSTRACT

Dairy heifers developed in certified organic programs, especially those utilizing pasture-based management schemes, have lower rates of gain than heifers raised in non-organic confinement production systems in temperate climates, such as in the Intermountain West region of the US. This study investigates the effects that different forages in a rotational grazing system have on development of organically raised Jersey heifers. Over three years, 210 yearling Jersey heifers were randomly assigned to one of nine treatments, including a conventional confinement control where animals were fed a total mixed ration or one of eight pasture treatments: Cache Meadow bromegrass (*Brumus riparius Rehmann*), QuickDraw orchard grass (*Dactylis glomerata* L.), Amazon perennial ryegrass (*Lolium perenne* L.), or Fawn tall fescue (*Schendonorus arundinaceus* [Schreb.] Dumort) and each individual grass interseeded with birdsfoot trefoil (*Lotus corniculatus* L., **BFT**). Each treatment had three blocks per year over the three year period with each block having a 0.4 ha pasture of each treatment. Every 35 d, over a 105 d period, heifers were weighed, measured for hip height, and blood samples were collected to determine serum insulin-like growth factor-1 and blood urea nitrogen concentrations. Fecal egg counts were also assessed. Heifer body weights (**BW**), blood urea nitrogen, and insulin-like growth factor-1 concentrations were affected by treatment when analyzed over time. Heifers on grass-BFT pastures had increased BW compared to heifers on monoculture grass pastures. Heifers receiving a total mixed ration or perennial ryegrass+BFT had increased BW gain over the 105 d period compared to heifers grazing tall fescue+BFT, orchard grass, perennial ryegrass, meadow bromegrass, or tall fescue. Whereas, individually for all grass species, heifers grazing +BFT pastures had greater ending BW and weight gain than heifers grazing the respective grass monocultures. Furthermore, weight gain for heifers on perennial ryegrass+BFT, meadow

bromegrass+BFT, and orchard grass+BFT were not different from those on a total mixed ration. Heifers grazing grass-BFT pastures had increased blood urea nitrogen compared to heifers grazing monoculture grass pastures. Heifer hip-height and fecal egg counts were not affected by treatment. These results show that the addition of BFT to organic pasture improves growth of grazing replacement heifers. Economic analyses also demonstrate that interseeding grass pastures with BFT results in an increased economic return compared to grazing monoculture grass pastures. Grass pastures interseeded with BFT may be a sustainable option to achieve adequate growth of Jersey heifers raised in an organic pasture scenario in a temperate climate.

Key Words: Jersey heifer, organic, pasture, birdsfoot trefoil

INTRODUCTION

Replacement heifer management is critical to maintain profitability in dairy operations. However, the cost of raising replacement heifers is the second largest expense incurred by dairies, only behind feed costs (Tozer and Heinrichs, 2001, Boulton et al., 2017). It is important that dairy heifers achieve appropriate growth in order to ensure maximum profitability and productivity. Previous research has demonstrated that pre-pubertal growth rates greater that 0.80 kg/d in Holsteins result in a reduction in first lactation milk production (Zanton and Heinrichs, 2005). In contrast, Holstein calves with lower growth rates, between 0.40 and 0.56 kg/d, are older at both puberty and calving (Raeth-Knight et al., 2009, Rincker et al., 2011). Many producers are able to grow their heifers at a rate within these margins by utilizing a conventional feed system that consists of delivering a total mixed ration (**TMR**) in a confined area allowing for control of nutrient intake (Hoffman et al., 1996, Tozer et al., 2003). While efficient, this method can be costly and producers welcome new strategies and alternatives to confined feeding. Additionally, organic producers must follow strict regulations, including a pasture requirement. As such, modern research aimed at finding ways to diminish expenses that do not negatively impact production, while still following organic requirements, is desired by producers (McBride, 2010).

Requirements for organic dairying, as established by the USDA, state that organic producers must let cattle graze pasture for the entire grazing season in their geographical region with a minimum of 120 d (USDA-AMS, 2019), during which time 30% of the ruminant's dry matter intake (**DMI**) must come from pasture. To accommodate this regulation, many organic dairy producers feed a primarily pasture-based diet, which also helps reduce high organic feed costs. However, producers who used the highest amount of pasture-based forage (75-100%) had the lowest net returns due to a 32% decrease in milk yield (McBride, 2010). Additionally, there is little research analyzing the effects of developing Jersey heifers on an organic pasture-based system in a temperate climate with little rainfall such as that found in areas of the Intermountain West region of the US.

To develop replacement heifers, pastures must provide nutrition that allows for adequate weight gain and skeletal growth, maintain or enhance reproductive performance, and improve rumen utilization of nitrogen. Utilizing grass-legume mixtures in pasture could help achieve these nutritional goals by supplying adequate amounts of herbage, energy, and protein. The ability of legumes to fix atmospheric nitrogen, leads to increased protein content of the pasture helping to improve forage yield and quality without application of fertilizers. Tannin containing legumes could also improve production of ruminants on pasture. Research has shown that legumes containing tannins can increase nitrogen utilization in the rumen, decrease the incidence of bloat, and act as a natural anthelmintic to decrease parasite load (Min et al., 2003, Patra and Saxena, 2011). The use of legumes in grass pasture, especially those that contain tannins, could positively influence performance of developing dairy heifers. Previous research from our group indicates that grass pastures interseeded with birdsfoot trefoil (**BFT**), a tannin containing legume, results in increased growth of beef steers (Waldron et al., 2020). Several other studies have analyzed performance of dairy heifers on pasture in other regions (Macdonald et al., 2007, Roche et al., 2015, Hayes et al., 2019), however no previous research has investigated the effects of different organic pasture forages on development of Jersey heifers in a climate similar to that of the Intermountain West region of the US. As such, the objective of the present study was to compare growth, health, and economic viability of Jersey heifers developed on an organic grass monoculture pasture, an organic grass pasture interseeded with a tannin containing legume

(BFT), or a conventional confinement setting (non-organic). Our hypothesis states that Jersey heifers developed on organic grass pasture interseeded with BFT will have improved growth, health, and be more economically viable when compared to heifers developed on organic monoculture grass pastures.

MATERIALS AND METHODS

All animal experiments were conducted following procedures approved by the Institutional Animal Care and Use Committee (IACUC protocol #2777 and #10063) at Utah State University. This study utilized 8 different pasture treatments and a TMR, for a total of 9 treatments. Each treatment utilized three blocks (pastures) per year over a three-year period (2016, 2017, and 2018). A total of 210 yearling Jersey heifers were purchased from commercial dairies (48 in 2016 from a single source, 81 in 2017 from a single source and 81 in 2018 from two different sources). All heifers utilized in the study were registered Jersey and had similar initial weights and birthdates. The experimental unit in the present study is pasture block. In 2016, two heifers were randomly allocated to one of three blocks in each pasture treatment and in 2017 and 2018, three heifers were randomly allocated to one of three blocks in each pasture or TMR treatment (n=9). In 2016, there were no Jersey heifers receiving a TMR, as such, the TMR treatment has an n=6 and includes data collected in 2017 and 2018. In May of each year, heifers were transported to the Intermountain Irrigated Pasture Project in Lewiston, Utah. Upon arrival, heifers began a two-week grazing acclimation period to ensure heifers could adequately consume forage from pastures. After the two-week transition period was completed, heifers were fasted for 12 h in preparation for initial sampling. As heifers were sampled at d 0, they were randomly assigned to one of three blocks within each pasture or TMR treatment.

Treatments and Pasture Information

Pasture Information. The pastures utilized in the present study have been described previously (Rose et. al., 2021). In brief, this research was conducted at the Utah State University Intermountain Irrigated Pasture Research Farm (41°57'01.85" North, 111°52'15.75" West, elev. 1,369 m, 46 cm annual precipitation and 56.1 precipitation days per year) located near Lewiston, UT, USA. The soils at the site are a Kidman fine sandy loam (Coarse-loamy, mixed, superactive, mesic Calcic Haploxerolls) and Lewiston Fine Sandy Loam (Coarse-loamy, mixed, superactive, mesic Calcic Haploxerolls). The site is within the semiarid Central Great Basin region of the western USA, characterized by hot, dry summers, and a majority of the annual precipitation as snowfall. In this particular area (Cache county, Utah, USA), the precipitation from winter-time snowfall is stored in reservoirs and used in the summer for irrigated crop production (Utah Climate Center, 2018). Yearly precipitation and temperature data for 2016, 107 and 2018 are presented in Rose et al. (2021).

Pasture Treatments. This study utilized eight different pasture treatments and a confinement TMR control. The eight pasture treatments consisted of four monoculture grass pastures and four mixed pastures. The four monoculture grasses used were: Cache Meadow bromegrass (*Brumus riparius Rehmann;* **MB**), QuickDraw orchard grass (*Dactylis glomerata* L,; **OG**), Amazon perennial ryegrass (*Lolium perenne* L.; **PR**), or Fawn tall fescue (*Schendonorus arundinaceus* [Schreb.] Dumort; **TF**). Mixed pastures consisted of one of the four monoculture grasses listed previously, mixed with BFT (MB+BFT, OG+BFT, PR+BFT, TF+BFT). All heifers on pasture had access to water and a trace mineral supplement. Pasture treatments were planted at the Intermountain Irrigated Pasture Project and were grazed for a 105 d period.

Three different blocks were utilized each year of the study with each block consisting of a 0.4 ha pasture of each treatment that was divided evenly into five 0.08 ha paddocks. Paddocks were separated with a single strand of poly-wire charged by a battery powered fence charger. Rotational stocking was used with a stocking period of 7 d, followed by a rest period of 28 d, such that the entire rotation cycle was 35 d. Three full rotations occurred each year, giving heifers a total of 105 d on pasture (20 June to 13 Oct., 2016 and 17 May to 30 Aug., 2017 and 16 May to 29 Aug., 2018). At the end of each 35 d rotation cycle, heifers were gathered and fasted for 12 h for sample collection before resuming the next 35 d cycle.

This study was conducted using organic dairy grazing protocols, so no treatment received commercial fertilizer However, as previously described by Rose et. al. (2021) approved organic sources of nitrogen were applied to the treatments. Chilean nitrate (sodium nitrate, 15-0-2, N-P-K) (SQM, Santiago, Chile) was applied at 28 kg N ha^{-1} in April to all treatments (both monoculture and mixtures). In addition, grass monocultures also received a second application of 28 kg N ha^{-1} of Chilean nitrate in July, and further received 35 kg N ha^{-1} in the form of hydrolyzed poultry feathers in June 2017 and March 2018 (80% CP/6.25=12.8% N) as a slow-release source of N. Paddocks were irrigated one week before grazing and within a week after grazing, so that pastures received 8.89 cm of water every 14-20 d. Precipitation data for the site Pasture samples were taken pre- and post-grazing to determine yield as well as nutritional quality of the individual pasture. An in-depth analysis of pasture samples and DMI has been previously reported (Rose et al., 2021). Table 1 shows the average nutritional quality for each of the nine treatments found from the analyses of pasture samples as well as the TMR.

Confinement Control. Heifers assigned to the confinement control were fed a TMR and had access to water and a trace mineral supplement for the 105 d period of the experiment. The confinement control was only used in the study during years 2017 and 2018. The TMR composition (DM basis) for 2017 was: 45% alfalfa haylage, 19% corn silage, 18% flaked corn grain, 9% beet pulp shreds, and 9% wheat straw. The composition for the TMR in 2018 (DM basis) was: 46% corn silage, 27% flaked corn grain, 22% alfalfa hay, and 5% wheat straw. Year differences between TMR compositions were due to feed resource availability. For ease of access to feeds and feed equipment, heifers receiving the TMR were moved from the Intermountain Irrigated Pasture Project to the Caine Dairy Teaching and Research Farm in Wellsville, Utah. Control heifers were separated by block into three different pens, with three heifers per pen. Control heifers were fed to achieve average daily BW gains similar to those desired by local producers that develop dairy heifers. The TMR was fed daily at 0700, and refusals were weighed, recorded, and discarded daily before feeding to determine intakes by block.

Every 7 d, TMR samples were collected and stored at -20°C. After collecting TMR samples over the 35 d period, one full grazing rotation, TMR samples were mixed and a composite sample taken. The composite sample was then sent to Cumberland Valley Analytical Services (Waynesboro, PA, USA) for analysis. The TMR nutrition analyses, with the pasture treatment analyses, are shown in Table 1. Every 35 d, control heifers were gathered and fasted for 12 h prior to sample collection similar to the heifers receiving pasture treatments.

Sample Collection

Samples from heifers were collected at four different time points: d 0, d 35, d 70, and d 105. All heifers were fasted for 12 h before sample collection. Weight, hip height, blood, and fecal samples were taken from each heifer at each time point. Weights were taken via an electronic scale. A regular hip-height measuring stick (Sullivan Supply, Dunlap, IA, USA) was used to determine hip height. Blood samples were collected via jugular venipuncture, using red top tubes, and allowed to clot at room temperature for 30 min before being stored and transported in a portable cooler. Fecal samples were collected in 50 mL conical tubes, put on ice, and taken to the Utah Veterinary Diagnostic lab for analysis of FEC. Fecal samples from 2017 were analyzed using the Wisconsin Sugar Flotation Test (David and Lindquist, 1982) and the 2018 samples were analyzed using the McMaster Egg Counting Technique (Mines, 1977).

Serum Metabolite Profiling

After blood collection, tubes were stored at 4°C for 24 h. Blood samples were then centrifuged at 1000 rpm for 15 min. Serum was removed from blood samples and stored at -20°C for subsequent analysis of BUN and IGF-1. A commercially available colorimetric assay was used to detect BUN in duplicate (Invitrogen, Urea Nitrogen Colorimetric Detection Kit; ThermoFisher Scientific). Serum samples were analyzed for IGF-1 in duplicate using the Human IGF-1 Quantikine ELISA Kit (SG100; R&D Systems). This kit has been shown to have 100% cross-reactivity with bovine IGF-1 (Moriel et al., 2012).

Economic Analysis

For economic comparisons, the total establishment costs, net annual financial impact, payback period, and breakeven organic premium of each treatment were calculated. The results were benchmarked against a conventional replacement dairy heifer operation feeding a TMR in confinement. The economic comparisons were made assuming the heifers were raised to a weight of 250 kg., bred, fed/grazed an additional 30 d to allow for pregnancy checks, and then subsequently sold as either open or bred conventional/organic heifers. All results were calculated assuming 100 animal units (**AU**), with an AU defined as a single Jersey heifer.

The total establishment costs for each pasture treatment were considered the initial investment into the treatment. As the pasture treatments consist of perennial forage species, only establishment costs of the first year were included. Establishment costs consisted of planting costs and seed cost. The planting costs were based on a 150-horsepower tractor and 15-foot drill. Planting costs consisted of repairs ($8.33/hr.), fuel ($13.20/hr.), lubrication ($1.98/hr.), labor ($16.50/hr.), and planter costs ($15.50/hr.). With 2.94 ha planted per hour, total planting costs were $23.62/ha for the monoculture treatments. Because the BFT mixed treatments were seeded twice to assure proper seed depth of each species in the mix, costs associated with planting BFT mixed treatments were assumed twice ($47.24/ha) those of the monocultures. The seed costs ($/ha) ranged from $66.68/ha (TF) to $160.52/ha (OG+BFT), based on previously described seeding rates (Rose et al., 2021). Planting and seed costs were combined to estimate the establishment costs ($/ha) for each of the treatments. Total establishment costs were calculated as the product of the establishment costs per hectare and the estimated required hectares for each pasture treatment. Mean herbage mass values from Rose et al. (2021) were used together with predicted DMI using previously described equations to calculate the required number of hectares for each treatment to produce the necessary feed assuming an 85% harvest efficiency (Saha et al., 2010). The required number of hectares ranged on average from 6.5 ha (MB+BFT) to 16.6 ha (PR).

The net annual financial impact was estimated using a partial budget. The partial budget included decreases expenses from TMR feed savings, as well as increased expenses from fertilization, irrigation, and the opportunity cost of the pasture treatment (land rent). The partial budget did not include labor to move the heifers to new plots, set up the electric fence, irrigate, mix and deliver the TMR daily, or clean the pens for the animals in confinement. For this analysis, the labor increases and cost savings were assumed equal between the pasture and confined fed animals. The decreased expense from reduced feeding of a TMR was estimated as the cost per kg DM of TMR (Utah prices were used to value the mixed ration) multiplied by the kg saved through grazing the selected pasture treatment. The average cost per kg DM of TMR for 2017 and 2018 was $0.175. Assuming 7.31 kg DM/AU/day (TMR predicted DMI using the equation as outlined by Saha et al. (2010)) over 113 d on feed (**DOF**) across 100 AU, the total TMR feed savings would be $14,456. This savings was assumed constant across all pasture treatments. The DOF for each treatment and TMR were estimated using the ADG values for each treatment with a target weight to begin breeding of 250 kg (Duplessis et al., 2015, Heinrichs and Jones, 2016). The DOF estimated for each treatment were then increased by 30 additional d in the partial budget analysis to allow adequate time for pregnancy checks and subsequent sale of each heifer as either a short bred or open heifer. DOF ranged from 82.5 d (PR+BFT) to 130.6 d (TF). The increased forage expense for each treatment was calculated as the product of total kg of feed required [DOF x predicted DMI x 100 (AU)] and the forage value ($/kg) calculated as

1) $$FV_i = \frac{LR}{(HM_i * HE_i)}$$

where FV_i is the calculated forage value ($/kg) for the ith pasture treatment, LR is the assumed irrigated land rental rate ($/hectare), $HM_i$is the pre-graze herbage mass (kg/ha for the ith pasture treatment, and HE_i is the assumed harvest efficiency percentage (i.e., 85%) for the ith pasture treatment. Forage value ranged on average from $0.07/kg (PR+BFT) to $0.14/kg (PR). Additional increases to expenses arose from irrigation and the application of organic fertilizer. Irrigation expenses were included at $60.54/ha (Pace et al., 2019). The annual fertilizer expenses for the selected pasture treatment were also included in the partial budget at a cost of $9.26kgN for the sodium nitrate and $9.19kgN for the hydrolyzed poultry feathers. The final element of the partial budget was increased or decreased income from sale of replacement heifers. Whether the sale of replacement heifers represents an increase or decrease in income, as compared to a confined feeding system, depends on the assumed difference in heifer conception rate as well as the price premium placed on organic heifers. The equation used to calculate the net change in income between grazing on selected pasture treatments as compared to feeding TMR in confinement was

$$\Delta I_i = (N_i * OP) + [N_i * \Delta C_i * (Pb - Po)] \quad \text{2)}$$

where ΔI_i is the net change in income for pasture treatment i, N_i is the total number of replacement heifers grazing the ith pasture treatment, ΔC_i is the change in conception rate for heifers grazed on the ith pasture treatment as compared to heifers fed in a dry lot, Po and Pb are the prices ($/head) for open and bred conventional replacement heifers, respectively, and OP is the organic price premium ($/head). For all pasture fed heifers, a conception rate decrease of 5% as compared to dry lot fed heifers was assumed based on previous research demonstrating that AI pregnancy rates tended to be lower for the grazing heifers as compared to the dry lot fed heifers (Funston and Larson, 2011). In addition to this 5% reduction, the conception rate of monoculture grazed heifers was further reduced an additional 5% for a total 10% reduction as compared to TMR fed heifers based on previous findings that decreased body weight gain prior to breeding results in lower conception rates at first service (Hayes et al., 2019). Values of $800 and $400 per head for conventional replacement bred and open dairy heifers, respectively, were used with an organic premium added of $225 per head (average premium determined through discussion with local organic producers).

The payback period for each pasture treatment was calculated by dividing the total establishment costs of each treatment by the annual net financial impact estimated using the partial budget.

The break-even organic premium was estimated as the premium required on the sale of organic replacement dairy heifers necessary for the net financial impact of grazing a selected pasture treatment (as compared to feeding TMR) to equal $0.

Statistical Analysis

Data was analyzed by use of a randomized complete block design with nine different treatments arranged into three blocks. Each block served as the experimental unit, where each block is defined as the mean of the data collected from the individual heifers on that block; there were two heifers on each of three pasture blocks in 2016 and three heifer on each of three pasture block in both 2017 and 2018. In 2016, there were no heifers being fed a TMR in confinement. All statistical analyses were done using the Proc Mixed statement of SAS® version 9.4 (SAS Institute, Cary, NC). Two analyses were carried out in the dataset. Treatment was analyzed as a fixed effect, comparing all nine treatments and the average values from heifers on each block across the study. Pasture type, with (**MIX**) or without (**MONO**) BFT, was also analyzed (n = 36) as a fixed effect, to determine if the presence of BFT in pasture influenced heifer growth and development. Heifers receiving TMR were eliminated from the pasture type analysis. Measures of heifer performance were analyzed within and across sampling days with block and year included as random variables. For the across sampling days (e.g., grazing rotation cycles) analyses, day was considered a repeated measure and the best covariance model was used for each trait (mostly compound symmetry). Post-hoc mean comparisons with LSD adjustments were completed to determine differences between individual treatments. Significance was determined at $P \leq 0.05$ for all comparisons. All values used for tables and figures are LSM.

RESULTS

Body Weight

Pasture Type. Heifer body weight (**BW**) was affected by both pasture type*day (P < 0.01) and day (P < 0.01) (Figure 1). Additionally, heifers who grazed MIX pastures tended (P = 0.06) to have greater BW when compared to heifers that grazed MONO pastures (Figure 1). Pasture type had no effect on heifer BW at d 0 or d 35 (P = 0.99, P = 0.17, respectively, Figure 1), but at d 70 and d 105 the heifers grazing MIX pastures had greater (P < 0.01) BW when compared to heifers receiving MONO pasture (Figure 1). Over the 105 d period, heifer weight gain also differed (P < 0.01) between MONO and MIX treatments, with heifers grazing MIX pastures having greater weight gain compared to heifers grazing MONO pastures (0.60 kg/d vs. 0.49 kg/d respectively, data not shown). Taken together, these data indicate that heifers grazing MIX pastures had greater BW and weight gain when compared to heifers grazing MONO pastures.

Treatment. Heifer BW was affected by treatment*day (P < 0.01), treatment (P = 0.01), and day (P < 0.01). Treatment had no effect on heifer BW on d 0 (P = 0.91) or d 35 (P = 0.14); however, BW was impacted at d 70 (P < 0.01), and d 105 (P < 0.01). Additionally, over the 105 d period, there was a change (P < 0.01) in gain (Table 2). At d 70 and d 105, heifers receiving TMR had greater (P < 0.05) BW compared to heifers grazing monoculture pastures (PR, OG, MB, TF) and TF+BFT (Table 2). Similarly, heifers grazing PR+BFT had greater (P < 0.05) BW at d 70 and 105 when compared to all monoculture pastures, with the exception of PR at d 70 (Table 2). Heifer weight gain over the 105 d period was greater (P < 0.05) for PR+BFT than all other treatments except heifers receiving TMR (Table 2). Heifers grazing TF had the lowest (P < 0.05) weight gains of all treatments (Table 2). Greater weight gains were observed for all +BFT treatments, including TF+BFT, compared to their individual respective grass monocultures

(Table 2). Overall, these data demonstrate that heifers receiving TMR or mixed pastures had greater BW and weight gains when compared to heifers grazing monoculture pasture grasses.

Hip-Height

There were no pasture type*day (P = 0.61) or treatment*day (P=0.65) interactions, nor was there an effect of pasture type (P = 0.16) or treatment (P = 0.42) on heifer hip-height (Table 3). Date of measurement was significant (P < 0.01) with hip-height increasing over the course of the grazing season (Table 3). Total hip height gain over the 105 d grazing period was greater (P = 0.05) in heifers grazing MIX pasture (Table 3); whereas, 105 d change in hip height among the 9 treatments only approached significance (P = 0.08) (Table 3). These data indicate that although pasture type did not alter hip-height over time, the heifers were indeed growing as the trial progressed.

Blood Urea Nitrogen

Pasture Type. Heifer BUN concentrations were affected by pasture type*day (P < 0.01) and pasture type (P < 0.01) when analyzed over time (Figure 2). At d 0 heifer BUN concentrations did not differ (P = 0.20) between pasture types (Figure 2). However, heifers receiving MIX pastures had greater (P < 0.01) BUN concentrations compared to heifers grazing MONO pastures at d 35, d 70, and d 105 (Figure 2). These data indicate heifers grazing MIX pastures had greater BUN concentrations when compared to heifers grazing MONO pastures.

Treatment. Heifer BUN concentrations were not affected by a treatment*day (P = 0.12) interaction or day (P = 0.32), but treatment (P < 0.01) had an effect (Table 4). At d 0 heifer BUN did not differ (P = 0.79) between treatments (Table 4). However, at d 35, d 70, and d 105 heifer BUN concentrations differed (P < 0.01) between treatments (Table 4). At d 35, heifers receiving PR+BFT, OG+BFT and TMR had greater (P < 0.05) BUN concentrations compared to heifers grazing all monoculture treatments (PR, OG, MB, TF, Table 4). At d 70, heifers grazing PR+BFT and OG+BFT had greater ($P < 0.05$) BUN levels compared to heifers grazing monoculture treatments (OG, PR, MB, TF) and TF+BFT (Table 4). At d 105, BUN levels were increased ($P < 0.05$) in heifers getting TMR, MB+BFT, PR+BFT, or TF+BFT when compared to those grazing monoculture grasses. These data indicate that heifers receiving mixed pasture treatments or TMR had greater BUN concentrations than heifers who grazed monoculture pasture treatments.

Insulin-like Growth Factor-1

Pasture Type. Heifer serum IGF-1 concentrations were not affected by a pasture type*day ($P = 0.14$) interaction, nor was a pasture type ($P = 0.87$) effect observed (Table 5). These data indicate that heifer IGF-1 concentrations vary by day, but do not appear to be affected by the pasture type consumed.

Treatment. Heifer IGF-1 concentrations were not affected by a treatment*day ($P = 0.23$) interaction but treatment ($P < 0.01$) and day ($P < 0.01$) were found to have an effect when analyzed over time (Table 5). Heifer IGF-1 concentrations at d 0 did not differ ($P = 0.85$) by treatment. However, at d 35, d 70, and d 105 heifer IGF-1 concentrations differed ($P < 0.05$) between treatments (Table 5). At d 35, heifers receiving TMR had greater ($P < 0.05$) IGF-1 concentrations compared to heifers who grazed monoculture pastures (PR, MB, OG, TF), MB+BFT, OG+BFT and TF+BFT (Table 5). Similarly, heifers grazing PR+BFT, MB+BFT, and OG+BFT had greater ($P < 0.05$) IGF-1 concentrations compared to heifers grazing TF. At d 70, heifers receiving TMR had greater ($P < 0.05$) IGF-1 concentrations compared to heifers grazing all other treatments, except for OG (Table 5). At d 105, heifers receiving TMR, MB or MB+BFT had increased ($P < 0.05$) IGF-1 concentrations compared to heifers grazing TF or TF+BFT

(Table 5). Heifer IGF-1 concentrations were not significantly different ($P < 0.05$) between each individual grass monoculture and its respective mixture with BFT. Taken together, these data indicate heifers receiving TMR, OG, and PR+BFT commonly had greater IGF-1 levels than heifers receiving other treatments.

Parasite Load

Fecal egg count data collected in the years 2017 and 2018 were analyzed separately as different methods to determine FEC were utilized each year. In both 2017 and 2018, a pasture type*day interaction was not found ($P = 0.88$, $P = 0.76$, respectively) nor was a pasture type effect ($P = 0.28$, $P = 0.30$, respectively) present when heifer FEC were analyzed over time (data not shown). However, heifer FEC was affected ($P < 0.01$) by day in 2017 and 2018 (data not shown) such that FEC increased over time. Additionally, heifer FEC was not affected ($P = 0.55$, $P = 0.93$, respectively) by a treatment*day interaction in 2017 or 2018, nor was a treatment effect ($P = 0.32$; $P = 0.61$, respectively) observed for either year (data not shown). However, a day effect ($P < 0.01$) was observed for both years when analyzed over time such that FEC increased over time (data not shown). These data indicate that there were no differences between treatments on FEC of the heifers.

Effect of Time

BW, hip-height, and IGF-1 each changed ($P < 0.01$) over the 105 d sampling period (Table 6). As expected, both BW and hip-height increased ($P < 0.01$) over time (Table 6). Day ($P < 0.01$) influenced heifer IGF-1 concentrations (Table 6). Heifers sampled at d 105 had increased ($P < 0.05$) IGF-1 concentrations when compared to heifers sampled at all other time points (Table 6). Heifers sampled at d 0 had increased ($P < 0.05$) IGF-1 concentrations when compared to heifers sampled at d 35 (Table 6). No effects (P = 0.32) of day were observed in BUN (Table 6).

Economic Results

Pasture type. The MIX pastures had an increased (P < 0.05) total establishment cost when compared to the MONO pastures (Table 7). Additionally, MIX pastures had an increased (P < 0.05) annual net financial impact and a lower (P < 0.05) payback period when compared to the MONO pastures (Table 7). The breakeven organic premium for MIX pastures was also lower (P < 0.05) than that of MONO pastures (Table 7). These data indicate that although the establishment cost is higher for MIX pastures, the economic return from developing dairy heifers on a MIX pastures is much greater than utilizing a MONO pasture.

Treatment. When comparing the MONO grass pastures, the total establishment cost of TF was lower (P < 0.05) than MB, OG and PR, while the total establishment cost of PR was increased (P < 0.05) compared to TF, MB and OG (Table 7). Comparison of total establishment costs among the MIX pastures showed that OG + BFT was increased (P < 0.05) compared to all three of the other MIX pastures (Table 7). PR was the only MONO pasture that had an increased (P < 0.05) total establishment cost when compared to TF + BFT and OG + BFT, but was decreased (P < 0.05) compared to OG + BFT (Table 7). Comparison of the annual net financial impact among the MIX pastures showed that PR was lower (P < 0.05) than TF, MB and OG, while MB and OG were increased (P < 0.05) when compared to both TF and PR (Table 7).The annual net financial impact was not different (P > 0.05) among the MIX pastures, but the annual net financial impact of each of the MIX pastures was increased (P < 0.05) when compared to each of the MONO pastures (Table 7). The payback period was similar (P > 0.05) between all eight of the different pasture treatments (Table 7). The breakeven organic premium was increased (P < 0.05) in PR compared to all other pasture treatments, while MB, OG and TF were increased compared to each of the MIX pastures (Table 7). There was no difference (P > 0.05) in the breakeven organic premium when comparing each of the MIX pastures (Table 7). Taken together, these data demonstrate that interseeding a grass pasture with BFT results in an overall increased economic return, however there are no real differences noted between the different grasses interseeded with BFT.

DISCUSSION

Monitoring growth of dairy heifers is important as heifers must reach approximately 55% of their mature BW at breeding by 13 to 15 mo of age allowing for a target age of first calving at 22 to 24 mo to be reached (Akins, 2016, Hayes et al., 2019). An age of first calving beyond 24 mo results in increased rearing costs stemming from increased days on feed an ultimately decreased producer profitability (Pirlo et al., 2000).The present study found that on average, Jersey heifers grazing MIX pastures had greater BW gain than heifers on MONO pastures. All heifers were weighed after a 12 h fast demonstrating that differences in weight were not due to differences in gut fill. The increased BW gain of heifers grazing MIX pastures could be due to the fact that grass+BFT pastures had increased ME and/or CP when compared to grass monoculture pastures (Rose et al., 2021). To the knowledge of the authors, no other grazing studies have been conducted using Jersey heifers in the Intermountain West region of the US on organic pastures. However, in a study utilizing beef heifers, Waldron et al. (2020) reported that beef steers grazing TF+BFT had greater BW gain than those grazing TF monocultures. In another study conducted in the Southern region of the US, it was found that bred Holstein heifers grazing native big bluestem and indiangrass had increased ADG compared to heifers grazing switchgrass, but no effects on ADG were observed when these grasses were interseeded with the legume red clover (Lowe et al., 2016). In another similar grazing study looking at Holstein heifers, it was reported that heifers grazing legume mixed pastures (alfalfa or BFT) had greater ADG (12-17% increase) compared to heifers grazing grass pastures (Barker et al., 1999). Taken together, the results of these studies demonstrate that there are conflicting results on whether inclusion of legumes in pastures impact growth of grazing heifers. However, the research presented by Waldron et al. (2020) and the present study were both performed in a similar region using non-organic or organic practices, respectively, and found interseeding grass pastures with BFT resulted in increased weight gain when grazed by growing beef steers or Jersey heifers. The differences in results from some of the other previously reported studies could be due to differences in breed (Holstein vs. Jersey), the type of grass (warm season vs. cool season) utilized in the research, or that the pastures utilized in the present study were treated organically.

Additionally, the results of the present study demonstrate that Jersey heifers receiving TMR had greater weight gains than all grass MONO pastures (PR, OG, MB, TF), but had similar BW gains to heifers grazing mixed pastures. These data indicate that animals grazing organic mixed pastures in the Intermountain West region of the US are capable of gaining as well as those receiving a non-organic TMR. Previous research has found that 7 mo old beef heifers fed TMR diets reached puberty 29 d younger than heifers grazing on dormant native pastures with no supplement (Marston et al., 1995). However, heifers grazing on pasture that received a 20% CP supplement had similar weights at breeding as heifers in a dry lot (Marston et al., 1995). Although Marston et al. (1995) did not look at the effects of including legumes, which have a higher CP than grasses, their data demonstrates that heifers consuming grass plus additional CP results in similar weight gain to those receiving a TMR. Taken together, the results of the present study, and those of others, demonstrate that high-quality grasses interseeded with BFT, or another source of CP, result in overall heifer BW gains similar to those fed a TMR. As such, organic grass-BFT mixed pastures are a sustainable alternative to feeding a TMR in a confined setting and should be considered a viable option for sustainable ruminant production on pasture in regions such as the Intermountain West.

However, in addition to BW gain, it is also important that producers analyze structural growth of their heifers to ensure that heifers are growing structurally and not just putting on fat. Hip height is often used as a measurement for producers to determine structural growth of heifers. In the present study, heifer hip height was only affected by d of measurement, with increasing hip height throughout the grazing season indicating that no treatments had nutrient deficiencies that severely restricted body growth. Previous research providing Holstein heifers with either high forage (75% DM) or high concentrate (75% DM) found no difference in structural growth, but also did not see a difference in ADG, likely because DMI was matched between the two different treatment (Zanton and Heinrichs, 2007). The study by Zanton and Heinrichs (2007) analyzed two different diets with much more variable nutrient composition than the diets utilized in the present study and also observed no difference in hip-height, but DMI was matched between the two diets. Another study found that increasing CP:ME ratio in the diet of Holstein heifers resulted in increased hip height (Gabler and Heinrichs, 2003). The CP:ME ratio in the present study likely did not vary enough to result in alteration in hip height.

Legumes have an increased CP concentration when compared to grasses. One physiological measure of protein intake is concentration of BUN. Research has shown that concentrations of BUN above 20 mg/dL may be detrimental to reproductive performance (Ferguson et al., 1988, Ferguson et al., 1993, Rajala-Schultz et al., 2001). As such, in the present study we wanted to ensure that Jersey heifers grazing the pastures interseeded with BFT did not have a BUN exceeding this level. In the present study, concentrations of BUN were greater in heifers that grazed MIX pastures or received a TMR compared to those consuming MONO pasture. However, it is important to note that none of the BUN values exceeded 20 mg/dL and the greatest BUN concentration reported in the present study was 16.3 mg/dL. In another study analyzing the influence of green grass-based diets it was found that diet had no effect on BUN concentration of crossbred dairy heifers (Habib et al., 2018). It was also found that increasing dietary concentrates in growing Holstein heifers resulted in a linear increase in BUN concentration (Zhang et al., 2018). However, studies done in lactating Jersey and Holstein cows grazing grass pasture have found that BUN levels stayed between 16-19 mg/dL, which is similar to our research findings (Kolver and Macmillan, 1994, Roche et al., 2005). Holstein cows put on grass pastures fertilized with 40-50 kg N/ha reached BUN levels of over 60 mg/dL (Ordonez et al., 2007). In the present study, less N fertilizer (28-37 kg N/ha) was applied to monoculture pastures, with CP contents across all treatments ranging from 8-19%, which is much lower than the previously cited studies and could be a reason why much lower BUN levels were reported. Additionally, no previous research has analyzed BUN levels of Jersey heifers grazing organic pastures.

The differences between heifer BUN concentrations from our research compared to the previously mentioned studies may also be due to the effect of CT from BFT. Condensed tannins have the ability to bind protein in the rumen, thus decreasing the amount of circulating urea in the animal (Min et al., 2003, Patra and Saxena, 2011). However, Rose et al. (2021) reported that CT levels among our research pastures ranged from 0.5-7.5 g CT/kg DM, whereas Min et al. (2003) reported that CT concentrations of 20-45 g CT/kg DM were ideal in reducing rumen forage protein degradation. Thus, CT from BFT may have had an effect on our heifer BUN concentrations, but probably didn't result in as great a reduction of BUN as we originally hypothesized due to the low levels of CT in our BFT. The lower concentration of BUN found in this study could have also been influenced by sampling after a 12 h fast, since BUN concentrations reach their peak four to six hours postprandial (Butler, 1998). Other data suggests that the optimal time to measure BUN in lactating cows was between 3 to 8 h after feeding, with 4 h after feeding being the optimal time (Hwang et al., 2001). More research needs to be conducted in Jersey heifers grazing organic pastures to determine how different pasture forages may impact BUN levels.

Serum IGF-1 levels may be an indicator of energy balance, but are not necessarily an indicator of overall nutrient balance (Kolver & Macmillan, 1994). In the present study, Jersey heifer IGF-1 concentrations did not differ between animals grazing MIX pastures or MONO pastures. Although heifers grazing MIX pastures had increased weight gain compared to those consuming MONO pastures, no difference in circulating IGF-1 concentration was observed. However, our results indicate that IGF-1 concentrations from heifers receiving a TMR (the numerically highest ADG observed) were higher than heifers who received TF (the numerically lowest ADG observed) throughout the study. Additionally, other research has found that polymorphisms in the IGF-1 gene are related to growth of Holstein-Friesian heifers (Siadkowska et al., 2006, Mullen et al., 2011). Previous research in beef steers has analyzed the effects that different levels of energy and protein (Low Protein, Low Energy: 1.96 ME/kg & 8% CP vs. Medium Protein, High Energy: 2.67 ME/kg & 11% CP) have on plasma IGF-1 and found that diet composition and intake influence plasma IGF-1 levels such that steers receiving medium protein and high energy diets had increased IGF-1 levels compared to steers receiving low protein and low energy diets (Elsasser et al., 1989). These researchers suggested that while CP may be responsible for basal IGF-1 levels, the actual IGF-1 response to diet may be more affected by available metabolizable energy (Elsasser et al., 1989). Similarly, in a study focusing on the effects of negative energy balance on the GH axis in lactating Holstein-Friesian cows, it was found that severe negative energy balance affected hepatic synthesis of IGF-1 (Fenwick et al., 2008). Previous research findings demonstrate that IGF-1 can be an indicator of energy balance (Elsasser et al., 1989, Fenwick et al., 2008, Kolver & Macmillan, 1994). However, in the present study the TMR had a numerically lower energy value than the TF pasture, despite the fact that the heifers receiving TMR had increased ADG compared to those grazing TF. These data do not match previous findings that increased energy increases circulating IGF-1 (Elasser et al., 1989, Fenwick et al., 2008). However, the CP in the TMR was increased compared to the TF pasture, which indicates that our results might more closely match dietary CP as opposed to energy. This data demonstrates that research on ruminant IGF-1 plasma concentrations on pasture is scarce; more research is needed to determine the relationship between ruminant serum IGF-1 concentrations and pasture type, specifically of Jersey heifers grazing organic pastures.

The addition of BFT to pastures did not have any effect on Jersey heifer FEC in the present study. Studies have found that CT from BFT can decrease FEC in ruminants (Min et al., 2003). It has also been found that lambs grazing forages that contained CT had a reduction in FEC (Niezen et al., 1998). Other research has suggested that BFT may reduce FEC in dairy heifers (Shepley et al., 2015). The results of the current study do not agree with the findings of these previous studies. The differences in results may be due to the low amount of CT (0.5-7.5 g CT/kg DM) reported in our pastures by Rose et al. (2021). In addition, it should be noted that the Jersey heifers used in this study had low numbers of parasites overall, making it difficult to detect any differences in FEC. Although other research suggests feeding ruminants BFT can reduce parasite load, our results indicate that BFT had no effect on parasite load. As such, additional research needs to be completed to determine how different varieties of BFT in an organic pasture may impact parasite load of developing dairy heifers of different breeds.

The findings of the economic analysis in the present study demonstrate that all treatments other than PR are estimated to have a positive annual net financial impact. This indicates that once the establishment costs have been paid, producers could expect a positive impact annually from producing organic replacement dairy heifers on these pasture treatments as compared to conventional heifers fed in confinement. When comparing the monocultures with the BFT mixed pasture treatments, it is important to consider how the differing fertilization rate influenced the results. The monoculture pasture treatments received twice the amount of sodium nitrate as compared to the BFT mixed pasture treatments as well as the application of the hydrolyzed poultry feathers. Additionally, the monocultures required more hectares on average as compared to the BFT mixed treatments to produce the required feed (resulting from less biomass per ha on average). This increased number of hectares along with the increased fertilization rate resulted in an average increase in fertilization expenses of $10,755 within the partial budget for MONO pastures as compared to MIX pastures. Fertilization requirements may vary and further investigation of the individual needs of each of the pasture treatments is required to more precisely evaluate the expected increases to fertilization expenses. Previous research comparing growth of beef steers consuming TF+BFT, TF+alfalfa and TF+non-organic N fertilizer found that steers consuming TF+BFT gained more than the other treatments and had an increased gross economic return (Waldron et al., 2020). The results of the present study and those from Waldron et al. (2020) demonstrate that interseeding grass pastures with BFT results increased weight gains and economic returns, despite different fertilization methods. Previous research in the midsouth United States comparing native warm season grasses with and without legumes found that feeding switchgrass alone resulted in the greatest economic return (Lowe et al., 2016). These data demonstrate that analyzing economic return of heifers grazing pasture is highly variable between different locations, fertilization type and rate, and pasture type.

CONCLUSIONS

Interseeding a legume, BFT, with grasses in an organic pasture increases Jersey heifer weight gain when compared to those grazing a monoculture grass, but were not different from those fed a conventional TMR. Furthermore, Jersey heifers grazing BFT mixed pastures had higher BUN concentration than animals on grass pastures. Even with higher levels of BUN, animals grazing BFT mixed pastures never surpassed BUN concentrations that are known to be detrimental to reproduction. Serum IGF-1 levels were also commonly higher in heifers fed a TMR compared to heifers grazing TF. Heifer parasite load and hip-height were not affected by the presence of BFT in pasture or any of the specific treatments. This research demonstrates that grazing Jersey heifers on organic grass-BFT mixed pastures may be a sustainable method to improve dairy heifer development in animals consuming pasture in a temperate climate similar to that found in the Intermountain West region of the US, especially those utilizing an organic system.

ACKNOWLEDGEMENTS

Joint contribution of the USDA-ARS and the Utah Agric. Exp. Stn. UAES Journal Paper No. XXXX. This work was supported by the USDA National Institute of Food and Agriculture (NIFA) through, 1) Western Sustainable Agriculture Research and Education program (WSARE) grant no. 2016-38640-25383/subaward SW17-046, and, 2) Organic Agriculture Research and Extension Initiative (OREI) grant no. 2017-51300-26866/project accession no UTA01375.

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Table 1. Nutrient analysis of individual pasture treatments and TMR, averaged over 3 years and separated by sampling period

Day	Treatments[1]	CP, %[2]	ADF, %[3]	aNDF, %[4]	Fat, %	ME, Mcal/kg[5]	Ash, %
0 - 35							
	MB	9.02	39.68	61.11	2.29	2.75	10.34
	MB+BFT	13.90	37.86	57.27	2.07	2.85	9.25
	OG	8.43	37.11	60.55	2.71	2.68	11.08
	OG+BFT	12.14	36.99	57.15	2.34	2.81	10.21
	PR	8.16	30.70	47.76	2.54	3.01	11.51
	PR+BFT	16.37	30.08	42.42	2.19	3.12	10.18
	TF	8.54	36.74	57.11	2.09	2.63	13.39
	TF+BFT	16.37	30.08	42.42	2.19	2.74	10.18
	TMR	14.31	27.43	37.84	3.03	2.40	8.96
	MONO	8.54	36.06	56.63	2.41	2.77	11.58
	MIX	14.69	33.76	49.81	2.20	2.88	9.95
35 – 70							
	MB	9.48	43.25	63.05	2.56	2.46	11.43
	MB+BFT	16.33	36.70	53.66	2.17	2.63	11.76
	OG	9.23	39.51	63.41	3.22	2.48	12.53
	OG+BFT	13.97	36.67	56.86	2.74	2.67	12.66
	PR	8.79	35.45	55.26	2.89	2.64	13.30
	PR+BFT	16.48	33.18	45.80	2.10	2.70	11.88
	TF	8.12	40.02	61.24	2.27	2.38	15.03
	TF+BFT	13.54	36.29	54.82	2.18	2.47	14.92
	TMR	14.54	30.54	41.44	2.88	2.32	8.74
	MONO	8.91	39.55	60.74	2.74	2.49	13.07
	MIX	15.08	35.71	52.79	2.30	2.62	12.80
70 - 105							
	MB	11.69	40.34	59.14	3.04	2.57	12.00
	MB+BFT	17.09	34.31	51.56	2.68	2.78	12.21
	OG	11.54	35.98	59.42	3.75	2.58	13.19
	OG+BFT	14.53	34.46	54.74	3.27	2.76	13.34
	PR	12.60	33.25	51.66	3.03	2.69	13.22
	PR+BFT	19.06	30.58	41.24	2.17	2.72	12.79
	TF	9.51	37.97	58.38	2.68	2.43	15.83
	TF+BFT	14.15	34.41	52.46	2.56	2.56	15.81
	TMR	13.40	32.45	43.36	2.42	2.28	8.11
	MONO	11.34	36.88	57.15	3.13	2.57	13.56
	MIX	16.21	33.44	50.00	2.67	2.71	13.54
0 - 105							
	MB	10.06	41.09	61.1	2.63	2.59	11.26
	MB+BFT	15.77	36.29	54.16	2.31	2.75	11.07
	OG	9.73	37.53	61.13	3.23	2.58	12.27

OG+BFT	13.55	36.04	56.25	2.78	2.75	12.07
PR	9.85	33.13	51.56	2.82	2.78	12.68
PR+BFT	17.3	31.28	43.15	2.15	2.85	11.62
TF	8.72	38.24	58.91	2.35	2.48	14.75
TF+BFT	14.69	33.59	49.90	2.31	2.59	13.64
TMR	14.08	30.14	40.88	2.78	2.33	8.6
MONO	9.6	37.5	58.17	2.76	2.61	12.74
MIX	15.33	34.3	50.87	2.39	2.74	12.1

[1]Treatments include: Meadow Bromegrass (MB), Meadow Bromegrass + Birdsfoot Trefoil (BFT) (MB+BFT) Orchard Grass (OG), Orchard Grass + BFT (OG+BFT), Perennial Ryegrass (PR), Perennial Ryegrass + BFT (PR+BFT), *AU*total mixed ration (TMR), average of all monoculture grass pastures (MONO), and average of all grass + BFT mixed pastures (MIX). The TMR confinefement control was only used in the study during years 2017 and 2018. The TMR composition (DM basis) for 2017 was: 45% alfalfa haylage, 19% corn silage, 18% flaked corn grain, 9% beet pulp shreds, and 9% wheat straw. The composition for the TMR in 2018 (DM basis) was: 46% corn silage, 27% flaked corn grain, 22% alfalfa hay, and 5% wheat straw. All treatments have n = 9, except TMR has n = 6.

[2]Crude Protein; [3]Acid Detergent Fiber; [4]Neutral Detergent Fiber (determined by amalayse); [5]Metabolizable Energy, calculated as total digestible nutrient x 0.04409 x 0.82 (NRC, 2001)

Table 2. Effect of different treatments on heifer body weights over the 105-d grazing period

	Weight (kg)[2]					
Treatments[1]	Day-0	Day-35	Day-70	Day-105	Gain	ADG
MB	199	208	229^{de}	251^{de}	52^{c}	0.50^{d}
MB+BFT	199	213	241^{abc}	262^{abc}	63^{b}	0.60^{c}
OG	194	212	231^{cde}	251^{de}	56^{c}	0.53^{d}
OG+BFT	198	215	238^{abcd}	262^{abc}	64^{b}	0.61^{bc}
PR	198	215	236^{bcd}	251^{cd}	53^{c}	0.51^{d}
PR+BFT	195	217	243^{ab}	265^{ab}	71^{a}	0.67^{a}
TF	199	210	223^{e}	240^{e}	41^{d}	0.39^{e}
TF+BFT	198	217	238^{bcd}	255^{bcd}	57^{c}	0.54^{d}
TMR	202	225	250^{a}	271^{a}	70^{ab}	0.67^{ab}
SEM	9.4	9.5	12.1	10.9	0.1	0.03
Treatment*Day[3]				$P < 0.01$	-	-
Treatment[3]				$P = 0.01$	$P < 0.01$	$P < 0.01$
Day[3]				$P < 0.01$	-	-

[1]Treatments include: Meadow Bromegrass (MB), Meadow Bromegrass + Birdsfoot Trefoil (BFT) (MB+BFT) Orchard Grass (OG), Orchard Grass + BFT (OG+BFT), Perennial Ryegrass (PR), Perennial Ryegrass + BFT (PR+BFT), and total mixed ration (TMR). The confinement control was only used in the study during years 2017 and 2018. The TMR composition (DM basis) for 2017 was: 45% alfalfa haylage, 19% corn silage, 18% flaked corn grain, 9% beet pulp shreds, and 9% wheat straw. The composition for the TMR in 2018 (DM basis) was: 46% corn silage, 27% flaked corn grain, 22% alfalfa hay, and 5% wheat straw. All treatments have n = 9, except TMR has n = 6.

[2]Values within columns represent the least square mean. Means within each column that have a different superscript represent differences ($P < 0.05$) between treatments within each time point. Those with treatment differences indicated by superscripts had an overall treatment effect of $P < 0.05$.

[3]P-values for Treatment*Day, Treatment, and Day when heifer body weights were analyzed over time with repeated measures.

Table 3. Effect of different pasture treatments and pasture types on heifer hip-height over the 105-d grazing period

	Hip-Height (cm)[5]				
Treatments[1]	Day-0	Day-35	Day-70	Day-105	Gain
MB	111.9	113.8	115.8	117.6	5.6
MB+BFT	111.5	114.3	115.9	118.4	7.0
OG	111.8	113.2	115.6	117.8	6.0
OG+BFT	112.2	113.6	116.1	118.1	5.9
PR	112.3	113.9	115.3	118.1	5.9
PR+BFT	111.9	114.1	116.3	118.2	6.3
TF	111.8	113.6	115.1	116.2	4.4
TF+BFT	112.5	114.4	116.8	118.2	5.7
TMR	112.7	114.9	117.7	119.0	6.2
SEM	1.9	1.7	1.9	1.3	1.0
Treatment*Day[3]				P = 0.65	-
Treatment[3]				P = 0.42	P = 0.08
Day[3]				P < 0.01	-
Pasture Types[2]					
Mix	112.0	114.1	116.3	118.2	6.2^{a}
Mono	111.9	113.6	115.4	117.5	5.5^{b}
SEM	1.8	1.7	1.9	1.3	0.9
Pasture Type*Day[4]				P = 0.61	-
Pasture Type[4]				P = 0.16	P = 0.05
Day[4]				P < 0.01	-

[1]Treatments include: Meadow Bromegrass (MB), Meadow Bromegrass + Birdsfoot Trefoil (BFT) (MB+BFT) Orchard Grass (OG), Orchard Grass + BFT (OG+BFT), Perennial Ryegrass (PR), Perennial Ryegrass + BFT (PR+BFT), and total mixed ration (TMR). The confinement control was only used in the study during years 2017 and 2018. The TMR composition (DM basis) for 2017 was: 45% alfalfa haylage, 19% corn silage, 18% flaked corn grain, 9% beet pulp shreds, and 9% wheat straw. The composition for the TMR in 2018 (DM basis) was: 46% corn silage, 27% flaked corn grain, 22% alfalfa hay, and 5% wheat straw. All treatments have n = 9, except TMR has n = 6.

[2]Pasture types include: Pastures with BFT (Mix) and pastures without BFT (Mono). Both mixed pastures and monoculture pastures have n = 36.

[3]P-values for Treatment*Day, Treatment, and Day when heifer hip-heights were analyzed over time with repeated measures.

[4]P-values for Pasture Type*Day, Pasture Type, and Day when heifer hip-heights were analyzed over time with repeated measures.

[5]Values within columns represent the least square mean. Means within each column that have a different superscript represent differences (P < 0.05) between treatments within each time point. Those with treatment differences indicated by superscripts had an overall treatment effect of P < 0.05.

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Table 4. Effect of different pasture treatments on heifer blood urea nitrogen (BUN) concentrations over the 105-d grazing period

	Blood Urea Nitrogen (mg/dL)[2]			
[1]Treatments	Day-0	Day-35	Day-70	Day-105
MB	12.3	9.9^{c}	10.3^{d}	11.6^{de}
MB+BFT	12.1	13.2^{ab}	14.7^{ab}	16.3^{a}
OG	13.6	11.5^{bc}	13.1^{bc}	14.7^{abc}
OG+BFT	12.3	14.4^{a}	16.0^{a}	14.9^{abc}
PR	13.2	11.3^{bc}	10.5^{cd}	13.1^{cd}
PR+BFT	12.7	15.4^{a}	16.1^{a}	15.8^{ab}
TF	13.7	10.1^{c}	9.7^{d}	10.2^{e}
TF+BFT	12.9	13.4^{ab}	13.1^{bc}	13.2^{cd}
TMR	12.6	15.4^{a}	14.9^{ab}	13.3^{bcd}
SEM	2.2	1.4	1.7	1.1
Treatment*Day[3]				$P = 0.12$
Treatment[3]				$P < 0.01$
Day[3]				$P = 0.32$

[1]Treatments include: Meadow Bromegrass (MB), Meadow Bromegrass + Birdsfoot Trefoil (BFT) (MB+BFT) Orchard Grass (OG), Orchard Grass + BFT (OG+BFT), Perennial Ryegrass (PR), Perennial Ryegrass + BFT (PR+BFT), and total mixed ration (TMR). The confinement control was only used in the study during years 2017 and 2018. The TMR composition (DM basis) for 2017 was: 45% alfalfa haylage, 19% corn silage, 18% flaked corn grain, 9% beet pulp shreds, and 9% wheat straw. The composition for the TMR in 2018 (DM basis) was: 46% corn silage, 27% flaked corn grain, 22% alfalfa hay, and 5% wheat straw. All treatments have n = 9, except TMR has n = 6.

[2]Values within columns represent the least square mean. Means within each column that have a different superscript represent differences ($P < 0.05$) between treatments within each time point. Those with treatment differences indicated by superscripts had an overall treatment effect of $P < 0.05$.

[3]P-values for Treatment*Day, Treatment, and Day when heifer blood urea nitrogen concentrations were analyzed over time with repeated measures.

Table 5. Effect of different pasture treatments on heifer Insulin-like Growth Factor-1 (IGF-1) concentrations over the 105-d grazing period

	Insulin-like Growth Factor-1 (ng/mL)[5]			
Treatments[1]	Day-0	Day-35	Day-70	Day-105
MB	150.9	136.1^{bc}	149.3^{bc}	178.3^{ab}
MB+BFT	153.1	151.1^{b}	148.4^{bc}	172.3^{ab}
OG	157.4	138.2^{bc}	159.5^{ab}	184.8^{a}
OG+BFT	158.3	148.6^{b}	146.9^{bc}	159.3^{bc}
PR	146.3	137.2^{bc}	147.0^{bc}	163.2^{abc}
PR+BFT	149.7	153.3^{ab}	151.2^{b}	184.3^{a}
TF	164.4	121.9^{c}	139.5^{bc}	141.9^{c}
TF+BFT	147.0	141.6^{bc}	130.0^{c}	142.3^{c}
TMR	164.2	180.3^{a}	179.4^{a}	184.2^{ab}
SEM	15.3	24.7	33.6	25.5
Treatment*Day[3]				P = 0.23
Treatment[3]				P < 0.01
Day[3]				P < 0.01
Pasture Types[2]				
Mix	152.0	148.7	143.9	164.7
Mono	154.7	134.3	148.5	167.5
SEM	22.9	22.9	31.7	24.6
Pasture Type*Day[4]				P = 0.14
Pasture Type[4]				P = 0.87
Day[4]				P < 0.01

[1]Treatments include: Meadow Bromegrass (MB), Meadow Bromegrass + Birdsfoot Trefoil (BFT) (MB+BFT) Orchard Grass (OG), Orchard Grass + BFT (OG+BFT), Perennial Ryegrass (PR), Perennial Ryegrass + BFT (PR+BFT), and total mixed ration (TMR). The confinement control was only used in the study during years 2017 and 2018. The TMR composition (DM basis) for 2017 was: 45% alfalfa haylage, 19% corn silage, 18% flaked corn grain, 9% beet pulp shreds, and 9% wheat straw. The composition for the TMR in 2018 (DM basis) was: 46% corn silage, 27% flaked corn grain, 22% alfalfa hay, and 5% wheat straw. All treatments have n = 9, except TMR has n = 6.

[2]Pasture types include: Pastures with BFT (Mix) and pastures without BFT (Mono). Both mixed pastures and monoculture pastures have n = 36.

[3]P-values for Treatment*Day, Treatment, and Day when heifer hip-heights were analyzed over time with repeated measures.

[4]P-values for Pasture Type*Day, Pasture Type, and Day when heifer hip-heights were analyzed over time with repeated measures.

[5]Values within columns represent the least square mean. Means within each column that have a different superscript represent differences (P < 0.05) between treatments within each time point. Those with treatment differences indicated by superscripts had an overall treatment effect of P < 0.05.

Table 6. The effect of sampling day on heifer body weights (BW), hip-heights, blood urea nitrogen (BUN) concentrations, and Insulin-like Growth Factor-1 (IGF-1) concentrations over the 105-d grazing period

	Sampling Day[2]					
Variable[1]	Day 0	Day 35	Day 70	Day 105	SEM	Day Effect[3]
BW	198^{d}	215^{c}	236^{b}	257^{a}	10	$P < 0.01$
Hip-Height	112.0^{d}	114.0^{c}	116.0^{b}	118.0^{a}	1.6	$P < 0.01$
BUN	13.0	12.7	13.0	13.7	0.5	$P = 0.32$
IGF-1	155.9^{b}	145.6^{b}	149.2^{bc}	168.1^{a}	22.5	$P < 0.01$

[1]Variables include heifer body weight (BW, kg), hip heights (cm), blood urea nitrogen (BUN, mg/dL), and Insulin-like Growth Factor-1 (IGF-1, ng/mL)

[2] Values within columns represent the least square mean. Means within each row that have a different superscript are different ($P < 0.05$) from one another.

[3]The effects of day when analyzed with repeated measures over the 105 d period

Table 7. Pasture treatment total establishment costs, annual net financial impact, payback period, and break-even organic premium

Treatment[1]	Total Establishment Cost[3]	Annual Net Financial Impact[4]	Payback Period (years)[5]	Breakeven Organic Premium[6]
MB + BFT	$1,923[c]	$26,246[a]	0.073[a]	-$37[c]
PR + BFT	$1,888[c]	$25,701[a]	0.073[a]	-$32[c]
TF + BFT	$2,021[bc]	$24,754[a]	0.082[a]	-$22[c]
OG + BFT	$2,325[a]	$24,583[a]	0.095[a]	-$20[c]
MB	$1,543[d]	$13,582[b]	0.128[a]	$90[b]
OG	$1,702[d]	$12,659[b]	0.151[a]	$99[b]
TF	$1,322[e]	$9,528[c]	0.153[a]	$130[b]
PR	$2,114[b]	$-843[d]	N/A	$234[a]
Pasture Types[2]				
MIX	$2,039[a]	$25,321[a]	0.081[a]	-$28[b]
MONO	$1,670[b]	$8,731[b]	0.171[b]	$137[a]

Note: Estimates are based on 100 animal units of replacement dairy heifers with d on feed for each treatment equal to the number of d estimated to reach the optimal breeding weight of 250 kg plus 30 additional d to allow for pregnancy testing and sale as either short bred heifer or open heifer.

[1]Treatments include: Meadow Bromegrass (MB), Meadow Bromegrass + BFT (MB+BFT) Orchard Grass (OG), Orchard Grass + BFT (OG+BFT), Perennial Ryegrass (PR), Perennial Ryegrass + BFT (PR+BFT), total mixed ration (TMR). All treatments have n = 9, except TMR has n = 6.

[2]Pasture types include: Pastures with BFT (Mix) and pastures without BFT (Mono). Both mixed pastures and monoculture pastures have n = 36.

[3]The total establishment costs for each pasture treatment are considered the initial cost of investment into the pasture treatments and are equal to the combined planting and seed costs ($/ha) for each treatment multiplied by the total amount of hectares needed to produce the required forage. The required forage is the amount necessary for the DOF of each treatment to allow the 100 AUs to reach the target breeding weight of 250 kg, have pregnancy tests administered, and be sold as short bred or open heifers.

[4]The annual net financial impact is the sum of the positive and negative changes within the partial budget of each pasture treatment.

[5]The payback period is calculated as the pasture treatment total establishment cost divided by the annual net financial impact. A "N/A" payback period indicates that the investment is expected to have a negative payback period indicating it would never be expected to pay off.

[6]Break-even organic premium is the premium ($/head) required on organic dairy heifers for the annual net financial impact of a pasture treatment to be equal to $0.

[3,4,5,6]Values within each column that have a different superscript are different ($P < 0.05$) from one another. Those with treatment differences indicated by superscripts had an overall treatment effect of $P < 0.05$.

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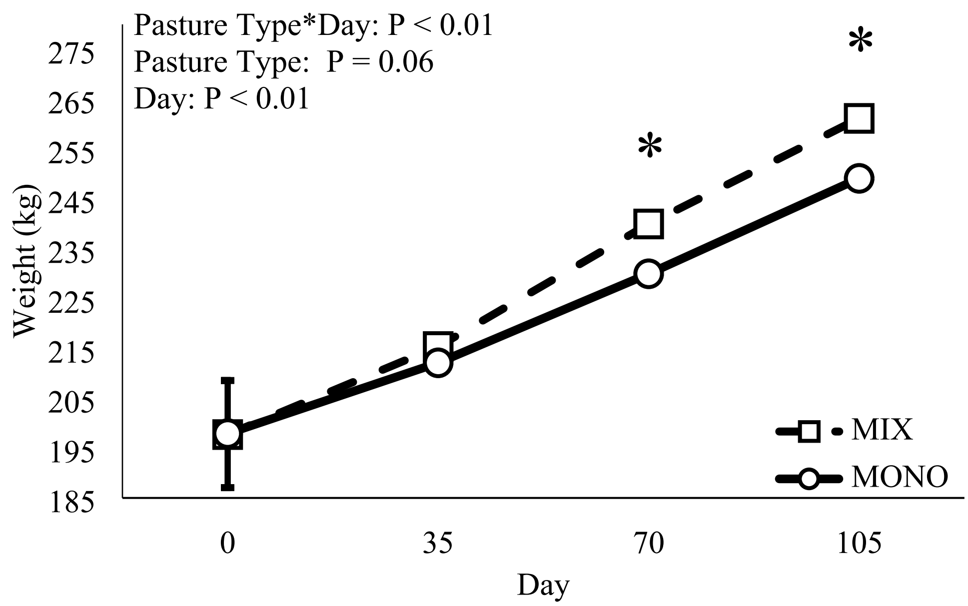

Figure 1. These data represent growth of Jersey heifers grazed in 2016, 2017 or 2018. A total of 192 heifers were used over the three-year period with two heifers per block in year 2016 and three heifers per pasture in 2017 and 2018. Each block of heifers serves as the experimental unit with treatments being either grass only pastures (MONO, n = 36) or grass interseeded with Birdsfoot Trefoil (MIX, n = 36). Weights were collected every 35 d over a 105 d period and analyzed to show the effects of pasture type*day, pasture type, and day. Differences (P < 0.05) between pasture types within each time point are indicated with a *.

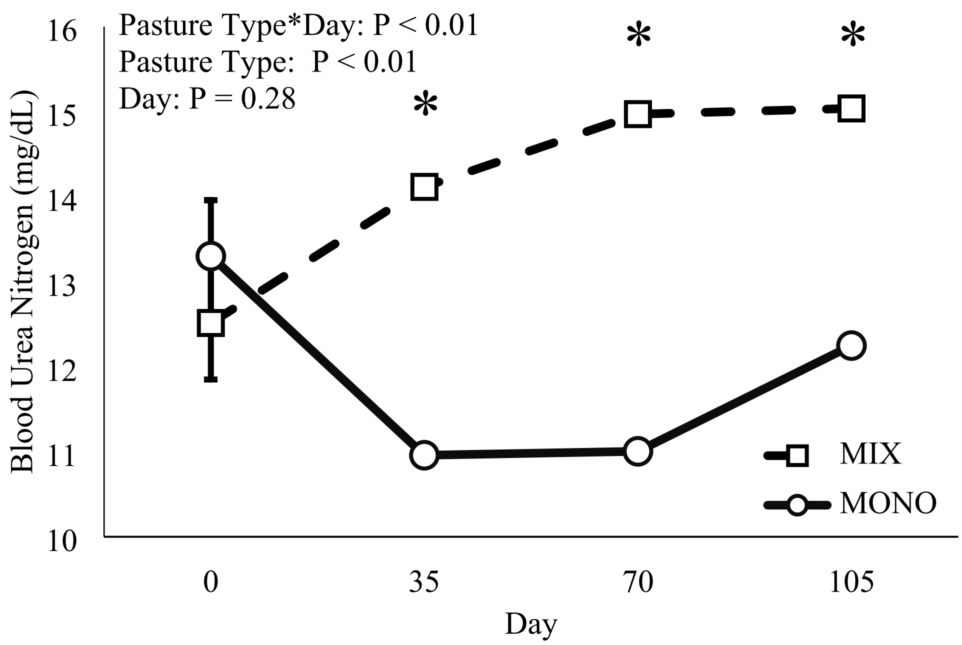

Figure 2. These data represent blood urea nitrogen concentrations of Jersey heifers grazed in 2016, 2017 or 2018. A total of 192 heifers were used over the three-year period with two heifers per block in year 2016 and three heifers per pasture in 2017 and 2018. Each block of heifers serves as the experimental unit with treatments being either grass only pastures (MONO, n = 36) or grass interseeded with Birdsfoot Trefoil (MIX, n = 36). Blood samples were collected every 35 d over a 105 d period and were quantified and analyzed to show the effects that pasture type*day, pasture type, and day can have on heifer blood urea nitrogen concentrations. Differences ($P < 0.05$) between pasture types within each time point are indicated with a *.