Grain Yield and Beef Cow–Calf Growth Performance in Dual-Purpose and Conventional Grain Wheat Production Systems and Stockpiled Tall Fescue Pasturing

Annesly Netthisinghe 1,* 1, Hunter Galloway 2, Fred DeGraves 1, Getahun E. Agga 3, and Karamat Sistani 3

1 Department of Agriculture and Food Sciences, Western Kentucky University, Bowling Green, KY 42101, USA; fred.degraves@wku.edu
2 Hampton Meats Inc., Hopkinsville, KY 422403, USA; hgalloway@hamptonmeats.com
3 Food Animal Environmental Systems Research Unit, USDA-ARS, Bowling Green, KY 42101, USA; getahun.agga@usda.gov (G.E.A.); karamat.sistani@usda.gov (K.S.)

* Correspondence: annesly.netthisinghe@wku.edu

Received: 24 July 2020; Accepted: 5 October 2020; Published: 10 October 2020

Abstract: Dual purpose wheat (Triticum aestivum L.) can be used for cattle grazing while producing grain from the same crop. In a two-year study, wheat forage production, grain yield, and growth performance of beef cow–calf pairs grazed on wheat pasture for 2–3 weeks in spring was compared with the conventional wheat grain production system and stockpiled tall fescue (Festuca arundinacea (L.) Schreb) pasturing. Grazing wheat resulted in grain yield (4.1 vs. 4.6 t ha$^{-1}$) and test weight (65.9 vs. 66.7 kg hL$^{-1}$) similar to the conventional grain production system. Wheat accumulated significantly lower forage dry matter yield (0.9 vs. 1.9 t ha$^{-1}$) in spring with higher crude protein (190.2–290.2 vs. 122.0–151.0 g kg$^{-1}$) and low fiber contents compared to the stockpiled tall fescue pasture. Wheat pasture presented risk for the development of grass tetany with regard to N, K, Na, and Mg contents. Calves grazed on wheat gained 1143–1370 g d$^{-1}$ body weight compared to the 826–879 g d$^{-1}$ in the stockpiled tall fescue pasturing. Cows had inconsistent and mixed body weight change response. With warmer temperatures and adequate precipitation controlled grazing of wheat in spring by beef cow–calf pairs offered weight gain benefits exceeding the stockpiled tall fescue pasturing and grain production similar to the conventional wheat grain system.

Keywords: wheat; tall fescue; beef cow–calf; grazing; grain yield; body weight gain

1. Introduction

Wheat (Triticum aestivum L.) can have a dual use as a forage for livestock grazing and produces grains from the same crop [1,2]. Wheat provides a high quality forage for livestock grazing [3,4]. Thus, a dual use of wheat can generate unique economic benefits both for grain production and the added value of body weight gain of pastured cattle. In general, wheat pastures have high moisture levels, soluble constituents, and crude protein (CP) concentrations exceeding 30% of dry matter (DM). The low fiber content of wheat forage may limit the ability to provide daily dry matter requirement for cattle (Bos taurus L.). However, with the influence of plant maturity, wheat forage harvested in the spring can have low CP concentration and high fiber contents [5] that are suitable for cattle grazing. Early jointing stage of wheat growth is defined as the time point at which the first growing points anywhere in a plot were elevated above ground level [6]. Several studies reported that winter wheat pasturing beyond the joint growth stage severely reduced wheat grain yield, on the other hand grazing succulent growth
prior to early joint stage had no to little effect on the subsequent wheat grain yield [7–9]. However, Christiansen et al. [10] reported that although light spring grazing of winter wheat did not affect the grain yield, straw yield decreased due to reduced plant height. Grazing wheat by stocker cattle is common practice in the Southern high plains of the U.S. [9]. It was estimated that 30–80% of the eight million hectares seeded annually to wheat in the U.S. Southern plains are grazed by livestock [11].

Tall fescue (*Festuca arundinacea* (L.) Schreb) is a well-adapted cool-season perennial grass in the southern United States [12]. Stockpiling or deferred grazing is a process of accumulating forage in situ for later grazing. Stockpiling tall fescue in the late summer or early fall is generally aimed to provide forage requirement for grazing cattle in the following fall and spring season when forage availability is limited. Both stockpiled tall fescue and wheat grazing synchronized with pre joint growth stage can serve as important feed sources for cattle spring grazing. Compared to the wheat grain production, grazing wheat has extra benefit of grain production and ability to lower economic risks. Understanding wheat forage quality characteristics in the spring, grain yield, and beef cow–calf growth performance of dual-purpose wheat crop in comparison to the stockpiled tall fescue pasturing and conventional wheat grain production system can help producers realize the benefits of crop-livestock mixed production and provides the opportunity to diversify wheat grazing options beyond the common stocker grazing. Studies evaluating the growth performance of beef cow–calf grazing operations on dual-purpose wheat system compared to conventional wheat grain production system and tall fescue pasturing are scare. The specific objectives of this experiment were (1) to compare the grain production and grain quality between dual-purpose wheat and conventional wheat grain production systems; (2) to examine wheat pasture production and quality characteristics in spring compared to stockpiled tall fescue pasture; and (3) to evaluate growth performance of beef cow–calves grazed on dual-purpose wheat and stockpiled tall fescue pasture fields.

2. Materials and Methods

This experiment was conducted at Western Kentucky University Agriculture Research and Education Complex, Bowling Green, KY (36°05′42″ N, 86°02′6″ W) during 2016–2017 and 2017–2018 seasons (hereafter referred to as 2017 and 2018) on Crider silt loam (fine-silty, mixed, active, mesic Typic Paleudalf) soil.

2.1. Field Management

Nine experimental field units, each with of 1.2 ha extent, were used for this experiment. The field had been used for hay production for three years prior to the experiment. Each year prior to initiating the experiment, the tall fescue pasture stand was harvested 2–3 times for hay production until stockpiling in September. Three tall fescue experimental fields randomly selected from the original establishment were used as tall fescue grazing experimental units. The tall fescue fields were fertilized with 87 kg N ha⁻¹ and P₂O₅ and K₂O as required by soil test in February and again with 43–43–32 kg ha⁻¹ N-P₂O₅-K₂O in September. After killing the tall fescue grass, the other six fields were seeded (50 kg ha⁻¹) with soft red winter wheat cultivar “Branson” in November 2016 and 2017. In February, the wheat fields received 54 kg N ha⁻¹. Three randomly selected wheat fields were used for the dual-purpose wheat treatment and the other three wheat fields were used for conventional wheat grain production treatment. In this way each grazing and grain production treatment was replicated three times. Due to the practical difficulty in developing infrastructure at multiple locations for grazing cattle, we combined three wheat grazing and three tall fescue fields and conducted beef cow–calf growth performance evaluation as an un-replicated experiment. Wester [13] and Hurlbert [14] indicated that un-replicated field experiments are resulted due to practical difficulties in replication but provide useful information to expand the current knowledge base and should be considered as guide for future replicated experiments. However, they stressed the importance of initial identical between the experimental fields to conduct un-replicated field experiments and the inferences from un-replicated field experiments should be confined only to the specific experimental fields and not for the entire population. The experimental
fields used for this study had a uniform management history as a single tall fescue field used for hay production for three consecutive years prior to the experiment. In addition, the experimental fields had similar (statistically non-significant) soil fertility status (Table 1) and environmental conditions (Figures 1 and 2) to ensure the initial identical field conditions for an un-replicated grazing treatment comparison for beef cow–calf growth performance.

Table 1. Initial soil properties of experimental fields in fall 2016 before establishment.

| Management system          | pH       | N          | P          | K          |
|----------------------------|----------|------------|------------|------------|
| Wheat dual-purpose         | 6        | 5.8 ± 0.3 a| 2.9 ± 0.0 a| 19.8 ± 5.0 a| 233 ± 13.8 a|
| Conventional wheat grain   | 6        | 5.8 ± 0.3 a| 2.8 ± 0.1 a| 19.8 ± 5.4 a| 232 ± 13.4.9 a|
| Tall fescue                | 6        | 5.9 ± 0.1 a| 2.9 ± 0.1 a| 19.9 ± 1.9 a| 232 ± 16.3 a|

† Mean ± SE. Numbers with letter a across management systems are significantly different at p < 0.05.

Figure 1. Average daily temperatures between 2016 and 2018 with 30-year average daily temperatures of the experimental site plotted by month.

The combined tall fescue and dual-purpose wheat pasture fields were used for cow–calf growth performance evaluation experiment (hereafter referred to as tall fescue and dual-purpose wheat pasture). The other three wheat planted fields were managed for grain production (hereafter referred to as conventional grain wheat). After the root system was well developed and wheat plants were at about 15 cm height, eight cow–calf pairs of Angus breed were introduced to the wheat grazing field in 2017 and 2018. Similarly, another eight cow–calf pairs with similar initial body weights were introduced to the stockpiled tall fescue grazing field. The initial body weights of the calves were 152 kg and 225 kg in 2017 and 2018, respectively. Similarly, the initial body weights of the cows were 415 kg and 580 kg in 2017 and 2018, respectively. Cow–calf grazing was started on 21 March 2017 (year 1), and 14 March 2018 (year 2) and grazing was terminated on 12 April 2017 (after 3 weeks), and on 28 March 2018 (after 2 weeks). The cold weather conditions in 2018 hampered early forage growth allowing a shorter grazing period than in 2017. Prior to grazing, wheat and tall fescue pasture samples were collected from six georeferenced locations across the two grazing fields. In both years,
grazing wheat was terminated before the first appearance of hollow stem of wheat above the crown as defined by Redmon et al. [9]. Tall fescue grazing by cow–calves was also terminated on the same days. The body weights of the cows and calves were recorded in the mornings (10:00 a.m.) at the beginning (day 0), at 1 week, and 2 weeks of grazing for both years. An additional body weight measurement was possible for the 2017 grazing after the 3 weeks. The two cow–calf groups were supplemented with a grain mixture at 0.6% body weight and a mineral mixture (22% salt, 2% Mg, 12% Ca, and 6% P) of free choice in 2017. Expecting a slower pasture growth under the cooler climate, the grain supplement was increased to 1% of body weight in 2018. The grain mixture provided in 2017 contained 11.7% crude protein (CP), 27% acid detergent fiber (ADF), and 28.2% neutral detergent fiber (NDF) and the mixture supplemented in in 2018 had 12.8% CP, 22.2% ADF, and 23.0% NDF.

![Figure 2](image)

**Figure 2.** Monthly precipitation of the experimental site for 2016–2018 period with 30-year average precipitation of the experimental site plotted by month.

### 2.2. Wheat Grain and Straw Production and Wheat and Tall Fescue Forage Production

Average wheat grain and wheat straw yields were estimated in June 2017 and 2018 by harvesting 1 m² areas at the two georeferenced locations marked within each experimental field. Grain yield was measured as weight of threshed and cleaned grain from the samples. Wheat grain test weights were recorded in duplicates collected from each 1.2 ha field. Wheat grain test weight was calculated by weighing the tare weight of 500 mL container filled with dry grain (12% moisture) and a test weight conversion chart was used for subsequent conversion (kg hL⁻¹). Wheat and tall fescue forage dry matter production and forage quality in the springs before grazing (in 2017 and 2018) and after grazing (only in 2017) were estimated by adopting the same procedure as described for wheat straw production estimation. Combined wheat straw, tall fescue, and wheat pasture samples from each field were dried at 60 °C until constant dry weight to determine dry matter production. Sub samples of dried composite wheat straw and pasture samples were ground to pass through a 1 mm screen before subjecting to composition analysis. Crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), and forage mineral concentrations were determined by Near Infrared Spectrometer (Technicon InfraAlyser 500, Bran+Luebbe Analyzing Technologies, Buffalo Grove, IL, USA) over wavelength range of 1100–2500 nm with 2 nm steps. Wet analysis data were used to develop prediction equations for NIR. Wheat grain CP, crude fat and starch contents were also determined by NIR on ground grain
samples at 1100–2500 nm. The weekly body weights of the cow-calves were recorded by a weighbridge (For-Most 30, Hawarden, IA, USA).

2.3. Initial Soil Fertility Characterization

Initial soil sampling was performed in fall 2016 prior to experimental setup. Each experimental field was marked with two geo-referenced locations for soil sampling. Fifteen soil samples were collected to 10 cm depth within 25 m radius of each geo-referenced location. Accordingly, the soil samples collected around the two geo-referenced locations represented 32% of the experimental field area. Each set of fifteen soil samples were combined to form a composite soil sample to represent each geo-referenced location. Soil data for each experimental plot was originated from the two composite samples of the two geo-referenced locations. Soil information derived from the composite soil samples were used to describe initial soil fertility characteristics of each experimental field. The composite soil samples were air-dried and ground to pass a 2-mm screen sieve and analyzed for pH, total N, and Mehlich-3 (M-3) extractable P, and K. Soil pH was measured using a glass electrode with a 1:1 soil/water ratio. Mehlich-3 extractable P and K concentrations were determined by emission spectroscopy on an inductively coupled spectrophotometer (Vista Pro Varian Analytical Instruments, Walnut Creek, CA, USA). Total soil N content was determined by high-temperature combustion in a Vario MAX C-N analyzer (Elementar Americas Inc., Mt. Laurel, NJ, USA) using a 2-g soil sample.

2.4. Statistical Analysis

Wheat grain and straw production, wheat, and tall fescue pasture production, and forage quality data were analyzed as $2 \times 2$ analysis of variance (ANOVA) model using the generalized linear model (GLM) procedure (SPSS.25; IBM Corporation, Armonk, NY, USA, 2018). Wheat management system (dual-purpose vs. conventional wheat grain production) or grazing pasture types (tall fescue vs. dual-purpose wheat) and year of study (2017 and 2018) were considered as two factors in the model. When wheat management system $\times$ year or grazing pasture type $\times$ year interaction effects were significant, wheat management system or grazing pasture type effects were analyzed separately for each year. Otherwise two-year averages of wheat management systems or grazing pasture type were compared by Student’s $t$ test ($p < 0.05$). Graybill [15] noted that sampling error within an un-replicated large experimental unit can be used to compare treatment effects and it is a statistically valid process. Accordingly, we restricted our inferences about cow–calf growth performance evaluation (comparison of grazing treatment effects) to the two specific combined grazing fields. Given the similar initial soil fertility in the tall fescue and dual-purpose wheat grazing fields (Table 1) and similar management history of the two fields, we considered any growth performance difference between the two cow–calf groups was attributed to the grazing pasture type effect [14]. Variation among cow–calf pairs within tall fescue and dual-purpose wheat fields was considered as variation inherent in each field and Student’s $t$ test was used to compare mean body weight gain difference between two pastures [13,14]. Within each group, there were eight cow–calf pairs that represented a unit of analysis. The cow–calf growth performance analysis was performed separately for the two years.

3. Results

3.1. Environmental Conditions

The environmental conditions at the experimental site varied during winter and spring seasons over the two–year study period. Daily temperatures (Naturally Aspirated Air Temperature; Vaisala HPM60 Temperature Probe) averaged above normal throughout winter and spring seasons in 2017, but temperatures were sub-normal in 2018 (Figure 1). Compared to 2018, there were warmer temperatures in 2017. Rainfall (Vaisala VRG101 All Weather Precipitation Gauge) varied from month to month and year to year, (Figure 2) with above normal precipitation during May–June periods. Overall, there was 132 mm precipitation surplus in the spring of 2017 compared to the 354 mm precipitation
occurred in 2018 which was equivalent to the long-term (30-year) average condition. The initial soil fertility as described by pH, N, P, and K levels between the wheat and tall fescue fields indicated similar soil fertility status with no significant difference among them (Table 1).

### 3.2. Wheat Grain and Straw Production and Quality

There was no interaction between wheat management system year for wheat grain yield and test weight. The grain yield and test weight were similar between the two-wheat management systems but were significantly different between the two years. In 2017, there was 55% (1.9 t ha⁻¹) higher wheat grain production compared to the 2018. Grain production and test weight in the two wheat management systems ranged 4.1–4.6 t ha⁻¹ and 65.9–66.7 kg hl⁻¹, respectively. The wheat grain test weight in 2017 was 6.5 kg hl⁻¹ higher than 2018. Grain quality data are available only for the 2018 experiment. There was significant wheat management system effect on CP, but the wheat grain starch and crude fat contents were not affected by the wheat management system (Table 2). The grain crude protein content was significantly higher in the grain wheat system than the dual-purpose wheat system.

### Table 2. Wheat grain and straw production and quality of dual-purpose and grain production management systems in 2017 and 2018.

| Management System          | System | n  | 2017       | 2018       | Average       |
|----------------------------|--------|----|------------|------------|---------------|
| Grain yield                |        |    |            |            |               |
| Dual-purpose               | 6      |    | 4.9 ± 0.4  | 3.3 ± 0.3  | 4.1 ± 0.3 a   |
| Conventional grain         | 6      |    | 5.6 ± 0.3  | 3.5 ± 0.1  | 4.6 ± 0.3 a   |
| Year average               | 12     |    | 5.3 ± 0.2 a| 3.4 ± 0.1 b|               |
| Grain test weight          |        |    |            |            |               |
| Dual-purpose               | 6      |    | 69.2 ± 0.5 | 62.7 ± 0.3 | 65.9 ± 1.0 a  |
| Conventional grain         | 6      |    | 70.1 ± 0.2 | 63.4 ± 0.3 | 66.7 ± 0.2 a  |
| Year. average              | 12     |    | 69.6 ± 0.3 a| 63.1 ± 0.2 b|               |
| Grain crude protein        |        |    |            |            |               |
| Dual-purpose               | 6      |    | -          | 144 ± 1.7 a|               |
| Conventional grain         | 6      |    | -          | 157 ± 3.4 b|               |
| Grain starch               |        |    |            |            |               |
| Dual-purpose               | 6      |    | -          | 671 ± 4.1 a|               |
| Conventional grain         | 6      |    | -          | 668 ± 5.4 a|               |
| Grain crude fat            |        |    |            |            |               |
| Dual-purpose               | 6      |    | -          | 18.5 ± 0.3 a|              |
| Conventional grain         | 6      |    | -          | 18.6 ± 1.3 a|              |
| Year average               | 12     |    | 18.4 ± 0.2 b| 18.1 ± 1.3 a|              |
| Straw yield                |        |    |            |            |               |
| Dual-purpose               | 6      |    | 3.0 ± 0.1  | 2.7 ± 0.2  | 2.8 ± 0.1 a   |
| Conventional grain         | 6      |    | 3.5 ± 0.0  | 3.3 ± 0.2  | 3.4 ± 0.2 b   |
| Year average               | 12     |    | 3.2 ± 0.1 a| 3.0 ± 0.2 a|               |
| Straw crude protein        |        |    |            |            |               |
| Dual-purpose               | 6      |    | 60.6 ± 4.9 a| 50.0 ± 1.7 a|              |
| Conventional grain         | 6      |    | 52.2 ± 1.6 a| 54.3 ± 2.3 a|              |
| Straw ADF                  |        |    |            |            |               |
| Dual-purpose               | 6      |    | 522 ± 13.6 | 535 ± 7.8  | 528 ± 4.8 a   |
| Conventional grain         | 6      |    | 511 ± 14.5 | 510 ± 10.6 | 511 ± 3.3 b   |
| Year average               | 12     |    | 517 ± 5.1 a| 523 ± 4.5 a|               |
| Straw NDF                  |        |    |            |            |               |
| Dual-purpose               | 3      |    | 745 ± 13.2 a| 748 ± 1.6 a|               |
| Conventional grain         | 3      |    | 755 ± 2.7 a| 747 ± 5.2 a|               |

† Mean ± SE; Numbers with different letters within a management system average column for parameters are significantly different at p < 0.05. Numbers with different letters within year average rows for parameters are significantly different at p < 0.05. Numbers with different letters within each year for parameters of two management systems are significantly different at p < 0.05.

Wheat crop management system by year interaction was not significant for the straw yield and ADF content of wheat straw. The dual-purpose wheat system produced significantly lower straw yield compared to the conventional wheat grain production system. There was 21% less wheat straw yield in the dual-purpose wheat system. However, wheat straw from the dual-purpose wheat system contained
17.6 g kg\(^{-1}\) higher ADF content compared to the conventional wheat grain system. The wheat crop management system or year did not affect wheat straw CP and NDF contents.

3.3. Forage Production and Quality

There was no significant pasture type (tall fescue/dual-purpose wheat) \(\times\) year interaction effect on forage DM yield. Both pasture type and year effects were significant on forage DM yield. On average stockpiled tall fescue pasture accumulated an extra 1.0 t ha\(^{-1}\) DM yield for the spring grazing than wheat pasture. Irrespective of the pasture type, in 2017 there was 1.1 t ha\(^{-1}\) higher DM production than in 2018. Pasture type by year interaction was significant for forage DM content, CP, ADF, NDF, and all minerals except Zn (Table 3). Tall fescue pasture contained comparatively higher DM content than the wheat pasture for both years. However, wheat pasture contained significantly higher CP than tall fescue pasture. Forage structural carbohydrates, ADF and NDF contents between the two pasture types were significantly different in 2017 but were similar in 2018. In 2017, the wheat pasture contained 58% and 78% lower ADF and NDF than the tall fescue, respectively. Pasture type effect on forage P and Ca content was significant in 2017 and wheat forage contained 95% higher P and 41% lower Ca compared to tall fescue pasture. Potassium concentration in wheat pasture was 2–4 times higher than the tall fescue pasture during the two-year period. Both pasture types contained similar concentrations of Mg content that ranged between 1.3–1.4 g kg\(^{-1}\). The two pasture types also had similar concentrations of Na, but in lower concentrations. Compared to the 2017, there was comparatively higher Na content in 2018. The two pastures contained similar forage Cu contents in 2017, but wheat pasture had 1.5 times higher Cu content than tall fescue in 2018. Pasture type by year interaction was not significant for forage Zn content and tall fescue pasture reported significantly higher average Zn content compared to wheat pasture (43.6 vs. 30.1 mg kg\(^{-1}\)).

3.4. Cow–Calf Performance on Wheat and Tall Fescue Pastures

The cows and calves grazed on two pastures had different initial body weights in the two years. The cow–calf pairs used in 2017 weighed 415 and 152 kg, respectively compared to the 580 and 225 kg in 2018. In the two years, calves that grazed on wheat for 2 weeks in spring gained a significantly higher body weight compared to the calves that grazed on tall fescue filed (1143–1370 vs. 826–879 g d\(^{-1}\)). Calves had lower body weight gains in 2018 compared to 2017 (Table 4). With the extended 1 week grazing period (week 3 measurement) in 2017, calves that grazed on wheat pasture had a lower overall mean body weight gain (1236 g d\(^{-1}\)) compared to the first two weeks of grazing (week 2 measurement). Cows expressed a mixed (body weight gains and losses) response in daily body weight change during the two grazing seasons (data: S.8). As a result, there were highly variable daily body weight gains among the cows with no ADG difference between the two grazing groups.

**Table 3.** Forage dry matter (DM) yield and quality of wheat and stockpiled tall fescue pastures before grazing in 2017 and 2018 and after grazing in 2017.

| Pasture Type               | Pre Grazing | After Grazing | Pre Grazing | Average |
|----------------------------|-------------|---------------|-------------|---------|
| DM yield                   |             |               |             |         |
| Dual-purpose wheat         | 6           | 1.3 ± 0.1     | 0.4 ± 0.1   | 0.9 ± 0.1 a |
| Tall fescue                | 6           | 2.6 ± 0.2     | 1.2 ± 0.1   | 1.9 ± 0.3 b |
| Year average               | 12          | 1.9 ± 0.2 a   | 0.8 ± 0.1 b |         |
| DM content                 |             |               |             |         |
| Dual-purpose wheat         | 6           | 188 ± 6.4 a   | 241 ± 13.1 a|         |
| Tall fescue                | 6           | 688 ± 35.9 b  | 606 ± 45.7 b|         |
| CP                         |             |               |             |         |
| Dual-purpose wheat         | 6           | 290 ± 12.3 a  | 198 ± 6.2 a | 190 ± 11.6 a |
| Tall fescue                | 6           | 122 ± 6.6 b   | 115 ± 0.6 b | 151 ± 5.9 b |
| ADF                        |             |               |             |         |
| Dual-purpose wheat         | 6           | 272 ± 6.1 a   | 293 ± 18.5 a| 336 ± 24.4 a |
| Tall fescue                | 6           | 429 ± 6.1 b   | 452 ± 1.0 b | 331 ± 10.6 a |
Table 3. Cont.

| Pasture Type     | 2017 Pre Grazing | 2017 After Grazing | 2018 Pre Grazing | 2018 After Grazing | Average Pre Grazing | Average After Grazing |
|------------------|------------------|--------------------|------------------|--------------------|---------------------|-----------------------|
|                  | NDF              |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 361 ± 8.0 a      | 482 ± 30.7 a       | 479 ± 21.2 a        |                       |
|                 | Tall fescue      | 6                  | 646 ± 4.9 b      | 676 ± 1.7 b        | 518 ± 17.7 a        |                       |
|                 | P                |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 4.3 ± 0.2 a      | -                  | 2.5 ± 0.4 a         |                       |
|                 | Tall fescue      | 6                  | 2.2 ± 0.1 b      | -                  | 2.7 ± 0.1 a         |                       |
|                 | K                |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 36.6 ± 0.5 a     | -                  | 23.0 ± 2.9 a        |                       |
|                 | Tall fescue      | 6                  | 8.2 ± 1.3 b      | -                  | 13.4 ± 1.2 b        |                       |
|                 | Ca               |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 3.6 ± 0.1 a      | -                  | 5.9 ± 0.7 a         |                       |
|                 | Tall fescue      | 6                  | 5.1 ± 0.1 b      | -                  | 4.4 ± 0.2 a         |                       |
|                 | Mg               |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 1.4 ± 0.1 a      | -                  | 1.3 ± 0.1 a         |                       |
|                 | Tall fescue      | 6                  | 1.7 ± 0.1 a      | -                  | 1.3 ± 0.1 a         |                       |
|                 | Na               |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 0.05 ± 0.01 a    | -                  | 0.1 ± 0.0 a         |                       |
|                 | Tall fescue      | 6                  | 0.04 ± 0.01 a    | -                  | 0.1 ± 0.0 a         |                       |
|                 | Cu               |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 7.2 ± 1.0 a      | -                  | 10.0 ± 0.4 a        |                       |
|                 | Tall fescue      | 6                  | 6.6 ± 0.2 a      | -                  | 6.7 ± 0.3 b         |                       |
|                 | Zn               |                    |                  |                    |                     |                       |
|                 | Dual-purpose wheat | 6                  | 34.8 ± 2.0       | -                  | 25.3 ± 1.5          | 30.1 ± 1.8 a          |
|                 | Tall fescue      | 6                  | 50.8 ± 3.3       | -                  | 36.3 ± 2.9          | 43.6 ± 3.0 b          |

† Mean ± SE. Numbers with different letters within pasture type average column for parameters are significantly different at p < 0.05. Numbers with different letters within year average rows for parameters are significantly different at p < 0.05. Numbers with different letters within each year for parameters of two pasture types are significantly different at p < 0.05.

Table 4. Initial body weights at grazing, average daily body weight gain (ADG) of cows and calves grazed on dual-purpose wheat and stockpiled tall fescue pastures in spring 2017 and 2018.

| Pasture Type     | 2017 | 2018 |
|------------------|------|------|
|                  | Calves                   | Cows                       |
| Body weight (kg) on day 0 | 8   | 8    |
| ADG: 0–2 Week average |      |      |
| Dual-purpose wheat | 1370 ± 72.9 a | 1143 ± 90.2 a |
| Tall fescue      | 879 ± 110.5 b | 826 ± 86.2 b   |
| ADG: 0–3 Week average |      |      |
| Dual-purpose wheat | 1236 ± 57.1 a | -            |
| Tall fescue      | 895 ± 74.9 b | -            |
| Body weight (kg) on day 0 | 415 ± 24.1 | 580 ± 102    |
| ADG: 0–2 week average |      |      |
| Dual-purpose wheat | 275 ± 467.6 a | 1479 ± 273 a  |
| Tall fescue      | 117 ± 329.5 a | 1297 ± 183 a  |
| ADG: 0–3 week average |      |      |
| Dual-purpose wheat | 621 ± 354.0 a | -            |
| Tall fescue      | 24.2 ± 67.9 a | -            |

† Mean ± SE (sampling error). Numbers with different letters within 2017 and 2018 for the two pasture types are significantly different at p < 0.05.

4. Discussion

There is increased interest to use wheat crop for the dual-purpose of grazing and grain production. Grazing winter wheat in spring can cover the feed deficit attributed to the slow rates of pasture growth in the winter. Proper grazing of dual-purpose wheat crop can generate income from both grain production and the value that is added as weight gain to growing cattle that graze on winter wheat forage. Proper management of both crop and animal production enterprises is vital to maximize the
efficient use of resources. This two-year study examined grain production and beef cow–calf growth performance of grazing dual-purpose wheat crop for 2–3 weeks in spring as compared to the tall fescue pasturing and conventional wheat grain production system.

The grazing of wheat did not cause any significant reduction in grain yield, test weight, and grain composition (starch and crude fat) except the significant decrease in grain CP content. Previous research has shown that even though grazing reduces foliage yield and photosynthetic tissues of wheat plant, if soil moisture is adequate, grazing will have minimal effect on wheat grain yield [9]. The experimental site received 352 mm precipitation exceeding the 30-year normal (Figure 2 and Table S1), adequate for sustainable wheat grain production and beef cattle growth performance. The air temperature affected wheat plant growth and grain production considerably. As compared to the 2017, there was 35% grain yield reduction in the cooler temperature that dominated the 2018 season (Figures 1 and 2). This indicates a higher potential for grain production and animal growth performance of dual-purpose wheat management under warmer air temperature and adequate precipitation. The two wheat management systems produced higher grain yield than 2.7–3.8 t ha$^{-1}$ previously reported for wheat grain system [16], and 0.8–3.4 t ha$^{-1}$ produced by dual-purpose wheat grazed in fall and spring [17]. Wheat grain test weight measures the bulk density of grain and is an important grain production quality parameter that is associated with the grain filling process. Although grazing can have a negative effect on wheat grain test weight by affecting the delivery of photosynthates within the plant [18], the negative effect of grazing on grain test weight indicated by Trent et al. [19] and Bishnoi and Hughes [20] was not evident in this experiment. The grains harvested in the dual-purpose wheat had similar grain test weight as was in the un-grazed conventional wheat grain production system. Environmental factors, especially the air temperature appeared to affect wheat grain test weight as well. The warmer weather conditions in 2017 (Figure 1), facilitated translocation of photosynthate, promoted grain filling, and resulted in higher grain test weight compared to the 2018. The colder temperatures permitted wheat plants a slower recovery from grazing and caused slower grain filling and resulted low-test weight in 2018 than in 2017. The leaf area reduction by grazing of wheat has a negative effect on the redistribution of N to the grain [18]. With the limited N redistribution, there was a significant grain CP reduction in the dual-purpose wheat system. The grain CP results from this experiment exceeded 110–116 g kg$^{-1}$ reported for conventional wheat grain crop [16]. However, the effect of leaf area reduction by grazing on redistribution of photosynthate [18] was not detected with regards to the grain starch and crude fat contents. The two wheat management systems resulted in similar grain starch and crude fat contents.

Wheat straw is a useful resource for filling the forage bulk deficits of livestock. As grazing reduces the plant height and early growth removal by animal grazing can reduce the subsequent straw yield in the dual-purpose system [10,21]. Results from this study revealed that grazing at early joint stage of crop growth caused a 16% straw yield reduction compared to the un-grazed conventional wheat grain production system. Wheat straw had high NDF content, thus indicated that there was low soluble carbohydrates in the wheat straw for livestock feeding. The wheat management practice impacted the ADF content, but not the CP or NDF contents. The wheat straw had low quality characteristics than the wheat forage harvested in spring. Progression of wheat plant growth to grain harvesting stage reduced CP and increased ADF and NDF in the plant tissue compared to the concentrations were in the spring harvested forage. The quality of wheat straw (CP, ADF, and NDF) did not differ considerably with the diverse weather conditions in the two years. The two wheat management systems produced straw with similar quality characteristics, but larger volume in the conventional grain production system.

In comparing the forage biomass production being a perineal grass stockpiled in fall, tall fescue produced 1.9 t DM ha$^{-1}$ for spring grazing with an extra 1.0 t ha$^{-1}$ DM yield than produced by dual-purpose wheat crop planted in fall. On average wheat crop could produce only 50% of tall fescue DM yield for spring grazing. Observed estimate of forage biomass production in spring was comparable to the 0.9–1.4 t ha$^{-1}$ reported by Lyon et al. [22] for wheat crop harvested at joint stage of growth. Fribourg [23] reported that early harvesting of tall fescue pasture in January produced 1.0 t ha$^{-1}$ DM yield. The results from this experiment showed that with the favorable weather
conditions tall fescue could accumulate extra DM yield (0.9 t ha\(^{-1}\)) in spring harvest compared to the early harvesting in January. The colder weather conditions slowed plant growth rate in 2018 and significantly reduced DM accumulation (0.8 vs. 1.9 t ha\(^{-1}\)) in the two grazing pastures compared to the warmer temperature that dominated 2017. Thus, in the cooler growing seasons higher feed supplementation would be beneficial to sustain growth performances of beef cattle.

Forage quality plays an important role in beef cattle production. The CP, ADF, and NDF contents of forages have great influence on DM intake and digestibility. The higher CP concentrations facilitate better forage intake and low fiber (ADF and NDF) contents improve the digestibility of forages. Although the wheat crop accumulated comparatively lower DM yield than tall fescue for spring grazing, wheat forage had higher levels of CP and lower ADF, and NDF. Beef cattle grazing on wheat pasture in spring had chance of in taking larger bulk of highly digestible forage than obtained from the tall fescue grazing. Horn [3] and Poysa [24] indicated that wheat pasture harvested at early joint stage contained <300 g ADF kg\(^{-1}\), <500 g NDF, and 266 g CP kg DM\(^{-1}\), which were similar to the contents reported in this study. Being a perennial grass, delay in harvesting reduced CP content and digestibility of tall fescue forage [23,25]. Despite late harvesting, tall fescue grazed in March–April had better forage quality characteristics than the tall fescue forage harvested in January (20–90 g kg\(^{-1}\) CP, 300–340 g kg\(^{-1}\) ADF, and 620–710 g kg\(^{-1}\) NDF) [23]. We presume that the warmer temperatures in spring with abundant rainfall might have initiated lush tall fescue pasture growth in March–April and produced higher quality forage than early harvesting in January [23].

Mineral composition of wheat pasture is a major concern as it may lead to metabolic disorders, such as grass tetany and nitrate toxicity in grazing livestock [26–28]. Grass tetany is characterized by an abnormally low levels of Mg in the blood serum and is caused by excessive concentrations of K and deficiency of Na and Mg in the diets [29,30]. In addition, Na is important in neutralizing elevated levels of serum NO\(_3\), which could cause nitrate toxicity in livestock. Forage N and K concentrations > 30 g kg\(^{-1}\) and > 40 g kg\(^{-1}\) are considered unsafe with regards to the occurrence of grass tetany and NO\(_3\) toxicity [30]. After frosts and freezes there is a high risk of grass tetany because of increased K content and decreased Na uptake in the forages [31]. In general, forage Na content exceeding 2 g kg\(^{-1}\) is considered safe for preventing e grass tetany. The two pastures had high but safer levels of N and K, but both pastures failed to meet with the 2 g kg\(^{-1}\) Na concentration required for safe feeding. The recommended ratio for Ca and P is 2:1 for beef cattle production [32]. Only the forage produced in 2018 had a proper balance of Ca and P required for better performance of beef cattle. Both pastures contained <2 g kg\(^{-1}\) Mg. This study suggests the importance of supplementing mineral mixture containing adequate levels Ca, P, Mg, and Na to the beef cow–calves grazing wheat pasture. Although there could have been a risk of developing metabolic disorders in beef cattle grazing wheat pasture in spring, the mineral supplementation practiced during the study prevented the occurrence of such incidence. Concentration of various nutrients in plant tissues depends on soil fertility, type of fertilizer applied, temperature, and soil moisture levels [31]. The cold temperatures have shown decreasing N, K, and Ca concentration in wheat forage [32]. The results from this study showed that cold weather conditions (2018) lowered N, P, and K accumulation in the wheat pasture, but increased Na content. Except the Na, mineral concentrations in the tall fescue pasture remained consistent in the two years. The two pastures showed different micro-nutrient accumulation responses where wheat forages contained higher Cu, but Zn was enriched in the tall fescue pasture.

As the wheat pasture had higher quality characteristics, it was expected that beef cow–calves grazing wheat pasture to show better growth performances than the tall fescue pasturing. However, the results from this study indicated that only the calves responded to the grazing high-quality wheat pasture, but not the cows. Calves grazed on wheat pasture gained extra 36–55 kg (316–493 g hd\(^{-1}\) d\(^{-1}\); 10–15 kg ha\(^{-1}\)) body weight during the first 2 weeks of grazing than the tall fescue pasturing. Further, it was noted that wheat forage quality deterioration occurred after the third week grazing period in 2017. However, there was no considerable quality change in the tall fescue pasture after the 3rd weeks (Table 3). The wheat forage quality estimations after the 3 week grazing period showed that CP content
in reduced from 290 (after 2 weeks) to 198 g kg\(^{-1}\) (by 32%) while the NDF increased from 361 (after 2 weeks) to 482 g kg\(^{-1}\) (33%). Plant maturity and increased proportion of stems in the grazed forage might be the probable cause of forage quality deterioration in the wheat pasture. Due to forage quality deterioration calves grazed on wheat pasture gained 1236 g hd\(^{-1}\)d\(^{-1}\) after the 3 weeks compared to the 1370 g hd\(^{-1}\)d\(^{-1}\) reported after the first two weeks of grazing. In contrast, the calves grazed on tall fescue pasture maintained a consistent body weight gain rate even after the 3 week grazing period (879 vs. 895 g hd\(^{-1}\)d\(^{-1}\)). Beef cow–calf producers using wheat grazing for beef cattle in spring should focus adhering shorter grazing cycles for better calf growth performances without affecting the subsequent grain production. However, tall fescue can be grazed for much longer periods than wheat pasturing without affecting the body weight gain benefits. The information from previous grazed out operations practiced in spring have shown mixed growth performance responses for calves. In a 56-day (March–May) grazed-out study, Gunter et al. [33] reported that calves (202 kg body weight) on wheat + rye (Secale cereale L.) mixture and tall fescue gained 964–1196 g d\(^{-1}\) (54–67 kg) and 446–535 g d\(^{-1}\) (25–30 kg), respectively. The growth performances reported in this study for calves agreed with [34] and were within the ranges of [33,34]. Compared to the calves, all the cows grazing dual-purpose wheat and tall fescue did not gain body weight. Some cows lost body weights during the grazing period (data: S 8). As this scenario was common to both the cow groups, we presume that shrink associated with acclimatization to the new grazing conditions may have caused the mixed growth response of cows. Furthermore, calves are at the rapid development stage than fully matured cows, thus calves showed better growth response for grazing than cows. Our results suggest that cows may require much longer grazing cycles to acclimatize and maintain their body weight. With the forage quality characteristics dynamics, it is feasible to adopt lengthy spring grazing cycles for tall fescue pasturing than grazing wheat. Extending dual-purpose wheat pasturing cycles beyond 2–3 weeks should be practiced carefully as it can affect the growth performance of calves negatively and can have adverse effect on the final grain yield and test weights [19]. As it was originated from a single field experiment, interpretation of beef cow–calf growth performances results from this study is valid for the two specific grazing fields. The growth performance differences found in this experiment warrant further investigation with treatments replicated.

5. Conclusions

Controlled grazing of wheat by beef cow–calves in spring for 2–3 weeks permits harvesting grain yield and test weight that are similar to that of the conventional wheat grain production system. Grazing wheat reduced grain crude protein but did not affect starch or crude fat contents. Wheat forage accumulated lower dry matter yield for grazing in spring compared to the fall stockpiled tall fescue pasture. With adequate precipitation and warmer spring temperatures, wheat forage has superior quality characteristics than the tall fescue pasture with higher CP, P, but lower ADF and NDF levels. Colder weather conditions induced similar forage quality in the two pastures. However, wheat pasture can accumulate N, K, Na, and Mg concentrations that could poses a risk for grass tetany. Producers may need to pay close attention on supplementary feeding of minerals for beef cattle grazing wheat pasture in spring. Calves benefitted more by grazing dual-purpose wheat in spring than grazing stockpiled tall fescue. Cows exhibited a highly variable, inconsistent, and mixed ADG response, thus, may require a longer acclimatization period for better growth performances. Use of dual-purpose wheat for beef cow–calf grazing in spring offers producers with more options to diversify wheat-based beef cattle production without adverse effects on grain yield and with added extra weight gain benefits that exceeds stockpiled tall fescue grazing.

Supplementary Materials: The following are available online at http://www.mdpi.com/2073-4395/10/10/1543/s1, Table S1: weather data for the experimental site 2016–2018.

Author Contributions: Conceptualization: H.G., A.N., and F.D.; investigation: H.G., A.N., F.D., G.E.A., and K.S.; methodology: H.G., A.N., F.D., G.E.A., and K.S.; writing—original draft: A.N.; writing—review and editing: H.G., A.N., F.D., G.E.A., and K.S. All authors have read and agreed to the published version of the manuscript.
Funding: This research was funded by the United States Department of Agriculture, through the USDA-ARS; Western Kentucky University cooperative research program.

Conflicts of Interest: The authors declare no conflict of interest regarding the publication of this paper.

Declaration: Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. department of Agriculture. USDA is an equal opportunity provider and employer.

References
1. Holliday, R. Fodder production from winter-sown cereals and its effect upon grain yield. *Field Crops Abstr.* 1956, 9, 207–213.
2. Winter, S.R.; Musick, J.T. Grazed wheat grain yield relationships. *Agron. J.* 1991, 83, 130–135. [CrossRef]
3. Horn, F.P. Chemical composition of wheat pasture. In *National Wheat Pasture Symposium Proceedings*; Horn, G.W., Ed.; Oklahoma Agricultural Experiment Station: Oklahoma City, OK, USA, 1984; Volume 115, pp. 47–54.
4. Winterholler, S.D.; Lalman, D.L.; Hudson, M.D.; Ward, C.E.; Krebsiel, C.R.; Horn, G.W. Performances, carcass characteristics, and economic analysis of calf-fed and wheat pasture yearling systems in the southern great plains. *Prof. Anim. Sci.* 2008, 24, 232–238. [CrossRef]
5. Bolsen, K.K. Feeding value of wheat silage and hay as wheat crop alternatives. In *Proceedings National. Wheat Pasture Symposium*; Horn, G.W., Ed.; Oklahoma Agricultural Experiment Station: Oklahoma City, OK, USA, 1984; Volume 115, pp. 55–64.
6. Dunphy, D.J.; McDaniel, M.E.; Holt, E.C. Effect of forage utilization on wheat grain yield. *Crop Sci.* 1982, 22, 106–109. [CrossRef]
7. Harwell, R.L.; Strickland, P.L.; Jobes, R. Utilization of Winter Wheat Pasture; Oklahoma Agricultural Experiment Station: Oklahoma City, OK, USA, 1976; p. 743.
8. Croy, L.I. Effects of clipping and grazing termination date on grain production. In *National Wheat Pasture Symposium Proceedings*; Horn, G.W., Ed.; Oklahoma Agricultural Experiment Station: Oklahoma City, OK, USA, 1984; Volume 115, pp. 35–40.
9. Redmon, L.A.; Krenzer, E.G.; Bernardo, D.J.; Horn, G.W. Effect of wheat morphological stage at grazing termination on economic return. *Agron. J.* 1996, 88, 94–97. [CrossRef]
10. Christiansen, S.; Svejcar, S.T.; Philips, W.A. Spring and fall cattle grazing effects on components and total grain yield of winter wheat. *Agron. J.* 1988, 81, 145–150. [CrossRef]
11. Pinchak, W.E.; Worrall, W.D.; Caldwell, S.P.; Hunt, L.J.; Worrall, N.J.; Conoly, M. Inter-relationships of forage and steer growth dynamics on wheat pasture. *J. Range Manag.* 1996, 49, 126–130. [CrossRef]
12. Stuedemann, J.A.; Hoveland, C.S. Fescue endophyte: History and impact on animal agriculture. *J. Prod. Agric.* 1988, 1, 39. [CrossRef]
13. Wester, D.B. Viewpoint: Replication, randomization, and statistics in range research. *J. Range Manag.* 1992, 43, 285–290. [CrossRef]
14. Hurlbert, S.H. Pseudo replication and the design of ecological field experiments. *Ecol. Monogr.* 1984, 54, 187–211. [CrossRef]
15. Graybill, F.A. *Theory and Application of the Linear Model*; Duxberry Press: New Scituate, MA, USA, 1976.
16. Boquet, D.J.; Johnson, C.C. Fertilizer effects on yield, grain composition, and foliar disease of double crop soft red winter wheat. *Agron. J.* 1987, 79, 135–141. [CrossRef]
17. Krenzer, E.G.; Tarrant, A.R.; Bernardo, D.J.; Horn, G.W. An economic evaluation of wheat cultivars based on grain and forage production. *J. Prod. Agri.* 1996, 9, 66–73. [CrossRef]
18. Mackown, C.T.; Rao, S.C. *Source-Sink Relations and Grain Quality of Winter Wheat Used for Forage and Grain Production*; Agronomy Abstract ASA: Madison, WI, USA, 1998; p. 148.
19. Trent, J.D.; Wallace, L.L.; Svejcar, T.J.; Christiansen, S. Effect of grazing on growth, carbohydrate pools, and mycorrhizae in winter wheat. *Can. J. Plant Sci.* 1988, 68, 115–120. [CrossRef]
20. Bishop, U.R.; Hughes, J.L. Agronomic performance and protein content of fall-planted triticale, wheat, and rye. *Agron. J.* 1979, 71, 359–360. [CrossRef]
21. Pumphrey, F.V. Semi dwarf winter wheat response to early spring clipping and grazing. *Agron. J.* 1970, 62, 641–643. [CrossRef]
22. Lyon, D.J.; Baltensperger, D.D.; Siles, M. Wheat grain and forage yields are affected by planting and harvest dates in the central great plains. *Crop Sci.* **2001**, *41*, 488–492. [CrossRef]

23. Fribourg, H.A.; Bell, K.W. Yield and composition of tall fescue stockpiled for different periods. *Agron. J.* **1984**, *76*, 929–934. [CrossRef]

24. Poysa, V.W. Effect of forage harvest on grain yield and agronomic performance of winter triticale, wheat, and rye. *Can. J. Plant Sci.* **1985**, *75*, 879–888. [CrossRef]

25. Fribourg, H.A.; Loveland, R.W. Production, digestibility, and perloline content of fescue stockpiled and harvested at different seasons. *Agron. J.* **1978**, *70*, 745–747. [CrossRef]

26. Clarke, R.T.J.; Reid, C.S.W. Foamy bloat of cattle. A review. *J. Dairy Sci.* **1974**, *57*, 753–785. [CrossRef]

27. Clay, B.R.; Hoehne, G.; Tillman, A.D. *Animal Problems in Grazing Wheat and Other Small Grains Pasture*; Oklahoma State University Extension Facts: Oklahoma City, OK, USA, 1973; pp. 3007–3307.

28. Bohman, V.R.; Horn, F.P.; Stewart, B.A.; Mathers, A.C.; Grunes, D.L. Wheat pasture poisoning. I. an evaluation of cereal pastures as related to tetany in beef cows. *J. Anim. Sci.* **1983**, *57*, 1352–1363. [CrossRef] [PubMed]

29. Grunes, D.L. Uptake of magnesium by different plant species. In *John Lee Pratt International Symposium on the Role of Magnesium in Animal Nutrition*; Fontenot, J.P., Bunce, G.E., Webb, K.E., Allen, V.G., Eds.; Virginia Polytechnic Institute Press: Blacksburg, VA, USA, 1983; pp. 23–28.

30. Mayland, H.F.; Grunes, D.L.; Lazar, Y.A. Grass tetany hazard of cereal forages based upon chemical composition. *Agron. J.* **1976**, *68*, 665–667. [CrossRef]

31. Mayland, H.F.; Grunes, D.L. Soil-climate-plant relationship in the etology of grass tetany. In *Grass Tetany*; Spec. Pub. No. 35; Rendig, V.V., Grunes, D.L., Eds.; ASA: Madison, WI, USA, 1979; pp. 123–175.

32. Stewart, B.A.; Grunes, D.L.; Mathers, A.C.; Horn, F.P. Chemical composition of winter wheat forage grown where grass tetany and bloat occur. *Agron. J.* **1981**, *73*, 337–347. [CrossRef]

33. Gunter, S.A.; Lusby, K.S.; Hubbell, D.S. Tall fescue for backgrounding in preparation for small-grain or bermudagrass pasture. *Prof. Anim. Sci.* **2005**, *21*, 93–96. [CrossRef]

34. Lomas, L.W.; Moyer, J.L.; Milliken, G.A. Grazing and finishing performance of steers that grazed nontoxic endophyte-infected tall fescue. *Forage Grazinglands* **2011**. [CrossRef]