Nutritional management of calves grazing wheat and small grain pasture

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Abstract

Small grain forages are a unique and economically important resource in the Southern Great Plains and in similar areas worldwide. Income is possible from both increasing value of stocker calves grazing during the fall and winter as well as the harvested grain. Wheat and other small grain species are used in this "dual purpose" production system if calves are removed from pastures at the first hollow stem development stage. As more producers have opted to forgo grain harvest in order to graze-out cropped acres, other small grains (oats, cereal rye, triticale, barley) and cool-season annuals (annual ryegrass) are often planted in mixtures. These alternative cool-season annuals and mixtures have similar protein and digestibility attributes to wheat pasture, so management and supplementation recommendations are similar. Risk factors of production include forage growth and climatic variation as well as the bloat provocative nature of the forage, which impacts performance, death losses and economics of the enterprise. Small grain forages are high in crude protein (17 to 35% of DM) and are highly digestible (up to 85% IVOMD), which is adequate for potential average daily gains in excess of 2.5 lbs per day. However, these performance levels are often not achieved in practice. Growth performance is impacted by forage availability, mineral deficiencies and imbalances, energy and protein imbalances in the rumen, and bloat. This review focuses on the nutritional management of stocker calves grazing small grain forages to improve predictability of performance and maintain economic sustainability.

Key words: growing calves, wheat pasture, supplementation, minerals, bloat

Introduction

Winter wheat (Triticum aestivum L.) pasture is a unique and economically important renewable resource in the Southern Great Plains and throughout the Southeastern United States. In Oklahoma and the Southern Great Plains, income can come from both harvested grain and the increased value of weight gain to growing cattle grazed on wheat pastures. Although this system has potential in other geographies, it is not as widely adopted in the Southeastern U.S. Carl Hoveland stated in a symposium in 198637 that "The greatest opportunity for improving profitability in Southeastern beef production lies in stockering weaned calves on high-quality cool-season annual or perennial pastures." That may still be the case today.

Wheat can be managed for dual use (both grazing and grain) without reducing grain production potential if calves are removed from crop fields at the emergence of the first hollow stem.[18, 22] Profit from grazing stocker cattle on wheat pasture and other small grains can be high for two reasons. First, the quality of the forage results in high animal performance at a time when most other forages are not actively growing. Second, prices of light-weight calves are seasonally low in the fall because of the large numbers of light-weight calves weaned. Third, there is typically a seasonal dearth of heavy feeders supplies in the spring.

The producer's decision to graze out or harvest the grain crop depends on a variety of factors such as the value of wheat grain, grain yield potential, forage production of the crop field in question, availability of calves, and value of gains added onto the growing calf. There has also been increased interest in using alternative cool-season annual species (such as cereal rye and oats, among others) as cover crops in crop rotation schemes.[20] These cover crops are often planted in complex mixtures of annual species selected for the agronomic benefits they provide. Also, if producers opt to forgo grain harvest in order to graze-out cropping acres, they are not limited to planting only wheat. Other small grains (oats, cereal rye, triticale, barley), annual ryegrass and cool-season annual brassicas (turnips, radishes other brassica species) may have agronomic benefits, but also have protein and energy values similar to wheat pasture, so management and energy supplementation recommendations are similar (mineral recommendations may differ).

Predicting performance of stocker cattle grazing cool-season annuals is challenging because of large variations in weather, and its variable effect on forage and cattle productivity. If weight gains of growing cattle cannot be predicted with some degree of accuracy, realistic breakeven prices cannot be calculated, and feedyard placement and finishing schedules can't be managed. Thus, management of financial risk is hampered by variability of production outcomes. The ability to predict cattle performance is important because the feedlot and stocker segments of the industry compete for supplies of stocker/feeder cattle, and coordinated beef production systems are becoming more prevalent.

Whether the crop is destined for grain harvest in a dual-purpose system or for grazeout, wheat and other cool-season annuals during the fall and winter present the same management decisions and potential pitfalls for stocker calves. Supplementation of cattle grazing cool-season annual forages improves production, reduces production risks, and removes much of the unpredictability of the wheat grazing enterprise. This is because supplements can be designed to 1) provide a more balanced nutrient supply including minerals, protein and energy; 2) carry feed additives such as ionophores and bloat preventive compounds; and 3) substitute supplement for forage at higher feeding rates where it is desirable to increase stocking rate in relation to existing forage resources, grazing management and/or marketing decisions.

In this review, we discuss nutritional management and supplementation of calves grazing cool-season annual forages to control production risk.

Forage growth and nutritive characteristics of small grain forages

In the fall and early spring, cool-season annual grasses planted into dedicated crop fields or interseeded into warm-season grass sods such as bermudagrass, have been used extensively for grazing stocker cattle to improve net-farm income in the Southern High Plains and Southeastern U.S. Improvements in net income are achieved with the availability of high-quality forages at a time of year when weaned cattle are at a seasonally low price and when other predominant forages are dormant and of low nutritive quality. Figure 1 shows the nutrient content of wheat pasture during the fall and spring in relation to the nutrient requirements of a 500-pound steer gaining 2.2 pounds per day. Wheat and other cool-season annual grasses are extremely high in CP (> 25% DM basis) and low in fiber (40 to 49% NDF and 19 to 29% ADF, DM basis) during the fall and early spring, prior to stem elongation.[11,13] Even though increases in cell wall fiber content (to over 50% NDF) and reductions in CP content (to < 20% on DM basis) are noted during April and May, CP and energy content is greater than animal requirements for a 500-pound growing steer to gain in excess of 2.2 pounds/day until the end of the spring grazing season. The nutrient-dense nature of cool-season annual forages indicates that low animal performance is likely due to restrictions in forage availability,[26,49,50] mineral deficiencies or imbalances, or metabolic disease.

Forage production of cool-season annual grasses follows a biphasic growth curve (Figure 2) in the Southern Great Plains and mid-South (Arkansas, Mississippi, Alabama and Georgia). Forage production is much greater in the spring than during the fall and winter (Figure 2), and common stocking rates of 500- to 600-pound calves are correspondingly greater in the spring grazeout period (at 1 to 3 calves per acre in the spring) than in the fall (with stocking rates ranging from 0.33 to 1 calves per acre[11,16]).

Stocking rate is a fundamental management variable with a distinct relationship to animal performance.[15] If stocking rate can be matched with forage availability, achieving the desired level of animal performance is more certain.

Setting stocking rate based on forage allowance (FA), defined as the pounds of available forage DM per pound of calf body weight, allows us to objectively set stocking rate for desired performance. Beck et al.[6] compiled forage and animal performance (using shrunk bodyweights) data from 8 years of experiments on wheat pasture,[14,46] and determined that maintaining FA at 3.5 pounds of forage DM/pound of steer BW resulted in maximized ADG at 2.7 pounds/day. For setting initial stocking rates, an initial FA of 5 pounds forage DM per pound steer body weight resulted in maximized ADG.[6] As FA decreased below this threshold, performance of steers decreased linearly. Although the FA analysis in Beck et al.[6] provides important management information, BW of all calves used in this analysis were within a narrow range. Dry matter intake by grazing calves is estimated best not by BW but by metabolic BW,[47] which is used in determination of animal unit equivalency.[43] As FA declines, forage intake and forage digestibility declines, which decreases animal performance.[49,50] As a proof of concept, Beck et al.[8] found that steers stocked on wheat pasture with FA at turnout of 4.5 pounds of forage DM/pound of steer BW gained 12% more than steers stocked with FA of 2.8 pounds of forage DM/pound of steer BW (2.69 vs 2.40

Figure 1: Crude protein and total digestible nutrient content of wheat forage. (Adapted from Beck et al., 2013). The blue lines indicate the requirements[47] of a 500-pound steer for energy and crude protein to gain 2.2 pounds per day.

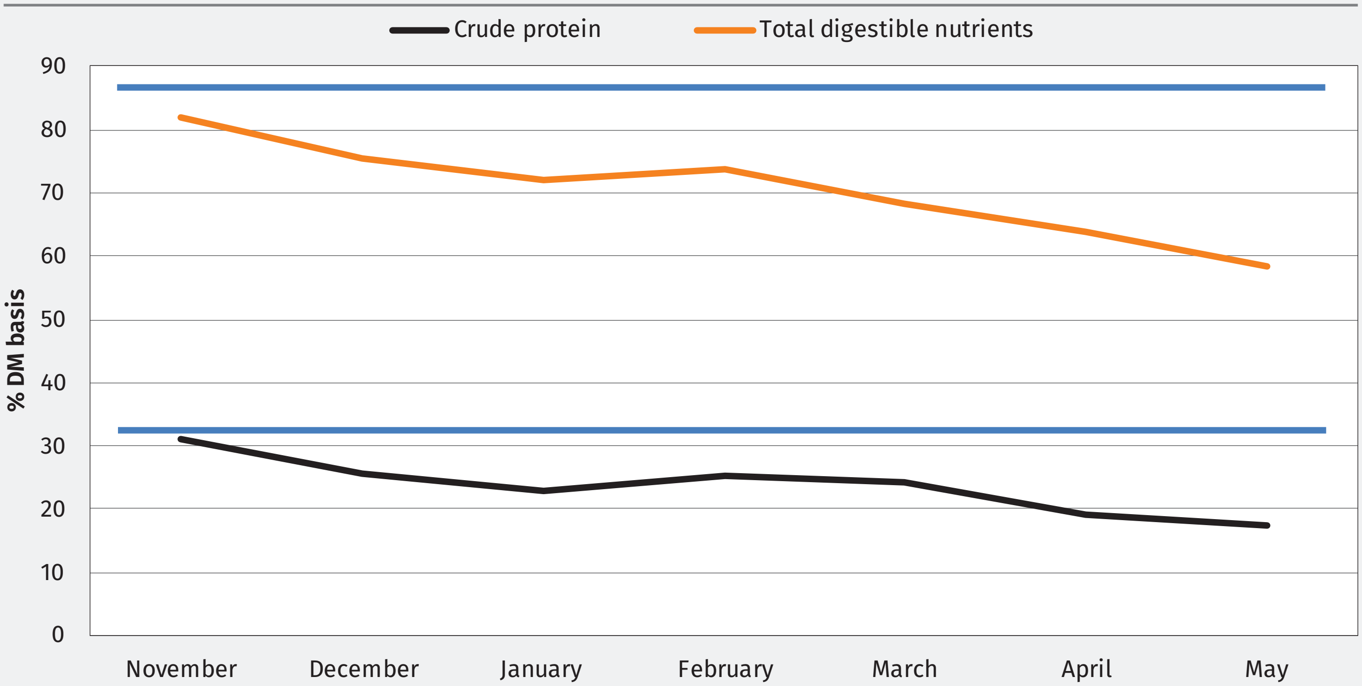
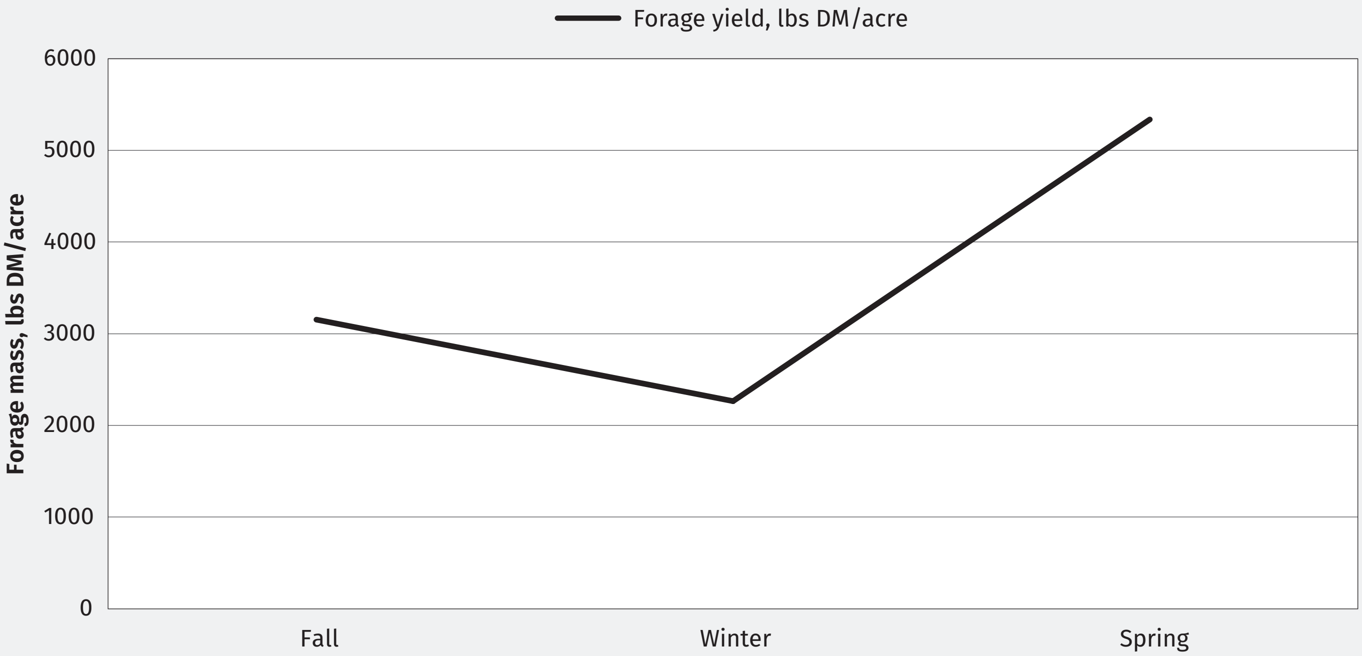


Figure 2: Seasonal wheat forage yield (pounds DM/acre) for the fall, winter and spring growing seasons. [Adapted from Bailey et al.,[3] Kim and Anderson[39] and Darapuneni et al.[17]]



pounds/day respectively). There are indications that using FA based on BW alone may not be as accurate in predicting performance across cattle with large BW ranges; there is need for research to define the FA-to-BW gain relationship based on metabolic BW (or animal unit equivalence) in place of actual animal BW.

Mineral content of wheat forage

There is considerable variation in the mineral composition of small grain forages, depending on management, growth conditions and soil mineral content. The data in Table 1 have been compiled from Fieser et al.,[21] Gunter and Combs[28] and Beck et al.[11] These experiments, conducted over a wide range in geography (central Oklahoma, northwestern Oklahoma, and northern Arkansas, respectively) indicate that Ca, Cu and Zn are deficient in wheat forage; P and Mg are adequate, while K is considered excessive for growing steers gaining 2.2 pounds per day.[47]

While Table 1 indicates that wheat forage contains marginal to sufficient P and Mg, K is excessive and Ca is inadequate for growing cattle. These values are characteristic of small grains forages in general. Therefore, Ca is the macromineral of primary concern in many wheat pasture-grazing situations. In these situations, wheat pasture stockers should be supplemented with an additional 6 to 10 grams of Ca per day. While this may seem like a very small amount of Ca, and therefore perhaps not important, the total Ca requirement of a 400-pound steer gaining 2 pounds per day is 28 grams.[47] The additional Ca could be included as calcium carbonate or limestone using grain- or byproduct-based supplements as a carrier, or in a complete mineral mixture.

The high K content of wheat forage is problematic because K interferes with Mg absorption in the gastrointestinal tract. Grass tetany is not considered a problem for growing cattle grazing small grain pastures, but is an issue with mature cows. Grass tetany in mature cows is caused by low blood Mg levels that can result from either low Mg intake or poor absorption. It is commonly a problem in nursing cows grazing small grain pastures in the spring[52] due to Mg excretion in the milk and reduced resorption of Mg from the bone in mature cows compared with younger cows or growing calves. Grass tetany potential is based on the ratio of the molecular weight of K to the molecular weights of Ca and Mg.[38] This is calculated by (K / 39) / ([Ca / 20] + [Mg / 12.1]) and should be < 2.2. In the case presented in Table 1, the grass tetany potential is 1.[76] This equation was developed for lactating cows and is not been tested for use in growing cattle. While it is a common misconception that growing cattle on small grain pasture can suffer from grass tetany, direct Mg deficiency is a real potential issue for growing cattle grazing small grain forages.

High dietary N has been associated with lower serum Mg and increased incidence of grass tetany as well.[23] Also, feeding high levels of P with low Ca levels has likewise been shown to reduce Mg absorption and serum concentration,[23] thus small grain pastures with their low Ca and higher P content are especially problematic in Mg nutrition.

Even though grass tetany is not an issue with young growing cattle, the complex interactions of high N, K and P along with low Ca in small grain forages shows that Mg deficiency may be problematic even though a laboratory analysis indicates adequacy. Magnesium should be supplied in mineral supplements to offset these mineral interactions. Using current mineral recommendations,[47] if one-half of the Mg in wheat is rendered unavailable due to mineral interactions, a mineral supplement with target consumption of 4 oz/day (as-fed basis) should contain 1.5 to 2% Mg. A mineral with a targeted intake of 2 oz/day should contain 3 to 4% Mg to provide adequate Mg for growing stocker calves. Feeding high levels of Mg often reduces mineral intake due to palatability issues,[35] so mineral consumption should be monitored and free-choice minerals with Mg levels over 5% should only attempted when really

Table 1: Average mineral content of wheat forage from Fieser et al.[21], Gunter and Combs[28], and Beck et al.[11] compared with the mineral requirements of a 500-pound growing steer gaining 2.2 pounds per day based on NASEM[47] requirements.

Mineral	Average content	Standard deviation	Requirement	Status
Calcium, % of DM	0.38	0.091	0.45	Deficient
Phosphorus, % of DM	0.25	0.057	0.23	Adequate
Magnesium, % of DM	0.16	0.031	0.15	Adequate
Potassium, % of DM	2.07	0.212	0.60	Excessive
Copper, ppm	7.19	1.807	10.00	Deficient
Zinc, ppm	22.14	5.878	30.00	Deficient

necessary. Mineral mixtures will not effectively offset mineral deficiencies if desired amounts are not consumed, therefore intake must be monitored. Arthington and Ranches[2] and McDowell[43] provide more comprehensive discussion on mineral nutrition of grazing beef cattle.

Mineral supplementation effects on steers grazing wheat pasture have been reported in experiments from two locations in Oklahoma (Oklahoma State University Wheat Pasture Research Unit [MPRU] reported by Fieser et al.[21] and USDA ARS Southern Plains Range Research Station [SPRRS] reported by Gunter and Combs[28]) and one location in Arkansas (University of Arkansas Livestock and Forestry Research Station [UA LFRS] reported by Beck et al.[7]). In these experiments, a balanced, complete mineral designed to match the deficiencies for growing calves grazing wheat pasture was offered (at the MPRU site, an additional treatment was included where the mineral also supplied monensin) in comparison to plain white salt (LFRS) or no supplemental mineral (MWPRU and SPRRS). The reported mineral supplement composition fed in these experiments is presented in Table 2. Mineral supplements contained greater Ca than P in order to correct the Ca deficiency and unbalanced Ca:P ratio (Table 1), and also contained low levels of K. Magnesium levels in the mineral supplements were designed specifically for wheat pasture stocker calves (i.e. lower Mg than mineral supplements designed for beef cows grazing pastures with high grass tetany potential.) Minerals were designed for target intake of 4 oz/day, and actual mineral intakes ranged from 107 to 112% (Gunter and Combs,[28] Beck et al.[7]) to 160% to 164% of the target (Fieser et al.[21]).

The gain responses of growing steers in these experiments are presented in Figure 3. Fieser et al.[21] found that providing a balanced mineral supplement did not significantly increase daily gains when performance was limited to 1.1 pound /day on wheat pasture in yr 1 (MWPRU, yr 1; Figure 2). Yet, growing steers fed a non-medicated mineral gained 0.48 pounds more per day than steers receiving no supplement when forage resources were adequate for gains in excess of 2.0 pounds/day (MWPRU, yr 2; Figure. 2). Gunter and Combs[28] showed that gains of calves provided a balanced mineral supplement were 20% (SPRRS, Fall; Figure 2) to 43% (SPRRS, Spring; Figure 3) greater than cattle that were provided no mineral supplement. Finally, Beck et al.[7] indicated that ADG was numerically increased by 0.22 pounds/day during the fall (UA LFRS, Fall; Figure 3) and significantly increased by 0.42 pounds/day during the spring (UA LFRS, Spring; Figure 3). Summarizing these 6 experiments in 3 disparate locations shows that a balanced, complete mineral increased gains of steers grazing wheat pasture by an average of 0.34 pounds/day.

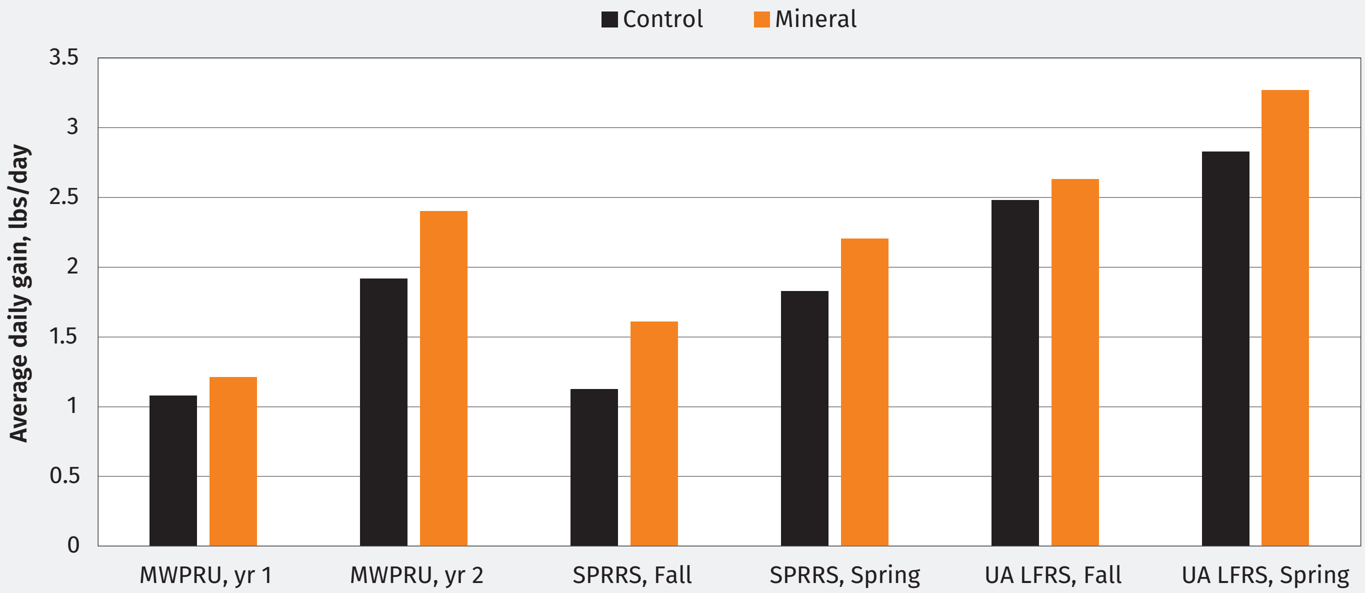
Feeding monensin on wheat pasture

Ionophores provide an economical way to increase ADG of growing stocker calves in both con-centrate-based supplementation programs[9], 33 or self-fed mineral supplements.[11,21] Ionophores change rumen fermentation patterns

Table 2: Reported composition of mineral supplements offered to growing calves grazing wheat pasture.

Citation	Fieser et al. [21] Year 1	Fieser et al. [21] Year 2	Gunter and Combs[28]	Beck et al.[7]
Study site	**MWPRU**	**MWPRU**	**SPRRS**	**UA LFRS**
Target intake, oz./day	4.0	4.0	4.0	4.0
Actual intake, oz./day	6.8	6.4	4.5	4.3
Calcium, %	10.8	11.7	15 to 17	17.5
Phosphorus, %	6.3	6.5	4.0	7.0
Salt, %	25.3	22.9	22.0	18.5
Magnesium, %	0.86	0.43	5.5	2.7
Potassium, %	0.96	0.88	-	0.1
Copper, ppm	899	767	650	1,200
Zinc, ppm	3,961	2,958	2,185	4,200

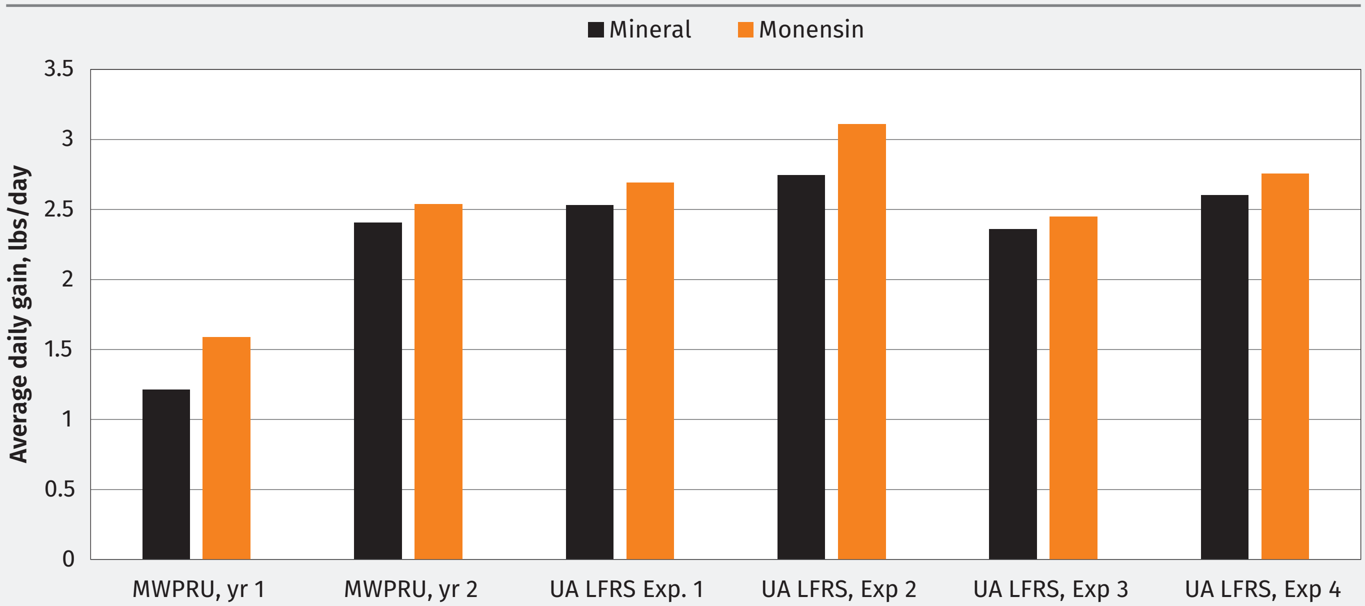
Figure 3: Response of steers grazing wheat pasture to supplemental free-choice mineral supplements compared with controls fed no mineral supplement (MWPRU, [Fieser et al.[21]] and SPPRS Fall and SPRRS Spring [Gunter and Combs[28]]), or white salt only. (UA LFRS [Beck et al.[7]]).



by inhibiting Gram-positive bacteria, increasing propionate production, decreasing ruminal acetate:propionate ratios, increasing protein digestibility, and in-creasing gluconeogenesis.[24,51]

Figure 4 illustrates the performance advantage of including an ionophore (monensin) in self-fed, complete mineral supplements for steers grazing wheat pasture in 6 experiments in Oklahoma (MPRU) and Arkansas (UA LFRS). Over 2 years of fall and winter grazing (WPRU, yr 1 and yr 2; Figure 4), Fieser et al.[21] found that monensin significantly improved ADG of steers by 0.37 pound/day in the first year when ADG of controls were limited to 1.1 pounds/day. However, ADG was only increased numerically by 0.13 pounds/day with monensin in the second year when gains of controls were less limited. In Beck et al.,[11] steer ADG was statistically increased by an average of 0.18 pounds/day (UA LFRS, Exp. 1 Figure 4) when an ionophore was fed. Growing steers in Weiss et al.[53] saw gain improvement of 0.2 lbs/day when offered monensin in free-choice mineral supplements (UA LFRS, Exp. [2,3,4]; Figure 4). The range of response to monensin for growing calves grazing wheat pasture was from 0.1 to 0.4 pound per day increase across the experiments presented in Figure 4. These experiments were conducted across a wide geographical area with

Figure 4: Response of steers grazing wheat pasture to free-choice mineral mixture containing the ionophore monensin compared with non-medicated mineral mixture. (Adapted from Fieser et al.[21] [MWPRU]; Beck et al.[11] [UA LFRS Exp [1]]; Weiss et al.[53] [UA LFRS Exp. [2,3,4]]).



both fall and spring wheat pasture and with wheat pasture that was adequate, but also that had limited forage availability and had supplemental silage on offer (Exp. 4; Figure 4).

Monensin provided in free-choice mineral supplements has been proven to be effective in improv-ing animal performance (Figure 4); however, including monensin may reduce mineral consump-tion, which does not always provide the full recommended daily dose of 200 mg monensin/calf.[11,35,53] Across all experiments presented in Figure 4, including monensin in the mineral decreased overall mineral consumption compared to the unmedicated mineral. Further, increasing monensin concentration from 800 g/ton to 1600 g/ton in the mineral led to greater re-ductions in mineral intake compared with non-medicated mineral.[53] Including monensin in a min-eral mixture decreased intake of the mixture by 55 to over 60%[11,21,53] compared to an unmedi-cated mineral, and in general, intake of the unmedicated mineral was in excess of the targeted intake. This reduction in intake can be perceived as a benefit, as it reduces the overall cost of the mineral program and potentially prevents over-consumption of mineral. Beck et al.[11] determined that providing monensin in a free-choice mineral supplement increased net return ($US/steer) by $15 to 25 (US) per steer by increasing gains and reduced total cost per pound of gain compared to an unmedicated mineral.

Frothy bloat

Frothy bloat is a major cause of concern for cattle grazing wheat, other small grain pastures, and legume pasture.[42] Bloat is the buildup of ruminal gasses that occurs when fermentation gas production is greater than gas expulsion via eructation.[42] Incidences of bloat and death losses from wheat pasture bloat can strike suddenly and without warning; the etiology of pasture bloat depends on forage conditions, weather, stocking rates and other management.[4,32,36] Wheat pasture frothy bloat is usually related to the formation of stable foam from a viscous slime layer on the top of the rumen mat formed from soluble proteins and carbohydrates released from the forage during digestion.[4] Gases released through fermentation percolate through the slime layer thereby forming stable foam, which entraps ruminal gasses, which then build up in the rumen. The chemical composition of wheat forage changes depending upon environmental growing conditions, stage of wheat plant growth or maturity, and fertility level;[6] therefore, forage nutritive value affects the likelihood that stable ruminal foam will be formed when wheat forage is grazed.[32]

When forage access is unlimiting, intake of wheat forage can be quite high, often over 2.8 to 3% of BW50 (DM basis). During the fall and early spring when forage growth rates are high, moisture content of wheat forage can be up to 75 to 85%6 with forage intakes of 60 to 100 pounds of total forage (as-grazed basis) for a 500-pound steer. The high forage intake rate and the rapid ruminal fermentation rate of wheat forage leads to production of rumen fermentation gases in large volumes, leading to bloat when eructation is inhibited.

Wheat forage ranges from 17 to over 30% CP6 (DM basis; Figure 1). At the times of year that wheat pasture frothy bloat is usually encountered in the fall and early spring, wheat forage is succulent and has CP contents of 25% to 30% (Figure 1). It is suspected that there is a relationship between the incidence of bloat in stocker cattle and CP, DM and cell wall content of wheat forage.[36] Horn et al.[36] reported that pastures where bloat occurred had less DM and less fiber (both neutral detergent fiber and acid detergent fiber) while the concentration of CP and soluble N fractions were greater. This indicates that there is a subtle relationship among growing conditions, soil fertility management and stocking rates as they affect wheat forage maturity, forage intake and the incidence of bloat.

Mature wheat forage (more days of growth accumulation) has greater cell wall and DM concentration than less mature wheat forage. The greater fiber (both ADF and NDF) and DM concentration likely reduces bloat-provocative, soluble protein and carbohydrate compounds. Greater fiber content will tend to promote ruminal contraction, rumination and saliva production, which may also have impacts on formation of the ruminal foam associated with bloat.[5]

Bloat occurs more frequently when wheat forage is rapidly growing and succulent in the fall and late-winter, through early February. This can be related to climatic conditions, such as when frost occurs following a period of rapid forage growth. The freezing temperatures tend to rupture plant cell walls and increase fragility and fractionation of leaf tissue that can result in rapid release of soluble cell contents conducive to ruminal foam formation.[36]

Grazing behavior of hungry cattle[27] leads to rapid consumption on initial turnout onto pastures. This can be a problem when rotational grazing management allows cattle to overgraze a paddock (reducing forage intake and increasing hunger) before turnout to the next paddock. A more common and practically important occurrence is during weather events during the late winter and early spring. Horn et al.[32] observed periods of limited grazing ahead of a storm front with intensive grazing activity by hungry cattle after the front's passing. Gregorini et al.[27] showed that cattle with lesser rumen fill had more rapid forage intake rates in forages, which is problematic for forages that are at a higher risk of bloat provocation.[36]

Mineral status associated with wheat pasture may also affect bloat. As described above, additional Ca is needed to meet the requirements of Ca for growth and to prevent a subclinical Ca deficiency (Table 1). Calcium and Mg have roles in muscle contraction, thus deficiencies could compromise ruminal motility and contribute to bloat. Magnesium content of forages appear to be adequate, but is of concern due to interactions of Mg with high N and K in small grain forages mentioned previously.

Monensin has been shown to decrease the incidence and severity of wheat pasture bloat,[25,35] although it has not been shown to prevent bloat. A meta-analysis of experiments comparing the severity of bloat in cattle grazing high-quality, bloat-provocative pastures indicated that feeding monensin resulted in a 20-percentage unit decrease in the incidence of bloat and also decreased mean bloat score.[25]

Poloxalene has been available to reduce the impacts of pasture bloat for over 60 years. Because poloxalene acts as a surfactant, it can reduce foam formation from bloat provocative pastures[4] and release entrapped gas. Poloxalene has not been shown to increase BW gains or performance.[35] When bloat occurs, poloxalene should be fed at dosages of 1 to 2 grams per 100 pounds of BW daily. Poloxalene is commercially available in a variety of forms for use in grazing programs, including feed additives, top dresses for concentrate supplements, mineral supplements, blocks and liquid feeds. Although self-fed formulations of providing poloxalene are available, it must be consumed by the animals daily, thus hand feeding of at-risk animals should be considered during periods of high bloat risk.

It is often not economical to feed poloxalene supplements throughout wheat pasture grazing. Monensin has advantages in improving BW gain performance (Figure 3) and reducing the incidence and severity of bloat.[25,35] Thus, a common strategy for managing bloat is to provide a supplement containing monensin to calves throughout the wheat pasture grazing period and substitute a similar, poloxalene-containing supplement during times of bloat outbreaks. With this approach, cattle are accustomed to going to a feeder when poloxalene feeding is needed, while the increased weight gain from the monensin improves the economics of the total supplementation program. We recommend producers should not wait until a challenge arises to introduce a novel supplement or supplement delivery program. To maximize the success of this bloat prevention strategy, calves should be acclimated to feeders and supplementation during preconditioning prior to turnout onto wheat pasture and supplementation should be maintained during grazing.

Producers often provide low-quality roughage such as wheat straw or prairie hay free-choice to cattle grazing wheat pasture in hopes of increasing utilization of the wheat forage and reducing bloat. It is theorized that low quality, high-fiber roughages will slow the rate of passage through the GI tract, reduce wheat pasture intake, and promote the formation of a rumen mat that will increase rumen motility and reduces gas capture. This was disproven by Mader et al.[41] and Mader and Horn,[40] who conducted studies to determine the effects of feeding straw or sorghum-sudan hay free-choice to calves grazing wheat pasture. Daily consumption of the low-quality roughage in the Mader et al. [41] and Mader and Horn[40] studies ranged from 0.15 to 0.4 pounds per day for wheat straw to 0.35 to 0.9 pounds per day for sorghum-sudan hay. Offering free-choice, low-quality roughage did not affect forage intake,[40] digestibility,[40] passage rate,[40] or weight gains.[41] Bloat was only observed during a short period in the last 2 weeks of the Mader et al.[41] experiment during a period in March, and there was no effect of low-quality roughage feeding on the incidence and severity of bloat. There was no bloat reported by Mader and Horn.[40] Feeding free-choice, low-quality roughage appears to be of little benefit for controlling bloat in wheat pasture.

Energy supplementation

Because the protein levels in this highly digestible forage are so high during the fall and early spring (Figure 1), the TDN:CP ratio is often less than 4:1. This indicates that there is not adequate available energy present in the rumen for maximal microbial growth. Proteins are not fully incorporated into microbial proteins and excess N is excreted via the urine. This impacts the type of supplements that should be used for cattle grazing wheat and other cool-season annual pas-tures. Initially, the incomplete incorporation and excretion of forage N led to theorization that ruminal bypass protein supplementation could improve performance responses. Research has since proven that protein supplementation on cool-season annuals and other high-quality pastures does not increase performance more than energy supplementation.[10,35]

Supplementation with small amounts of energy-based supplements based on cereal grains (corn or grain sorghum) or digestible fiber byproduct feeds such as wheat middlings or soybean hulls have been used to provide ruminal available energy to correct the imbalanced TDN:CP ratio in wheat pasture.[35] Steer performance is improved by these energy supplements fed at low rates (<0.5% of bodyweight).[1,12,21,48]

A summary of 7 experiments showing the effect of energy supplementation on weight gain of stocker cattle grazing wheat pasture is presented in Table 3. When supplements were offered, with minerals and ionophore included in the supplement,[1,21,48] performance was increased by 0.43 to 0.75 pounds per day compared with providing only a free-choice mineral mixture in 3 experiments. This resulted in 2.7 to 4.7 pounds of supplemental feed per pound of added gain. In another experiment,[21] gains were only increased by 0.09 pounds/day (supplement conversion of 20.5 pounds of supplemental feed per pound of added gain). This low gain response was observed when gains of unsupplemented control calves were excellent at 2.4 pounds/day. Fieser et al.[21] also provided supplemental concentrate and the mineral/monensin mixture separately and found no difference in performance and supplemental efficiency compared with providing supplements as a single package, indicating that method of delivery is unimportant in performance response. Beck et al.[12] offered supplemental soybean hulls to steers grazing wheat pasture with a complete mineral mixture offered separately which did not contain an

Table 3: Effect of small package supplementation on gain response and supplemental efficiency of growing calves grazing cool-season annual pasture.

Citation	Mineral in supplement	Monensin in supplement	Supplement rate, pound/day	Control ADG	Supplemented ADG	Supplemental efficiency
Andrae et al.[1]	Yes a	Yes	1.55	2.31	2.87	4.2
Paisley et al., [48]	Yes a	Yes	1.83	2.53	2.92	4.7
Fieser et al. [21] (yr 1)	Yes a	Yes	2.0	1.21	1.96	2.7
Fieser et al. [21] (yr 1)	Ad libb	Ad libc	2.0	1.21	1.79	3.5
Fieser et al. [21] (yr 2)	Yes a	Yes	2.0	2.40	2.49	20.5
Fieser et al. [21] (yr 2)	Ad libb	Ad libc	2.0	2.40	2.54	14.7
Beck et al.[12]	Ad libb	No	3.3	2.00	2.23	14.3

[a] Supplement offered was based on ground grain sorghum and wheat middlings and provided required minerals and monensin[35].
[b] Mineral offered ad libitum separately from concentrate supplements in a self-fed complete mineral mixture.
[c] Mineral mixture provided to grazing calves contained monensin at 809 mg/pound.

ionophore, gains in this case were increased by 0.23 pounds/day but required over 14 pounds of supplement per pound of added gain. The efficiency of gain response to energy supplementation programs without adding an ionophore is often in excess of 10 pounds of supplement per pound of added gain,[12],[19] and providing an ionophore often improves supplemental efficiency by increasing performance of grazing calves by an average of 0.17 pounds/day across experiments,[25] thus improving the economics of the supplementation programs. The supplement-feeding rate in these experiments is not high enough to allow stocking rate to be increased by replacing forage intake with concentrate supplements. To do this, greater supplementation rates are required.

Energy supplementation to stretch a shortage of wheat pasture

Energy supplements are often used to alter the relationship of FA to animal gain to improve the economics of wheat grazing, regardless of the nutritional benefits previously discussed. Often, FA in practice is lower than optimal for maximal ADG (3 to 5 pounds of forage DM/pound of steer bodyweight). This can be due to poor growing conditions, or the fact that producers wish to increase stocking rates during the fall and winter because the cattle required for grazeout can be purchased at advantageous prices the preceding fall. Feeding moderate amounts of an energy supplement to growing cattle on wheat pasture can be used to offset a lack of forage, and allow for increased stocking rates. This tool increases the stability of the wheat pasture stocker enterprise and improves the predictability of cattle performance, which decreases production risk.

Research at the OSU Wheat Pasture Research Unit near Marshall, Okla., evaluated types of energy supplements for growing cattle on wheat pasture.[34] A high-starch, corn-based supplement was compared to a high-fiber, byproduct feed-based supplement. The high-fiber energy supplement was a blend of wheat middlings and soybean hulls, and both supplements provided 40 mg monensin per pound of feed. The supplements were hand fed 6 days per week at about 0.75% of body weight (for example, 4 pounds per day for a 533-pound steer) and stocking rate was increased by 22 to 44% compared to unsupplemented pastures. During the 3-year period, fall and winter ADG were increased 0.33 pounds/day by energy supplementation along with the increase in stocking rate, regardless of type of energy supplement, with an average supplement consumption of 0.65% of bodyweight. Wheat forage intake decreased by 0.91 pound for every pound of supplement consumed,[16] resulting in supplement conversions of 5 pounds of supplement per pound of increased gain per acre. This increase in gain performance along with increasing stocking rates can be an economically powerful tool when additional calves are needed. This supplementation approach can also maintain performance of growing calves when forage production is lacking to meet production goals. Some caution is warranted, however, in that the animal's grazing behavior, forage intake, and weight gain response to energy supplementation may change as FA changes.[45] Specifically, energy supplementation may not reduce wheat forage intake as much as expected when FA is already low, which is precisely the situation in which wheat forage "sparing" would be desirable. Additional research in this area is needed to fully understand these complex interactions.

An alternative that many producers consider is to stock their wheat pastures appropriately during the fall and winter, and maintain the "extra" cattle in a drylot on a cost-effective, limit-fed growing diet until they can be stocked on grazeout wheat with adequate FA in the spring. Hersom et al.[30,31] grazed growing steers on wheat pasture stocked for a high rate of gain, a low rate of gain, or kept steers on dormant native range through the winter. High gain wheat pasture steers gained 2.4 to 2.8 pounds/day, low gain wheat pasture steers gained only 1.2 to 1.5 pounds/day, and steers maintained on dormant native range gained 0.35 pounds/day.[30] Wheat calves had more GI track fill than steers wintered on native range in one of the years, but GI tract fill did not differ among treatments in the other year.[30] Steers on the high-gain wheat treatment were fatter,[30,31] but had less total offal and total GI organ weight when expressed as grams/kg empty body weight than low gain wheat steers or dormant native range steers.[31] The increase in relative proportion of offal and GI tract is expected in steers as we manage cattle for gains close to maintenance. This is one of the mechanisms for compensatory gain, where nutritionally-restricted calves consume more when realimented to normal intake, which increases gains temporarily. However, this also increases maintenance energy requirements.[31]

In Arkansas, Williamson et al.[54] restricted gains of calves in drylot to 1.3 pounds/day for 106 days before turnout onto grazeout wheat in one experiment, or in a second experiment, restricted gains by increasing stocking rates before grazeout. In the first year, calves maintained in drylot expressed no compensatory gain. In fact, calves fed in drylot gained 1.3 pounds/day in drylot and 1.2 pounds per day during the 64-day grazeout period, while steers kept on pasture throughout the winter gained 1.7 pounds per day during the winter and 2.79 pounds/day during grazeout.

In the second experiment,[54] calves were managed for high gain on wheat and ryegrass pasture stocked at 1.75 acres/calf or for low gain on wheat and ryegrass pasture stocked at 0.75 acres/calf without supplemental feed. During the fall and winter grazing period, high-gain calves gained 2.5 pounds/day vs 0.7 pounds/day for low-gain calves. During the 48-day grazeout period, calves managed for low gains during the fall and winter were able to express compensatory gain during spring grazeout (3.15 pounds/day for low-gain calves vs 2.17 pounds/day for high-gain calves), but only made up for 25% of the pre-grazeout restricted bodyweight. In an attempt to hold calves for wheat pasture, Gunter et al.[29] put cattle on toxic endophyte tall fescue during the fall before turning out on wheat in late January. Steers grazing tall fescue gained only 80 pounds (1.1 pounds/day) compared with others steers that gained 130 pounds (1.8 pounds/day) during the same period on wheat pasture. When all steers were placed on wheat pasture through grazeout, steers previously on tall fescue with restricted gains gained the same as steers that were previously on wheat pasture (211 pounds or 2.6 pounds/day). Managing for compensatory gain must be carefully considered because the bodyweight differences in restricted calves is rarely fully made up (compensation of 20 to 80% is common), and even partial compensatory gains are not guaranteed.

Conclusion

Dual-purpose wheat pasture is a unique resource available to producers in the Southern Great Plains, with massive potential for applications in the Southeastern United States and other cereal grain producing areas around the world. Other cool-season annual grasses provide similar nutritional attributes and management challenges for grazing livestock.[6,13]. These forages are high in protein and highly digestible; potential gains for calves grazing these forages can be over 2.5 to 3 pounds/day. Limits to production include forage growth, bloat, and the unbalanced nutrient supply, especially rapidly, ruminally-available soluble protein compounds, resulting in loss of N as urea via urinary excretion. Cool-season annual grasses are also often deficient and unbalanced in trace and macro minerals (primarily Ca, Mg, Cu, and Zn). Bloat is primarily an issue at times when rapid growth of immature forage allows for high rates of intake of forage with highly available soluble plant cell contents (both proteins and sugars) that combine to form a stable foam and inhibit eructation of rumen gases. Minerals associated with muscle contraction (such as Ca and Mg) are deficient and/or unbalanced, and are also implicated in the etiology of bloat.

Producers can use low supplementation rates of a high-energy, low-protein feed while calves are grazing adequate forage early in the fall and winter to correct the imbalanced energy:protein ratio of the forage, carry minerals and feed additives, and keep calves accustomed to supplementation. When bloat is encountered, supplements providing proloxalene can easily be exchanged for the regular supplement. If forage conditions change, such as forage shortfall due to drought or protracted cold weather, a different supplement can be used to maintain performance. This supplement would be designed for higher feeding rates with lower inclusions rate of feed additives. These approaches are cost-effective solutions to address several of the nutritional and management challenges associated with grazing wheat and other cool-season annual pastures discussed herein.

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