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Adding Value to Crop Production Systems by Integrating Forage Cover Crop Grazing

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Abstract

In addition to their value as cereal grains, wheat (*Triticum aestivum* L.) and triticale (× *Triticosecale* Wittmack) are important cool-season annual forages and cover crops. Yearling steer (*Bos taurus*) performance was compared in the spring following autumn establishment as for age cover crops after soybean [*Glycine max* (L.) Merr.] grain harvest. Replicated pastures (0.4 ha) were no-till seeded in three consecutive years into soybean stubble in autumn, fertilized, and grazed the following spring near Ithaca, NE, USA. Each pasture (n = 3) was continuously stocked in spring with four yearling steers (380 ± 38 kg) for 17, 32, and 28 d in 2005, 2006, and 2007, respectively. In 2005, average daily gain (ADG) for steers grazing triticale exceeded the ADG for wheat by 0.31 $\text{kghd}^{-1}\text{d}^{-1}$. In 2006, wheat ADG exceeded that for triticale by 0.12 $\text{kghd}^{-1}\text{d}^{-1}$. In 2007, steers grazing wheat lost weight, while steers grazing triticale gained 0.20 $\text{kghd}^{-1}\text{d}^{-1}$. Based on the 3-year average animal gains valued at \$1.32 kg^{-1}, mean net return (\$ ha^{-1} yr^{-1}) was \$62.15 for triticale and \$22.55 for wheat. Since these grazed cover crops provide ecosystem services in addition to forage, grazing could be viewed as a mechanism for recovering costs and adds additional value to the system. Based on this 3-year grazing trial, triticale was superior to wheat and likely will provide the most stable beef yearling performance across years with variable weather for the western Cornbelt USA.

Keywords

Cover crops, Soybean, Triticale, Wheat

1. Introduction

One of the most common cropping rotations in the eastern Great Plains and Midwest USA is maize (*Zea mays* L.) followed by soybean [*Glycine max* (L.) Merr.]. Within this cropping rotation, the two most used cropping sequences are maize-soybean-maize and maize-maize-soybean in a 3-yr rotation. Maize residue provides good soil cover plus an inexpensive and reliable forage for late autumn and winter grazing by beef cattle (*Bos* spp.) with approximately 2 million ha of maize residue grazed each year in Nebraska alone [1]. The soybean component of the rotation may lack adequate winter soil cover and limit forage opportunities for livestock grazing. Seeding winter cereal forage crops into soybean stubble is one way to address the lack of adequate soil cover while providing livestock forage the following spring. Compared to maize, the limited residue following soybean reduces establishment risk and increases the probability of successfully establishing forage cover crops. Little information is available for producers to integrate forage cover crops into a crop-livestock system and on the grazing livestock response from forage cover crops in multifunctional cropping systems in the Great Plains and Midwest USA.

In the southern Great Plains, winter wheat (*Triticum aestivum* L.) is used extensively and is a major forage source for autumn and spring grazing [2]. While the potential forage production in annual-only forage systems is readily apparent, it is less apparent when incorporating annual forages into grain cropping systems. In the northern half of the Midwest and Great Plains, the remaining growing degree days after harvesting either longer season maize hybrids or longer season soybean maturity groups are inadequate to produce any appreciable amount of autumn forage from autumn seeded winter annual cereals. However, planting a winter annual species such as winter wheat or winter triticale (× *Triticosecale* Wittmack) in the autumn as a cover crop may permit enough spring growth to provide a short-season pasture crop in the spring. This would be advantageous because forage production in early spring limits livestock production potential in the Great Plains and Midwest. In much of the region, livestock producers often move cattle from winter grazing on maize stover directly to perennial cool-season grass pastures in spring or feed hay prior to moving to spring pastures.

Interest is increasing in utilizing the winter small grains for forage, bioenergy, and cover crops, including their use as a double-cropped option in grain crop rotations [3] [4]. Winter wheat and winter triticale are well suited for double-cropped forage systems following maize and soybean production to extend the spring grazing season and provide a cover crop in the Great Plains and Midwest. Baenziger and Vogel [5] suggested that winter triticale could be planted after maize or soybean harvest, with the forage available the following year before planting another annual summer crop.

From a forage management standpoint, small grain annual forages offer production flexibility. However, the risks and trade-offs associated with this increased flexibility are also increased. Including annual forages into cropping systems provides a readily available source of high-quality grazing. These can be used to provide alternative grazing options, extend the grazing season, increase dollar return per hectare, and intensify management.

The objective of this study was to compare the grazing potential of winter wheat and winter triticale planted as a double-cropped forage following soybean in eastern Nebraska and their potential economic value. This information would help identify which winter small grain species may provide the most dependable forage production and livestock performance for forage that is double-cropped or cover-cropped as part of an integrated beef production system in the region.

2. Materials and Methods

Certified seed of "Millenium" winter wheat and "NE422T" winter triticale was obtained from commercial vendors. Pastures were seeded after soybean harvest in late September to early October 2004, 2005, and 2006and grazed in spring 2005, 2006, and 2007 at the University of Nebraska's Eastern Nebraska Research, Extension and Education Center (UNL-ENREEC) near Ithaca, NE (41.17˚N. Lat., 96.47˚W. Long., Elevation 366 m) on an Aksarben silty clay loam soil (fine, smectitic, mesic, Typic Argiudoll). Experimental units were three 0.4 ha pastures of each species arranged as a randomized complete block design. Each experimental unit was uniformly cropped in maturity group 1 glyphosate-tolerant soybean using standard management practices before pasture seeding. Pastures were no-till seeded in October after soybean harvest into stubble using a Truax no-till drill (Truax Company, Inc., Minneapolis, MN, USA) at a depth of 2.5 cm and a seeding rate of 320 PLS m^{-2}. Broadleaf weed competition was minimal and no pasture herbicides were required. Ammonium nitrate (NH_4NO_3; 34-0-0) was surface applied using a broadcast spreader at 67 kg N ha^{-1} after planting in autumn 2004, 2005, and 2006. Each pasture was randomly assigned to at the beginning of the study and planted to the same species and variety during all three years of the study. Cross fences were removed each spring after grazing to facilitate soybean planting, spraying, harvesting, and pasture seeding.

Each pasture was continuously stocked with four crossbred yearling steers (380 ± 38 kg) in spring 2005, 2006, and 2007. Grazing animals were identified by unique ear tag numbers, assigned to a specific pasture treatment based on ear tag number, and visually verified for appropriate pasture location throughout each grazing cycle. Cattle were penned for at least 5 d while being limit fed at 2% of body weight a diet consisting of 50% wet corn gluten feed (Sweet Bran, Cargill Inc., Blair, NE) and 50% hay on a dry matter (DM) basis. Cattle were then weighed on 2 consecutive d to obtain an average beginning limit-fed body weight [6]. The same feeding and weighing procedures were used before and after the grazing period to determine initial and final weight to minimize any effects due to fill [6]. This is a maintenance diet developed for stabilizing animal weights, so the 5 d of limit feeding was not included in the yearling performance data. Grazing was initiated on 20 April in 2005, 28 April in 2006, and 2 May in 2007. Grazing was terminated in all pastures when the first of the nine pastures reached 5 cm stubble height. Soybean was no-till drill seeded into the grazed cover crop stubble.

Herbage from each pasture was sampled the day before grazing started and at 7-d intervals during grazing and when grazing ceased to determine forage mass and nutritive value. Each pasture was subsampled at three random locations for a particular harvest date and then pooled to create a single sample for analysis for the experimental unit on that date. The three forage sampling locations within a pasture were randomly selected by walking a transect across each pasture, randomly placing the quadrat and clipping samples from where the quadrat came to rest. Nutritive value assessments included in vitro dry matter digestibility (IVDMD), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL). Total DM forage mass was determined by hand-clipping all herbage to a 2.5 cm stubble height within three, 0.54 m^2 rectangular quadrats randomly-located within each pasture.

Harvested samples were dried in a forced-air oven at 55˚C to a constant weight and dry weight was determined. Dried samples were ground to pass a 2 mm screen in a Wiley mill followed by a 1 mm screen in a cyclone mill (Thomas-Wiley Mill Co., Philadelphia, PA) and scanned on a near-infrared reflectance spectrophotometer (NIRS; Model 6500, Silver Spring, MD). A calibrationset of 100 samples for IVDMD, NDF, ADF, and ADL, and 60 samples for CP was chosen by cluster analysis of the reflectance data [7]. Calibration samples were analyzed in triplicate for IVDMD with the ANKOM Rumen Fermenter (ANKOM Technology Corp., Fairport, NY) using the procedures described by Vogel *et al.* [8]. Crude protein concentration (%N × 6.25) was determined by the LECO combustion method (Model FP 428 and FP 2000, LECO Corp., St. Joseph, MI) [9] [10]. Calibration samples were analyzed in duplicate for NDF and ADF with the ANKOM Fiber Analyzer (ANKOM Technology Corp., Fairport, NY) using the procedures described by Vogel *et al.* [8] and the ANKOM ADL procedure (ANKOM Technology −9/99, Method for Determining Acid Detergent Lignin in Beakers). Laboratory means were used to develop calibration equations by partial least squares [7]. Values for IVDMD, CP, NDF, and ADL were predicted for each year with a single calibration equation per variable.

Analysis of variance (ANOVA) procedures were used to test for differences among species for ADG, total gain ha^{-1}, forage mass, IVDMD, CP, NDF, ADF, and ADL. Statistical significance is at the 0.05 probability level unless otherwise stated. Pasture was the experimental unit for all analyses.

3. Results

Differences in precipitation distribution (**Figure 1**) resulted in 17 grazing d in 2005, 32 grazing d in 2006, and 28 grazing d in 2007. Precipitation in October each of the years when the cereal cover crops were established was only about

50% of the long-term average precipitation for the month resulting in the slow establishment of the cereals which affected their spring productivity (**Figure 1**). In each year of this study, grazing on the cool-season annual pastures was initiated when forage growth in all six pastures was at least 10 cm.

In 2005, grazing began on 20 April when wheat and triticale were elongating but not reproductive. By 5 May, forage had been trampled and grazed to less than 5 cm in the wheat and triticale pastures and cattle were removed from all pastures (**Figure 2**). The wet April immediately prior to grazing in 2005 resulted in trampling of much of the aboveground biomass, limiting the available for age

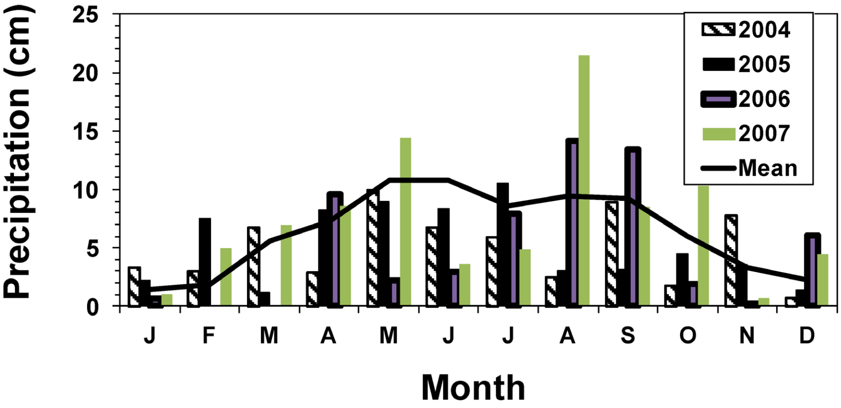

Figure 1. Monthly precipitation received at Ithaca, NE in 2004, 2005, 2006, and 2007 (NOAA, 2008). Monthly mean precipitation is represented by the solid line. Total annual precipitation was 604, 627, and 592, and 91.1 mm in 2004, 2005, 2006, and 2007, respectively, with a 30-year average of 766 mm.

Figure 2. The pastures were continuously stocked until forage became limiting in one of the cool-season annuals as in this wheat pasture on 5 May, 2005 near Ithaca, NE, the last day of grazing in 2005. Soybean was no-till seeded directly into the forage stubble.

and shortening the grazing period to 17 days in 2005. In 2006, cattle began grazing on 28 April and were removed from the pastures on 30 May. In 2007, cattle began grazing on 2 May and were removed from the pastures on 29 May.

3.1. Livestock Performance

Steer ADG and total gains were positive for both forages in 2005 and 2006, but only steers grazing triticale gained weight during the grazing period in 2007 (**Table 1**). The mean ADG for steers grazing wheat and triticale ranged from −0.22 to 1.64 kg $hd^{-1}d^{-1}$ during the grazing periods in 2005, 2006, and 2007.

The mean total gains for steers grazing wheat and triticale ranged from −62 to 385 kg ha^{-1} during the grazing periods in 2005, 2006, and 2007. In 2005 and 2006, livestock performance for both small grain forages were positive, with the greatest gains occurring in triticale in 2005 and wheat in 2006. However, in 2007, only steers grazing triticale gained weight, while steers grazing wheat lost weight. During the 3-year grazing trial, steers grazing triticale averaged greater ADG and weight gain than steers grazing wheat, and triticale provided the most stable steer performance across years in this study.

3.2. Forage Mass and Nutritive Value

Forage mass was variable across the 3-year study (**Table 2**). Mean grazing period forage mass was similar for wheat and triticale in 2005 (**Table 2**). However, in 2006 and 2007, wheat produced 23% greater forage mass than triticale.

Forage nutritive value as measured by IVDMD and CP was variable across the 3-year study (**Table 2**). In 2005, and wheat and triticale had similar IVMDM, but CP was greater for wheat. In 2006, there was no difference between the IVDMD and CP for wheat and triticale. However, in 2007, the IVDMD and CP were both greatest for triticale. The forage nutritive value for both wheat and triticale was favorable for animal performance and suggests that intake rather than diet quality caused the differences in animal performance.

The differences in NDF were variable across years. In 2005 and 2007, NDF in triticale was lower than that for wheat (**Table 2**). However, in 2006 NDF for wheat was lower than that for triticale. Similarly, there were no differences for ADF concentration in 2005 across species. The ADF concentration for wheat and triticale was similar in 2006. In 2007, triticale had the lowest ADF concentration. Acid-detergent lignin was greatest in 2007 and lowest in 2005, within and across species.

Some of our findings were contradictory to those of Twidwell *et al.* [11], who noted that forage nutritive value of triticale, from the boot to soft-dough growth stage, was lower than wheat forage. The differences in results could be due to different cultivars being used in the two studies or increased nutritive value in improved triticale cultivars. In this study, we noted that triticale usually had the lowest forage mass coupled with the greatest nutritive value compared with wheat.

Table 1. Beef cattle gains on fertilized winter wheat and winter triticale pastures at Ithaca, NE in 2005, 2006, and 2007. Each pasture was grazed by 4 yearling steers for 17, 32, and 28 days in 2005, 2006, and 2007, respectively.

Species	2005	2006	2007	Mean	2005	2006	2007	Mean
	Average daily gain (kg hd^{-1})				Total body weight gain (kg ha^{-1})			
Wheat	0.88	1.22	−0.11	0.66	122	385	−29	159
Triticale	1.19	1.10	0.20	0.83	165	347	55	189
LSD				0.13				29

Table 2. Grazing period mean forage mass (FM), in vitro dry matter digestibility (IVDMD), crude protein concentration (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) of available forage from winter wheat and winter triticale pastures grazed by beef cattle near Ithaca, NE. Values represent the mean of samples collected from 3 pasture replicates for each species at 7-d intervals from grazing initiation to grazing completion in 2005, 2006, and 2007.

Strain	Year	FM	IVDMD	CP	NDF	ADF	ADL
		Mg ha^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}
Wheat	2005	1.13	764	275	588	289	38.1
Triticale		1.01	762	264	583	281	37.5
Wheat	2006	2.72	720	164	594	317	41.9
Triticale		2.21	715	161	607	330	42.9
Wheat	2007	1.47	667	200	637	341	52.7
Triticale		1.20	691	221	618	325	51.1
SE		0.13	6.4	7.0	4.3	4.3	1.0

4. Discussion

There is an abundance of published data on the agronomic performance of small grain forages [2] [12] [13] [14]. In all forages including cool-season annuals, season of growth and plant maturity are considered the primary factors determining forage nutritive value. However, the year-to-year variability in both forage mass and nutritive value observed in this study suggests that there may be other overriding influences. The differences in forage nutritive value were minor and almost always above the general recommendations to support animal gains [15].

Forage mass nutritive value of rainfed, cool-season annuals varies broadly based on variations in weather. In Michigan, planting cereal rye and triticale into maize residue produced 6.5 and 8.1 Mg ha^{-1} of biomass, respectively, in a wet year, but only 1.6 and 1.2 Mg ha^{-1}, respectively in a dry year, indicating the potential yield variability in dryland cover crops [14]. In Kansas, Harmoney and Thompson [13] analyzed forage yield and nutritive value from a 9-year. small grain trial and concluded that environment was more important than cultivar due to the cultivar x environment interaction.

In our study, there were variable spring growth and production patterns. Much of this variability can be attributed to differences in weather conditions, but planting date may be an important factor as well. For example, Griggs [12] recognized that earlier autumn seeding dates for small grain forages resulted in greater spring forage yield. Even though pastures were no-till seeded in early October during all three years of this study, minimal autumn precipitation occurred. The favorable forage nutritive value in wheat and triticale appears to offset the lower forage yields. Earlier planting in autumn likely would have benefited both forages.

The observed differences in animal gain were likely due to the maturity differences of the forage cover crops. As plants rapidly matured in the spring, the nutritive value of the small grain forage cover crops declined while forage mass increased. During the 2 years when grazing occurred as plants were in the early elongation stages of development, livestock gains were favorable. However, in the third year when plants were in the boot stage as grazing began, livestock gains were poor. Carefully managing grazing initiation in these small grains will help reduce the likelihood of steers losing weight while grazing.

A likely explanation for the negative ADG for wheat in 2007 was that the advanced maturity of the forage on offer limited the ability of steers to intake adequate nutrients. The combination of the advanced maturity and the decrease in forage digestibility reduced the ability of the steers to intake enough forage to meet the energy maintenance levels for this weight class of yearling steers.

This is a classic situation where available forage and forage nutritive value is adequate to support livestock gains, but the morphology of the forage source restricts the ability of the animal to graze enough forage to intake adequate nutrients. In 2007, available forage was similar for wheat and triticale on common days of the year (**Figure 3**), but IVDMD and CP were typically greatest for triticale and lowest for wheat on common days of the year (**Figure 4**). It appears the slightly greater IVDMD and CP for triticale and the reduced stems and inflorescences provided enough nutrient intake to result in positive animal gains. The available forage and nutritive value of wheat were adequate to support positive animal gains. However, it appears these yearlings grazing wheat needed additional forage intake to gain weight. Anecdotal reports of steers losing weight while grazing small grain for ages occur occasionally, but research reports are lacking. Although our interests were beef production potential from spring grazing monoculture small grains, there may be value in grazing of mixtures of cool-season annual grasses.

5. Conclusions and Implications

Using small grains for cover crops or for forage is becoming increasingly popular with producers. However, it is difficult to quantify all the economic benefits of these small grains. Our data provides unique opportunities to quantify the net returns from grazing winter wheat and winter triticale in the western Corn belt

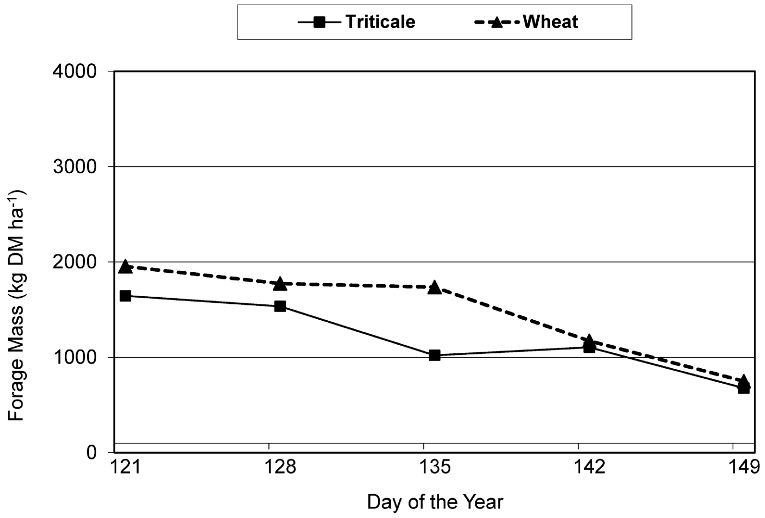

Figure 3. Forage mass on a dry matter basis for triticale and wheat forage on 7-d intervals before, during, and after grazing on pastures near Ithaca, NE in 2007.

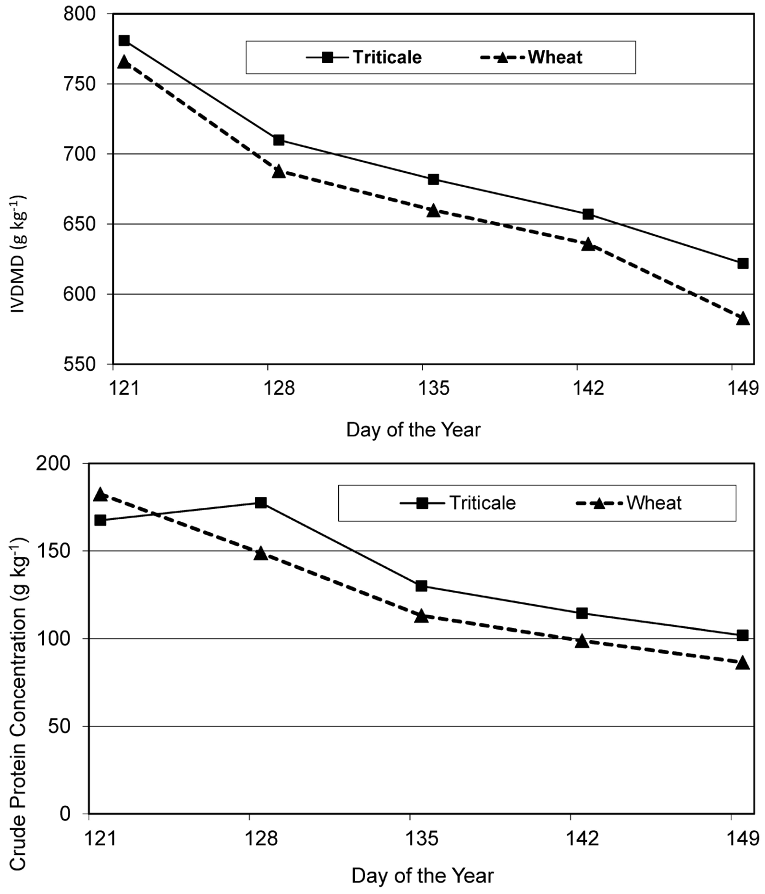

Figure 4. In vitro dry matter digestibility (IVDMD) and crude protein concentration (CP) for triticale and wheat forage on 7-d intervals before, during, and after grazing on pastures near Ithaca, NE in 2007.

USA. Assuming the same costs for each small grain crop and a field size of 65 ha, a typical field size in the western Corn belt, we estimated the agronomic inputs (seed, seeding, fertilizer, & herbicides, and application costs minus overhead) and animal inputs (temporary electric fence and hauling water daily) using 2017 costs for eastern Nebraska (**Table 3**). Using the 3 yr average animal gains per ha for each small grain and a value of \$1.32 kg^{-1} of animal gain, triticale had the greatest net return (\$62.15 ha^{-1} yr^{-1}) followed by wheat (\$22.55 ha^{-1} yr^{-1}). Since these small grains provide ecosystem services in addition to forage, grazing could be viewed as a mechanism for recovering costs and does not necessarily need to have positive net returns to benefit the system. Further economic analyses are needed to evaluate other potential returns and manage risk at the farm scale. For example, increasing carrying capacity for cows may provide more value than gain for yearlings.

The grazing performance data suggests that opportunities exist for improving the management of forage cover crops following soybean. While there are many positives to incorporating small grain annual forages into existing cropping systems, it is important to recognize that differences in production, nutritional value, and animal gain exist and may have unexpected results. For small grain grazing following soybean in the central Great Plains, there is a 2- to 5-week window of opportunity for spring grazing. Cereal rye may provide an advantage since it begins spring growth earlier than either triticale or wheat, resulting in a much earlier maturity for cereal rye which also causes forage quality to decline more quickly. Additionally, starting grazing earlier in the spring will likely improve forage utilization and limit some of the grazing issues associated with advanced maturity.

Table 3. Mean agronomic inputs, animal inputs, beef cattle yearling gain per ha, animal return per ha, and mean net return per ha for fertilized wheat and triticale pastures at Ithaca, NE in 2005, 2006, and 2007. Pastures were planted in autumn after soybean harvest and grazed the next spring for 17, 32, and 28 days in 2005, 2006, and 2007, respectively. Stocking rate was 4 steers per 0.4 ha pasture with 3 replicates per small grain pasture per year. Animal gain is the 3-yr mean body weight gain per ha for steers grazing each small grain pasture.

Small grain	Agronomic input costs†	Animal input costs††	Animal gain	Animal return†††	Mean net return††††
	\$ ha^{-1} yr^{-1}	\$ ha^{-1} yr^{-1}	kg ha^{-1} yr^{-1}	\$ ha^{-1} yr^{-1}	\$ ha^{-1} yr^{-1}
Wheat	170.26	17.07	159	209.88	22.55
Triticale	170.26	17.07	189	249.48	62.15

† Agronomic input costs (\$ ha^{-1} yr^{-1}) included seed, seeding, fertilizer, weed control, and application costs minus overhead [16].

†† Animal input costs (\$ ha^{-1} yr^{-1}) included the cost to install and remove temporary fencing at \$7 per ha and water hauling at \$12.18 per day (6.4 km per day × \$0.34 per km + 0.5 hours labor at \$20 per hour). Based on a 64.7 ha pasture and an average of 26 grazing days per year, the 3-year average water cost is \$4.89 per ha and a total animal input cost of \$17.07 ha^{-1} yr^{-1}.

††† Animal return (\$ ha^{-1} yr^{-1}) was calculated as \$1.32 kg^{-1} of animal gain.

†††† Mean net return (\$ ha^{-1} yr^{-1}) was calculated as the difference between animal return, agronomic costs, and animal costs (animal return-agronomic costs-animal costs).

Based on these findings, it appears the negative results in our data occurred from normal environmental variation and subsequent agronomic response. Additionally, it is important to note the difficulty in capturing absolute animal performance estimates in 17- to 32-day grazing periods, a perpetual problem with spring small grain grazing studies in the western Corn belt. Consequently, the 3-year average animal performance estimates likely provide the most meaningful information.

Although 3 years of continuous soybean is not a common management practice, other management strategies used in this study were typical for the Corn Belt. A majority of the soybean harvest in this region is completed by mid- to late-October. Consequently, most small grain planting would occur after October 15, which does not allow enough time for small grains to accumulate enough forage for grazing before the first killing frost. This limits forage cover crop choice following soybean to the winter small grain forage species, such as cereal rye, triticale, wheat, or barley (*Hordeum vulgare* L.). Producers in the western corn belt typically plant soybeans with a range of maturity to spread out the harvesting season. Fields planted to early maturing soybeans would increase the likelihood of grazing forage cover crops the following spring. Winter annual small grain cover crops planted after later maturing soybeans would still have conservation benefits but spring grazing opportunities may be limited depending on yearly climatic fluctuations. Additionally, planting these cover crops each year after soybeans provides an opportunity for at least a short-term continuous soybean production system that could significantly reduce or eliminate exogenous N fertilizer application compared to current maize-soybean crop rotations.

Currently, the primary use for triticale is as a cover crop or double-cropped forage planted in the autumn after maize or soybean harvest. This use can provide a cover crop to meet conservation compliance on sandy soils and a source of high-quality forage which can be grazed or harvested in spring before planting maize or soybean in the annual crop rotation. Using regionally-adapted improved cultivars will optimize animal performance.

Statement

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Abbreviations

ADF, acid detergent fiber; ADL, acid detergent lignin; ADG, average daily gain; BW, body weight gain; CP, crude protein concentration; DM, dry matter content; FM, forage mass; IVDMD, in vitro dry matter digestibility; NDF, neutral detergent fiber.

Conflicts of Interest

The authors assert that there are no conflicts of interest about the publication of this paper.

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