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Overseeding Annual Ryegrass and Cereal Rye into Soybean as Part of a Multifunctional Cropping System: II. Forage Yield and Nutritive Value

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Abstract

Annual ryegrass (*Lolium multiflorum* Lam.) and cereal rye (*Secale cereale* L.) are two forages that could fit well into mixed row-crop/livestock operations because they can be used both as a cover crop and as a source of winter pasture. Yet few researchers have studied how to integrate these forages in a soybean [*Glycine max* (L.) Merrill]-winter pasture-corn (*Zea mays* L.) rotation. An experiment was conducted where these forages were overseeded at different stages of soybean development over two years. All treatments yielded over 2,250 lb of forage per acre each year (with the best treatments yielding over 3,000 lb/acre), which would supply much needed pasture for winter grazing. While all treatments provided adequate amounts of forage, overseeding into soybean at the R 6.5 stage (at leaf drop) consistently produced the greatest yields for both annual ryegrass and cereal rye. Forage nutritive value from annual ryegrass was slightly better than for cereal rye, but both had crude protein concentrations of more than 17% and neutral detergent fiber of less than 56%. The results show that livestock operations in the lower Midwest could use cereal rye and annual ryegrass overseeded into soybean as part of a row crop–winter pasture–row crop rotation.

Introduction

Pasture is typically the most economical source of nutrients for beef cattle (5) but the availability of forage from pasture fluctuates throughout the year. In the lower Midwest, the longest period of inadequate forage supply from pasture is from mid-December through mid-March (9). A resource often overlooked in the lower Midwest is the use of winter annual forages planted into row-crop fields. Besides the benefits as a cover crop (6), the establishment of a winter annual forage prior to or immediately after soybean harvest has the potential to provide winter pasture for the lower Midwest's 4.9 million beef cows and 2 million stocker calves (11). High-quality feed in autumn is especially attractive to producers who would use a winter annual forage as feed for retained ownership of spring-born stocker calves (3). Although this could increase the profitability of both beef and row-crop operations, little research has been done to examine the prospective benefits of winter annual forages as part of a multifunctional cropping system in the lower Midwest.

Annual ryegrass and cereal rye are two forages that beef producers in the lower Midwest are interested in to extend the grazing season for beef cattle. Recent economic analyses show that extending the grazing season with annual ryegrass or cereal rye can reduce winter feed costs for beef cattle by more than 40% (1). Beef producers are interested in annual ryegrass because it produces 1 to 2 tons of high-nutritive value feed per acre before December and an additional 2 to 4 tons in the spring (2,3). Cereal rye is also an option for extending the grazing season. It is the most winter hardy of the small grains, and it is also the most productive because it grows into late autumn and again in early spring (16).

Although the potential is enormous to plant annual ryegrass or cereal rye as a winter forage crop on the lower Midwest's 26 million acres of soybean fields, there are still some questions that need to be answered regarding this practice. Perhaps one of the most important questions that producers want answered is: "When should I plant annual ryegrass or cereal rye into soybean fields to maximize autumn forage growth?" A review by Evers (4) suggested that planting annual ryegrass and/or cereal rye six to eight weeks prior to the first killing frost is essential to having forage available for winter pasturage. One limitation to seeding a winter annual forage after soybean harvest would be the limited number of growing days prior to cold weather. Overseeding these crops prior to harvest of soybean would provide more possible days of growth in autumn.

We hypothesized that beef cattle producers in the lower Midwest could overseed cereal rye or annual ryegrass into soybean as a source of forage for autumn and early spring grazing. Further, we thought that overseeding cereal rye or annual ryegrass into soybean during the growing season would provide more forage growth prior to winter compared to waiting until after grain harvest. Our objective was to determine how seeding date impacts forage production of annual ryegrass and cereal rye when overseeded into soybean fields.

Overseeding Annual Ryegrass and Cereal Rye into Soybean for Winter Forage

Forage growth from annual ryegrass and cereal rye overseeded into standing soybean was studied at Bradford Research and Extension Center, near Columbia, MO (38°57'N, 92°20'W) during the autumn, winter, and spring of 2003-2004 and 2004-2005. Hereafter the 2003-2004 season will be referred to as Year 1, and the 2004-2005 season as Year 2.

Annual ryegrass and cereal rye treatments were overseeded at soybean reproductive stages R 5.5, R 6.5, and R 8. A detailed description of the planting dates, an explanation of soybean reproductive stages, and the experimental protocol for the soybean and the subsequent corn crop are described in detail in a companion paper (17). Either 'Saddle Pro' annual ryegrass or 'Wintergrazer 70' cereal rye was overseeded into soybean at 35 and 125 lb, respectively, of pure live seed per acre (Fig. 1). The annual ryegrass and cereal rye was overseeded with a drop type seeder. After soybean harvest in mid-September, ammonium nitrate at 60 lb of N as per acre was broadcast to stimulate annual ryegrass and cereal rye growth. In early March, an additional 60 lb of N per acre were applied to maximize spring growth.

Fig. 1. Cereal rye seedlings that were overseeded at soybean reproductive stage R 5.5.

Table 1. Harvest dates for Year 1 and Year 2 of annual ryegrass and cereal rye overseeded at different soybean reproductive stages. Year 1 was the autumn and spring of 2003-2004 and Year 2 was autumn and spring of 2004-2005. Forage was harvested when an individual treatment averaged 15 rising plate meter units (8 to 10 inches in height).

Species	Reproductive stage of soybean	Year 1 harvest dates	Year 2 harvest dates
Annual ryegrass	R5.5	30 Oct, 5 April, 19 April, 26 April	25 Oct, 8 Nov, 15 April, 25 April
Cereal rye	R5.5	24 Oct, 2 April, 14 April, 26 April	25 Oct, 1 April, 15 April, 25 April
Annual ryegrass	R6.5	30 Oct, 24 Nov, 5 April, 19 April, 26 April	25 Oct, 8 Nov, 15 April, 25 April
Cereal rye	R6.5	24 Oct, 2 April, 14 April, 26 April	25 Oct, 1 April, 15 April, 25 April
Annual ryegrass	R8	17 Nov, 5 April, 19 April, 26 April	8 Nov, 15 April, 25 April
Cereal rye	R8	2 April, 14 April, 26 April	8 Nov, 1 April, 15 April, 25 April

Starting in early October, forage growth from overseeded plots was evaluated weekly by taking 20 readings from each plot using a rising plate meter (14). When the average of the five replications for a treatment reached 15 rising plate meter units, forage from that treatment was harvested as described below. Annual ryegrass and cereal rye were typically 8 to 10 inches tall when 15 rising plate meter units were attained. Once a treatment reached 15 rising plate meter units, forage yield was determined by clipping three, 4.1-ft × 25-ft strips from each plot. Harvest dates are listed in Table 1. All forage was harvested using a Hege 212 sickle-type forage harvester (Wintersteiger, Waldenburg, Germany) set to leave a three-inch stubble. The combined fresh mass of the three strips in each plot was recorded. A 0.75-lb (± 0.05 lb) sub-sample from each plot was dried at 122°F for at least 96 hours in a forced air oven to determine dry matter. To better understand the seasonality of forage production, forage yield was divided into three categories: autumn, spring, and total yield. After the samples were dried, the forage was ground to pass through a 0.04-inch (1-mm) screen using a cyclone mill (Udy Corporation, Fort Collins, CO).

Crude protein, acid detergent fiber, and neutral detergent fiber were measured from ground samples with near infrared reflectance spectroscopy (NIRS) using the scanning, calibration, and validation methods described by Marten et al. (8) (Table 2). Crude protein for calibration samples was determined by measuring total N content using a LECO FP-428 (LECO Corp., St. Joseph, MI) and then multiplying N values by 6.25. Acid detergent fiber and neutral detergent fiber for calibration samples were determined using the methods described by Van Soest et al. (19). Crude protein, acid detergent fiber, and neutral detergent fiber were calculated as autumn and spring averages. These averages were weighted according to the yield for each harvest within each period.

Table 2. Near-infrared reflectance spectroscopy calibration and validation statistics for crude protein, acid detergent fiber, and neutral detergent fiber.

Constituent	n	Mean (%)	SEC[w] (%)	SECV[x] (%)	R^{2}[y]	1-VR[z]
Crude Protein	129	18.7	0.9	1.1	0.98	0.97
Acid detergent fiber	128	28.6	2.1	3.0	0.95	0.90
Neutral detergent fiber	131	46.9	2.0	2.9	0.97	0.94

[w] SEC = standard error of calibration.

[x] SECV = standard error of cross-validation in modified partial least squares regression.

[y] R^2 = Coefficient of determination for calibration.

[z] 1-VR = 1 minus the variance ratio calculated in cross-validation during modified partial least squares regression.

Statistical Analysis

The six treatments were replicated five times in a completely randomized design [30 total plots (5 replications × 6 treatments)]. Analysis of variance was conducted on forage type by seeding date combinations (main plots in a 2 × 3 factorial arrangement), years (sub-plots), and when appropriate, harvest period (sub-sub-plots) and all possible interactions using the model outlined by Steel and Torrie (18). Statistical Analysis Systems software (version 8.2) was used to analyze the data (SAS Institute Inc., Cary, NC). All interactions on main effects and all possible interactions were considered significant when $P < 0.05$. Interactions with between treatments and years were significant for nearly all measurements, so statistical analyses were conducted for each year separately.

Forage Yield of Annual Ryegrass and Cereal Rye in a Multifunctional Cropping System

Autumn forage yield. In autumn of Year 1, annual ryegrass overseeded at R 6.5 and cereal rye overseeded at R 5.5 yielded the most autumn forage, averaging 1,326 lb/acre (Fig. 2). Cereal rye overseeded at R 8 yielded the least autumn forage as it never reached the 15 rising plate meter units (8- to 10-inch height) needed to trigger a forage harvest. In autumn of Year 2, annual ryegrass overseeded at R 6.5 yielded 1,669 lb/acre which was 23 to 62% more than the other treatments. The lowest yielding treatments in autumn of Year 2 were the cereal rye overseeded at R 5.5 and R 6.5 which averaged only 773 lb/acre. While there were some variations among treatments between years, annual ryegrass overseeded at R 6.5 consistently yielded well in autumn. While our best-yielding treatment produced slightly less forage than that reported by Kallenbach et al. (7), their seeding method was into a prepared seedbed, so it is understandable that in our overseeding scenario autumn forage yields were less. Work by Evers (4) found that overseeding annual ryegrass into existing bermudagrass sods yielded less autumn forage than when planted into a prepared seedbed. Annual ryegrass overseeded into soybean responds similarly.

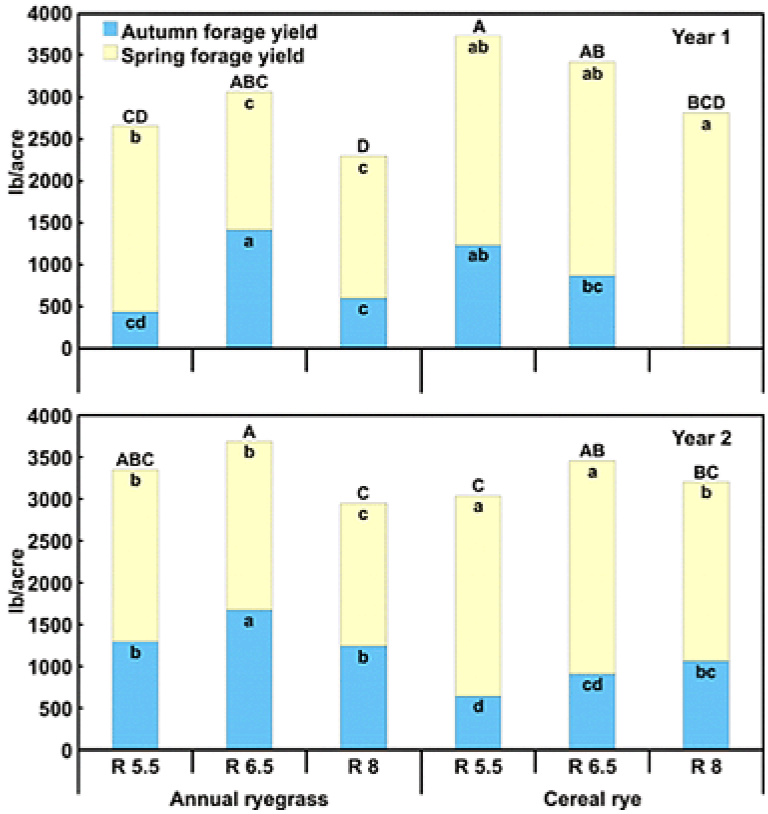

Fig. 2. Autumn, spring, and total forage yield of annual ryegrass and cereal rye overseeded into soybean at different reproductive stages. Year 1 was the autumn and spring of 2003-2004 and Year 2 was the same time in 2004-2005. Bars with different letters within a year are significantly different ($P < 0.05$) using Fisher's protected LSD. Lower case letters inside bars are for autumn and spring yield and capital letters on top of bars are for total forage yield.

Spring forage yield. In spring, cereal rye began to grow earlier and thus, tended to produce more spring forage than annual ryegrass (Fig. 2). Cereal rye's spring forage production was similar each year, with all of these treatments yielding approximately 2,500 lb/acre. Annual ryegrass yields in spring were sometimes equal to, but often less than, those of cereal rye. The cereal rye yields from our experiment in the spring are similar to the results reported by Moyer and Coffey (10), and both the annual ryegrass and cereal rye yields are similar to those of Kallenbach et al. (7) in the second year of their study. The annual ryegrass in this study was at a disadvantage to cereal rye, as both forages were terminated in late April to allow for a corn crop to be planted. Thus, while the cereal rye had nearly completed its annual growth before this time, the annual ryegrass was still actively growing and would have produced additional spring forage if the cropping system would have permitted it.

Total forage yield. Total forage yield varied among treatments, but annual ryegrass and cereal rye overseeded at R 6.5 were always in the highest yielding group (Fig. 2). In Year 1, annual ryegrass overseeded at R 6.5 and cereal rye overseeded at R 5.5 and R 6.5 averaged 3,407 lb/acre, which was 33% more than the lowest yielding treatment. For Year 2, the annual ryegrass overseeded at R 5.5 and R 6.5 and the cereal rye overseeded at R 6.5 yielded the most total forage (average of 3,496 lb/acre).

Our data show that the R 6.5 stage is the best time to overseed both annual ryegrass and cereal rye into soybean, as this timing consistently gave the greatest total forage yields. Additionally, the annual ryegrass overseeded at R 6.5 consistently yielded the most autumn forage from year to year. Annual ryegrass overseeded at R 6.5 would be best for winter-feeding, as it offers the greatest autumn yields and thus more days of grazing in late autumn. The autumn growth could also be stockpiled and grazed later in the winter (7). Cereal rye overseeded at R 6.5 consistently yielded the most spring forage. It offers the benefit of having the most forage available early in the spring, which is an important feature for year-round grazing systems (10).

Nutritive Value of Annual Ryegrass and Cereal Rye in a Multifunctional Cropping System

Crude protein was approximately 11 percentage units greater in autumn than spring but, with one exception, crude protein was equal within a harvest period for all treatments both years (Fig. 3). The one exception was in the autumn of Year 1, when cereal rye overseeded at R 6.5, had a crude protein concentration of 31%, which was three percentage units greater than any other treatment. Crude protein never fell below 17% in any treatment; this concentration is more than sufficient for nearly any class of beef or dairy cattle (12,13).

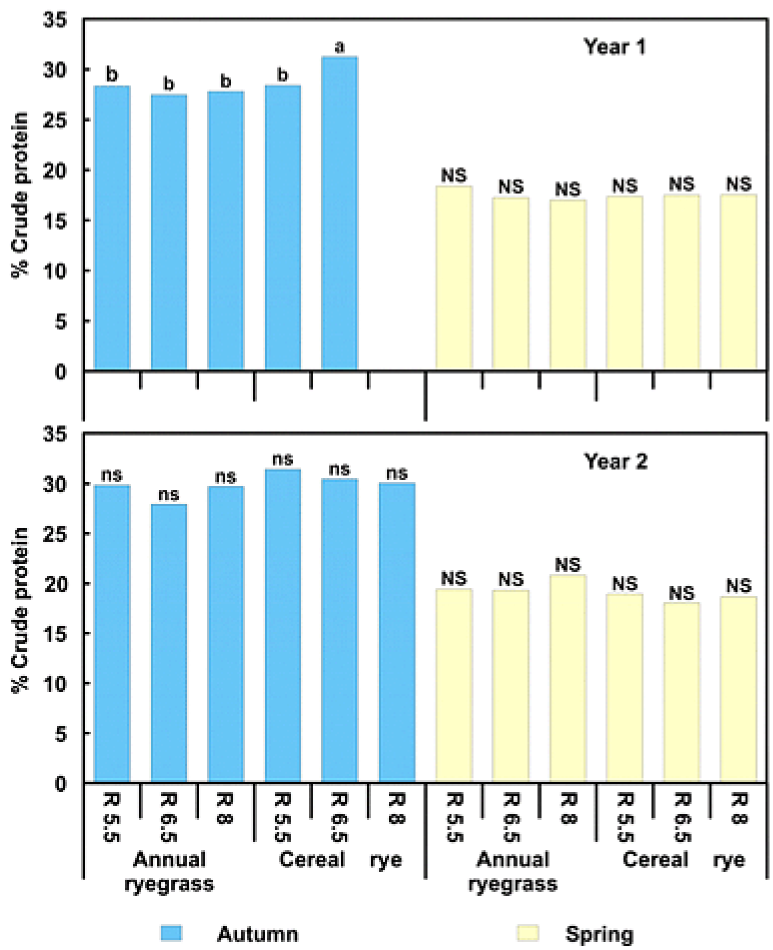

Fig. 3. Crude protein of annual ryegrass and cereal rye overseeded into soybean at different reproductive stages. Year 1 was the autumn and spring of 2003-2004 and Year 2 was the same time in 2004-2005. Data were weighted according to the yield from each harvest within a period. Bars with different letters within a year and harvest period (autumn or spring) are significantly different ($P < 0.05$) using Fisher's protected LSD.

Acid detergent fiber was equal for all treatments in the autumn of both years (Fig. 4) but overall it was lower in autumn of Year 1 (average of 18%) than autumn of Year 2 (average of 21%). In spring, acid detergent fiber for all treatments increased compared to autumn, but annual ryegrass increased less than cereal rye. In the spring of both years, the annual ryegrass treatments were approximately seven percentage units lower in acid detergent fiber than the cereal rye treatments. Neutral detergent fiber was consistent between autumn and spring for both years with an average concentration of 55% (Fig. 5). While neutral detergent fiber for individual treatments was sometimes different statistically, the differences are not expected to be important biologically or in terms of expected animal performance (12,13).

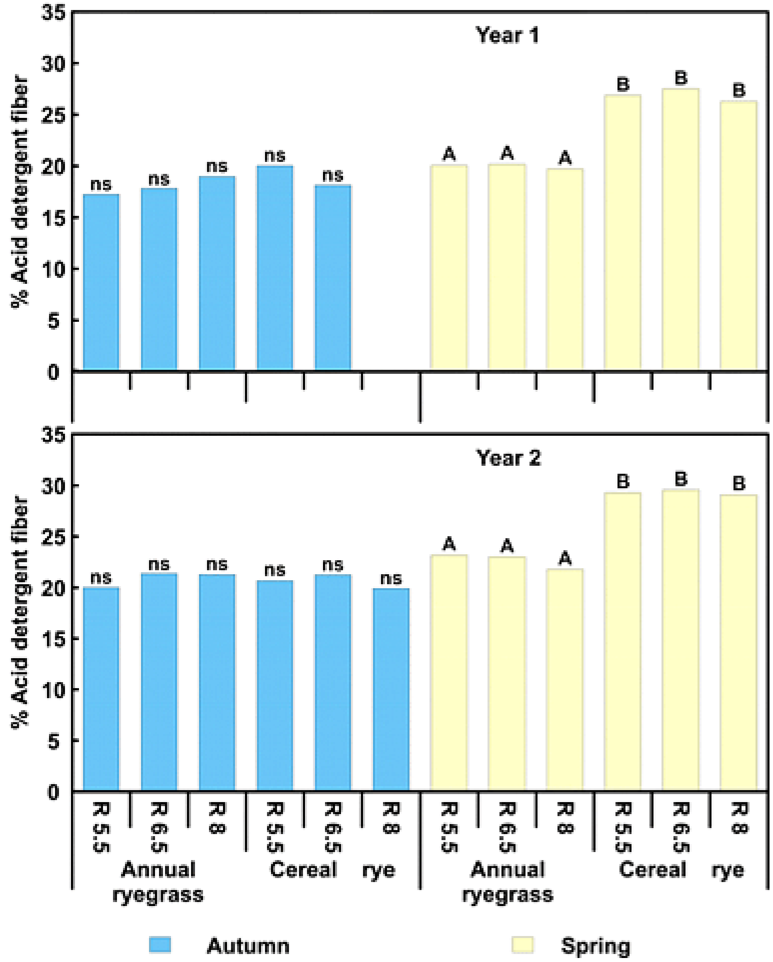

Fig. 4. Acid detergent fiber of annual ryegrass and cereal rye overseeded into soybean at different reproductive stages. Year 1 was the autumn and spring of 2003-2004 and Year 2 was the same time in 2004-2005. Data were weighted according to the yield from each harvest within a period. Bars with different letters within a year and harvest period (autumn or spring) are significantly different ($P < 0.05$) using Fisher's protected LSD.

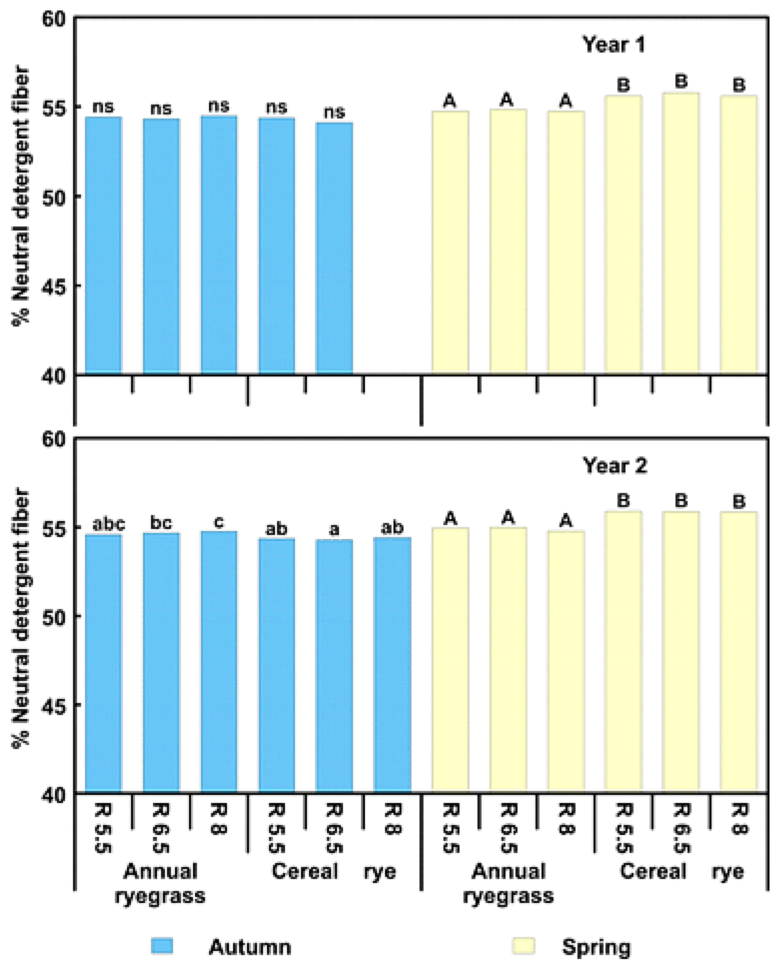

Fig. 5. Neutral detergent fiber of annual ryegrass and cereal rye overseeded into soybean at different reproductive stages. Year 1 was the autumn and spring of 2003-2004 and Year 2 was the same time in 2004-2005. Data were weighted according to the yield from each harvest within a period. Bars with different letters within a year and harvest period (autumn or spring) are significantly different ($P < 0.05$) using Fisher's protected LSD.

Our forage nutritive values are similar to those reported by Kallenbach et al. (7) in Missouri and Redfearn et al. (15) in Oklahoma. The nutritive value of both annual ryegrass and cereal rye is excellent but annual ryegrass usually equals or surpasses cereal rye. The high crude protein and low acid detergent fiber concentrations throughout the year show that both of these forages rival early bloom alfalfa in crude protein and corn silage in energy. One characteristic of cereal rye is that it matures earlier in the spring than annual ryegrass, and thus its use as a high-nutritive-value forage after April is limited in much of the lower Midwest. Annual ryegrass's low acid detergent fiber and high crude protein would be sufficient to support beef calves gaining 2.0 or more lb/day or lactating dairy cows (12,13). Its comparatively long window of use also makes it easier for producers to manage.

Conclusions

These results demonstrate that livestock operations in the lower Midwest could use annual ryegrass and cereal rye overseeded into soybean for winter grazing. All treatments yielded over 2,225 lb/acre per year (with the best treatments yielding over 3,000 lb/acre), which would supply much needed pasture for winter grazing. While all treatments provided adequate amounts of forage, overseeding at the soybean R 6.5 stage consistently produced the most forage for both annual ryegrass and cereal rye. Other treatments yielded an equal amount of forage in some years, but not in both years. Additionally, the annual ryegrass overseeded at R 6.5 consistently yielded the most autumn forage from year to year and thus would be best for winter-feeding. Conversely, the cereal rye overseeded at R 6.5 consistently yielded the most spring forage. Its growth habit would allow early spring grazing. Cattle producers could designate some acres to annual ryegrass and some to cereal rye to maximize grazing benefits. The high nutritive value of these forages makes them excellent feed for nearly all classes of livestock including stocker calves and lactating dairy cows. Future research should incorporate the greatest yielding treatments into a "systems" study that includes grazing livestock.

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