Integrating Livestock and Cropping Systems: Interseeding Cereal Rye into Corn for Late Season Grazing

Soder, K.J.*
*USDA-ARS, University Park, PA

Keywords: Cereal rye; corn; grazing; integrated; interseed.

Abstract
Corn (*Zea mays)* grown for grain is harvested too late in the year in many temperate regions to establish a cover crop to provide winter ground cover and an opportunity for late season grazing. The objective of this project is to evaluate the effect of interseeding cereal rye (*Secale cereale*) into corn for use as grazed forage after corn grain harvest on corn grain yield and additional grazing day/ha. In a 4-year study, corn was planted (64,246 plants/ha) in spring on two, 4.8-ha fields in central Pennsylvania. Cereal rye was interseeded (135 kg/ha) into the corn at the V4-V6 stage. Corn was harvested as grain in November and each field was divided into six, 0.8-ha paddocks and randomly assigned to either grazed (**GRAZ**) or ungrazed (**NG**) treatments. Beef cattle frontal-grazed three of the paddocks (four cows/paddock) in each field approximately four to five weeks after corn grain harvest and, if growth allowed, again in early spring before subsequent corn planting. Corn fodder (after grain harvest), corn grain and cereal rye yields were monitored each fall. Cereal rye growth was also monitored in early spring. On average, the cereal rye (plus the corn stover) provided enough forage for an additional 115-130 grazing days/ha in the fall. While early spring growth has the potential to provide even greater forage yields than fall, growth is much less dependable than fall. Corn grain yields did not decrease as a result of grazing, or of repeated plantings of corn year to year, ranging from 9,516-10,088 kg/ha across GRAZ and NG paddocks except in 2019 (dry year) when corn grain yields averaged 6,053 kg/ha across both GRAZ and NG treatments.

Introduction
Corn (*Zea mays*) crops harvested as grain in late fall do not provide opportunity for a cover crop to be established in many temperate regions. This land sits fallow over winter, resulting in increased potential for nutrient leaching and soil erosion. Cover crops interseeded into growing corn can provide an established cover crop after corn harvest to provide soil coverage over the winter (Liebig et al., 2015; Curran et al., 2018; Antosh et al., 2022). Cover crops were initially planted for conservation benefits. However, with feed costs comprising >50% of operational costs on livestock farms, grazing these cover crops may provide opportunity to utilize this additional forage and reduce stored feed costs. Finding strategies to extend the grazing season beyond the traditional growing season could substantially decrease feed costs, thereby improving farm profitability. Many farmers are reluctant to plant or graze cover crops due to perceived concerns about significant cost with no immediate economic benefit, soil damage from animal hooves, and reduced ground cover after grazing. There is great opportunity to combine the need for low-cost feed along with the conservation benefits of cover crops into a novel approach to increase the overall economic and environmental sustainability of small farms. Grazing cover crops interseeded into cash crops could provide added revenues and increase nutrient cycling in the system while also providing ecosystem services that can affect long-term productivity and economics. However, the tradeoffs between cash crop productivity and environmental effects are not fully understood. The objective of this project is to evaluate the effect of interseeding cereal rye (*Secale cereale*) into corn for use as grazed forage after corn grain harvest on corn grain yield and additional grazing day/ha.

Materials and Methods

Beginning in spring 2018 and continuing through fall 2021, two, 4.8-ha fields located approximately 1.6 km apart at the Russell E. Larson Agricultural Center, Rock Springs, Pennsylvania [40° 43’ 00” N, 77° 56’ 24” W; Hagerstown silt loam with slopes of 3-8% (fine, mixed, semiactive, mesic Typic Hapludalfs)] were sprayed with 2.34 L/ha glyphosate [N-(phosphonomethyl) glycine] and 1.17 L/ha dimethenamid-P (55%) to control existing vegetation. Fields were no-till planted with 98-day relative maturity corn (64,246 plants/ha) in May. Both fields were fertilized at corn planting with liquid ammonium phosphate (10-34-0) starter fertilizer at a rate of 37 L/ha and sidedressed with liquid N (30%) fertilizer at a rate of 94 L/ha. Cereal rye was interseeded (135 kg/ha) with an Interseeder™ planter (Interseeder Technologies, LLC) when corn reached the V4-V6 stage, and liquid N fertilizer was again sidedressed at a rate of 393 L/ha. Corn was harvested as corn grain in late October/early November and corn grain weights were recorded. Beginning in mid- to late-November of each year, both fields were subdivided with temporary electric fence into six, 0.8-ha paddocks and randomly assigned one of two treatments [graze corn stover/forage (**GRAZ**), or no grazing of corn stover/forage (**NG**)].

Twenty-four beef cows (four cows per paddock) were frontal-grazed in each of the six GRAZ paddocks (three paddocks at each site) starting in mid- to late-November until corn stubble and cereal rye was 90% consumed. No back fencing was used due to lack of additional forage growth and the need to return to a centralized water source. Cows were checked daily, had ad libitum access to fresh water and were managed under Penn State University IACUC (Institutional Animal Care and Use Committee) protocols. If spring green-up was early enough the following year, 24 cows from the same herd frontal-grazed (four cows per paddock as in the fall) the cereal rye in the same GRAZ paddocks as in the fall, starting in early- to mid-April until forage was 90% consumed, or until the cows had to be removed for preparation for corn planting, which ever came first. Fall grazing occurred in the years 2018, 2020, and 2021. No fall grazing occurred in 2019 due to lack of cereal rye growth from insufficient precipitation. Spring grazing only occurred in 2021 due to lack of early spring growth in both 2019 (late arrival of spring) and 2020 (cereal rye stand failure and COVID restrictions on research activities).

One day prior to initiation of grazing in spring and fall, four, 1.0 m^2 quadrats per paddock were collected and separated into corn residue and cereal rye. After each grazing (or prior to corn planting if grazing did not occur in spring), four quadrats per paddock in to both GRAZ and NG treatments were collected for post-grazing forage availability of corn residue and cereal rye. After the spring grazing (or when corn planting time arrived in years spring grazing did not occur), both fields were sprayed as stated above to kill residual forage in preparation for the next corn planting. Grazing days/ha was calculated as [(number of cows * number of days grazed)/total ha grazed].

Statistical analysis on corn grain yield and forage biomass was conducted using the MIXED procedure in SAS 9.4 (SAS Institute, Cary, NC, USA). Least square means were separated using Fisher’s least significant difference test ($\alpha = .05$). There were no site by treatment interactions, therefore means are presented as an average across both sites.

Results and Discussion

Table 1 shows results for pre-grazing and post-grazing corn stover, cereal rye, and total biomass yields. Not unexpectedly, there were differences ($P < 0.05$) among years for corn grain and cereal rye yields primarily due to variations in precipitation and temperature patterns each year. Delayed spring growth in 2019 due to dry weather resulted in minimal cereal rye growth, so grazing was not conducted. Biomass yield was lower in fall 2019 due to 35% less precipitation than the annual average for that location, with even greater precipitation deficits during critical growing stages for forage and corn growth and ear development. Cereal rye did not compete with the corn that year, resulting in negligible biomass production, therefore there was no fall grazing in 2019. In spring 2020, cereal rye had very little regrowth which was a carryover effect from 2019, resulting in no grazing or biomass data collection. COVID restrictions on research activities also prohibited grazing during spring 2020. Paddocks that were not

Table 1. Pre- and post-grazing corn stover and interseeded cereal rye aboveground dry matter (DM) biomass (± standard error) for grazed (GRAZ) and non-grazed (NG) paddocks (averaged across both sites).

	Season						
Item	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020	Spring 2021	Fall 2021
Pre-graze biomass, ton DM/ha							
GRAZ paddocks							
Corn stover	5.93 ± 0.49	0	4.92 ± 0.40	0	5.14 ± 0.47	0	5.14 ± 0.49
Rye	1.09 ± 0.10	0.44 ± 0.02	0.42 ± 0.02	0.07 ± 0.02	0.72 ± 0.05	1.11 ± 0.07	0.77 ± 0.05
Total	6.92 ± 0.42	0.44 ± 0.02	5.34 ± 0.35	0.07 ± 0.02	5.86 ± 0.17	1.11 ± 0.07	5.91 ± 0.40
NG paddocks							
Corn stover	5.38 ± 0.37	0	4.92 ± 0.49	0	5.71 ± 0.49	0	5.06 ± 0.57
Rye	0.33 ± 0.82	0.42 ± 0.02	0.42 ± 0.02	0.10 ± 0.02	0.82 ± 0.07	0.87 ± 0.07	0.84 ± 0.10
Total	5.95 ± 0.37	0.42 ± 0.02	5.34 ± 0.47	0.10 ± 0.02	6.53 ± 0.13	0.87 ± 0.07	5.90 ± 0.38
Graze? YES/NO	YES	NO	NO	NO	YES	YES	YES
Days Grazed	26	----	----	----	24	21	23
Grazing days/ha[1]	130	----	----	----	120	105	115
Post-graze biomass, ton DM/ac							
GRAZ paddocks							
Corn stover	2.37 ± 0.32	----	----	----	2.10 ± 0.25	0	2.49 ± 0.20
Rye	0.49 ± 0.03	----	----	----	0.20 ± 0.02	3.48 ± 0.30	0.37 ± 0.02
Total	2.86 ± 0.27	----	----	----	2.30 ± 0.23	3.48 ± 0.30	2.86 ± 0.25
NG paddocks							
Corn stover	5.51 ± 0.54	----	----	----	4.99 ± 0.62	0	5.85 ± 0.67
Rye	0.96 ± 0.07	----	----	----	0.84 ± 0.05	5.71 ± 0.52	1.01 ± 0.12
Total	6.47 ± 0.42	----	----	----	5.83 ± 0.52	5.71 ± 0.52	6.86 ± 0.62

[1]Grazing days/ha calculated as [(number of cows * number of days grazed)/total ha grazed]

grazed (NG) had greater ($P < 0.05$) cereal rye biomass in spring 2021 due to biomass not being removed the preceding fall. Grazing days/ha ranged from 115-130 during the fall. The only spring grazing period (2021) was 105 in length. However, this grazing was cut short due to the need to prepare the fields for the next corn crop.

Post-grazing biomass of cereal rye in spring 2021 was greater ($P < 0.05$) than pre-grazing height for both GRAZ and NG treatments. For the GRAZ treatment, this was due to not having enough animals to keep up with the rapid spring growth. Additional animals would be needed (which were not accessible to us due to IACUC restrictions on animal numbers and the availability of animals from the commercial farm during spring calving), or the forage could be harvested and stored for later use on a commercial farm. In years where fall crop was low or failed, commercial farmers may graze cattle on the corn stover alone since the animals would be readily available on the farm. However, due to the need to import cattle for the current study, the decision was made not to graze if cover crop biomass was insufficient for a sustained grazing period. Another option, particularly in the spring time, would be mechanical harvest of the forage if animals were not available at the time.

Annual ryegrass (*Lolium multiflorum*) was interseeded into the corn for two years prior to the data presented herein. However, the annual ryegrass did not emerge early enough in the spring to allow for grazing prior to seeding the next crop of corn, therefore, cereal rye was used instead during the years included in this study to evaluate whether cereal rye would emerge early enough in the spring to allow for sufficient grazing.

Corn grain yields were typical for the northeastern U.S. (Grover et al., 2009; Curran et al., 2018) and did not differ ($P > 0.05$) between GRAZ and NG treatments or among years with the exception of 2019 when grain yields were 37-40% lower ($P < 0.05$) than other years (with no difference between GRAZ and NG treatments; Figure 1). This was due to the reduced precipitation in 2019, particularly with significant moisture shortages during critical growing stages for forage and corn growth and ear development. These results suggest that weather patterns were more influential on corn grain yields than inteseeding cereal rye into repeated corn crops under conditions similar to those in the current study.

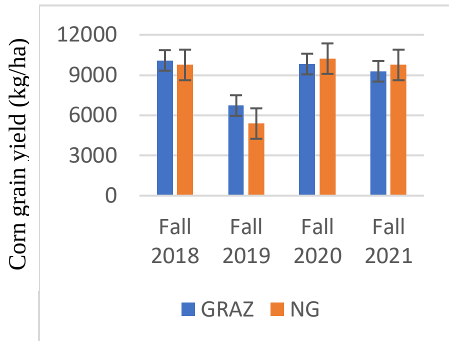

Figure 1. Grain yields for corn (kg/ha) interseeded with cereal rye and either grazed (GRAZ) or not grazed (NG) by beef cattle after corn grain harvest and again in early spring. Error bars are standard error of the mean.

Conclusions

Results of this study showed that late-fall grazing of cereal rye interseeded into growing corn did not negatively impact corn grain yields with repeated corn planting. On average, the cereal rye (plus the corn stover) provided enough forage for an additional 115-130 grazing days/ha in the fall. While early spring growth of the cereal rye has the potential to provide even greater forage yields than fall, it is much less dependable than fall due to the potential of delayed spring growth or lack of winter precipitation under the conditions of the current study.

References

Antosh, E., M.A. Liebig, M.A., Archer D.W., and Luciano, R. 2022. Cover crop interseeding effects on aboveground biomass and corn grain yield in North Dakota. *Crop, Forage Turfgrass Mgmt*, 2022:8e20148. https://doi.10.1002/cft2.20148

Curran, W.S., Hoover, R.J., Mirsky, S.B., Roth, G.W. Ryan, M.R., Ackroyd, V.J., Wallace, J.M., Dempsey, M.A., and Pelzer, C.J. 2018. Evaluation of cover crops drill interseeded into corn across the Mid-Atlantic. *Agron. J.*, 110:435-443. https://doi.org/10.2134/agronj2017.07.0395

Grover, K.K., Karsten, H.D., and Roth, G.W. 2009. Corn grain yields and yield sustainability in four long-term cropping systems. *Agron. J.*, https://doi.org/10.2134/agronj2008.0221x

Liebig, M.A., Hendrickson, J.R., Archer, D.W., Schumer, M.A., Nichols, K.A., and Tanaka, D.L. Short-term soil responses to late-seeded cover crops in a semi-arid environment. 2015. *Agron. J.*, 107:2011-2019. https://doi.10.2134/agronj15.0146