Forage production and calf gains when grazing oats following corn harvest

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INTRODUCTION

Grazing livestock on fall planted double-cropped annual forages (DCAFs) may provide opportunities for producers to extend their grazing season between summer range and winter residue grazing. DCAFs, commonly referred to as cover crops, have increased in popularity recently (SARE/Conservation Technology Information Center, 2016). Cover crops provide numerous agronomic advantages for land owners, including soil conservation, weed control, and economic incentives (grazing rent). In addition, fall planted cover crops may provide animal gains and economic benefits for livestock producers and land owners.

Planting date plays a major role in the yield potential of cover crops, and later planting dates result in limited yields due to fewer growing degree days (GDD; Wiedenhoeft and Barton, 1994). Koch et al. (2002) concluded that planting date was the single largest factor determining fall cover crop forage production. Corn and soybeans are the most common crops in Nebraska; however, due to limited GDD, they provide limited opportunities for DCAF production. Nonetheless, corn silage (CS) and high-moisture corn (HMC) harvest may provide an opportunity for Nebraska producers to take advantage of fall planted DCAFs. A mixture of annual ryegrass and a winter rye-oat planted after CS resulted in 0.81 kg/d average daily gain (ADG) when grazed by dairy heifers with no impact on subsequent corn yield (Fae et al., 2009). However, little research is available evaluating calf performance when grazing oat monocultures, brassicas, or a mixture of these forages. Therefore, the objective of this study was to determine calf gains and forage production of oats following CS or HMC harvest, as well as their impact on subsequent crop yields.

MATERIALS AND METHODS

All procedures involving animal care and management were approved by the University of Nebraska Lincoln’s Institutional Animal Care and Use Committee.

Field and Planting Details

In a 4-yr study, a pivot irrigated field located at the Eastern Nebraska Research and Extension Center near Mead, NE, was utilized to determine oat forage production and calf gains following CS and HMC harvest, as well as their effects on subsequent crop yield. The 42-ha field was split into a corn and soybean rotation (21 ha each). Corn and soybeans were planted with 76-cm row spacing. The half of the field planted to corn was split again into CS (10 ha) and HMC (11 ha).
Each treatment (n = 6) contained three replications for sampling crop yields and two replications for forage sampling. Replication varied between crop and forage sampling in order to provide larger paddocks for grazing. Treatments included DCAF followed by grazing (Cov-G), DCAF without grazing (Cov-NG), and no DCAF (NC-NG). Treatments were initially applied in 2013; however, due to herbicide restrictions, no grazing occurred until 2015.

Each year, corn was harvested as either CS or HMC, and double cropped with an oat monoculture, and grazed according to treatment. Horsepower oats were drilled at 108 kg/ha following CS and HMC harvest, and a 32% ammonium nitrate fertilizer was applied at a rate of 44.8 kg/ha. In 2018, due to limited emergence of the oats planted on the CS, Horsepower oats were replanted on the CS at 108 kg/ha on the day that oats were planted on the HMC.

**Forage Production Measures**

Initial oat biomass was sampled in late October to determine forage production, and to determine stocking rates. Total biomass was measured by randomly selecting (0.91 x 0.57 m) areas within each treatment paddock that contained cover (CS Cov-G, CS Cov-NG, HMC Cov-G, and Cov-NG). Due to differences in paddock size, grazed treatments were sampled in five locations per replicate, whereas non-grazed treatments were sampled in three locations per replicate. Forage was clipped at ground level, bagged, and dried for 48 h in a 60 °C oven to determine initial biomass. After the grazing period, forage biomass was sampled the same as initial biomass, and transects were taken to determine percent cover. Transects were taken using a 30.5-m tape stretched randomly across areas within each treatment. At each 0.30 m, it was determined whether the soil was covered or not, these were then averaged to determine a percentage of cover at each area. Similarly to biomass samples, five transects per replicate were taken in the grazed treatments and three transects per replicate were taken in the non-grazed treatments to determine percent cover. Furthermore, corn stover was sampled on the HMC side to account for the total amount of residue removed due to grazing. GDD were calculated for each treatment to account for differences in planting date.

During initial biomass sampling, forage quality samples were taken for each treatment (two replicates per treatment) containing oats. Samples were taken by randomly clipping oats at ground level uniformly across each paddock. Samples were dried at 100 °C for 24 h to determine dry matter (DM) and analyzed for organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

**Crop Yield**

CS, HMC, and soybean yields were collected to determine subsequent crop yields following the previous years’ imposed treatments. Corn and soybean yields were collected by hand harvest methods (Lauer, 2002). Hand harvest of CS included cutting the corn plant at the first node for 5.33 m at three locations per replicate. Corn rows were alternated within each replicate for sampling. Corn ears were then removed, weighed wet, shelled, dried, and weighed back to determine corn and cob DM. Dry cob weights were included in the dry stover yields. The remainder of the corn plant was ground through a chipper, weighed wet, and subsampled. Subsamples were dried and weighed back. Upon determination of DM, the corn ear DM and stalk DM were used to determine CS yield per hectare.

HMC utilized a similar hand-harvesting method. Corn ears were removed, and the ear and remaining plant stover (husk, leaf, and stalk) were weighed separately. Three corn plants and three ears were taken as a subsample from each 5.33-m bundle, and were dried to determine DM content. Cobs and grain were placed back in the oven for another 24 h, or until dry to determine corn grain yield. Cob weights were included in the dry stover yields. DMs were used to calculate corn grain and stover yield per hectare.

Soybean plants were hand harvested at ground level. Samples were then bundled, and dried in a drying room at 60 °C until threshing. During threshing, grain and stover were collected, weighed wet, and dried. DM oven weights for the grain and stover were used to calculate soybean grain and stover yield per hectare.

**Cattle Grazing and Management**

Sixty-two steer calves (initial body weight [BW] = 212 kg; SD = 9 kg) in 2015, 55 (initial BW = 228 kg; SD = 13 kg) in 2016, 34 (initial BW = 210 kg; SD = 13 kg) in 2017, and 36 (initial BW = 230 kg; SD = 3 kg) in 2018 were utilized for oat grazing. Prior to grazing, steers were limit fed a common diet of 50% Sweet Bran (Cargill Wet Milling, Blair, NE) and 50% alfalfa hay for 5 d, then weighed for 3 consecutive days to establish initial BW (Watson et al., 2013). Cattle were stratified with high BW steers grazed on the CS, and low BW steers grazed on the HMC. Steers were grazed 108 kg/ha on the day that oats were planted on the CS, Horsepower oats were replanted on the CS at 108 kg/ha on the day that oats were planted on the HMC.
by BW and assigned randomly to paddocks with two paddocks in the CS and HMC treatments. Due to differences in available forage, number of head varied between paddocks. Therefore, a set number of head were determined to be testers within each treatment paddock. In 2015 and 2016, 10 hd per paddock were assigned as testers, whereas only 5 hd per paddock were assigned as testers in 2017 and 2018. Grazing performance was determined based upon the tester performance averaged over all calves in the treatment paddock.

Calves were implanted with 36 mg Zeranol (Ralgro, Merck Animal Health, Madison, NJ) and turned out into their respective paddocks in early November. Treatments were grazed until forage availability was determined to be limiting intake (62, 42, 48, and 30 d, respectively over the 4 years). Stacking rates were calculated using a predetermined 70-d grazing period, with a 60% grazing efficiency; intakes estimated at 2.5% of BW; and initial biomass measurements for oats of kg DM/ha within each grazing paddock. Additionally, 13% of the corn residue was assumed available for grazing. Upon removal from the grazing treatments, steers were limit fed the same 50:50 alfalfa and Sweet Bran diet for 8 d and were weighed for 3 consecutive days to limit differences in gut fill and determine ending BW (Watson et al., 2013).

**Statistical Analysis**

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Paddock was the experimental unit for calf performance and oat forage quality data. Treatment was analyzed as a fixed effect for steer performance, and subsequent corn and soybean yields. Treatment means were separated using the pdiff statement when the F test was significant. Data were considered to be significantly different at P ≤ 0.05.

**RESULTS AND DISCUSSION**

**Forage Production and Quality**

Oat forage biomass production was greater following CS than HMC with 2,475 kg DM/ha compared to 1,020 kg DM/ha, respectively (P < 0.01, Table 1). Corn stover from the HMC provided 1,871 kg DM/ha making total kg DM/ha between the treatments similar. Nonetheless, due to limited oat emergence on the CS in 2018, HMC oat biomass was more similar to CS than in previous years. Furthermore, GDD were significantly different for the two treatments, with oats planted on CS averaging 649 d and HMC averaging 354 d, respectively (P <0.01). Significantly greater forage production following CS is likely due to the difference in average GDD between the treatments and cover from the HMC residue. Due to HMC residue, percentage ground cover, estimated using transects, was significantly different between CS and HMC (66.8% and 86.6% respectively; P < 0.01).

| Item                  | Treatment |          |          |          |          |
|-----------------------|-----------|----------|----------|----------|----------|
| Calf performance      | CS¹       | HMC²     | SEM      | P-value  |
| Initial BW, kg        | 223       | 222      | 6.5      | 0.53     |
| Ending BW, kg         | 269       | 246      | 7.8      | 0.02     |
| ADG, kg               | 1.07      | 0.58     | 0.173    | 0.01     |
| Gain, kg/ha           | 111       | 65       | 30.3     | 0.04     |
| Forage production     |           |          |          |          |
| Biomass, kg/ha        | 2,475     | 1,020    | 174.5    | <0.01    |
| GDD³                  | 965       | 647      | 41.8     | <0.01    |
| Cover, %⁴             | 66.8      | 86.6     | 3.60     | <0.01    |

SEM = standard error of the mean.

¹Calf performance and forage production of oats seeded after CS harvest.

²Calf performance and forage production of oats seeded after HMC harvest.

³Biomass determined prior to the grazing period.

⁴GDD of oats = [maximum temperature (°C) − minimum temperature (°C) (if minimum temperature < 0, then set = 0)] summed from day oats seeded to day initial oat biomass sampled.

⁵Percent cover determined by transects after the grazing period.

Forage production and calf gains

| Item                  | Treatment |          |          |          |          |
|-----------------------|-----------|----------|----------|----------|----------|
| Calf performance      | CS¹       | HMC²     | SEM      | P-value  |
| Initial BW, kg        | 223       | 222      | 6.5      | 0.53     |
| Ending BW, kg         | 269       | 246      | 7.8      | 0.02     |
| ADG, kg               | 1.07      | 0.58     | 0.173    | 0.01     |
| Gain, kg/ha           | 111       | 65       | 30.3     | 0.04     |
| Forage production     |           |          |          |          |
| Biomass, kg/ha        | 2,475     | 1,020    | 174.5    | <0.01    |
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⁵Percent cover determined by transects after the grazing period.

Treatment averages.

**Statistical Analysis**

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Paddock was the experimental unit for calf performance and oat forage quality data. Treatment was analyzed as a fixed effect for steer performance, and subsequent corn and soybean yields. Treatment means were separated using the pdiff statement when the F test was significant. Data were considered to be significantly different at P ≤ 0.05.

**RESULTS AND DISCUSSION**

**Forage Production and Quality**

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Nutrient quality of oats (OM, CP, NDF, and ADF) is reported in Table 2. Oat OM was not different (P = 0.38) whether it was planted following CS or HMC harvest (86.7% and 87.0%, respectively). Nonetheless, CP was greater in the oats seeded following HMC compared to CS at 22.7 and 18.0%, respectively (P < 0.01). Oats planted following HMC harvest were less mature than those following CS, likely contributing to the increase in CP content. There was a tendency (P = 0.09) for oats planted after CS to have greater NDF compared to HMC (38.3% and 35.9%, respectively). Furthermore, ADF was greater for oats following CS compared to HMC (24.0 vs. 21.9, respectively; P < 0.01). Earlier planted forages will have greater NDF content compared to those planted later in the growing season (Wiedenhoeft and Barton, 1994). In addition, as the plant matures, structural components such as cellulose and lignin increase, thus, increasing ADF content (Van Soest, 1963).
Calf Performance

Calf initial and ending BW, ADG, and gain are reported in Table 1. Steers grazing oats following CS had greater ending BW than those grazing after HMC (269 and 246, respectively; \( P = 0.02 \)). Accordingly, calves grazing the CS treatment had greater ADG than steers grazing the HMC treatment (\( P = 0.01 \)) with an ADG of 1.07 and 0.58 kg/d, respectively and gain per hectare was greater for the CS treatment than the HMC treatment (111 kg/ha and 65 kg/ha, respectively; \( P = 0.04 \)). Cox et al. (2017) reported an ADG of 0.72 kg/d when grazing an oat–turnip–radish mix planted after CS harvest for 71 d, which is similar to the gains observed in the current experiment.

Crop Yields

Subsequent soybean grain yields were significantly different (\( P < 0.01 \)) based on the corn crop it followed, with soybeans succeeding CS yielding an average of 4,152 kg DM/ha compared to 3,970 kg DM/ha for those following HMC (Table 3). Furthermore, soybean grain yields were not significantly different due to the presence of DCAF (\( P = 0.30 \)). Nonetheless, an interaction was observed between corn treatment and DCAF treatment (\( P = 0.01 \)). The interaction suggests that when soybeans were planted after HMC, the DCAF treatments had no impact on subsequent yield. However, when soybeans followed CS, Cov-NG reduced yields compared to either NC-NG or Cov-G. Regardless of the corn treatment, grazing DCAF did not appear to impact subsequent soybean yields. Soybean stover yields were not affected by corn or DCAF treatments (\( P \geq 0.14 \)). Subsequent

Table 2. Four-year averages for forage quality of oats planted after corn silage (CS) and high-moisture corn (HMC) harvest

| Item  | CS\(^2\) | HMC\(^3\) | SEM  | \( P\)-value |
|-------|---------|---------|------|-------------|
| OM    | 86.7    | 87.0    | 0.01 | 0.38        |
| CP    | 18.0    | 22.7    | 0.91 | <0.01       |
| NDF   | 38.3    | 35.9    | 0.02 | 0.09        |
| ADF   | 24.0    | 21.9    | 0.01 | <0.01       |

SEM = standard error of the mean.
\(^2\)All treatment means are percentages.
\(^3\)Nutrient content of oats seeded after CS harvest.
\(^1\)Nutrient content of oats seeded after HMC harvest.

Table 3. Four-year averages for subsequent soybean yields (kg DM/hectare) following oat forage with and without grazing\(^1\)

| Item\(^5\) | Treatment\(^2\) | SEM | \( P\)-value |
|-----------|-----------------|-----|-------------|
|           | Cov-G | Cov-NG | NC-NG | Cov-G | Cov-NG | NC-NG | SEM | Corn | Cover | Int. |
| Soybean grain yield | 4,153\(^{ab}\) | 3,977\(^{bc}\) | 4,342\(^{c}\) | 4,053\(^{bc}\) | 3,998\(^{bc}\) | 3,859\(^{c}\) | 263.8 | <0.01 | 0.30 | 0.01 |
| Soybean stover yield | 3,519 | 3,815 | 3,614 | 3,758 | 3,512 | 3,648 | 232.5 | 0.93 | 0.97 | 0.14 |

SEM = standard error of the mean.
\(^{ab}\)Significance of different superscripts (\( P < 0.05 \)).
\(^1\)Average soybean yields from 2016, 2017, and 2018 following oats planted after CS or HMC harvest, with and without grazing.
\(^2\)Cov-G = grazed oats, Cov-NG = ungrazed oats, NC-NG = ungrazed without oats drilled.
\(^3\)Subsequent soybean yields in a rotation with CS.
\(^4\)Subsequent soybean yields in a rotation with HMC.
\(^5\)All treatment means are kg DM/hectare.

Table 4. Four-year averages for subsequent corn yields (kg DM/hectare) following oat forage with and without grazing\(^1\)

| Item\(^3\) | Treatment\(^2\) | SEM | \( P\)-value |
|-----------|-----------------|-----|-------------|
|           | Cov-G | Cov-NG | NC-NG | Cov-G | Cov-NG | NC-NG | SEM | Corn | Cover | Int. |
| Corn silage yield | 19,207 | 16,285 | 19,609 | 1092.9 | 0.10 |
| HMC grain yield | 13,966 | 13,234 | 12,778 | 684.2 | 0.48 |
| HMC stover yield | 9,207 | 8,931 | 8,100 | 435.9 | 0.21 |

SEM = standard error of the mean.
\(^1\)Average CS and HMC yields from 2017, and 2018 following oats planted after CS or HMC harvest, in 2016 and 2017.
\(^2\)Cov-G = grazed oats, Cov-NG = ungrazed oats, NC-NG = ungrazed without oats drilled.
\(^3\)All treatment means are kg DM/hectare.
corn yields were compared across treatments for 2017 and 2018, to evaluate the impact of grazing in 2015 and 2016, respectively. CS yields, HMC grain, and HMC stover yields were not different among treatments ($P \geq 0.10$; Table 4). Fae et al. (2009) reported no impact on subsequent crop yields from cover crop forages with or without grazing of the forage.

Grazing double-cropped oats following corn harvest provides producers an opportunity to add additional weight to weaned calves, and may offer an economic incentive to cropping systems with no impact on subsequent crop yields. Due to fewer GDD, substantially less forage production is observed following HMC harvest, leading to less desirable gains compared to oats planted after CS. Seeding and grazing of oat forage following CS offer numerous benefits for livestock and crop producers.

**LITERATURE CITED**

Cox, J. L., K. E. Hales, K. M. Ulmer, R. J. Rasby, S. D. Shackleford, H. C. Freetly, and M. E. Drewnoski. 2017. The effects of backgrounding system on growing and finishing performance and carcass characteristics of beef steers. J. Anim. Sci. 95:5309–5319. doi:10.2527/jas2017.1934.

Fae, G. S., R. M. Sulc, D. J. Barker, R. P. Dick, M. L. Eastridge, and N. Lorenz. 2009. Integrating winter annual forages into a no-till corn silage system. Agron. J. 101:1286–1296. doi:10.2134/agronj2009.0144.

Koch, D. W., C. Kercher, and R. Jones. 2002. Fall and winter grazing of brassicas—a value-added opportunity for lamb producers. Sheep Goat Res. J. 17:1–13.

Lauer, J. 2002. Methods for calculating corn yield. Available from http://corn.agronomy.wisc.edu/AA/pdfs/A033.pdf.

SARE/Conservation Technology Information Center. 2016. Corn, Annual report 2015–2016: Cover crop survey analysis. Available from https://www.sare.org/Learning-Center/From-the-Field/North-Central-SARE-From-the-Field/2016-Cover-Crop-Survey-Analysis.

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. 2. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Anal. Chem. 46:829–835.

Watson, A. K., B. L. Nuttelman, T. J. Klopfenstein, L. W. Lomas, and G. E. Erickson. 2013. Impacts of a limit-feeding procedure on variation and accuracy of cattle weights. J. Anim. Sci. 91:5507–5517. doi:10.2527/jas.2013-6349.

Wiedenhoeft, M. H. and B. A. Barton. 1994. Management and environment effects on brassica forage quality. Agron. J. 86:227–232. doi:10.2134/agronj1994.0002196200860020003x