Forages and pastures symposium: cover crops in livestock production: whole-system approach. Can cover crops pull double duty: conservation and profitable forage production in the Midwestern United States?

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ABSTRACT: Data from a recent survey suggest that the major reasons Nebraska farmers plant cover crops are to improve soil organic matter, reduce erosion, improve soil water holding capacity, produce forage, and increase soil microbial biomass. Many of these benefits appear to be positively correlated with production of above-ground biomass. Thus, selecting species that will produce the greatest biomass should be beneficial for both soil conservation and forage production. Furthermore, the limited data available suggest that grazing of cover crops does not have large negative crop production, soil, or environmental impact. In the Midwestern United States, the production window following wheat harvest, male row destruction in seed corn, and to a lesser extent following corn silage harvest is long enough to produce 2,500 to 4,500 kg DM per hectare of high-nutritive value, fall forage. In the past 4 yr, we have conducted eight trials using predominantly oats and brassicas planted in mid- to late-August. Forage nutritive value of oats and brassicas is extremely high in early November (70% to 80% IVDMD; 14% to 23% CP) and remains high through December with only a 4% to 7% unit decrease in IVDMD and no change in CP concentration. Thus,

it appears that delayed grazing could be an option to maximize potential forage yield. Fall-weaned calves (200 to 290 kg BW) grazing oats with or without brassicas in November and December (48 to 64 d) at stocking rates of 2.5 to 4.0 calves per hectare have ADG between 0.60 and 1.10 kg. The cost of gain has ranged from \$0.53 to \$2.08/kg when accounting for seed costs plus establishment (\$60 to 117/ha), N plus application (\$0 to 58/ha), fencing (\$11/ha) and yardage (\$0.10 calf⁻¹ d⁻¹). Although soybeans and corn harvested for grain do not provide a large enough growing window to accomplish fall grazing, similar dual purpose cover crop practices are often accomplished by planting winter-hardy small grain cereal grasses, such as cereal rye or winter triticale in the fall and grazing in the spring. However, traditional planting dates for corn and soybean result in a 30 to 45 d grazing period prior to corn and a 45 to 60 d period prior to soybean planting. Planting cover crops to provide late fall or early spring grazing has potential. However, incorporating forage production from cover crops into current cropping systems greatly increases the need for timeliness of management since the window of opportunity for forage production is quite narrow.

Key words: brassicas, cereal rye, cover crop, forage, oats

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INTRODUCTION

In the Midwestern United States, corn and soybeans make up the majority of the cropland acres. The specialization of crops grown can cause some negative soil and environmental consequences, including nitrate leaching, erosion, and loss of soil organic matter (SOM). Cover crops have shown potential to improve some of these conditions (Strock et al., 2004; Kaspar and Singer, 2011; Blanco-Canqui et al., 2015b). However, the increased management and costs of planting cover crops to offset these conditions may be difficult to economically warrant for the individual farmer as these conditions affect society but may not affect the farmer in the short term. If the use of cover crops can have a short-term economic benefit while providing the conservation benefits described, their incorporation can benefit both society and the individual farmer. Utilization of cover crops as a forage source for cattle may provide this opportunity. The purpose of this paper is to discuss the current state of knowledge regarding using cover crops as a source of forage in the Midwestern United States and potential impacts of grazing cover crops on soil conservation benefits.

POTENTIAL OF COVER CROP FORAGE IN MIDWESTERN SYSTEMS

Fall and Winter Grazing

In the late summer, after harvest of wheat, male row destruction in seed corn and harvest of corn silage, cover crops can be planted, which can produce biomass for fall grazing. Even though these crops make up a very small portion of the cropland acres in Nebraska, they currently represent a large proportion of acres in which cover crops are currently being used. A recent survey in Nebraska found that wheat, seed corn, and corn silage represent 41% of the cover-cropped acres planted by farmers (Drewnoski et al., 2015).

Fall forage yield for small grain forages is typically negatively correlated with winter hardiness (Maloney et al., 1999). This means that oats (*Avena sativa*) and winter sensitive (spring) varieties of triticale ($\times$ *Triticosecale*), wheat (*Triticum aestivum*), and barley (*Hordeum vulgare*) will yield more in the fall than cereal rye (*Secale cereal*) or winter hardy varieties of triticale, wheat, or barley. In systems where planting cover crops can occur in the late summer, planting winter sensitive species can provide an opportunity for fall and winter grazing.

Brassicas such as turnips (*Brassica rapa*), rapeseed (*Brassica napus*), and radishes (*Raphanus sativus*) are also commonly used in late summer plantings (Drewnoski et al., 2015) and can produce high nutritive value forage for a relatively low seed cost. Although there can be significant differences in yield and nutritive content among brassica species when grown in the summer, differences when grown in the fall appear to be much less (Gaillard and Allison, 1988). The yield of turnips (four cultivars), rapeseed (three cultivars), and radish (one cultivar) when planted in mid-August in Northeastern Colorado did not differ, ranging from 2,576 to 3,685 kg/ha (Villalobos and Brummer, 2015). The NDF, CP, and IVDMD varied among cultivars but all had low NDF concentrations (19% to 23%), high CP concentrations (19.3% to 25.5%), and very high digestibility (85% to 93% IVDMD) (Villalobos and Brummer, 2015). In two sheep digestion studies, the response to brassicas appeared to be more similar to the response of a concentrate than forage in the rumen, and it appears that they can even cause negative associative effects on cell wall digestion of hay (Lambert et al., 1987; Cassida et al., 1994). However, in both of these studies, digestible dry matter intake of sheep (*Ovis aries*) was maximized between 70% and 100% brassica in the diet.

Potential challenges do exist with the use of brassicas as a forage source. The high S concentrations (0.56% to 0.71% S; Lenz et al., 2017) and low NDF concentrations suggest that diets consisting solely of brassicas may result in polioencephalomalacia (McKenzie et al., 2009). It has also been proposed that the high water-soluble carbohydrate (WSC) content and low NDF content could lower ruminal pH and result in a risk of subacute acidosis (Westwood and Mulcock, 2012), although to the best of our knowledge no ruminal pH data are available when feeding brassicas. Additionally, brassicas contain secondary compounds, such as S-methyl cysteine sulfoxide and glucosinolates, which can cause reduced feed intake (Barry, 2013). Due to these limitations, it is recommended that brassicas be fed in combination with other forages (Barry, 2013).

Delayed grazing in the fall may be advantageous for both forage and conservation purposes, because it allows maximal biomass production of late-summer-planted cover crops. Villalobos and Brummer (2015) found that digestibility of brassicas does not appear to change rapidly with maturity in the fall and they maintain nutritive value into the winter. Likewise, Coblenz and Walgenbach (2010), in Wisconsin, reported that digestibility of

oats does not decrease substantially with maturity in the fall. Forage samples taken over the winter (early November through early January) over a 2 yr period in Nebraska showed that the nutritive value of oats and brassicas was extremely high (70% to 80% IVDMD; 14% to 23% CP in early November) and remained high through December with only a 4% to 7% unit decrease in IVDMD and no change in CP concentrations (Lenz et al., 2017). Thus, when using oats with or without brassicas, it appears that delaying grazing until mid- to late-November could be an option to maximize potential forage yield without giving up forage nutritive value.

Given that these late-summer-planted cover crops are of high-nutritive value and available at a time of year when weaned cattle are at a seasonally low price, it seems reasonable that there would be an opportunity to use these cover crops to background calves. To evaluate this potential, eight experiments have been conducted to assess the use of winter-sensitive cool season species planted in mid-August after wheat (two trials at Mead, NE) or termination of alfalfa (three trials at Clay Center, NE) and late August or early September after corn silage harvest (four trials; two at Clay Center, NE, and two at Mead, NE) for grazing of fall-weaned calves during November and December.

In experiment 1, a 5-species mix was planted after wheat that contained oats (17 kg/ha), purple top turnip (2.2 kg/ha), sorghum [*Sorghum bicolor* (L.) Moench.; 1.1 kg/ha], crimson clover (*Trifolium incarnatum* L.; 1.1 kg/ha), and sunflower (*Helianthus* spp.; 2.2 kg/ha). The species composition of the forage produced was not quantified, but visually oats and purple top turnip dominated the sward. No additional N was added after wheat harvest (Ulmer et al., 2016). In experiment 2, a 5-species mix was planted after wheat that contained oats (17 kg/ha), purple top turnip (3.4 kg/ha), daikon radish (3.4 kg/ha), sorghum (5.6 kg/ha), and safflower (*Carthamus tinctorius* L.; 4.5 kg/ha). The forage produced was 47% radish, 23% turnip, 19% oat, and 11% sorghum (DM basis) with no safflower. Liquid feedlot manure was applied prior to planting of the cover crop to provide 235 kg N/ha for the subsequent corn crop (Ulmer et al., 2016). In experiments 3 and 4, oats (94 kg/ha), daikon radish (2.2 kg/ha), and turnip (1.7 kg/ha) were planted and N was applied via the pivot at 53 kg N/ha (Cox et al., 2017). In experiment 5, oats (101 kg/ha) were planted and fertilized with 45 kg N/ha (Ulmer et al., 2016). In experiment 6, oats (94 kg/ha), daikon radish (2.2 kg/ha), and turnip (1.7 kg/ha) were planted and N was applied via the pivot

at 54 kg N/ha (Unpublished). In experiment 7, a monoculture of oats (112 kg/ha), was planted on one-half of a pivot and a mix of oats (56 kg/ha) and rapeseed (3.9 kg/ha) was planted on one-half (Unpublished). In experiment 8, a monoculture of oats (101 kg/ha) was planted and N was applied at 45 kg/ha (Unpublished). In these experiments, fall-weaned calves (200 to 290 kg BW; *Bos taurus*) grazed in November and December (48 to 64 d) at stocking rates of 2.5 to 4.0 calves per hectare and gained between 0.60 and 1.10 kg/d (Table 1).

Costs for each experiment were calculated using fertilizer and seed prices from the last 4 yr (Table 2) with seeding, fertilizer application, fencing, yardage, transportation, and mineral costs held constant. Cover crop seed prices were obtained from Green Cover Seed (Bladen, NE; K. Berns, personal communication). Fertilizer prices were based on 45% N urea obtained from Index Mundi (Barrientos and Soria, 2017). The most commonly charged custom seeding rate (\$37/ha) and dry fertilizer application rates based on a survey of custom operators in Nebraska were used (Wilson and Jansen, 2016). Fencing was assumed to be temporary two-wire electric fence at a cost of \$10.87/ha. Yardage was charged at \$0.10·calf⁻¹·d⁻¹. Transportation costs were assumed at \$2.48 per loaded km (most commonly charged rate; Wilson and Jansen et al., 2016) for 64 km for 60 calves at a cost of \$2.64 per calf. Free choice mineral was charged at \$0.07·calf⁻¹·d⁻¹. Net returns for backgrounding calves in these experiments were calculated using the above costs and cattle prices from Nebraska auction price data (Livestock Marketing Information Center, unpublished data).

The mean forage establishment costs from 2013 through 2016, for which each of the experiments is shown in Figure 1. Forage establishment costs ranged from \$64 to \$160/ha with average of \$123/ha. Although there was some variation in seed cost among experiments, the main factor affecting variation in cost of establishment was the application of N fertilizer. Experiments with N applied had 1.75 times greater establishment costs than those that did not (\$152/ha vs. \$86/ha). The cost of gain of each experiment is shown in Figure 2 and was calculated using establishment costs plus the following: fencing, yardage, transportation, and mineral costs. Cost of gain varied substantially among experiments, ranging from \$0.53 to \$2.08/kg. It should be noted, however, that all but one experiment (experiment 4) had a cost of gain that was less than reported annual feedlot cost of gains (Waggoner, 2017) for those years. As

Table 1. Summary of grazing fall (November through January) grazing experiments conducted in Eastern Nebraska using late summer planted cover crop

Exp.	Location	Cover crop	Planting date	Yield ^a , kg/ha	Composition, % of DM			Sex	n	Initial BW, kg	Days of grazing	AUM/ ha	ADG, kg ^b	Gain, kg/ ha
					Grass	Brassica								
1	Mead, NE	5 species mix	Aug. 17, 2013	2,466	ND	ND		Steer	3	205	48	1.75	0.91 ± 0.019	108
2	Mead, NE	5 species mix	Aug. 15, 2014	4,036	26	74		Steer	3	266	53	4.27	0.70 ± 0.073	56
3	Clay Center, NE	Oats, turnip, radish	Sept. 8, 2014	3,811	54	46		Steer	4	278	64	2.95	0.94 ± 0.032	170
4	Clay Center, NE	Oats, turnip, radish	Aug. 25, 2015	4,708	59	41		Steer	4	291	66	3.42	0.50 ± 0.002	96
5	Mead, NE	Oats	Sept. 3, 2015	3,139	100	0		Steer	2	213	62	4.00	0.59 ± 0.051	53
6	Clay Center, NE	Oats, turnip, radish	Aug. 15, 2015	6,053	72	28		Heifer	4	217	62	2.40	0.73 ± 0.107	111
7a	Clay Center, NE	Oats, rape	Aug. 20, 2016	4,260	80	20		Steer	2	265	99	4.68	1.05 ± 0.033	255
7b	Clay Center, NE	Oats	Aug. 20, 2016	4,260	100	0		Steer	2	265	99	4.69	0.95 ± 0.022	233
8	Mead, NE	Oats	Sept. 3, 2016	2,466	100	0		Steer	2	229	42	2.23	1.09 ± 0.091	87

^aYield measured in early November.^bMean ± SEM.**Table 2.** Prices of seed and nitrogen in 2013 through 2016 used to calculate costs of cover crop establishment

Item	2013	2014	2015	2016	Mean
	Cost, \$/kg				
Oats	0.64	0.66	0.55	0.46	0.57
Purple top turnip	4.40	3.96	3.74	3.63	4.05
Daikon radishes	5.50	5.50	4.95	4.29	5.04
Sorghum	2.43	2.51	2.10	1.76	2.18
Crimson clover	3.20	2.88	2.72	2.64	2.94
Sunflower	1.27	1.27	1.14	0.99	1.16
Fertilizer, N ^a	0.75	0.70	0.60	0.44	0.62

^aBased on 45% N urea prices. **Figure 1.** Cost of late-summer-planted cover crop establishment for eight experiments conducted in Eastern Nebraska.

with establishment costs, one of the main factors increasing the cost of gain in these grazing systems was fertilizer costs, with those experiments (3, 4,

5, 6, and 8) in which N fertilizer was applied having the greatest cost of gain (all above \$1.20/kg). Another factor that affected cost of gain during fall

Figure 2. Cost of gain (\$/kg) for calves grazing late-summer-planted cover crops for 40 to 100 d in fall (November through January) in Eastern Nebraska and feedlot cost of gains (\$/kg) reported by Waggoner et al. (2017).

Figure 3. Predicted net return (\$/calf) using calf price from 2013 to 2016 and calf performance from eight experiments where late-summer-planted cover crops were grazed for 40 to 100 d in fall (November through January) in Eastern Nebraska.

grazing was weather (temperature and precipitation). A good illustration of this, is the comparison of experiments 3 and 4, as costs were the same per calf, but the ADG was 0.41 kg less in 2015 (experiment 4) than in 2014 (experiment 3). Forage nutritive value and availability did not differ substantially between the years; however, six rain events occurred during the grazing period in 2015, whereas only two events occurred in 2014. This resulted in calves having wet hair coats for a much greater period of time in 2015 and significantly raised their maintenance energy requirements (Cox et al., 2017). The difference in growth performance resulted in cost of gain averaging \$1.24/kg in 2014 but \$1.94/kg in

2015. Also, in one of the eight trials (experiment 6), cattle had to be removed before the forage was fully utilized because ice restricted grazing.

Corn silage is often used by feedlots in the Midwest and is typically planted on land close to the feedlot. Planting of oats with or without brassicas on the earliest harvested fields may provide a cost effective forage source to background calves in the fall and allow them to buy more calves than their drylot capacity during the period of typically seasonally low prices. The net return (Figure 3) over buying calves in January or February is shown in Figure 3. Due to fluctuations in the cattle markets, there was substantial variation from year to year in

net return for each of the experiments. However, on average, net returns over the past 4 yr would have been positive for seven out of the eight experiments, with a mean net return across year and experiment of \$68/calf.

These forages could be used to develop heifers or graze fall-calving cows, instead of backgrounding calves. When the grazing days, BW of calves, and stocking rate for each of the experiments are combined with the fertilizer, seed, seeding and fencing costs on a per-hectare basis to calculate cost per animal unit month (AUM; 454 kg BW animal unit), the resulting values ranged from \$20 to \$69/AUM with a mean of \$44/AUM (Figure 4). The average pasture rental rate in Nebraska, from 2013 to 2016, ranged from \$28 to \$44/AUM, with an average of \$39/AUM (Jansen, 2017). Thus, it appears that these forage sources could be competitive with alternative grazing opportunities, especially since their availability would be outside of the traditional pasture grazing period.

Spring Grazing

Soybeans and corn harvested for grain do not provide a large enough growing window after harvest to produce enough growth to provide adequate forage biomass for fall grazing. In fact, even in high-moisture corn systems, the harvest date appears to be too late to provide adequate fall growth when oats are drilled after harvest in mid-September in Eastern Nebraska (Ulmer et al., 2016).

The idea of aerial seeding to establish the cover crop before harvest has been and continues to be researched; however, thus far successful establishment is unpredictable and often with limited forage biomass (Wilson et al., 2014). However, drill-planting winter-hardy, small grain cereal grasses, such as cereal rye, winter wheat, or winter triticale after

harvest of corn or soybeans in the fall can provide grazing in the spring. However, these small grain forages have the potential to negatively affect yield of the subsequent corn crop (Kaspar and Bakker, 2015), especially if not terminated early enough in water-limited regions. Currently, the traditional planting dates for corn allow for 30 to 45 d grazing period prior to corn planting.

Cereal rye and triticale have not been shown to have negative impacts on subsequent soybean yields (Moore et al., 1994) and can be terminated at or even after planting if low soil moisture is not a concern. Thus, when coupling the later planting date of soybeans with the possible later termination date of the cover crop, the window for spring grazing can approach 45 to 60 d prior to soybean planting.

Cereal rye is often preferred for use in these systems because it is greater yielding earlier in the spring than the other winter-hardy small grain cereals (Maloney et al., 1999), and it is ready to graze before wheat and triticale (Mitchell et al., 2017). However, minimal data are available on calf ADG or carrying capacity when grazing small grain forage crops in the Midwestern United States. The forage nutritive value of cereal rye can be quite high when grazed in early spring. When cereal rye was planted in early November in Eastern Nebraska and steers (318 kg BW; stocked at 4.9 steers/ha) began grazing in early April, they gained 1.45 kg/d, over a 22 d period (2.47 AUM/ha; unpublished data). However, timing of grazing can substantially affect the nutritive value of the forage and growth performance of cattle. Mitchell et al. (2017) noted that ADG of steers (380 kg BW) grazing cereal rye, winter wheat, or triticale from late-April to late-May, planted in Eastern Nebraska, ranged from -0.22 to 1.64 kg, over a 3 yr period, with no species having a consistent advantage across year. The low rates of gain appeared to be due to increased forage maturity at turn out in some years. The mean ADG

Figure 4. Cost per animal unit month (AUM) for grazing late-summer-planted cover crops in the fall in Eastern Nebraska.

across forage species and year was 0.73 kg, with an average of 26 d of grazing, at a stocking rate of 10 steers/ha. This resulted in a forage harvest of 7.0 AUM/ha.

Although these spring forage sources can be used to grow yearlings that will later move to perennial grass in the late spring, these forages can also be grazed by lactating spring calving cows. When the grazing days obtained above are combined with fertilizer (67 kg N/ha), seed (103, 68, and 91 kg/ha at a cost of \$0.46, \$0.51, and \$0.66/kg for wheat, cereal rye, and triticale, respectively), seeding, and fencing costs to calculate cost per AUM, values ranged from \$16 to \$35/AUM with a mean of \$24/AUM (Figure 5). These data suggest that despite the short spring grazing window, grazing winter-hardy small grain cereals can be cost effective. Like fall grazing, weather is the greatest potential barrier to spring grazing in the Midwestern United States. This is because wet conditions in early spring can cause issues with trampling of forage and decreased animal growth performance.

CONSERVATION IMPACTS OF GRAZING COVER CROPS

The economic estimates above charge all of the establishment costs of the cover crop to the cattle enterprise and do not take into account the possibility of potential soil conservation benefits. The impact of grazing on the soil conservation benefits of cover crops will depend on grazing management. Mismanaged grazing such as excessive biomass removal rates, high stocking densities, and grazing during wet conditions can lead to decreased cover, soil structure, and/or infiltration rates (Warren et al., 1986). On the other hand, with proper grazing management, these negative effects are curtailed (Twerdoff et al., 1999; Agostini et al., 2012; Franchin et al., 2014; Blanco et al., 2017). Although

grazing or haying reduces the amount of residue left on the soil surface, cover crops can still protect soil from erosion and maintain soil properties if sufficient surface cover is left (Blanco-Canqui et al., 2013). In Georgia, Franzluebbers and Stuedemann (2008 a,b) reported that cattle grazing about 90% of the forage produced by cover crops for 2.5 yr had minimal effects on soil physical properties in two cropping systems (corn or sorghum with a cereal rye cover crop and winter wheat with summer pearl millet cover crop) under no-tillage and conventional tillage. The authors found that grazing of cereal rye and pearl millet did not affect soil bulk density (a measure of porosity of the soil that is used to gauge potential compaction) or stability of soil aggregates when compared with not grazing the cover crop.

Grazing did, however, appear to have additional positive effects on soil microbial biomass. Soil microorganisms are essential to the sustainability of cropping systems as microbes recycle carbon and nutrients (Falkowski et al., 2008). Grazing can affect microbial abundance (Franzluebbers and Stuedemann, 2015) and community interactions through increased manure inputs which provide more easily decomposable OM than the plant material supplied in nongrazed systems.

Penetration resistance is used to study soil compaction and surface crusting which can potentially influence root growth and water movement. Previous studies suggest that presence of cattle on cropland in winter and early spring can increase penetration resistance of the soil (Clark et al. 2004; Franzluebbers and Stuedemann, 2008a; Radford et al., 2008; Fae et al., 2009). In general, the effects of grazing are, however, usually below threshold levels which would impede root growth, confined to the soil surface (0 to 10 cm), and are short-lived due to natural amelioration processes such as wetting-drying or freezing-thawing cycles and the

Figure 5. Cost per animal unit month (AUM) of spring grazing late-fall-planted winter-hardy cover crops in Eastern Nebraska.

biological action of roots and soil organisms that create macropores (Greenwood and McKenzie, 2001). In Ohio, Fae et al. (2009) noted that grazing of annual ryegrass and a mixture of winter rye and oats, managed under a no-tillage corn silage system, increased soil penetration resistance by 7% to 15% the first year, but, 1 yr later, penetration resistance values decreased to levels similar to non-grazed treatment. Furthermore, grazing of cover crops did not affect subsequent corn silage yields. A long-term study (9 yr) in North Dakota observed that winter grazing of annual crop residues had no effect on water infiltration rates in the spring (Liebig et al., 2011).

Much of the SOM benefits of cover crops in no-till systems are derived from the retention of plant root C. Gale and Cambardell (2000) found that root-derived C inputs were greater than above-ground oat residue contributions for oats grown under a no-till system. A study conducted in Canada (Mapfumo et al., 2002) examined grazing intensity, on root growth in triticale. Grazing intensity was based on plant height at start of grazing and at end of grazing with grazing being initiated at 11, 12, and 21 cm and ended at 3, 4, and 6 cm for light, moderate, and heavy grazing intensities. These researchers found that root mass production did not differ due to grazing intensity. In this study, root mass production was almost 4000 kg/ha in the top 30 cm of the soil profile with about 60% of the root mass in the top 15 cm. Likewise, in Australia, Kierkegaard et al. (2015) found that grazing had no substantial effect on rooting depth or root mass in wheat unless the wheat was grazed during early growth when the primary root system was still developing. Both of these studies suggest that properly managed grazing has little impact on root growth of small grains. Thus, it is reasonable to assume that properly managed grazing of cover crops would not negatively affect SOM benefits of cover crops. Grazing of cover crops removes plant carbon, but recycling of carbon through manure enhances soil carbon accumulation (Soussana et al., 2004; Blanco-Canqui et al., 2015a).

Potential Barriers

In the Midwestern United States, the majority of farm operations are no longer integrated with individuals having knowledge and expertise in a particular area (specialization in either crop or cattle production). For these integrated crop-cattle systems to occur on a larger scale, partnerships may need to be formed. When considering

using cover crops for forage, there is a need to consider how management, including planting dates of both the cash crop and cover crop, harvest date, fertility management, and herbicide use, will affect the entire system. Additionally, there are concerns about the cover crop becoming weedy. This has happened with both cereal rye and annual ryegrass [*Lolium multiflorum* (Lam.)]. Recently, there have been problems with cover crops serving as a host for pests (McMechan et al., 2017).

In conclusion, grazing cover crops can be used to offset the production costs and, in many cases, result in economic returns exceeding costs of establishment. The limited literature available suggests that grazing cover crops will not negate the soil benefits of adding cover crops into a cropping system. In fact, grazing could have additional positive effects on soil microbial biomass through manure addition. Therefore, there are potential opportunities for both economic incentives and soil benefits for crop producers to incorporate grazing of cover crops into their system. However, incorporating forage production into current cropping systems greatly increases the need for timeliness of management since the window of opportunity for forage production is quite narrow.

Conflict of interest statement. None declared.

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