Proceedings, Western Section, American Society of Animal Science

Vol. 66, 2015

Interseeding cool-season forages into corn to increase yield and quality of residue grazed in the fall

L. Villalobos*and J.E. Brummer*[1]

*Department of Soil & Crop Sciences, Colorado State University, Fort Collins, CO 80523

ABSTRACT: Six forage species/mixtures were interseeded into irrigated grain corn to evaluate their yield and nutritional quality as a means of improving diets for beef cattle grazing cornstalks during the fall. Species evaluated included annual ryegrass (*Lolium multiflorum*), crimson clover (*Trifolium incarnatum*), Fridge winter triticale (X *Triticosecale*), a mixture of annual ryegrass plus crimson clover, a brassica mixture (Barkant turnip [*Brassicas rapa*], Barnapoli rape [*Brassica napus*], Groundhog radish [*Raphanus sativus var.oleifer* Strokes], and Pasja hybrid [Chinese cabbage {*Brassica rapa* L. *chinensis*} x Turnip hybrid]), and a mixture of winter triticale plus the brassica mix. The cool-season forages were interseeded at the V6 growth stage of corn on June 30, 2014. DM yield (p=0.0013), CP (p=0.0149), aNDF (p=0.0001), and *in-vitro* true digestibility (IVTD, p=0.0027) differed among the interseeded forages. Annual ryegrass and the brassica mix had the highest yields (596 and 790 kg ha^{-1}, respectively). The CP content of all treatments was higher than that of cornstalks (5.2% vs. 18.3-26.1%) and had the potential to provide supplemental protein for beef cattle grazing corn residue. The fiber content of the interseeded cool-season forages was lower than cornstalks (73.5% vs. 23.4-44.2%), being particularly low in the brassica mix and the brassica mix plus winter triticale. Except for crimson clover (77.7%), all treatments had high IVTD values (89.4-92.1%), with all forages having higher values than cornstalks (57.7%). The cost per kg of DM and kg of CP of the interseeded forages varied widely because of differences in seeding rates, seed cost, DM yield, and CP content. Annual ryegrass and the brassica mix were the treatments with the lowest costs ($0.18 and $0.17 kg^{-1} of DM and $0.96 and $0.72 kg^{-1} of CP; respectively), having values similar to good quality alfalfa hay with a current market price of $154 t^{-1}. Interseeding cool-season forages can increase the quality of biomass offered to beef cattle grazing cornstalks during the fall. This should be combined with strip grazing to maximize utilization of the high quality cool-season forages that can grow during the fall. This practice can reduce supplementation costs for producers while improving nutrient cycling through a more even spread of manure across the field.

Key words: cattle, corn, beef, forages, grazing, interseeding, protein.

INTRODUCTION

Cornstalks grazed by beef cattle, mostly cow/calf systems, represent a cheap and efficient way to utilize the plant biomass left after grain harvest (Klopfenstein et al., 1987). The main problem with grazing cornstalks is the relatively low protein content and digestibility of the corn residue (Fernandez-Rivera and Klopfenstein, 1989) which makes supplementation, especially with protein, necessary in order to meet the nutritional requirements of cattle (NRC, 2000).

Grazing cornstalks can be expanded to yearling cattle, but adequate forage quality must be available in order to maintain animal gains (Fernandez-Rivera and Klopfenstein, 1989). Such opportunities must fit economically and logistically in a farming-ranching system (Klopfenstein et al., 1987). Interseeding cool-season forage species into corn is an agronomic management practice by which producers can increase the quality of the forage offered to beef cattle.

The objective of this study was to evaluate the yield and nutritional quality of cool-season forages interseeded into corn for fall grazing under Colorado growing conditions. Most studies where forages have been interseeded into corn have been conducted in the eastern United States (Scott et al., 1987; Baributsa et al., 2008). In our study, differences in yield and quality as affected by forage species/mixture were considered indicators of the potential to increase forage quality provided to beef cattle grazing cornstalks into the fall and winter.

MATERIALS AND METHODS

Study Location and Implementation

This study was conducted during the summer-fall growing season of 2014 at Colorado State University's Agricultural Research, Development and Education Center (ARDEC), located about 15 km northeast of Fort Collins, Colorado (40.39°N, 104.59°W, elevation 1555 m).

Table 1. Seeding rates of species and mixtures of forages interseeded into corn.

Forages (code)	Seeding rate (kg ha^{-1})
Annual ryegrass (AR)	22.5
Crimson clover (CC)	13.5
AR + CC	13.5 + 9.0
Winter triticale (WT)	112
Brassica mix (BM)	11.2
WT + BM	60.5 + 6.7

Six forage species/mixtures were interseeded into grain corn that was at the V6 growth stage on June 30, 2014 (Table 1). The species seeded included annual ryegrass (*Lolium multiflorum*), crimson clover (*Trifolium* *incarnatum*), and Fridge winter triticale (X *Triticosecale*) The brassica mix was comprised of equal parts Barkant turnip (*Brassicas rapa*), Barnapoli rape (*Brassica napus*), Groundhog radish (*Raphanus sativus var.oleifer* Strokes), and Pasja hybrid (Chinese cabbage [*Brassica rapa* L. *chinensis*] x Turnip hybrid).

To interseed the forages, a 3 m wide Gandy® box was mounted on a 3-point toolbar to meter the seeds. Three sets of 3 wavy blade coulters were attached to the toolbar to lightly disturb the soil in the strips between corn rows. The seeds were broadcasted into each tilled strip through 3 tubes that were mounted about 30 cm above the soil surface. The wavy blades were set to prepare a 40 cm wide seedbed between each row. Sprinkler irrigation was applied to the corn at a rate of 25 mm per week through mid-September.

Harvesting Protocol and Laboratory Analysis

Dry matter yield (DMY) was assessed on November 10, 2014, by hand clipping three, 0.75 m by 0.75 m frames per treatment to ground level, one within each interseeded row. Plant material was collected in paper bags, placed in a forced-air oven and dried at 60°C for 72 hours, and weighed. Yields were then converted to kg ha^{-1}. The samples were later ground for nutritional analysis through a Wiley® Mill (Model 4) equipped with a 2 mm screen and then through a Foss® Tecator Cyclotec Sample Mill (Model 1093), also equipped with a 2 mm screen, to homogenize the material. The samples were analyzed using a LECO TruSpec® CN268 Elemental Combustion analyzer (St Joseph, MI, USA) to obtain the nitrogen content which was then multiplied by 6.25 to estimate crude protein (CP) content (AOAC, 1990). Neutral detergent fiber (aNDF) and i*n-vitro* true digestibility (IVTD) (Van Soest and Robertson, 1985; Van Soest et al., 1991) were determined using an Ankom® 200 fiber analyzer (Methods 13 and 3, respectively). For the digestibility analysis, rumen fluid was collected from 2 fistulated steers that were being fed a mixed forage-corn diet. The samples were incubated for 48 hours.

Statistical Methods

The study was laid out using a randomized complete block design with three replicates per treatment. Dry matter yield, CP, aNDF, and IVTD were analyzed by analysis of variance using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). The model included forage species/mixture as the main factor and block (replicate) as the random factor. Mean separations were estimated using the Tukey test within PROC MEANS (SAS Inst. Inc., Cary, NC).

Cost Analysis

The cost of interseeding cool-season annual forages into corn was estimated by using the seed cost and cost of machinery used (tractor and interseeder). The biomass yield was multiplied by a utilization factor of 75% and the total cost was then divided by the utilizable biomass of each treatment to estimate the cost per kilogram of utilizable DM. The biomass yield was then multiplied by the percent CP to obtain the yield of protein in kilograms per hectare which was then multiplied by the utilization factor of 75%. The total cost per hectare was divided by the kilograms of utilizable protein per hectare to estimate the cost per kilogram of CP.

RESULTS AND DISCUSSION

Dry Matter Yield and Nutritional Quality

Dry matter yields differed among the interseeded forage species (p=0.0013), with the annual ryegrass and brassica mixture having the highest yields whereas crimson clover and winter triticale produced much lower biomass (Table 2). The two mixtures evaluated (AR+CC and WT+BM) had intermediate levels of DMY that were higher than crimson clover and winter triticale, but still lower than the highest yields achieved. Yield of the mixtures was dominated by the annual ryegrass and brassicas and was lower than the straight treatments due to the lower seeding rate for these species in the mix (Table 1).

The CP content also differed among the interseeded forage species (p=0.0149). On average, CP for the cool-season forages evaluated was four times the content of the cornstalks (Table 2). A low CP content for irrigated cornstalks has been reported as the first-limiting factor for weight gain when calves graze cornstalks (Klopfenstein et al., 1987; Fernandez-Rivera and Klopfenstein, 1989). The brassica and WT+BM mixtures were the treatments with the highest CP. Although the annual ryegrass and crimson clover had lower CP values, their content would still more than meet the requirements of beef cattle (NRC, 2000).

For fiber content as measured by aNDF, the interseeded species evaluated fell into 2 groups (p=0.0001, Table 2). The brassica and WT+BM mixtures were the treatments with the lowest aNDF contents averaging 24.4%. The other species and mixtures evaluated averaged 41.6% aNDF. All the forage species in this study had an aNDF content much lower than that of the cornstalks. Fernandez-Rivera and Klopfenstein (1989) had reported NDF values of 85% and 80.7% for irrigated and dryland cornstalks, respectively.

Although the treatment effect was significant for IVTD (p=0.0027), only one species, crimson clover, was significantly lower in digestibility compared to the other species and mixtures evaluated, averaging just under 78% (Table 2). All of the other cool-season forages had values of IVTD higher than 89%. Compared to the cornstalks, all of the forages evaluated had higher IVTD values. Cornstalks can only be grazed after the plants have reached physiological maturity which makes them low in digestibility (Klopfenstein et al., 1987; Fernandez-Rivera and Klopfenstein, 1989). Digestibility integrates the nutritional quality of a feedstuff and is an indicator of the potential nutrients available to livestock. The combination of cool-season forages with the cornstalks can provide high quality protein and fiber, however, the type of grazing management used could impact overall forage utilization and subsequent nutrient intake (Fernandez-Rivera and Klopfenstein, 1989). Rotation systems, in particular strip grazing with every day or every few day moves, can control the tendency of animals to select for the cool-season forages while encouraging more even utilization of the cornstalks. This will result in a more uniform intake of nutrients over time and capitalize on the higher quality of the cool-season forages.

Table 2. Dry matter yield and nutritional quality of forages interseeded into corn.

Forages	Yield (kg ha^{-1})	CP (%)	aNDF (%)	IVTD (%)
Cornstalks[†]	6873	5.2	73.5	57.7
Annual ryegrass	596^{ab}	18.9^{c}	39.9^{a}	90.7^{a}
Crimson clover	18^{d}	18.3^{c}	42.9^{a}	77.7^{b}
AR + CC	358^{bc}	20.1^{bc}	39.3^{a}	91.5^{a}
Winter triticale	58^{cd}	22.3^{abc}	44.2^{a}	90.0^{a}
Brassica mix	790^{a}	23.9^{ab}	25.3^{b}	89.4^{a}
WT + BM	428^{b}	26.1^{a}	23.4^{b}	92.1^{a}

[†] Not included in statistical analysis

Dry Matter and Crude Protein Costs

The cost of interseeding cool-season forages into corn varied by the seed cost and the seeding rates applied (Table 3). The cost to run the tractor with interseeder was the same for all treatments. Winter triticale was the treatment with the highest seeding rate and highest total cost. The two treatments with lower yields (i.e. crimson clover and winter triticale) resulted in the highest costs per kg of DM produced. If using good quality alfalfa (18% CP and 150 RFV) with a current market price of \$154 t^{-1} as a supplement, the cost per kg of DM would be \$0.175 after adjusting to a dry matter basis (\$154/(1000 kg x 88% DM)). The brassica mix and annual ryegrass had the lowest costs per kg of DM produced which were similar to the cost for alfalfa hay.

Table 3. Costs for interseeding forages into corn and resulting cost per kilogram of dry matter (DM) yield.

Forages	Seed cost (\$ ha^{-1})	Total cost (\$ ha^{-1})*	Utilizable DM cost (\$ kg^{-1})**
Annual ryegrass	32.11	81.61	0.18
Crimson clover	48.90	98.40	7.28
AR + CC	51.87	101.37	0.37
Winter triticale	133.13	182.63	4.19
Brassica mix	52.61	102.11	0.17
WT + BM	103.44	152.94	0.47

* Tractor and interseeder operation cost used was \$49.50 ha^{-1}
** Assuming 75% utilization by cattle

Like with DM yield, annual ryegrass and the brassica mix were the treatments with the highest CP yields, followed by the WT+BM mixture which was favored by having the highest CP content of all the treatments (Table 4). The utilizable protein was assumed to be a constant value (75%) of what the cattle can consume when grazing. The cost per kg of CP produced for the cool-season forages evaluated in this study varied widely due to the combination of DMY and CP. However, similar trends to those mentioned above were evident where crimson clover and winter triticale were the treatments with the highest costs.

Annual ryegrass and the brassica mix had the lowest costs per kg of utilizable protein (Table 4). These latter values were comparable to the cost of protein from good quality alfalfa hay (18% CP, \$0.97 kg^{-1}) with the brassica mix being cheaper at \$0.72 kg^{-1}. Being a cash crop, alfalfa hay prices are variable. At the current market price of \$154 t^{-1}, interseeding cool-season forages such as annual ryegrass and brassicas can compete favorably with the common practice of feeding alfalfa hay as a supplement when grazing cornstalks. If the market price for alfalfa goes up, the economics of interseeding cool-season forages into corn will be even more favorable and can definitely help provide the nutrients required to maintain rumen microbial activity (Klopfenstein et al., 1987).

Table 4. Protein yield and resulting cost per kilogram of crude protein yield of forages interseeded into corn.

Forages	Protein yield (kg ha^{-1})	Utilizable protein (kg ha^{-1})*	Protein cost (\$ kg^{-1})
Annual ryegrass	112.80	84.60	0.96
Crimson clover	3.29	2.47	39.84
AR + CC	72.15	54.11	1.87
Winter triticale	12.95	9.71	18.80
Brassica mix	189.15	141.86	0.72
WT + BM	111.65	83.74	1.82

* Assuming 75% utilization by cattle

Interseeding cool-season forages into corn will require the use of strip grazing to achieve the most efficient utilization of the corn residue/forage combination. Livestock managers may require training in these types of grazing management techniques and there will be some labor costs associated with moving electric fences every day or every few days. The cattle may also need time to acclimate to this type of management. On the other hand, producers have the potential to save money on purchased supplements such as alfalfa hay, even at current market prices of \$154 t^{-1}. The additional labor required to move electric fences will be offset by the costs associated with the storage, hauling, and feeding of other types of protein supplements.

IMPLICATIONS

Interseeding of cool-season forages into corn can provide a higher-quality diet for beef cattle grazing cornstalks during the fall. Supplementation of harvested feeds such as alfalfa hay represents a large expense for producers that graze their cattle on cornstalks. Production costs in beef cattle systems can be reduced by interseeding cool-season forages which have the potential to meet the nutritional requirements of cows as well as growing and finishing animals.

Integration of crop and livestock systems is feasible and can provide benefits to producers and to the environment. Through strip grazing, producers can optimize utilization of the cornstalks interseeded with cool-season forages while more evenly spreading the manure across the entire field thus reducing the need for future fertilization.

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