Intake and Digestibility of Improved Selections of Tall Fescue and Orchardgrass Hays

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ABSTRACT

Improved cool-season grass cultivars may add production potential to ruminant enterprises across the North–South transition zone. Quality among hays of 'MaxQ' ('Jesup' with novel endophyte), HM4 ('HiMag' with novel endophyte No. 4) and 'Cajun' (without endophyte) tall fescues [*Lolium arundinaceum* (Schreb.) Darbysh.] and 'Persist' orchardgrass (*Dactylis glomerata* L.) was evaluated. Forage was harvested in the flag-leaf stage in three of 4 yr and a regrowth (late flag-leaf to heads-emerging stage) in 1 yr. Goats (four trials) consumed MaxQ, HM4, and Persist similarly (P = 0.12; mean = 2.49 kg 100^{-1} kg body weight [BW]) and Cajun least (P < 0.01; mean = 1.62 kg × 100^{-1} kg BW). Apparent digestibility was similar among tall fescues ($P \geq 0.07$; mean = 609 g kg^{-1}), but MaxQ and Cajun were greater than Persist ($P \leq 0.05$; mean = 610 and 623 vs. 582 g kg^{-1}). Digestible dry matter intake (DMI) was similar among MaxQ, HM4, and Persist ($P \geq 0.09$; mean 1.49 kg 100^{-1} kg BW). Steers (three trials and Cajun not evaluated) consumed more Persist than MaxQ (P = 0.01; 2.40 vs. 2.14 kg 100^{-1} kg BW) or HM4 (P = 0.01; 1.98 kg 100^{-1} kg BW). MaxQ had greater apparent digestibility than HM4 (P = 0.01) or Persist (P = 0.04; 626 vs. 585 vs. 597 g kg^{-1}, respectively) but digestible DMI of MaxQ and Persist was similar (P = 0.12; mean = 1.39 kg 100^{-1} kg BW). Improved tall fescue cultivars, with novel endophyte, offer the ruminant producer a cool-season forage of similar quality as orchardgrass for their enterprise.

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Abbreviations: ADF, acid detergent fiber; BW, body weight; CELL, cellulose; CP, crude protein; Diff, difference; DM, dry matter; DMI, dry matter intake; HEMI, hemicellulose; HM4, 'HiMag' tall fescue infected with the novel No. 4 endophyte; NDF, neutral detergent fiber; NIRS, near-infrared reflectance spectroscopy.

Perennial cool-season grasses continue to make a major contribution to agriculture across the upper South. Both tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh.] and orchardgrass (*Dactylis glomerata* L.) are adapted cool-season forage grasses in this region. Tall fescue, however, is the predominate forage grown for both pasture and hay across the North–South transition zone, which extends from the Atlantic coast to 96° W longitude and from about 32° N to 38° N latitude (Burns and Chamblee, 1979; Burns and Bagley, 1996; Sleper and West, 1996). Reduced animal body condition and daily performance, however, has been associated with the presence of toxic endophyte(s) [*Neotyphodium coenophialum* (Morgan-Jones & Gams.) Glenn, Bacon & Hanlin] in tall fescue. Consequently, the literature on animal responses from tall fescue before the recognition and removal of the toxic endophyte from the forage is difficult or nearly impossible to interpret. These relationships and shortcomings have been well summarized (Fribourg and Waller, 2005; Hill, 2005; Sleper and West, 1996; Spiers et al., 2005).

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To improve cool-season forage production across the North–South transition zone, and especially in the more southern portion, requires germplasm with improved tolerance to heat and drought to extend the growth period and improve stand longevity. In the case of tall fescue, this needs to be achieved without the presence of the toxic endophyte (Hopkins and Alison, 2006). Recently, three tall fescue cultivars were released that offer this potential. 'Cajun', developed farther south (Auburn, AL), was released as a high-yielding cultivar with low toxic endophyte levels (Pedersen et al., 1989). 'Jesup', developed for the southern portion of the transition zone (Bouton et al., 1997), was infected with a novel (nontoxic) endophyte (AR542) of *N. coenophialum* to improve its tolerance to summer stress without reducing animal performance (Bouton et al., 2002) and marketed as 'MaxQ' tall fescue (Pennington Seed Inc., Madison, GA). The third cultivar, 'HiMag', selected for improved mineral balance to reduce risk of grass tetany (Sleper et al., 2002), was modified by inserting the novel (nontoxic) endophyte (No. 4) of *N. coenophialum* and designated HM4. When grazed, HM4 supported steer average daily gain that was nearly double that of 'Kentucky 31' tall fescue with the toxic endophyte present (Nihsen et al., 2004).

Orchardgrass, also adapted across the northern portion of the zone, has generally been known for its limited persistence (2–3 yr after establishment) but generally desirable nutritive value (Van Santen and Sleper, 1996). Consequently, orchardgrass tends to be used in rotational farming systems with high-input animal enterprises such as dairy farming (Burns and Bagley, 1996). However, the nutritional value (i.e., in vitro dry matter [DM] disappearance, crude protein (CP), neutral detergent fiber (NDF), and constituent fiber concentrations) of orchardgrass and tall fescue is frequently similar when harvested and compared at the same maturity (Archer and Decker, 1977a, 1977b; Barker et al., 1988; Prigge et al., 1999; Wagner 1954; Sheaffer and Marten, 1986). Recently, an orchardgrass cultivar designated Persist was released with improved persistence and potentially better adapted to the South (Conger, 2003).

These improved forage selections warrant evaluation for hay and pasture sources, as they could contribute to both beef and dairy production systems across the upper South (Burns and Bagley, 1996). The objective of this study was to compare the nutritive value constituents and subsequent quality of Cajun, MaxQ, and HM4 tall fescue with Persist orchardgrass without the confounding influence of the toxic endophyte in the fescue hays. Hays were obtained in each of four years and evaluated in seven intake and digestion trials (four using goats and three using steers).

MATERIALS AND METHODS

Two experimental sites, both a fine, kaolinitic thermic Typic Kanhapludult (Cecil clay loam) soil, located at the Lake Wheeler Road Field Laboratory, Raleigh, NC (133-m elevation at 35°52' N, 78°47' W), were used to produce the experimental hays. A seedbed was prepared and approximately 1.0 ha each of Cajun, an early fescue cultivar with low (<5%) toxic endophyte infection selected from 'AU Triumph' (Pedersen et al., 1989), and HiMag infected (≥85%) with the novel No. 4 endophyte (HM4; Univ. of Arkansas, Fayetteville) were seeded 8 Nov. 2002. A second area was prepared and approximately 1.8 ha of MaxQ, Jesup tall fescue infected (≥85%) with the novel AR542 endophyte (Pennington Seed, Inc., Madison, GA), and 1.8 ha of HM4 tall fescue were seeded 5 Oct. 2004. Persist orchardgrass was seeded in an adjacent 3.2-ha area with similar seedbed preparation on 19 Oct. 2005. All forages were established by drilling 22 kg ha^{-1} into a prepared seedbed. All experimental hay fields were fertilized with P and K according to soil test. Nitrogen, as ammonium nitrate, was applied at 78 kg ha^{-1} N in early March (initial growth) and before each regrowth that was used in animal evaluation.

All hays were cut with a conventional mower-conditioner set to leave a 7.6-cm stubble, tedded daily to reduce drying time, and were baled at approximately 850 g kg^{-1} DM with a conventional square baler. At each harvest the hays were tagged by cultivar and transported to the Forage-Metabolism Unit and stored on wooden pallets in a well-ventilated experimental hay barn until fed.

Before feeding, each experimental hay was passed through a hydraulic bale press (Van Dale 5600, J. Starr Industries, Fort Atkins, WI) with stationary knives spaced at 10 cm. This process reduced the hay into 7- to 13-cm lengths with essentially no leaf loss, which aids the feeding of the animals and minimizes the potential for hay to be tossed out of the manger. The processed hays were stored in carts for subsequent feeding. Hays were evaluated by animals under the supervision and approval of the university's Institutional Animal Care and Use Committee (IACUC no. 06-055-A) during the winter following the summer of harvest.

The hays for animal evaluation were obtained from four harvests. Harvest 1 consisted of initial-growth Cajun and HM4 tall fescue cut in the flag-leaf stage from Site 1, 9 June 2003. Harvest 2 was initial growth of MaxQ and HM4 cut in the late flag-leaf stage from Site 2, 9 May 2005. Harvest 3 consisted of regrowth (initial growth removed 15 May) of MaxQ and HM4 tall fescue and Persist orchardgrass cut in the late flag-leaf to head-emerging stage from Site 2, 7 July 2006. The fourth and final harvest consisted of initial growth of MaxQ and HM4 tall fescue and Persist orchardgrass cut in the flag-leaf stage from Site 2, 8 May 2007.

Experiment 1 (Evaluation Using Goats)

The hays from each harvest were evaluated by Boer × Spanish wether goats (*Capra hircus* L.) in four independent trials. Trial 1 compared HM4 and Cajun tall fescues, Trial 2 compared HM4 and MaxQ tall fescues, and Trials 3 and 4 compared HM4 and MaxQ tall fescues and Persist orchardgrass. Mean animal weight ranged from 28.5 to 33.1 kg in Trial 1 (7 goats treatment^{-1}; n = 14), 33.7 to 43.2 kg in Trial 2 (6 goats treatment^{-1}; n = 12), 23.8 to 49.8 kg in Trial 3 (6 goats treatment^{-1}; n = 18), and 13.8 to 26.1 kg in Trial 4 (6 goats treatment^{-1}; n = 18) and averaged 31.7 kg (±4.53 kg) for the experiment over all trials. The trials were conducted in a building constructed for small-ruminant research with moderate temperature control (ambient air maintained >13 and <24°C). All trials were conducted in a randomized complete block design.

The goats were held in individual digestion crates and had free access to salt blocks (NaCl = 960–980 g kg^{-1}, Zn ≥5 g kg^{-1}, Mn ≥4 g kg^{-1}, Cu ≥2.5 g kg^{-1}; Buckeye Feed Mills, Dalton, OH) and water. When they were initially placed in crates, they were fitted with a collection harness for future fecal collections. Goats were standardized on common, nonexperimental tall fescue hays in Trials 1 and 2 and on common, nonexperimental orchardgrass hays in Trials 3 and 4, fed at 15% excess for 14 d. This allowed conditioning to the crates and to the harness. Goats were then blocked by weight in groups of two or three, depending on trial, to form a replicate; then each animal within each group was randomly assigned to a treatment. The intake phase of each trial consisted of a 21-d period, with the first 7 d used for adjustment and the last 14 d to estimate dry matter intake (DMI) (Burns et al., 1994). A recorded weight of hay was fed once daily, allowing a targeted 15% excess that was based on intake of the previous day. A daily sample of the fed hay was obtained for each animal, and composites were saved for each animal × treatment combination on a weekly basis. Weighbacks were taken daily, saved separately for each animal × treatment combination, and composited each week.

Apparent digestibility was determined immediately after the intake phase. At initiation of the digestion phase, a canvas collection bag was positioned on the harness and fitted with a plastic insert for total fecal collection. During a 5-d collection phase, the fecal bags were emptied and the feces weighed daily, thoroughly mixed, and 5% of the fresh fecal weight was placed in a freezer (−15°C).

Experiment 2 (Evaluation Using Steers)

The hays from Harvests 2, 3, and 4 were also evaluated by grade Angus steers (*Bos taurus* L.) in three independent trials. Trial 5 compared HM4 and MaxQ tall fescues and Trials 6 and 7 compared HM4 and MaxQ tall fescues and Persist orchardgrass. Mean steer weights ranged from 263 to 313 kg in Trial 5 (7 steers $treatment^{-1}$; n = 14), 249 to 292 kg in Trial 6 (5 steers $treatment^{-1}$; n = 15), and from 236 to 288 kg in Trial 7 (5 steers $treatment^{-1}$; n = 15) and averaged 275.4 kg (±6.7 kg) over all trials for the experiment. All trials were conducted in a randomized complete block design. The trials were conducted in an animal facility consisting of a metal structure partitioned into a feed preparation area on one end, an enclosed but well-ventilated middle area equipped with digestion crates with moderate temperature control (ambient air maintained >10°C and <24°C). A third section, equipped with a raised, basketweave metal platform and fitted with Calan electronic gates (American Calan Inc., Northwood, NH) was used to control animal access to mangers for individual intake measurements. The intake area was beneath an extension of the roof with three open sides. In the intake phase, each animal was electronically keyed to allow access to only one of the 12 mangers per pen. Animals lounged in a common area with free access to blocks of mineralized salt (940 g kg^{-1} NaCl, 2.5 g kg^{-1} Zn, 1.5 g kg^{-1} Fe, 3.0 g kg^{-1} Mn, 0.15 g kg^{-1} Cu, 0.09 g kg^{-1} I, and 0.025 g kg^{-1} Co; United Salt Corp., Houston, TX) and water. Before each experiment, animals were conditioned to the electronic gates. Thereafter, animals were standardized on common, nonexperimental tall fescue hays in Trials 5 and 6 and on a common nonexperimental orchardgrass hay in Trial 7. Animals were fed at 15% excess for 14 d, blocked by weight into groups of two or three, depending on trial, to form a replicate, and randomly assigned to a forage treatment within group.

The intake phase of each experiment consisted of a 21-d period with the first 7 d used for adjustment and the last 14 d to estimate daily DMI (Burns et al., 1994). A recorded weight of hay was fed twice daily allowing a targeted 15% excess that was based on the previous day's intake. A daily sample of the fed hay was obtained for each animal and composites made on a weekly basis. Weighbacks were taken twice daily, saved separately for each animal × treatment combination, and composited each week.

The digestion phase immediately followed each intake period. The animals were moved from the intake area into digestion crates. The digestion phase consisted of a 7-d adjustment period followed by a 5-d total fecal collection (12 d). A recorded weight of forage was fed twice daily targeted at 15% excess of the previous day's intake. A daily sample of the fed hays was obtained and the weighback saved separately for each animal × treatment combination and composited for the 5-d collection period.

Feces were collected on a plastic sheet placed on the floor immediately in back of each digestion create. Feces were removed periodically throughout the day and the daily total weighed for each of the five consecutive days. Feces were thoroughly mixed daily, and 5% of the fresh weight was placed in a freezer (−15°C).

Laboratory Analysis

In each trial, five types of samples were obtained for each animal on each treatment (cultivar). These consisted of a weekly composited feed and weighback sample from the 14-d intake phase, a composited feed and weighback sample from the 5-d digestion phase, and a composited fecal sample from the 5-d digestion phase. This totaled 310 samples from Exp. 1 (four goat trials) and 220 samples from Exp. 2 (three steer trials). The samples were oven-dried (55°C) and weighed for DM determination, ground in a Wiley mill (Thomas Scientific, Swedesboro, NJ) to pass a 1-mm screen, thoroughly mixed, and a subsample stored at room temperature until analyzed.

The composition of feed, weighback, and fecal samples from the intake and digestion phases of each experiment were estimated using near-infrared reflectance spectrophotometry (NIRS). Samples were scanned in a Model 5000 NIRS with WinISI, version 1.5 software (FOSS North America, Inc., Eden Prairie, MN). The H statistic (0.6) was used to identify samples with different spectra. These samples were subsequently analyzed by wet chemistry, added to existing libraries, and used to develop NIRS calibration equations to predict the various estimates of nutritive value (Table 1).

Total N was determined colorimetrically (AOAC, 1990) with a Technicon Autoanalyzer (Bran and Luebbe, Buffalo Grove, IL) and CP was estimated as 6.25 times total N. The fiber fractions, NDF and acid detergent fiber (ADF), were estimated in a batch processor (Ankom Technology Corp., Fairport, NY), and sulfuric acid (72% w/w) was used to determine cellulose (CELL) and lignin according to Van Soest and Robertson (1980). Hemicellulose (HEMI) was determined by difference (NDF − ADF).

Statistical Analysis

The trials were combined and the data were analyzed as a series of randomized complete block experiments (PROC MIXED; SAS Institute, 2004). The mixed model included a random term for trial and animals within trials and a fixed term for treatments. Means for all variables found significant were compared

Table 1. The number (*n*) of samples (includes library samples and 40 feed, 54 weighback, and 34 fecal samples chosen from seven trials), range for each forage or fecal constituent predicted by near-infrared reflectance spectrophotometry, and associated SE of calibration (SEC) and SE of cross validation (SECV) over all experiments.

Item†	*n*	Range	SEC	R^2	SECV	R^2
		g kg^{-1}			g kg^{-1}	
Feed and weighback						
CP	279	75–205	3.2	0.98	3.6	0.98
NDF	281	552–750	9.5	0.94	11.2	0.92
ADF	278	273–446	6.2	0.96	7.2	0.94
CELL	278	229–364	4.5	0.96	5.2	0.94
Lignin	282	21–116	2.9	0.94	3.2	0.93
Feces						
CP	422	52–174	3.1	0.98	3.5	0.98
NDF	417	439–774	13.7	0.96	14.8	0.95
ADF	422	264–438	10.3	0.91	12.6	0.86
CELL	419	185–339	6.1	0.96	6.8	0.96
Lignin	414	55–157	6.6	0.92	7.5	0.89

†CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; CELL = cellulose.

by a set of contrasts. The combined analyses were not balanced and least square means were used for comparisons. Differences in all animal responses and in forage composition were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Two experiments were conducted, Exp. 1 using goats and Exp. 2 using steers. Goats provided eating behavior and a digestive tract of an intermediate feeder in which the diet typically consists of both browse and pasture (Hofmann, 1998). Cattle, in contrast, are grazing animals with digestive tracts that reflect a greater ability to process cellulosic materials (Van Soest, 1982). Hays of the same experimental lot (harvest and cultivar) were evaluated separately by each ruminal species.

Experiment 1

Goat Responses

Dry matter intake as kg 100^{-1} kg body weight (BW) differed among cultivars, with goats consuming HM4 and MaxQ tall fescue and Persist orchardgrass similarly and least of Cajun tall fescue (Table 2). The DM digestion of the three tall fescue cultivars was similar ($P = 0.07$). Persist was less digestible than either MaxQ or Cajun, but similar to HM4. The NDF and its constituent ADF, HEMI, and CELL were all digested similarly among the tall fescue cultivars, averaging 647, 617, 676, and 690 g kg^{-1}, respectively. In general, the digestion of NDF and its constituent ADF and CELL were similar between Persist and the tall fescue cultivars. The noted exception was that the Persist NDF was relatively less digestible than MaxQ. The Persist HEMI was relatively less digestible than the HEMI of HM4 and Max Q (Table 2).

Table 2. Dry matter intake, apparent dry matter and fiber fraction digestibilities, and digestible intakes of tall fescue and orchardgrass cultivars fed to goats (oven-dry basis).

Cultivar	Intake‡	Digestion†					Digestible intake				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	kg 100^{-1} kg	g kg^{-1}					kg 100^{-1} kg				
Tall fescue§											
HM4	2.44	593	642	608	676	686	1.45	1.04	0.49	0.55	0.49
MaxQ	2.57	610	659	624	691	698	1.56	1.11	0.50	0.61	0.50
Cajun	1.62	623	653	619	685	690	0.99	0.68	0.31	0.37	0.30
Orchardgrass¶											
Persist	2.47	582	636	619	653	685	1.46	1.06	0.53	0.53	0.51
Significance (*P*)											
Treatment	<0.01	0.03	0.13	0.55	<0.01	0.56	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	10.73	4.95	4.42	5.81	3.81	4.16	13.75	13.10	14.16	12.87	12.63
Comparisons											
Tall fescue											
HM4 vs. MaxQ	0.12	0.10	0.09	0.20	0.09	0.22	0.09	0.12	0.56	0.02	0.50
HM4 vs. Cajun	<0.01	0.07	0.48	0.56	0.51	0.79	<0.01	<0.01	<0.01	<0.01	<0.01
MaxQ vs. Cajun	<0.01	0.47	0.74	0.85	0.67	0.73	<0.01	<0.01	<0.01	<0.01	<0.01
Orchardgrass											
Persist vs. HM4	0.82	0.37	0.54	0.43	0.03	0.92	0.94	0.71	0.09	0.33	0.31
Persist vs. MaxQ	0.27	0.03	0.04	0.75	<0.01	0.25	<0.17	0.33	0.22	<0.01	0.66
Persist vs. Cajun	<0.01	0.05	0.36	0.99	0.07	0.78	<0.01	<0.01	<0.01	<0.01	<0.01

†DM = dry matter; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

‡Body weight basis.

§Each value is the mean of 25 goats for HM4; 18 goats for MaxQ; 7 goats for Cajun.

¶Each value is the mean of 12 goats.

The digestible DMI and digestible intakes of NDF and its fiber constituents, except HEMI, generally varied with DMI. Both HM4 and MaxQ had similar digestible intake of DM, NDF, and its constituent fiber, except HEMI, which was greatest for MaxQ. Both HM4 and MaxQ had greater digestible intake of DM, NDF, and constituent fiber than Cajun. On the other hand, Persist orchardgrass had similar digestible intakes of DM, NDF, and fiber fractions as HM4 and MaxQ, but less digestible intake of HEMI than MaxQ. The digestible intakes of all variables were greater for Persist compared with Cajun. Although Cajun had some toxic endophyte present (<5.0%), the concentration was not associated with reduced DMI as it was well below the 10% infection level considered safe (Tracy and Renne, 2005).

The similarity in digestible DMI between tall fescue (MaxQ and HM4) and Persist orchardgrass is consistent with recent literature findings after evaluation and removal of the toxic endophyte from tall fescue. Prigge et al. (1999) reported similar nutritive value and animal daily gains when endophyte tall fescue and orchardgrass was grazed in the spring. Also, Coblenz et al. (2006) reported similar cow–calf performance (daily gain, total gain, and weaning weight) when grazing endophyte-free tall fescue and orchardgrass.

Table 3. Nutritive value of fed hays (FH) and the difference (Diff = weighback – FH) in crude protein (CP) concentration of tall fescue and orchardgrass cultivars fed to goats (oven-dry basis).

Cultivar	CP			Fiber constituent[†]			
	FH	Diff	NDF[‡]	ADF	HEMI	CELL	Lignin
	g kg^{-1}						
Tall fescue[§]							
HM4	141	−8.7	662	329	333	290	34
MaxQ	146	−12.7	657	314	343	279	31
Cajun	138	−36.7	651	323	328	275	34
Orchardgrass[¶]							
Persist	139	−4.1	684	358	326	302	40
Significance (*P*)							
Treatment	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	2.73	60.71	1.18	1.52	1.48	1.10	4.60
Comparisons							
Tall fescue							
HM4 vs. MaxQ	<0.01	0.81	0.07	<0.01	<0.01	<0.01	<0.01
HM4 vs. Cajun	0.10	<0.01	0.02	0.03	0.06	<0.01	0.94
MaxQ vs. Cajun	<0.01	<0.01	0.25	0.01	<0.01	0.05	<0.01
Orchardgrass							
Persist vs. HM4	0.10	0.50	<0.01	<0.01	<0.01	<0.01	<0.01
Persist vs. MaxQ	<0.01	0.64	<0.01	<0.01	<0.01	<0.01	<0.01
Persist vs. Cajun	0.71	<0.01	<0.01	<0.01	<0.51	<0.01	<0.01

[†]ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[‡]NDF = neutral detergent fiber.

[§]Each value is the mean of 25 goats for HM4; 18 goats for MaxQ; 7 goats for Cajun.

[¶]Each value is the mean of 12 goats.

Hay Composition

The fed hays were all adequate in CP for wether goats (NRC, 1981) but concentrations were greater in MaxQ than in HM4 and Cajun, whereas HM4 and Cajun were similar. Persist had CP concentrations similar to Cajun and HM4 but less than MaxQ (Table 3).

Among tall fescue cultivars, the NDF concentration in HM4 was greatest and similar to MaxQ, with Cajun least but similar to MaxQ (Table 3). Persist had a greater NDF concentration than the tall fescues. Compared with MaxQ, HM4 had greater concentrations of ADF and CELL but similar HEMI and lignin. The hay of MaxQ had least ADF and lignin but greater HEMI and CELL than Cajun. In general, Persist had greater concentrations of most fiber constituents than the three tall fescue cultivars. However, HEMI concentration was similar in Persist and Cajun, whereas MaxQ had greater HEMI than the other three forages (Table 3).

The least DMI but favorable DM digestion reported for Cajun (Table 2) indicates that selective consumption of the forages may have occurred. Frequently, ruminants will selectively consume leafy material and avoid stem and dead fractions if given the opportunity (Stobbs, 1973). Consequently, because tall fescue has a wide difference in CP concentrations between leaf and stem (Burns et al., 2006), selectivity should be reflected in a reduction in CP concentration in the weighback compared with the fed hay. Subtracting the CP concentration of the weighback (data not shown) from the CP concentration of the fed hay provided a difference (Diff) value for comparison (Table 3). In general, the Diff values for MaxQ and HM4 tall fescue and Persist were all similar, indicating that selectivity was similar between these cultivars. On the other hand, Cajun had greater Diff values, indicating increased degree of selectivity. This was consistent with the relatively low rank of Cajun among the tall fescue cultivars (Table 2).

Fecal Composition

The fecal composition further indicates the differences noted above among the experimental hays. The CP and NDF and its fiber fraction concentrations in the feces of HM4 and MaxQ were generally similar (Table 4). The exceptions are ADF and CELL, which differed, but these differences are probably of little biological importance. On the other hand, both HM4 and MaxQ differed from Cajun, with Cajun having least concentrations of CP but greatest concentrations of NDF and its fiber constituents. Differences were not significant for CELL or for ADF between HM4 and Cajun and for HEMI between MaxQ and Cajun (Table 4).

The fecal composition from feeding Persist hay was lower in CP and greater in NDF concentrations and its

Table 4. Crude protein (CP), neutral detergent fiber (NDF), and fiber constituents of feces from goats fed tall fescue and orchardgrass hays (oven-dry basis).

Cultivar	CP	NDF	Fiber constituent†			
			ADF	HEMI	CELL	Lignin
	g kg^{-1}					
Tall fescue‡						
HM4	142	577	313	264	223	75
MaxQ	142	570	301	270	216	75
Cajun	130	600	315	284	227	67
Orchardgrass§						
Persist	128	597	325	271	234	87
Significance (*P*)						
Treatment	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	5.39	3.14	3.62	4.32	4.59	5.45
Comparisons						
Tall Fescue						
HM4 vs. MaxQ	0.75	0.23	<0.01	0.15	0.03	0.91
HM4 vs. Cajun	<0.01	0.03	0.76	0.03	0.55	<0.01
MaxQ vs. Cajun	0.02	0.01	0.05	0.07	0.10	<0.01
Orchardgrass						
Persist vs. HM4	<0.01	0.01	0.01	0.12	0.01	<0.01
Persist vs. MaxQ	<0.01	<0.01	<0.01	0.75	<0.01	<0.01
Persist vs. Cajun	0.56	0.79	0.20	0.12	0.29	<0.01

†ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

‡Each value is the mean of 25 goats for HM4; 18 goats for MaxQ; 7 goats for Cajun.

§Each value is the mean of 12 goats.

fiber constituents compared with feces from feeding either HM4 or MaxQ hay, but generally similar to Cajun hay. The exception being HEMI, in which Persist was similar to both HM4 and MaxQ, but greater in lignin than Cajun (Table 4).

Experiment 2

Steer Responses

In contrast to the result of the goat trial, steers consumed more of Persist orchardgrass, compared with both HM4 and MaxQ tall fescues, and more MaxQ than HM4 (Tables 2 and 5). Digestibilities of the hays, however, were greatest for MaxQ but Persist and HM4 were similar. The digestibilities of NDF and its constituent fiber fractions were similar between Persist and HM4, with the exception of a greater digestibility of ADF in Persist. The digestibilities of NDF, ADF, and CELL were also similar between MaxQ and Persist but MaxQ had greater HEMI digestion. This is consistent with results reported by Prigge et al. (1999), who noted that ADF of spring-harvested orchardgrass hay was greater than tall fescue, but both were similar in in vitro DM disappearance and were consumed similarly by steers.

Digestible DMI was greatest for Persist compared with HM4 but similar to MaxQ (Table 5). Digestible intakes of NDF and its fiber constituents reflect DMI being greatest for Persist, except for HEMI, which was similar to MaxQ. The two tall fescue cultivars differed in digestible intake of NDF and its fiber constituents, with MaxQ having greater values than HM4.

The similar digestible DMI for steers fed MaxQ and Persist is consistent with the results from goats in Exp. 1. Also, it is consistent with the similar animal performance between endophyte-free tall fescue and orchardgrass reported by both

Table 5. Dry matter intake, apparent dry matter and fiber fraction digestibilities, and digestible intakes of tall fescue and orchardgrass cultivars fed to steers (oven-dry basis).

Cultivar	Intake‡	Digestion†					Digestible intake				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	kg 100^{-1} kg	g kg^{-1}					kg 100^{-1} kg				
Tall fescue§											
HM4	1.98	585	651	613	686	695	1.15	0.86	0.40	0.46	0.40
MaxQ	2.14	626	690	656	719	732	1.34	0.98	0.45	0.54	0.44
Orchardgrass¶											
Persist	2.40	597	660	650	683	720	1.44	1.11	0.57	0.55	0.53
Significance (*P*)											
Treatment	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	10.43	5.13	5.12	6.03	4.16	4.80	11.16	12.00	12.05	12.28	11.13
Comparisons											
Tall fescue											
HM4 vs. MaxQ	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02
Orchardgrass											
Persist vs. HM4	<0.01	0.38	0.54	0.03	0.78	0.10	<0.01	<0.01	<0.01	<0.01	<0.01
Persist vs. MaxQ	0.01	0.04	0.07	0.69	<0.01	0.45	0.12	0.02	<0.01	0.58	<0.01

†DM = dry matter; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

‡Body weight basis.

§Each value is the mean of 17 steers.

¶Each value is the mean of 10 steers.

Prigge et al. (1999) and Coblentz et al. (2006) noted above.

Hay Composition

Crude protein concentrations of the fed hays were greater for MaxQ, with Persist least (Table 6). Concentrations of CP, however, were greater for each cultivar than the requirements (114 g kg^{-1} DM) for a 270-kg steer to gain 1 kg d^{-1} (NRC, 1996). The NDF was greatest in Persist hays compared with HM4 or MaxQ, whereas the two tall fescue cultivars were similar. The fiber fractions differed between Persist and the tall fescue cultivars, with Persist greater in ADF, CELL, and lignin but least in HEMI. Further, MaxQ had least ADF, CELL, and lignin but greater HEMI than HM4. Selective consumption by steers was also examined, as noted above for goats, by comparing Diff values between CP concentrations in the weighback (data not shown) and the fed hays (Table 6). The Diff values for CP were similar between the HM4 and MaxQ hays, indicating that selectivity was similar between both. The Diff values for Persist, however, were greater compared with either HM4 or MaxQ, indicating an increased degree of selectivity over the tall fescue cultivars.

Table 6. Nutritive value of fed hays (FH) and the difference (Diff = weighback – FH) in crude protein (CP) concentration of tall fescue and orchardgrass cultivars fed to steers (oven-dry basis).

Cultivar	CP		NDF‡	Fiber constituent†			
	FH	Diff		ADF	HEMI	CELL	Lignin
	g kg^{-1}						
Tall fescue§							
HM4	130	2.2	671	332	339	292	36
MaxQ	134	–2.3	666	319	347	282	33
Orchardgrass¶							
Persist	124	–10.7	693	360	333	307	50
Significance (*P*)							
Treatment	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV (%)	2.65	163.47	1.38	1.43	1.67	1.10	4.33
Comparisons							
Tall fescue							
HM4 vs. MaxQ	<0.01	0.12	0.11	<0.01	<0.01	<0.01	<0.01
Orchardgrass							
Persist vs. HM4	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Persist vs. MaxQ	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01

†ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
‡NDF = neutral detergent fiber.
§Each value is the mean of 17 steers.
¶Each value is the mean of 10 steers.

Fecal Composition

Crude protein of the feces reflected the as-fed hay composition with the feces from Persist orchardgrass having the least concentration and feces from HM4 and MaxQ hays similar (Table 7). Feces from Persist hay also had similar NDF, ADF, HEMI, and CELL concentration compared with feces from HM4 hay, but the feces from Persist were greater in lignin concentrations. Feces from MaxQ hay, on the other hand, had least ADF and lignin concentrations compared with feces from Persist hay.

SUMMARY AND CONCLUSIONS

Goats consumed MaxQ and HM4 tall fescues and Persist orchardgrass similarly (2.49 kg 100^{-1} kg BW) and least of Cajun tall fescue (1.62 kg 100^{-1} kg BW). Further, goats also digested MaxQ, HM4, and Cajun similarly (609 g kg^{-1}), but only MaxQ and Cajun were digested greater than Persist (617 vs. 582 g kg^{-1}). This resulted in digestible DMIs that were similar among MaxQ and HM4, and Persist (1.49 kg 100^{-1} kg BW). Using digestible DMI as an index to animal performance, these data indicate that either MaxQ or HM4 tall fescue or Persist orchardgrass would be expected to give similar animal daily responses.

Steers evaluating MaxQ and HM4 tall fescues and Persist orchardgrass consumed the most Persist (2.40 kg 100^{-1} kg BW) compared with MaxQ (2.14 kg 100^{-1} kg BW) and HM4 (1.98 kg 100^{-1} kg BW), of which MaxQ consumption was greater than HM4. Steers, however, digested MaxQ greater than either HM4 or Persist, with HM4 and Persist being similar. The resulting digestible DMIs were similar between MaxQ and Persist, and both had digestible DMIs that were greater than HM4. The similarity in digestible DMI between Persist

Table 7. Crude protein (CP), neutral detergent fiber (NDF), and fiber constituents of feces from steers fed tall fescue and orchardgrass hays (oven-dry basis).

Cultivar	CP	NDF	Fiber constituent†			
			ADF	HEMI	CELL	Lignin
	g kg^{-1}					
Tall fescue‡						
HM4	133	565	309	256	215	83
MaxQ	135	553	294	260	204	80
Orchardgrass§						
Persist	126	572	311	260	212	90
Significance (*P*)						
Treatment	<0.01	0.13	<0.01	0.69	0.03	<0.01
CV (%)	3.67	3.99	3.97	4.88	5.59	6.17
Comparisons						
Tall Fescue						
HM4 vs. MaxQ	0.34	0.14	<0.01	0.44	0.01	0.11
Orchardgrass						
Persist vs. HM4	<0.01	0.49	0.69	0.51	0.58	<0.01
Persist vs. MaxQ	<0.01	0.07	<0.01	0.96	0.11	<0.01

†ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
‡Each value is the mean 17 steers.
§Each value is the mean of 10 steers.

and MaxQ is associated with the compensating shifts in DMI and apparent DM digestion. These data indicate that in a cattle production setting either MaxQ or Persist could be expected to give similar animal daily responses.

In general, both small- and large-ruminant producers have the option of either an improved tall fescue with novel endophyte or orchardgrass as a perennial cool-season forage. The selection of one forage over another may be predicated on agronomic characteristics, such as seasonal growth distributions and yield, regrowth rate, and stand longevity, and not entirely on animal performance.

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