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Ruminant Preference for Bermudagrass Hay With and Without Exposure to Swine Lagoon Effluent

J. C. Burns, Professor, Departments of Crop Science and Animal Science, North Carolina State University; Collaborator, U.S. Department of Agriculture—Agricultural Research Service

D.S. Fisher, Previously U.S. Department of Agriculture—Agricultural Research Service and presently, Statistician, Syngenta Biotechnology, Inc., Research Triangle Park, N.C.

E. S. Leonard, Research Analyst, Department of Crop Science, North Carolina State University and U.S. Department of Agriculture—Agricultural Research Service

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Contents

Abstract

Bermudagrass frequently serves as a receptor of swine lagoon effluent in active swine operations. This experiment evaluated the subsequent acceptance of such effluent-treated hay by ruminants. Six Coastal bermudagrass hays were evaluated for preference. Four hays were grown on a long-term waste field and consisted of one cut prior to effluent application (Hay-1), one cut on the same day after effluent application (Hay-2), one cut 1 day later (Hay-3), and one cut 2 days after effluent application (Hay-4). Two additional hays (Hay-5 and Hay-6) were cut from two different bermudagrass fields (A and B, respectively) with no history of receiving swine lagoon waste. In general, among hays produced on the waste treated field, cattle (steers) showed modest preference for the hay that was cut prior to effluent application (Hay-1 vs. Hays-2, -3, and -4), whereas sheep and goats consumed little hay overall with no preference evident among the four hays. Hays produced from the non-waste treated fields were strongly preferred by cattle, sheep, and goats. Further, hay from one of the non-waste treated fields (Hay-6, field B) was preferred over hay from the other non-waste treated field (Hay-5, field A) and is consistent with greater in vitro dry matter disappearance (IVTD) and crude protein (CP) and lesser neutral detergent fiber (NDF). Bermudagrass hay from swine lagoon waste fields can have a role in ruminant production systems, but when fed as the sole ration, animal dry matter intake may be only modest.

Introduction

The major forage species used as a receiver of swine lagoon effluent in the Upper South has been a selection of one of the perennial bermudagrass cultivars. Bermudagrass is the predominant spray-field forage because of its adaptability relative to its growth characteristics. These characteristics include abundant rhizome and stolon production, which give bermudagrass its capability to spread and fill into open areas, its greater yield potential, and consequently, its capacity for uptake and removal of waste elements. Especially important is the uptake of soluble nitrogen from the waste field environment. Bermudagrass also has a long history as a hay source in many ruminant production systems because it is persistent, it responds to nitrogen fertilization, and it is of an acceptable quality for ruminants when properly managed. This use has provided a potential market for bermudagrass grown on swine waste fields and harvested as hay.

Because of the abundance of water and nutrients, bermudagrass spray fields can become a mixture of forage and weedy plant species. Furthermore, a decrease in dry matter intake of bermudagrass hay fed to steers has been noted when forage harvested for hay had received treated swine lagoon effluent, even when the effluent was delivered by subsurface drip irrigation (Burns et al., 2009). Our objectives in this study were two-fold. The first objective was to compare the preference among bermudagrass hays cut from a dedicated spray field with hays cut from non-waste fields. The second objective was to compare preferences when cutting for hay was delayed over several days after exposure to swine lagoon effluent. We were also interested in observing whether preference patterns exhibited for the hays were similar among ruminant species.

Materials and Methods

A well-established stand of 'Coastal' bermudagrass (Cynodon dactylon [L.] Pers.), consisting of about 6 acres and previously devoted to annual (>5 years) applications of swine lagoon effluent, served as the experimental site. The field was first subdivided into strips and irrigation lines were placed for effluent application. Prior to initiation of the experiment, twenty random forage subsamples were hand cut to the soil surface from each strip. The subsamples were composited by strip, thoroughly mixed, and a subsample was separated into bermudagrass and weeds. The field averaged 46% bermudagrass and 54% weeds (predominately crabgrass), which is probably fairly typical for long-term-use spray fields in the industry.

At initiation of the experiment (day 0), one random strip was cut for hay prior to effluent application. The remainder of the field received swine lagoon effluent from 9:00 a.m. to 11:00 a.m. A second random strip, the first from the effluent treated area, was cut for hay on the same day (day 0) at 2:00 p.m. Subsequent random strips were cut at approximately 2:00 p.m. on the following 2 days (day 1 and day 2). These constituted Hays 1, 2, 3, and 4, respectively. To obtain a contrast with bermudagrass hay receiving recommended chemical fertilizer and without previous exposure to effluent application as a waste field, two bermudagrass hays were cut from two different fields (A and B) and designated as Hays 5 and 6. These methods resulted in the following six treatments:

Treatment	Description
Hay 1	No effluent applied; cut from an active waste field.
Hay 2	Same day post effluent application; cut from an active waste field.
Hay 3	One day post effluent application; cut from an active waste field.
Hay 4	Two days post effluent application; cut from an active waste field.
Hay 5	Chemically fertilized; cut from a non-waste, well-managed field (A).
Hay 6	Chemically fertilized; cut from a non-waste, well-managed field (B).

All hays were cut with a mower conditioner set to leave a 3- to 4-inch stubble. When dry, the hays were baled with a conventional square baler, and the bales were stored by treatment on wooden pallets in a hay-storage barn until fed. At feeding, the hays were passed through a hydraulic bale press with knives set at 4-inch intervals to, reduce them to 3- to 5-inch lengths with essentially no leaf loss. This preparation aided in feeding of the animals and reduced the opportunity for animals to toss the offered hay out of the containers.

Preference Experiments

Preference experiments were conducted with cattle (Exp. 1), sheep (Exp. 2), and goats (Exp. 3). Six animals of each species were used in each experiment. Prior to initiation of a preference trial, the animals were standardized for 14 days on Coastal bermudagrass hay from a single source. Six cattle, consisting of British crossbred steers, were standardized and used in Exp. 1. In the case of sheep and goats, eight Katahdin ewe sheep and eight Boer male goats were standardized, and the six with the most similar dry matter intake were used for preference estimates in Exp. 2 and Exp. 3, respectively. The tester animals then began a 6-day introduction phase in which each animal was randomly exposed to each of the six experimental hays.

Preference evaluation followed the introductory phase, and all three preference experiments were conducted similarly. A weighed amount of hay was offered in random pairs (left/right orientation) to individual animals in separate pens in each experiment. During the experiment, animals were carefully observed so that, in case of a strong preference, no more than 50% of the offered hays were consumed. This measure avoided the possible shift in preference due to limited hay availability. Each evaluation was conducted for 30 minutes. During this exposure, the animals were disturbed after 15 minutes to make them reselect. After 30 minutes, the containers were removed and weighed for subsequent dry matter intake and intake rate determinations. In the case of steers, preference was video recorded and eating time was determined for each treatment. This time was used to compute an intake rate (grams/minute). In the case of sheep and goats, the hay was consumed for the 30-minute period; consequently, only the dry matter intake and intake rate are reported, as the time and intake rate would give the same statistical responses.

Two sets of evaluations occurred each day for steers, requiring 8 days to complete their experiment. Only one set of evaluations occurred each day for sheep and goats, requiring 15 days to complete their experiments. At each evaluation, a subsample of the offered hay and of the resulting weighback (uneaten hay) was taken and composited for each animal, resulting in six samples each of the fed hay and of the weighback for each experiment. All samples were dried in a forced air oven at 170°F and used to determine dry matter intake. The samples were then ground in a Wiley mill to pass through a 1 mm screen and stored for subsequent laboratory analysis. Samples were analyzed for in vitro true dry matter disappearance (IVTD), total nitrogen multiplied by 6.25 to determine crude protein (CP), neutral detergent fiber (NDF) and its fiber constituents of acid detergent fiber (ADF), cellulose (CELL), and lignin.

Multidimensional Scaling

This method was used to assess how many criteria were being used to determine preference among the six hay treatments. Hays were presented in pairs, and the relative intake of each hay in each pair was then expressed as a preference within the pair. If equal quantities were consumed then there was no (0) preference expressed. If, on the other hand, only one hay of the pair was consumed, then the preference was large for that hay over the other hay in the pair. The differences were then graphed to determine which hays the animals perceived to be similar and which they perceived to be different.

Statistical Analysis

The data were analyzed statistically to examine main effects, and a set of orthogonal contrasts was used to compare treatments within the analysis of variance. The single degree of freedom contrasts compared chemical fertilized hay with the others, no-effluent with effluent treated hays, and the linear or lack of fit (quadratic) response to days post effluent application. The data were then examined by multidimensional scaling as described above.

Results and Discussion

Short-Time Intake

Preference—noted by dry matter intake (DMI)—was strongly against hays that had been harvested from swine effluent waste fields (Table 1). Only the cattle showed a significant variation in preference among the hays harvested from the long-time spray field. In this case, steers preferred the hay that was harvested prior to effluent application (Hay-1, day 0) compared with hays made after effluent application (Hay-2, day 0; Hay-3, day 1; Hay-4, day 2). The noted preference by steers for Hay-3 (day 1) over either Hay-2 (day 0) or Hay-4 (day 2) is difficult to explain, but is evident for both DMI and time spent feeding, whereas intake rates were generally similar. Intake rates were also similar among the hays for both sheep and goats.

All three ruminant species preferred the hays that were fertilized and harvested from a non-waste environment compared with hays that were associated with waste application. Further, all three species preferred Hay-6 harvested from non-waste field B over Hay-5 harvested from non-waste field A (Table 1).

Forage Composition

The nutritive value of the hays fed to cattle, sheep, and goats (Tables 2, 3, and 4, respectively) were altered by effluent application and, perhaps to some extent, by the slight delay (maximum of 3 days) in harvest. Some differences in composition would also be expected among the experiments due to bale-to-bale variation during the course of the experiments as well as to both sampling and laboratory error. In the cattle trial where Hay-1 was preferred over the hays receiving effluent (Hays 2, 3, and 4), the IVTD and CP of Hay-1 were actually least, with NDF variable (Table 2). Apparently, steers found the effluent treated hays objectionable. The same composition differences were also noted for the same hays fed in the sheep (Table 3) and goat (Table 4) trials, but none of the four hays were consumed well and no preference was exhibited among them.

Hays harvested from non-waste fields were preferred by all three ruminant species over hays harvested from a waste environment. Further, all three species preferred Hay-6 from non-waste field B over Hay-5 from non-waste field A. This selection is consistent with the greater IVTD and CP and lesser NDF concentrations of Hay-6 over Hay-5.

Table 1. Short-term dry matter intake (DMI) and intake rate in Exp. 1 (cattle), Exp. 2 (sheep), and Exp. 3 (goats).

Treatment[1]	Exp. 1 (Cattle)			Exp. 2 (Sheep)		Exp. 3 (Goats)	
	DMI[2]	Time	Rate	DMI	Rate	DMI	Rate
	gram (g)	min	g/min	gram (g)	g/min	gram (g)	g/min
Hay 1 (pre)	716^{c}	11.1^{c}	67^{a}	91^{c}	1.5^{c}	74^{c}	1.2^{c}
Hay 2 (post)	355^{e}	5.2^{de}	89^{a}	83^{c}	1.5^{c}	73^{c}	1.4^{c}
Hay 3 (post)	485^{d}	7.1^{d}	57^{a}	65^{c}	1.2^{c}	71^{c}	1.2^{c}
Hay 4 (post)	332^{e}	4.6^{e}	56^{a}	69^{c}	1.3^{c}	55^{c}	0.9^{c}
Hay 5 (none)	1120^{b}	15.0^{b}	86^{a}	301^{b}	5.0^{b}	201^{b}	3.5^{b}
Hay 6 (none)	1573^{a}	18.3^{a}	88^{a}	469^{a}	9.3^{a}	421^{a}	8.3^{a}
Significance (*P*):							
Treatment	<0.01	<0.01	0.28	<0.01	<0.01	<0.01	<0.01
MSD[3]	118	2.0	55	56	1.0	59	1.1
Pre vs. Post	<0.01	<0.01	0.99	0.45	0.69	0.77	0.99
Post:							
Linear	0.72	0.56	0.10	0.65	0.77	0.58	0.37
LOF[4]	0.02	0.03	0.36	0.67	0.69	0.78	0.87
None vs. Other	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01
No Waste (5 vs. 6)	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01
CV[5]	15	19	46	29	28	37	36

[1] Pre = prior to effluent application; post = after effluent application; none = chemical fertilizer and no effluent application.
[2] Each value is the mean of six animals.
[3] MSD = minimum significant difference based on the Waller-Duncan K ratio (k=100) t -test. Means with different superscripts differ.
[4] LOF = lack of fit or quadratic component.
[5] CV = coefficient of variation.

Table 2. Nutritive value[1] of the as-fed (AF) hay and its weighback (WB) when fed to cattle in Exp. 1 (oven dry matter basis).

Treatment[2]	IVTD		CP		NO3 – N		NDF		ADF		Cellulose		Lignin	
	AF3	WB3	AF	WB	AF	WB	AF	WB	AF	WB	AF	WB	AF	WB
	%													
Hay 1 (pre)	69.2^{c}	68.8	8.9^{e}	8.7	0.018^{f}	--	72.4^{bc}	71.4	39.1^{ab}	38.4	34.5^{ab}	34.1	4.74^{a}	4.52
Hay 2 (post)	71.3^{ab}	70.8	10.4^{cd}	10.4	0.081^{c}	--	71.8^{d}	70.7	38.9^{b}	38.7	34.2^{bc}	33.9	4.73^{a}	4.59
Hay 3 (post)	72.2^{a}	71.6	10.2^{d}	9.9	0.037^{e}	--	73.5^{a}	72.0	39.5^{a}	39.5	34.6^{a}	34.5	4.67^{a}	4.58
Hay 4 (post)	71.0^{b}	69.7	10.8^{c}	10.4	0.067^{d}	--	72.9^{b}	71.7	38.7^{b}	38.5	34.1^{c}	33.8	4.67^{a}	4.56
Hay 5 (none)	64.7^{d}	64.8	14.2^{b}	13.8	0.136^{a}	--	72.4^{c}	71.6	34.0^{c}	34.2	29.1^{d}	29.3	4.97^{a}	4.93
Hay 6 (none)	68.8^{c}	68.6	15.7^{a}	15.2	0.114^{b}	--	68.3^{e}	67.9	31.1^{d}	31.7	26.8^{e}	27.4	4.40^{b}	4.46
Significance (*P*):														
Treatment	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
MSD4	1.03		0.4		0.010		0.5		0.5		0.4		0.11	
Pre vs. Post	<0.01		<0.01		<0.01		0.14		0.80		0.23		0.28	
Post:														
Linear	0.57		0.12		0.01		<0.01		0.43		0.81		0.36	
LOF5	0.04		0.04		<0.01		<0.01		0.01		0.01		0.53	
None vs. Other	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		0.63	
No Waste (5 vs. 6)	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
CV6	1.4		3.3		12.4		0.7		1.3		1.1		2.2	

[1] IVTD = in vitro true dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.
[2] Pre = prior to effluent application; post = after effluent application; none = chemical fertilizer and no effluent application.
[3] Each value is the mean of six samples (n=6).
[4] MSD = minimum significant difference based on the Waller-Duncan k-ratio (k=100) t-test. Means with different superscripts differ.
[5] LOF = lack of fit or quadratic component.
[6] CV = coefficient of variation.

Table 3. Nutritive value[1] of the as-fed (AF) hay and its weighback (WB) when fed to sheep in Exp. 2 (oven dry matter basis).

Treatment[2]	IVTD		CP		NO_3 – N		NDF		ADF		Cellulose		Lignin	
	AF[3]	WB[3]	AF	WB	AF	WB	AF	WB	AF	WB	AF	WB	AF	WB
	%													
Hay 1 (pre)	69.4^{c}	68.3	9.31^{d}	9.3	0.063^{bc}	--	72.1^{c}	71.7	39.2^{ab}	38.8	34.2^{b}	33.9	4.61^{c}	4.57
Hay 2 (post)	72.0^{a}	71.6	10.3^{c}	10.1	0.041^{d}	--	72.2^{c}	71.3	38.3^{c}	38.2	33.3^{c}	33.3	4.64^{bc}	4.62
Hay 3 (post)	72.2^{a}	71.4	10.4^{c}	10.1	0.058^{cd}	--	73.4^{a}	73.0	39.4^{a}	39.5	34.6^{a}	34.8	4.62^{bc}	4.59
Hay 4 (post)	71.0^{b}	70.5	10.3^{c}	10.1	0.052^{cd}	--	72.8^{b}	71.8	38.9^{b}	38.7	34.1^{b}	34.3	4.72^{b}	4.56
Hay 5 (none)	64.1^{d}	63.1	13.9^{b}	13.3	0.129^{a}	--	72.5^{bc}	72.6	34.0^{d}	35.0	28.9^{d}	29.9	5.07^{a}	5.24
Hay 6 (none)	69.0^{c}	67.4	14.9^{a}	14.4	0.080^{b}	--	68.8^{d}	68.4	31.9^{e}	33.0	27.2^{e}	27.8	4.48^{d}	4.66
Significance (*P*):														
Treatment	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
MSD[4]	0.7		0.4		0.019		0.6		0.5		0.4		0.10	
Pre vs. Post	<0.01		<0.01		0.16		0.02		0.11		0.31		0.23	
Post:														
Linear	0.01		0.93		0.28		0.07		0.05		<0.01		0.15	
LOF[5]	0.03		0.73		0.20		<0.01		<0.01		<0.01		0.22	
None vs. Other	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
No Waste (5 vs. 6)	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
CV[6]	1.0		3.2		24.5		0.7		1.3		1.1		2.0	

[1] IVTD = in vitro true dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.
[2] Pre = prior to effluent application; post = after effluent application; none = chemical fertilizer and no effluent application.
[3] Each value is the mean of six samples (n=6).
[4] MSD = minimum significant difference based on the Waller-Duncan k-ratio (k=100) t-test. Means with different superscripts differ.
[5] LOF = lack of fit or quadratic component.
[6] CV = coefficient of variation.

Table 4. Nutritive value[1] of the as-fed (AF) hay and its weighback (WB) when fed to goats in Exp. 3 (oven dry matter basis).

Treatment[2]	IVTD		CP		NO_3 – N		NDF		ADF		Cellulose		Lignin	
	AF[3]	WB[3]	AF	WB	AF	WB	AF	WB	AF	WB	AF	WB	AF	WB
	----------	----------	----------	----------	----------	----------	%	----------	----------	----------	----------	----------	----------	----------
Hay 1 (pre)	69.9^{c}	68.9	9.3^{c}	9.1	0.065^{c}	--	71.9^{bc}	71.7	39.1^{b}	38.9	34.4^{a}	34.2	4.56^{c}	4.57
Hay 2 (post)	73.5^{a}	72.5	10.5^{b}	10.4	0.049^{d}	--	71.5^{c}	71.2	38.0^{c}	37.7	33.5^{b}	33.3	4.54^{c}	4.58
Hay 3 (post)	73.3^{a}	72.0	10.2^{b}	10.0	0.063^{cd}	--	73.0^{a}	72.5	39.8^{a}	39.4	34.5^{a}	34.5	4.72^{b}	4.64
Hay 4 (post)	71.4^{b}	70.3	10.6^{b}	10.1	0.048^{d}	--	72.4^{b}	71.7	38.7^{b}	38.9	33.9^{b}	34.3	4.68^{b}	4.57
Hay 5 (none)	65.0^{d}	63.2	14.7^{a}	14.0	0.148^{a}	--	72.1^{b}	71.9	33.9^{d}	34.6	28.7^{c}	29.4	5.05^{a}	5.15
Hay 6 (none)	69.2^{c}	67.8	15.0^{a}	14.1	0.086^{b}	--	68.3^{d}	68.6	31.6^{e}	33.1	27.0^{d}	27.8	4.41^{d}	4.71
Significance (*P*):														
Treatment	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
MSD[4]	0.9		0.4		0.016		0.5		0.5		0.4		0.11	
Pre vs. Post	<0.01		<0.01		0.11		0.09		0.32		0.04		0.10	
Post:														
Linear	<0.01		0.70		0.95		<0.01		0.01		0.09		0.03	
LOF[5]	0.07		0.09		0.06		<0.01		<0.01		<0.01		0.05	
None vs. Other	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		0.01	
No Waste (5 vs. 6)	<0.01		0.11		<0.01		<0.01		<0.01		<0.01		<0.01	
CV[6]	1.2		3.1		19.5		0.7		1.3		1.2		2.3	

[1] IVTD = in vitro true dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.
[2] Pre = prior to effluent application; post = after effluent application; none = chemical fertilizer and no effluent application.
[3] Each value is the mean of six samples (n=6).
[4] MSD = minimum significant difference based on the Waller-Duncan k-ratio (k=100) t-test. Means with different superscripts differ.
[5] LOF = lack of fit or quadratic component.
[6] CV = coefficient of variation.

Multidimensional Scaling of Dry Matter Intake

The results of statistical analysis by multidimensional scaling (MDS) varied among the three animal species in preference for the hays. The MDS analysis of dry matter intake indicated that cattle and sheep were making selections based on two criteria while the goats were making selections based upon a single criterion (Figure 1).

In the case of cattle, the first criterion was associated with forage nutritive value (ADF, P<0.01; Cellulose, P<0.01; ADF Ash, P=0.02; CP, P=0.02). We had limited degrees of freedom (n=6) and, consequently, limited statistical power. This may have resulted in our failure to detect any correlation with the in vitro estimate of digestibility (IVTD; P=0.10). The variation in ADF and the other estimates of fiber, however, was similar to the variation in effluent application. It is possible that the reason that IVTD was not correlated with this dimension is that the dimension is more closely related to the effluent treatment than nutritive value. The second criterion was given less weight in selection and was not correlated with any of the estimates of nutritive value. For example, the two hays produced using inorganic nitrogen fertilizers (Hay-5 and Hay-6) were separated in this dimension. In the second dimension, Hay-6 was similar to Hay-2 and Hay-4 while Hay-5 was similar to Hay-1 and Hay-3, but we had no measured variable that explained this association.

The preference results from sheep were similar in the first dimension to those from cattle. The first dimension appeared to be associated with nutritive value (ADF, P<0.01; CELL, P<0.01; CP, P=0.02). The second dimension, however, was correlated with Lignin (P<0.01). This correlation may have been in response to texture, but the limited degrees of freedom once again make additional research necessary.

In contrast to the cattle and sheep, the goats appeared to select the forages on a single criterion, but this criterion was similar to the first dimension of the cattle and sheep. The dimension was associated with nutritive value (NDF, P=0.02; ADF, P=0.01; CELL, P=0.01; ADF Ash, P=0.02; CP, P=0.02).

We found no correlation with IVTD in all three animal species. In other studies we have often found correlation with IVTD to be among the strongest indicators of preference. This may indicate that the effect of effluent was confounded with the nutritive value in this particular set of observations, and additional research may be required to test for the effects of effluent apart from nutritive value. The relative magnitude of the effects is difficult to test with this dataset, but other work (Burns et al., 2009) has shown an impact on forage intake.

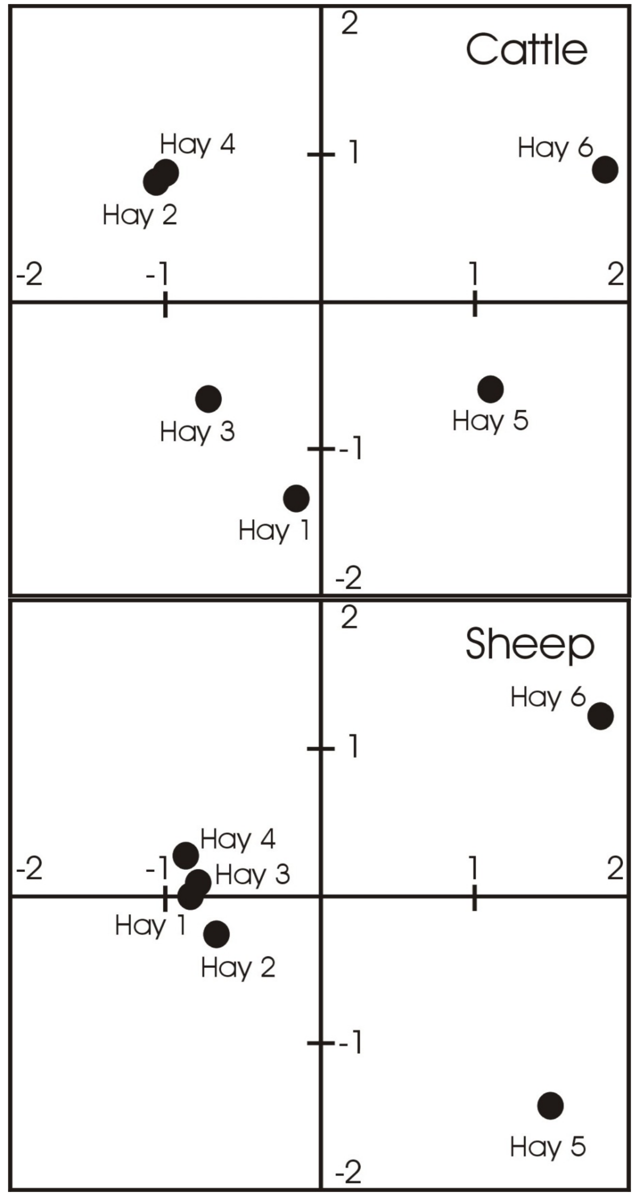

Figure 1. *Graphical display of the two dimensional relationships expressed by cattle and sheep preference.*

Summary

- Cattle (steers) detected a difference with modest consumption between bermudagrass hay harvested prior to swine lagoon effluent application compared with hays harvested after effluent application.
- Sheep and goats consumed little of the bermudagrass hays harvested from the effluent spray field whether the hays were cut before or after effluent application.
- All three ruminant species preferred bermudagrass hays harvested from non-waste treated fields.
- All three ruminant species preferred the bermudagrass hay from the non-waste treated field that was greatest in IVTD and CP and least in NDF concentrations.
- Bermudagrass hay from swine lagoon effluent spray fields has a role in ruminant production systems, but when offered as the sole diet, expect dry matter intake to be only modest.

References

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