USING GRASS FORAGES IN DAIRY CATTLE RATIONS

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INTRODUCTION

Alfalfa and corn silages are the predominant forages used in dairy rations in the U.S. However, there are many areas that have soil resource limitations that limit the potential for growing either alfalfa or corn silage. When these crops are grown on these soils, yields are low and the cost of forage dry matter (DM) produced is high. The persistence of alfalfa stand life is also limited in these situations. Grass forages are an excellent agronomic option to grow on these soils. With proper harvest management and nitrogen fertilization, high yields of high quality forages can be produced. In New York, both the southern and northern portions of the state have soil resource limitations in some areas that limit the use of alfalfa or corn silage. Grass forages also have an advantage over alfalfa in terms of manure nutrient application in herds with comprehensive nutrient management plans. Herds utilizing rotational pasture systems in the Northeast have traditionally relied on mixed stand grasses as the predominant forage. There have been a large number of research papers evaluating the incorporation of grass forages in rations containing alfalfa or corn silage. This topic has been covered in a recent conference (Combs, 2012). This paper will focus on the use of grass forages as the primary forage in lactating cow rations. A recent paper covered the production and harvesting of grass forages (Johnson, 2011).

GRASS VERSUS LEGUME FORAGES

Table 1 contains nutrient composition data for legume and grass silages analyzed at the Dairy One Forage Lab over a 1 year period. A primary difference between legume and grass silages is the ADF to NDF ratio. This is wider in grasses since they have a larger hemicellulose fraction. The hemicellulose content of forage can be estimated by subtracting the ADF from NDF. Lignin, as a % of NDF, is also lower in the grass samples. Even though the 30-hour IVTD values are similar for these forage types, the 30-hour NDFD of grasses is higher than alfalfa.

A recent paper reviewed some of the considerations when comparing legume and grass forages (Paulson et. al., 2008). Recently, Mertens and Huhtanen (2007) presented a paper dealing specifically with the use of grass forages in dairy rations. They used the NDF energy intake system to formulate example rations using grass forages. A forage mixture with 25% alfalfa (40% NDF) and 75% grass (55% NDFD) was used to develop maximum forage rations for cows producing 77 to 121 lbs. of milk per day and an optimum NDF intake of 1.2% of body weight. The 48-hour in vitro NDFD was 60% for the grass forage. Total dry matter intake increased from 47.5 to 64.9 lbs. / per day as milk production increased while total ration NDF decreased from 36.1 to 26.5%. The forage mixture decreased from 61.4 to 36.9% of the total ration dry matter

with increasing milk production. A second example was for a cow producing 99 lbs. of milk per day when the same forage mixture was used but the NDF content of the grass varied between 51 and 59%. As the grass forage NDF increased, forage decreased from 52.4 to 43.3% of the total ration dry matter while total DMI was relatively constant. A third simulation was done assuming that the 48-hour in vitro NDFD was 76%. In this situation, total NDF intake was increased to 1.28% of body weight. Forage decreased from 71.1 to 42.8% of the total ration dry matter as milk production increased. These simulations provide examples of the relationships between forage NDF, NDFD and level of milk production on the quantity of forage that can be incorporated into a ration. Murphy (2004) indicated that NDF intake could be as high as 1.4 – 1.5% of body weight in rations based on high quality grasses.

Table 1. Nutrient Composition of Alfalfa and Grass Forages[1]

	Alfalfa Silage, average	Alfalfa silage, normal range[2]	Grass silage, average	Grass silage, normal range
DM, %	41.37	30 – 52.8	38.3	24.5 – 52.1
Crude protein, % of DM	21.88	18.8 – 25	15.6	11 – 20.2
Soluble CP, % of CP	57.6	48 – 67.1	52.1	41.2 – 63
ADF, % of DM	34.4	30.2 – 38.7	37.9	32.2 – 43.6
NDF, % of DM	44.4	38.4 – 50.4	57.85	50 – 65.7
Lignin, % of DM	7.46	6.05 – 8.87	5.39	3.7 – 7.1
Fat, % of DM	3.73	2.95 – 4.51	3.98	3 – 4.93
Ash, % of DM	10.9	8.7 – 13.1	9.5	6.9- 12.1
NE-l, Mcal/lb.	0.64	0.57 – 0.7	0.57	0.48 – 0.67
IVTD, % - 30 hour	78.6	74.5 – 82.7	77.8	72.3 – 83.2
NDFD, % - 30 hour	50.6	44.3 – 56.8	61.9	55.1 – 68.7
Ammonia-N - % of total N	10.66	2.24 – 19.1	10.7	0.79 – 20.6
Calcium, % of DM	1.37	1.1 – 1.65	0.61	0.4 – 0.83
Phosphorus, % of DM	0.34	0.28 – 0.39	0.34	0.25 – 0.42
Magnesium, % of DM	0.27	0.22 – 0.32	0.23	0.16 – 0.29
Potassium, % of DM	2.74	2.2 – 3.28	2.5	1.76 – 3.26

[1] Source: Dairy One Forage Lab, samples analyzed between May, 2011 and April, 2012

[2] Normal range = Average plus or minus 1 standard deviation

FORAGE INTAKE IN DAIRY CATTLE

A key consideration in evaluating forages for potential use in dairy rations is potential forage and total ration dry mater intake. There are a number of factors that influence potential forage intake. These include NDF content, NDF digestibility, passage rate, particle size, effective NDF, fill potential, fragility of the particle and indigestible NDF. Mertens (2010) has provided updated information on the NDF-Energy Intake system for formulating dairy rations. A total ration NDF intake of 1.25% of body weight was found to optimize production of 4% fat corrected milk across various forages when corn and soybean meal were primary energy and protein sources in the ration. If an amylase-treated NDF organic matter value is used, the NDF intake value is lowered to 1.2% of body weight. This value may not be the maximum NDF intake that a cow could consume but is an estimate of the maximum intake while maximizing milk production. This predicted value includes both forage and non-forage components in the ration. This system can be used to develop rations with either maximum or minimum levels of forage.

GRASS FORAGES IN LACTATING COW RATIONS

Table 2 is a summary of a number of research studies using grass forages in dairy rations. In some studies, there was a direct comparison of alfalfa and grass forages. There is some variation in the trial designs in terms of how the quantity of forage to be included in the ration was determined. This makes it difficult to make direct comparisons between studies and assess the true potential differences between alfalfa and grass forages.

Broderick et. al. (2002) compared alfalfa and perennial ryegrass silages in dairy cattle rations with the same total ration NDF content. The alfalfa ration was 51% forage while the ryegrass rations contained 41% forage. Both dry matter intake and milk production were higher for cows on the alfalfa rations. A second trial at Wisconsin also compared alfalfa and perennial ryegrass in dairy rations (Hoffman et. al., 1998). In this trial, both rations were about 69% forage. Milk production and dry mater intake were higher for cows fed alfalfa silage.

Voelker Linton and Allen (2008) compared cows fed alfalfa silage (43% NDF) and orchardgrass silage (48% NDF). These rations contained 23% forage NDF but differed in the proportion of forage in the total ration. There were no differences in 3.5% fat corrected milk or dry matter intake due to forage type. Weiss and Shockey (1991) also compared alfalfa silage (40% NDF) and orchardgrass silage (52% NDF) in dairy rations. These forages were fed in rations containing 20, 40 or 60% grain. Cows fed alfalfa silage consumed about 4 lbs. more ration dry matter per day but there were no differences in milk production between the 2 forages. There was no benefit in this trial of feeding rations containing more than 40% grain.

Table 2. Lactation Trials Comparing Alfalfa and Grass Forages

Trial	Forage Source	NDF in Forage, % of DM	Forage, % of Ration DM	Total Ration NDF,%	Forage NDF, % of Total Ration DM	Forage NDF Intake, % of Body Weight	Ration DMI, lbs.	Milk, lbs./day	Milk Fat, %
Cherney et.al. 2002a	OG[a]	50.8	48.2	37.4	24.5	0.92	45.1	77.4	3.73
"	OG	56.1	44.1	38.8	20.6	0.86	37.6	69.5	3.94
Cherney et.al., 2002a	OG	55	50	34.6	27.5	1.07	49.3	66.4	3.53
	OG	55	60	38.1	33	1.18	45.1	64.2	3.52
	OG	55	70	42	38.5	1.11	38.1	59.6	3.58
	OG	55	80	46.3	44	1.23	35.6	56.3	3.44
Cherney et.al., 2004	ALF	40.6	62.1	27	25.2	1.05	56.1	89.1	3.7
	OG1	51.3	53.5	27.9	27.4	1.11	59.4	88.9	3.41
	OG2	49.2	51.2	32.3	25.2	0.96	49.1	75.7	3.69
	FES1	45	58.9	28.8	26.5	1.13	59	88.9	3.46
	FES2	55.1	48.2	32	26.5	0.98	49.9	81.2	3.61
Broderick et. al., 2002	ALF	43.5	51.2	27.8	22.3		55.4	90.4	3.08
	PRYE	49.5	40.6	27.7	20.1		37	78.3	2.8
Weiss and	ALF	40.1	80	35.4	32.1		46.9	52.4	3.86

Shockey, 1991									
	ALF	40.1	60	30.6	24.1		49.3	60.1	3.06
	ALF	40.1	40	25.6	16		51	60.9	3.04
	OG	52.5	80	45.8	42		37.6	46.4	3.58
	OG	52.5	60	39.1	31.5		45.1	59	3.28
	OG	52.5	40	30.9	21		48	58.5	3.26
Enu et.al., 2003	EGS	74.9	83.3	63.8	62.4	1.78	36.1	63.6	3.44
	EGS	74.9	71.1	58.7	53.2	1.6	40.5	68.9	3.72
	EGS	74.9	56	48.3	41.9	1.32	40.7	72.8	3.35
	EGS	74.9	29.2	31	21.8	0.82	49.5	81.8	3.43
Hoffman et. al, 1998	ALF	43.8	69.7	35.7	30.5	1.12	49.5	69.9	3.61
	PRYE	46.8	68.1	37.1	31.9	1.05	44.7	66.4	3.76
Hansen et. al., 1991	ALF	49.5	60	38.5	29.7	1	44	62.6	
			50	32.1	24.7	0.84	44.4	65.4	
			40	25.7	19.8	0.7	45.8	68.2	
	BRG	63.6	60	47.2	38.2	1.35	46.1	64.9	
			50	39.2	31.8	1.11	45.3	68.4	
			40	31.12	25.4	0.89	45.;5	68.9	
Cherney et. al., 2003	FES	60	46.8	35.1	28.1	1.07	47.4	87.2	3.25
			57.7	39.6	34.6	1.31	44.9	84.4	3.45

Cherney et. al., 2002b	ALF	34.2	84	30.2	28.3	1	45.1	71	3.66
	FES	56.1	51	31.3	28.6	1.17	54.1	89.1	3.33
Dewhurst et. al., 2003	ALF	45	65.6	39.9			44.9	60.9	
	GR	52.7	62	44			40	54.8	
Voelker Linton and Allen, 2008	ALF	42.6	53	26.3	22.5	0.87	46	60.9	3.98
	OG	48	48	27	23	0.86	44	61.4	4.39

[a] Alf = alfalfa, OG = orchardgrass, FES = tall fescue, PRYE = perennial ryegrass, BRG = bromegrass, EGS = Eastern gamagrass

A series of trials have been done at Cornell evaluating a variety of grass forages to replace alfalfa in dairy rations. Table 2 contains data from these trials. One of the early trials compared early and late cut orchardgrass (Cherney et. al., 2002a). These orchardgrass silages contained 37 to 39% NDF. The forage feeding level used was 0.95% of body weight as forage NDF. Milk production and dry matter intake were significantly higher for cows fed the early cut orchardgrass. A second component of this trial used an orchardgrass silage (55% NDF) fed at 50, 60, 70 and 80% of the total ration dry matter. Ration NDF levels increased from 34.6% to 46.3% as the proportion of the orchardgrass increased. Dry matter intake and milk production decreased linearly as the level of forage in the ration increased. Total ration NDF intake was similar for all 4 levels of forage inclusion in the ration.

A trial was conducted by the same workers using 2 levels of tall fescue (Cherney et. al., 2003). The tall fescue silage used during this trial ranged between 55 and 63% NDF. Rations used contained either 46.8 (36% NFC) or 57.7% tall fescue silage (31% NFC). Milk production was higher for cows fed the lower tall fescue and higher NFC rations (87 vs. 84 lbs.). Dry matter intake was also higher for these same cows. Feed efficiency was similar for both rations. A later trial compared alfalfa, fescue or orchardgrass silages for mid-lactation cows (Cherney et. al., 2004). Two orchardgrass silages (49 and 51% NDF, two tall fescue silages (45 and 55% NDF) and one alfalfa silage (41% NDF) were used. All rations were formulated to contain 0.95% of body weight as forage NDF. Actual forage NDF intakes ranged from 0.96 to 1.13% of body weight. Milk production was similar for the alfalfa, one orchardgrass (51% NDF) and one tall fescue (45% NDF) at about 89 lbs. per day. Dry matter intake also did not differ between these 3 rations. However, cows fed orchardgrass and fescue consumed slightly more grain that cows fed alfalfa. Milk production and dry matter intake were lower for the other orchardgrass and fescue rations.

Kammes and Allen (2012) conducted a trial using early cut (44.9% NDF) and late cut (54.4% NDF) orchardgrass silages. Rations were formulated to contain 25% forage NDF and 30% total NDF. This resulted in forage to concentrate ratio of 58:42 for the early cut orchardgrass (EC) and 46:54 for the later cut forage (LC). The 30-hour NDFD values were 69.4 and 57.3% for the EC and LC forages. Indigestible NDF (INDF) was determined using a 120 hour in vitro fermentation. In the EC forage, INDF was 24.1% of total forage while it was 26.6% in the LC silage. There were no differences in dry matter intake between the 2 rations but actual milk production and milk fat % were significantly lower on the EC ration. The higher actual milk production on the LC ration could be related to a 1.2 lbs. higher daily starch intake on the LC ration. However, there were no differences in either the lbs. of 3.5% fat corrected milk produced or daily milk fat yield.

Table 3. Lactation Trials Using Alfalfa and Grass Pastures

Trial	Forage Source	NDF in Forage, % of DM	Forage, % of Ration DM	Total Ration NDF, %	Forage NDF, % of Ration DM	Forage NDF Intake, % of Body Weight	Ration DMI, lbs.	Milk. Lbs./day	Milk Fat, %
Bargo et. al., 2002	Mixed Grass	49.9	60	36.5	30	1.08	47.5	62.7	3.13
Reis and Combs, 2000	Grass: legume (50:50)	38.1	100	38.1	38.1		30.6	48	3.89
		38.1	71.8	30.6	27.3		38.9	59	3.5
		38.1	49.3	25.9	18.8		43.6	66.9	3.08
Delahoy et. al., 2003	OG (Expt. 1)	45.7	67.6	36.8	30.9	1.04	48.9	53.5	3.65
	OG (Expt. 2)	51.8	59.6	39.9	30.9	1.01	44.7	60.5	3.53
Holden et. al., 1994	Mixed Grass (April)	41.3	65.2	34.6	26.9	1	46.9	79.2	2.8
Kolver and Muller, 1998	Mixed Grass	43.2	100	43.2	43.2	1.46	41.8	65.1	3.72
Ruiz et. al., 2001	OG (green chop)	51.8	74.3	39.8	38.5	1.43	45.8	62.7	3.42
Schor and Gagliostro, 2001	Mixed Grass (SBM)	45	70	35	31.5	1.1	43.1	54.8	3.3
	Mixed Grass (BM)	45	75	38.6	33.8	1.38	50.3	64.5	3.26

PASTURE RESEARCH RESULTS

The data in Table 3 is from selected studies using grass forages in pasture based systems. These studies used grass as the only forage. Milk production varies depending on the proportion of grass forage in the ration and the quality of the grass. These grass forages were consistently < 50% NDF and accounted for 60 to 100% of the total ration dry matter consumed. The most striking parameter is the high levels of forage NDF consumed per day when expressed as a percent of body weight. The range is 1.01 to 1.46% which is much higher than the 0.9% that has frequently been used as a maximum forage intake guideline. This may reflect the high quality, vegetative grass used in most of these studies.

EXAMPLE DAIRY HERD RATIONS

Table 4 contains sample rations from 8 herds that utilize grass forages in their rations rather than alfalfa due to soil resource considerations. These herds were selected based on high milk production levels. Most of these herds use varying ratios of corn silage to grass silage. Herd A also fed .9 lbs. of straw. However, note that Herd C used basically an all grass silage feeding program plus 3 lbs. of dry hay. The small amount of corn silage listed is actually a seasonally available sweet corn cannery byproduct. This is a 250 cow herd that usually ships 75-85 lbs. of milk per cow per day depending on the quality of the grass forage at harvest. Key points from this table are:

1. Grass silage NDF's range from 46 to 57%. Our goal for grass silage in early lactation cow rations is 50 to 55% NDF. These herds have high quality grass forages available.
2. The percent of the total ration as forage ranges from 42 to 78%.
3. Total ration NDF ranges from 20.2 to 33.8% of the total ration dry matter.
4. Forage NDF intake, expressed as a % of body weight, ranges from 0.8 to 1.18%. These herds are feeding high levels of forage NDF.
5. Ration crude protein levels range from 14.3 to 17.7%. A number of these herds are feeding high forage, low protein rations. Herd D has fed a low CP (<15%) ration for about 3 years and consistently ships about 90 lbs. of milk per cow per day.

The data in Table 4 is provided to indicate that high levels of milk production can be attained using grass forages in place of alfalfa in dairy rations. It is important to remember that these herds produce "high quality" grass forages that are high in nutrient value and digestibility. Higher NDF grass forages will not be able to support these levels of milk production without high levels of grain feeding that can impair animal health.

Table 4. Example Herd Rations for Holstein Herds Using Grass Forages

Item	Herd A	Herd B	Herd C	Herd D	Herd E	Herd F	Herd G	Herd H
Formulated Milk, lbs./day	88	90	88	90	90	90	80	78
DMI, lbs./day	59	52	53.5	54.5	56.5	55.3	51	48
Grass forage NDF, %	48.3	47.5	57.5	53	48	48	46	52.8
Forage, % of Ration DM	63.7	49	42	59	49	61	78	60
Total Ration NDF, %	33.3	33.3	36	31.4	32.5	34.2	35.4	32.3
Ration Forage NDF, % of DM	29.3	23.8	24.3	28	20.2	26.8	33.8	27.4
Forage NDF intake, % of BW	1.11	1.04	0.9	1	0.81	1.04	1.18	0.86
Ration CP, %	15.8	17.7	15.7	14.3	16.6	16.7	15.3	17.3
Corn silage, lbs. DM/day	13.4	11.5	1.5	17	14.8	16.5	24	12.8
Grass silage, lbs. DM/day	23.2	14	21	12	13	17	16	16

SUMMARY

High quality grass forages can support high levels of both dry matter intake and milk production when used as the primary forage in dairy cattle rations. In many research studies, similar levels of milk production have been reported when grass forages were compared with alfalfa. These observations should provide confidence to dairy producers regarding the potential for incorporating grass forages in dairy rations. The question of what forages should be produced on the farm is largely a decision based on soil resources and forage management systems. There are significant forage crop acres that are not suited to alfalfa production but can be used very effectively for growing grasses. A number of states in the Northeast and Midwest conduct forage variety yield trials and publish data on yields of alfalfa and grass forages. This information should be

used as part of the decision making process in terms of which forage to grow on specific farms. A challenge is that the grass varieties from the various companies often change faster than animal intake and performance data can be obtained on specific grass varieties. However, both research and on-farm observations do support the value of including high quality grass forages in dairy rations.

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