Potassium Fertilization of Forage Grasses for Dry Cows

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Introduction

For the past two years the focus of forage research at Miner Institute has involved the fertilization of grasses for dry cows. There has been considerable research on achieving maximum yield and nutrient concentration for grasses fed to lactating dairy cows. Fertilization and harvest management systems are recommended with the goal of maximum economic forage yields and forage quality sufficient to support high levels of milk production. This research has explored the fertilization rates and stand management necessary to produce grass forage suited to the particular needs of dry cows. This is of concern to farmers in Japan as well as the U.S. since many farms in both countries are not able to successfully grow and harvest alfalfa and rely on grass as the main forage.

There is increasing concern in the U.S. about the effect of high levels of potassium (K) in dry cow rations. Ruminant nutritionists recommend that grasses grown for dry cows fertilized minimally or not at all. (Beede, 1992; Perkins, 1993) Forage analysis summaries from Japan reveal that grasses there also contain higher than desirable levels of potassium. Japanese corn silage is significantly higher in potassium than corn silage harvested in the Northeastern U.S.

While a K concentration of 0.9-1.0% in lactating cow rations is sufficient, these animals can accommodate forages with a relatively wide range of K concentrations, with a maximum tolerable level of 3% (NRC, 1989). The K requirement of dry cows is 0.65% of the total ration dry matter, and should not exceed 1.5% (Chase, 1994). Dry cow rations with high K concentrations are often associated with post-calving metabolic disorders. Since dry cows should be offered rations with a high proportion of forage, K levels in forages fed to dry cows should be less than 2%. (Chase, 1994).

Until recently, fertility research on forage grasses has focused on maximum economic yields with little concern about K concentration. While forage grasses respond modestly to K fertilization, as maximum economic yields are achieved K concentration increases dramatically. This information has been known for many years; research over thirty years ago found significantly higher K content of mixed forage grasses as the annual K_2O rate was increased from 50# to 300#/A. The 50# rate resulted in visual K deficiency symptoms, but rates exceeding this did not consistently increase yields. (Brown, 1969) Research in Pennsylvania (Marriott, 1961), on the other hand, showed significant timothy yield increases with 200#/A K_2O.

Limited research suggests that forage grass species differ considerably in their uptake of K, and accumulate different levels of tissue K at the same K fertilization rate. In Ohio, identical fertilization resulted in timothy with lower K concentrations than orchardgrass or reed canarygrass. (Van Keuren, 1984) Although not the result of comparative trials, forage analysis summaries report higher K levels for orchardgrass than for timothy. (Morrison, 1959; NRC, 1989)

Dairy farmers, ruminant nutritionists, and agronomists need to know how much K fertilizer can be applied to forage grasses to achieve high yields while maintaining tissue K levels below 2%.

The ideal level of fertilization will depend not only on harvest management but also on the forage species used.

Objectives

1. Compare three species of forage grasses for yield, forage quality, and mineral concentration at three levels of K fertilization.

2. Develop a two-cut harvest management system that can result in grass forages with 10-16% crude protein and 50-60% NDF, levels that are close to ideal for dry cows.

3. Develop a "Grass Management for Dry Cows" system which suggests a potassium fertilization level for each of the three forage species, and which indicates which species would be recommended based on soil fertility and planned fertilization programs.

Procedures

"Shawnee" orchardgrass, "Toro" timothy, and "Palaton" reed canarygrass were seeded at 8-10#/A in 3.1 meter strips on 20 July, 1994 in a Malone sandy loam soil with very low soil P and K levels. These grasses were found to head at almost exactly the same time in Pennsylvania State University variety trials. An application of 224 kg/Ha of 8-20-30 was band applied to all plots at seeding. Muriate of potash (0-0-60) was applied on 8 September, 1994 in 7.4 meter strips at four rates: 0, 90, 146, and 235 kg/Ha of K_2O. The plots were clipped once for weed suppression, and no harvest was taken in 1994. The experimental design was a split-plot with four replications where species were the main plot and fertilizer rate the subplot.

Nitrogen was applied on 18 April, 1995 at 76 kg N/Ha. First harvest was on 1 June, 1995, at which time orchardgrass was 5% headed and timothy and reed canarygrass were in the late boot stage. On 9 June, 81kg N and 52 kg P_2O_5/Ha were applied and second harvest taken on 27 July. Second harvest was delayed because drought reduced regrowth, especially of timothy.

In 1996, nitrogen was applied on 17 May at 56 kg N/Ha. Wet conditions delayed application until this time. First harvest was on 3 June, when the grasses were in the late boot stage of development. Second harvest was on 30 July. The interval between first and second harvests in both years was 57 days. The 1995 growing season was warm and dry, while the 1996 growing season was cool and wet.

Results

Forage yield

Reed canarygrass was the highest yielding species in both 1995 and 1996. (Table 1) In 1995 timothy had the lowest yield, while in 1996 orchardgrass was lowest yielding. These results were expected since timothy responds well to moist conditions (1996) and orchardgrass to relatively dry conditions (1995), while reed canarygrass has a wide range of adaptation to soil moisture.

Table 1. Forage Yield by Species, kg/Ha

Species	1995	1996	2-Year Mean
Orchardgrass	6364 a	4097 a	5230 a
Timothy	5659 b	4774 b	5216 a
Reed Canary	6988 a	5760 c	6374 b

None of the species responded well to potassium fertilization. (Table 2) There was no yield response to the first increment of fertilizer, which was the rate recommended by Cornell University based on soil analysis. In 1995, there was a yield response only to the highest rate of fertilization. In 1996, there were yield responses to the two highest rates of fertilization compared to the 90 kg/Ha rate, but not compared to the unfertilized control. Forage yields (100% dry matter basis) were lower in 1996 because of the cool, wet weather.

Table 2. Forage Yield by Fertilizer Rate, kg/Ha

Potassium rate	1995	1996	2-Year Mean
0	6195 a	4772 ab	5483 ab
90	5894 a	4416 b	5155 b
146	6190 a	5191 a	5690 ac
235	7164 b	5131 a	6147 c

Potassium concentration

Timothy had lower forage potassium concentrations than orchardgrass or reed canarygrass in both 1995 and 1996. For each year and each harvest, timothy had the lowest K concentration and orchardgrass the highest. (Table 3) However, potassium concentration was generally higher than desirable for balancing dry cow rations. In 1995, second cut timothy and reed canarygrass forage had K concentrations of less than 2.5%, and with careful ration formulation could be used in prefresh cow diets.

Table 3. Potassium Concentration by Species

Species	1995-1st	1995-2nd	1996-1st	1996-2nd	Mean
Orchardgr	3.05 a	2.79 a	3.21 a	3.06 a	3.03 a
Timothy	2.64 b	2.20 b	2.64 b	2.60 b	2.57 b
Reed Can.	2.75 b	2.41 c	3.11 a	2.72 b	2.75 c

While the grasses did not have a strong yield response to fertilization, for each species every increment of fertilizer K increased tissue K content. (Table 4) Second cut K concentrations were lower than those for the first cut, and concentrations were higher in the cool, wet 1996. This is to be expected, since potassium uptake is greater under cool, moist conditions. Only for second cut in 1995 (data not shown) did the K concentrations of unfertilized timothy approach the 2.0% level preferred for dry cows.

Table 4. Potassium Concentration by Fertilizer Rate

K Rate	1995-1st	1995-2nd	1996-1st	1996-2nd	Mean
0	2.40 a	2.33 a	2.71 a	2.53 a	2.49 a
90	2.67 ab	2.34 a	3.00 b	2.82 b	2.71 b
146	2.91 b	2.54 b	3.23 c	2.84 b	2.88 c
235	3.28 c	2.65 b	3.28 c	2.99 b	3.05 d

Soil test levels

For both 1995 and 1996, the control (no potassium fertilizer) treatment was the most economical for all three species, even with the low soil fertility of the test site. An annual application of 90 kg/Ha of potassium was adequate to maintain soil K levels, while higher rates rapidly increased soil test K levels. (Table 5)

Table 5. Changes in Soil K Level, ppm

Potassium rate	Aug.1995	Aug.1996	Change
0	37	25	-12
90	33	35	+2
146	34	68	+34
235	46	83	+37

Forage quality (Forage analysis summaries are in Appendices 2-4)

In both 1995 and 1996, first cut orchardgrass had the highest crude protein and lowest ADF and NDF levels. However, second cut orchardgrass had the lowest protein and highest fiber levels. In both years, first cut orchardgrass was at a slightly later stage of development than the other species, approximately 5% heads showing vs. no heads for timothy and reed canarygrass. This suggests that when evaluating different species, stage of morphological development may not be a reliable indicator.

Crude protein concentrations were over 12%, which is acceptable for dry cow rations. In few cases were NDF levels under 60%, the maximum level considered ideal for dry cows 2-3 weeks prepartum. More recently, however, dry cow rations are being fed successfully using forage grasses with approximately 65% NDF. All grasses were at 66% or less NDF for first and second harvests in both years.

Comments and interpretive summary

In spite of beginning soil test potassium levels that according to the Cornell University Nutrient Analysis Laboratory are quite low, we found it difficult to produce grass forage with acceptably low K concentration. There has been little research in the U.S. calibrating soil analyses for grass production. The dense, fibrous root system of grasses allows them to thrive on lower available soil K levels than a crop such as alfalfa. Therefore, a soil test K level that is low for alfalfa or corn may be quite sufficient for perennial grasses.

Second cut grasses were lower in potassium in both years, suggesting that farmers should focus on second cut grass for dry cows 2-3 weeks prepartum. First cut grasses can be used for dry cows more than three weeks prepartum, or other livestock. Potassium concentrations will be higher in a cool, wet season regardless of species selected.

Based on this research, it appears that timothy is the best species for dry cow forage. However, reed canarygrass may also be acceptable because of higher concentrations of anions, resulting in a more favorable dietary cation-anion difference (DCAD). More research is needed on this subject. It is apparent, however, that orchardgrass is not a good choice. Not only did orchardgrass forage have higher concentrations of K regardless of fertilizer rate, but in our research this species contained 8 to 15 times as much sodium as timothy or reed canarygrass, having a moderately adverse effect on DCAD.

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APPENDICES

Appendix 1. Soil Analyses, ppm, August 1996

Species	pH	P	K	Mg	Ca
Orchardgr.	6.4	1	45	147	1497
Timothy	6.2	1	61	137	1400
Reed Canary	6.3	1	52	127	1576

Appendix 2. Forage Analysis, First Harvest 1995 (%)

Species	CP	ADF	NDF	Ca	P	Mg	K

Orchardgr.	17.5	36.7	62.7	.37	.20	.19	3.05
Timothy	15.8	39.0	65.8	.43	.21	.15	2.65
Reed Can.	16.9	38.2	64.4	.38	.20	.20	2.75

Appendix 3. Forage Analysis, Second Harvest 1995 (%)

Species	**CP**	**ADF**	**NDF**	**Ca**	**P**	**Mg**	**K**
Orchardgr.	16.0	35.5	66.6	.66	.17	.31	2.79
Timothy	17.6	32.6	62.4	.80	.19	.22	2.20
Reed Can.	17.7	32.4	65.6	.70	.19	.29	2.41

Appendix 4. Forage Analysis, First Harvest 1996 (%)

Species	**CP**	**ADF**	**NDF**	**Ca**	**P**	**Mg**	**K**
Orchardgr	19.0	30.3	60.6	.41	.18	.18	3.21
Timothy	17.8	32.3	62.6	.36	.17	.13	2.84
Reed Can.	16.3	35.0	64.3	.34	.21	.19	3.11

Appendix 5. Forage Analysis, Second Harvest 1996 (%)

Species	**CP**	**ADF**	**NDF**	**Ca**	**P**	**Mg**	**K**
Orchardgr	12.5	38.3	63.7	.48	.21	.22	3.06
Timothy	13.1	34.6	58.3	.48	.19	.16	2.60
Reed Can.	13.2	37.7	62.7	.42	.23	.23	2.72

Appendix 6. Precipitation and Heat Units, 1 April-30 July 1995-96

Year	**Precipitation, mm**	**Heat Units**

1995	182	1400
1996	490	1235
31-year Mean	291	1382